A FORMAL STUDY OF SYLLABLE, TONE, STRESS AND DOMAIN
IN CHINESE LANGUAGES

by

San Duanmu

Submitted to the Department of
Linguistics and Philosophy
in Partial Fulfillment of the Requirements
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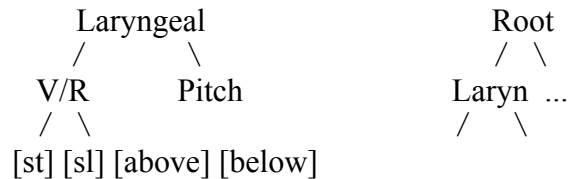the Degree of Doctor of Philosophy in Linguistics

ABSTRACT

This thesis makes a close examination of syllable, tone and stress in Chinese languages, in order to find out general properties that are shared by all natural languages. It offers the following related claims

(1)   All Chinese syllables have the following uniform underlying structure

```
    σ
   /\
  O  R
  | /\
  X X X
```

(2)   The general tonal model is as follows

```
        Laryngeal              Root
        /      \               / \
      V/R      Pitch         Laryn ...
      / \                     / \
   [st] [sl] [above] [below]
```

where the tonal structure is part of the segmental feature geometry under a Root node. The V/R node represents both consonant voicing and tonal register. The Pitch node is specified for tone bearing segments only.

(3)   The tone bearing unit is the moraic segment, or equivalently, the segment in the rime, whether it is a vowel or any consonant. A geminate has two Roots and may serve as two tone bearing units.

(4)   Contour segments do not exist. Their absence is attributed to a universal principle, the No Contour Principle (NCP), which is given as follows

```
     *X
     /\
  [αF][-αF]
```
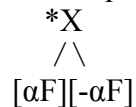
(5)   The tonal domain is the stress domain. Most syntax-phonology mismatches are due to lack of stress in some constituents.

Thesis Supervisor: Dr. Morris Halle
Title: Institute Professor

ACKNOWLEDGEMENTS

Special thanks to Noam Chomsky, for providing the driving force in an endeavor that has brought so many inquiring minds together.

In the past months, I have fully devoted myself to the writing of this thesis, in the hope of getting closer to what the above people and I have been looking for, so as to partly repay them for their help.

This thesis is dedicated to Fu Yan, Youyou and my parents.

NOTES ON REFORMATING

The dissertation was reformatted in summer 2005 mainly to correct typographic errors and update the phonetic fonts. Although most page numbers have changed, little other re-writing was made.

San Duanmu
August 22, 2005.

FOREWORD

This is a slightly revised version of my Ph.D. dissertation. Most corrections are stylistic, and the page numbers have almost remained unchanged. I would like to have made more extensive revisions, added more illustrations and expanded Chapters 4 and 5. However, this has to be left for another occasion.

San Duanmu
October 15, 1990.

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NOTATIONS

PHONETIC SYMBOLS (sometimes):

ng = ŋ   H = ɦ   ? = ʔ   6 = ə

In addition, the boundaries '/ /' and '[ ]' are not always distinguished.

SYLLABIC SYMBOLS:

σ = syllable   O = Onset   R = rime   N = nucleus   μ = mora

FEATURE GEOMETRY TERMS:

Rt = Root   Lar = Laryngeal   SL = Supra-Laryngeal
Pl = Place   SP = Soft-Palate   Dor = Dorsal
Cor = Coronal   Lab = Labial

DISTINCTIVE FEATURES:

[cg] = [constricted glottis]   [sg] = [spread glottis]
[sl] = [slack vocal cords]   [st] = [stiff vocal cords]
[cont] = [continuant]   [cons] = [consonantal]
[nas] = [nasal]   [ant] = [anterior]
[dis] = [distributed]   [bk] = [back]
[hi] = [high]   [lo] = [low]
[rd] = [round]

CHAPTER ONE

OUTLINE

This is a formal study of the relations among syllable, tone, stress, and domain in Chinese languages. It is formal in two ways. First, it intends to explore general principles that hold for all human languages. Therefore, it studies not just one Chinese language, but a family of them; frequent references will be made to languages in other parts of the world as well. Second, it employs, and in turn contributes to, recent phonological theories, such as feature geometry, tonal models, templatic morphology, underspecification, syllabic structure, contour features, tone bearing unit, stress metrics, and phonology-syntax mismatches. This thesis studies syllable, tone, stress and domain together because these issues are closely interrelated, and so may illuminate each other. For example, the analysis of the syllable sheds much light on the analysis of tone, and the analysis of tone sheds light on the analysis of stress, and vice versa.

I first discuss in Chapter 2 the syllabic structure in Chinese languages. I propose that all Chinese languages have just one underlying syllabic structure, with one segment slot for the onset and two for the rime, as given below

(1)   σ   σ = syllable
          ╱╲   O = onset
        O   R   R = rime
        │ ╱╲
        X X X

In previous analyses, Chinese languages have a range of possible syllables, such as C, V, VG, VC, GV, GVG, GVC, CV, CVG, CVC, CGV, CGVC, CGVG, CVGC, CGVGC, etc. For example, in Chao (1968), Mandarin has the following syllables

(2)   a. a 'filthy'   b. tian 'heaven'
        c. i 'clothes'   d. m 'Uh-huh'

Similarly, according to Xu et al (1981) Shanghai has the following syllables

(3)   a. n 'fish'   b. m 'mu (a measure of land)'
        c. pa? 'eight'   c. kua? 'scrape'

In the analysis I propose, all syllables in (2) and (3) have the same structure, which are shown in (4) and (5) respectively, where Ø is a zero onset.

(4)   a.   σ   b.   σ   c.   d.   σ
              /\   /\   /\   /\
             O R   O R   O R   O R
             | /\ | /\ | /\ | /\
             X X X   X X X   X X X   X X X
             | \/ | | | \ | /   \ | /
             Ø a   tʸ a n   i   m

(5)   a.   σ   b.   σ   c.   σ   d.   σ
              /\   /\   /\   /\
             O R   O R   O R   O R
             | /\ | /\ | /\ | /\
             X X X   X X X   X X X   X X X
             \ | /   \ | / | | | | | |
               n   m   p a ?   kʷ a ?

The fixed syllabic skeleton will trigger two processes. First, if the coda is not filled, the nuclear segment will spread to the coda. Second, if the onset is not filled, either the nuclear segment will spread to the onset, as in (4c), or the onset will be specified to what is commonly called the 'zero onset', as in (4a). Thus, in every syllable, all the three slots are filled.

To justify my analysis, I will argue for the points below

(6)   a.   Every Chinese syllable has an obligatory onset.
       b.   Pre-nucleus G is in the onset.
       c.   The onset has just one X slot.
       d.   Every rime has two X slots.

Extensive evidence for (6) will be discussed, including distribution, feature structure, dialectal variations, duration, pitch contours, suffixation processes, cooccurrence restrictions, and language games.

The choice for representing (1) with an X tier, rather than in the moraic system of Hyman (1985) or Hayes (1989), which has no X tier, is not due to an ignorance of the importance of the mora. Rather, it is mainly due to the need for a mechanism that will trigger the obligatory onset. In this respect, my position differs from that of Hayes (1989) in that for Hayes, nothing can trigger an obligatory onset.

The underlying structure (1) may have limited surface variations, conditioned by phonological environments. For example, the final syllable in Fuzhou may be lengthened by an extra mora or X slot (cf. Wright 1983), the Mandarin stressless syllables will be shortened by a mora or X slot, the Shanghai syllable is shortened by a mora or X slot in nonfinal positions, etc.

While uniform syllabic structure has been reported for CV languages, to my knowledge there has been no such proposal for a more complex syllable type. The claim that all Chinese languages have a uniform syllabic structure has consequences for historical phonology. For example, the historically 'zero onset' now has much variation cross-dialectally, but regular onsets have largely remained without dramatic change. It would be of much interest for feature theories how the zero

onset has undergone changes. Our claim also has consequences for current phonological theories. I will discuss its implications for the V/C segregation hypothesis of McCarthy (1989) and for the moraic theory of Hyman (1985) and Hayes (1989).

In Chapter 3, I discuss the representation of tone. I will argue for the following tonal model

(7)   Laryngeal
             /   \
         V/R   Pitch
         / \   / \
     [st] [sl] [above] [below]
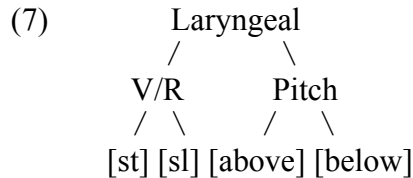
This model is part of feature geometry. It identifies voicing in consonants with register in vowels, both being executed by the same articulator V/R (Voicing/Register). I have labeled the articulators V/R and Pitch in plain words, instead of in specific articulatory terms, because I am not fully sure which laryngeal mechanisms they exactly relate to, although my own speculation is that V/R is related to the vocalis, and Pitch to the cricothyroid muscles.

I have introduced the features [above] and [below] (loosely corresponding respectively to [H] and [L] of Yip 1980 and Hyman 1989) for several reasons. Features like [stiff], [slack], [H], [L], etc., strongly suggest binary activities. It is well-known, however, that for pitch, humans can articulate and perceive far more levels than are found in tone languages. It is therefore slightly misleading to use tonal features like [H] and [L], as if the vocal cords are restricted to such binary activities. On the other hand, the question remains why so few tonal levels are utilized in human speech. The answer, I suggest, is twofold. First, humans are good at relative pitch, but poor at absolute pitch. Second, people's pitch ranges differ from time to time, and from person to person. Given a tone, it is hard to tell how high it is, and harder still to tell how high it is for a stranger. On the other hand, given two points, it is easy to tell whether the pitch is going up or down, even if the difference is very slight. The fact that the tone speaker rarely mis-locates a tone level, even with a stranger who has an unknown pitch range, suggests that what s/he depends on must be relative pitch. It is likely that the tone speaker is making use of a reference pitch level; any tone above it is H, below it L, and otherwise M. The key is, what supplies this reference level? Four facts suggest that it is the onset. First, onsets are never tone bearers (cf. Hyman 1985). Second, acoustic studies show that tone (i.e. the expected pitch contour) does not begin until the nuclear vowel, and that onset pitch, overall, remains at the mid level (Kratochvil 1970, Howie 1976). Third, tone languages usually have obligatory onsets, as I have independently argued for all Chinese languages. Fourth, to my knowledge, no tone language has more than three tone levels without splitting them into two registers. Register, however, is distinguished by voice quality cues, and not by pitch (cf. Duanmu 1990, 1991).

[above] and [below] intend to reflect the relative nature of pitch and the importance of the onset. Onsets, overall, supplies the reference pitch level. If the pitch of the nucleus goes above it, the tone is H; if the pitch of the nucleus goes below it, the tone is L; otherwise the tone is M. If the onset pitch declines in speech, H, L and M decline too; this is probably the case of downdrift. [above] and [below] refer to an effort by the Pitch articulator to move the pitch above, or below, the reference line, wherever this line is at a particular point. Having said the above, though, I will often use [H] and [L] as short hand for [above] and [below] later in the chapters.

The model (7) permits a maximum of nine level tones, which are compared with those in Hyman (1989) below.

(8)   Hyman (1989): TBU TBU TBU TBU TBU TBU TBU TBU TBU
                         | | | | | | | | |
        Tonal Root: o   o   o   o-L o-L o-L o-H o-H o-H
                         | | | | | | | | |
        Tone: o   o   o   o   o   o   o   o   o
                         | | |\ | | |\ | | |\
                         H   L   LH   H   L   LH   H   L   LH

        Letter: H   L   M   !H   !L   !M   H'   L'   M'
        ! = downstep; ' = raised

(9)   Duanmu   Letters
        [-st, -sl, +above, -below]   H
        [-st, -sl, -above, -below]   L
        [-st, -sl, -above, +below]   M
        [-st, +sl, +above, -below]   !H
        [-st, +sl, -above, -below]   !L
        [-st, +sl, -above, +below]   !M
        [+st, -sl, +above, -below]   H'
        [+st, -sl, -above, -below]   L'   ! = lowered
        [+st, -sl, -above, +below]   M'   ' = raised

No language in the world has as many tone levels as permitted by my model or by Hyman's. To my knowledge, the largest number of level tones in any reported languages is five (e.g. Chang 1953). The fact that no language uses the entire tonal inventory is no theoretical problem, however, since no language uses the entire known segmental inventory (which, according to Maddieson 1984, contains a few hundred segments). As many languages do not utilize ingressive airstream mechanisms, many languages do not utilize tonal register; this will leave the maximal tonal levels to three. On the other hand, if a language has more than four level tones, my model predicts that it must have register, which in most cases comes from onset voicing, either historically or directly. To my knowledge, this prediction is correct.

The model (7) will be compared with the tonal models of Halle & Stevens (1971), Kingston & Solnit (1988), Yip (1980, 1989a), Hyman (1989), Bao (1989) and Bao (1990a), against a wide range of well-observed cross-linguistic tonal phenomena, such as tonogenesis, tone split, depressor consonants, blocker consonants, pitch and register spreading, etc.

Since (7) identifies register with voicing, it predicts that in tone split, caused by onset voicing, there is always a relation of 'voiceless-high' and 'voiced-low'. However, as Kingston & Solnit (1988) point out, there are many cases of voiceless-low and voiced-high. This leads them to suggest that there is no necessary relation between voicing and register or tone height. I will discuss voiceless-low and voiced-high and argue that, as Yue-Hashimoto (1986) suggests, they are caused by tonal 'flip-flop', which took place after tone split. Two crucial arguments are that

voiceless-low and voiced-high are found only in languages that have lost onset voicing, and that switching rules, of which tonal flip-flop is a sub-case, are independently motivated.

I next address the issue of contour tones. I first discuss the CTU (contour tone unit), which has been proposed by Pike (1948), W. Wang (1967), Fromkin (1972), Gandor & Fromkin (1978) (but see Maddieson 1979), M. Chen (1986), Newman (1986), Chan (1989), Bao (1990), and most of all, Yip (1989a). I will argue, however, that there is no good evidence for CTUs. I then argue that there is no evidence that the syllable or the rime, as a whole, may serve as the TBU (tone bearing unit), unlike what has been previously suggested (e.g. Wang 1967, Chao 1968, Yip 1980, Yip 1989a, Bao 1990a). Instead, the TBU is always the mora bearing segment, or the segment in the rime, be it a vowel or any consonant. A geminate has two Roots (cf. Selkirk 1988a) and so may serve as two TBUs. I next argue that simple contour tones always fall on bimoraic syllables, and that complex (convex and concave) contour tones always fall on trimoraic syllables. This is true of not only Chinese languages, but also African languages, such as Igbo, Margi, Mende and Tiv, which have previously been used as evidence that a contour tone may fall on a short syllable. In other words, there is a direct relation between the tone bearing ability of a syllable and its rime length, and a TBU can carry no more than one tone.

My model treats tone as 'segmental', i.e. as part of feature geometry. This view was proposed before by Woo (1969), who has been much criticized by autosegmental phonologists (Williams 1971; Leben 1973, 1978; Goldsmith 1976; Anderson 1978; Yip 1980; etc.). However, with the development of feature geometry (Clements 1985; Sagey 1986; McCarthy 1988; Halle 1989), such criticisms have largely become irrelevant, and the idea of 'autosegment' has lost much content. For example, in feature geometry, each feature is on an independent tier (except [cons] and [son] perhaps, cf. McCarthy 1988), so a feature can spread without being an 'autosegment', i.e. without being detached from the rest of the 'segment'. Indeed, since tone is THE archetype autosegment, one wonders whether there is any autosegment left.

Sagey (1986) proposes that a segment may contain a multi-valued feature, as in

(10)   X   X = any node
           /\   F = any feature
      [αF] [-αF]   α = any value

Such segments are called 'contour segments'. Specifically, Sagey proposes three kinds of contour segments, contour tones, affricates and pre- and post-nasalized consonants. Our arguments against contour tones naturally invite an examination of the other two contour segments. I will argue that there is no compelling evidence for either of them. In particular, I will argue that all the cases Sagey uses as arguments for seeing affricates as [-cont, +cont] can be explained if we assume that affricates are [-cont, +strident]. There is, therefore, no evidence that affricates are contour segments. In addition, I will examine the languages in the UPSID (Maddieson 1984) and show that, of the eighteen or so languages in which Maddieson has posited pre- and post-nasalized stops, either such segments are predictable from the nasality of the surrounding vowels, or such segments do not contrast with (or freely alternate with) plain nasals or plain stops, or such segments are accountable as clusters. There is, therefore, no good motivation for positing underlying pre- or post-nasalized stops in any language. The result that no language has underlying pre- and/or post-nasalized consonants casts doubt on the existence of such segments

at the surface level. Because of the lack of evidence for any contour segment (cf. also Herbert 1975, 1986; Steriade 1989), I will maintain the strongest position that no contour segments exist. I will attribute the lack of contour segments to a universal principle, exactly opposite to (10), and call it the No Contour Principle (NCP), as shown below

(11)   The No Contour Principle (NCP):   *X
$$\overset{*X}{\underset{[\alpha F][-\alpha F]}{/\,\backslash}}$$

Physiological motivations for the NCP will be explored. I will also show that the NCP constitutes the real essence of what are commonly called the 'association conventions' (Williams 1976, Goldsmith 1976, Clements & Ford 1979, D. Pulleyblank 1986, and others).

In Chapter 4, I discuss stress. I show that to obtain the correct stress assignment, both syntactic bracketing and syntactic labeling must be available for stress assignment, as proposed by Halle & Vergnaud (1987). This is seen in what I call 'non-head stress' (NHS) assignment, common in a number of Chinese languages. The notions 'head' and 'nonhead' are defined as follows

(12) X^{n+1} or X^{n+1} (mirror image)
           $/\,\backslash$ $/\,\backslash$
           X^n YP   YP X^n

In the structural relation in (12), YP is the 'nonhead' and X^n the 'head'. In NHS assignment, greater stress is assigned to the nonhead. In addition, the 'XP stress' assignment, by which the initial (or the final) syllable of an XP gets stress, also requires syntactic bracketing and labeling information.

In Chapter 5, I argue that the stress domain is the tonal domain, in agreement with Yip (1980) and Wright (1983). I will illustrate the point by the tonal domains in Mandarin and Shanghai. In Mandarin, tones seem to be syllable bound, while in Shanghai, tones seem to be phrase bound. I will argue that the difference in the tonal domains is due to the different stress patterns in the two languages: in Mandarin, every regular syllable has stress, while in Shanghai, every phrase has a stress.

I next discuss syntax-phonology mismatches (SPMs). I suggest that most SPMs are explicable in terms of stress. Specifically, I show that most, if not all, SPMs are due to the lack of stress on the head of a constituent, either by deletion or because the head is lexically weak. A headless constituent by convention lose its status (Halle & Vergnaud 1987) and subsequently merges with a neighboring constituent in the following manner

(13)   Syntax: ...[   ][   ][   ]...
         Stress (no mismatch):   ...[*   ][*   ][*   ]...
         Stress Deletion: ...[*   ][   ][*   ]...
         Constituent Merger (mismatch):   ...[*   ][*   ]...

An example is seen in the following Shanghai phrase

(14)   invite   he   come   'to invite him to come'
     [$_{VP}$ tçing [$_{NP}$ yi [$_{VP}$ le   ]]]
       (*   )(*)(*   ):   Expected stress/tonal domains
       (*   )(   )(*   ):   Stress deletion from the pronoun
       (*   )(*   ):   Constituent merger & mismatch

As I will argue, in Shanghai, the stress/tonal domain begins from the left boundary of a syntactic XP, and ends just before another XP. Therefore, (14) should form three stress/tonal domains. The stress on pronouns, however, may be deleted, and so the constituent (domain) headed by it will also be lost. The result is a SPM, i.e. with two stress/tonal domains for three syntactic XPs. Similarly, consider the following example

(15)   buy   some cup   tea   'to buy some (cups of) tea'
     [$_{VP}$ ma [$_{ClP}$ liang pe [$_{NP}$ zo]]]
       (*   )(*   )(*   ):   Expected stress/tonal domains
       (*   )(   )(*   ):   Stress deletion from the pronoun
       (*   )(*   ):   Constituent merger & mismatch

The first syllable of the ClP (classifier phrase) liang may mean either 'two' or 'some'. When it means 'some', it is unstressed, and so the stress domain headed by it is lost, giving a SPM.

The above stress-based account of SPMs does not require notions like c-command or dominance (e.g. Hayes 1984, Nespor & Vogel 1986), nor notions like 'phonological word' (e.g. Selkirk & Shen 1988).

The power of a syntax-dependent analysis of stress/tonal domains goes beyond the calculation of proper phonological output. I will show that stress/tonal domains provide cues for the analyses of a number of areas in Chinese syntax, such as incorporation, classifier structures, and de structures.

The rest of this thesis is largely the substantiation of the claims I have presented above. None of the claims have been easy to establish. In my own opinion, (1) and (7) are most thoroughly argued for, and (11), the NCP, is of the greatest potential significance.

CHAPTER TWO

THE SYLLABLE

2.0. Introduction

In this Chapter I examine the syllabic structure in Chinese languages.[1] Since it is ==impossible== to look at every dialect, I will take one representative from each dialect family. According to Yuan (1960: 22), there are eight Chinese dialect families, Northern, Wu, Xiang, Gan, Hakka, Yue, Southern Min, and Northern Min, represented, respectively, by Mandarin, Shanghai, Changsha, Nanchang, Meixian (Moi-yan), Cantonese, Xiamen (also called Amoy or Taiwanese) and Fuzhou. I will examine these eight languages in section 2.1 and show that they all have a uniform syllabic structure of three slots, one in the onset and two in the rime, as shown below

(1)   The Uniform Syllabic Structure of Chinese
```
     S              S = syllable
    / \             O = onset
   O   R            R = rime
   |  / \
   X X X
```

Since the eight languages represent all the dialect families, we expect the conclusions to be true of all Chinese languages. Arguments will be given from feature geometry, underspecification, segmental distribution, the sonority scale, duration, language games, tone bearing unit, reduplication, and ==riming== in poetry.

That Chinese languages have a uniform syllabic structure is further supported by the analysis of morphological suffixation and rime change in several Chinese languages, which is discussed in section 2.2. It is also supported by the analysis of language games (Fanqie languages), discussed in section 2.3, and the cooccurrence restrictions on labials, discussed in section 2.4.

In section 2.5 I discuss some implications of the Mandarin syllable for the V/C segregation theory of McCarthy (1989a) and the moraic theory of Hayes (1989) and Hyman (1984, 1985). I show that although Chinese has a rigid syllabic structure, there is no V/C segregation, unlike what is proposed in Yip (1989b) and L. Cheng (1989). This means that V/C segregation must not only depend on rigid templates, but perhaps also on whether the templates carry morphological information. I also show that the moraic theory of Hayes and Hyman, in which moras are the only constituents of the syllable, must be extended to handle empty onsets, so that it in several ways resembles the X tier theory (Levin 1985, Lowenstamm & Kaye 1986).

2.1. The Syllabic Structure of Chinese Languages

---

[1]. I do not distinguish the terms 'language' and 'dialect' in this study.

2.1.1. Mandarin

In traditional analyses (e.g. Hockett (1947), Chao (1968), R. Cheng (1966), C.Cheng (1973), Norman (1988)), the Mandarin syllable is divided into an 'initial' and a 'final', which roughly correspond to 'onset' and 'rime' respectively. The complete inventories are given below (Chao 1968, 22 & 24, with minor changes):

(2)   a. Mandarin Initials (underline = retroflex)

p	pʰ	m	f	
t	tʰ	n		l
ts	tsʰ		s	
t̠s	t̠sʰ		s̠	r̠
tɕ	tɕʰ		ç	
k	kʰ		x	(Ø)

     b. Mandarin Finals

ẓ	ṛ	A	ɤ	ai	ei	ɑu	ou	an	ən	ɑŋ	əŋ	oŋ	er
i		iA	iɛ	iai		iɑu	iou	ian	iən	iɑŋ	iŋ	ioŋ	
u		uA	uo	uai	uei			uan	uən	uɑŋ	uəŋ		
ÿ			ÿɛ					ÿan	ÿn				m

All initials are single segments. [Ø] stands for the 'zero onset', to which we return shortly. There are at least fourteen possible syllable shapes, C, V, N, VG, VN, GV, GVG, GVN, CV, CVG, CVN, CGV, CGVN, and CGVG, where G is a glide and N a nasal or [r]. For example

(3)   a. e   'goose'
         b. tian   'heaven'
         c. tiao   'jump'
         d. m   'Uh-huh'

I propose below that all regular Mandarin syllables have a uniform structure of three X slots.[2] I will first follow the 'X tier' theory of syllable (Levin (1985), Lowenstamm & Kaye (1986)), in which a segment is linked to an X slot, and a geminate is linked to two (or more) X slots. In addition, a syllable may consist of an onset and a rime, and the rime in turn may consist of a nucleus and a coda. A comparison with the moraic theory will be given later. Thus (3a-c) are analyzed as (4a-c), where S = syllable, O = onset, R = rime, and Ø = zero onset.

---

[2]. Stressless syllables and interjections 'a' and 'ou', may have fewer than three segments. We return to this later.

```
(4)  a.      S            b.      S           c.      S           d.      S
            /\                   /\                  /\                  /\
           O  R                 O  R                O  R                O  R
           |  /\                |  /\               |  /\               |   /\
           X  X  X              X  X  X             X  X  X             X  X  X
           |  \/                |  |  |             |  |  |              \ |/
           Ø  e                 t  a  n            t  a  o              m
                                  y                 y
```
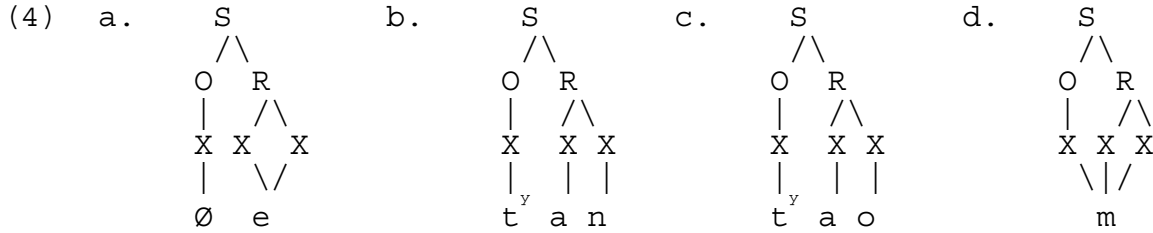
To justify (4), I will argue for the following points

- a.   Every syllable has an obligatory onset.
- b.   Pre-nucleus G is in the onset.
- c.   The onset has just one slot.
- d.   Every rime has two X slots.

2.1.1.1. Obligatory 'zero onset'
Chao (1948, 2-3; 1968, 20) notes that Mandarin syllables that are not written with an onset have a 'zero onset' (cf. (1)). When the nucleus is a high vowel, i.e. [i u ü], or the syllabic consonant [m], e.g. m 'Uh-huh', the zero onset is [y w ÿ m] respectively. We assume that [+high] or [+cons] nuclei obligatorily spread to the zero onset. When the nuclear vowel is [-high], however, the zero onset has four variants

(5)   a.   velar nasal [ŋ]

       b.   velar or uvular unaspirated ==fricative==/continuant [ɣ]

       c.   glottal stop [ʔ]

       d.   glottal unaspirated continuant [ɦ] (which Chao calls 'true vowel' onset).

Apart from being variants of the zero onset, (5a-d) do not occur in onsets; (5a) occurs in codas only, while (5b-d) do not occur at all. The zero onset is not a phonetic epiphenomenon, as one finds in English words like /aut/-->[ʔaut] 'out', where onsetless syllables may optionally start with a glottal stop. Rather, the Mandarin zero onset has phonological consequences. Its presence not only prevents linking the vowel directly to the preceding coda in ==pronunciation==, as shown in (6.i.e) and (6.ii.) (which are common mis-pronunciations made by English speakers), but may also change the place of the preceding coda to velar (F.K. Li (1966, 300), Chao (1968, 20))[3]

---

[3]. In contrast, the weak ==interjection== syllables /a/ and /ou/ allow linking, and do not change /n/ in the preceding coda to velar (Li 1966:300, Chao 1968:20)

/tian a/	--->	a.	*[tian ʔa]	
heaven INTERJ		b.	*[tian ɣa]	(ɣ = dorsal [+cons, +cont])
Heavens!		c.	*[tiaŋ ɣa]	
		d.	*[tiaŋ ŋa]	
		e.	[tiana] or [tianna]	

Unlike in English, where geminates contrast with non-geminates (u**n**easy v. u**nn**eeded), in Mandarin there is no such contrast. It is therefore not clear whether /tian + a/ surfaces as [tiana] or [tianna]. If the former, it means that weak syllables need not have an onsets. If the latter, as is

(6)   i.   /mian ao/   --->   a.   [mian ʔao]

                cotton coat   b.   [mian ɣao]

                'cotton padded coat'   c.   [miaŋ ɣao]

                                        d.   [miaŋ ŋao]

                                        e.   *[mianao]   (Cf. English: 'ran out' [rænaut])

       ii.   /tian an men/ ---->   a.   [tian ʔan men]

                'Tiananmen'   b.   [tian ɣan men]

                                        c.   [tiaŋ ɣan men]

                                        d.   [tiaŋ ŋan men]

                                        e.   *[tianan men]

Evidently, (5a-d) are real segments and we reach our conclusion that every Mandarin syllable has an onset.

However, there remain two important questions. First, what is the relation among the variants of the zero onset? Second, what is the underlying segment from which (5a-d) derive? In terms of features (Chomsky & Halle (1968), Halle & Stevens (1971), Sagey (1986)), (5) can be described as[4]

(7)   a.   [ŋ]:   [+cons, +nasal, -cont] dorsal with [±back] options

       b.   [ɣ]:   [+cons, -nasal, +cont] dorsal with [±back] options

       c.   [ʔ]:   [-cons, +cg, -sg]   [cg] = [constricted glottis]

       d.   [ɦ]:   [-cons, -cg, -sg]   [sg] = [spread glottis]

---

claimed by Chiang (1989), then even weak syllables must have an obligatory onset. Suppose the latter is the case, then the fact that the zero onset of a regular syllable does not trigger gemination of the preceding coda, while that of a weak syllable does, can be explained by assuming that the domain of syllabification is a regular syllable (which is basically a morpheme/word in Chinese) plus any weak suffix attached to it (or, since regular syllables carry stress, the domain of syllabification is a stress domain, cf. Yip 1980). Consider

   /mian ## ao/-->[mian ## Øao]   /tian a/-->[tianna]
   'cotton-padded coat'   'Oh, heavens!'

The syllabification boundary ## prevents gemination of /n/ in the former (thus forcing the zero onset to become /Ø/) but not in the latter. There is some evidence that weak syllables indeed have an obligatory onset, as noted in Chao (1968:46). Consider

   /ni a/-->[ni(y)a] 'Oh, you!'   /ta a/-->[ta ya] 'Oh him!'

If it is not clear in the former whether /i/ geminates, there is no doubt that /y/ is inserted in the latter as an onset. It seems therefore that both regular and weak syllables have obligatory onsets. If so the position of this paper is even stronger.

[4]. [+c.g.], [-c.g.], [+s.g.] and [-s.g.] roughly correspond respectively to traditional terms 'glottal stop', 'glottal continuant', 'aspirated' and 'unaspirated'. Cf. Halle & Stevens (1971).

There is apparently no common feature among (7a-d), so they can hardly derive from the same segment. One may suggest that (7a-d) derive from a featureless segment, written as /[]/. But this solution has three difficulties. First, it is not clear whether any language has completely featureless segments.[5] Second, although underlying segments may be radically underspecified so that all redundant information is absent (Archangeli & Pulleyblank (1989)), it is not clear if real segments can be underspecified to such a degree that multiple derivations are possible. Third, by definition, a segment should not only contrast with other segments but also with segmentlessness (i.e. with nothing-ness). In English, for example, /ɔl/ 'all' contrasts with /tɔl/ 'tall', and [bi:] 'bee' with [bi:**t**] 'beet'; in the former pair the onset [t] contrasts with onsetlessness, and in the latter pair the coda [t] contrasts with codalessness. In Mandarin, however, there is no contrast between the 'zero onset' and onsetlessness, e.g. there is no contrast between /e/ and /[]e/.

Let us look at (7a-d) again. If /ɣ/ is not [-son] but [+son], then [+son] is a common feature. However, if we posit a single-featured segment /[+son]/ for (7a-d), we face the same difficulties with positing /[]/, namely /[+son]/ allows multiple derivations and does not contrast with segmentlessness.

Another possibility is to posit /ŋ/ as the underlying form of the zero onset, and to derive /ɣ ʔ ɦ/ from it by language particular rules. This analysis is similar to the one proposed by Cheung (1986) and Yip (1988) for the Cantonese zero onset. This approach has two merits. First, since /ŋ/ occurs in codas independently, positing an onset /ŋ/ makes the distribution of /ŋ/ complete. Second, before non-high vowels, the zero onset is indeed realized, mostly, as [ŋ] in Cantonese and Chengdu, among many other dialects. However, this analysis has three drawbacks. First, there is no explanation why /ŋ/ never occurs before /i u ÿ /, either in Mandarin or in Cantonese or in Chengdu, while the other two nasal onsets /n m/ do. Second, deriving /ɣ ʔ ɦ/ from /ŋ/ for the Mandarin zero onset requires unnatural rules; besides, there is no independent evidence for such rules. Third, historical onsets /n m/ have largely remained unchanged cross dialects, yet the historical zero onset has many dialectal variations. For example, before non-high vowels, the zero onset is basically [n] in Baoding, [ŋ] in Chengdu and Cantonese, and [ʔ] in Meixian (Hashimoto 1973:91). If the zero onset has been underlyingly /ŋ/, there is the question of why [n m] have remained unchanged, yet [ŋ] has given rise to so many variations.[6]

Clearly, we cannot derive (7a-d) from an underlying segment. Moreover, since (7a-d) never contrast with one another, they cannot be derived from different segments either. This is a dilemma. The solution, I suggest, is that (7a-d) are purely triggered by the obligatory onset position. In other words, every Mandarin syllable must have an onset, as shown below

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[5]. For example, the English plural morpheme in 'sheep' has no phonological features, and is never considered a segment.

[6]. One may also question the thesis that since [ŋ] occurs in the coda it should also occur in the onset. In English, for example, [ŋ] occurs in codas but not in onsets. Although the English velar nasal is derived from an underlying cluster [n+g] (Chomsky & Halle 1968), I speculate that the Chinese velar coda perhaps could be analyzed in the same way historically.

```
(8)                    S                    *        S
                      / \                             |
                 Onset  R                             R
                   |    ...                          ...
                   X
```
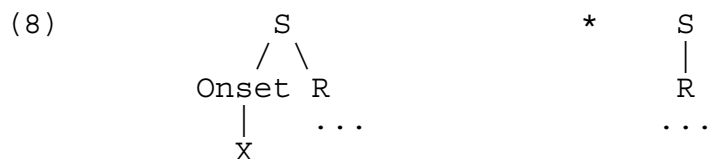
When there is no consonant to fill the onset position, and when the nuclear vowel is [-high], the onset position is specified into one of the variants in (7). Let us see this in detail. Since there is no evidence for a default consonant in Mandarin, nor evidence for default feature values, we must consider all possible ways of specification, as shown below

```
(9)    a.                                 [  ]
                                           |
                                        [+cons]
               ----------/    |    \----------
               |              |              |
            coronal         labial         dorsal
           /   |           /    \          /    \
      [+nas]  [-nas]   [+nas]  [-nas]  [+nas]  [-nas]
        |     /   \      |     /   \     |     /   \
        | [+cont] [-cont]|  [+cont] [-cont] | [+cont] [-cont]
        |   |     |      |    |     |    |    |     |
      */n/ */s r/ */t tʰ/ */m/ */f w/ */p pʰ/ /ŋ/  /ɣ *x/  */k kʰ/
                                           (7a)   (7b)
```

```
       b.              [  ]
                        |
                     [-cons]
                     /    \
                 [+sg]    [-sg]            sg = spread glottis
                   |      /   \            cg = constricted glottis
                   |  [+cg]  [-cg]
                   |    |      |
                 */h/  /ʔ/    /ɦ/
                 (7c)  (7d)
```
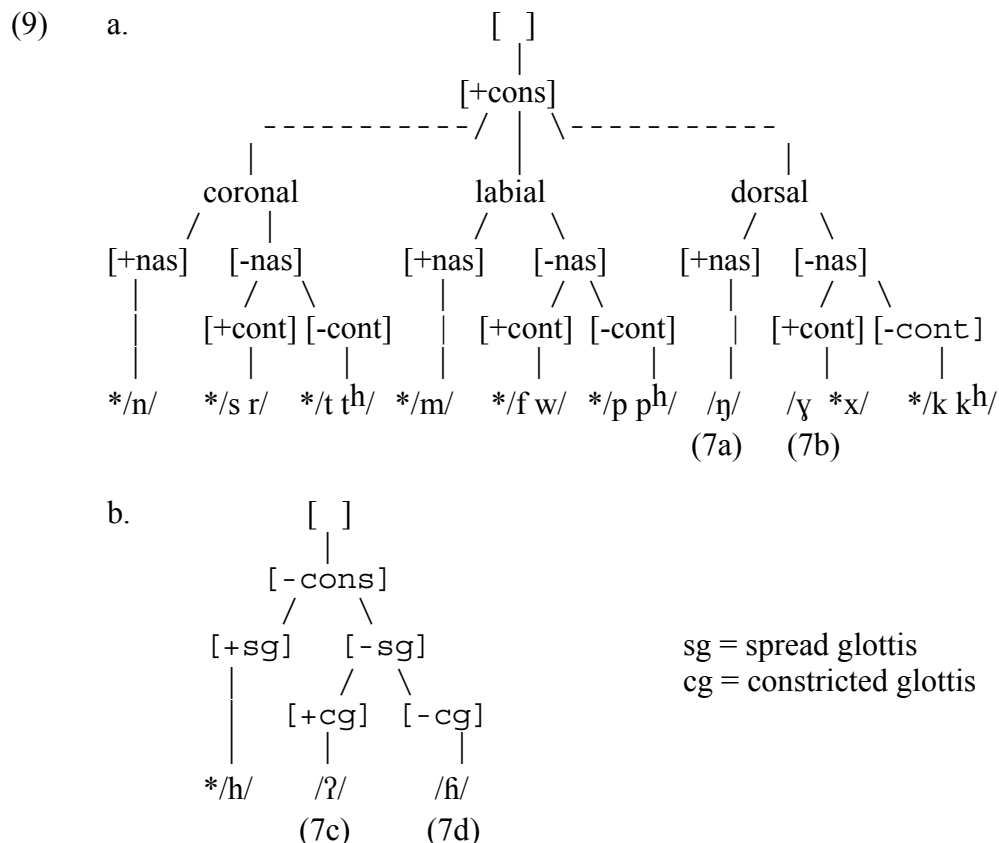
(9a, b) are not feature trees, but flow charts of all possible ways of specifying the zero onset. We start with [], i.e. no features. The first feature we come across is [cons]. Since there is no evidence of default values, we may choose [+cons] or [-cons]. If [+cons], as in (9a), we obligatorily need place features (cf. Chomsky & Halle 1968, who argue that segments that have no place features, i.e. with just laryngeal features, are [-cons]). One way to get place features is to spread the place node from the nuclear vowel. However, since the nucleus is [-high], spreading its place node to the onset will make the latter a [-high] vowel, too, which I assume is disallowed by general principles. So the onset cannot get its place node from the nuclear vowel. In addition, since there is no evidence that Mandarin has a default place, we must consider all three places (labial, coronal or dorsal) in turn. Let us follow the dorsal branch (the ==right-hand== branch under [+cons] in (9a)). We next consider [±nas]. If [+nas], we get /ŋ/, which is (7a). If [-nas], we further consider [±cont]. If [+cont], we get /ɣ/, which is (7b), and /x/, which confuses with the

real /x/ and is rejected.[7] If [-cont] we get /k k^h/, which both confuse with the real /k k^h/ and are rejected. This completes the dorsal branch. If we follow through the other two branches in (9a), we will see that their outputs all confuse with underlying onset segments, so none is taken.[8]

The outputs /ŋ ɣ/ are both dorsal; they may further assimilate in [back] with the nuclear vowel. Although onsets and [-high] vowels rarely assimilate in place, it is common that they assimilate in [back]. In English, for example, /k/ is [+back] in 'call' and [-back] in 'can'. This completes (9a).

If, in the beginning, we choose [-cons], as in (9b), then no place node is needed. The next choice is [±sg]. If [+sg], we get /h/, which confuses with the real /h/ and is rejected.[9] For [-sg], we further choose [±cg]. If [+cg], we get (7c), otherwise (7d). Since Mandarin onsets do not contrast in voicing, [±stiff VC, ±slack VC] do not play a role. This completes (9b). Thus (9a, b) give all and only the expected realizations of the zero onset.

It is perhaps not crucial which features are filled in first. The key here is that one first generate all possibilities, then filter out those that are already underlying (e.g. [k p ...]) and those that are not permitted by Mandarin phonotactics (e.g. [+slack] or [+voice], assuming that sonorants are unspecified for [voice]; clicks; ...).[10]

2.1.1.2. Pre-nuclear G is in the onset
The pre-nuclear glide G in (C)GVG, (C)GV or (C)GVN is commonly analyzed as part of the rime (cf. (1b)). I give six arguments to show that it is in the onset.

First, there is no phonetic evidence that Mandarin pre-nuclear CG are two segments. As Chan (1985:67) points out, what is transcribed as [k^w-] in Cantonese has the same pronunciation as what is transcribed as [kw-] or [ku-] in Mandarin; the distinction between [k^w-] and [ku-] is 'phonological'. The phonological argument in turn is given as follows (Chan 1985)

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[7]. Many phonological rules, such as German final devoicing, do not care whether the output introduces ambiguity. Still, the realization process here does seem to care. This must be a language particular option. Note that in German final devoicing, there is just one output for each input, while in Mandarin zero onset realization, there are alternative outputs. Whether avoiding neutralization depends on the availability of alternative outputs remains to be seen.
[8]. For simplicity I omitted affricates, retroflexes and the lateral /l/. This does not affect our discussion, however.
[9]. Mandarin /h/ assimilates to the vowel in place and becomes dorsal [x] or palatal [ç].
[10]. In other dialects, such as Baoding (Y.F. Li, p.c.), Meixian (Hashimoto 1973:86-87,91) and Chengdu, what corresponds to the Mandarin zero onset has fewer variants. For example

MANDARIN	BAODING	MEIXIAN	CHENGDU	
ʔan/ɦan/ŋan/ɣan	nan	ʔan	ŋan	'peaceful'
yi	yi	yi	yi	'clothes'

These dialects, it seems, have default values for underspecified features. In addition, default specification seems to ignore ambiguity, so that in Baoding, both /nao/ 'head' and /ao/ 'coat' become [nao]. The number of variants of the zero onset does not affect the argument that the onset is obligatory, however.

In Cantonese, since the labialization only occurs with [k], the canonical shape of the syllable in Cantonese can be analyzed as being CV(V)C instead of C(C)V(V)C. To account for the labialized velar consonant, one extra initial consonant, [kʷ], is added to the inventory of initials.

In the case of Mandarin, both the labial element and the palatal element occur with the full set of initial consonants. It would not be economical to posit three series of consonants: a plain series, a labialized series, and a palatalized series. Thus, in the phonological analysis of Mandarin, a simpler and more elegant solution would be to posit a consonant cluster in which the second consonant is a labial or palatal glide. (67-68)

The main reason for analyzing CG- as a cluster in Mandarin is to reduce the underlying consonant inventory; this is, of course, a legitimate desire. Nevertheless, we gain little insight if consonant reduction is done at the cost of increasing the complexity of the Mandarin syllable, or in the absence of independent arguments for a particular syllabic structure. Moreover, as we will show later, viewing Mandarin pre-nuclear CG as a segment at surface need not increase the underlying inventory of Mandarin consonants.

The second argument comes from language games, i.e. 'Fanqie' or 'secrete' languages. In such games, a syllable is first reduplicated (which reduplication theory to follow is immaterial to our point), then one or both syllables are modified. Consider a game language from a Mandarin dialect Chengdu (Liu 1944)

(10) a.   Reduplicate the syllable.
      b.   Replace the first onset with [n].

(11) a.   ma --> ma-ma   --> **n**a-ma   'mother'
      b.   gao --> gao-gao --> **n**ao-gao   'tall'

As stated in (10), a syllable is first copied, then the onset of the first syllable is replaced by /n/. This language may give an indication as to where pre-nuclear G belongs; if in the onset, it should be replaced in the first syllable, otherwise it should stay there. Consider

(12) a. ie   -->   ie-ie   -->   ne-ie   (*n**i**e-ie)   'grandfather'
      b. niang -->   niang-niang --> nang-niang (*n**i**ang-niang) 'goodness'
      c. tuei   -->   tuei-tuei   -->   nei-tuei   (*n**u**ei-tuei)   'correct'
      d. guai   -->   guai-guai   -->   nai-guai   (*n**u**ai-guai)   'strange'
      e. hsÿe   -->   hsÿe-hsÿe   -->   ne-hsÿe   (*n**ÿ**e-hsÿe)   'snow'
      f. chÿan -->   chÿan-chÿan --> nan-chÿan   (*n**ÿ**an-chÿan) 'curl'

In all cases, pre-nuclear G is replaced with the onset, suggesting that it is in the onset, and not in the rime. Other Fanqie languages support the same conclusion. We will come back to them in section 2.3.

The third argument is from tone bearing ability. In his acoustic studies of Mandarin tones, Howie (1976, 218) notes that

the domain of tone in Mandarin is not the entire voiced part of the syllable, as is traditionally described, but rather is confined to the syllabic vowel and any segment that may follow it in the syllable.

In other words, tone is borne by the rime, not the onset. Now, by 'syllabic vowel', Howie means the nuclear vowel; pre-nuclear G is not included. This means that pre-nuclear G is not a tone bearing unit. Although Howie does not discuss CGVV and CGVN syllables, yet, since all pre-nuclear G, whether initial or medial, are traditionally considered part of the rime (cf. (1)), Howie's argument applies to all pre-nuclear G. In his F_0 tracings (pp201-214, Types 2-3), it is seen that the F_0 contours are quite irregular on pre-nuclear G, but agree with the expected contours very well from the nuclear vowel on. Note that it is not the case that glides are poor tone bearers; when a glide is in the nucleus or the coda, its F_0 contour is fully regular. It is particularly interesting to note that, in GG syllables /yi yü wu/, where the second G is the nuclear vowel, the F_0 contour is irregular on the first G but regular on the second. This clearly shows that w.r.t. tone bearing ability, pre-nuclear G belongs to the onset, not the rime.

The fourth argument concerns structural adjacency. Before we give the argument, let us consider five possible structures in which the position of pre-nuclear G differs. Take the syllable <u>tian</u> 'sweet' for example, shown in (13), where I = Initial and F = Final.

```
(13)   a.   /\       b.   /\      c.   /\       d.   /\      e.    /\
            O  R          O  R         I  F          O  R          I  F
            |  /\        /\  /\        |  /\         |  /\         | /|\
           tY a n       t i  a n      t i /\        t N  C        t ian
                                         a n          /\ |
                                                     i a n
```

(13a) is the structure I argue for. (13b) is proposed by Bao (1990b:328) and Fu (1990). (13c) is proposed by R. Cheng (1966) and Y. Lin (1989); it also resembles the structure proposed by Harris (1983) for Spanish (but see Carreira 1988 for an alternative analysis of Spanish data without (13c)). (13d) is proposed by Bao (1990b:342) for Taiwanese and Kunshan. (13e) is assumed by Y. Lin (1989), Bao (1990) and Fu (1990) as an alternative for Taiwanese; it is also assumed, often tacitly, in most other analyses of Chinese languages. We will now see evidence that only (13a) is the correct analysis.

It has been noted that the Mandarin mid vowel /ə/ assimilates in [back] (and [round]) with an adjacent glide, on either side (cf. C. Cheng (1974), Battistella (1984), Hyman (1975))

(14)   a.   /fəi/-->[fei] 'fly'   /diə/-->[die] 'saucer'
        b.   /dəu/-->[dou] 'bean'   /duə/-->[duo] 'many'
        c.   /diəu/-->[diou] (*dieu) 'throw' /duəi/-->[duei] (*duoi) 'team'

/ə/ becomes [e] in (14a), where /i/ is adjacent, and becomes [o] in (14b), where /u/ is adjacent. In (14c), where both /i u/ are adjacent, /ə/ assimilates to the coda. C. Cheng (1974) suggests that, if possible, /ə/ assimilates to the segment on the right, otherwise it assimilates to the segment on the left. There is, however, no explanation for the directionality of the assimilation. Battistella

suggests that the apparent directionality is a result of structural adjacency. In particular, in (13a, b, c) the nuclear vowel is structurally closer to the coda than to the pre-nuclear G. If the structure of the Mandarin syllable is either of (13a, b, c), we do not have to stipulate the directionality for the assimilation of /ə/; /ə/ simply assimilates to the structurally closest segment, i.e. the coda if there is one, otherwise the pre-nuclear G. In contrast, (13d, e) cannot explain why the coda has greater influence on the nuclear vowel than the pre-nuclear G. Thus, (14) disfavors (13d, e), leaving (13a, b, c) as possible alternatives. We will compare (13a, b) shortly in section 2.1.1.3. Before then, let us turn to the next argument, which shows why (13c) is not the correct analysis.

In the fifth argument I show that pre-nuclear CG- forms a structural unit, and so (13c) cannot be the correct analysis. The evidence comes from some Chinese dialects in which there is a switch between [f-] and [hu-]. For example, compare Mandarin with Santai, a Mandarin dialect spoken in the province of Sichuan (for the moment I follow the traditional transcription, where pre-nuclear G is written as a segment)

(15)   Mandarin   Santai

       huei   fei   'ashes'
       fei   huei   'to fly'
       huang   fang   'yellow'
       fang   huang   'house'
       hei   he   'black'
       hao   hao   'good'

Mandarin [hu-] and [f-] are changed to [f-] and [hu-] in Santai respectively. Mandarin [h-], however, remains unchanged in Santai. Since Mandarin and Santai belong to the same dialect family, it is reasonable to assume that they have similar syllable structures, i.e. either (13a, b) or (13c). The fact that [f-] may replace [hʷ-] and in turn be replaced by the latter show that [hu-] must be a structural constituent. Similarly, all other pre-nuclear CG's should also be structural units. In other words, (13c), in which pre-nuclear CG do not form a constituent, cannot be the correct analysis.

Other cases of the alternation between [f-] and pre-nuclear [hu-] is also found, as Lü (1962) notes

> in some (Chinese) dialects [f-] and [hu-] are not distinguished. Either may be freely used in place of the other. They are...free variants.

Such cases confirm that, in these dialects at least, (13c) cannot be the correct analysis.

The final argument comes from riming. Two syllables rime in Chinese if they have the same nucleus and coda; the onset C and pre-nuclear G have no effect.[11] This is true throughout history,

---

[11]. More specifically, two syllables rime if they have the same surface nucleus and coda; two syllables whose nuclei and codas are identical underlyingly but different at surface may or may not rime (thanks to K. Hale for pointing this out to me). For example, as mentioned above, in an open syllable, the Mandarin mid vowel /6/ assimilates in [back] and [round] to the glide on the left, and if there is no glide to the left, /ə/ is realized as [ɤ] (unrounded back mid vowel). Thus,

from the earliest recorded poems in <u>Shijing</u> (<u>The Book of Songs</u>) (L. Wang (1957:3-4)), to present day poems.[12] If pre-nuclear G is in the onset, the explanation is simple: two syllables rime if they have the same rimes. However, if pre-nuclear G is in the rime, then one has to explain why different rimes can rime.

We will have more to say about pre-nuclear G when we discuss language games and cooccurrence restrictions later in the chapter. The traditional assumption that pre-nuclear G is in the rime is probably influenced by <u>Qieyun</u>, one of the oldest and most important 'riming books', written around 600 A.D. In <u>Qieyun</u> a syllable is split into two parts, the initial consonant, often called the 'initial', and the rest, often called the 'final'. Altogether 206 'finals' are distinguished and arranged in table form. Although the 206 'finals' include pre-nuclear G, those that differ only in pre-nuclear G are permitted to rime in poems (L. Wang 1957:4). With respect to riming, there-fore, a 'final' is not the same as a 'rime', since different 'finals' can rime. Strictly speaking, then, <u>Qieyun</u> is more than a riming book; it provides phonological distinctions not only between those 'finals' that do not rime, but also between those 'finals' that rime. There is the question of why <u>Qieyun</u> does not group pre-nuclear G with the 'initial', i.e. the onset consonant. My speculation is that it is probably due to an arbitrary choice, given that <u>Qieyun</u> does not give arguments for grouping pre-nuclear G with 'finals' anyway. The common assumption that pre-nuclear /i u/ were historically in the rime has also been challenged recently by F.K. Li (1980b), who argues that pre-nuclear /u/ was historically not a rime segment but a secondary articulation on the onset C. It

---

/die/-->[die] (e.g. 'dad'), /duə/-->[duo] (e.g. 'many') and /də/-->[dɤ] (e.g. 'gain'). To my knowledge, [die] and [duo] do not rime. However, [duo] and [dɤ] occasionally rime, as seen in the following lines (from the 1989 Spring Festival Gala Celebration TV Show, CCTV, Beijing, transcribed in Pinyin, where 1, 2, 3 and 4 mark the four tones)

   ...
   jin4 qin1 jie2-hun1 hai4 chu4 duo1,
   close kin marry   bad effects many   'Inbreeding marriages have many bad effects,'

   zhe4 yang4 xia4-qu4 liao3-bu4-de2.
   this way go-on   terrible   'It will be terrible if such things go on.'

The riming syllables <u>duo</u> and <u>de</u> have the same underlying nuclei (both being [ə]) but different surface nuclei ([o] and [ɤ] respectively).

[12]. Another example of modern riming is seen in the lines below (from the Taiwanese TV series <u>Ba Qian Li Lu Feng He Yun</u>, directed by Lin Feng)

   ...
     liu shi qi ba,   'People in their sixties,
     yang niao zhong hua.   raise birds and tend flowers.
     qi shi qi ba,   People in their seventies,
     zheng xie ren da.   sit in PCC and the People's Congress.
     ba shi qi ba,   People in their eighties,
     zhen xing zhong hua.   revitalize China.'
               (PCC: Political Consultative Conference)

where [ba], [da] and [hua] rime. That is, pre-nuclear consonant and glides have no effect on riming.

remains to be shown whether pre-nuclear /i/ was also part of the onset.

2.1.1.3. The onset has one slot

Having shown that pre-nuclear G is in the onset, I next show that pre-nuclear CG is a single segment. In other words, I argue that what are traditionally written as pre-nuclear 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. The view that pre-nucleus CG is two segments is based on the assumption that pre-nuclear G is in the rime. Once we see that pre-nuclear G is in the onset, there is no more support for that view. There is, on the other hand, further evidence for our analysis. If pre-nuclear CG were an onset cluster, we would expect other onset clusters as well. In particular, there is a cross-linguistic tendency that if a language allows an onset cluster C_iC_j, where the sonority distance between them is not the largest, then it should allow an onset cluster C_iC_k, where the sonority distance is larger (Greenberg (1964), Harris (1983), Selkirk (1984), Steriade (1982)). This means that if /li-lu- ni- nu-/ are good onsets, we would expect /pl- kl- pr- kr-/ to be good, too, since the sonority distance is larger in the latter set (assuming the sonority hierarchy of vowel-glide-liquid-nasal-fricative-stop). However, in Mandarin we do find the former set, /lia/ 'two', /luan/ 'egg', /nian/ 'year' and /nuo/ 'move', but not the latter set, /*pla *kla *pra *kra/. This fact is unexplained if pre-nuclear CG are a cluster.

In contrast, if pre-nuclear CG are a single segment C^G, the result is what we would expect. The reason is that Mandarin allows /i u/ as secondary articulations but not /l r/, so /li- lu- ni- nu-/ are good and /pl- kl- pr- kr-/ bad. This is not an unusual restriction; it is far more common cross-linguistically to find dorsal and labial secondary articulations than coronal secondary articulations (cf. Maddieson 1984).[13]

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[13]. It is not clear why coronal secondary articulations are less common. It is probably due to the fact that coronal sounds are acoustically more robust and so they tend to be primary articulations.

There is another possible reason why [l] is a bad secondary articulation. According to Sagey (1986), a secondary articulation is represented by adding a minor articulator node to the feature tree of a given segment. In addition, all manner/stricture features belong to the major articulator; manner features of minor articulators are interpreted either by general principles (e.g. [-cons] as a universal default) or predictable on a language particular basis (Sagey 1986:272). Now Hegarty (1989) has argued that [lateral] is a manner feature, attached to the Root node instead of the coronal node. Consider [p] and [p^l] in this light

```
(i)    [p]  Root  ┐            (ii)   *[p^l]  Root ┐           SL = Supra-laryngeal
             / \                              / \
         [-cont] SL                       [-cont] SL
               |            │                    |            │
               Pl                               Pl
               |            │                    / \          │
              Lab <─┘                       Cor  Lab<─┘
                                             |
                                           [+ant]
```
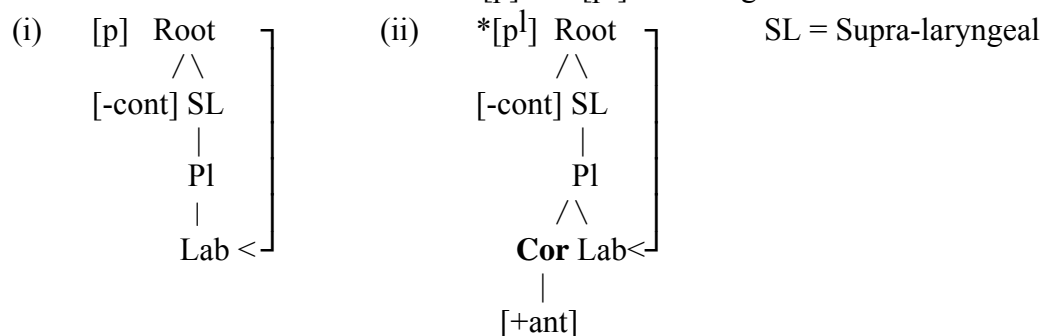
The articulator of [l] is 'coronal'. If we add this to [p], as shown in (ii), however, we do not get [p^l], since there is no feature [+lateral]. If we add [+lateral] to the Root node, it will become a property of the major articulator 'labial'. So we never get [p^l] as a well formed complex segment.

Additional evidence for (13a) and against (13b, c) comes from the [f-] and [hu-] alternation (cf. section 2.1.1.2). Let us take a close look at the process. According to (13b, c), in which [hu-] contains two segments, there is no good explanation as to how two segments could become one and, especially, how one segment could become two. In contrast, according to (13a), where [h^w-] is single segment (a double articulation), there is a simple explanation. The representations of [f-] and [h^w-] are as follows (following the feature geometry of Sagey 1986, where the pointer points at the 'major articulator')

(16)   [f-] ┌──   Rt   [h^w-] ┌──   Rt
         │   / | \   │   / | \
         │   Lar SL [+cons]   │   Lar SL [-cons]
         │ | | │ | |
         │   [+sg] Pl   │   [+sg] Pl
         │ | │ |
         └──> Lab   └──> Lab   [sg]=[spread glottis]
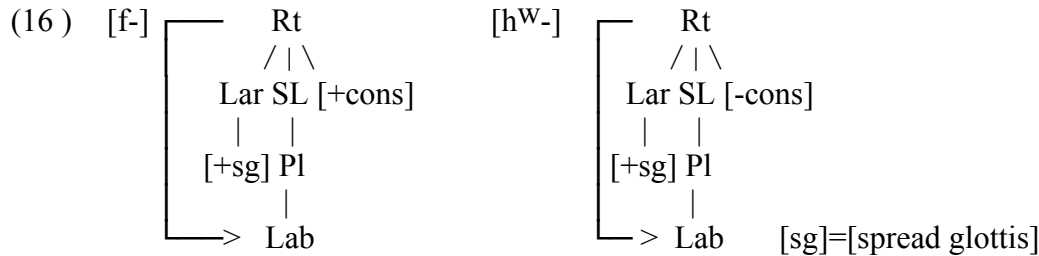
There are two differences between [f-] and [h^w-]. First, the pointer goes to Labial in [f-] but to Laryngeal in [h^w-]. Second, the value of [cons] is plus in [f-] but minus in [h^w-]. We may, however, consider the second difference as a consequence of the first. When the pointer in [f-] is changed from Labial to Laryngeal, [+cons] must also change to [-cons], since according to Chomsky & Halle (1968) all laryngeal sounds (i.e., in terms of feature geometry, those sounds with the Laryngeal node as the major articulator) are [-cons]. Similarly, when the pointer in [h^w-] is changed from Laryngeal to Labial, [-cons] must also change to [+cons], too, since,

---

On the other hand, Sagey's argument equally supports the opposite view, namely, (ii) is the representation of [p^l]. This is because minor articulators do not need manner features. For example,

  (iii)   Root   ┐
                 / \   │
       [-cont] SL   │
                 | │
                 Pl   │
                / \   │
            Lab Cor <   ┘
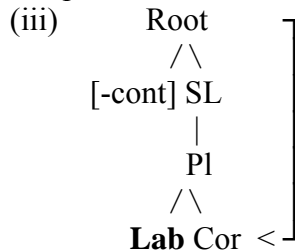
As a default, (iii) will be interpreted as [t^w], rather than [t^f] or [t^p], by the universal default [-cons] for minor articulators. Similarly, [+son] could also be a universal default feature for the minor articulator, because secondary articulation is generally sonorant. Thus, (ii) will be interpreted as [p^l] rather than, say, [p^s] or [p_], because oral [+son, +ant] implies [+lateral]. In general, the minor articulator 'coronal' will be interpreted, universally perhaps, as [^l] (if it is [+ant]) or [^r] (if it is [-ant]). It will not be interpreted as [t] or [s] or [θ], etc.

It has been tentatively proposed that, similar to other Sino-Tibetan languages (such as Tai), Ancient Chinese had onset clusters C_1C_2, where C_2 is a liquid ([l] according to Dong 1954, and [r] according to F.K. Li 1980b). Our analysis offers the possibility that even Ancient Chinese had a single onset.

presumably, there is no [-cons] aspirated labial sound. If this analysis is correct, then the change between [f-] and [h^W-] is simply a change of the object of the pointer. And this analysis is possible only if we assume (13a).

2.1.1.4. The rime has two X slots

Two points need be shown: (i) the rime has at most two slots, and (ii) the rime has at least two slots. For (i), we note that diphthongs do not occur in closed syllables (cf. (2b)). This shows that the rime cannot contain three segments. In addition, when the diminutive suffix /r/ is added to a syllable, the original coda is deleted (cf. Chao 1968)

(17)   ya+r --> yar   yan+r --> yar   guai+r --> guar
        'tooth'   'edge' (*ya**n**r)   'strange' (*gua**i**r)

All this is natural if the Mandarin rime has just two slots.

It is easy to see that (ii) is true for CVN and CVV syllables (cf. (2b)), e.g. /bai/ 'white', /bau/ 'thin', /ban/ 'half', /bang/ 'help'. The question is whether (ii) is true for the so-called 'CV' syllables. I will give two arguments that it is. First, it is a phonetic fact that the Mandarin 'CV' syllable has a long vowel. This can be seen by comparing translations of names, e.g. çi:-çi:-li: 'Sicily', where the Mandarin syllables are clearly longer. Phonetically, it is well-known that all regular Mandarin syllables, e.g. /ta/ 'he', /tai/ 'embryo' and /tang/ 'soup', have similar durations (e.g. Howie (1976)). If these syllables do not have the same rime length, namely two X slots, there is no reason why they should have the same duration. In English, for example, 'hike' and 'hack' markedly differ in duration, because the former has one more rime slot. The fact that Mandarin /ta tai tang/ have similar durations shows that vowels are long in open rimes and short in diphthongs and closed rimes. What is traditionally transcribed [CV] is in fact [CV:]. Why then did traditional transcriptions fail to reflect this fact? The reason is that Mandarin vowels do not contrast in length. However, the lack of length contrast can mean one of three things: (i) all vowels are long; (ii) all vowels are short; or (iii) vowel lengths are predictable. We have seen that Mandarin vowels do vary in length, so (i) and (ii) cannot be correct. This leaves (iii) the right answer, and our analysis correctly predicts length variations.

The second argument for (ii) is that phonetically the rime duration of a weak syllable is about 50% the rime duration of a regular syllable (Woo (1969), Lin & Yan (1988), Yang (1988)).[14] In addition, Lin & Yan (1988) show that when a full syllable is weakened, the duration loss mostly comes from the drop of the coda or the off-glide of a diphthong. For example, when fang (in ti fang 'place') is weakened, the coda /ŋ/ is dropped, and the vowel is nasalized and reduced towards schwa. In our terms, when weakened, a syllable loses the final rime slot. Note that coda loss is not a universal consequence for weakened syllables. In English, for example, it is the nucleus that seems to undergo most weakening, as the following show

(18)   /-**de**nt/ --> /-dnt/   /-**da**i/ --> /-di/   /-s**u**n/ --> /-sn/
        stud**en**t   Sund**ay**   Whits**un**

---

[14]. The onsets of weak and full syllables do not differ so much in length.

2.1.1.5. Summary
I have argued that a regular Mandarin syllable has a fixed length of three slots, one in the onset and two in the rime, and that pre-nucleus G is not a rime segment but a secondary articulation on the onset.

The phonological derivation of a morpheme is as follows.[15] A morpheme is supplied with a sequence of segments and a fixed syllable structure. Association follows a few simple rules given below, together with examples (omitting Onset, Rime, Nucleus, Coda nodes; Ø = one of (7a-d), /ə/ = schwa)

(19) a.   Link the most sonorant segment to the nucleus.
      b.   Link other segments.
      c.   If the coda is empty, spread the nuclear segment to it.
      d.   If the onset is empty and if the nucleus is [+high] or [+cons], spread the nuclear segment to it.[16]
      e.   Specify the zero onset (cf. (9)).

(20) a. /i/ --> [yi:]   / | \   19a   / | \   19c   / | \   19d   / | \
          'one'   XXX   →   XXX   →   XXX   →   XXX
                                       | | /   \ | /
                           i   i   i   i

      b. /m/ --> [m::]   / | \   19a   / | \   19c   / | \   19d   / | \
          'Uh-huh'   XXX   →   XXX   →   XXX   →   XXX
                                       | | /   \ | /
                           m   m   m   m

      c. /e/ --> [Øe:]   / | \   19a   / | \   19c   / | \   19e   / | \
          'goose'   XXX   →   XXX   →   XXX   →   XXX
                                       | | / | | /
                           e   e   e   Øe

      d. /an/→ [Øan]   / | \   19a   / | \   19b   / | \   19e   / | \
          'peace'   XXX   →   XXX   →   XXX   →   XXX
                                       | | | | | |
                           a n   a n   a n   Øa n

      e. /na/→ [na:]   / | \   19a   / | \   19b   / | \   19c   / | \
          'hold'   XXX   →   XXX   →   XXX   →   XXX
                                       | | | | | /
                           n a   n a   n a   n a

---

[15]. Chinese morphemes are dominantly monosyllabic.
[16]. We may formalize this and say that nuclei above a certain sonority degree do not spread to the empty onset. Intuitively, onsets cannot contain highly sonorant sounds, e.g. [-high] vowels. However, it is not clear where glottal onsets /ʔ ɦ/ should lie on the sonority hierarchy. I therefore leave this somewhat informal rule as it is.

f. /nan/→ [nan] / | \   19a   / | \   19b   / | \
    'south'   XXX   →   XXX   →   XXX
                             | | | |
                  n a n   n a n   n a n

g. /gu/→ [gu:]   / | \   19a   / | \   19b   / | \   19c   / | \
    'drum'   XXX   →   XXX   →   XXX   →   XXX
                             | | | | | /
                  g u   g u   g u   g u

h. /guan/→[guan] / | \   19a   / | \   19b   / | \   / | \
    'official'   XXX   →   XXX   →   XXX   i.e.   XXX
                             | / | | | | | |
                  guan   gu an   gu a n   gʷa n

i. /guə/→[guo]   / | \   19a   / | \   19b   / | \   19c   / | \
    'state'   XXX   →   XXX   →   X XX   →   X X X
                             | | V | | | |
                  guə   gu ə   gu ə   Rt Rt Rt
                                                     | | /
                                                     SL SL
                                                     | |
                                                     Pl Pl
                                                    / \ / \
                                                   Dor Lab Dor
                                                          / \
                                                      [-hi] [-lo]

There are several points to note. First, vowel length is no underlying, but derivative from the syllabic structure. Second, where glides link to (e.g. the onset, the nucleus, or both) <mark>depends</mark> on what other segments there are. For example, in (20g), /u/ is the most sonorant segment, so it is linked to the nucleus first. In (20h), /u/ cannot link to the nucleus, because the more sonorant /a/ has taken the position first; in addition, the Labial node of /u/ cannot link to /a/ to form a rounded low vowel, since Mandarin does not have rounded low vowels; instead, both /g u/ are linked to the onset, that is, they form a double articulation [gʷ]. In (20i), /ə/ occupies the nucleus first, and /g u/ form a doubly articulated onset [gʷ]; but now /u/ can also also link to the nucleus (specifically, the Labial node of /u/ (and its feature [back], which is not drawn) is linked to /ə/) to create [o], since Mandarin does allow [o]. (20) shows that there is no need to posit four series of underlying consonants /C Cʸ Cʷ Cᵘ/; the latter three are the outcome of the fixed syllable structure. In addition, there is no need to posit an underlying difference between high vowels and glides, since it is predicted by the syllabic structure. This completes our analysis of the Mandarin syllable.

Although no one has previously claimed, formally, that Mandarin syllables have a uniform structure, the idea must have been envisaged by some of my predecessors. For example, Chao (1968:18-23) divides the Mandarin syllable into four components, 'initial', 'medial', 'vowel' and

'ending', and suggests that initialless syllables have the 'zero initial', medialless syllables have the 'zero medial', and endingless syllables have the 'zero ending'. Similarly, Yip (1982:647) states that

> I take it that morphemes in Chinese consists of an invariant monosyllabic skeleton...(T)he skeleton is constant in any given dialect...

However, neither Chao nor Yip made their claims explicit. In fact, Yip allows some slots in the syllabic skeleton to be unfilled (p647), and this weakens the claim of a fixed skeleton, since one may always posit the maximal skeleton, and derive shorter skeletons by leaving some slots unfilled.

2.1.2. Shanghai[17]
Shanghai has the following inventory of 'initials' and 'final' (Xu et al 1981:145)

(21)   Initials:

p	ph	b	f	v	?m	Hm
t	th	d			?n	Hn
ts	tsh		s	z	?l	Hl
tç	tçh	dZ	ç	Z	$?n_y$	Hn_y
k	kh	g	h		?ŋ	Hŋ
					?	H

        Finals:

z	ɑ	o	O	ɤ	E	ø
i	iɑ		iO	iɤ	iE	
u	uɑ				uE	uø
ÿ						ÿø
r	m	n				
ã	ɑ̃	ən	oŋ	ɤ?	o?	ə?
iã	iɑ̃	in	ioŋ	iɤ?	io?	iI?
uã	uɑ̃	uən		uɤ?		uə?
		ÿn				ÿI?

The inventory does not seem to be an optimal analysis, for there are a number of missing positions; it will, however, not affect our discussion. As in Mandarin, all 'initials' are single segments. A suffixed /h/, as in /ph/, indicates aspiration. Sonorant initials are of two kinds. Those that are transcribed with a prefixed /?/, such as /?m/, pattern with voiceless obstruents and occur in upper register tones only. Those that are transcribed with a prefixed /H/, such as /Hm/, pattern with voiced obstruents and occur in lower register tones only. I suggest that the former set of sonorants have stiff vocal cords, and the latter set have slack vocal cords. More discussion on laryngeal features will be given in Chapter 3. Syllables with the 'zero onset' in Mandarin have /?/ or /H/ in Shanghai, depending on whether they are in the upper or the lower register respectively. Each 'final' must take one and only one 'initial'.

---

[17]. Data in this section refers to New Shanghai (Xu et al 1981). The same arguments apply to Old Shanghai (Chao 1928, Sherard 1972, Shen 1981). The two varieties differ mainly in sandhi patterns, and slightly in segments.

Let us now consider rime length. Our arguments that Mandarin pre-nuclear G is secondary articulation of the onset equally apply to Shanghai. This leaves the longest rime with two segments, such as /ong o?/. Moreover, like in Mandarin, all rimes, except those ending in /?/, have similar duration. Rimes ending in /?/ have much shorter durations, due partly to the glottalization of the vowel, and partly to the silence of /?/. We will therefore follow the same arguments for Mandarin and consider Shanghai vowels to be long in open rimes and short in closed rimes.

Unlike Mandarin, however, Shanghai has no diphthongs (cf. (21)). In addition, while in Mandarin, /n ŋ/ codas minimally contrast (e.g. /da/ 'big', /dan/ 'egg', /dang/ 'swing'), in Shanghai there is no minimal coda contrast. /n ŋ ?/ are in complementary distribution, occurring with [-low,-back] vowels, [-low, +back] vowels and glottal vowels respectively. Moreover, [+low] vowels do not occur with /n ŋ/ but with /~/. It is possible, therefore, that the Shanghai rime has one segment, with /~ n ŋ/ being manifestations of nasality, and /?/ a partial manifestation of glottality, in addition to the glottalness of the vowel.

It is not obvious which analysis is correct, i.e. whether the Shanghai syllable is bimoraic or monomoraic. I suggest that the Shanghai syllable is bimoraic in isolation (and in final positions perhaps) but monomoraic otherwise. One reason is that in nonfinal positions, the /?/ coda is dropped, but the glottalness of the vowel remains (Chao 1928; Xu et al p150). In addition, in isolation a Shanghai syllable may bear two tones, but nonfinally it may bear just one.[18]

It remains to be shown that the syllabic /z n m r/ can span three segments (or two in nonfinal positions). Evidence again comes from language games. Take Mo-ma from New Shanghai (omitting voicing diacritics [H ?] for sonorants)[19]

(22)   Basic rules of mo-ma from Shanghai:
       a.   reduplicate
       b.   replace the first rime with /o/.

(23)   ma -->   mo ma   'mother'
       ŋ -->   o ŋ (speaker A)   'fish'
                 ŋ o ŋ (speaker B)
       tie? --> tio-tie?   'iron'
       iã -->   io- iã   'sheep'

The data show that for Speaker A, /ŋ/ has the zero onset, and for Speaker B, /ŋ/ has the onset /ŋ-/. In our view, Speaker A does not spread /ŋ/ to the onset position, while B does, as shown below

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[18]. It remains to be shown whether the Shanghai syllable is lengthened in isolation, or shortened nonfinally. If the former, my claim that all Chinese syllables are bimoraic must be modified somehow.

[19]. This is a game language played among children. My two informants A and B were born and raised in Shanghai. A is in his mid twenties, and B is her in late twenties.

(24) Speaker A: σ → σ   Speaker B: σ → σ

```
Speaker A:      σ    →    σ            Speaker B:      σ    →    σ
               /\        /\                           /\        /\
              O  R      O  R                         O  R      O  R
              |  /\     |  /\                        |  /\     |  /\
              XXX       XXX                          XXX       XXX
               \/       | \/                          \/       \|/
               ŋ        Ø  ŋ                           ŋ         ŋ
```

where /Ø/ stands for a realization of the zero onset, which in this case is /H/. A syllabic segment that spans across three slots is found in Mandarin and other Chinese dialects (Chao 1931). The words /tie?/ and /iã/ shows that the pre-nuclear [i] is in the onset, as we predict. We conclude that, like Mandarin, Shanghai has the uniform syllabic structure in given (1).

2.1.3. Meixian (Moi-yan)

The inventory of Meixian initials and finals is given below (Hashimoto 1973:91, 92, 96)

(25) Initials:

b	p	f	m	
d	t		n	l
z	c	s		
g	k		ŋ	
Ø		h		

Finals:

a	au	ai	am	ab	an	ad	aŋ	ag
ua		uai			uan	uad	uaŋ	uag
ia	iau	iai	iam	iab	ian	iad	iaŋ	iag
e	eu		em	eb	en	ed		
ue					uen	ued		
ie	ieu							
o		oi			on	od	oŋ	og
uo		uoi			uon	uod	uoŋ	uog
io		ioi			ion		ioŋ	iog
z	u	i	zm	zb	zn	zd		
	ui				un	ud	uŋ	ug
	iu		im	ib	in	id		
					iun	iud	iuŋ	iug

Like in Mandarin and Shanghai, the Meixian has no cluster initials. /Ø/ stands for the 'zero initial', which has the value [?] before non-high vowels, [v] before a nuclear /u/ and [y] before a nuclear [i]. Pre-nuclear /i u/ also become [y v] respectively when the initial is /Ø/. These facts are what we would predict: [?] is the default segment, non-high vowels spread to the empty onset position, and pre-nuclear G is the onset if there is no other consonant.

For the finals, Hashimoto writes /b d g/ for the Ru Sheng codas instead of the more traditional /p t k/, as used in Yuan (1960), but this need not concern us here. Let us instead focus on the number of segments in the rime. We mentioned already that pre-nuclear /i u/ are [y v] when there

is no initial consonant. This is evidence that, like in Mandarin, pre-nuclear G in Meixian is part of the onset. This leaves the longest rime with two segments, CC, VG, and VC. The remaining question is whether C and V rimes have two slots. Unfortunately, Hashimoto does not say whether C and V rimes have the same durations as CC, VG and VC rimes. However, in view of the traditional custom of not marking length in most Chinese dialects, and the fact that in many such dialects open and closed rimes in fact do have similar durations (e.g. Mandarin, Chengdu and Shanghai), and the fact that in those dialects where length is marked, such as in Cantonese, open vowels are always marked long, and in the absence of counter-evidence, I will assume that all Meixian rimes have the same length of two slots. Thus, Meixian also has the uniform syllabic structure in (1).

2.1.4. Xiamen (Amoy)

Xiamen or Amoy originates from the city of Xiamen. It is also known as Taiwanese, being a major dialect spoken in Taiwan, due to demographic migrations. Like in Mandarin, Amoy does not permit onset clusters. The Amoy 'final' inventory is given below (Luo 1956:10)

(26) Open:

		a	O	o	e	ai	au
i	iu	ia		io			iau
u	ui	ua			ue	uai	

Nasalized:

		ã	Õ	ẽ	ãĩ		ãũ
ĩ	iũ	iã					iãũ
	uĩ	uã			uãĩ		

Closed:

	am		an		aŋ	Oiŋ
im	iam	in	ian	iəŋ	iaŋ	iOŋ
		un	uan		uaŋ	
	ap		at		ak	Oik
ip	iap	it	iet	iət	iak	iok
		ut	uat			

Syllabics: m   ŋ

This does not seem to be an optimal analysis, for again there are many missing positions. In particular, where we expect /Oŋ Ok/, we see /Oiŋ Oik/. This has been corrected in more recent analyses (J. Lin 1975, Lu 1977), where there are /Ong Ok/ but no /Oiŋ Oik/. Given this, and following the reasoning given for Mandarin, it is apparent that Amoy again has a uniform syllabic structure as in (1). In particular, the onset has one slot, the pre-nuclear G is in the onset, the longest rimes have two slots, and V and C syllables are geminates.

P. Li (1985) and Bao (1990b) suggest that evidence from language games (Fanqie languages) shows that, in Taiwanese, the pre-nuclear G is in the rime. Y. Lin (1989) and Fu (1990) argue for the same conclusion, drawing evidence from cooccurrence restrictions. I will treat this issue in sections 2.3 and 2.4 respectively, and show that their arguments are either inconclusive or make incorrect predictions. I will further show that if we assume the Taiwanese syllabic structure to be the same as in other Chinese languages, as in (1), we can give a successful account of both the

Fanqie data and the ==labial-labial== cooccurrence restrictions.

Amoy provides additional evidence for the bimoraic rime. It comes from literary v. colloquial styles of speech. Most nasalized vowels appear only in colloquial speech. In literary speech, they appear as VN. However, nasalized diphthongs remain as such in literary speech

(27)   Colloquial   Literary (Lu 1977:13-16)
        ã   am
        ẽ   iŋ
        ĩ   ieŋ
        iã   iŋ
        iÕ   ioŋ
        iũ   ioŋ
        uã   uan
        uãĩ   uan/uai
        Õ   ⌉
        ãĩ |
        ãũ |──── no nasal coda counterparts.
        iãũ |
        uĩ |
        uãĩ   ⌋

It is interesting to note that in literary speech /uãĩ/ either remains nasalized, or appears as either /uai/ or /uan/. The fact that nasalized diphthongs never appear as VGN follows if XX is the maximal rime length.

2.1.5. Fuzhou

Like previous languages discussed above, Fuzhou also does not permit onset clusters. However, unlike previous languages, Fuzhou seems to allow up to three rime segments, i.e. with diphthong in closed syllables, thus showing apparent counterevidence to the claim that Chinese rimes have two slots. There are many discrepancies among different descriptions of Fuzhou rimes. Consider first the 'final' inventory given by Liang (1982), which is one of the largest, with 49 members

(28) a/ɑ   E/   oe/   o/O   i/Ei   u/ou   ÿ/øÿ
                            øÿ/Oÿ

      aŋ/ɑŋ   Eiŋ/aiŋ   øÿŋ/Oÿŋ   ouŋ/Ouŋ   iŋ/Eiŋ   uŋ/ouŋ   ÿŋ/øÿŋ
                 Ei?/ai?   øÿ?/Oÿ?   ou?/Ou?

      a?/ɑ?   E?/   oe?/   o?/O?   i?/Ei?   u?/ou?   ÿ?/øÿ?

      ia/iɑ   ie/iE   ÿo/ÿO
                 ieu/iEu

      iaŋ/iɑŋ   ieŋ/iEŋ   ÿoŋ/ÿOŋ

      ia?/iɑ?   ie?/iE?   ÿo?/ÿO?

      ua/uɑ   uo/uO

uaŋ/uɑŋ   uoŋ/uOŋ

ua?/uɑ?   uo?/uO?

ai/ɑi

au/ɑu   Eu/

uai/uɑi   uoi/uOi   m   n   ŋ

Each rime has two forms, separated by a slash. The form before the slash occurs with high tones, and that after the slash with low tones. It can be seen that vowels in low tone forms are generally lower than their high tone counterparts. The syllabic nasals do not vary with tones, apparently because vowel lowering cannot apply. The correlation between low tones and low vowels, and high tones with high vowels, is a well-known phenomenon, but the mechanism that underlies this correlation is not exactly known (cf. Hombert 1978 for a review). We will therefore leave the explanation open. Five rimes, [E oe E? oe? Eu], are not given their low tone counterparts, for reasons Liang does not provide. The inventory has many missing slots, and is clearly not an optimal analysis. Let us compare it with that of Wright (1983)

(29)	a	e/a	oe	(o/O)	i/ei	u/ou	ÿ/øÿ
	aŋ	eiŋ/aiŋ	øÿŋ/Oÿŋ	ouŋ/Ouŋ	iŋ/eiŋ	uŋ/ouŋ	ÿŋ/øÿŋ
	a?	ei?/ai?	øÿ?/Oÿ?	ou?/Ou?	i?/ei?	u?/ou?	ÿ?/øÿ?
	ia	ie		iO		iu	
	iaŋ	ieŋ		iOŋ			
	ia?	ie?		iO?			
	ua			uO			
	uaŋ			uOŋ			
	ua?			uO?			
	ai		øÿ/Oÿ				
	au						
	uai		uei			m	n	ŋ

Wright's inventory does not have [E?/ɑ? o/O o?/O? oe]. The absence of [o/O] is likely due to an oversight, since it appears in Tao (1930), Chao (1931), and Liang (1982), as well as in Wright's own data (e.g. p.322 to 'many', p.376 ko 'brother'). In addition, many rimes, especially those with low vowels, do not have alternations. This is natural, since it is hard to further lower low vowels.

Like Liang's inventory, Wright's has many missing positions. In particular, the column under [oe] probably could be merged with the column under [e/a]; the former can fill the positions beginning with [u] under the latter. On the other hand, [uei], which Liang writes [uoi/uOi], can be moved to the column under [o/O]. Moreover, the column under [ÿ/øÿ] may either be merged with the column under [i/ei], to fill the positions beginning with [u], or be merged with the column under [u/ou], to fill the positions beginning with [i]. This gives us a system with five vowels [i e a o u], as shown below

(30) a   e/a   (o/O)   i/ei   u/ou
      aŋ   eiŋ/aiŋ   ouŋ/Ouŋ   iŋ/eiŋ   uŋ/ouŋ
      a?   ei?/ai?   ou?/Ou?   i?/ei?   u?/ou?
      ia   ie   iO   iu
      iaŋ   ieŋ   iOŋ
      ia?   ie?   iO?

      ua   oe(=ue)   uO   ÿ/øÿ(=ui)

      uaŋ   øÿŋ/Oÿŋ(=ueŋ) uOŋ   ÿŋ/øÿŋ(=uiŋ)

      ua?   øÿ?/Oÿ?(=ue?) uO?   ÿ?/øÿ?(=ui?)

      ai
      au
      uai   øÿ/Oÿ(=uei)   uei(=uoi)   m   n   ŋ

We next consider which form is derived, the low tone form or the high tone form. If the low tone form is underlying, there are at least two difficulties. First, [a] will split, some becoming [e] and some remain [a]. Second, many common rimes will be missing, such as [i iŋ u e]. In contrast, if the low tone form is derived, there is no difficulty. Clearly, then, the simpler analysis is to assume the low tone form as derived. Let us then disregard the low tone rimes. The inventory becomes

(31) a   e   o   i   u
      aŋ   eiŋ   ouŋ   iŋ   uŋ
      a?   ei?   ou?   i?   u?
      ia   ie   iO   iu
      iaŋ   ieŋ   iOŋ
      ia?   ie?   iO?
      ua   oe(=ue)   uO   ÿ(=ui)

      uaŋ   øÿŋ(=ueŋ)   uOŋ   ÿŋ(=uiŋ)

      ua?   øÿ?(=ue?)   uO?   ÿ?(=ui?)

      ai
      au
      uai   øÿ(=uei)   uei(=uoi)   m   n   ŋ

It will have been noted that although nuclear /i u/ are lowered in low tone rimes, pre-nuclear /i u/ are never lowered. This agrees with our analysis that pre-nuclear /i u/ are part of the onset, so they are not tone bearing and thus not subject to lowering.[20] Now ignoring pre-nuclear [i u],

---

[20]. It will have been noted that, although Wright writes [O] after [i u] in the [o/O] column for both high and low tone members, Liang gives finer distinctions, with [o] for the high tone members and [O] for the low tone members. If we follow Liang's analysis, we may further disregard pre-nuclear [i u], and the inventry will become

there are six rimes that contain three segments, [eŋ ei? ouŋ ou? øÿŋ øÿ?]. However, they occur in places just where we expect [eŋ e? oŋ o? øŋ ø?]. The question is, which set is underlying? If the former, we see a situation where there are simple rimes like [e o ø] and complex rimes like [eiŋ ei? ouŋ ou? øÿŋ øÿ?], but not intermediate rimes like [eŋ e? oŋ o? øŋ ø?] or [ei ou]. This is against a universal tendency that if a language allows complex structures, it also allows simpler structures. We will therefore favor the alternative analysis and assume [eŋ e? oŋ o? øŋ ø?] to be underlyingly.

Why [eŋ e? oŋ o? øŋ ø?] should be phonetically realized as [eiŋ ei? ouŋ ou? øÿŋ øÿ?] is an open question. Liang (p38) notes that the coda [?] varies with [k] non-contrastively in Fuzhou; he chooses to write [?] for all of them. T. Wang (1969), on the other hand, chooses to write those Fuzhou codas as [k] instead of [?]. Thus the [+high] of [k ŋ] may have played a role.

We mentioned above that the Fuzhou onset has one slot. We have seen that the longest rime in Fuzhou has two slots. The same argument given for Mandarin that monophthongs are geminates applies to Fuzhou. Consider the following measurements of rime length (calculated from the data in Wright 1983:60-62)

(32)   RIME (nonfinal)   TOKENS   AVERAGE
       a   160 168 144 156 132 160 164   155
       aŋ   258 244 236 256 238 252 236 260 264   249
       au   144 152 232 192 192 160   179
       ai   164 156 212 160 122 188 208   173

       RIME (final)   TOKENS   AVERAGE
       a   332 400 280 360 372   349
       aŋ   452 368 396 368 492   414
       au   296 336 232 340   301
       ai   280 324 456 380 460 348   375

Apart from the fact that a nasal coda makes the rime longer, [a] has similar durations as [au] and [ai] both in domain final positions (where the syllable is stressed) and in non-domain final positions.[21] Clearly, monophthongs are long vowels, and we conclude that, underlyingly, the Fuzhou

---

a	e		o	i	u			
ang	eing		oung	ing	ung			
a?	ei?		ou?	i?	u?			
ai								
au								
uai	øÿ(=uei)		uei(=uoi)			m	n	ŋ

[21]. The stress domain in Fuzhou, which is also the sandhi domain, seems to starts from the right edge of an XP and extends leftwards to the next left edge of XP, similar to that of Xianmen (Amoy) discussed in Chen (1987).

syllable has a fixed length of three segments, in the structure given in (1).[22]

There is a remaining question. What is the rime length in low tone forms? Many low tone forms contain diphthongs in closed syllables, suggesting three segments. Before we draw a conclusion, three further facts must be noted. First, the low tone forms occur only finally. Non-finally, only high tone forms occur, even if the rime carries a low tone.[23] Second, both high and low tone forms are comparable in length either finally, or non-finally, while all rimes in final positions are longer than in non-final positions, due to stress. Third, the only complex contour tone, 242 or LHL (ignoring register for exposition), occurs only finally. These facts suggest that in final positions the rime is lengthened to three X slots, due to stress, in line with the analysis of Wright. A similar case is found in Mandarin, where a floating H of the Third Tone is realized only finally, accompanied by a lengthening of the rime.

2.1.6. Cantonese

The Cantonese onset contains one segment. In addition, /w/ is the only pre-nuclear glide, which is commonly analysed as the secondary articulation of the onset, similar to our treatment in Mandarin. There are, however, striking differences in the duration of Cantonese rimes. According to some analyses, the durational differences come from a contrast between short and long vowels (e.g. the 'Yale system' of Huang & Kok 1960). Other analyses attribute the differences to tense/lax qualities of the vowel (e.g. Wong 1954). Still others consider both length and quality to be playing a joint role (e.g. Kao 1971). The differences in approach are reflected in the following three versions of the Cantonese 'final' inventory

(33)   Wong (1954) (in Kao 1971, p36):

a			E	i		O	oe	u	y	
ai	Ai	ei				Oi				
au	Au			iu	ou					
							oey			
am	Am			im						m
an	An			in		On	oen	un	yn	
aŋ	Aŋ		Eŋ	iŋ		Oŋ	oeŋ	uŋ		ŋ
ap	Ap			ip						
at	At			it		Ot	oet	ut	yt	
ak	Ak		Ek	ik		Ok	oek	uk		

---

[22]. Wright's data are not rich enough to compare the lengths of other rimes. For example, there are just two tokens of non-final [i] and no token of [ing].
[23]. There is additional support for positing the high tone form as underlying. In nonfinal positions, commonly called 'sandhi positions', only 'high tone' forms occur, with both high and low tones. The 'sandhi tones', however, are in agreement with the voicing of the onset. On the other hand, tones in final positions, commonly called the 'original tones', disagree with onset voicing. It is therefore more natural to take non-final forms as underlying, i.e. the somewhat misleadingly called 'high tone' forms.

(34) Huang & Kok (1960) (in Kao 1971, p39):   (L = long, S= short)

L	S	L	S	L	S	L	S	L	S	L	S	L
a		e		i		o		eu		u		yu
aai	ai		ei			oi			eui	ui		
aau	au			iu		ou						
aam	am			im								
aan	an			in			on	eun		un		yun
aaŋ	aŋ	eŋ			iŋ		oŋ	euŋ			uŋ	
aap	ap			ip								
aat	at			it			ot	eut		ut		yut
aak	ak	ek			ik		ok	euk			uk	

(35) Kao (1971, p40):   (L = long, S= short)

L	S	L	S	L	L	S	L	S	L	L
A		e		i	o		oe		u	y
Aj	aj		Ej							
Aw	aw			iw		Ow				
Am	am			im						m
An	an			in	on			oen	un	yn
Aŋ	aŋ	en	Eŋ		oŋ	Oŋ	oeŋ			ŋ
Ap	ap			ip						
At	at			it	ot			oet	ut	yt
Ak	ak	ek	Ek		ok	Ok	oek			

Wong considers quality alone to be distinctive. Huang & Kok take the opposite view, favoring length rather than quality. Kao follows the middle road and includes both length and quality. Phonetically, there are both length and quality differences between the 'short' and 'long' Cantonese vowels (Kao). The question is, which is a phonological feature? Since length and quality cooccur, ideally there should be evidence for one or the other rather than both.

It can be seen in (35) that distributionally, length is defective. Of all the 'long-short' pairs, only one, /a A/, contrast in all environments. For the other pairs, most in Kao's analysis, and all in the other two analyses, are in complementary distribution. There is, therefore, no compelling reason for positing length as a phonological feature. The difference between /a A/ may be attributed to quality alone.[24]

Let us now consider the segments in the rime. We see that 'short' vowels do not occur in open syllables. This means that the rime has at least two slots. The question is whether the rime could have three slots. Having excluded length as contrastive, the only possibility is closed diphthong rimes. In Huang & Kok's analysis, we see /eun eut .../. However, comparing Huang & Kok's analyses with those of Wong and Kao, we see that /eu/ of Huang & Kok is a notational variant of the front round mid vowel /oe/. Thus all the Cantonese rimes contain either a long vowel or two segments.

---

[24]. However, if we assume that /a A/ are different segments, there is the question of why only /A/ occurs in open syllables, while /a/ does not. I leave this problem open. Thanks to M. Yip for pointing this out to me.

It remains to be explained why there is such a sharp contrast in duration between Cantonese 'long' and 'short' vowels. Consider the measurements by Ng (1989:22), based on fifty-four mono-syllabic words read in isolation

(36)	Rime type	Onset	Nucleus	Coda	Syllable (in ms)
	V:	100	507	0	607
	V:G, V:N	100	362	228	690
	V:P	72	240	38 (+200)	350 (+200)
	VG, VN	103	216	295	614
	VP	88	136	59 (+200)	283 (+200)

(V: = long, V = short, P = /p t k/, G = /i u y/, N = /m n ŋ/)

The overall picture of Ng's findings is similar to that of Kao (cf. Kao, 57). There are two striking facts to note. First, 'short' vowels in /VP/ rimes are less than a third of 'long' vowels in /V:/ rimes. It is well-known, however, that Chinese syllables with /p t k ?/ codas (all unreleased) are generally much shorter than other syllables, due in most cases, and probably in all cases, to a glottal quality of the vowel. This is shown by the fact that 'long' vowels in /V:/ rimes have twice the length (507ms) of 'long' vowels in /V:P/ rimes (240ms). Second, in comparable environ-ments, 'long' vowels are about 1.7 times the length of 'short' vowels (362ms v. 216ms, and 240ms v. 136ms). This is still a considerable difference. In Swedish, for example, long vowels are about 1.5 times the length of short vowels (Elert 1964). A ratio of 1:1.7 therefore ought to be large enough to establish a short/long vowel contrast in Cantonese. However, the 1:1.7 ratio is misleading if taken at face value. Recall that 'long' and 'short' vowels are in complementary dis-tribution, and the length difference is not between minimal pairs. How this should bias the interpretation can be seen in the following example. In Ng's data, there are seven syllables in the /C_k/ environment, /pAk sEk tsoek tsok/ for 'long' vowels, and /pak sik fuk/ for 'short' vowels. We see, however, that the 'long' vowels are also lower than the 'short' ones, and phonetically, low vowels are longer than high vowels. Taking this into consideration, the real length contrast between 'long' and 'short' vowels should be smaller.

There are two pieces of further evidence for the fixed length hypothesis. First, we see that /p t k/ codas are about 200ms shorter than nasal or glide codas. This is because the lengths of /p t k/ codas, all unreleased, were measured up to, but not beyond, the closure (Ng, p.c.). It will be naive to base segmental analysis on absolute duration. For example, [s] is probably at least twice as long as [d], but we do not consider [s] as containing two segments. Similarly, the fact that /p t k/ codas are much shorter than /i u m n .../ codas is no evidence that syllables containing the former is one mora/segment shorter. In other words, compensations must be made for intrinsic segmental differences before length arguments can be meaningfully used. It is reasonable, there-fore, to add some silent duration to /p t k/ codas, to make them comparable in length with the other codas, as Cheung suggests (p127). In particular, we may add 200ms, the average length of /i u y m n ŋ/ codas, to /p t k/ codas (shown in brackets in (36)). Once we do this, then all syll-ables become comparable in length, from 550ms to 690ms, or with a ratio of 1:1.25 between the shortest and the longest. Second, we note that 'long' vowels in open syllables, such as /ma: tse: po: fu:/, are about 1.7 times the length of the same 'long' vowels in syllables with /i u y m n ŋ/ codas, such as /fa:i me:ŋ ho:n mu:i/. This agrees with our analysis that all rimes have two slots; a 'long' vowel in an open syllable occupies both slots, and a 'long' vowel in a closed syllable

occupies just one slot (the other slot being taken by the coda).[25]

In conclusion, Cantonese also has a constant syllabic structure, as shown in (1).

2.1.7. Changsha

The initial and final inventories of Changsha are as below (Yuan 1960:104) (underline = retroflex, ' = aspiration, Ø = zero onset)

(37)   Initials:

p	p'	m	f	t	t'	n/l	k	k'	ŋ	x	Ø
tç	tç'	nʸ	ç	<u>ts</u>	<u>ts'</u>	<u>s</u>	<u>z</u>				

Finals:

z/<u>z</u>	a	o	ə		ai	ei	au	əu	õ		
i	ia	io		ie			iau	iəu		iẽ	
u	ua		uə		uai	uei					
ÿ	ÿa			ÿe	ÿai	ÿei				ÿẽ	
an	ian	uan	ÿan	ən	in	uən	ÿn	oŋ	ioŋ	ə(:)n	n

---

[25]. Ng observes that

'long vowels seem to have shorter codas than short vowels in the same context, so that in general, there is a complementary relationship between the vowels and the codas.' (p23-24)

Similar remarks were made by others (Chao 1947:22, Chen & Bai 1958, Yuan et al 1960, Dow 1972:161 and Hashimoto 1972:290, cited in Cheung 1986:124-126). This is as expected. The bimoraic rime has a constant length; if the nucleus takes up more time, the coda has less left, and if the nucleus takes less, the coda has more. It is, however, not clear to me how, phonologically, two segments compensate each other in time. Cheung suggests that the mora is a literal measure of length, that the minimal perceptual unit is a 'semi-mora' (half a mora), and that, in Cantonese, the onset, the vowel and the coda share two moras (four semi-moras), in the following manner (135-136,146)

```
Structure:        σ          σ          σ
                 /\         /\         /\         O = onset
                O R        O R        O R         R = rime
                | |        | /\       | /\        V = vowel
                | V        | VCd      | VCd        Cd = coda
                | /|       |/\|       |/ |         μ = mora
                μ μ        μ μ        μ μ
Syllable:       CV:        CV:C       CVC
                           CV:G
Length Ratio:   1:3:0      1:2:1      1:1:2
```

In every case, the onset has a semi-mora, i.e. a fourth of a syllabic length. The ratio of duration among the onset, the vowel and the coda is 1:3:0 in the first structure, 1:2:1 in the second, and 1:1:2 in the third. In addition, the ratio of vowel length is 3:2:1 in the three structures. As we can see, Ng's measurements match Cheung's predictions only very roughly.

The initials are all single consonants. The finals are similar to those of Mandarin, where diphthongs do not occur in closed syllables. We may therefore follow the same arguments given for Mandarin and assume that pre-nuclear glides are in the onset and that single vowels are long, and conclude that the Changsha syllable also has a fixed structure of three segment slots.

2.1.8. Nanchang

Following are the initial and final inventories of Nanchang (Yuan 1960:128-9) (' = aspiration, Ø = zero onset)

(38)   Initials:

labial	p	p'	m	f			
coronal	t	t'	(n)	ts	ts'	s	l
palatal	tç	tç'	nʸ			ç	
dorsal	k	k'	ŋ				
glottal	Ø					h	

Finals:

z	a	o	E	ə	an	on	En	ən	at	ot	Et	ət
i	ia		iE				iEn	in			iEt	it
u	ua	uo			uan	uon	uEn	un	uat	uot	uEt	ut
ÿ		ÿo				ÿon		ÿn		ÿot		ÿy
	ai			əi								
	au		Eu	əu	aŋ	oŋ			ak	ok		
			iEu	iu	iaŋ	ioŋ		iuŋ	iak	iok		iuk
	uai		uEu	ui	uaŋ	uoŋ		uŋ		uok		uk
n	ŋ											

All the initials are again single consonants. The finals, too, are similar to those of Mandarin, where diphthongs do not occur in closed syllables. Following the same arguments, we again conclude that the Nanhang syllable has a fixed structure of three segment slots.

2.1.9. Summary

I have argued that Mandarin, Shanghai, Meixian (Moi-yan), Xiamen (Amoy), Fuzhou, Cantonese, Changsha and Nanchang have a uniform syllable structure of three segments, one for the onset and two for the rime. Since the languages represent all the eight major Chinese dialect families, it is reasonable to assume that all Chinese languages have this uniform syllable structure. While uniform syllabic structure has been reported for CV languages, to my knowledge no such claim has been made for a more complex syllable type. It is of some theoretical significance that, for the first time, not only one language, but a family of languages are shown to have one and the same syllabic structure. Our finding well reflects the cardinal role the syllable plays in Chinese phonology. Moreover, our finding has important consequences for several areas of phonological investigation, some of which are examined in section 2.3. Before then, let us look at further evidence that Chinese languages have a uniform syllable structure.

2.2. Suffixation and Rime Changes[26]

In this section we examine how the diminutive suffix causes changes in the rime of the root noun in five Chinese languages, Mandarin, Chengdu, Jiyuan, Yanggu and Heshun. Evidence will support the hypothesis that Chinese has a uniform syllable structure.

2.2.1. The Mandarin [r] Suffix

The Mandarin diminutive morpheme is a retroflex vowel, written here as [r]. It can be a monosyllabic word by itself, meaning 'child' or 'son'. When this morpheme is suffixed to a (monosyllabic) noun, it adds a diminutive meaning, and the root-suffix combination fuses into one syllable. The data are taken from Wang & He (1985), an experimental study with fifty young Beijing natives. However, I will write pre-nuclear [u i ü] as [w y ÿ] or [^{w} ^{y} ^{ÿ}] and vowels in open rimes as long. For example

(39)　a. /hua/-->[h^{w}a:]　　　'flower'
　　　b. /r/-->[Ør:]　　　　　'son'
　　　c. /hua+r/-->[h^{w}ar]　'flower'　　　　　(Ø = the zero onset)

[r] is not just added to the noun. When the noun has a coda, it is replaced

(40)　/pan+r/-->[par]　　　'dish'　　　　　　/pai+r/-->[par]　　　'plate'

The diminutive forms of [pan] and [pai], therefore, are identical. Our analysis gives the following derivations

(41)　a. /r/ -->[Ør:]　　　/|\　　/|\　　　　　(Ø = zero onset)
　　　　　'son'　　　　XXX → XXX
　　　　　　　　　　　　　　　| ∨
　　　　　　　　　　　r　　Ø r

　　　b. /hua/-->[h^{w}a:]　/|\　　/|\　　/hua+r/-->[h^{w}ar]　/|\　　/|\
　　　　　'flower'　　　XXX → XXX　'flower (dim)'　　XXX → XXX
　　　　　　　　　　　　　　| ∨　　　　　　　　　　　　| ∨　　||| |
　　　　　　　　　　　h u a　　h^w a　　　　　　　　h^w a r　　h^w a r

　　　c. /pan/-->[pan]　/|\　　/|\　　/pan+r/-->[par]　/|\　　/|\
　　　　　'dish'　　　XXX → XXX　'dish (dim)'　　XXX → XXX
　　　　　　　　　　　　　||| |　　　　　　　　　　　||| |　　|| \
　　　　　　　　　　　p a n　　p a n　　　　　　　　p a n r　　pa(n)r

---

[26]. Affixation processes in Chinese have just recently attracted much attention of linguists. For an excellent and extensive treatment, cf. Y. Lin (1989). My approach differs from hers in that she follows traditional analyses and assumes that Chinese languages have varying syllable types.

```
d. /pai/-->[pai]    / | \    / | \    /pai+r/-->[par]    / | \    / | \
   'plate'          XXX → XXX          'plate (dim)'      XXX → XXX
                     | | |                                 | | |   | | \
                    p a i    p a i                        p a i r  p a(i)r
```

In (41a), [r] has a syllabic template and becomes [Ør:]. When used as a suffix, [r] has no independent syllabic template, so it replaces the last segment of the root, which we assume is syllabified on the previous cycle. In addition, [r] surfaces as [+lo] after [a], [+hi] after [u] (cf.(47a)) and [-hi,-lo] otherwise, which we have not shown (nor do Wang & He). I assume that [r] is unspecified for height and assimilates in height to the nuclear V. When [r] occurs alone, as in (41a), it gets [-high,-low] as default values.

Spectral analysis also shows that the [r] coda adds a retroflex color to the nuclear vowel (Wang & He, 27), which, however, is not marked in traditional descriptions. We assume, following feature geometry, that the coronal node of [r] spreads to the nuclear vowel, as shown below

```
(42)   /ba+r/ --> [bar] 'handle' (Mandarin)        [bar] 'bar' (A. English)
       X X X                                       X X X
     ... | |                                     ... | |
        Rt Rt                                       Rt Rt
       ... ...                                     ... ...
        Pl Pl                                       Pl Pl
       | \ |                                        | |
       Dor Cor                                     Dor Cor
        | |                                         | |
      [+lo][-ant]                                 [+lo][-ant]
```

The Mandarin [bar] 'handle (dim.)' is different from the American English [bar] 'bar'. In the former, the nuclear vowel is retroflexed (shown by underline), via the spreading of the Coronal node from the coda to the nucleus. In the latter, there is no ==Coronal== spreading, so the nuclear vowel is not retroflexed.

Let us consider further cases

```
(43)   /gəŋ+r/-->[gə̃r]        'thick soup (dim.)'
       /gən+r/-->[gər]        'root (dim.)'
```

If the [r] suffix replaces the coda, we expect the diminutive forms of [gəŋ] and [gən] to be identical. However, the nuclear vowel is nasalized in 'thick soup (dim.)' but not in 'root (dim.)'. The difference may be attributed to the fact that, in unsuffixed forms, the nuclear vowel is nasalized before [ŋ] but not before [n], as shown below

```
(44)   /gəŋ/-->[gə̃ŋ]          'thick soup'
       /gən/-->[gən]          'root'
```

It is not clear, in current feature theories, why the nucleus is nasalized before [ŋ] but not before [n]. It is probably because in anticipation of the velar closure in [ŋ], the soft palate is lowered

earlier. In any case, this difference in nasality is kept in the diminutive forms.

Let us now look at more complicated cases. Consider the following (in Wang & He's notations)

(45)   a. /gou+r/-->[gour]   'hook (dim.)'
        b. /hu+r/-->[hur]   'lake (dim.)'
        c. /dau+r/-->[daur]   'knife (dim.)'

Here we expect the coda [u] in (45a, c) to be replaced, but in Wang & He's transcriptions it stays. This is unexpected, because in other cases so far, [r] replaces the coda, and because Mandarin diphthongs do not occur in closed syllables elsewhere. However, my own work with native Beijing speakers suggests that (45) should be transcribed as below

(46)   a. /gou+r/-->[gor^w]   'hook (dim.)'
                b. /hu+r/-->[hur^w]   'lake (dim.)'
                c. /dau+r/-->[dar^w]   'knife (dim.)'   (underline = retroflexion)

There is no diphthong before [r]; instead, the coda is a rounded [r]. In other words, what Wang & He transcribe as [-ur] in [daur] is in fact [-r^w].

We now must ask, where does the rounding on [r] come from? In (46a, b), it may come from the nuclear vowel. In (46c), however, the source is not so obvious: if the coda [u] is replaced in (46c), how can [r] acquire rounding? Here I will suggest that the rounding on [r] indeed comes from the replaced [u], i.e. the Labial node of the replaced [u] is reattached to [r]. The idea that floating elements may be reattached to nonfloating segments is not new. In tonology, for example, it is common knowledge that a floating tone (i.e. the Pitch node of a feature tree, as we will discuss in Chapter 3) from a deleted segment may be reattached to another segment.

We now give the derivations of (46b, c) below (in Sagey's 1986 notations)

(47)   a.   [h u:]+ r   [h u r]   [h u r^w]
              X X X   →   X X X   →   X X X
              | | | | | | | | |
              Rt Rt Rt Rt   Rt Rt Rt   Rt Rt Rt
              ... ∨ | ... | | ... | |
                  SL   SL   SL SL   SL SL
                  | | | | | |
                  Pl   Pl   Pl Pl   Pl   Pl─────┐
                  /\ | /\ | / |\ | │
                 Dor Lab Cor   Dor Lab Cor   Dor Lab Cor │
                                                         └───┴─────<─┘

b.   [d a u]+ r   [d a (u) r]   [d a (u) r]
    X X X   →   X X   X →   X X   X   →
     | | | | | | | | |
    Rt Rt Rt Rt   Rt Rt Rt Rt   Rt Rt Rt Rt
    ... ...
       | | | | | |
      Pl   Pl   Pl   Pl   Pl Pl
      /\ | /\ | /\ /\
   Dor Lab Cor   Dor Lab Cor   Dor **Lab** Cor

[d a r^W]   [d <u>a</u> r^W]   (underline = retroflexion)
 X X X   →   X X X
 | | | | | |
 Rt Rt Rt   Rt Rt Rt
 ... ...
    | | |
   Pl   Pl Pl
  /\   /\ /\
 Lab Cor   Dor Cor Lab
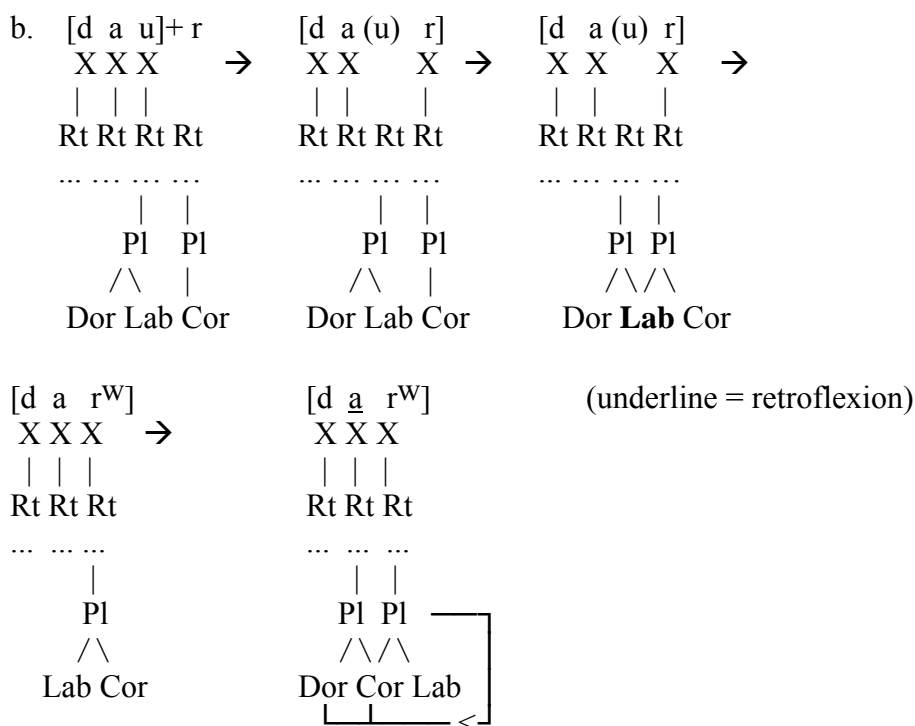
In (47a), after [r] is integrated into the coda, [u] spreads its Dorsal (with [+hi] undrawn) and Labial nodes to [r], while [r] spreads its Coronal to [u]. The geminate vowel [u:] is drawn with two Root nodes rather than one; for reasons cf. Selkirk (1988a) and Chapter 3. In (47b), [u] is first replaced, and then its Labial node is re-attached to the coda [r]; the rest of [u] is discarded. [a] does not acquire the Labial node from [u], as is independently seen in (45c), probably because [a] is [-round] in Mandarin. Finally, [r] spreads the Coronal node to [a], while [a] spreads its Dorsal node (with [+lo] undrawn) to [r].

The process in which elements in a replaced/floating segment is reattached to a nonfloating segment is crucial for the analysis of (46c). I will introduce the term 'feature recycling' to refer to this process. More specifically, I propose that feature recycling has the following four aspects

(48)   a.   Features and/or articulators in a floating/replaced segment may be reattached (i.e. recycled) to a nonfloating segment, without changing the existing features and articulators in the latter.
    b.   Which articulators/features to recycle is a language particular option.
    c.   Feature recycling observes the phonotactics of the language in question.
    d.   Feature recycling is local.

The purpose of (48d) is to prevent long distance recycling, e.g. the [+round] of a replaced coda [o] or [u] should not be recycled onto the onset.[27]

---

[27]. This is seen in the Fanqie language Mai-ka, where

    xou --> xai-kou --> xai-kou (*x^{W}ai-ka)
         ou x

It should also be noted that feature recycling adds features to a nonfloating segment but does not change its features. Therefore, feature recycling is different from multiple associations of two or more segments to one slot. Such multiple associations have been proposed by E. Pulleyblank (1984, 1986) and Chan (1985), as illustrated below

(49)   C   C   V   V   V   V
          /\   /\   /\   /\   /\   /|\
          k u   u k   i u   i a   u a   uai

          [k^W]   [k^W]   [ü]   [e]   [o]   [ö]

The multiply associated segments are 'unordered' and 'simultaneous' (Chan 1985:68-69, quoting E. Pulleyblank 1984). Thus, the two representations of [k^W] are identical. Similarly, for [ö], which is made up of three segments, there can be six identical representations. That two or more segments combine to give one is called the 'fusion process' (Chan 1985:78).

The purpose of (49) is to reduce the underlying inventory of consonants and vowels. However, this theory differs in significant ways from the theory of feature geometry. For example, Sagey (1986) argues that, in a feature tree (under an X slot) an articulator (e.g. Dorsal, Coronal, Labial) can appear at most once. In (49), however, under every slot (C or V), there are at least two Dorsal nodes.

Another characteristic of (49) is that multiply associated segments may contain contradictory features. For example, in the representation of [e], the segment [i] is [+high,-back], while [a] is [+low, +back]. If [i] and [a] are articulated 'simultaneously', what happens to the contradictory features? Chan (1985:78-79) stipulates some rules for the 'vowel fusion process', among them
> If the elements have different vowel heights such that one is [+high,-low] and the other is [-high, +low], the resultant vowel is [-high,-low].

> If one of the elements is ... [+front], the resultant vowel bears the plus feature assignment.

In other words, if vowels differ in height, we take the average height, yet if vowels differ in frontness, the front vowel wins.

My proposal of feature recycling differs from multiple associations in two ways. First, in my proposal, only one segment may be linked to an X slot, and in a segment, no articulator or feature may appear more than once. For example, if a nonfloating segment has a Labial node, it cannot receive another Labial from a floating segment. Second, feature recycling can only ADD features and nodes to a nonfloating segment, and does not CHANGE its features or nodes. For example, if a nonfloating segment is [+high], it cannot receive [+low] to become [-high,-low]. Similarly, if a nonfloating segment is [+back], it will not be overridden by a floating [-back].

After the syllable is reduplicated, the first rime is replaced with [ai] and the second onset with [k]. The floating vowels [ou] has [+round], but [+round] cannot attach to [a] nor to [i], since Mandarin does not have [O], nor permit [ü] in the coda. Neither can [+round] attach to the first onset [x] to create [x^W-], because recycling must be local.

It should have become clear that feature recycling is a formal and constrained notion. Indeed, the popular 'autosegmental' phenomenon that when a vowel is delete its tone may survive is probably a subcase of feature recycling: both the vowel and its tone stays floating, but for phonotactic reasons only the tone may be recycled. We will see more of feature recycling in section 2.2.3.

In summary, the diminutive suffix [r] in Mandarin replaces the coda of the root rime. Replaced segments, such as [u], may be recycled, subject to phonotactic constraints.

2.2.2. Chengdu

Like in Mandarin, the diminutive suffix in Chengdu is also [r]. In addition, [r] can be a monosyllabic word by itself, meaning 'child' or 'son'. Unlike in Mandarin, however, the [r] suffix in Chengdu replaces the both X slots in the rime, rather than just the coda. The tone remains that of the root noun.

(50)		Underlying	Mandarin	Chengdu	Gloss
	a.	/gən+r/	[gə̠r]	[gr:]	'root'
	b.	/gəŋ+r/	[gə̠̃r]	[gr:]	'thick soup'
	c.	/gau+r/	[ga̠rʷ]	[gr:]	'cake'
	d.	/gou+r/	[go̠rʷ]	[gr:]	'dog'

Since both the nucleus and the coda are replaced, many distinctions are lost in Chengdu. For example, (50a-d) remain distinct in Mandarin, but are neutralized Chengdu.

Unlike the nuclear vowel, pre-nuclear glides [i u ü] are not replaced in the diminutive form in Chengdu. This is seen below

(51)	a.	/bian+r/ →	[bʸr:]	'side'	cf.	/ban+r/-->[br:] 'class'
	b.	/guan+r/ →	[gʷr:]	'hall'	cf.	/gan+r/-->[gr:] 'stem'
	c.	/ia+r/ →	[ʸr:]	'bud'		
	d.	/uan+r/ →	[wr:]	'bowl'		
	e.	/üan+r/ →	[ÿr:]	'yard'		

This is further evidence that pre-nuclear glides are not in the rime but in the onset, as we argued in section 2.1.

2.2.3. Jiyuan

Jiyuan (He 1981, Y. Lin 1989b, 1990) has two diminutive suffixes. We look at one of them here. First, consider the patterns below[28]

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[28]. In He (p6, p11), [i] and [i?] change to [i:u]. It is not clear why He writes [i:u] rather than [iu], since there is no [iu] elsewhere for [i:u] to contrast with. I suggest that He wants to indicate that [i] is the nucleus rather than [u], therefore the length mark can be ignored.

(52)   Root Rime   Dim. Rime
        i, i?   iu
        u, u?   u[29]
        a, au, a?, e   O
        ia, iau, ia?, ie   iO
        ua, ua?, ue   uO
        üe, üa?   üO

        an   ã
        ian   iã
        uan   uã
        üan   üã
        aŋ   Õ

        iaŋ   iÕ

        uaŋ   uÕ

        üaŋ   üÕ

The patterns in (52) are not complete. Some cases were not found, and some have too few examples so that their reliability is in doubt, such as [l]-->[lou] (He, p11). I have only included the clear cases here. We want to find out what features the suffix has, and how it affects root rimes. We can see right away that pre-nuclear [i u ü] do not play a role, in line with our assumption that they are not in the rime; we will therefore ignore them. In addition, we will assume that vowels are long in open rimes, as argued in section 2.1. Moreover, [a] is [-back] before [n] in Jiyuan (He, p6); He does not mark it, but we will. After the above readjustments, we have the following patterns

(53)   Root Rime   Dim. Rime
        a.   i:, i?   iu
        b.   u:, u?   u:
        c.   a:, au, a?, e: O:
        d.   æn   æ:
        e.   aŋ   Õ:

I suggest that the suffix is a segment with the features [+back, +round], and this segment replaces the coda of the root rime, like the [r] suffix in Mandarin. The reason to consider the suffix a segment, rather than just two features [+back, +round], is that it replaces the coda [?] in (53a, b, c), [u] in (53c), [n] in (53d) and [ŋ] in (53e), instead of simply adding the features [+back, +round] to those codas. The derivations of (53a) and (53b) are clear; here, after the suffix takes over the coda slot, [i] in (53a) and [u] in (53b) spread [+hi] to the coda. We next look at [a:], [au] and [a?] in (53c). Since [a] is the only underlying low vowel, we assume that it is unspecified for [back]. When the suffix is added, its [+back] and [+round] are spread to [a], while [a] spreads [+low] to the coda, as shown below

---

[29]. He (1981) found no data showing changes in /u u?/. He suggests that their <mark>diminutive</mark> forms are the same as their root forms.

(54)   a.   [a:]+[+back, +round]-->[O:]

```
        Rime         →              Rime    →                    Rime
         /\                         /  \                          /\
        XX      X                  X    X                        X X
        \/      |                  |    |                        | |
        Rt      Rt                 Rt   Rt                       Rt Rt
        ...     ...                ...  ...                      ...  ...
        Pl      Pl                 Pl   Pl                       Pl  Pl
        |       /\                 |    /\                       /\/\
        Dor   Lab Dor              Dor Lab Dor                  Dor Lab Dor
        |       |                  |     |                      /\    /└─┐
      [+low] [+back]            [+low] [+back]              [+low] [+back]│
                                                                └────────┘
```

b.   [au]+[+back, +round]-->[O:]

```
        Rime        →               Rime     →                   Rime
         /\                         /  \                          /\
        X X  X                     X     X                        X X
        | |  |                     |     |                        | |
        Rt Rt Rt                   Rt    Rt                       Rt Rt
        ...  ...  ...              ...   ...                      ...  ...
        Pl      Pl                 Pl    Pl                       Pl  Pl
        |       /\                 |     /\                       /\/\
        Dor   Lab Dor              Dor Lab Dor                  Dor Lab Dor
        |       |                  |     |                      /\    /└─┐
      [+low] [+back]            [+low] [+back]              [+low] [+back]│
                                                                └────────┘
```

c.   [a?]+[+back, +round]-->[O:]

```
        Rime        →               Rime     →                   Rime
         /\                         /  \                          /\
        X X  X                     X     X                        X X
        | |  |                     |     |                        | |
        Rt Rt Rt                   Rt    Rt                       Rt Rt
        ...  ...  ...              ...   ...                      ...  ...
        Pl      Pl                 Pl    Pl                       Pl  Pl
        |       /\                 |     /\                       /\/\
        Dor   Lab Dor              Dor Lab Dor                  Dor Lab Dor
        |       |                  |     |                      /\    /└─┐
      [+low] [+back]            [+low] [+back]              [+low] [+back]│
                                                                └────────┘
```
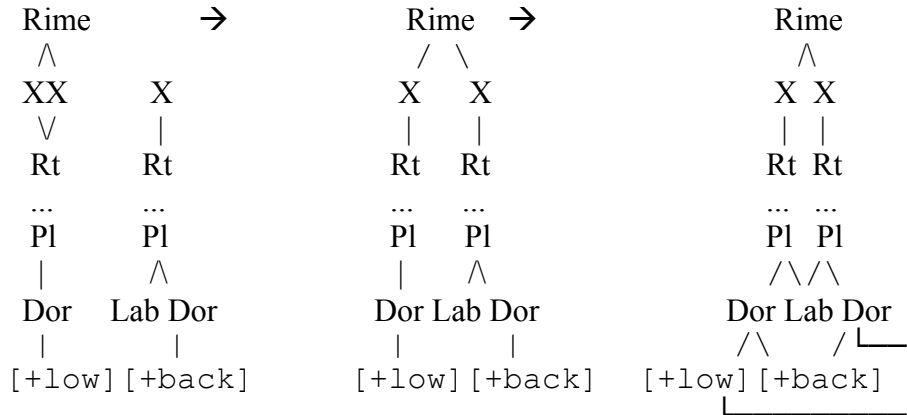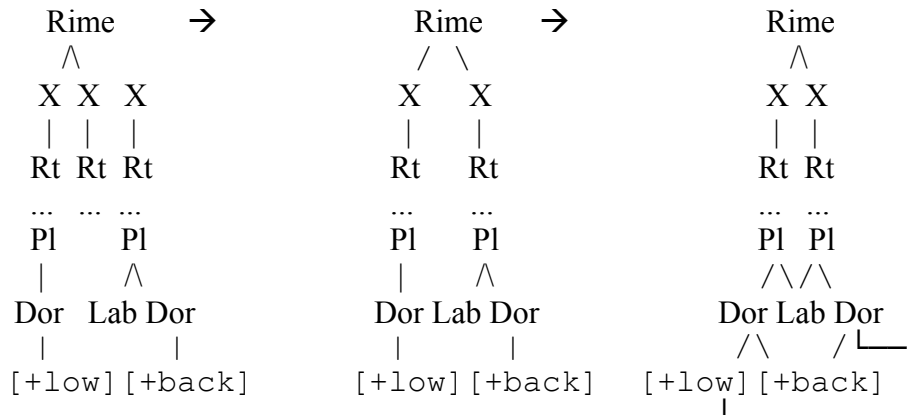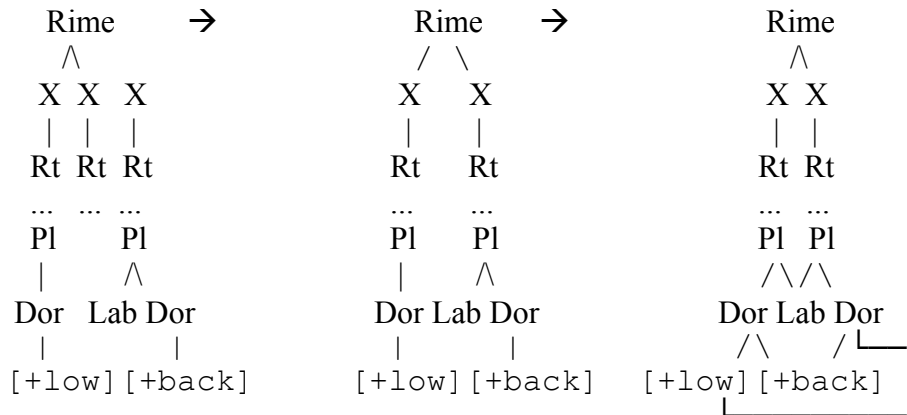
Note that, like in Mandarin, the suffix is not simply concatenated to the root syllable; if it were, (54b) would surface as [au]. Instead, the suffix first replaces the original coda, then its Labial node and [+back] spread to the nucleus [a], making the latter [O]. The nucleus [a] in turn spreads

[+low] to the coda, making the latter [O], too. The result is a geminate [O:]. In (54b, c), after the spreading between the nucleus and the coda, the features in the replaced [u ?] can no longer be recycled, and hence are not drawn. For example, the coda in (54b) acquires [+low] from the nucleus, so it cannot acquire the conflicting [+high] from the floating [u]. This shows that in filling unspecified features in the suffix, features from the nucleus are preferred to those from the replaced coda (cf. also (47b), where the new coda [r] gets the Dorsal node from the nucleus [a], not from the old coda [u]).

The derivations in (54) show a different representation of geminates. Geminates are usually represented as having two X slots but sharing all the other nodes (e.g. Clements 1985, Sagey 1986). In contrast, the geminate [O:] in (54) has separate feature trees down to the very lowest articulator level; this result goes even beyond the two-root theory of Selkirk (1988a). We will see in Chapter 3 that the fact that a geminate may have two root nodes has consequences for the notion of the tone bearing unit.

The derivation for (53e) [aŋ]-->[Õ:] is similar to (54b, c), as shown below

(55)   [aŋ]+[+back, +round]-->[Õ:]

```
        Rime        →        Rime        →            Rime
         /\                  / \                        /\
        X  X  X             X    X                     X  X
        |  |  |             |    |                      |  |
        Rt Rt Rt            Rt   Rt                    Rt  Rt
        ... ... ...         ...  ...                   ... ...
        Pl    Pl            Pl   Pl                    Pl  Pl
        |     /\            |    /\                    /\/\
        Dor  Lab Dor        Dor Lab Dor               Dor Lab Dor
         |       |           |       |                /\    / └──┐
        [+low] [+back]      [+low] [+back]           [+low] [+back]  │
                                                              └──────┘
```
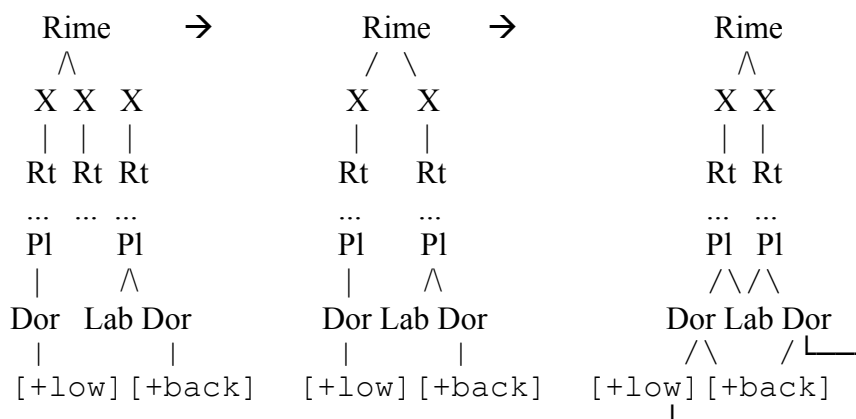
The nasality from the replaced [ŋ] will be recycled by an independent step, which for simplicity we have not drawn. Next consider [e:] in (53c). Since [e] is the only underlying mid vowel, we assume that it is unspecified for [back] or [low], but only as [-high], along the lines of Archangeli & Pulleyblank (1989) perhaps. The derivation is as follows

(56)   [e:]+[+back, +round]-->[O:]

```
     Rime         →            Rime    →              Rime
      /\                        / \                    /\
     XX      X                 X   X                  X X
     \/      |                 |   |                  | |
     Rt      Rt                Rt   Rt                Rt Rt
     ...     ...               ...   ...              ... ...
     Pl      Pl                Pl   Pl                Pl Pl
     |       /\                |     /\               /\/\
     Dor   Lab Dor             Dor Lab Dor           Dor Lab Dor
     |        |                 |      |              /\      /
   [-hi]  [+back]             [-hi] [+back]         [-hi] [+back]
```
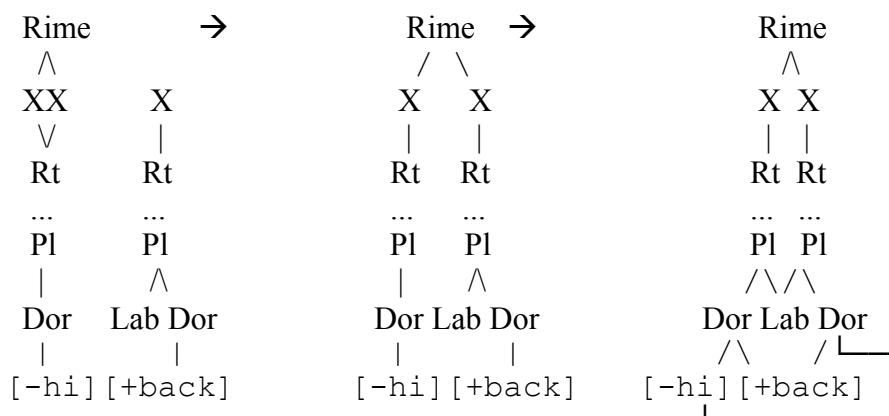
Since Jiyuan does not have [o], [-hi, +back] is specified as [+low]. We finally consider the derivation of (53d)

(57)   [æn]+[+bk, +rd]   [æ]+[+bk, +rd]   [æO]   [æ:]

```
     Rime      →            Rime      →            Rime     →            Rime
      /\                     / \                    /\                    /\
     X X  X                 X    X                 X   X                 X   X
     | |  |                 |    |                 |   |                 |   |
     Rt Rt Rt               Rt    Rt               Rt   Rt               Rt   Rt
     ... ... ...            ...   ...              ...  ...              ...  ...
     Pl   Pl               Pl   Pl                Pl   Pl               Pl   Pl
     |    /\               |     /\               |     /\              |    |
     Dor Lab Dor           Dor Lab Dor           Dor Lab Dor          Dor  Dor
      /\     |              /\     |              /\    /\             /\  /
   [-bk][+lo] [+bk]      [-bk][+lo] [+bk]      [-bk][+lo][+bk]       [-bk][+lo]
```
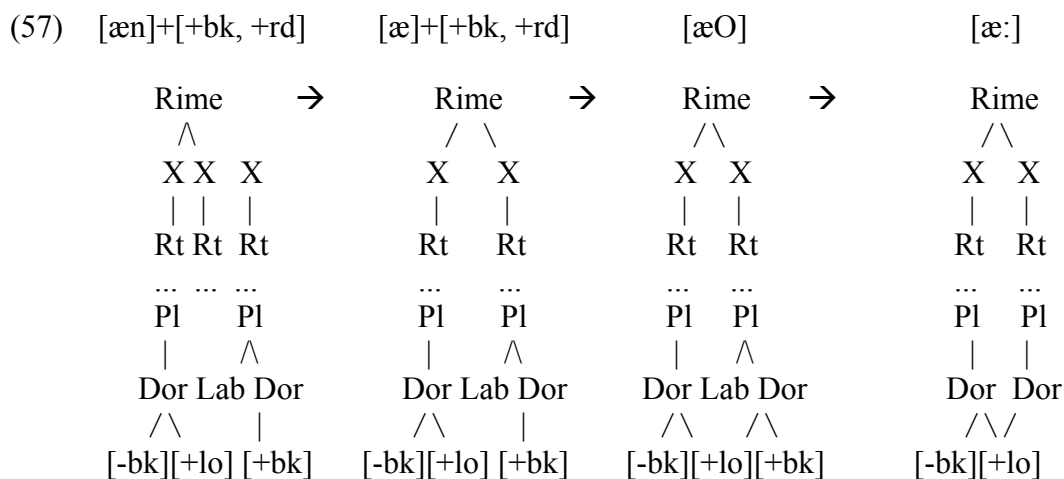
Since [æ] is [-back], it cannot receive [+back] from the suffix. In addition, since Jiyuan does not have [Ö], [æ] does not receive the Labial node from the coda. After [æ] spreads its [+low] to the coda, we have two low vowels [æO]. But, to my knowledge, no language has two low vowels in one syllable, so I will assume that [æO] as a rime is ruled out by universal phonetics. Consequently, [æO] is simplified to [æ:] instead.

The following patterns, in He's notations, cannot be easily accounted for in the present analysis

(58)   Root Rime   Dim. Rime
       a.   l   ləu
       b.   z   zəu
       c.   əi   i:u
       d.   ai   iO
       e.   uai   üO
       f.   ən, in   i:ŋ
       g.   ü, ün, un, ung, ü?   ü:ŋ

Some are clearly exceptions, such as [ü]-->[ü:ŋ] and [ü?]-->[ü:ŋ] in (58g). (58a, b) seem to be accountable, if the schwa is epenthetic; the same seems to be true of (58c). (58d, e) seem to show long distance feature recycling, where the replaced coda [i] appears as, or adds onto, the pre-nuclear glide. I leave them for future studies.

2.2.4. Yanggu (Dong 1985)

The diminutive suffix we look at is again [r]. But unlike in Mandarin, the processes here are more complicated. I will again write each rime as bimoraic. In addition, Dong uses two symbols for the suffix (basically, [l] if the nucleus is [i] or [ü], and [r] otherwise), but since the two symbols are in complementary distribution, I will just use [r]. Further, Dong does not mark retroflexion on the vowel, but given the facts of Mandarin, where the vowel before the [r] suffix is retroflexed but not marked in any analysis, I suspect that many vowels in Yanggu (a Mandarin dialect) are also retroflexed before [r]. My suspicion is shared by H.J. Wang (p.c., 1990), who has worked extensively on dialects in areas near Yanggu. Consequently, I will add retroflexion on vowels. Consider first the simple cases

(59)   Root Rimes   Dim. Rimes

        a.   ĩn, i: ir
        b.   z: r:
        c.   ũn, ü: ür
        d.   z̲:   r̲:

(60)   a.   a:, ãŋ   a̲r
        b.   uãn   u̲ær
        c.   E(æi), æ̃n   æ̲r
        d.   uɤ:, uɤi, uɤ̃n, uɤ̃ŋ   u̲ɤr
        e.   u: r̲ʷ:
        f.   au   a̲rʷ
        g.   ou   o̲rʷ
        h.   uE(uæi), uæ̃n   u̲Er
        i.   ɤ:, ɤi, ɤ̃n, ɤ̃ŋ   ɤ̲r
        j.   ua:, uãŋ   u̲ar   underline = retroflex

We see that, like in other dialects, the coda is replaced. Then the retroflection spreads across the whole rime. We see also that, unlike Jiyuan, Yanggu does not recycle nasality from replaced [n ŋ], but like Jiyaun, Yanggu does recycle [+round] from replaced [u], as in (60f, g).

Note that in (59a, c), retroflexion does not spread to [i ü], due to obvious phonetic incompatibility. Phonologically, however, this incompatibility is not easy to represent. The main question is whether [i ü], and other palatals, have a Coronal node (beside a Dorsal node), and if so, what features should it dominate (cf. Chomsky & Halle 1968, Sagey 1986, Mester & Ito 1989, L. Cheng 1989). Mester & Ito (p287) suggests that palatals have a Coronal node that dominates [-ant]. It seems to me, however, that Chinese [i ü] and palatals are [+ant], since the

tongue tip is in front of the alveolar ridge, not behind. If so, then their incompatibility of palatals with retroflexives is clear: the former are [+ant], and the latter are [-ant]. Next consider the following

(61)   Root Rimes   Dim. Rimes
     a.   a:, ãŋ   l<u>a</u>r
     b.   uãn   l<u>uæ</u>r
     c.   E(æi), æ̃n   l<u>æ</u>r
     d.   uɤ:, ũŋ   l<u>uɤ</u>r

     e.   u: lr^W:
     f.   au   l<u>a</u>r^W
     g.   ou   l<u>o</u>r^W

The root rimes in (61) are the same as those in (60), but in (61) there has appeared an [l] before the diminutive rimes. Dong (p273) says that forms in (61) occur with non-palatal, non-retroflex coronal onsets, namely [t d ts ds n s], while forms in (60) occur with retroflex or non-coronal onsets. For example

 (62)   a. /dau+r/-->[dlar^W]   'knife'
        b. /bau+r/-->[bar^W]   'bag'

The question is, what is the nature of [l] in (61)? And where does it come from? If it is a segment, then (62a) will contain an onset cluster. This goes against the fact that Chinese does not otherwise have onset clusters. However, [l] is unlikely to be an independent segment. The reason is that [l] occurs only with coronals like [d t] but not with non-coronals like [p b]; yet, as a cross-linguistic tendency, we would expect just the opposite. For example, English has [pl- bl-] but not [tl- dl-]. To understand [l], we recall that retroflexion from the suffix [r] spreads left over the entire rime. We also note that the [l] in (61) is retroflex in quality (Dong p276). It is clear then that [l] is simply the retroflex feature [-ant], which is spread from the suffix to the onset. This analysis offers a natural explanation of why [l] does not appear with non-coronal onsets, nor with retroflex coronals, nor with palatals. In non-coronals, there is no coronal node to which [-ant] can attach to. In retroflex coronals, there is already [-ant], so the spreading is vacuous. Finally, palatals are incompatible with retroflection, probably because the former are [+ant] and the latter is [-ant], as we discussed earlier. Thus, all the distributions are as predicted.

Finally, we consider the last set of patterns

(63)   Root Rimes   Dim. Rimes
     a.   ia:, iãŋ   i:l<u>a</u>r
     b.   iE(æi), iæ̃n   i:l<u>æ</u>r
     c.   ie, ieŋ   i:l<u>e</u>r
     d.   iau   i:l<u>a</u>r^W
     e.   iou   i:l<u>o</u>r^W
     e.   üɤ, üŋ   ü:l<u>ɤ</u>r
     f.   üãn   ü:l<u>æ</u>r

This set of sounds all have pre-nuclear [i] or [ü], and their diminutive forms have all become bisyllabic. The reason seems to be that the retroflex feature [-ant] attempts to spread over the entire syllable, as we saw in (62). But in (63) the spreading is blocked by [i ü], due to the incompatibility of [+ant] in [i ü] and [-ant] from [r]. This incompatibility seems to have split the syllable into two, and according to our uniform syllabic structure hypothesis, each syllable has developed into a bimoraic one.

In summary, the Yanggu retroflex suffix [r] replaces the coda of the root rime and then the feature [-ant] spreads over the entire syllable. If the spreading is blocked by a pre-nuclear front glide, the syllable breaks into two right after the glide. Our analysis makes it unnecessary to propose 'circumfixation' (Yip p.c., 1990) or 'suffixation plus infixation' (Y. Lin 1989b), both of which are rarely found in other Chinese dialects.

2.2.5. Heshun

The last language we consider is Heshun, which has a yet different diminutive suffix (Tian 1986). This suffix lengthens the root syllable. Consider the following, in Tian's notations

(64)   Root Rime   Dim. Rime
         a   aː
         ia   iːa
         ua   uːa
         uɤ   uːɤ
         i   iː
         u   uː
         ü   üː
         ai   aːi
         uai   uːai
         uei   uːei
         Ou   Oːu
         iOu   iːOu
         iŋ   iːŋ
         ueŋ   uːeŋ
         a?   aː
         ia?   iːa
         ua?   uːa
         ...

Tian does not say whether the diminutive forms are monosyllabic or bisyllabic. But it is clear from the transcriptions that many must be bisyllabic, such as [iːa], [uːai] and [iːOu]. In the absence of counter-evidence, I will assume that all diminutive forms are bisyllabic. In addition, Tian does not mark vowels as long in open rimes. In view of these consideration, (64) can be rewritten as follows

(65)   Root Rime   Dim. Rime
   a.   a: a:a:
   b.   ia   i:a:
   c.   uai   u:ai
        ...

I propose that the Heshun diminutive suffix consists of an empty syllabic template. For
illustration, we show the derivations of (65) below, where Ø = the zero onset.

(66)   a. /a/-->[Øa:Øa:]

    b. /ia/-->[yi:Øa:]

    c. /uai/-->[wu:_ai]
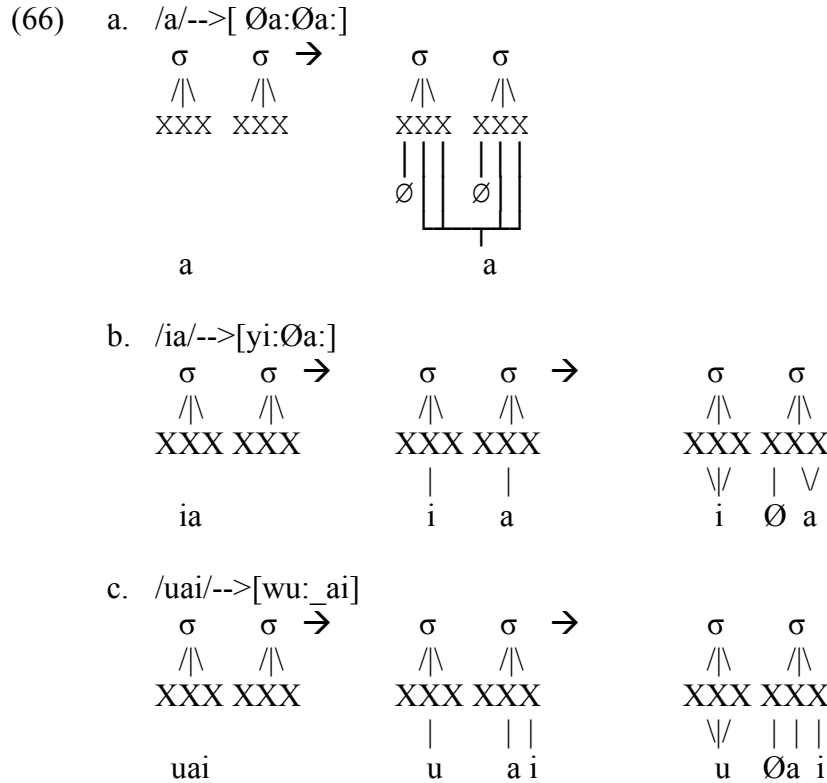
Unfortunately, Tian's paper is very brief (two and a half pages), therefore my analysis can only
be tentative. It would be very interesting to to find out how the tonal patterns change in the
diminutive forms. Tian (p372) says that the root tone remains 'basically unchanged' in the
diminutive forms. Exactly how this is done must be left for further studies.

2.2.6. Summary

Suffixation and rime changes are an intricate area in Chinese phonology. A preliminary survey
shows that our proposal that Chinese languages have a uniform syllabic structure accounts for a
wide range of suffixation phenomena. We have also seen that features recycling is a necessary
mechanism in accounting for nasality in Jiyuan and rounding in Mandarin. This mechanism will
also be seen in Fanqie languages, to which we now turn.

2.3. Language Games (Fanqie Languages)

The most popular Chinese language games are Fanqie languages. Basically, a Fanqie language first reduplicates a given syllable, then modifies the onset of one of them, and/or modifies the rime of the other. Following Chao (1931), which is the most detailed description of Fanqie languages, the output of the syllable ma 'mother' in a Fanqie language is used to be the name of that Fanqie language. Thus, Na-ma, Mai-ka and Mo-pa will change ma 'mother' respectively as follows

(67)   Language   Input   Reduplicate   Onset-change   Rime-change
        Na-ma: ma -->   ma-ma -->   na-ma -->   na-ma
        Mo-pa: ma -->   ma-ma -->   ma-pa -->   mo-pa
        Mai-ka: ma -->   ma-ma -->   ma-ka -->   mai-ka

In Na-ma, only the first onset is changed. In Mo-pa and Mai-ka, the first rime and the second onset are changed.

A major problem in analyzing Fanqie languages lies in the treatment of the pre-nuclear G. According to Chao (1931:353), pre-nuclear G has three kinds of behavior; it may belong to the initial, or to the final, or to both, as shown below (following the original transcriptions)

(68)   Na-ma: tuei --> nei-tuei   'correct'   (Liu 1944:74)
(69)   Mo-pa: liã --> lo-tiã   'two'   (Chao 1931:338)
(70)   Mai-ka: xuei --> xuai-kuei   'return'   (Chao 1931:324)

In Na-ma, the pre-nuclear [u] 'belongs to the initial', i.e. [u] and the initial [t] form a unit, which is replaced together by [n] in the first syllable. In Mo-pa, the pre-nuclear [i] 'belongs to the final', i.e. [i] and [ã] forms a unit, which is replaced together by [o] in the first syllable, and which stays together in the second syllable. In Mai-ka, the pre-nuclear [u] 'belongs to both the initial and the final', i.e. it stays with the initial [x] in the first syllable, and it stays with the final [ei] in the second syllable.

The different behaviors of the pre-nuclear G is accountable if we make the assumptions that the pre-nuclear G may (sometimes) be an independent segment and that Chinese languages (both base languages and Fanqie languages) may differ in their syllable structures, especially w.r.t. the position of the pre-nuclear G (for details, cf. Yip 1982 and Bao 1990b).

Such assumptions, however, are not available in my analysis. This is because I am claiming that all Chinese languages have a uniform syllabic structure, and that all pre-nuclear G's are in the onset (either the secondary articulation of the initial cosonant, or the onset itself, if there is no initial consonant). Moreover, if all Chinese languages have a uniform syllabic structure, it is natural to assume that all Fanqie languages do, too. Therefore, I must account for the three behaviors of the pre-nuclear G from a fresh perspective. I will now show that, with the notion of feature recycling (cf. section 2.2), such an account is not only possible but in several ways superior to previous ones. I take Na-ma, Mai-ka and Mo-pa in turn.

2.3.1. Na-ma

The Na-ma case, in which the pre-nuclear G 'belongs to the initial', is in favor of our claim that pre-nuclear G is part of the onset. In section 2.1.1.2 we gave the following analysis (in Liu's transcriptions)

(71)   a.   Reduplicate the syllable.
       b.   Replace the first onset with [n]

(72)   tuei --> tuei-tuei --> nei-tuei   'correct'

In step two, both [t] and [u] are replaced in the first syllable, suggesting that [tu] forms the onset unit, in agreement with our view that [tu] is [t^W].

However, one must ask why feature recycling does not place in (72). If it does, we should see the following

(73)   t^{W}ei -->   t^{W}ei-t^{W}ei --> n(t^W)ei-t^{W}ei -->   *n^{W}ei-t^{W}ei
                                       X   X
                                       | |
                                      Rt Rt   Rt
                                       | | |
                                      SL SL   SL
                                      ∧ | ∧
                                      SP Pl Pl   SP Pl
                                        /∖/∖   /∖
                                      Cor Lab Cor   Cor Lab

Since Na-ma permits secondary articulations [^{W} ^{y} ^{ÿ}], once [t^W] is replaced, we expect its Labial node to be recycled to the new onset [n], creating [n^W], as shown above. This, however, does not happen. There are two possible explanations. First, feature recycling does not happen in Na-ma. Second, feature recycling is an automatic process, but Na-ma has an additional rule to simplify the first onset. I will assume the second explanation for three reasons, first, it is a stronger claim, second, feature recycling takes place in both Mai-ka and Mo-pa, and third, there is more evidence of onset simplification in Mo-pa, to be seen shortly. Let us then revise the rules for Na-ma as follows

(74)   Na-ma Rules:
       a.   Reduplicate the syllable.
       b.   Replace the first onset with [n]
       c.   Simplify the first onset (i.e. delete the minor articulator).

Since feature recycling is assumed to be an automatic process, i.e. applying whenever possible, it is not written in the rules. It should be noted that, even with (74c), the Na-ma syllable has the same uniform structure as we proposed for all Chinese languages, i.e. one onset slot and two rime slots, and that the pre-nuclear G, if present, is in the onset.

2.3.2. Mai-ka

In Mai-ka, based on Mandarin, the pre-nuclear G 'belongs to both the initial and the final'. Superficially then it is not clear where the pre-nuclear G belongs. I suggest that it has the following analysis

(75)   Mai-ka Rules:
        a.   Reduplicate the syllable.
        b.   Replace the first rime with [ai].
        c.   Replace the second onset with [k].

All the three rules are regular Fanqie rules, i.e. reduplication, onset modification, and rime modification. Let us see how they interact with feature recycling to give the correct results. Consider the derivations for [ma] 'mother' and [x^wei] 'return'

(76)   ma x^wei
        (75a):   ma-ma x^wei-x^wei
        (75b):   m(a)ai-ma x^w(ei)ai-x^wei
        (75c):   m(a)ai-k(m)a x^w(ei)ai-k(x^w)ei
        FR :   mai-ka x^wai-k^wei   (FR = feature recycling)

Floating (i.e. replaced) segments are shown in brackets. We first consider whether floating vowels can be recycled. In the word <u>ma</u>, the floating vowel is [a], which has the node Dorsal and the features [+low]. Dorsal cannot be recycled, since the new vowels [ai] both have Dorsal already; [+low] cannot be recycled, either, since the new [a] already has [+low], and the new [i] has [+high], which is in conflict with [+low]. Therefore, nothing from the floating [a] can be recycled. Following the same reasoning, nothing can be recycled from the floating [ei] in the word <u>x^wei</u>.

We next consider floating consonants. Like its source Mandarin, Mai-ka allows three secondary articulations [^{w} ^{y} ^{ÿ}]; this means that only two features may be recycled, [+round] under Labial and [-back] under Dorsal. Now in <u>ma</u>, the floating [m] has neither [+round] nor [-back], so it is discarded. In <u>x^wei</u>, however, we can recycle [+round], with its Labial node, from the floating [x^w].

It is interesting to consider <u>wan</u> 'curved', which we expect to become [wai-k^wan]. However, the real output is [vai-kan]. The difference is explained by an additional Mandarin rule u-->v/#__, i.e. initial /u/ becomes labio-dental /v/ (Chao 1931:322), and we assume (like Chao) that this rules is carried over to Mai-ka. The derivation now becomes

(77) uan --> van --> van-van --> v(an)ai-van --> v(an)ai-k(v)an --> vai-kan

As before, [an] has nothing to recycle (Mandarin does not have nasalized vowels). In addition, the floating /v/ no longer has [+round], so we get [vai-kan] as expected.

2.3.3. Mo-pa

Let us now consider Mo-pa, based on Kunshan. Here the pre-nuclear G 'belongs to the rime'. I suggest the following rules

(78)   Mo-pa Rules:
    a.   Reduplicate the syllable.
    b.   Replace the first rime with [o].
    c.   Switch the value of [cont] of the second onset, and [α cont] --> [α voice].
    d.   Simplify the first onset (i.e. delete the minor articulator).

The first three rules are again regular Fanqie rules (reduplication, onset modification, and rime modification), similar to those in Mai-ka.[30] The last is similar to that in Na-ma, and will be further justified immediately. The derivation of (69), liã-->lo-tiã, is as below, where FR = feature recycling.

(79)   (78a)   (78b)   (78c)   FR   (78d)
        l^{y}ã ----> l^{y}ã-l^{y}ã ---> l^y (ã)o-l^{y}ã ---> l^y (ã)o-t^{y}ã ---> l^{y}o-t^{y}ã   ----> lo-t^{y}ã

Let us see what can be recycled. The first syllable produces a floating [ã], which has [+nasal] and [+low]. [+nasal] cannot be recycled by the new rime [o], since Mo-pa does not have [õ] (Chao 1931:335-339); [+low] cannot be recycled either, since [o] is [-low]. So nothing in [ã] is recyclable. In the second syllable, the onset is modified, not replaced. So there is no floating item to recycle. In particular, the pre-nuclear G stays unaffected in the second onset as a minor articulator, since the onset modification only switches the value of [cont]. The result [l^{y}o-t^{y}ã] further undergoes (78d), whereby the minor articulator of the first onset is deleted, giving the final output [lo-t^{y}ã].

In previous analyses of Mo-pa (based on Kunshan), and similar Fanqie languages such as La-pi (based on Taiwanese), the pre-nuclear G is assumed to be in the rime (Chao 1931, P. Lin 1985, Bao 1990b). This approach gives a simpler analysis of the pre-nuclear glide in words like l^{y}ã or liã 'two'. Take Bao's (1990b:346) analysis for example

(80)   Mo-pa Rules:
    a.   Reduplicate the syllable.
    b.   Replace the first rime with [o].
    c.   Switch the value of [cont] of the second onset, and [α cont] --> [α voice].

      (80a)   (80b)   (80c)
(81)   liã ----> liã-liã ----> lo-liã ----> lo-tiã

Compared with my analysis (78), (80) is simpler in two ways. First, there is no assumption of feature recycling. Second, there is no assumption of onset simplification. On the other hand, (80) assumes, without independent evidence, that Mo-pa (and its source Kunshan) has a different

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[30]. The second onset has additional modifications that need not concern us here. In addition, Mo-pa treats [l] as [+cont], not [-cont. For our purpose, it suffices to note that [l] changes to [t] in the second onset.

syllabic structure from languages like Mandarin and Chengdu, while (78) assumes that all Chinese languages (base or Fanqie) have the same syllabic structure. We already saw in section 2.2. that feature recycling is independently motivated. The crucial difference between (78) and (80), then, lies in whether there is onset simplification and whether the pre-nuclear G in Kunshan is in the rime.

To choose between the two theories, we want to find a case where they make different predictions. Such a case is found in the GV syllable. In our analysis, the pre-nuclear G is in the onset, and since it is a simple onset, onset simplification does not apply, so G should appear in the first output syllable. In the analysis of (80), G is in the rime, and so it should be replaced with V in the first syllable by [o]. Moreover, in our analysis, G (being an onset) should switch [cont] and [voice] in the second syllable, while in the analysis of (80), G (being in the rime) should not be changed in the second syllable. Take [iO] 'want' for example, the two theories predict different derivations, shown in (82), where [o] is [-low] and [O] is [+low].

(82)		G IN THE ONSET	G IN THE RIME
	Input:	iO	iO
	Reduplicate:	iO-iO	iO-iO
	Replace first rime:	i(O)o-iO	o-iO
	Change second onset:	i(O)o-tçO	o-iO
	Feature recycling:	io-tçO	---
	Onset simplification:	---	---
	Output:	io-tçO	o-iO

(83)   iO --> io-tçO   'want'   (Chao 1931:336)

In our analysis, the floating [O] in the first syllable cannot be recycled. In addition, [i] becomes [tç] in the second syllable after switching [cont] and [voice]. In the analysis of (80), [i] should disappear in the first syllable and remains unchanged in the second. (83) shows that our is correct.[31]

Our analysis of Mo-pa should apply to La-pi, which is based on Taiwanese. As mentioned earlier, Bao (1990b) and P. Lin (1985) assume that, since in La-pi the pre-nuclear G 'belongs to the rime', its source language should have the same property, too. We have shown that, in Mo-pa, where the pre-nuclear G has been thought to 'belong to the rime', it is actually in the onset. I also predict that in La-pi, G in GV syllables is also in the onset. Unfortunately, in P. Lin (1985), the source of La-pi, there is no data on GV or GVC syllables (such as [ua ue ue? ...]). Therefore, I have to leave the prediction open.

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[31]. Bao (1990b:345) has cited one GV syllable from Chao (1931:338)
        jI --> jo-tçi (where [j] = [y])   'have'
But Bao does not see it (not other GV syllables) as a problem for his analysis, probably due to an oversight. Note that Chao uses [j] (=[y]) and [i] alternately for the pre-nuclear palatal glide, probably for tonal reasons.

2.3.4. Summary

I have shown that, with the independently motivated notions of feature recycling and onset simplification, we can account for all Fanqie languages in a consistent way, employing just the three standard Fanqie rules, reduplication, onset modification, and rime modification, without assuming different syllabic structures for either base or Fanqie languages. Moreover, our analysis makes correct predictions about the GV syllables in Mo-pa, where other analyses fail. The successful treatment of Fanqie languages confirms of our claim that all Chinese languages have a uniform syllabic structure in given (1).

2.4. Cooccurrence Restrictions on Labials

It has been widely noted that many Chinese languages have cooccurrence restrictions (CR) on labial sounds. This issue is of interest to us not only because it has direct implications for the phonological theory (the OCP, the V/C segregation, the definitions of adjacency, the status of secondary articulation in feature geometry, etc., cf. McCarthy 1986, 1989a; Mester 1986; Selkirk 1988b; Yip 1989b; Y. Lin 1989a; L. Cheng 1989; Fu 1990), but also because it has been used as evidence for the view that Chinese languages differ from one another with regard to syllabic structures (Y. Lin 1989a, b, Fu 1990). In this section I will offer an analysis of the labial CR in three Chinese languages, Mandarin, Cantonese and Taiwanese, and show that there is no compelling evidence that these languages have different syllabic structures.

Before we proceed, it should be borne in mind that no analysis of Chinese labial CR is likely to be conclusive. This is because some key aspects in labial CR remain open. I will give three examples, the difference between a CR and a gap, the difference between primary and secondary articulations, and the difference between a Labial node dominating [+round] and a Labial node alone.

First, consider the distinction between a CR and a gap. A CR refers to a systematic lack of distribution, while a gap refers to an accidental lack of distribution. The native speaker normally has the intuition to tell a gap from a restriction. Gaps are potential syllables, which may be invented at any time and accepted immediately. Restrictions, on the other hand, hold even for invented syllables. In English, for example, both [frot] and [fraum] are lacking; [frot] is a gap, while [fraum] is due to a restriction.

In Chinese, however, the case is less clear. The native speaker normally does not have a clear intuition about whether a missing syllable type is an accidental gap or due to a restriction. For example, Mandarin has for labial consonants [b p m f]; [b] does not cooccur with [ou], but [p m f] do (*[bou], [pou] 'dissect', [mou] 'stratagem', [fou] 'float'). The lack of [bou] is clearly a gap, but [bou] hardly sounds like a possible syllable to the native speaker. Similarly, Mandarin has four tones (1, 2, 3 and 4), but the syllable [bian] occurs with just three ([bian1] 'side', *[bian2], [bian3] 'flat', [bian4] 'change'). The lack of [bian2] is again clearly a gap, but again [bian2] hardly sounds like a possible Mandarin syllable. It is not clear why CRs and gaps are less distinct in Chinese; it is probably due to the fact that Chinese has a highly restricted inventory of syllables. Mandarin has about 400 syllables (excluding tonal contrasts and the [r] suffix; 1300 if tonal contrasts are included); the size is comparable in other dialects. This is a very small inventory in view of the fact that Mandarin has about twenty consonants, that most of the consonants may in addition be labialized and/or palatalized, and that Chinese allows three segments in a

syllable. As a result, every speaker is fully familiar with the totality of actual syllables, and any syllable outside the totality is immediately recognized as alien.

To look for real CR, then, we must look for systematic lack of distributions, instead of relying on native intuition. But what is systematic is not easy to tell, either. For example, consider the Mandarin cases below

(84)   *biou *piou miou   'false' *fiou

Labials do not occur with [iou], except [m]. Are the majority cases gaps or is [miou] an exception? Similarly, all Mandarin syllables of the form (C)iVi are bad (where C is any consonant and V any vowel), except the single word [iai] 'cliff'. Hockett (1947), Fudge (1968:267) and Fu (1990:13) consider this word an exception and suggest a CR *[iVi]. It could be true that [iai] is dropping out of use (becoming [ia] or [ai]), but how much value should we place on the CR *[iVi]? It may be an emerging CR, or it may be the case that Mandarin speakers want to phase out a rare pattern. In addition, even if [iVi] were completely absent in Mandarin, one may perhaps still consider it a gap, or an uninteresting idiosyncrasy, if [iVi] occurs in other dialects. Finally, consider another set of Mandarin examples

(85)   ?bia   *biang   bian 'change'   bie 'hold back'
        ?pia   *piang   pian 'cheat'   pie 'skim'
        *mia   *miang   mian 'cotton'   mie 'extinguish'
        *fia   *fiang   *fian   *fie

[bia] and [pia] appears only as onomatopoeias. Is the lack of distribution in the first two columns systematic? In a sense it is, because there is no exception. But in another sense it is not, because there is no theoretical motivation to differentiate the first two columns from the last two. Systematicness, therefore, must also be theory internal, so is CR. We do not want to suggest that Mandarin has a CR against [bia] and [biang], because [ia] and [iang] do not form a natural class in contrast to [ian] and [ie].

Let us turn to the difference between primary and secondary articulations. According to Sagey (1986), the place node of the primary articulation is the 'major articulator', to which a 'pointer' is directed; the place node of a secondary articulation is the 'minor articulator', which receives no pointer. Halle (1989:8) further proposes that, as a principle, every sound must have a major articulator; if there is just one articulator, it is the major one, and receives the pointer. In contrast, according to Mester (1986) and Selkirk (1988b), there is no pointer in the feature tree; instead, the place node of a secondary articulation is dominated by the place node of the primary articulation. In other words, in Sagey's framework, all labial nodes, major or minor, lie on the same tier, while in the framework of Mester and Selkirk, primary and secondary place nodes do not lie on the same tier. This is shown below

(86)   Sagey: ┌─   Rt   Rt ─┐   Mester & Selkirk: Rt   Rt
                 │   │   │   │   │   │
                 │   Pl   Pl │   Dor   Lab
                 │   /\   │   │   │
                 └─>Dor Lab   Lab<─┘   Lab
                     [kʷ]   [p]   [kʷ]   [p]
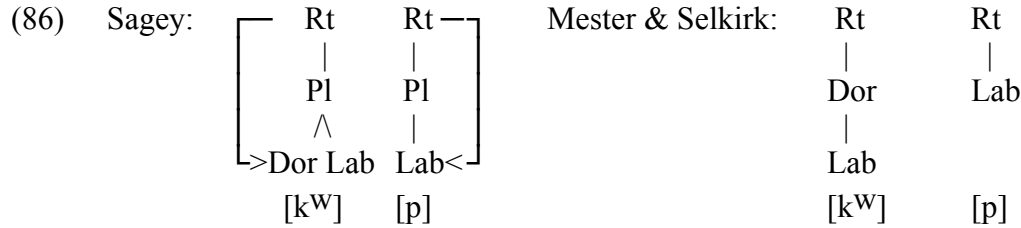
Conceptually, Sagey's representation has an articulatory interpretation. In contrast, the domination of one articulator over another in the representation of Mester abd Selkirk appears to be a pure formalism. We will, not focus on aesthetic judgement. Now, in many cases, the labial CR is sensitive to whether an articulator is primary or secondary, as we will see below. In the framework of Mester and Selkirk, the difference is natural: the primary and the secondary articulators do not lie on the same tier. In the framework of Sagey, on the other hand, something else has to be said.

Finally, we consider the representation of labiality. If labiality is 'privative (Steriade 1987), we may represent labials with a bare Labial node and non-labials without it. We may, however, also represent some labials with a bare Labial node, and some with a Labial node dominating [+round]. This mechanism will enable us to differentiate labials that behave differently w.r.t. CR. For example, Y. Lin (1989a) suggests that all labial consonants have a bare Labial node, while all labial vowels have a Labial node dominating [+round]. So far, however, there is no generally accepted representation.

Bearing the above uncertainties in mind, let us look at the labial CR in Chinese and attempt a solution.

2.4.1. Mandarin

Relevant distributions of Mandarin labials are given below (following the transcription of Chao 1968)[32]

(87)   a.   bi 'pen'   pi 'skin'   mi 'rice'   *fi
       b.   bu 'cloth'   pu 'shop'   mu 'female'   fu 'rich'
       c.   *bü   *pü   *mü   *fü
       d.   *bua   *pua   *mua   *fua
       e.   buo 'wave'   puo 'slope'   muo 'touch'   fuo 'Buddha'
       f.   *guau   *kuau   *duau   *tuau   *uau
       g.   bau 'wrap'   pau 'run'   mau 'cat'   fou 'float

---

[32]. The set [buo puo muo fuo] is usually transcribed as [bo po mo fo], but as Chao (1968:30) points out, 'the actual pronunciation is still buo, puo, and so on'. This is seen by contrasting cognates in Mandarin and Chengdu

   Mandarin: bʷo   pʷo   mʷo
   Chengdu: bo   po   mo
              'wave'   'slope'   'touch'
where the pronunciations are different.

First, since (87a, b) are good, we will consider (87c) a gap. (87b, g) show that [b p m f] may cooccur with [u], while (87f) shows that [u] cannot cooccur with [u]. Leaving (87d, e) for the moment, let us see how [b p m f] differ from [u]. Three possible approaches come to mind. First, [b p m f] are primary labials, while [u] is primary dorsal and secondary labial (Fu 1990, L. Cheng 1989). Second, [b p m f] are consonants, while [u] a vowel (Y. Lin 1989a). Third, [b p m f] are unspecified for [round], while [u] is (Y. Lin 1990).

Both Fu and L. Cheng suggest that [b p m f] and [u] differ in whether their Labial node is primary. Following Mester (1986) and Selkirk (1988b), Fu assumes that the Labial node in [u] is dominated by the primary articulator Dorsal, so that it lies on a different tier from the Labial node in [b p m f]

(88)   [b p m f]:   Rt   [u]: Rt
                        | |
                       Lab   Dor
                                             |
                                            Lab
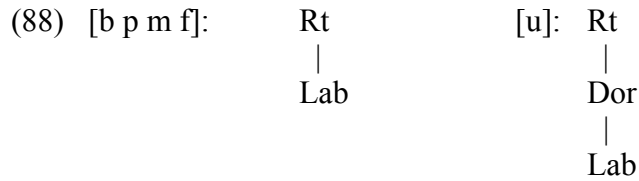
This approach may account for the contrast between (87b, g) v. (87f), but cannot account for the contrast between (87d) and (87e).

I will suggest here that underlyingly all labials have a bare Labial node, unspecified for [round], and that there is a redundancy rule

(89)   ...   --->   ...   (where Lab is not primary)
         | |
        Lab   Lab
                               |
                            [+round]
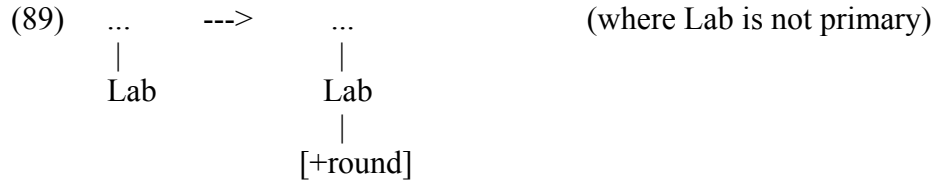
In addition, I suggest that the Mandarin labial CR be *[+round...[+round], instead of *Labial...Labial. This directly accounts for the badness of (87f), where both the pre-nuclear glide and the coda are [+roud], and the goodness of (87b, g), where the labial onsets are not [+round].

Let us turn to (87d, e). Let us also write the pre-nuclear [u] as [ᵂ] (cf. our discussion in section 2.1), as shown below

(90)   a.   *bᵂa   *pᵂa   *mᵂa   *fᵂa
        b.   bᵂo 'wave'   pᵂo 'slope'   mᵂo 'touch'   fᵂo 'Buddha'

I suggest that Mandarin has the following restriction

(91)   *   ... ─┐
                | │
               Lab   │
                | │
            [+round]<┘
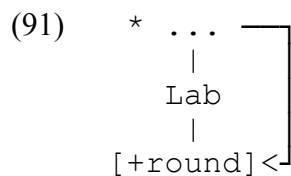
That is, primary Labials cannot be [+round]. This will exclude (87d) = (90a). For (90b), recall
that Mandarin [o] is underlyingly [ə] (schwa), whose rounding comes from the spreading of
Labial from a neighbouring segments (cf. C. Cheng 1973). The derivation of /bə/-->[bᵂo] is
given below (for convenience, we have not shown the open vowel as long)

(92)   [b   ə]   -->   [b   ??]   -->   [bᵂ   o]
         ┌─ Rt   Rt─┐   ┌─ Rt   Rt─┐   ┌─ Rt Rt─┐
         │ ...   ... │   │ ...   ... │   │ ... ... │
         │ Pl   Pl │   │ Pl   Pl │   │ Pl   Pl │
         │ | | │   │ | / | │   │ | / | │
         └─>Lab Dor<─┘   └─>Lab Dor<─┘   └─>Lab Dor<─┘
                                                                    |
                                                                [+round]
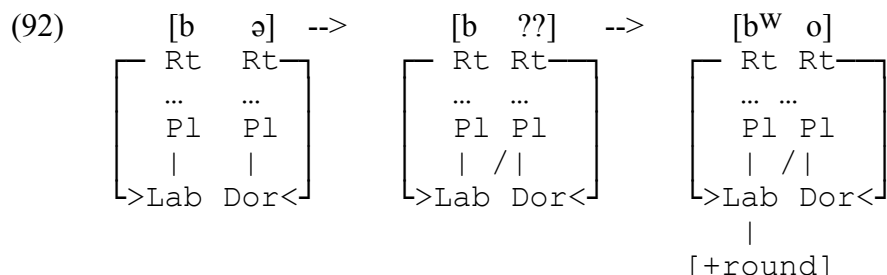
The Labial node of [b] first spreads to [ə]. Now this Labial node is both the major articulator for
[b] and the minor articulator for [o], and so neither (89) nor ((91)) applies. Our prediction here,
then, is that the Labial may or may not become [+round]. This prediction is correct. For many
Mandarin speakers (type A), the Labial node does become [+round], and for other Mandarin
speakers (type B), it does not, as the following shows

(93)   Underlying: /bə/   /pə/   /mə/   /fə/   /ə/
       Type A: [bᵂo]   [pᵂo]   [mᵂo]   [fᵂo]   [ɤ]

       Type B: [bɤ]   [pɤ]   [mɤ]   [fɤ]   [ɤ]
       Gloss: wave   slope   touch   Buddha   goose

The default value for /ə/ is the unrounded mid back vowel [ɤ], as seen in [ɤ] 'goose'. For type B
speakers, the Labial node does not become [+rd], so the /ə/ after [b p m f] does not become [o]
but becomes the default [ɤ]. Note that it is not the case that Type B speakers never have [o], as
the following shows

(94)   Underlying: /uə/   /duə/   /guə/   /gəu/
       Type A: [wo]   [dʷo]   [gʷo]   [gou]
       Type B: [wo](*[wɤ])   [dʷo](*[dʷɤ])   [gʷo](*[gʷɤ])   [gou](*[gɤo])
       Gloss: I   many   state   dog

This is what we predict: when a Labial is secondary, it automatically becomes [+round]. This
happens in [dᵂ] and [gᵂ]. It also happens in [w] and [u], which we need not distinguish
(although we used different transcriptions).

To my knowledge, no previous analysis has succeeded in accounting for all of (87a-g) and (93).
We have done so by assuming that pre-nuclear G is part of the onset.

2.4.2. Cantonese

Relevant patterns for the labial CR in Cantonese are given below (Kao 1971, Cheung 1986, Yip 1989b, L. Cheng 1989)

(95)   a. pam 'pump'   pip 'beep'   mam 'food' (babby talk)
        b. *bim   *pap   *mip   *fap   ...

(96)   a. po 'old lady'   mo 'slow'   fo 'goods'   fu 'rich'
        b. *pü   *pö   *mü   *mö   *fü   *fö

(97)   a. *up *op *um *om   *uw *ow *üp *öp *üm *öm *üw *üw
        b. p'aw 'run' pam 'pump' pip 'beep'   mam 'food' (babby talk)
        c. *waw   *kʷaw   *wam   *kʷam   *wip   *kʷip
        d. wo 'and'   kʷo 'fruit'   kʷong 'light'   kʷok 'country'

As seen in (95), labial consonants sometimes cooccur and sometimes do not. In fact, most such syllables do not occur; the few that do occur are mostly (all?) loan words, onomatopoeias, and baby talk. Nevertheless, we will consider all of (95) possible, and those in (95b) as gaps.[33] This is because in some patterns, such as (97a, c), even loan words, onomatopoeias, and baby talk do not occur. Similarly, in (96a) we see that labial consonants may occur with round vowels, and so we will again consider (96b) as gaps. There is evidence for this view (Yip 1989b, citing Cheung 1986: 242-243)

(98)   p'ey yu: --> p'ü   'for example'
        pat yü   --> pü   'it'd be better'

In contracted speech, [p'ü] and [pü] do occur, showing that these are possible syllables.

The real problem, then, is to explain (97). The difference between (97b, c) may be attributed to whether the Labial node is primary or secondary, to which we will come back shortly. (97a) shows a nucleus-coda CR. (97c) show a onset-coda CR. (97d), however, shows a lack of onset-nucleus CR. As Yip (1989b) notes, this asymmetry is puzzling. Structurally, the nucleus-coda relation is closest, the onset-nucleus relation farther, and the onset-coda relation the fartherest. If CR holds for the closest and the fartherest relations, why not for the intermediate relation? Here I suggest that (97a) is a gap. There are two reasons. First, as Yip (1989b) notes, Cantonese mid vowels have limited distributions; not only are [*om *op ...] missing, but [*em *ep et ...] are also missing. So the lack of (97a) cannot be attributed to labial CR alone. Second, Taiwanese has [Om] 'fill up' and [kOp] 'throw down' (Lu, 12, 17), which suggest that a labial CR on nucleus-coda cannot be general. I will therefore, only consider (97b, c, d).

Before I offer my analysis, it is necessary to consider some independent differences between [p t k m n ŋ] onsets and [p t k m n ŋ] codas in Chinese. It is well known that Chinese [p t k] codas (as contrast to post nucleus [p t k] in English) have several special properties. First, they are

---

[33]. *[fap] is probably an exception. L. Cheng (p3) cites proposals that [f] is underlyingly [xʷ]. If so, [f] should pattern with [kʷ].

glottalized. Second, they are unreleased. Third, as I will argue in Chapter 3, they are tone bearing, even if the tone they carry is not heard. Finally, they alternate with or have become the glottal stop [?] in many dialects. These properties show that Chinese [p t k] codas have a Laryngeal node, which dominates [+c.g.]. I suggest, in addition, that it is the Laryngeal node that is the primary articulator in Chinese [p t k] codas, not the Labial, Coronal or Dorsal respectively. Similarly, Chinese [m n ŋ] codas also have some independent properties, too. In many Chinese dialects [m n ŋ] codas alternate with or have merged to pure nasality. In addition, as Hashimoto (1973:95) notes of Meixian

> ([m n ŋ] onsets) are the so-called "croissant", with strong off-glides, and are a kind os explosive, while ([m n ŋ] codas) are "decroissant" sounds, with on-glides and no off-glides, and are "aplosives."

I suggest that Chinese [m n ŋ] codas are primary Soft-Palate, and secondary Labial, Coronal and Dordal respectively. The featural differences between Chinese [p t k m n ŋ] onsets and codas are shown below (in Sagey's 1986 notations)

(99)   a.   In Onsets:

```
         p          t          k          m          n          ŋ
        . . .⌐      . . .⌐     . . .⌐      . . .⌐     . . .⌐      . . .⌐
         |   |       |   |      |   |      / \  |     / \  |      / \  |
        Lab<⌐      Cor<⌐      Dor<⌐      SL Lab<⌐   SL Cor<⌐    SL Dor<⌐
```

        b.   In Codas:

```
          p           t           k          m           n           ŋ
      ⌐ . . .      ⌐ . . .     ⌐ . . .     ⌐ . . .     ⌐ . . .     ⌐ . . .
      |   / \      |   / \     |   / \     |   / \     |   / \     |   / \
      L->Lar Lab   L->Lar Cor  L->Lar Dor  L->Lar Lab  L->Lar Cor  L->Lar Dor
          |            |           |
       [+c.g.]      [+c.g.]     [+c.g.]
```
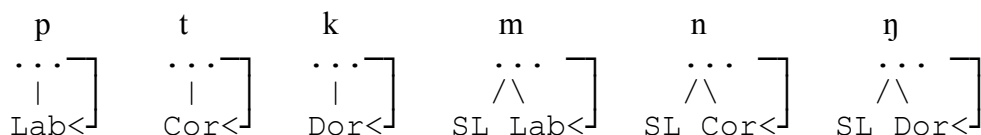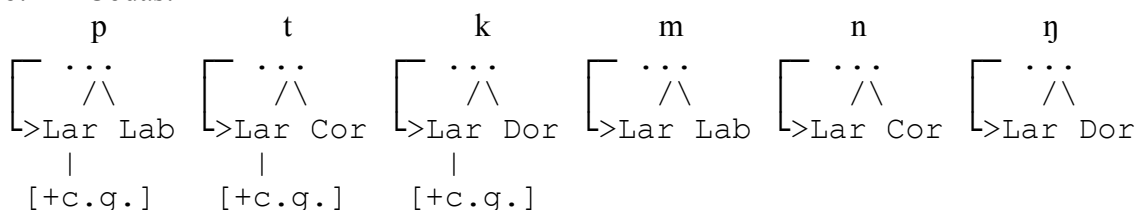
The proposal of (99c) is entirely new, and so some comment is in order. First, the major articulators in [p t k] are shown to be Laryngeal. However, Halle (1989:8) suggests a principle

> The major articulator of a consonantal speech sound is one of the PLACE articulators.

The conflict between (99b) and Halle's constraint is only apparent, however. What are traditionally written as [p t k] (or [b d g] in Hashimoto 1973) are in fact [?^{p} ?^{t} ?^{k}] (or [?^{b} ?^{d} ?^{g}]), with the feature trees in (99b), where Laryngeal is the major articulator and Labial, Coronal and Dorsal the minor articulators. These sounds, therefore, are [-cons] and not [+cons], in agreement with Halle's principle. The widely observed coda change [p t k]-->[?] is the deletion of the minor articulator. Moreover,

Similarly, in (99b), the major articulators of [m n ŋ] codas are all Soft-Palate; Labial, Coronal and Corsal are minor articulators. In the theory of Trigo (1988), a sound with the Soft-Palate as the major articulator is called a 'nasal glide'. In (99b), [m n ŋ] will all be nasal glides, even though each has a minor articulator. The widely observed coda change [m n ŋ]-->[˜] is the

deletion of the minor articulator, parallel to [p t k]-->[ʔ].[34]

Having justified (99b), let us now account for (97). I suggest that, like in Mandarin, Cantonese has the rule by which a secondary Labial becomes [+round] while a primary Labial does not. In addition, Cantonese is subject to *[+round]-[+round]. In (97b), the Labial node of the codas are secondary, and so [+round], but the Labial nodes of the onsets are primary, and so not specified for [+round]. Thus, there is no violation of *[+round]-[+round]. (97c), on the other hand, the Labial nodes in the onsets [w kᵂ] and the codas [w p m] are both secondary, so they are all [+round], violating the CR *[+round]-[+round]. Finally, in (97d), the Labial nodes in [w kᵂ o] are all secondary and hence [+round]. Thus, these words should be bad. What happens here, I suggest, is that the Labial of the onset and that of the nucleus have merged to one, so that there is no more violation of *[+round]-[+round].[35] Note that the Labial merger cannot take place in (97b, c) without changing [a] to [+round], due to feature percolation.

L. Cheng (1989) assumes that all labials have a bare Labial node, and she has to propose three labial CRs for Cantonese (p20)

(100) a.   onset-coda: *labial-labial
       b.   onset-nucleus: *labial-[front round vowels]
       c.   nucleus-coda: *[round vowels]-labial

In addition, L. Cheng has to assume, without independent evidence, that the primary articulators in [kᵂ ü ö] are all Labial (instead of Dorsal, as is customarily assumed). Moreover, L. Cheng cannot exclude the pattern [wVw] (where V is any vowel), which is a major offending pattern (L. Cheng, p24).[36]

2.4.3. Taiwanese

Although there are dialects of Taiwanese (Southern Min), what we discuss below should be fairly general properties of them. Relevant patterns for the labial CR are given below (Luo 1956, Lu 1977, Zhang 1983, Y. Lin 1989a, pre-nuclear glides are written as [u])

(101) a.   Om 'fill up'   kOp 'throw down'   (Lu, 12, 17)
               *um   *up   *op   *om   *ou   ...

       b. Labial consonant onsets cooccur with round vowels:
               bo 'hat' pio 'watch'   p'un 'basin'   ...
               pau 'wrap' bau 'trade' biau 'seedling' ...

---

[34]. If [m n ŋ] codas, as nasal glides with a minor articulator, are [-cons], then every segment in the rime is [-cons]. The notion mora may then be seen as a [-cons] segment in the rime.

[35]. Cantonese mid and high vowels have very limited distributions. I leave it open whether Cantonese has underlying [o], or whether [o] is derived from a mid vowel by acquiring Labial from a neighboring segment as in Mandarin.

[36]. L. Cheng (p.c.) notes that of the three syllables [wVp], [wVm] and [wVw], none of which occurs, the last sounds worst.

    c. Labial consonant onsets cooccur with pre-nuclear [u]:
         pue 'cup'   bue 'buy'   p'ua 'broken'   ...
         (cf. pe 'fly', be 'sister', p'a 'pat', ...)

    d. Labial consonant onsets do not cooccur with [p m] codas:
         *pim   *pam   *pap   *bip   *bem   ...

    e. Pre-nuclear [u] does not cooccur with coda [u]:
         *uok   *uau   *kuau ...

    f. Pre-nuclear [u] does not cooccur with [p m] codas:
         *uam   *kuam   *uap   *huap
         (cf. uan 'aid', kuan 'observe', uat 'get over', huat 'punish', ...)

    g. Pre-nuclear [u] does not cooccur with round nbuclear vowels:
         *kuo   *uo
         (cf. ue 'shoe', ue? 'narrow',   kue 'chicken', ...)

Y. Lin considers there to be a CR on a labial vowel and a labial coda, but as we see in (101a), some such syllables do occur, so this pattern must be possible. (101b, e, f) may again be accounted for along the lines we suggested for Mandarin and Cantonese. Specifically, we assume that a Labial is unspecified for [+round], but will be filled with [+round] by (89) if the node is secondary (i.e. a minor articulator). In addition, we assume that [p m] are primary Labial in the onset, but secondary Labial in the coda. More evidence for the last assumption comes from the observation of Luo (1956:16)

    In the coda, [-p], [-t] and [-k] end at closure; there is merely a gesture without sound, and we cannot hear the release. Therefore they are not real 'plosives' but 'imlposives'... In colloquial speech, most [-m], [-n] and [-ŋ] codas tend to become nasalization [~], whereas most [-p], [-t] and [-ŋ] codas tend to become a glottal stop [?].

Further, we assumes that there is the CR *[+round]-[+round].

In (101b), only the codas will be specified for [+round] by (89), but the onsets will not; so all words are good. In (101e, f), the Labial node in the pre-nuclear [u] is secondary, hence [+round], and the labial vowels and codas will also be [+round], hence all words are bad.

(101c) should be good whether the pre-nuclear [u] is a segment or not. If it is, it is secondary Labial and hence [+round], but the onset [p b p'] are not specified for [+round], so there is no CR violation. On the other hand, if [pu- bu- p'u-] are double articulations, i.e. [p^w b^w p'^{w}] as I claim, there is no CR violation, either. (101c) simply shows that, unlike Mandarin, Taiwanese permits both rounded and unrounded labials (e.g. [p-] v. [p^w-]), a property that is common in many languages. The contrast between [p p^w] can be represented below

(102)   [p]   ... ⌐   [pʷ]   ... ⌐
                │   ]   │   ]
               Lab<⌐   Lab<⌐
                                                 │
                                              [+round]
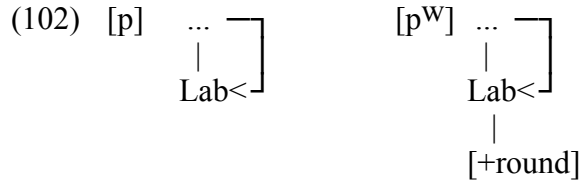
Recall that we have suggested (89), which assigns [+round] to a bare secondary Labial. The fact that a primary Labial may be underlyingly specified for [+round] does not affect (89).

We now look at (101d). Recall that this pattern is also rare in Cantonese, but we have considered it a gap, since a few examples are found. Is it possible that (101d) is also a gap in Taiwanese? I have found no direct evidence. However, there is indirect evidence. Consider

(103)   a.   huat mng --> huap mng 'grow angry'   (Luo, 17)
        b.   bet bOng --> bep bOng 'die out'   (Lu, 25)

[huat] and [bet] become [huap] and [bep] before a labial. It is not clear whether it is generally true that assimilation processes are subject to CRs. There is, however, evidence that at lease some phonological process is subject to CR (Yip 1989b). I will, therefore, tentatively consider (101d) as a gap. This completes all patterns in (101).

Finally, we look at (101e). [*kuo *uo] should be bad, since [u] and [o] are both [+round]. However, they should be good if the two Labial nodes in [u] and [o] merge to one, as we proposed for Cantonese. Why does this not happen in Taiwanese? Is node merger optional when faced with CR? I have no good answer here, and have to leave it open.

It should be borne in mind that the above analysis is only preliminary, and that there are many unsolved issues. We will mention two of them. First, consider

(104)   Om 'fill up'   (Lu, 12)
        kOp 'throw down'   (Lu, 17)

(105)   kut bOng --> kup bOng 'dig grave'   (Lu, 25)

The words in (104) appear in colloquial speech only, and do not have written forms. Similarly, [kut] becomes [kup] before a labial. We have used these words to argue that (101a) is a good pattern. In many descriptions of Taiwanese, however, these words are not cited. If we ignore them (as Y. Lin 1989a does), then our analysis of the labial CR will be quite different. Moreover, similar revisions probably have to be made to our analysis of Cantonese.

The second open issue is that there are many other distributional gaps. Consider the following inventory of Taiwanese finals (i.e. pre-nuclear glides plus rime, from Zhang, omitting syllabic nasals and nasalized vowels)

(106)

	i	a	ua	ia	e	ue	ui	O	o	io	u
m	im	am		iam							
n	in	an	uan	ian							un
ŋ	iŋ	aŋ		iaŋ				Oŋ		iOŋ	
i		ai	uai								
u	iu	au		iau							
p	ip	ap		iap							
t	it	at	uat	iat							ut
k	ik	ak		iak				Ok		iOk	
?	i?	a?	ua?	ia?	e?	ue?	ui?		o?	io?	u?

The leftmost column shows possible codas. It is striking that apart from [i a], all other vowels have highly defective distributions with codas. We clearly have not determined the underlying vowels, and so any analysis of CRs must remain open.

Y. Lin (1989a) suggests that round vowels, including [u] (whether it is before, in, or after the nucleus), are [+round], and that round consonants, whether in the onset or coda, have just a bare Labial node without [+round]. She also considers (101a) a gap (without mentioning the good [Om kOp]). In addition, she proposes the following rules

(107) For the syllable:
         a. *Lab Lab   b.   *Lab Lab
                                       | |
                               [+round] [+round]

(108) For the Rime:
         a. *Lab Lab   b.   *Lab Lab   c. *Lab Lab
                                      | | |
                              [+round] [+round]   [+round]

Two CRs apply to the syllable, while one more applies to the rime. Assuming that the pre-nuclear [u] is in the rime, Y. Lin is able to account for all patterns in (101). However, as L. Cheng (p16) points out, Y. Lin's analysis has the defect that the same two rules are stated twice, in (107a, b) and (108a, b). Thus, a syllable like *[kuau] is ruled out twice, once by (108b), and again by (107b). This apparently is a weakness. In contrast, we have assumed just one CR *[+round]-[+round], and have maintained that the pre-nuclear [u] is in the rime.

2.4.4. Summary

I have given an analysis of the labial CR in Mandarin, Cantonese and Taiwanese. I have suggested that, for all three dialects, a bare Labial node will become [+round] if it is a minor articulator (cf. (89)), and that there is one labial CR *[+round]-[+round], instead of several (cf. L. Cheng 1979, Y. Lin 1989a, b, Fu 1990). I have shown, I hope, that as far as facts are clear, my analysis not only achieves at least comparable results as Yip (1989b), Y. Lin (1989a, b), L. Cheng (1989) and Fu (1990), but also accounts for a range of independent properties of [p t k m n ŋ] codas. Finally, I have shown that the pre-nuclear glide is always in the onset, and that there is no compelling evidence to analyze it otherwise.

2.5. Some Theoretical Implications

In this section we discuss the implication of our analysis of the Chinese syllable for two phonological theories, the V/C segregation of McCarthy (1989a), and the moraic theory of the syllable (Hyman 1984, 1985; Hayes 1989). I show that although Chinese has a rigid syllabic structure, there is no evidence of V/C segregation, unlike what Yip (1989b) and L. Cheng (1989) suggest. McCarthy's (1989a) prediction, therefore, needs to be refined. I also show that the obligatory onset in Chinese languages presents a problem for the moraic theory in which the onset has no independent status.

2.5.1. V/C Segregation

McCarthy (1989a) suggests that if the morphemes of a language have fixed 'templatic' structures, or 'sufficiently restrictive root structure constraints', then underlyingly consonants and vowels in this language must lie in separate planes. This is termed V/C segregation. For example, the Arabic word <u>samam</u> 'poisoned' underlyingly consists of a vowel /a/ and two consonants /sm/, together with the template CVCVC

```
(109)  a.     *C V C V C                  b.        a
              |  \ X /                              /\
                s   a m                         C V C V C
                                               |     \ /
                                                s     m
```
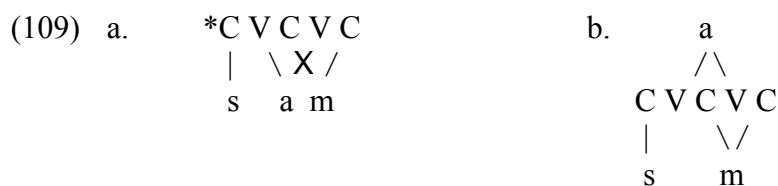
With the given template, to get the right output, we only need to know the ordering among consonants, and that among vowels, but not that between consonants and vowels. Moreover, not only is the ordering between consonants and vowels redundant, but their segregation is necessary; if they lie in the same plane, as in (109a), we get line crossings, violating a fundamental constraint in phonology (McCarthy (1989a, 73)).

Chinese morphemes/syllables have fixed structures, as we have argued, so there should be V/C segregation; indeed, L. Cheng (1989) and Yip (1989b) suggests that Cantonese has V/C segregation. I will show below, however, that, given a set of consonants and a separate set of vowels, we cannot predict the syllable in a simple way.

McCarthy (1989a) uses a CV template in place of syllabic structures. We have used an X tier and no CV template. It is not clear how the two systems can be translated into each other. Consider the following Mandarin syllables

```
(110)   [m::]         [na:]        [nan]        [?an]        [?e:]
        'Uh-huh'      'hold'       'south'      'peace'      'goose'


(111)   CCC           CVV          CVC          VVC          VVV
```

In our analysis, all the syllables have the same structure (cf. (1)); in a CV analysis, there are different templates, as in (111) (assuming [?] is [-cons]; cf. Chomsky & Halle (1968)). Of

course, it is in principle possible that Mandarin syllables have several templates. The problem is that such templates are predictable from the given segments. For example, given /m/, the structure must be [m::] or CCC, given /di/ it must be [di:] or CVV, and given /dan/ it must be [dan] or CVC. This renders the CV template utterly superfluous. It is not the CV template that dictates the way segments are organized; rather it is the segments that dictate what the CV template should be.

If instead the Mandarin syllable simply translates into CVV, where glides in onsets (as in [ya:]) are considered consonants and consonants can link to V (as in [m::] and [nan]), we can derive all syllables similar to the way we discussed in section 2.1.1.5:

(112)   a.   Link the most sonorant segment to the first V.
        b.   Link other segments.
        c.   Spread the segment under first V to the second V.
        d.   If C is empty and if the segment under first V is [+high] or [+cons], spread the segment under first V to the C.
        e.   Specify the zero onset (cf. section 2.1.1.1).

(113)   a.   /i/ → [yi:]   CVV (112a) CVV (112c) CVV (112d) CVV
             'one'   → | → |/   →   \|/
                              i   i   i   i

        b.   /m/ → [m::]   CVV (112a) CVV (112c) CVV (112d) CVV
             'Uh-huh'   → | → |/   →   \|/
                              m   m   m   m

        c.   /e/ → [Øe:]   CVV (112a) CVV (112c) CVV (112e) CVV
             'goose'   → | → |/   → | |/
                              e   e   e   Ø e

        d.   /an/ → [Øan]   CVV (112a) CVV (112b) CVV (112e) CVV
             'peace'   → | → | | → | | |
                              an   a n   a n   Øa n

        e.   /na/ → [na:]   CVV (112a) CVV (112b) CVV (112c) CVV
             'hold'   → | → |/   → | |/
                              na   n a   n a   n a

        f.   /nan/ → [nan]   CVV (112a) CVV (112b) CVV
             'south'   → | → | | |
                              nan   nan   n a n

This CVV is identical to our XXX syllable, with V being the nucleus, C to the right of V the coda, and C to the left of V the onset.

So far we have not assumed V/C segregation. Let us see whether the CVV analysis works when we do. It is easy to see that the answer is no. Consider the words /an/-->[Øan], /na/-->[na:] and

/nan/-->[nan] in (113d-f). Assume, as McCarthy (1989a) does, the Obligatory Contour Principle, which forbids identical segments in sequence (e.g. */nn/). The three words will then have the same representations {a, n, [CVV]}.[37] There is no way to derive three different structures.

One may attempt two ways to solve this problem. First, one may posit a featureless segment /[]/, so that /an/ is {a, []n, CVV}, /na/ is {a, n[], CVV} and /nan/ is {a, n, CVV}. But we have shown in section 2.1.1.1 that this is untenable. In particular, /[]/ never contrasts with segmentlessness. We never find, for example, a contrast between /[]e[]/ = {e, [], CVV} and /e/ = {e, , CVV}. Moreover, in the V/C segregation theory, every segment must lie either on the C tier or the V tier, and one has to make an arbitary decision as to which tier /[]/ should lie on. The second way is to posit [ŋ] as the zero onset, and derive other variations of the zero onset by rules, as suggested in L. Cheung (1986) and Yip (1989b). In this analysis, /an/ is {a, ŋ n, CVV} and /na/ is {a, n, CVV}. Yet /nan/ is also {a, n, CVV}, which cannot be distinguished from /na/. In addition, positing /ŋ/ for the zero onset has several problems in itself, as I have argued in section 2.1.1.1. There is no explanation, for example, why /ŋ/ never occurs before glides, whereas /m n/ do. Secondly, there is no explanation why the historical zero onset, had it been /ŋ/, has so many variations in different dialects, while the historical /n m/ have relatively few. Third, in languages like Mandarin, there is no simple rule to derive other variants of the zero onset, such as /H ?/, from /ŋ/. In view of the above problems, I will consider both solutions inadequate. And I will conclude that the /an/-/na/-/nan/ paradigm presents a genuine problem for the assumption that Chinese has V/C segregation.

The fact that Chinese lacks V/C segregation need not mean that McCarthy's (1989a) generalization is wrong. There is an important difference between Arabic and Chinese languages. In the former, syllabic templates carry morphological information. In the latter there is just one uniform template; no morphological information is carried by the syllabic structure (cf. however, the marginal case of Heshun in section 2.2.5). V/C segregation, therefore, may depend on two conditions: whether a language has rigid templates, as McCarthy (1989a) proposes, and whether the templates carry morphological information.[38] Why the latter condition is needed, however, remains open.

2.5.2. The Moraic Theory

There is strong evidence that the mora plays an important role in phonology (Hyman 1984, 1985, McCarthy & Prince 1989, Halle & Vergnaud 1987, Halle 1990, etc.). It is not very clear, however, what the exact relation is between the mora and the syllable. In particular, it is not clear whether the mora is the only constituent in a syllable, or whether notions like onset, rime, nucleus, etc., are still needed. In this section I discuss the moraic theory of Hayes (1989). To a large extent, Hayes' theory resembles that of Hyman (1984, 1985). A central assumption in their analyses is that the onset has no independent dominating node (it either is directly dominated by the syllable node, or shares a dominating mora node with the nuclear vowel). I will show, however, that in their analyses, there is no simple way to represent an obligatory onset position. Let us take Hayes's theory for illustration.

---

[37]. We follow McCarthy's (1989) notation whereby in {A, B, [C]}, A is the vowel sequence, B the consonant sequence, and C the template.

[38]. Thanks to an anonymous reader for suggesting the second condition.

Hayes argues that syllabic theories based on the X tier or the CV template--the 'X theories'--should be replaced by a moraic theory. The latter is more constrained in that it has no such nodes as onset and rime, nor the X or CV tier, as shown below for /pai/

```
(114)   σ                σ              σ          σ =syllable
        ∧               /|\            /|\         O=onset
       O  R             CVV           | μ μ        R=rime
       |  ∧             | | |         | | |        μ=mora
       XXX              p a i         p a i
       | | |
       p a i
```
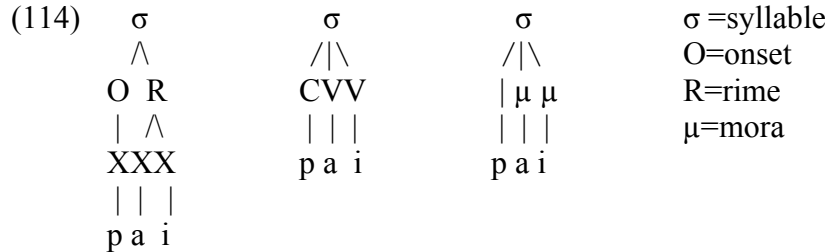
Hayes' argument is based on compensatory lengthening. But first let us look at the issue from a different angle, the problem of fixed syllable structures.

Consider Mandarin and Semitic languages, where syllabic templates are independen of segments. In the X theory, the X tier or the CV template serves as a place holder to which segments may attach. In the moraic thery, onset segments are linked to the _ node directly, while rime segments are linked to the _ node via mora nodes. Thus there are place holders (moras) for rime segments, but nothing for onset segments. X theories can distinguish fixed CV and V syllables (CV and V templates), but the moraic theory cannot

```
(115)   σ  σ            σ    σ            σ      *σ
        ∧  |            ∧    |            |      /|
       OR  R           CV    V            μ      μ
       | | |
       XX X
```
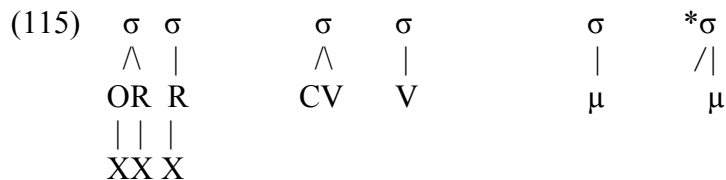
In languages that have an obligatory onset, V usually becomes CV (F. Dell p.c., 1990). In X theories, this is easy to represent

```
(116)   σ  →  σ
        ∧      ∧
       OR     OR
       | |    | |
       XX     XX
        |     | |
        V     CV
```
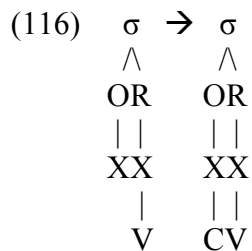
The onset position triggers C-insertion. C may also depend on the properties of V, e.g. [i]-->[yi] and [a]-->[?a]. In the moraic theory, nothing can trigger such processes

(117)   σ
        |
        μ
        |
        V
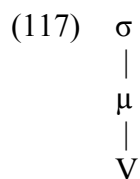
One may propose a rule for the obligatory onset, to extend a link from the σ node to the segment under the μ node

(118)   σ →   ⌐ σ   σ →   ⌐ σ   σ   σ
        | | | | | | | = [y] | = [?]
        μ | μ   μ | μ   i   a
        | | | | | |
        i   └> i   a   └> a
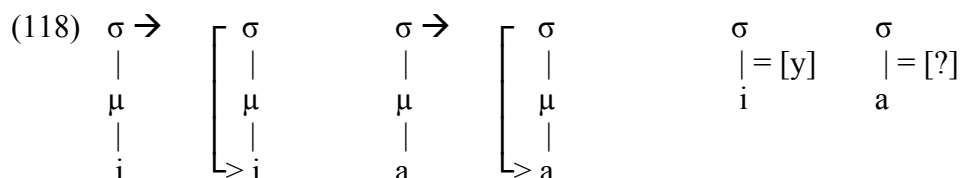
where /i/ directly under σ is interpreted as [y] and /a/ under σ as [?]. A similar view is suggested in E. Pulleyblank (1984, 1986), according to which /a/ has a glide variant, which may be the same as the zero initial (before non-high vowels). In this analysis, the obligatory onset is fully dependent on the nuclear segment. In particular, for each nuclear vowel, there should be just one variant of the zero onset. However, we already mentioned that the Mandarin zero onset has several realizations before non-high vowels (cf. section 2.1.1.1). Thus, (118) cannot be the correct analysis. The crucial point is that an obligatory onset has an independent status; it does not entirely depend on the preceding or the following segment.

A better solution is to make use of feature geometry. Take the version of McCarthy (1988), where the Root node contains two features [son] and [cons]

(119)   ⌐ sonorant   ⌐   Lar = Laryngeal node
           └ consonental ┘   Place = Place node
             / | \   ... = details omitted
        Lar … Place ... [cont]
          ...   ...

We may propose an empty Root node [] as a place holder for the obligatory onset. Hayes (pp282-283) in fact explicitly allows empty Root nodes. Let us examine this in detail. Although Hayes does not use feature geometry, the following discussion is in line with his assumptions.

First, if the onset position has an empty Root node, there is no reason why rime positions do not. Let us assume they all do. Fixed V and CV syllables can now be distinguished, and the derivation /i/-->[yi] and /a/-->[?a] can be shown

(120)   Syllable tier: σ   σ
                         | / |
        Mora tier: μ | μ
                         | | |
        Root tier: [ ]   [ ][ ]   ([ ] = empty Root socket)

(121)   /i/->[yi]

```
         σ  --->        σ    --->        σ
        / \            /  \             /  \
       |   μ          |    μ           |    μ
       |   |          |    |           |    |
      [] []          [] ┌-cons┐       [...] ┌-cons┐
      ┌-cons┐           └+son  ┘           \└+son  ┘
      └+son  ┘            |                 \/
        |               Place              Place
      Place
```

(122)   /a/->[ʔa]

```
         σ  --->        σ    --->        σ
        / \            /  \             /  \
       |   μ          |    μ           |    μ
       |   |          |    |           |    |
      [] []          [] ┌-cons┐       [...] ┌-cons┐
      ┌-cons┐           └+son  ┘        |   └+son  ┘
      └+son  ┘            |             ∅      |
        |               Place              Place
      Place
```
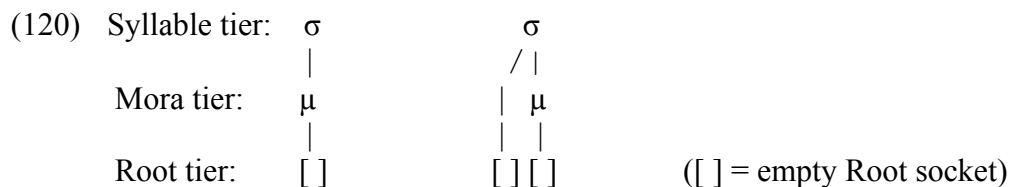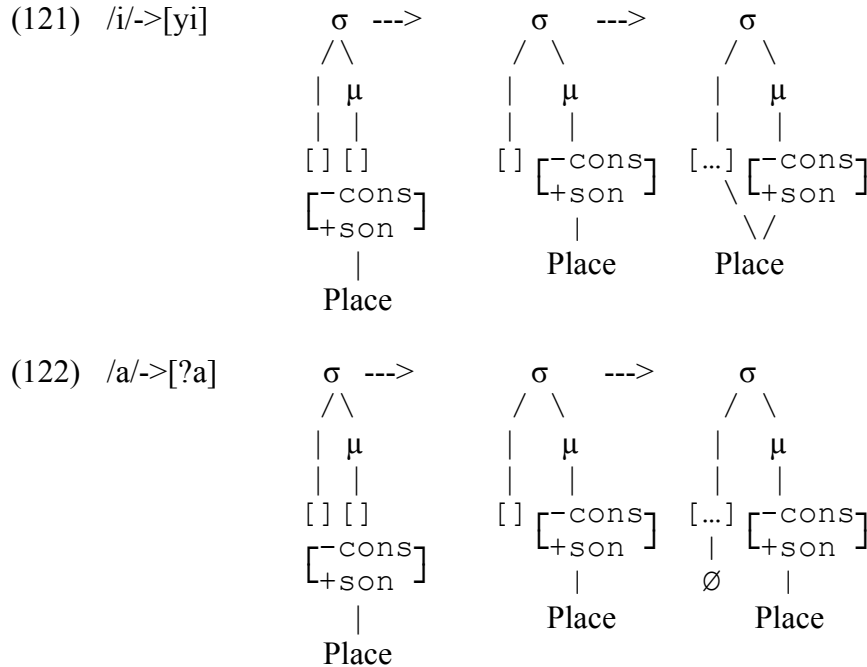
In (121) the feature tree of /i/ (omitting some details) is first linked to the [] under μ. This is done by plugging the Root into the given Root socket. The Place node is then spread to the onset [], triggering some specifications in it. In (122), after /a/ is plugged into the [] under μ, its Place node does not spread, so the onset [] is specified by some language particular rules.

Although the moraic theory now handles fixed structures, it does so at a cost. It has lost most of the virtues originally claimed. In most aspects, it resembles the X theory

(123)   X THEORY   MORAIC THEORY
        onset   segment/Root dominated by σ (to the left of rime)
        rime   segment/Root dominated by μ
        nucleus   segment/Root dominated by first μ
        coda   segment/Root dominated by second μ
        X slot   empty Root slot
        ...   ...

What is more, as in the X theory, where, when a segment deletes, the X slot may stay, in the moraic theory when a segment deletes, the Root slot may stay. Deletion may be thought of as unplugging the Root node of a segment from the Root socket, leaving an empty slot behind. This is in fact what Hayes (pp282-283) assumes for the Onondaga onset deletion.

But this move undermines Hayes' central point, which is that CL (compensatory lengthening) is triggered by free slots. According to Hayes, in the X theory, the deletion of any segment leaves an X slot behind, thus triggering CL. In the moraic theory, the deletion of a rime segment leaves a mora slot behind, thus triggering CL, but the deletion of an onset segment leaves nothing behind, thus not triggering CL. This is called the 'onset-rime asymmetry' of CL. However, we saw above that once the moraic theory contains a Root tier, the deletion of any segment, from the onset or the rime, may leave a Root socket behind, and this can trigger CL. Therefore, the onset-

rime asymmetry no longer exists.

It will not save the CL argument by stipulating that segment deletion always removes the Root node. One may equally stipulate for the X theory that segment deletion removes the X slot, and that nucleus (and coda) nodes trigger CL. Thus the two theories still end up identical.

2.5.3. Summary

I have shown that although Chinese languages have a uniform syllabic structure, there is no evidence of V/C segregation, unlike what is suggested by Yip (1989b) and L. Cheng (1989). It seems, therefore, that V/C segregation depends not only on rigid templates, as McCarthy (1989a) proposes, but also on whether the templates carry morphological information. In addition, I have shown that the moraic theories of Hayes (1989) and Hyman (1984, 1985), in which moras are the only constituents in a syllable, cannot handle the obligatory onset, especially the zero onset, unless empty Root nodes are permitted. But this move undermines the compensatory lengthening argument for the moraic theory, and brings the moraic theory closer to the X-theory. There is a likelihood, however, that the X tier is superfluous once the Root tier is allowed to contain empty Roots, although relevant facts are not clear enough for a conclusion.

I have little doubt that the mora plays an important phonological role. As McCarthy & Prince (1989) has convincingly shown, in Arabic templatic transfer, the mora is the central counting unit. In addition, it is well-known that the mora is fundamental to stress assignment (Halle & Vergnaud 1987; Halle 1990, among others). Furthermore, as we will discuss in Chapter 3, there is an important tonal difference between segments in the onset and segments in the rime; the former are never tone bearers, but the latter often are, irrespective of the intrinsic properties of a segment. This difference is most likely due to whether a segment carries a mora, as Hyman (1984, 1985) suggests.

What seems to be the case, though, is that moras are not the only constituents of the syllable. It is also possible that moras and syllables lie in different 'planes' (to borrow a term from Halle & Vergnaud 1980), i.e. moras are dependent on, but not constituents of, the syllabic structure.

CHAPTER THREE

TONE

3.0. Introduction

In this chapter I discusses the universal representation of tone, the issue of contour tones, the TBU (tone bearing unit), and the theory of contour features in general.

I first survey a range of tonal models, against a range of cross-linguistic tonal phenomena, such as tonogenesis, register split, depressor consonants, consonant blocker, tone and/or register spreading, etc., and argue for a tonal representation given below

(1)   Laryngeal
               /   \
          V/R   Pitch
          / \   /   \
        [st][sl][above][below]
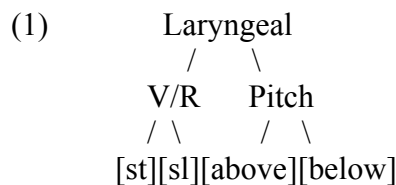
This model identifies voicing in consonants with register in vowels, both being executed by the same articulator V/R. The other articulator, Pitch, controls pitch. Exact articulatory mechanisms for V/R and Pitch will be explained later. (1) permits a maximum of nine tone levels, as Hyman (1989) argues for. As most languages utilize just a small subset of all possible consonants, most tone languages utilize just a subset of the nine possible level tones. For example, if a language does not utilize register (the V/R node), it will just have up to three tonal levels. In a larger picture, (1) is part of the entire feature geometry, as shown below

(2)   Root
               / \
          Lar   ...
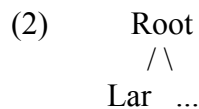
The Laryngeal node may also dominate other articulators, e.g. Arytenoids (for aspiration features), and perhaps Tongue-Root (cf. McCarthy 1989b, Halle 1989); we will, however, not be concerned with them. The choices for the node labels and features in (1) will be clarified, and (1) will be compared with other tonal models in detail in sections 3.1.

Since (1) identifies voicing with register, it predicts that during tone split, voiceless onsets always leads to the upper register and voiced onsets to the lower register. There are, however, many cases of 'voiceless-low' and 'voiced-high', i.e. syllables with historically voiceless onset now have lower register tones, and syllables with historically voiced onsets now have upper register tones. Yue-Hashimoto (1986) argues that such cases are due to a process that she calls tonal 'flip-flop', which takes place AFTER tone split. On the other hand, Kingston & Solnit (1988) argue that voicing is independent of register. I will discuss these issues in section 3.2. and show that there is evidence in Yue-Hashimoto's favor.

In section 3.3 I discuss contour tones and TBUs. A 'contour tone' is one that has a changing pitch height, such as a rise or a fall, while a 'level tone' is one that has a constant pitch height, such as a high level or a low level. There are three ways of representing contour tones. Take a rise for example

(3)   a.   σ   b.   σ   c.   σ
              | / \ |
          [+rise]   L   H   o   o = tonal root
                                              / \
                                             L   H

(3a) considers a rise to be a contour unit; this view has a long tradition, originating from the famous Chao (1930) letters and formalized in W. Wang (1967). (3b) on the other hand considers a rise to be made of two level tones, L and H; this view is advocated by Woo (1969), Williams (1976), Leben (1973) and most autosegmental phonologists today. In (3c), a rise is not only made of LH, but the LH forms a unit at the tonal root level. This is called a 'contour tone unit' (CTU). CTU is most forcefully argued for in Yip (1989a), although it is also proposed in Gandour & Fromkin (1978), Newman (1986), Chan (1985), Bao (1990a), among many others.

I will not discuss (3a); for criticisms, see Woo (1969) and Yip (1980). There is also no doubt that many surface contour tones are clusters of level tones, as in (3b) (pending clarifications on TBU, to which we return immediately). The question now is, are there CTUs? I will review major arguments for CTUs, and show that none is conclusive. I will thus conclude that there is no CTU.

I next discuss what the TBU is. There are three proposals, the syllable or the rime (e.g. Yip 1980, Bao 1990a), the mora (e.g. Hyman 1984), and the segment in the rime (Woo 1969, updated with autosegmental mechanisms). The difference between the latter two is shown below

(4)   a.   σ   b. ⌐ σ ⌐   c. σ   σ = syllable
              /\   /\   /|\   O = onset
        ⌐ μ μ ⌐   μ μ   O R A   R = rime
        | /\ /\ | | | | /\ | A = appendix
        | p a i k | p a i k   p a i k   μ = mora
        | | | | | |
        └> H L <┘   H L   H L

Suppose the syllable [paik] is bimoraic and bears HL. In (4a), the TBU is the mora; but since [p] and [k] are both under the μ nodes (cf. Hyman 1984), they share tones with [a] and [i]. In (4b), the TBU is also the mora; but since only [a] and [i] are under the μnodes, the TBU is in effect the mora carrying segments. In (4c), the TBUs are the segments in the rime, i.e. [a] and [i]. Since I am not aware of any evidence that onsets and post-rime elements (let us call them appendices) do share tones with rime segments, I will disregard (4a). In addition, I will not distinguish (4b, c) but consider them notational variants. (4b) and (4c) are also equivalent for geminates such as [a:]

(5)   a.   σ   or   σ   b.   σ
            ∧   ∧ |
           μ μ   μ μ   Rime
            ∨ | | ∧
            a   Rt Rt   Rt Rt
            ∧   ∧ ∧   ∧ ∧
           H L   H a L   H a L

In (5a), [a:] is two TBUs because it has two moras; [a:] may or may not have two Roots here, which we will not go into. In (5b), [a:] is also two TBUs, because it has two Roots (Selkirk 1988a), hence are in effect two segments.

There is no doubt that in many languages, such as LuGanda (Clements 1986), the TBU is not the syllable, but the mora. The question is whether the TBU can be the syllable or the rime in other languages, particularly Chinese languages, as Yip (1989a) and Bao (1990a) suggest. It is possible that the TBU parametrically varies from language to language. However, I will argue that there is no compelling evidence that it does. Instead, I will argue that the TBU is always the mora carrying segment. This uniform analysis of the TBU not only is a more constrained theory, but also agrees with the independently motivated tonal model (1), which is part of the segmental feature geometry.

Having discussed the CTU and the TBU, I next discuss how many tones a TBU may bear. There are three views. According to Woo (1969), a TBU can carry just one tone. In contrast, according to Goldsmith (1976), if tones outnumber TBUs, all excess tones must be realized on the last TBU; there is no upper limit as to how many tones a TBU may bear. According to Williams (1976) and D. Pulleyblank (1986), there is also no universal upper limit, although some languages forbid more than one tone per TBU, even if there are excess tones. Finally, according to Bao (1990a), there is a limit of two tones per TBU.

Woo's position is the strongest, and the most vulnerable. It claims that universally no TBU may carry a contour tone; if a syllable carries a contour tone, it must (at least) be bimoraic. Woo's position hinges on there being a direct relation between the tone bearing ability of a syllable (i.e. how many tones it may carry) and its rime length, whereas the position of Goldsmith, Williams and D. Pulleyblank, among others, hinges on there being no such relation. There is evidence in Woo's favor. For example, it is generally true that a monomoraic syllable carries one tone and a bimoraic syllable carries two. In addition, cross-linguistically, it is very rare that a syllable carries more that three tones, and it is perhaps not a coincidence that a syllable is rarely longer than three moras. On the other hand, there have been claims that a monomoraic syllable may carry two tones, as D. Pulleyblank (1986) claims to be the case in Tiv.

I will show that in Chinese languages, there is indeed a direct relation between the tone bearing ability of a syllable and its rime length. I will also argue that in at least two African languages, Igbo and Tiv, the same relation holds, unlike what D. Pulleyblank claims. On the other hand, I am not aware of clear evidence that a monomoraic syllable indeed carries two or more tones without lengthening. I will, therefore, stick to the strongest hypothesis that no TBU may carry a contour tone, until clear counter-evidence is seen.

In section 3.4 I discuss the theoretical implications of one tone per TBU for the theory of contour features in general. Sagey (1986) has proposed three kinds of contour features, contour tones, affricates, and prenasalized stops. I have argued against contour tones. Steriade (1989) has argued that affricates do not have contour features. I will also show, following Herbert (1975, 1986), that no language has underlying prenasalized stops. These results suggest that there are perhaps no contour features at all. If this is correct, it will be a very strong constraint on phonological theories.

3.1. The Representation of Tone

In this section I compare seven tonal representations, that in (1) and those below

(6)   a. Laryngeal   b. TBU   c. TBU   d.   TBU
               / \   / \ | |
            [st] [sl]   Register Tone   Register   o
                                                              | / \
                                                            Tone   Register Tone

        e. Laryngeal   f. Vocal-cords
               / \   / \
          Tonal Nontonal   CT Vocalis
            | | | |
         ⎡st ⎤ ⎡voice⎤   [st][sl]
         ⎣sl ⎦ ⎣.... ⎦

(6a) is proposed by Halle & Stevens (1971) and subsequently assumed in many other works (e.g. Sagey 1986, McCarthy 1988). (6b) is proposed by Yip (1980). (6c) is proposed by Yip (1989a) and, with minor variations, Hyman (1989). (6d) is proposed by Bao (1989). (6e) is proposed by Kingston & Solnit (1988). (6f) is proposed by Bao (1990a). This list is not exhaustive, but representative, I hope. Aspiration features will not be discussed here, although they interact with tone and voicing in some way (Matisoff 1970, F.K. Li 1980). In addition, I will say nothing about the relation between implosives and tone.

The comparisons will focus on how each model handles the following array of well-observed tonal phenomena

(7)   a.   In nontonal languages like English, vowels have a higher initial pitch after [-voice] obstruent onsets, and a lower initial pitch after [+voice] obstruent onsets (e.g. Hombert 1978).

        b.   [-voice] and [+voice] onsets lead to high and low tones respectively in Sino-Tibetan tonogenesis (e.g. Haudricourt 1954, Matisoff 1973).

        c.   [-voice] and [+voice] onsets lead to upper and lower register tones respectively in Chinese languages (e.g. Yeu-Hashimoto 1986). In Bantu languages, 'depressor consonants' lower the tone of neighboring vowels (e.g. Laughren 1984).

d.   In some languages, e.g. Nupe and Ngizim, [-voice] obstruents block L-spreading, [+voice] obstruents block H-spreading, while sonorants block neither (Hyman & Schuh 1974).

e.   In many languages, consonants do not block tone spreading.

f.   In Mon-Khmer languages, loss of onset voicing does not lead to tonogenesis, but to changes in vowel quality and/or vowel height (e.g. Gregerson 1976, Huffman 1976, Kingston & Solnit 1988).

g.   Tones may spread without affecting register (e.g. Yip 1980).

h.   Register may spread without affecting tone (Bao 1990).

i.   Upper and lower register tones often overlap in pitch.

j.   There are reported languages with five level tones (Black Miao and Tauhua Yao) and at least four rising and four falling tones (Gweabo).

k.   Tones are related with each other, i.e. they fall into natural classes. For example, in a language that has four tonal levels, H, M' (raised mid), M, and L, there are relations between H and M', between M and L, between H and M, and between M' and L. Similarly, a contour tone M'H has a closer relation to LM rather than to HM' or to ML, and so on (e.g. Yip 1980).

(7a-f) reflect segment-tone interactions, while (7g-k) reflect the internal structure of tone and the relations among them. I will show that (6a, e) are successful largely with the first set of phenomena, while (6b-d) are successful largely with the second set. (6f), which has incorporated properties from both (6a) and (6b-d), is able to account for most of (7). Finally, (1), which is a further improvement on (6d), accounts for all of (7). Before we see how each model accounts for (7) in detail, however, let us begin with a more traditional system, the Chao letters, which has dominated Chinese tonology for six decades and is still by far the most influential in Chinese tonology today.

3.1.1. Chao Letters

Chao (1930) designed a tonal marking system which divides a speaker's normal pitch range into five equal levels, referred to, from the highest to the lowest, by the letters 5, 4, 3, 2, and 1

(8)   5   ⊤   (highest pitch)
        4   ⊣
        3   ⊣
        2   ⊣
        1   ⊥   (lowest pitch)
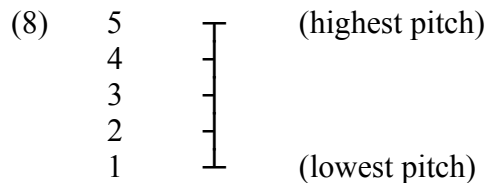
A tone is usually given two numbers, indicating the initial and the final pitch respectively. For example, the Mandarin first tone is [55], a high level tone, and the Mandarin fourth tone is [51],

a falling tone from the highest pitch to the lowest. Similar letter systems have been used by other people, such as Doke (1926), who uses nine letters 1 through 9 to mark pitches from the highest to the lowest in Zulu, and Sapir (1930), who uses four letters 1, 2, 3 and 4 to mark pitches from the highest to the lowest in Gweabo.

Chao letters (as well as other tone letters) have serious limitations. First, it is intrinsically vague. For example, the choice of five levels is not based on phonological principles, as Chao acknowledges, but on a balance between phonetic details and phonological distinctions. In addition, as Chao remarks, a distinction between one degree (e.g. between 44 and 55, between 24 and 35, and between 12 and 13) is usually not significant, but that between two degrees usually is. Such lack of precision is well known to workers on Chinese tones, and it is common that two transcriptions of the same dialect do not give exactly the same letters for the same tones. For example, in nonfinal positions, the Mandarin third tone is transcribed as [21] in Chao (1968) but [11] in Chao (1931) and Wang (1979). Similarly, the Shanghai tone named 'Yang Ru' is transcribed as [2] in Jiangsu Sheng He Shanghai Shi Fangyan Diaocha Zhidao Zu (1968) but [13] in Shen (1981). Such flexibility causes serious problems when one attempts to translate Chao letters into a level tone system, such as that of Yip (1980) or Hyman (1989), whose primitives (excluding register) are simply H and L. For example, [2] could be L or H in the lower register, and [13] must be LH in the lower register; but what is the Yang Ru tone of Shanghai, which is transcribed as [2] by some and [13] by others? Similarly, in the lower register, [11] is clearly L, and [31] is probably HL, but what is [21]? It could be HL (Bao 1990:105-111 for Wenzhou), or L (Yip 1980:280 for Mandarin third tone). An ambiguity of such an extent is too large to tolerate in an explicit theory.

A second problem with Chao letters lies in their dubious status between a phonetic system and a phonemic one. Chao himself does not believe there to be a clear cut between the two systems (Chao 1934/1957). Whether Chao is right or wrong, the dubious status of Chao letters causes considerable confusion. For example, in transcribing Old Shanghai, Shen (1981:132) says[1]

> The real value of Yin Ping is 52; this paper marks it as 53. The real value of Yin Qu is 33 or 24; this paper marks it as 35. The real value of Yang Qu is 113 or 13; this paper marks it as 13. The real value of Yin Qu is a short tone 5 or 4; this paper marks it as a short tone 55. The real value of Yang Ru is a short tone 23; this paper marks it as a short tone 13.

Similarly, in his transcription of Lhasa tones, Hu (1980:25) says

> In the marking system with five levels, (the Lhasa high level tone) is 44. For visual clarity, it is written as 55.

Such practice is extremely common. It is, to some extent, justified. If [44] does no contrast with [55] in a language, why not write it as [55]? And given the tendency that the fewer vowels a language has, the more widely dispersed they are in the vowel space, probably there are times people pronounce [44] as [55]. But the question is not so simple. Take Mandarin for example. There are four syllable tones. Nonfinally, Chao (1968) writes them as [55], [35], [21] and [51]. But why does Chao not write them as [55], [15], [11] and [51], since there is no [15] and [11] in Mandarin? One may suspect that [35] and [15] probably contrast in other languages, but in fact

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[1]. Yin Ping, Yin Qu, etc. are names of the tones.

they never do (Bao 1990:123). Similarly, to my knowledge, [21] and [11] never contrast. On the other hand, [33] and [24] do contrast in Gao'an (Yan 1981), but that did not prevent Shen from writing [33] as [24] in Old Shanghai, as we saw above. It must be the case, then, that some people do not, or do not always, modify the phonetic values in their transcriptions, such as Chao (1968) probably did not for Mandarin. But if some people modify the phonetic values, and some do not, then there is sure to be confusions. What is more, many people simply do not say whether they have or have not made modifications in their transcriptions.

When one reads Chao letters, therefore, one cannot be exactly sure what the pitch values are, although one can be sure that they must be somewhere close to the given letters. This in many cases does not matter. But in some cases, it matters a great deal. For example, [24] is close both to [35] and to [13]. Now [35] is an upper register tone, but [13] is a lower register one. If one wants to 'modify' [24], which direction should one choose? We saw above that Shen has changed [24] to [35] yet [24] to [13]. Maybe Shen had good reasons for doing so, but such changes, which are not uncommon, are very critical.

A third problem with Chao letters is that they are based on phonetic and/or perceptual terms. There is, however, growing evidence that phonological features are articulator based (cf. for example, Lieberman & Mattingly (1985) for the viewpoint of the motor theory, and Clements (1985), Sagey (1986), Halle (1988) and McCarthy (1988) for the viewpoint of feature geometry).

A fourth problem with Chao letters is their total inability to account for the interactions between consonants and tone. In particular, there is no way for Chao letters to reflect the well-known relation between voiced onsets and low tones, and between voiceless onsets and high tones.

A fifth problem with Chao letters is that they cannot explain the relations among tones. For example, if a language has [55], [33], [22] and [11], there is usually a relation between [55] and [22], but not between [22] and [33]. Chao letters cannot explain why [22] may relate to the more distant [55] and not to the closer [33]. In contrast, in a register system such as Yip (1980:44-51), such relations are nicely captured.

The above problems strongly show that, although Chao letters may serve as a crude measure of pitch, they have little phonological value, because they provide no insight to the nature of tone. In contrast, a feature system such as (6b, c) not only can represent pitch values at an accuracy comparable to Chao letters, but also can explain the relations among tones, the nature of sandhi rules, and the interaction between tone and segments, as we will see shortly.

It is perhaps too easy to criticize a system which was designed sixty years ago, and which was probably intended to be no more than an aid to the field linguist. Nevertheless, since most Chinese data are recorded in Chao letters, a clear understanding of their limitations, both theoretical and practical, cannot be overemphasized.

3.1.2. Halle & Stevens (1971)

The very fact that consonant voicing interacts with tone on vowels strongly suggests that there are features common to both consonants and vowels. This fact is captured in (6a), an articulatory model proposed by Halle & Stevens (1971, hence H&S). The same features [st] and [sl] (for

[stiff vocal cords] and [slack vocal cords]) are interpreted as voicing on consonants and pitch
height on vowels in the following fashion

(9)   Consonants   Vowels
        [+st -sl]   -voice   H
        [-st -sl]   M
        [-st +sl]   +voice   L
        *[+st +sl]

[+st, -sl] is interpreted as [-voice] on obstruent consonants and H (high pitch) on vowels, [-st, -sl]
as voicing state on sonorant consonants and M (mid pitch) on vowels, and [-st, +sl] as [+voice]
on obstruent consonants and L (low pitch) on vowels. [+st, +sl] is considered an impossible
combination.

In this model, [p] has stiff vocal cords, hence will give a higher initial pitch to [a] in [pa].
Similarly, [a] in [ba] will have a lower initial pitch. This is true whether the language is tonal or
not (cf. Hombert 1978). Now consider tonogenesis in Lhasa Tibetan (Hu 1980:31, ' = aspiration)

(10)   Classic Transcription: kho   go   tho   do   sa   za
        Present Pronunciation: k'ó   k'ò   t'ó   t'ò   sá   sà
        Gloss: he   hear   number   two   mud   eat

The loss of contrast in onset voicing has lead to the emergence of tones on vowels. Tonogenesis
is common in many Asian languages (e.g. Haudricourt 1954, Matisoff 1973). In the H&S model,
this process is seen as the spreading of the Laryngeal node from the consonant to the vowel, as
represented below

(11)   a.   [k'   a] →   [k'   á]
                    Root Root   Root Root
                      | \ /
                    Laryngeal   Laryngeal
                     / \   / \
                   [+st] [-sl]   [+st] [-sl]

        b.   [g   a] →   [g   à] →   [k'à]
                    Root Root   Root Root
                      | \ /
                    Laryngeal   Laryngeal
                     / \   / \
                   [+sl] [-st]   [+sl] [-st]
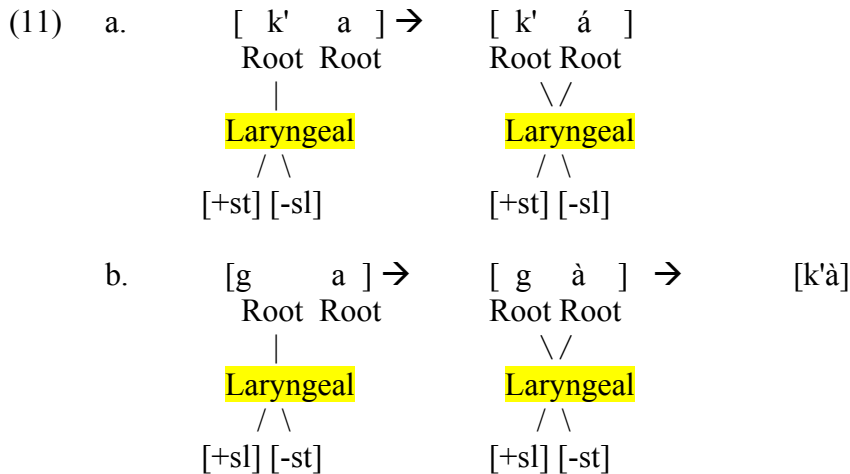
For exposition, the H&S model is embodied in the feature geometry of Sagey (1986). In (11a),
the Laryngeal node of [k'] spreads to the [a], giving it a high tone. Similarly, the Laryngeal node
of [g] spreads to [a], giving it a low tone. [g] further undergoes devoicing to become [k'à].[2]

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[2]. The devoicing process may be seen as first delinking the Laryngeal node from [g], and then
filling it with [+st, -sl] as a default value. That [+st] is the default value is supported by the fact

The first stage corresponds to classic Tibetan. The final stage is found in Lhasa. The intermediate stage, before [g] devoices, is found in Xiahe, where the 'tones' on the vowels are 'habitual' and 'very close to (the tones) in the Lhasa dialect', but they are not distinctive (Hu, p36).

The H&S model can also explain the blocking effects of consonants on tone spreading. Consider the schematized patterns of 'consonant blockers' in Nupe and Ngizim (Hyman & Schuh 1974:107)

(12)   L-spreading to right   H-spreading to right
    a.   [àpá] --> [àpá] (*[àbă])   b.   [ápà] --> [ápâ]
    c.   [àbá] --> [àbă]   d.   [ábà] --> [ábà] (*[ábâ])
    e.   [àwá] --> [àwă]   f.   [áwà] --> [áwâ]

Voiceless obstruents block H spreading, voiced obstruents block L spreading, while sonorants block neither. The H&S model may accounts for (12) as follows

(13)   a. [à   p   á]   ---->   [à   p   á]
            Root   Root   Root   Root   Root   Root
             | | | | | ┌─>┘ |
            ...   Laryngeal Laryngeal   ...   Laryngeal Laryngeal
                   / \   / \   / \   / \
                 [+st] [-sl] [+st] [-sl]   [+st] [-sl] [+st] [-sl]

        b. [á   p   à]   ---->   [á   p   â]
            Root   Root   Root   Root   Root   Root
             | | | | | ┌─>┘ |
            ...   Laryngeal Laryngeal   ...   Laryngeal Laryngeal
                   / \   / \   / \   / \
                 [+st] [-sl] [-st] [+sl]   [+st] [-sl] [-st] [+sl]

        c. [à   b   á]   ---->   [à   b   ă]
            Root   Root   Root   Root   Root   Root
             | | | | | ┌─>┘ |
            ...   Laryngeal Laryngeal   ...   Laryngeal Laryngeal
                   / \   / \   / \   / \
                 [-st] [+sl] [+st] [-sl]   [-st] [+sl] [+st] [-sl]

        d. [à   b   à]   ---->   [à   b   à]
            Root   Root   Root   Root   Root   Root
             | | | | | ┌─>┘ |
            ...   Laryngeal Laryngeal   ...   Laryngeal Laryngeal
                   / \   / \   / \   / \
                 [-st] [+sl] [-st] [+sl]   [-st] [+sl] [-st] [+sl]

that, almost universally, when onset voicing is neutralized, the outcome is [-voice], rather than [+voice].

```
e.  [   à          w          á    ] ---->        [   à          w          ă   ]
      Root       Root       Root                    Root      Root       Root
       |          |          |                        |    ┌────>────────┐  |
   Laryngeal   ...     Laryngeal                  Laryngeal            Laryngeal
      / \              / \                           / \                 / \
   [-st] [+sl]      [+st] [-sl]                   [-st] [+sl]         [+st] [-sl]

f.  [   á          w          à    ] ---->        [   á          w          â   ]
      Root       Root       Root                    Root      Root       Root
       |          |          |                        |    ┌────>────────┐  |
   Laryngeal   ...     Laryngeal                  Laryngeal            Laryngeal
      / \              / \                           / \                 / \
   [+st] [-sl]      [-st] [+sl]                   [+st] [-sl]         [-st] [+sl]
```

In all cases, there is a spreading of the Laryngeal node to the second vowel. In (13a-d), the spreading comes from adjacent [p] or [b]; in (13e, f), since the adjacent [w] does not have Laryngeal features, it is transparent, and the spreading comes from the first vowel. In (13a, d), the spreading effect does not show up, since the spread node is the same as that of the second vowel; in other cases, the spread node differs from the one on the final vowel, and this shows up as an additional tone.

The account in (13) differs from that of the original authors. According to Hyman & Schuh (1974), all spreadings come from the tone of the first vowel. According to (13), some spreadings come from the vowel, while others come from the consonant. The difference is not trivial. For example, since the H&S model claims that spreading may come from the onset, as in (13a-d), it also predicts spreading to happen in such syllables as [pà]->[pâ], [àpà]->[àpâ], [bá]->[bă] and [ábá]-->[ábă][3]. However, Hyman & Shuh do not report such cases in Nupe and Ngizim. The analysis of Hyman & Shuh does not have this problem.

The H&S model has more serious problems, too. First, as seen in (9), it only provides up to three tonal levels. Yet, there are reported languages that have four or more tonal levels. For example, Black Miao has five (Anderson 1974:145, citing F.K.Li, values in Chao letters)

(14)   la 11 'candle'   la 22 'to move away' la 33 'cave'
       la 44 'a classifier'   la 55 'short'

Chang (1953) also reports that Hei Miao (Black Miao) and Tahua Yao have five level tones each. According to Sapir (1930), Gweabo has four pitch levels, which he marks 1 for the highest and 4 the lowest. In addition, Sapir claims that there are six possible rising tones (43, 42, 41, 32, 31 and 21) and six falling tones (12, 13, 14, 23, 24, 34), which, he claims, are all attested. Although Sapir does not provide the complete paradigm, he gives the following examples (p34)

(15)   e 1 ke 21 'I am narrow'   ke 43 'you are narrow'
       a 3 ke 41 'we are narrow'   mu 32 'octopus'

---

[3]. Thanks to M. Yip for making this point to me.

If the four rising tones (21, 43, 41 and 32) contrast with each other, there must be four tonal levels. What is more, Hyman (1989) argues that as many as nine tonal levels are needed to describe all tonal phenomena. It is of course possible to add more features, hence more contrasts, to a tonal system. But the question is not so simple with the H&S model. The reason is that, since tone is identified with voicing, an increase in tonal contrasts means an increase in voicing contrasts. There is, however, no evidence that any language exhibits more than three voicing contrasts.

A second problem with the H&S model is that, in many languages, tones may spread across consonants irrespective of their voicing values. Consider a case in Yoruba (Pulleyblank 1986:110)

```
(16)    dídùn   -->     dídûn   'sweetness'
         | |            |/|
        H  L           H  L
```

where H spreads from [i] to [u] across the voiced [d]. In the H&S model, the feature representation of [dídùn] before spreading is as below

```
(17)    d           í           d           ù           n
        ...        Root        Root        Root         ...
                    |           |           |
                 Laryngeal  Laryngeal  Laryngeal
                  /  \        /  \        /  \
               [+st][-sl]  [-st][+sl]  [-st][+sl]
```

For [u] to become HL, we need to spread H from [i] across [d]. But this cannot be done, since the Laryngeal features of [d] should block the spreading. It is not possible do the spreading suprasegmentally either, since the process in (16) takes place after tone-to-segments association.

A third problem with the H&S model is that it cannot handle 'register', the importance of which is convincingly argued for in Yip (1980).

A fourth problem lies in H&S's account of tonogenesis, shown in (11). In this analysis, the transfer of onset voicing to the vowel inevitably gives rise to tones. However, in Mon-Khmer languages, this does not happen. Instead, the loss of onset voicing leads to a change in vowel quality and/or vowel height (cf. Gregerson 1976, Huffman 1976). We will return to this issue later.

Finally, it should be pointed out that there have been little experimental evidence for the features [st, sl], and so the H&S model largely remains a hypothesis. Despite the inadequacies, the strength of the H&S model remains, namely, it provides an articulatory theory that captures some relation between voicing and tone in a simple way.

3.1.3. Kingston & Solnit (1988)

The model of Kingston & Solnit (1988, hence K&S) adopts the H&S features [st, sl], but does not identify them with voicing. Instead, [st, sl] are exclusively tonal features, which are independent of nontonal features such as [voice].

The greatest strength of the K&S model seems to lie in its account of tonogenesis and the register problem in Mon-Khmer (Gregerson 1976, Huffman 1976).[4] K&S's account of tonogenesis is similar to that of the H&S model in that there is a spreading of [st, sl] from the onset to the vowel. For example, Tibetan [k'a]-->[k'á] may be represented as follows

```
(18)              [ k'    a ]                    [ k'   á ]
                 Root   Root       --->         Root Root
                   |      |                       |    |
                 Laryn  Laryn                   Laryn Laryn
                    /\                           / \ /
             Nontonal Tonal                 Nontonal Tonal
                  |      |                       |    |
             [voice] [+st]                  [voice] [+st]
             [ ... ] [-sl]                  [ ... ] [-sl]
```
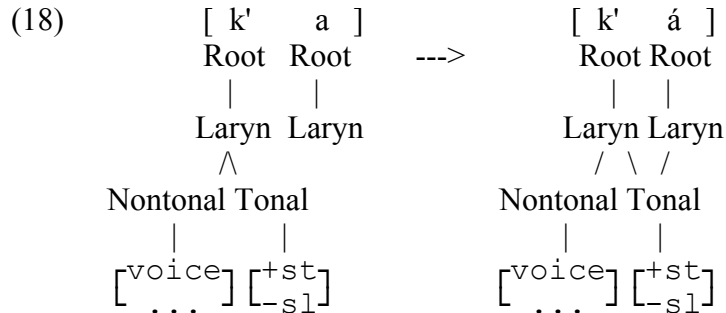
The Tonal node of [k'] spreads to [a], giving the latter a high tone. However, K&S differ from H&S in an important respect. For H&S, [st, sl] in consonants are their voicing features, and there are no other tonal features. But for K&S, consonants may not only have voicing features, but also tonal features, even in a non-tonal language, i.e. even if vowels have no tonal features. K&S suggest that whether consonants carry tones is a parametric option. While this suggestion may in principle be correct, it is counter-intuitive that consonants have tones when vowels do not.

Nevertheless, a separation of voicing from tone enables K&S to account for the Mon-Khmer register, a problem which H&S cannot handle. In many Mon-Khmer languages, the loss of onset voicing contrast has not lead to tonogenesis, but a split of vowel quality, or what is usually called 'register' (Gregerson 1976, Huffman 1976). Vowels of the 'first register' occur with (originally) [-voice] onsets, and vowels of the 'second register' occur with (originally) [+voice] onsets. Vowels of the first register are said to be 'clear, normal, head, tense, ...', while those of the second are 'deep, breathy, sepulchral, chest, ...'. In the analysis of K&S, this phenomenon may be seen as a spreading of the Nontonal node from the onset to the vowel, with subsequent delinking of the Nontonal node from the onset in some dialects, perhaps. Exactly what features are involved in this process are not discussed in K&S, however.

The K&S model has several problems. First, like the H&S model, it offers up to three tonal levels, too few for quite a number of reported languages. Second, it cannot capture the notion of tonal register (Yip 1980). Third, its representation misses an important concept in feature geometry, namely 'articulator'. Consider the K&S model again, repeated below

---

[4]. K&S do not give derivations for tonogenesis or the Mon-Khmer register split, but the following is what they would say, to my understanding.

(19)   Laryngeal
            / \
        Tonal Nontonal
          | |
        ⌈st⌉ ⌈voice⌉   [c.g.] = [constricted glottis]
        ⌊sl⌋ ⌊c.g. ⌋
               ...
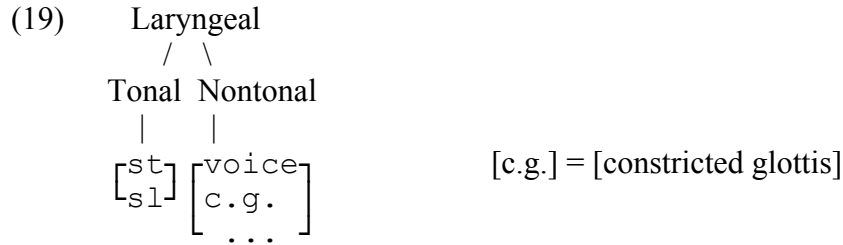
The Laryngeal node dominates two nodes, Tonal and Nontonal, which in turn dominate features. According to Sagey (1986), it is important that all features are dominated by 'articulators', which execute features. In the K&S model, however, it is not clear what articulators Tonal and Nontonal refer to.

A further problem lies in K&S's account of tone split, or what K&S call 'tonomitosis'. In tonomitosis, an original tone splits to two according to onset voicing. For example, a rising tone in Shanghai is, in Chao letters, 24 with [-voice] onsets but 13 with [+voice] onsets. Tone split may also be called register split, because the higher tone is now in the [+upper] register and the lower tone [-upper] register (Yip 1980). In K&S's view, tone split involves a spreading of [st, sl] from the onset to the vowel, as shown below (K&S, 23)

(20)   [C   V]   --->   [C   V]
         Laryn   Laryn   Laryn   Laryn
          /\   /\   /\   /\
         NT T   T NT   NT T   T NT
         ... | | ...   ... | / | ...
            ⌈st⌉   ...   ⌈st⌉ ...
            ⌊sl⌋   ⌊sl⌋
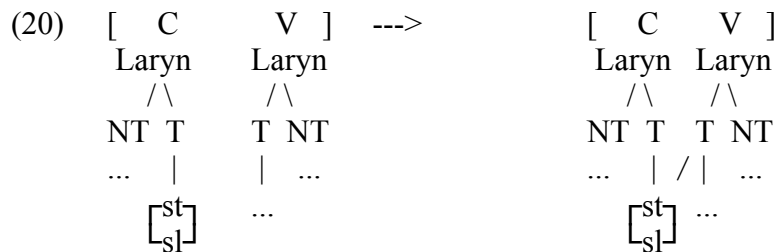
There are two problems with this representation. First, it is not the usual practice in feature geometry to spread a set of features at one step without a dominating node. Second, it is not clear whether the spreading should lower (or raise) the tone on the vowel, or create a contour tone on it. For example, suppose [bá] undergoes tone split, we expect the H on [á] to be lowered. K&S will represent the process as below

(21)   [b   á]   --->   [b   ?]
         Laryn   Laryn   Laryn   Laryn
          /\   /\   /\   / \
         NT T   T NT   NT T   T NT
         ... | | ...   ... | / | ...
            [+sl] [+st]   [+sl] [+st]
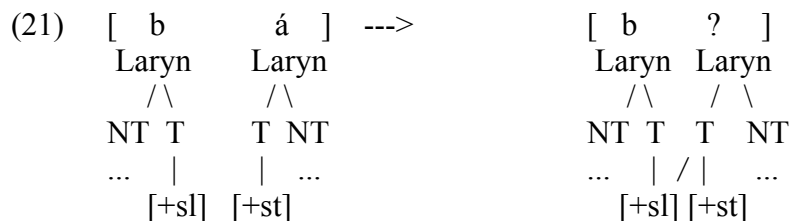
The resulting tone on [a] is [+sl, +st], or [L H]; this sequence, however, is usually interpreted as a rise (Sagey 1986, Yip 1980, 1989), instead of a lowered H. If [L H] is interpreted as M, in the fashion of Hyman (1989), one may ask how K&S would represent a rise. Similarly, in [bà], [b] may lower [à] still further, as in the case of Zulu depressor consonants (Doke 1926, Laughren 1984). K&S's representation of the process is the same

(22)   [b   à] --->   [b   ?]
        Laryn   Laryn   Laryn Laryn
         /\   /\   /\   / \
        NT T   T NT   NT T   T   NT
        ... | | ...   ... | / | ...
          [+sl] [+sl]   [+sl] [+sl]
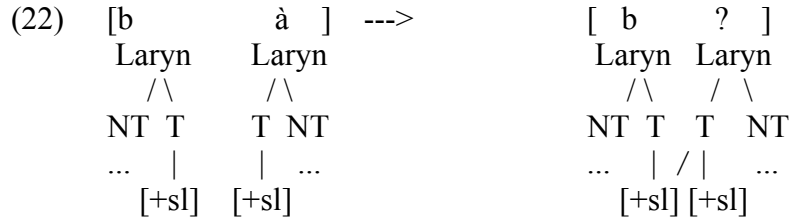
This time, after spreading, the resulting tone on [a] is [+sl, +sl], or [L L]. Again, it is not clear why this sequence should be interpreted as a lowered L, or why spreading should have taken place at all.

As a final comment, we note that for K&S, [voice] is independent of tone, or [st, sl]. In other words, K&S deny the widely held belief that there is a relation between [-voice] and higher tones, and between [+voice] and lower tones. In fact, K&S claim that in tone split, [+voice] onsets could give rise to lower tones and [-voice] onsets to higher tones, contrary to the popular belief. K&S's reason is that in many languages, syllables with originally [+voice] onsets now have higher tones, while syllables with originally [-voice] onsets now have lower tones. Yue-Hashimoto (1986) suggests that such cases are due to a process AFTER tone split, and not DURING tone split. She calls the post-split process tonal 'flip-flop'. We will come back to this issue in section 3.2.1 and show that there is evidence in Yue-Hashimoto's favor.

3.1.4. Yip (1980)

The most important contribution of Yip (1980) is perhaps the notion of tonal register. This concept nicely captures the interrelations among tones. For example, if a language has four tone levels, H, M' (raised M), M and L, they will be represented as below

(23)   TBU   TBU   TBU   TBU
                / \   / \   / \   / \
        [+upper] [+H]   [+upper] [-H]   [-upper] [+H] [-upper] [-H]
               H   M'   M   L
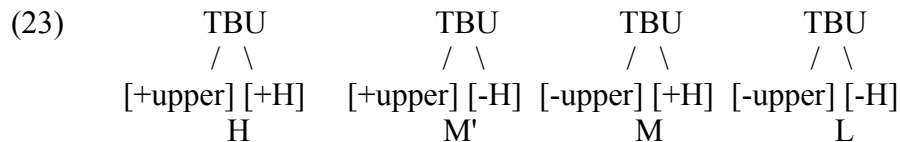
This model predicts that there are relations between H and M', both being [+upper], between M and L, both being [-upper], between H and M, both being [+H], and between M' and L, both being [-H]. All such relations are attested (cf. Yip 1980:44-50).

The major problem with Yip's (1980) model is that it does not reflect the interactions between consonants and tone. The retreat from the H&S position is largely due to the numerous problems facing the H&S model. However, the cost of this retreat is that Yip's (1980) model offers no explanation for tonogenesis, tone split, depressor consonants, and other segment-tone interactions.

3.1.5. Yip (1989a) and Hyman (1989)

The model of Yip (1989a) is similar to that of Hyman (1989). They differs from that of Yip (1980) in one way, as shown below

(24)   Yip (1980):   TBU   Yip (1989a):   TBU
                      / \ |
                Register Tone   Register
                                                          |
                                                        Tone
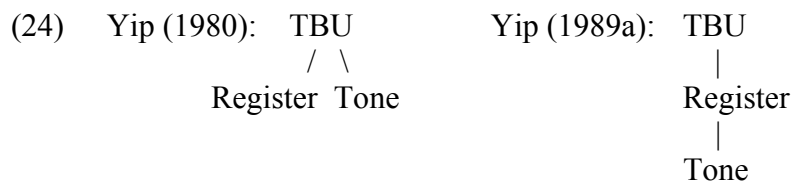
While Register and Tone are in a sister relation in Yip (1980), they are in a dominance relation in Yip (1989a). This change is probably motivated by two reasons. First, there are cases where Register and Tone both spread. This means that Register and Tone should have a common node other than the TBU, since, in feature geometry, multiple spreadings are generally prohibited (Clements 1985). Second, while there are cases where Tone spreads alone, there seem to be few cases where Register spreads alone, especially across syllables. This is natural if Register dominates Tone.

The model of Yip (1989a) differs from that of Hyman (1989) in three ways. First, while Yip has two contrasts on each tier, Hyman has three, giving nine tonal levels; their representations, together with corresponding letters in traditional transcriptions, are shown below

(25)   Yip (1989a):   TBU   TBU   TBU   TBU
                        | | | |
        Register: [+upper]   [+upper]   [-upper]   [-upper]
                        | | | |
        Tone: [+raised]   [-raised]   [+raised]   [-raised]

        Letter: H   M'   M   L

(26)   Hyman (1989):   TBU TBU TBU TBU TBU TBU TBU TBU TBU
                         | | | | | | | | |
        Tonal Root: o   o   o   o   o   o   o   o   o
                         | | | |\ |\ |\ |\ |\ |\
        Tone: o   o   o   o L o L o L o H o H o H
                         | | |\ | | |\ | | |\
                         H   L   LH   H   L   LH   H   L   LH

        Letter: H   L   M   !H   !L   !M   H'   L'   M'
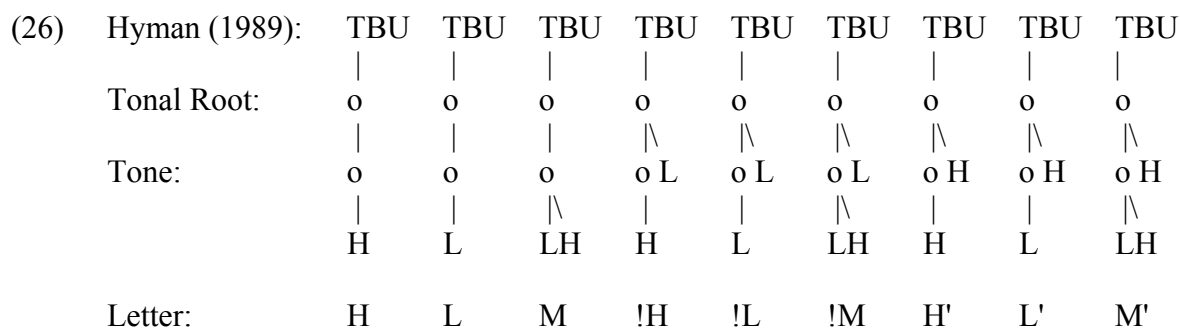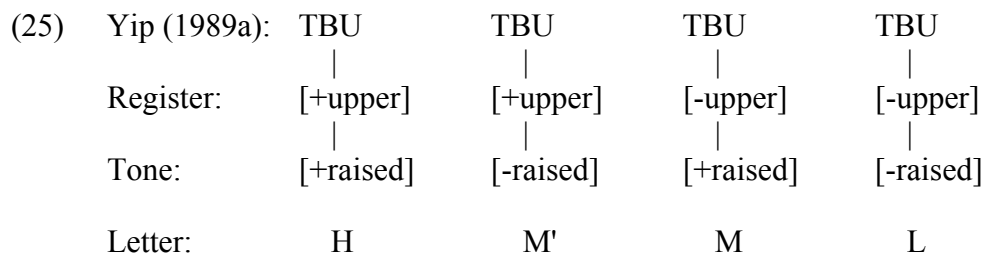
'Tonal root' and Tone of Hyman correspond to Register and Tone of Yip respectively. !H, !M and !L refer to downstep H, M and L respectively, and H', L' and M' refer to raised H, M and L respectively. The difference in how many tonal levels each model provides is probably not a big issue, however. One may easily add more levels to Yip's model, pending empirical evidence.

The second difference is that, in Yip (1989a), the Register feature [upper] cannot spread without the Tone feature [raised], but in Hyman's model, [H] and [L] of the Tone Root tier may spread independent of [H] and [L] of the Tone tier. Bao (1990a) reports that in Wuyi, Register may spread independent of Tone. If this is true, then Yip's (1989a) model must be modified.

The third difference is that, in Yip (1989a), Register and Tone involve different features ([upper] v. [raised]), while in Hyman (1989) they are given the same features [H] and [L]. In fact, Hyman

allows [H] and [L] to be linked to both tiers at the same time, as the following show (Hyman, p5, p7)

(27)   a.   TBU   TBU   b.   TBU
                 | | |
                 o ─┌─ o   ┌─ o
                 | | | |
                 o   o | o
                 | | | / |
                 L─┘ H   L   H

                 L   !H   !M
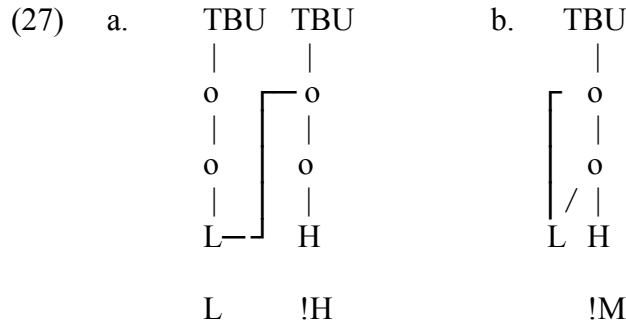
This system is justified only if Register and Tone have the same acoustic and/or articulatory correlates (say pitch or vocal cords tension). However, the phonetic study of Duanmu (1990) suggests that while Tone correlates with F0, Register mainly correlates to voice quality. If Duanmu is correct, Register and Tone must involve different features.

The models of both Yip (1989a) and Hyman (1989) inherit the strength of Yip's (1980) model in that they nicely reflect the interrelations among tones, but they also inherit the weakness of Yip (1980) in that little is said about segment-tone interactions.

3.1.6. Bao (1989)

The model of Bao (1989) differs from those of Yip (1989a) and Hyman (1989) in one respect: in the former Register and Tone are sisters, while in the latter they are in a dominance relation, as shown below

(28)   Bao (1989):   TBU   Yip (1989a) & Hyman (1989):   TBU
                         | |
                         o   Register
                       / \ |
                 Register Tone   Tone
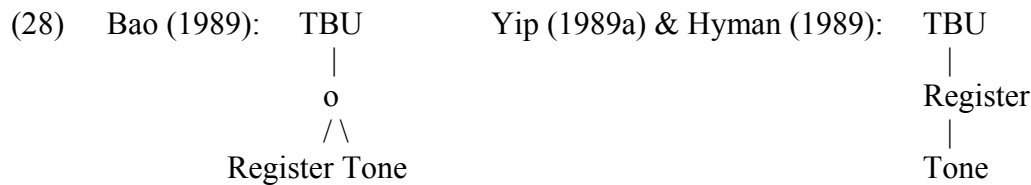
The motivation for change, Bao argues, is that Register may spread independent of Tone. Consider Wuyi (Bao 1989, G. Fu 1984)[5]

(29)   sa 24 v^wo 31   --->   sa 24 f^wo 53   'half-cooked rice'
        [+u, LH]   [-u, HL]   [+u, LH]   [+u, HL]
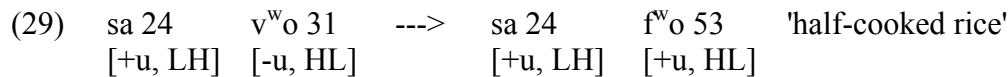
In (29), the register of the first syllable [sa] replaces that of the second [v^wo], changing [v^wo] from [31] to [53], i.e. changing the pitch range without changing the contour. The additional change of [v]-->[f] will be explained later. Although independent Register spreading is rare, yet if it exists, Bao's move is justified.

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[5]. G. Fu and Bao write [vuo] and [fuo] for the word 'rice', which I write as [v^wo] and [f^wo], for reasons given in Chapter Two.

Like Yip (1980, 1989a) and Hyman (1989), however, Bao's (1989) model does not reflect segment-tone interactions. This shortcoming is overcome in Bao (1990a).

3.1.7. Bao (1990a)

The model of Bao (1990a), repeated below, incorporates the virtues of both the articulatory model of H&S and the register models of Yip (1980, 1989a), as well as elements from feature geometry

```
(30)     Vocal-cords    or      Vocal-cords
          /    \                 /     \
        CT   Vocalis          Register  Tone        (CT = Cricothyroid)
         |      |                |        |
        [st]   [sl]             [st]     [sl]
```

```
(31)     Features:     [+st, +sl]      [+st, -sl]      [-st, +sl]      [-st, -sl]
         Vowel:            H              M'              M               L
         Consonant:    [+voice]        [+voice]        [-voice]        [-voice]
```
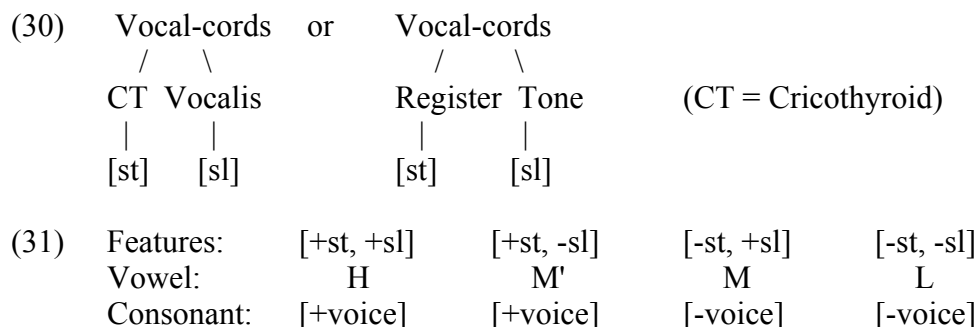
A similar model, though less articulated, was proposed earlier in Meredith (1988). Following Yip, Bao splits the tonal structure into two components, Register=CT and Tone=Vocalis. Following H&S, Bao adopts the features [st, sl] and identifies consonant voicing with Register, both being controlled by the CT node. Following Sagey (1986), Bao suggests that Register/voicing is executed by the articulator CT, and Tone by Vocalis. Bao's model gives two voicing contrasts and four tonal levels.

It is clear that Bao's model allows spreading of Register and Tone, of Register alone, and of Tone alone. It may also explain why the initial pitch of [a] is higher in [pa] and lower in [ba]. Although Bao does not discuss tonogenesis, tone split, depressor consonants, etc., such issues may also be handled, as we will see in the next section.

In my view, Bao's model in (30) is fundamentally correct. Except for a few minor changes, most of it will be adopted in the model I argue for below.

3.1.8. The Present Model

The model I argue for is basically similar to that of Meredith (1988) and Bao (1990a). It is repeated below

```
(1)          Laryngeal
              /    \
           V/R    Pitch              (V/R = Voicing/Register)
           / \     / \
        [st][sl][above][below]
```
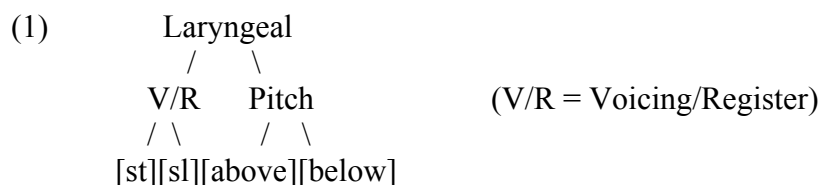
(1) differs from (30) in a few ways. First, while (30) gives two voicing contrasts, (1) gives three. Evidence for three voicing states can be found in consonant blockers (Hyman & Schuh 1974) and numerous tone split cases, where sonorants differ from [+voice] and [-voice] obstruents (unlike the suggestion of Mester & Ito (1989:279), therefore, [voice] will not be 'universally privative'). Similarly, (1) permits three Pitch contrasts, for the reason that in languages like Yoruba, there are three tonal levels but little evidence of Register. Second, while Bao suggests that the articulator for Register/voicing is the cricothyroid muscles, and that that for Tone is the vocalis muscles, I do not find the evidence clear.[6] Therefore I have labeled the articulators with non-articulatory terms, although, I speculate, V/R probably relates to the vocalis muscles and Pitch to the cricothyroid muscles (unlike Bao's speculations). Third, while Bao considers both Register and Tone to be of vocal cord tension, with an ==arbitrary== choice of [st] for one and [sl] for the other, to me they should have different features. Specifically, V/R is probably related to vocal cord tension (thus [st, sl]), but Pitch is probably related to vocal cord thickness. Moreover, I use Pitch for Tone, not just to save 'tone' for the entire structure, but there is evidence that, while Register normally affects pitch, it primarily affects voice quality (Duanmu 1990, 1991).

The features [above] and [below] are my own innovations. It is well-known that humans can articulate and perceive far more pitch levels than are found in tone languages. It is therefore misleading to use tonal features like [H] and [L], or [thick] and [thin], as if the vocal cords are restricted to such binary activities. However, the question remains why so few tonal levels are utilized in human speech. The answer, I suggest, is twofold. First, humans are good at relative pitch, but poor at absolute pitch, both in generation and in perception. Second, people's pitch ranges differ from time to time, and from person to person. Thus, given a tone, it is hard to tell how high it is, and harder still to tell how high it is for a stranger. On the other hand, given two levels, it is easy to tell whether the pitch is going up or down, even if the difference is very slight. If the tone speaker has a reference pitch level, so that any tone above it is H, below it L, and otherwise M, then his/her job will be much ==easier==. The fact that the tone speaker rarely mislocates a tone level, even with strangers, suggests that s/he indeed has this reference level. The key is, what supplies this reference level? I suggest that it is the onset. Acoustic studies show that tone (i.e. expected pitch contour) does not begin until the nuclear vowel, and that onsets, overall, remain at the mid pitch level (Kratochvil 1970, Howie 1976). Further support comes from the fact that tone languages usually have obligatory onsets, as I have independently argued for all Chinese languages. What is more, there is no tone language, to my knowledge, that has more than three tone levels without ==splitting== them into two registers. Register in turn independently supplies voice quality cues (cf. Duanmu 1990). [above] and [below] reflect the relative nature of pitch and the importance of the onset. They refer to an effort by the Pitch articulator to move the pitch above, or below, the reference line, wherever this line is at a particular point.

(1) gives a total of nine tonal levels, same as given in Hyman (1989). There is, however, an important difference. To Hyman, the nine tonal levels are nine pitch levels, but to me, the case need not be so. It is true that in (1), the higher the register, the stiffer the vocal cords, and so the higher the pitch. But vocal cord stiffness (Register) may be offset by vocal cord thickness

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[6]. For example, there seem to be at least three ways to affect pitch, (i) tensing the vocal cords by the vocalis muscles, (ii) stretching them via cricothyroid muscles, and (iii) lowering the larynx (cf. Ohala 1978, Anderson 1978). Phonologically, however, we seem to need just two notions, Register and Tone, and it is not clear which notion relates to which mechanism.

(Pitch), since the two mechanisms are independent. In particular, Duanmu (1990) shows that, in Shanghai, Register is always reflected by voice quality, but not always by pitch, and that tones in a higher register need not always be higher in pitch (though they usually are). If this finding has generality, then the nine tone levels are not distinguished by pitch alone. Instead, voice quality will split them in three Registers, and in each register, there are at most three pitch levels. Specifically, for any language that has more than three level tones, such as Black Miao and Tahua Yao Chang (1953), there should be voice quality differences among the tones. I leave this prediction open.

A final difference between (30) and (1) lies in the position of tone in the overall feature geometry, as shown below

(32)   a.   Root   b.   Root
                        / \   / \
              Laryngeal ...   Laryngeal   ...
              / | \   / | \
          ... VC   Glottis   V/R Pitch Ary
              / \   / \   ...   .   Ary = Arytenoids
          CT VOC [cg] [sg]   VOC = Vocalis
          | | VC = Vocal-cords
         [st] [sl]   CT = Crico-thyroid
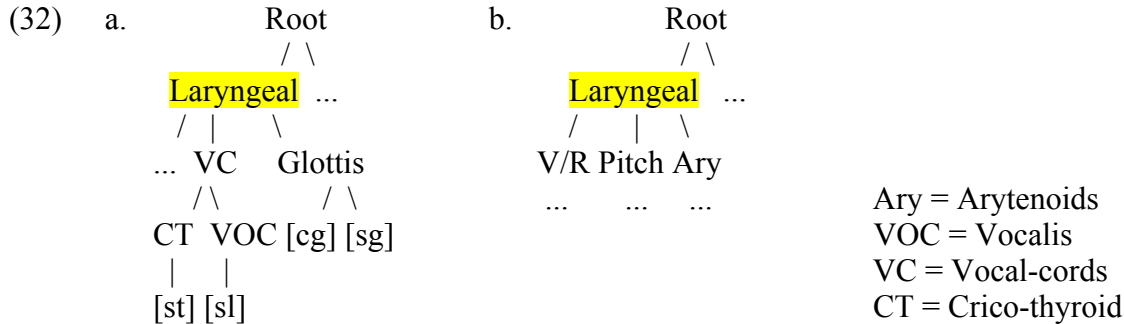
In (32a), from Bao (1990a,153), Laryngeal dominates VC and Glottis. While Glottis is an articulator, VC probably is not, since VC itself dominates two articulators CT and VOC; thus, there seems to be a confusion of levels. In my model (32b), Laryngeal dominates three articulators, V/R, Pitch and Arytenoids (controlling aspiration); this model predicts that when V/R and Pitch both spread, Arytenoids should go with them, since they are all under Laryngeal. Relevant evidence is not clear on this point, and I leave it open.

With the notion Register (from Yip 1980), (1) can reflect the interrelations among tones. With [st, sl] (from Halle & Stevens), (1) can explain why [a] has a higher initial pitch in [pa] and a lower initial pitch in [ba]. Let us now see how (1) accounts for more complicated facts in (7). For convenience, I will often write [H] for [above] and [L] for [below].

3.1.8.0. Too Many Contrasts?
(1) gives up to nine level tones. To my knowledge, the largest number of underlying level tones in a language is five (Black Miao and Tahua Yao, in Chang 1953). Five out of nine is not an unreasonable ratio, considering how few segments a language uses out of the entire known inventory (cf. Maddieson 1984). Nevertheless, in bimoraic syllables, (1) in principle allows up to 9x9=81 contour tones, far exceeding the inventory in any language (most Chinese languages have below eight underlying syllable tones). What is more, if onset consonants also bear tones (Kingston & Solnit 1988), the potential number will go much higher.

To reduce the potential number to a realistic level, I suggest the following two universal constraints

(33)   a. Only segments in the rime (bearing a mora) can be assigned Pitch.
         b. One Register per syllable.

(33a) has been a widespread assumption, and (33b) has been proposed in Yip (1980, 1989a) and Bao (1989, 1990a). Both constraints have broad empirical support.[7] But why should there be these constraints? The explanation for (33a), I suggest, is that onsets have the function of supplying the reference pitch level, so they cannot be TBU any more (cf. our earlier discussions of [above] and [below]). The explanation for (33b) is that tonal registers come from onset voicing during tone split, and there is just one onset in each syllable. Of course, further questions remain: why do vowels not have their own V/R before tone split? Are all tone languages derived from non-tone languages? I have to leave these questions open.

3.1.8.1. Spreading
It is clear that (1) allows the spreading of V/R and Pitch, V/R alone, or Pitch alone. In addition, (1) predicts that consonants are usually transparent to Pitch spreading, but opaque to V/R spreading; this is because consonants usually have the V/R node, but not the Pitch node (unless they occur in the rime). This explains why long distance Pitch spreading is common (e.g. Sietsema 1989), but long distance V/R (Register) spreading is rare. When V/R does spread, it must change the voicing of the intervening consonants. This can be seen in Wuyi (G.Fu 1984, Bao 1990a), repeated below

(14)   sa 24 v^wo 31   --->   sa 24 f^wo 53   'half-cooked rice'
        [+u, LH]   [-u, HL]   [+u, LH]   [+u, HL]

When the second syllable changes from the lower register [-u] to the upper register [+u], its onset changes voicing, too, as illustrated below

(34)   24   31   24   53
        [s   a v^w o]   --->   [s a f^w o]
        ...   [+u]   [-u]   ... [+u]   [+u]
                 V-C V-C V-C   V-C V-C V-C
                 | | | |
                 V/R V/R V/R   V/R
                 | | | |
                 [+st] [+sl] [+sl]   [+st]

Let us ignore the issue of contour tone here, and focus on how V/R spreads from [a] across [v^w] to [o]. Since [v^w] and [o] already have V/R, the only way to do it is to replace their V/R nodes

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[7]. (33) reduces potential bimoraic tones to 3x3=9 without Register, or 3x3x3=27 with Register. There is likely a further constraint that pitches contrast by direction and not by degree. I have already argued that H, L and M do not contrast by their absolute heights, but by their being rising, falling and leveling, respectively, from the onset pitch. Similarly, pitch alone should not contrast [53] and [51] nor [13] and [15], unless there are other cues. For example, Igbo contrasts [HM] and [HL] on single syllables, but to my ear [HM] is [533] and [HL] is [51] in Chao letters; [HM] (or [H!H], from [HLH]) is clearly longer and has a period of leveling after the initial fall, while [HL] is a straight fall. (Thanks to P. Ihionu for discussions and for being the informant.) If this additional constraint is correct, there are just 9-2=7 bimoraic tones without Register, or 3x7=21 with Register; both seem to be reasonable numbers.

with that of [a], changing [v^w] to [f^w] and [o 31] to [o 53].[8] Tone split and depressor consonants are other cases of V/R spreading, which will be discussed in section 3.1.8.4.

Most African languages have two or three tones, and spreading is common. The fact that African tone spreading does not cause onset voicing change shows, in our theory, that such tones are related to Pitch, not V/R (Register).

3.1.8.2. Translation from Chao Letters
In Yip (1980,1989a) both Register and Tone are properties of pitch. The translation from Chao letters is simple

Register	Tone	Chao Letters
[+upper]	[+high]	5
	[-high]	4
		3
[-upper]	[+high]	2
	[-high]	1

All tones above 3 are [+upper], and all below 3 are [-upper]. It is, however, very common that [+upper] tones overlap in pitch with [-upper] tones. For example, Shanghai has two rising tones [24] and [13] (Xu et al 1981). [24] is [+upper], and [13] [-upper]. Yet the initial pitch of [24] is lower than the final pitch of [13]. Similarly, what is called [53] in Shanghai in fact spans the

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[8]. There is also an alternative analysis. Consider additional data
   (i) Hneng 213 kau 53 --> Hneng 213 kau 53 (*Hneng 213 gau 31)
        [-u]   [+u]   [-u]   [+u]   [-u]   [-u]
[Hn] indicates murmured [n], which we assume to be [-u]. In (i) [-u] does not spread. In other words, [+u] spreads, but [-u] does not, i.e. we see an asymmetry between [-u] and [+u]. Following the theory of underspecification, we may assume that, in both consonants and vowels, underlyingly only [+st] is specified, and [+sl] is not, as illustrated below

```
(ii)    a.      a           v^W      o           -->      a           f^W      o
                [+u]                 [-u]                  [+u]                 [+u]
                V-C     V-C     V-C                        V-C     V-C     V-C
                 |                                          |  ┌───────┴───────┐
                V/R                                        V/R
                 |                                          |
                [+st]                                      [+st]


        b.      ...eng    k      a ...  --> (no change)
                [-u]             [+u]
                        V-C    V-C
                         |      |
                        V/R    V/R
                         |      |
                        [+st]  [+st]
```

In (iia), V/R of [a] spreads, because nothing blocks it. In (iib), [..eng] has no V/R, so there is nothing to spread. There is therefore no [-u] and [+u] asymmetry.

entire pitch range, although it is [+upper] (cf. Zee & Maddieson 1979 and Duanmu 1990 for F0 contours). Such overlaps must be attributed to phonetic effects by Yip, as well as by Hyman (1989) and Bao (1989, 1990a).

In my system, Register is primarily a voicing property; its effect on pitch is secondary. There is thus no rigid relation between Register and F0, nor is there a simple translation from Chao letters. For me, a rise in the upper register normally has a higher overall pitch than a rise in the lower register, but some overlap is possible. For level tones, I predict that [+st, +H] normally has a higher pitch than [+sl, +H], but [+st, +L] may or may not have a higher pitch than [+sl, +H]. In a language with four tones, Yip has one translation, but I have (at least) two

(35)		[55]	[33]	[22]	[11]
Yip, Bao:		[+u, +H]	[+u, -H]	[-u, +H]	[-u, -H]
Duanmu:	i.	[+st, +H]	[+st, -H]	[+sl, +H]	[+sl, -H]
	ii.	[+st, +H]	[+sl, +H]	[+st, -H]	[+sl, -H]

In particular, I entertain (ii), where [33] is in the lower register and [22] in the upper.

Tones like [51] and [15] are not permitted in Yip (1980), because every tone must be either [+upper] or [-upper], and so no tone should cross the mid-pitch 3. Thus, Mandarin [51] is modified to [53] (cf. Yip 1980:283-284).[9] The problem with this analysis is that too many tones must be modified. In his survey of Chinese dialects, Packard (1989,20) finds that 33% of all contour tones cross the mid-pitch 3. This ratio, Packard argues, is too high to be attributed to phonetic effects. The solution, Packard suggests, is to allow a syllable to have two values for Register. The problem with Packard's analysis is that it fails to reflect the fact that Register comes from onset voicing during tone split, and so it is hard to explain where the second Register value comes from. In my analysis, there is no need to modify [51], [15], etc., and so no need to posit two Register values per syllable. For me the relation between Register and F0 is not rigid, so there is no prohibition on crossing the mid-pitch. Besides, for me a language need not have Register at all (or have [-st,-sl] for all tones); in this case [LH] may well be [15] and [HL] may be [51]. I suspect that many Northern dialects, such as Mandarin, belong to this kind.

3.1.8.3. Mon-Khmer Register and Tonogenesis
The loss of onset voicing contrast may either lead to a change in vowel quality, as in Mo-Khmer, or to tonogenesis, as in Tibetan. It has been a major puzzle how the same source may lead to two outcomes. Below I show that (1) can provide an account.

3.1.8.3.1. The Mon-Khmer Register
In Mon-Khmer languages, historical onset voicing is often lost. But unlike in Lhasa Tibetan, the loss of onset voicing has not led to tonogenesis in Mon-Khmer, but to a split in vowel quality. Mon-Khmer vowels are divided into two 'registers'. The first and second registers occur with

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[9]. Yip argues that in words like da(T4) shu(T4) 'big tree', the first T4 is [53], so T4 is underlyingly [53]; the fact that T4 is [51] in final positions is due to 'a phonetic detail'. However, T4 is [51] not only finally but also nonfinally, as in dian(T4) ying(T3) 'movie' and bian(T4) le 'changed'. It is the [53] da(T4) shu(T4) that is more likely due to phonetic effects, partly because in such words, the first syllable has less stress (Chao 1968:29).

(originally) voiceless and voiced onsets respectively. Vowels in different registers have different voice qualities and/or height; relevant facts are summarized below (from Gregerson 1976:323)

(36)

	Onset	Vowel Quality	Vowel Height	Pitch
First Register	(original) surd	normal head clear tense	more open, onglided	relatively higher
Second Register	(original) sonant	deep breathy sepulchral chest relaxed	close, centering diphthongs	relatively lower (larynx also lowered)

It is not clear how to convert Gregerson's terms into features. Nevertheless, a sketchy outline can be drawn. Suppose, following Halle & Stevens, that the vocal cords are stiff in voiceless obstruents and slack in voiced obstruents, a transfer of these properties to the vowel will lead to 'normal and clear' quality and 'relatively higher' pitch in the former, and 'deep, breathy and relaxed' quality and 'relatively lower' pitch in the latter. Moreover, it is well-known that the pharyngeal cavity is narrowed in voiceless obstruents, and widened in voiced obstruents. This may have lead to 'more open' vowels after voiceless obstruents, due to retracted tongue root, and more 'close' vowels after voiced obstruents, due to advanced tongue root, via enhancement. After the changes in vowel height, the voice quality (due to vocal cord tension), i.e. 'clear' v. 'breathy', or in our terms [+st] v. [+sl], become redundant and may then drop out. This is what happened to modern Cambodian, according to Huffman (1974:578), who suggests the following stages

(37) Stage 1: voicing distinctions on onsets; no vowel differentiation.
      Stage 2: voicing distinctions on onsets; with complementary register (i.e. voice
                quality) split in vowels.
      Stage 3: optional loss of onset voicing; register split in vowels becoming distinctive.
      Stage 4: full loss of onset voicing; registers remain fully distinctive on vowels.
      Stage 5: changes in vowel height and diphthongization; loss of register contrast.

In his survey of Mon-Khmer, Huffman found 'each of the five stages mirrored in one or more of the fifteen languages' he looked at. Ignoring Stage 3 and 5, the development of modern Cambodian is represented in our analysis as follows

(38) C   V   C   V   C   V
      Lar Lar →   Lar Lar ---> Lar Lar
       | | / |
      V/R   V/R   V/R
       | | |
      [...]   [...]   [...]

Mon-Khmer register will help us understand tonogenesis. But before then, we need to introduce discuss the notion 'acoustic enhancement', proposed recently by Stevens & Keyser (1989).

3.1.8.3.2. Enhancement

In feature geometry, features that appear and disappear together during assimilation processes are grouped under the same node. Assimilation processes, therefore, are each seen as the spreading of a node (cf. Clements 1985). An additional merit of feature geometry is that the feature groupings turn out to match human articulators; this coincidence, in Halle's words, 'is a fact of some significance' (Halle 1988:9).

There are, however, many cooccurrence relations that feature geometry fails to capture. For example, cross-linguistically, [+stiff vocal cords] and [+spread glottis] (or [-voice] and [+aspirated]) tend to cooccur, and [+slack vocal cords] and [-spread glottis] (or [+voice] and [-aspirated]) tend to cooccur. But feature geometry has nothing to say as about such relations. Similarly, cross-linguistically, front vowels tend to be unrounded and back vowels tend to be rounded, but feature geometry is again unable to give any explanation. Note that the cooccurring features [back] and [round] belong to different articulators (Dorsal and Labial), which in feature geometry have little to do with each other.

Stevens & Keyser suggest that the above cooccurrence relations may be captured by the notion 'acoustic enhancement'. For example, back vowels have longer front cavity, which gives a lower formant; lip rounding will make the front cavity still longer, which gives a even lower formant. [+round], therefore, acoustically enhances [+back]. On the other hand, front vowels have a shorter front cavity, which gives a higher formant; unrounding the lips will make the front cavity still shorter, which gives a even higher formant. [-round], therefore, enhances [-back]. Similarly, aspiration enhances voicelessness and lack of aspiration enhances voicedness. Enhancement offers a vital supplement to feature geometry by capturing cooccurrence relations that are left out in the latter. It also offers the basis for redundancy rules. For example, [-back] and [-round] need not both be specified; specifying one will trigger the specification of the other. We will see below that enhancement plays a key role in our account of tonogenesis and blocker consonants.

3.1.8.3.3. Tonogenesis

We now turn to tonogenesis. Recall that in Kingston & Solnit's analysis, tonogenesis happens when the onset spreads its tonal features to the vowel. Their analysis assumes that in classic Tibetan consonants have tones while vowels do not. This assumption is highly counter-intuitive, and unsupported by independent evidence. I will now offer a different analysis. I will assume that in non-tonal languages vowels are unspecified for Pitch, and that onsets are universally unspecified for Pitch. Below is the analysis of Tibetan tonogenesis (Hu 1980)

(39)   a.   kʰo-->kʰó

```
                  i                  ii
            Lar  Lar -->   Lar Lar  -->     Lar Lar
             |             | /              | / |
            V/R            V/R              V/R  Pitch
             |             |                 |    |
            [+st]          [+st]            [+st] [+H]
```

b. go-->kʰò

```
              i                ii                iii
         Lar  Lar -->    Lar Lar  -->    Lar Lar  -->    Lar      Lar
          |              | /             | /\            |        /\
         V/R             V/R             V/R  Pitch      V/R  V/R  Pitch
          |              |               |    |          |    |    |
         [+sl]           [+sl]           [+sl] [+L]      [+st] [+sl][+L]
```
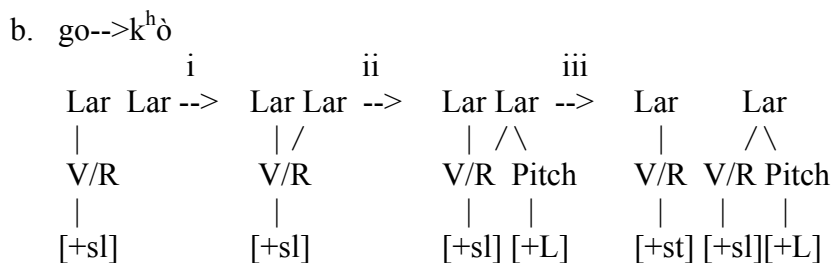
In (39a), in step (i), [kh] spreads its V/R to [o]. In step (ii), which is the crucial step, the vowel acquires [+H], triggered by [+st]. This step has no explanation in feature geometry, but as we have already discussed, it can be accounted for by 'enhancement'; both [+st] and [+H] enhance high pitch, and so the presence of one tends to trigger the other as a redundancy rule. Note that the onset does not acquire [+H] by acoustic enhancement, for the reason that, universally perhaps, onsets do not bear tones. (39b) is accounted for in the same way, except [g] further devoices to become [kʰ] by another rule.

All four stages in (39) are attested. The first stage, before V/R spreading, corresponds to classic Tibetan. The second stage, between (i) and (ii), corresponds to Mon-Khmer languages, where vowels show voice quality split but no tone. The third stage, between (ii) and (iii), corresponds to Xiahe and other Amdo Tibetan dialects, in which voicing is not yet lost and vowels carry 'habitual tones' (Hu 1980). The last stage, after (iii), corresponds to Lhasa and other Weizang dialects, where onset voicing is lost.

3.1.8.4. Tone Split and Depressor Consonants
A good case of tone split is seen in Shanghai, where onset voicing causes a register split (e.g. Yip 1980)

(40)   Upper   song 24 'give'   so: 24 'sun-bathe'
        Lower   zong 13 'heavy'   zo: 13 'tea'

As the Chao letters show, all four words are rising; [song] and [so:] are high rises, and [zong] and [zo:] low rises. Historically, the four words had the same tones; now their tones are split according to onset voicing. Voiceless onsets, as in [song] and [so:], give rise to the upper register, and voiced onsets, as in [zong] and [zo:], give rise to the lower register. In our analysis, tone split on [song] and [zong] can be represented as follows

```
(41)    a.  [s        o       ŋ ]        [ s   o       ŋ ]
           Lar      Lar     Lar --->    Lar Lar     Lar
            |        |       |           | /\        |
           V/R     Pitch   Pitch        V/R Pitch   Pitch
            |        |       |           |    |       |
           [+st]   [+L]    [+H]         [+st] [+L]   [+H]
```

b. [z   o   ng]   [z   o   ŋ]
     Lar   Lar   Lar --->   Lar Lar   Lar
      | | | | / \ |
     V/R   Pitch Pitch   V/R Pitch Pitch
      | | | | | |
    [+sl]   [+L]   [+H]   [+sl] [+L]   [+H]   [H] = [above]
                                                      [L] = [below]

We assume that, universally, onsets are unspecified for Pitch features, and that before register split, rime segments are unspecified for V/R features. The V/R node of the onset is then spread to the nuclear vowel, and probably further to the coda (which we have not shown). The V/R node is not yet deleted from the onset in Shanghai, so register is not yet fully distinctive.[10] But onset voicing is lost in many other Chinese languages, such as Cantonese, leaving register a distinctive feature.

Our account of tone split can be applied to Bantu 'depressor consonants', which are voiced obstruents that lower the tone of a neighboring vowel (cf. Laughren 1984 and references cited there). In Laughren's analysis (p209), depressor consonants have the feature [+slack vocal cords]; this is in agreement with our analysis. Consider a case in Zulu (Laughren, p210)

(42)   a. 3 2 2-8 9   b.   6 6 3-8 9
            isihla: lo 'seat'   izihla: lo 'seats'
            | \/\/   \/   /\/
            L H L   L! H L   (L! = extra L)

The numbers indicate pitch, with 1 being the highest and 9 the lowest. We see that the initial vowel is 3 in (42a) but 6 in (42b); this is because [z] is a depressor, which lowers L to extra L. The extra L of the first vowel is later spread to the second vowel by an independent rule. In our analysis, the pitch lowering effect can be seen as V/R spreading from the depressor to the vowel. For illustration, we show the changes in the first two segments

(43)   i   z   i   z
        L   L!
        Lar   Lar --->   Lar Lar
         | | / \ |
       Pitch   V/R   Pitch V/R
         | | | |
        [+L]   [+sl]   [+L] [+sl]   [L] = [below]

In the input, the vowel [i] has the Pitch feature [+below] (i.e. L) and no V/R feature, while the depressor [z] has the V/R feature [+sl] (i.e. lower register) and no Pitch feature. [z] then spreads its V/R node to [i], making the latter [+below, +sl], i.e. a lowered L, or L in the lower register.

---

[10]. In Shanghai, tone split happens in initial and isolated syllables only. For older speakers the onset voicing contrast is still maintained, but for many younger speakers onset voicing is neutralized. In non-initial syllables, the onset voicing contrast is maintained for both speakers, and there is no tone split.

Although Zulu depressor consonants may push an adjacent H away, as seen in (42), they do not lower H tones. This is show below (Laughren, p219)

(44)   um!fazi... 'woman'   i!nkunzi... 'bull'
        |/   \ / | \ /
        H L H L   H L   H L   (*H L H! L)

In (44), the depressor [z] has no effect; it does not lower H. It is not clear whether depressors ever lower H in other languages. In any case, we need to explain why [+sl, +H] does not occur in Zulu. The answer, I suggest, lies in enhancement. [+sl] and [+H] disagree in enhancement; the former lowers pitch, while the latter raises it. It is natural, therefore, that [+sl, +H] is ruled out in Zulu, for the same reason that [+round, -back] is ruled out in English.

3.1.8.5. Blocker Consonants
I have assumed that onsets are universally unspecified for Pitch. They are, therefore, transparent for Pitch spreading. This is true in many languages, such as in Yoruba (Pulleyblank 1986:110), where H and L may spread across any consonant. Below is an example

(45)   [d   í   d   ù   n] →   [d   í   d   û   n]
        ...   Lar   Lar   Lar   ...   ...   Lar   Lar   Lar   ...
                 | | | | | |
                 Pitch V/R   Pitch   Pitch V/R   Pitch
                 | | | | | |
                 [+H]   [+sl] [+L]   [+H]   [+sl] [+L]

There are, however, languages in which consonants may block tone. Blocker consonants are reported in Nupe and Ngizim (Hyman & Schuh 1974), repeated below

(12)   a.   [àpá] --> [àpá] (*[àbǎ])   b.   [ápà] --> [ápâ]
        c.   [àbá] --> [àbǎ]   d.   [ábà] --> [ábà] (*[ábâ])
        e.   [àwá] --> [àwǎ]   f.   [áwà] --> [áwâ]

[p] blocks L-spreading, [b] blocks H-spreading, while [w] blocks neither. In (12a). Consider (12d) first, whose derivation is as follows

(46)   [á   b   à]   --->   *[á   b   â]
        Lar   Lar   Lar   Lar   Lar   Lar
        | | | | | |
        Pitch   V/R   Pitch   Pitch V/R   Pitch
        | | | | | |
        [+H]   [+sl] [+L]   [+H]   [+sl] [+L]

Ignoring Supralaryngeal features, (45) and (46) are exactly alike. Why then is (45) good and (46) bad? This is a problem for any theory. We must propose a language particular rule by which [+sl] blocks [+H]. But why is there such a rule? Why, for example, do we NOT find [+st] blocking [+H]? The answer, I suggest, again lies in enhancement. [+H] and [+st] enhance each

other, both giving higher pitch, so they are likely to occur on the same segment; the same is true for [+L] and [+sl]. On the other hand, [+H] and [+sl], or [+L] and [+st], disagree in enhancement, so they are less likely to occur on the same segment. Enhancement, however, is not a principle, but a tendency. A tendency may be observed in some languages but not in others.

We can now see why [+H] may spread across [+sl] in Yoruba but not in Nupe and Ngizim. Suppose that, when a feature F spreads across a segment S, S acquires F by phonetic percolation, [b] in (45) and (46) will then acquire [+H] after the spreading, and become [+H, +sl]. Nupe and Ngizim apparently disallows such a combination, due to enhancement incompatibility; Yoruba, on the other hand, apparently tolerates it. The same explanation may be given to (12a).

3.1.9. Summary

I have compared seven tonal models, (1) and (6a-f), against a wide range of facts summarized in (7). I have shown that only (1) successfully accounts for all the facts. I have left some topics undiscussed, however, notably 'downstep', 'upstep', and the effect of ejectives on tone. I leave them for further studies.

Tone has been considered suprasegmental (W. Wang 1967), segmental (Woo 1969), and autosegmental (Williams 1971/1976 and most current workers). In a sense, (1) treats tone as segmental. However, integrated in feature geometry (Clements 1985; Sagey 1986; McCarthy 1988; Halle 1989), (1) avoids most criticisms Woo has received from autosegmental phonologists (Williams 1971/1976; Leben 1973, 1978; Goldsmith 1976; Yip 1980; etc.). In particular, in feature geometry, most features are on independent tiers (except [cons] and [son] perhaps, cf. McCarthy 1988), so features may spread without being 'autosegments', i.e. without being detached from the rest of the 'segment'. Indeed, once tone, the archetype autosegment, is gone, one wonders if there is any autosegment left.

3.2. Tonal 'Flip-Flop'

In our tonal model, voicing is identified with Register, so in tone split, there is a relation of 'voiceless-high' and 'voiced-low', i.e. voiceless onsets should lead to higher tones, and voiced onsets to lower tones. Yue-Hashimoto (1986) notes that, although we generally find voiceless-high and voiced-low, it is not uncommon to find voiceless-low and voiced-high, i.e. tones with historically voiceless onsets are now lower that tones with historically voiced onsets. Let us call the latter case 'Register-reversal'. In her survey of 997 Chinese dialects, Yue-Hashimoto found 340 cases of Register-reversal in 'citation tones', i.e. tones on isolated syllables. Her survey is summarized below (Yue-Hashimoto 1986:164)

(47) | Dialect Family | Number of Dialects | Ping | Shang | Qu | Ru |
|---|---|---|---|---|---|
| Northern | [782] | 217 | 0 | 3 | 6 |
| Xiang | [77] | 5 | 0 | 3 | 0 |
| Gan | [46] | 14 | 0 | 3 | 9 |
| Yue | [39] | 5 | 0 | 2 | 4 |
| Hakka | [19] | 3 | 0 | 0 | 16 |
| Min | [39] | 7 | 4 | 20 | 18 |
| Wu | [49] | 0 | 0 | 0 | 0 |

Ping, Shang, Qu and Ru are names of the four classic Chinese tones before tone split. Most dialects do not show Register-reversal; for example, in the Northern family, there are 226 reversed tones out of 782 dialects, where each dialect may have up to eight tones). Nevertheless, the number of reversals (340 in all) is significantly large that it poses a potential problem for the generalization of voiceless-high and voiced-low.

Kingston & Solnit (1988) argue that Register-reversal is evidence that there is no relation between voicing and Register (in their words between voicing and tone). Yue-Hashimoto, on the other hand, argues that voiceless-high and voiced-low is universally true, and that Register-reversal is due to tonal 'flip-flop' (a notion from Wang 1967), which takes place after tone split. Yue-Hashimoto's position depends on two crucial points: first, Register-reversal happens AFTER tone split, and second, there is independent evidence of flip-flop rules. As we will see, both points are correct.

We look at tonal flip-flop first, which is an instance of a more general 'switching rule' $[\alpha F] \rightarrow [-\alpha F]$, where $[F]$ is any feature. If switching rules exist, it is then natural to assume tonal flip-flop, such as $[+H] \rightarrow [-H]$, $[+sl] \rightarrow [-sl]$, etc. Independent switching rules are not unusual. A well-known case is the Great Vowel Shift in English (Chomsky & Halle 1968). Another case is found between Santai and Mandarin, where [hw] switches with [f]

(48) | Mandarin | Santai | |
|---|---|---|
| hwei | fei | 'ashes' |
| fei | hwei | 'to fly' |
| hwang | fang | 'yellow' |
| fang | hwang | 'house' |
| hei | he | 'black' |
| hao | hao | 'good' |

What is [hw] in Mandarin, which preserves the older onsets, has changed to [f] in Santai, and [f] to [hw]. A simple [h] in Mandarin, however, does not change to [f] in Santai.[11] Note that there is

---

[11]. The switch between $[h^w]$ and [f] may be one of the value of [cons], as shown below (in the feature geometry of Sagey 1986 and McCarthy 1988)
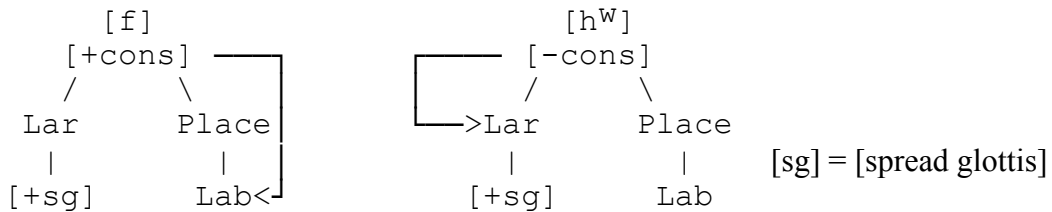
no apparent trigger for the switch. Thus, there is no theoretical problem to assume tonal flip-flop, even if there is no apparent trigger.

Let us now look at the time of tonal flip-flop. As Yue-Hashimoto notes, all languages that exhibit tonal flip-flop has lost onset voicing contrast, an observation that is also confirmed by Kingston and Solnit (p33). Consider (47) again. There is one family, the Wu family, in which Register-reversal has not taken place. This is no accident. Of all families, only Wu has preserved onset voicing contrast; all the others have lost it. This fact supports the assumption that Register-reversal took place after tone split.

There are three further points if interest about (47). First, in the Northern family, Register-reversal occurs mostly with Ping. This is because in this family the other three tones often have not undergone split. Second, in the Min family, there is a much higher rate of Register-reversal that in other families, and it occurs with all of Ping, Shang, Qu and Ru. There are, however, two special properties of Min dialects. First, Min has domain final stress (cf. Wright 1983, Chen 1987). Second, there is extensive tone sandhi in nonfinal positions, but as Yue-Hashimoto notes (p167)

> (A)ll of the Min dialects show a reversal of pitch values in tone sandhi--namely, the Yin (i.e. voiceless onset) tone is higher in pitch and the Yang (i.e. voiced onset) tone is lower in pitch. Moreover, tone sandhi may involve either the Yin or the Yang or both categories, but still results in a higher overall pitch for the Yin category and a lower overall pitch for the Yang category.

In other words, although many citation tones show voiceless-low and voiced-high, in non-final positions all tones are voiceless-high and voiced-low. This fact has lead Woo (1969), Hashimoto (1982) and Ting (1982) to suggest that the underlying tone of a Min syllable is the nonfinal tone, not the final or citation tone; the final tone undergoes Register-reversal probably due to the final stress, as Yue-Hashimoto suggests.[12]

```
         [f]                        [hʷ]
      [+cons] ───┐       ┌─── [-cons]
       /     \   │       │    /     \
     Lar    Place│       └─>Lar    Place
      |      |   │          |       |      [sg] = [spread glottis]
    [+sg]   Lab<─┘        [+sg]     Lab
```
The two representations are identical, except in the value of [cons] and the pointer. However, the pointer switch follows from [cons] switch, since [+cons] cannot have Laryngeal as the major articulator, nor can [-cons] have Labial as the major articulator.

[12]. The fact that extra stress may cause pitch reversal is perhaps also true in English. For example, English stressed syllables normally have high pitch and unstressed ones low pitch. But if one wants to emphasize the entire sentence, i.e. in a sense put extra stress on every syllable, there can be a pitch reversal, as shown below

	what	a	good	i-	dea	
Stress	*	.	*	.	*	* = stress
Normal Pitch	H	L	H	L	H(L)	(L) = final pitch drop
Emphatic Pitch	L	H	L	H	L	

For the third point, we note that in Hakka Register-reversal occurs mostly with Ru. We expect, following the analysis of Min, that in nonfinal positions, the reverse will take place, i.e. voiceless-Ru returns to a high tone and voiced-Ru to a low tone. This is indeed true in Raoping, Miaoli (Si Xian), and Taoyuan, as shown below (Yue-Hashimoto, p166)

(49)	RAOPING	Nonfinal	Final	
		45	31	voiceless-Ru
		31	45	voiced-Ru

(50)	MIAOLI	Nonfinal	Final	
		5 or 3	2	voiceless-Ru
		2	5	voiced-Ru

(51)	TAOYUAN	Nonfinal	Final	
		4	53	voiceless-Ru
		31 or 33	55	voiced-Ru

While it is not very apparent, which features switch final tones to nonfinal tones, it is clear that in all the three Hakka dialects Yue-Hashimoto discusses, nonfinal tones are voiceless-high and voiced-low.

In summary, Register-reversal does not pose a problem to our model (1), which assumes voiceless-low and voiced-high, because Register-reversal takes place after tone split, and because switching rules are independently motivated.

3.3. Consonant TBU and the Ru Syllable

Unlike Woo (1969), who stipulates that only vowels and sonorant consonants can be TBUs (tone bearing units), the model (1) allows obstruents to be TBUs, too, i.e. to have the Pitch node. On this point my position is similar to that of Kingston & Solnit (1988). However, my position differs from that of Kingston & Solnit in that they permit consonants to bear tones ANYWHERE, while I assume that consonants are assigned tones only when they occur in the rime. Consonant TBUs are found in both African and Chinese languages. Consider a case in LuGanda (Clements 1986)

(52)	a.	kùlábà	'to see'	
	b.	kùlábìká	'to be visible'	

(53)	a.	kùlíNNá	'to climb'	(N is palatal nasal)
	b.	kùcóppá	'to become a pauper'	

(...the best way to survive an accident,)	is	not	to	get	in-	to	one
Stress	.	*	.	*	.	.	*
Normal Pitch	L	H	L	H	L	L	H(L)
Emphatic	H	L	H	L	H	H	L

The <mark>emphatic</mark> form of the second sentence is heard from a TV commercial.

All the words have the pattern [LHLH], and the TBU is the moraic segment, or the segment in the rime. In (52a) the final [H] does not show up, because the word is one mora short. In (53a), the third tone [L] is carried by [N], because [N] is in the rime. Similarly, in (53b), the third tone [L] is carried by [p], even though [p] is an obstruent and voiceless. That [N] and [p] carry [L] is supported by the fact that the last vowel [a] in (53a, b) carry [H]; if [N] and [p] did not carry [L], it should appear on the final [a], as in (52a).

Many Chinese languages have Ru syllables, whose coda is one of [p t k ?]. For Woo, Ru syllables have just one TBU, the nucleus, but for me all Ru syllables should have two TBUs, the nucleus and the coda. 'Ru tones' (i.e. tones on Ru syllables) phonetically differ significantly from 'non-Ru tones', not only because the pitch on [p t k ?] can not be heard, but also because the [p t k ?] codas are usually glottalized, hence obscuring the pitch on the nuclear vowel as well. For this reason, traditional analyses usually list Ru tones separately from non-Ru tones. However, phonologically, many Ru tones are no different from non-Ru tones. Consider a case in Shanghai (Xu et al 1981, in Chao letters)

(54)   Monosyllabic Bisyllabic   Trisyllabic   Quadrisyllabic
      A: 34   33 44   33 55 31   33 55 33 31
      B: 5 or 4   3 44   3 55 31   3 55 33 31
              LH   L H   L H L   L H L L

B is a Ru tone, with a glottal vowel and a glottal coda [?]; A is a non-Ru tone. Both A and B are upper register tones. A and B give the same phrasal patterns [L H (L...)]. Since in Shanghai, the tones of a phrase come from the initial syllable, it is reasonable to consider both A and B as [LH]. In a phrase, [H] spreads to the second syllable; further syllables get default [L] (realized as [31] finally and [33] otherwise, cf. Selkirk & Shen 1988, Duanmu 1988). The fact that B is a short [5] (or [4] by the measurements of Zee & Maddieson 1979:99) must be due to the fact that [H] on the coda [?] cannot be heard, and that [L] on the vowel is blurred by glottalization.

If the [p t k] codas can bear tone, there is the question of whether they should change to [b d g] when the tone is in the lower register, i.e. [+sl]. In my analysis, they should, because [+sl] is [+voice]. However, no traditional transcription indicates such change. There are two explanations. First, the Register value of a syllable may be carried by the nucleus alone, and need not be spread to the coda. Second, Chinese [p t k] codas are unreleased, so even if there is voicing changes in them, the change will not be heard, and naturally, not transcribed.

Taiwanese gives further evidence of obstruent TBUs. In Taiwanese, a syllable changes its (citation) tone when it occurs in nonfinal positions. Two tones of interest to us are shown below (Tsay 1990)

(55)   Citation/Final   Nonfinal
      Yang Ru   2   4 / 53
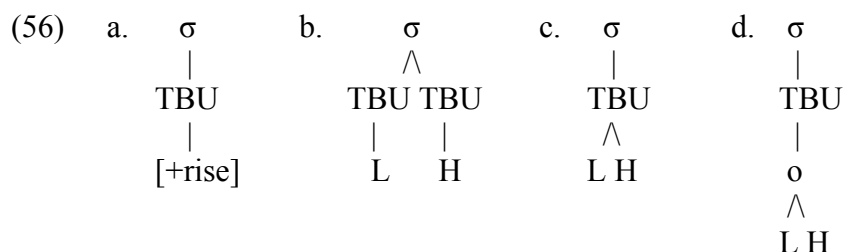   Yin Qu   11   53

Ru tones are short, shown by underline. Qu tones do not have obstruent codas and are long. Let us assume, for exposition, that the nonfinal tone is the sandhi tone. For [2], there are two changes. When the coda is [?], it is dropped and the new tone is a long [53]; when the coda is [p t

k], the new tone is a short [4]. The question is, why does [2] have different outputs? Looking at [11]-->[53], we see an answer: there is just one rule for both [2] and [11], namely, they both are [L] (in the lower register) in citation, and they both change to [HL] (in the upper register) in nonfinal positions. We hear [53] as [4] on a syllable with a [p t k] coda, because the [L] is carried by the coda and cannot be heard.

If all Chinese syllables are bimoraic, and if the tone on the [p t k ?] codas cannot be heard, then all Ru syllables should surface with a level tone only. However, it has been widely noted that in Cantonese, a Ru syllable may under certain conditions carry a rising tone (cf. Yip 1980). We will come back to this issue in section 3.6.

3.4. Contour Tone Unit (CTU)

When a syllable carries a contour tone, such as a rise, there are four possibilities, as shown below

(56)   a.   σ   b.   σ   c.   σ   d.   σ
             | ∧ | |
            TBU   TBU TBU   TBU   TBU
             | | | ∧ |
          [+rise]   L   H   L H   o
                                                                ∧
                                                               L H

In (56a) [rise] is a primitive feature (cf. W. Wang 1967). In (56b) there are two TBUs, each bearing one tone. In (56c) there is one TBU, which bears two tones. In (56d), there is one TBU, which also bears two tones, but the two forms a unit. Due to the criticisms of Woo (1969), Yip (1980), Williams (1976) and others, I will not consider (56a). Strictly speaking, (56b) is not a contour tone, so I will not consider it either. (56c) concerns whether a TBU may bear more than one tone, to which we will return later. Here we focus on whether the contour tone unit (CTU), as in (56d), is justified.

CTU has been proposed, though not always formalized, by many people, among them, Pike (1948), W. Wang (1967), Fromkin (1972), <mark>Gandour</mark> & Fromkin (1978) (but see Maddieson 1979), M. Chen (1986), Newman (1986), Chan (1989) and Bao (1990). The most forceful arguments for CTU, however, is in Yip (1989a). Yip proposes three pieces of evidence for CUT, the OCP effect on CTU, the free occurrence of CTUs, and CUT spreading. I will review Yip's arguments below and show that none of them is conclusive. I will thus conclude that there is no CTU.

3.4.1. Free Occurrence

In African languages, contour tones mostly occur on the final syllable. This is attributed to the 'association conventions', variously formulated in Williams (1976), Leben (1973), Goldsmith (1976), Clements & Ford (1979), Halle & Vergnaud (1982), and D. Pulleyblank (1986). In Chinese languages, however, contour tones freely occur in nonfinal syllables. Yip (1989a) argues that if the association conventions are universal, then the nonfinal contour tones in Chinese must be CTUs. Yip's argument, however, is based on the assumption that the TBU in

Chinese is the syllable. If, on the other hand, the TBU is the mora or rime segment, and every Chinese syllable has two TBUs (cf. Chapter 2), then the free occurrence of contour tones in Chinese is no evidence for CTU. It is particularly interesting to note that, although simple contour tones, such as LH or HL, enjoy free occurrence in Chinese, complex contour tones, such as HLH or LHL, do not. This fact leads Yip (1989a) and Bao (1990a) to stipulate that a CTU may underlyingly consists of just two level tones. In our analysis, however, the 'freedom' of simple contour tones follows from the fact that all Chinese syllables are underlyingly bimoraic.

3.4.2. The OCP

Many Chinese contour tones undergo dissimilation. Mandarin, for example, has the famous [T3 T3]-->[T2 T3], where the third tone ([214] in Chao letters) changes to the second tone ([35]) before another third tone. Similarly, in Danyang there is the rule [24 24] → [42 24], by which two rising tones become a fall and a rise. Yip argues that such changes are due to the OCP (Obligatory Contour Principle, Leben 1973 and McCarthy 1986) applied to CTUs. Take the Danyang [24 24]-->[42 24] for example

(57)   a.   σ   σ   b.   σ   σ
                  | | /\   /\
                  o   o   L H   L H
                 /\   /\
                L H   L H
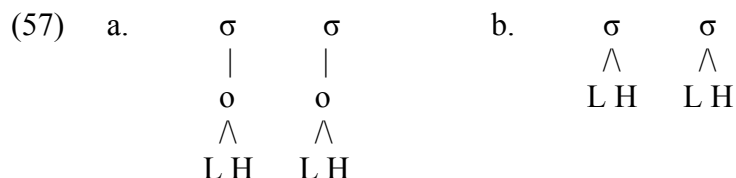
In (57a) the two CTUs are identical, so the OCP applies. In (57b), there is no identical sequence of tones, so the OCP should not apply. If [24 24] is as in (57a), we can explain the dissimilation. But if [24 24] is as in (57b), we cannot attribute the change to the OCP.

Yip's argument depends on the assumption that the OCP applies to all pairs of identical tones. However, tonal dissimilation occurs only sporadically in Chinese. For example, in Mandarin, [214 214] undergoes change, but none of [55 55], [35 35] or [51 51] does. Similarly, [24 24] in Danyang undergoes change, but [35 35] in Mandarin does not. This is unexplained in Yip's analysis. It would be circular to assume that those contour tones that undergo dissimilation are CTUs and those that do not are clusters, unless there is independent evidence. It seems therefore that whether a pair of identical tones change or not is a dialect particular option.

3.4.3. CTU Spreading

The strongest argument for CTU is that it may spread as a unit. While I am not able to examine all reports of CTU spreading in the literature, I will discuss those reported in Chinese languages, namely, Danyang, Changzhi and Wenzhou. I will show that there is no evidence of CTU spreading.

3.4.3.1. Danyang

Danyang is perhaps the most widely cited case of CTU spreading (Chen 1986, Yip 1989a, Chan 1989, Bao 1990a). Lü (1980), the single source on Danyang, gives the following tonal patterns (pp87-88, in Chao letters)[13]

(58)   Citation/Monosyllabic: 11   33   24   55

(59)   Bisyllabic   Trisyllabic   Quadrisyllabic
         a.   11-11   11-11-11   11-11-11-11
         b.   42-11   42-11-11   42-11-11-11
         c.   42-24   42-42-24   42-42-42-24
         d.   33-33   33-33-33   33-33-33-33
         e.   24-55   24-55-55   24-55-55-55
         f.   55-55   55-55-55   55-55-55-55

Lü (p88) states that the sandhi pattern of a phrase is primarily determined by the first syllable. This seems clear in (59), where, except (59c), all non-initial syllables bear the same tone. At face value, then, Danyang shows tone spreading, left to right, after deleting tones on noninitial syllables, similar to the case of Lhasa and Gêrzê. In particular, we see L-spreading in (59a, b), M-spreading in (59d) and H-spreading in (59e, f). However, the regularity in (59) is only apparent, as we will see immediately.

It is, first of all, not clear what the underlying tones are. In particular, there are just four citation tones, but six phrasal patterns. In addition, it is notorious that Danyang citation tones do not correspond to phrasal patterns in any clear manner, even though Lü states that the initial syllable plays a major role. Consider the following bi-syllabic patterns (Lü pp90-98)

(60)

	33	55	24	11
33	42 11	55 55	55 55	55 55
	24 55	42 11	42 11	42 11
	33 33		33 33	33 33
	55 55		42 24	42 24
			24 55	11 11
				24 55
55	33 33	42 24	42 24	42 24
	55 55	33 33	33 33	33 33
	42 24	55 55	55 55	42 11
	42 11			

---

[13]. According to Lü (p87), on short syllables, [33] is [3] and [24] is [4]; since this does not affect our discussion, I have not listed them separately.

24	33 33	42 24	24 55	24 55
	42 24	33 33	55 55	55 55
	55 55	11 11	33 33	42 11
	42 11	24 55	42 24	42 24
	42 42		11 11	33 33
11	11 11	11 11	11 11	11 11
	42 24	42 24	42 24	42 24
			33 33	

In the <mark>leftmost</mark> column are the citation tones of the first syllable, and in the top row are those of the second syllable. For a given pair of citation tones, there are from two to six quite unrelated sandhi patterns. Similarly, in tri-syllabic phrases, for any given initial citation tone, there are from two to five quite unrelated sandhi patterns, as shown below (Lü pp100-101)

(61)

33	55 55 55
	42 11 11
	24 55 55
	33 33 33
	42 42 24
24	24 55 55
	55 55 55
	42 42 24
	33 33 33
	11 11 11
55	33 33 33
	42 42 24
11	11 11 11
	42 42 24

It should be clear by now that the regularity in (59) is superficial, and that sandhi patterns are not derivable simply from the tone of the initial syllable.

Before we review previous analyses of Danyang, a note about its background is in order. Danyang city lies on the border between the Northern and the Wu dialect families. Tone sandhi is poor in Northern dialects, but rich in Wu dialects. The cross-dialectal influence is reflected in Danyang, which has two styles of speech, literary (such as when reading a newspaper or making a speech) and colloquial. The two speeches have different citation tones. In addition, there is little sandhi in literary speech; the sandhi patterns we discuss occur only in colloquial speech. The two speeches are not always clear-cut, though. Colloquial expressions may occur with <mark>colloquial</mark> tones (and sandhi) even in literary speech, and literary expressions may occur with literary tones (and lack of sandhi) even in colloquial speech. This may in part explain the chaotic nature of Danyang tone.

Previous analyses have, rightly, given up on deriving bi-syllabic patterns from citation tones (Chen 1986, Yip 1989, Chan 1989 and Bao 1990). Instead, six 'word melodies' (not syllable/citation tones), have been proposed. This approach is exemplified in Bao (1990), who states (p77)
We will not be concerned with the relationship between the lexical tones and the phrasal bi-syllabic tone patterns. Suffice it to say that the tone melody of a phrase depends on the historical origin of the initial syllable of the phrase, rather than its tone. It is not possible to derive the phrasal tone melody from the lexical tones of the component syllables.

Bao proposes the following 'word melodies', for the patterns in (59a-f) respectively (pp80-81)

(62)   a. [11]   b. [42-11]   c. [24]   d. [33]   e. [24-55]   f. [55]
            L   HL-L   LH   M   LH-H   H

It is not hard to see that by spreading L in (62a, b), M in (62d) and H in (62e, f), to the right, (59a, b, d-f) are easily derived. For (59c), Bao gives the following analysis

(63)   24   24   24   24 24 24 24   42 42 42 24
                             | / | | \ | | | | | | | |
         σ σ σ σ →   σ σ σ σ →   σ σ σ σ →   σ   σ σ   σ →   σ   σ   σ   σ

First, all syllable tones are deleted, except the 'word melody' [24], which is a CTU (contour tone unit). Next, [24] is linked to the initial syllable. Then [24], as a unit, spreads to other syllables. Then 'tier conflation' applies. Finally, [24] dissimilates to [42] before another [24] by the following rule

(64)   [24] --> [42] / ___ [24]

This rule is specifically called for by Lü (p88). The analysis of Bao (1990) is essentially the same as that of Chan (1989), and, to a large extent, in spirit with Chen (1986) and Yip (1989). Central to all of them is the claim that there is CTU spreading in the pattern (59c).

I will now point out some problems in the above approach. First, it is not clear whether 'tier conflation' should apply to a contour feature that spreads across two or more syllables. For example, the geminate affricate [ts:] never becomes [tsts].[14] Second, while it is possible that the underlying tone (the 'word melody') of a Danyang syllable differs from its citation tone, it is far from obvious how the 'word melody' analysis derives citation tones on monosyllables, which, after all, are mostly 'words' themselves. Nevertheless, I will not pretend to be able to offer a better solution. Instead, I will focus on a more serious problem in the previous analyses. This is the problem of the sandhi domain. An important fact that is overlooked in previous analyses is that the domain of the pattern (59c) is different from the domains of the other patterns. To be specific, a regular sandhi domain is sensitive two things, the syntax of the phrase, and the lengths

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[14]. Yip (1989b,160) suggests that if the affricate [ts] spreads over two adjacent positions, it is [tts] or [tss], but if it spreads over two non-adjacent positions, it will become [ts...ts]. Now in Yip's analysis of Danyang, the TBU is the syllable, so when [24] spreads over two or more syllables, it should not become [24 24 ...], since all the syllables are ajacent.

of the words. For example, [NP VP] never forms a domain, nor does [V NP]; they normally each form two domains. In contrast, [A N] usually forms one domain. Secondly, in [A N] structures, [σ σσ] forms one domain, yet [σσ σ] forms two (i.e. [σσ|σ]), where [σ] refers to a monosyllabic word and [σσ] a bisyllabic one. Similarly, in quadrisyllabic [A N] structures, [σ σσσ] forms one domain but [σσσ σ] forms two; [σσ σσ] may form either one or two domains. The reason why word lengths affect sandhi domains is probably due to stress, which we will not go into here. Now if we compare the domains of the patterns in (59), we come to the surprise: while all the other patterns occur in [σ σσσ] phrases, (59c) never does. Similarly, in trisyllabic [σ σσ] phrases, the dominant patterns are (59a, b, d-f), which, in addition, are largely insensitive to citation tones of noninitial syllable. In contrast, (59c) is merely a minor pattern, occurring at a relatively low frequency, and is largely sensitive to the citation tones of noninitial syllables. What is more, in those phrases in which (59c) does occur, most or all of the component syllables have the citation tone [24] (either in colloquial speech or in literary speech).

The above facts point to a very different origin of (59c); they indicate that (59c), which is a minor pattern, is not derived from CTU spreading, but from applying the dissimilation rule (64) to an underlying sequence of [24 24 ...]. While this analysis does not account for all (59c) phrases, due to the chaotic nature of Danyang, it does cover the majority of them.

What I intend to show is that irregular sandhi patterns in a language like Danyang should be taken with caution. In any case, there is little evidence that (59c) is derived from CTU spreading.

3.4.3.2. Changzhi

The facts of interest in Changzhi occur with the diminutive suffix [te?] and what we will call the adjective suffix [ti]. When these suffixes are added to a monosyllabic stem, the citation tone of the stem is basically copied on the suffix. Below are the patterns (Hou 1983:260-261)

(65)		Yin Ping	Yang Ping	Shang	Yin Qu	Yang Qu	Ru
	Citation tones:	213	24	535	44	53	54

(66)	σ_{stem}:	213	24	535	44	53	54	
	$\sigma_{stem}+\sigma_{suffix}$:	213-213	24-24	535-535	44-535	53-53	54-54/44-44	

The historical names of the citation tones are given, but they need not concern us. The underline in [54] and [44] indicates a syllable with a glottal coda. In addition, [54] has two suffixed forms, which again will not concern us.

Bao (1990:83-88) suggests that the tone patterns in the suffixed forms are derived by spreading the citation tone of the stem to the suffix, and then deleting the citation tone from the latter. This, he suggests, is evidence for CTU spreading. There is an exception [44]-->[44-535], for which we expect [44]-->[44-44]. Bao suggests that [44] is the default tone which is underlyingly unspecified; it therefore has nothing to spread, and so the suffix carries its own citation tone, which is [535].

There is an alternative to this analysis, in which the tone is not spread from the stem, but copied from it. Take [53]-->[53-53] for example

(67)   H L   H L   H L
          | | | | | |
       XXX --->   XXX XXX
                          | V | V
        lO ti   l O   t i   'old'
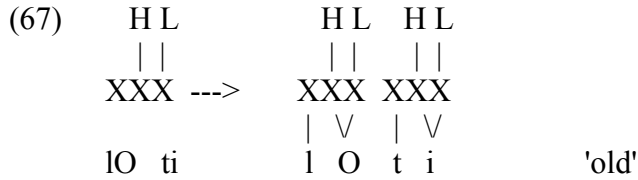
The adjective suffix first triggers reduplication of the syllable structure of the stem, together with its tone [54], which in this case is HL in the upper register, then associations proceed as before. We already saw in section 2.2.5 that syllable structure copying is a possible morphological process.

Let us now compare the two analyses. First, consider [44]-->[44-535], the exception for both analyses. In my account, there is no good explanation. I have to assume that [44-44] is changed to [44-535], due, probably, to dissimilation of some sort. In Bao's account, this is a also problem. There is, first, no other evidence that [44] is a default tone. Second, although the citation tone of the suffix [ti] is [535], that of [te?] is not [535] but [54]. Therefore, even though Bao can assume that the [535] in [44-535] may come from the underlying tone of the suffix [ti], the same assumption does not hold for the suffix [te?]. To derive [44-535] for the [te?] suffix, Bao has to make similar assumptions as I have.

The two analyses also differ in another respect. Recall that I assume register to be identical to voicing; the same is assumed in Bao (1990). Thus, if there is a spreading of register, there should be relevant voicing changes in the consonants in between (cf. the Wuyi case in (14), (28)-(30) above). Now, in Bao' analysis, [535] should be an upper register tone and [213] a lower register tone. If [535] and [213] both spread across the onset [t] in [te?] and [ti], [t] should show voicing changes. But there is no such change. In my analysis, there is no spreading, but copying, thus there should be no voicing change.

In conclusion, there is little evidence that Changzhi has CTU spreading.

3.4.3.3. Wenzhou
Like Danyang, Wenzhou is a borderline dialect whose sandhi patterns are not strictly predictable from the underlying tone of the initial syllable, but are sensitive to the underlying tones of all member syllables. The case of interest to us is given below (Zheng-Zhang 1080:248)

(68)

	31	42
35		
24	42-1	
11		
42	11-33	

The leftmost column shows the citation tones, in Chao letters, of the first syllable, and the top row shows those of the second syllable. All output patterns are [42-1], except [42] plus [31], which is [11-33]. [1] is a low tone on an unstressed syllable, in contrast to [11], which is a low tone on a stressed syllable.

Zheng-Zhang (p248) notes that, in slow speech, [42-1] may become [42-21], but she does not consider the slight drop in final pitch to be of significance. Bao (1990:105-111), on the other hand, takes a different view. He considers [21] to be a weakened [31], which is not [L] but [HL]. The output [42-1] is thus seen as [42-31]. Having made this assumption, Bao proposes the following analysis. In the above combinations, the citation tone of the second syllable, [31] or [42], is spread, as a CTU, to the first syllable, replacing the latter's own tone. Then he proposes a rule, which raises the register of a stressed syllable to [+upper], and lowers that of an unstressed syllable to [-upper].

There are three questions about this analysis. First, there is no evidence that stressed syllables become [+upper] and unstressed ones become [-upper]. In the output [11-33], for example, the first syllable is stressed but in the [-upper] register. Second, it is counter-intuitive that the tone of the unstressed syllable (i.e. the second), rather than that of the stressed one (i.e. the first), should dominate the sandhi phrase. Instead, it is usually the tone of the stressed syllable that dominates, especially in Wu dialects, of which Wenzhou is a member. Finally, there is insufficient evidence that [21] is [HL], rather than [L]. It should be added that, besides [42-1], there are twelve other bisyllabic patterns (including [11-33] above), none of which shows tone spreading, let alone CTU spreading, from the second syllable to the first. I will therefore conclude that there is no CTU spreading in Wenzhou.

3.4.4. Summary

I have reviewed three major arguments of Yip (1989a) for CUT (free occurrence of CTU, the OCP on CTU, and CTU spreading) and shown that none is valid in Chinese languages. I have not been able to review similar claims in other languages, such as Lalana Chinatec cited in Yip (1989a, 162). However, since most arguments for CTU are from Chinese languages, and since the strongest, CTU spreading, comes entirely from Chinese languages, I will conclude that there is little evidence of CTU in any language.

3.5. Tone Bearing Unit

There are three assumptions of what the TBU is, the syllable or the rime (e.g. Wang 1967, Chao 1968, Yip 1980, Bao 1990a), the mora (e.g. Hyman 1984, Clements 1986), and the segment in the rime (Woo 1969, updated with autosegmental mechanisms). The difference between the latter two is shown below

(69)   a.   σ   b. ⌜ σ ⌝   c. σ   σ = syllable
              ∧   ∧   /|\   O = onset
          ⌜ μ μ ⌝   μ μ   O R A   R = rime
          | ∧ ∧ | | | | ∧ | A = appendix
          | p a i k | p a i k   p a i k   μ = mora
          | | | | | |
          ⌞> H L <⌟   H L   H L

Suppose the syllable [paik] is bimoraic and bears HL. In (69a), the TBU is the mora; but since [p] and [k] are both under the μ nodes (cf. Hyman 1984), they share tones with [a] and [i]. In (69b), the TBU is also the mora; but since only [a] and [i] are under the μnodes, the TBU is in

effect the mora carrying segments. In (69c), the TBUs are the segments in the rime, i.e. [a] and [i]. The difference between (69a, b) depends on whether onsets and post-rime elements (let us call them appendices) share tones with rime segments. There are two views. The traditional one is expressed in the following words

> 'Phonetically, of course, the domain of the tone is over the entire voiced portion of the syllable.' (W.S-Y. Wang 1967:95)
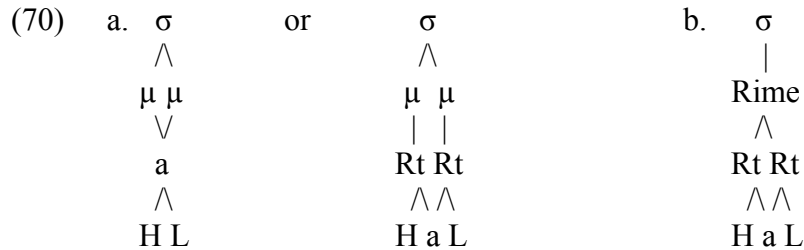
> '(Tone) is primarily the pitch pattern of the voiced part of the syllable, so that, if the initial is voiced, the tone begins with the initial and spreads over the whole syllable, while, if the initial is voiceless, the tone is spread over the final only...For example, in *nian* the tone begins with *n*, but in *tyan*, it does not begin until *y*.' (Chao 1968:19, 25)

The other view comes from phoneticians, as expressed in the words below

> '(That tone spreads over the entire voiced part of the syllable) is quite untrue from the strictly phonetic viewpoint: instrumental analysis of the fundamental frequency patterns of Mandarin syllables commonly shows that voiced initial consonants have erratic Fo characteristics, which obviously do not contribute to the general tonal tendency of the given syllable.' (Kratochvil 1970:515)

> '(T)he domain of tone in Mandarin is not the entire voiced part of the syllable, as is traditionally described, but rather is confined to the syllabic vowel and any segment that may follow it in the syllable.' (Howie (1976:218)

Since the traditional view is based more on intuition than on evidence, I will take the latter view, and so disregard (69a). In addition, I will not distinguish (69b, c) but consider them notational variants. (69b) and (69c) are also equivalent for geminates such as [a:]

(70)   a.   σ   or   σ   b.   σ
            ∧   ∧ |
           μ μ   μ μ   Rime
            ∨ | | ∧
            a   Rt Rt   Rt Rt
            ∧   ∧ ∧   ∧ ∧
           H L   H a L   H a L

In (70b), [a:] is two TBUs because it has two Roots (cf. Selkirk 1988a and our discussion of Jiyuan in section 2.2.3), hence are in effect two segments. In (70b), [a:] is also two TBUs, because it has two moras; [a:] may or may not have two Roots here, which we will not go into.

Because there is evidence that the onset does not share tone with the rime, I will not consider the assumption that the TBU is the syllable. We are thus left with two possible TBUs, the rime as a whole, and the segment in the rime.

There is no doubt that in many African languages, such as LuGanda (Clements 1986), the TBU is not the syllable, but the mora, as shown below

(71)   a.   kùlábà   'to see'
        b.   kùlábìká   'to be visible'
        c.   kùkáàbá   'to cry'

(72)   a.   kùlíNNá   'to climb'   (N is palatal nasal)
        b.   kùcóppá   'to become a pauper'

All patterns are have [LHLH]. In (71a) the final [H] does not show up, because the syllable is one mora short. In (71c), [aa] carries two tones, because it is two segments, as we assume. In (72a), the third tone [L] is carried by the consonant [N], because [N] is in the rime (or carries a mora). Similarly, in (72b) the first [p] carries [L], because it is in the rime.

So the question is whether the TBU can be the entire rime in other languages. It is possible that the TBU varies parametrically, so that it is the moraic segment in African languages, but the rime in Chinese languages. However, there is no compelling evidence that it does.

The assumption that the Chinese TBU is the rime is probably due to two facts. First, in traditional analyses, there seems to be little relation between the structure of a syllable and the tone it bears. For example, in traditional analyses, the Mandarin syllable may be CV, CVN, CVV, CGV, CGVN, CGVV, etc., any of which may bear any of the four syllable tones. Second, in a phrase, each syllable largely keeps its tone; there is little shifting going on. Consider the following Mandarin word

(73)   51 51 51   5 1 5 (151)
        xü-li- ya   -->   *xü-li-ya   'Syria'
                                         | | |
        HL HL HL   H L H (LHL)

(74)   51 51 51   51 51 51
        xü-li- ya -->   xü- li- ya   'Syria'
                        |\ |\ |\
        HL HL HL   HL HL HL

In traditional analyses, the three syllables are all monomoraic. According to the association conventions (e.g. Goldsmith 1976, D. Pulleyblank 1986), we expect to see the derivation (73), where excess tones shift to the right. The correct derivation, however, is (74), without rightward tone shifting.

The above two facts have lead to two widespread assumptions in Chinese phonology: the TBU is the syllable/rime as a whole, and the syllabic tone is a unit. In my analysis, neither assumption is necessary. I have already shown that there is no independent evidence for CTU. I have also argued in Chapter 2 that all Chinese syllables are bimoraic. My analysis of *xü-li-ya* is as follows

(75)   x ü---   l i--- y a   'Syria'
           /\   /\   /\
        Rt Rt   Rt Rt Rt Rt
         | | | | | |
         H L   H L   H L

Since every TBU (Root in the rime) carries just one tone, it is expected that the tones are stable. Consider another case in Mandarin

(76)   214   'north'   214 35 --> 21 35   'North Pole'
        bei   bei-ji   (*21 535)

(77)   b e i --> b e   i   b e i-- j i ---> b e i-- j i
         | | | ∧ | | ∧ | | ∧
        Rt Rt   Rt Rt Rt   Rt Rt Rt Rt   Rt Rt Rt Rt
         | | | | | | | | | | | | |
        M L H   M L H   M L H M H   M L M H

The syllable [bei] is [214] in isolation, where it is longer than syllables with [55], [35] or [51]. In nonfinal positions, as in [bei-ji], [bei] is [21]. Supposing [214] is [MLH], there are two questions to ask. First, why is it [21] in nonfinal positions? Second, why is the [H] of [214] not realized on the second syllable [ji], as we would expect from the association conventions? My answer to the first question is that nonfinal syllables are bimoraic, so that the [H] of [214] cannot be realized; in final positions, the syllable may be lengthened to trimoraic, so all tones of [214] can be realized. The answer to the second question, as I will argue in Chapters 4 and 5, is that in Mandarin the tonal domain is the stress domain, and since most syllables are stressed, the tonal domain is in effect the syllable.

In summary, there is no compelling evidence that the TBU can be the rime. I will therefore assume that the TBU is always the moraic segment. This uniform analysis of the TBU not only is a more constrained theory, but also agrees with the independently motivated tonal model (1), which is part of the segmental feature geometry.[15]

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[15]. Compare the following two representations of the Mandarin word [man 51] 'slow' (omitting Register)

```
    Bao (1990a):  m a  n          Duanmu:   m a    n
                   \ /                       |    |
                   Rime                     Lar  Lar
                    |                        |    |
               Vocal-cords             Pitch Pitch
                    |                        |    |
                  Vocalis               [+H]  [+L]
                  /  \
              [-sl] [+sl]
```

In my analysis, the tones directly link to the Laryngeal nodes of [a] and [i]. In Bao (1990a), the TBU is the rime, and [51]=[HL] is a CTU; the Vocal-cords node of [HL] hangs on the Rime. It is not clear how, in Bao's representation, the tone structure is interpreted on [a] and [i]. Bao (p2) suggest that

'After tone sandhi rules have applied, t(one) is linked to the laryngeal node of the head of TBU through the process of segmentalization.'

In other words, tone is initially assigned to the rime, but finally falls on the nucleus. Phonetic studies show, however, that in Mandarin tone is carried by both the nucleus and the coda, rather than the nucleus alone (Kratochvil 1970, Howie 1976).

3.6. How Many Tones Can a TBU Bear?

According to Woo (1969), a TBU can bear just one tone. According to Williams (1976), Leben (1973,1978), Goldsmith (1976), and D. Pulleyblank (1986), there is no upper limit as to how many tones a TBU may bear, although some languages forbid more than one tone per TBU, as is the case in Kikuyu (Clements & Ford 1979).

Woo's position is stronger, and so more vulnerable. It hinges on there being a direct relation between the tone bearing ability (TBA) (i.e. how many tones a syllable may bear) and the rime length. In contrast, the position of Williams, Leben, Goldsmith, and D. Pulleyblank hinges on there being no such relation. It is generally true that a monomoraic syllable carries one tone and a bimoraic syllable carries two. In addition, cross-linguistically, it is very rare that a syllable bears more that three tones, and it is perhaps not a coincidence that a syllable is rarely longer than three moras. Indeed, the central element of the association conventions, as formulated in D. Pulleyblank (1986,11), is the one-to-one relation between tones and TBUs. On the other hand, there have been claims that a monomoraic syllable may carry two tones (e.g. Williams 1971/1976 for Margi, Leben (1973) for Mende, D. Pulleyblank (1986) for Tiv).

I will argue that in Chinese languages, there is indeed a direct relation between the TBA and the rime length. I will also argue that in at least two African languages, Igbo and Tiv, similar relation holds. The same seems to be true for Margi and Mende (Leben 1973:27, Innes 1969). On the other hand, I am not aware of clear evidence that a monomoraic syllable indeed carries two or more tones without lengthening. I will, therefore, stick to the strongest hypothesis that no TBU may carry a contour tone, until clear counter-evidence is seen.

To show the relation between the TBA and the rime length, I show two points

(78)   a.   When the TBA is increased, the rime must be lengthened.
       b.   When the rime is shortened, the TBA is reduced.

Evidence for (78a) abounds. In Fuzhou, for example, the convex tone [242] occurs only in final positions, where the syllable is stressed and extra long (for rich phonetic data, cf. Wright 1983). Similarly, the Mandarin [214] occurs in final positions only, where, as is well known, the syllable is again extra long (cf. Wu 1986 for spectrograms).[16] The same is true in Suzhou (Ye

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[16]. Although it is long noted that [214] is the longest tone in Mandarin, there is, to my knowledge, no direct report on the length contrast between Mandarin [21] and [214]. This is probably because past researches have not turned our interest in this direction. Comparing the lengths of ma 'horse' in ma[21] che[55] 'horse cart' and qi[35] ma[214] (not qi[35] ma[21], which is an optional pronunciation) 'to ride a horse', my intuition is that [214] is from 50% to 100% longer than [21]. Reported measurements of the four Mandarin citation tones do not show this much length difference. There are two reasons. First, in isolation, all syllables may be lengthened, so citation [214] need not be much longer than citation [55]. Second, in many phonetic studies, syllables were read in a carrier sentence; for example, in Howie's study, all syllables were read in the following carrier sentence (Howie 1976:147)
    zhege ___ zi, shi Lao Li xiede.

1979, Xie 1982, Qian & Shi 1983, P. Wang 1983) and Wuxi (Chan & Ren 1986, Yip 1989c), where convex and concave tones occur finally only and are longer.

The restriction of convex and concave tones to final syllables, and the rarity of them in nonfinal syllables, has lead Bao (1990a, 62) to propose that 'concave/convex contour are surface phenomena'. To me, it follows from the fact that Chinese syllables are underlyingly bimoraic (cf. Chapter 2), and that final syllables may be lengthened to trimoraic.

The same is true for Ru syllables, which have [p t k ?] codas. Since the tone on the coda cannot be heard, Ru syllables should generally appear as bearing a level tone; this prediction is correct. However, it has been noted that in Cantonese, a Ru syllable may under some circumstances bear a rising tone (cf. Yip 1980, 60-65). In my analysis, it should be the case that such a Ru syllable is lengthened to a trimoraic one, with two moras on the vowel and one on the coda. This prediction seems to be borne out, as Chao (1947) points out that syllables in such circumstances are rather longer.

Evidence for (78b) may be seen in Shanghai. As I suggested in Chapter 2, the Shanghai syllable is bimoraic in isolation but monomoraic nonfinally. A piece of evidence is that [?], the only coda in Shanghai,[17] is dropped nonfinally (Xu et al 1981), yet the syllable is not lengthened. In contrast, when the [?] coda is dropped in Southern Min dialects, the nuclear vowel is lengthened (e.g. T. Dong 1954, J. Lin 1975, Chen 1987, Tsay 1990). Now the Shanghai syllable may carry two tones in isolation and finally, but just one tone nonfinally (Xu et al). This is what we expect: when the rime is shortened, its TBA is reduced.

Let us now turn to African languages. First consider Margi (Williams 1971/1976)

(79)   a. fi-->   fi 'to swell'   b. fi+ani-->fyani-->fyani 'to make swell'
                    /\ | |
            LH   LH   LH   LH   L H

Williams argues that Woo's (1967) system cannot handle (79). But updated with autosegmental mechanisms and feature geometry, Williams' conclusion is no longer true, as the following shows

---

  this   word be   written
  'This word ___ was written by Lao Li.'
In this environment, the syllable in question is not in a final position, and so the Mandarin third tone does not appear as [214].
[17]. Shanghai has no diphthongs. Some descriptions use another coda [ŋ], which I assume to be nasalization for two reasons. First, when the vowel is low, there is no velar closure, e.g. [ã] but not [a ŋ] (Xu et al). Second, there is no contrast between [ŋ], [m] and [n] in the coda, although in the nucleus we see [n] 'fish' and [m] 'mu (a measure of land)' (Xu et al).

(80)   fi   ---->   fi   --->   f i   'to swell'
       | | / \
       Rt   Rt   Rt   Rt
                        | | |
        Lar   Lar   Lar   Lar   Lar   Lar
        | | | | | |
       Pitch Pitch   Pitch Pitch   Pitch Pitch
        | | | | | |
       [+L] [+H]   [+L] [+H]   [+L] [+H]

(81)   fi + ani --->   fʸani --->   fʸa n i
       | | | | | | |
       Rt RtRt   Rt Rt   Rt Rt
                                         | |
        Lar   Lar   Lar   Lar   Lar Lar
        | | | | | |
       Pitch Pitch   Pitch Pitch   Pitch Pitch
        | | | | | |
       [+L] [+H]   [+L] [+H]   [+L] [+H]

In (80), L first links to [i]. To link H, another Root has to be created, since in feature geometry, each articulator appears just once. The output is [fií], with a long vowel. In (81), after the hiatus rule, each tone is linked to a rime segment. The analysis of (80) and (81) is exactly like that of (79), except in one point: the vowel in [fi] remains short in (79) but becomes long in (80). Williams did not reject Woo's analysis on the basis of Woo's prediction on vowel length, nor did Williams discuss whether the vowel in [fi] is in fact long. The reason, I suspect, is due to lack of phonetic evidence on vowel length. In addition, phonemic transcriptions are not always reliable; as we have discussed in Chapter 2, although open vowels are long in Chinese, they are rarely so transcribed. The difference between (79) and (80)-(81), therefore, have to be left open.

Leben (1973,27) argues that in Mende, short syllables like [mba] may carry a contour tone. However, as Leben notes, the length of such syllables are in debate. While Spears (1967a, b) transcribe them as short syllables, Innes (1969) transcribe them as long. Although Leben follows Spears, it is likely that Innes is correct. This is because if lengthening is predictable, people tend not to transcribe it, as we have seen in Mandarin, but one will not transcribe a syllable as long unless it is indeed long.

A similar case in found in Igbo, where, in traditional transcriptions, a short vowel may again bear two tones, as shown below (Green & Igwe 1963, 7)

(82)   Adha   riri ji   'Adha ate yam.'
       | |\ | | |
       L   HL   L L   H

The second [a] bears two tones, but it is transcribed as short. This seems to be a counter-example for the claim that the TBA depends on rime length. However, we note that Igbo does not have long v. short vowel contrast; if vowel length is predictable, it is likely that it is not transcribed. The question is, when a vowel bears two tones, is it in fact long? My work with P. Ihionu, a

native Igbo speaker, shows that the vowel is always long when it bears two tones, and as Ihionu puts it, 'it sounds like two syllables'.

As a final case, let us consider Tiv. D. Pulleyblank (1986) argues that in Tiv, the TBA is unrelated to the rime length; a contour tone may fall on either (C)VC or (C)V, as he summarizes below (p215)

(83) a.   Contour tones occur only in word final positions.
      b.   Falling tones are possible on surface syllables of the forms (C)V and (C)VC.
      c.   Rising tones are possible only on surface syllables of the form (C)VC.

D. Pulleyblank cites the word mba 'be' to show that it may bear HL finally, but H nonfinally, without changing the rime length, as seen below (p216)

```
(84)   unyinya mba 'there are horses'          mba van 'they are coming'
       |   |   |   |\                          |   ||
       L   L   L   H L                         H !HL
```

However, D. Pulleyblank's claim is puzzling. The reason is that his data are from Abraham (1940/1968) and Arnott (1968), yet Arnott specifically emphasizes the following point (Arnott, vi)

> Sequences consisting of a consonant + a vowel (CV) and marked HL should be read as sequences of consonant + a double vowel (CVV) with High-Low tones (e.g. for ha[HL], be[HL] read haa[HL] and bee[HL]), since they are systematically comparable with other words which Abraham spells with a double vowel, e.g. maa[LL], vaa[LL].

In addition, for the very word 'be', Abraham clearly transcribes it as long finally, and short nonfinally, as shown below (Abraham, p5, p74)

```
(85)   iyor mbaa              mbaa+vende-->mba vende
       |  |     ||                         |   |   |\
       L  L     HM            HM   L   H    H   L   H L
       'there are people'     'they habitually refuse'
```

Moreover, a survey of the entire vocabulary in Abraham (1940) shows that there is just one word, *hihi*, in which LH falls on a short vowel. This is probably due to an inconsistency in Abraham's transcriptions, as Arnott suggests above, and as is seen in [vende] in (85), where the final vowel is not written as long, although it bears two tones. In any case, it seems to me that, unlike D. Pulleyblank's claim, Tiv supports the assumption that there is a relation between the TBA and the rime length.

I have shown that there is broad evidence, both in Chinese and in African languages, that the TBA is directly related to the rime length. On the other hand, I am not aware of clear evidence to the contrary. I will therefore assume the view, introduced by Woo, that each TBU can bear just one tone.

3.7. The Theory of Contour Features

Sagey (1986) proposes that a feature may take on more than one value in a segment. Such features are called 'contour features', and segments with them are called 'contour segments'. Sagey discusses three kinds of contour segments, as shown below (p49)

(86)   a.   x   b.   x   c.   x
               /\   /\   /\
          [-cont] [+cont]   [-stiff] [+stiff]   [+nasal] [-nasal]

(86a) is found in affricates, (86b) in a vowel with a contour tone, and (86c) in pre-nasalized stops. The values of a feature is not limited to two; Sagey allows at least three, as in the pre- and post-stopped nasal [dnd] in Kaingang (p96)

(87)   Soft-Palate
             / | \
          [-nas][+nas][-nas]

Contour features undoubtedly add great power to feature geometry. In this section, we will examine whether this power is needed. There is some indication that it is not. For example, of all possible contour features, most are not found. Typical contour features are restricted to those in (86). Nevertheless, if those in (86) are real, contour features must be recognized. The missing distributions may, one hopes, be filled as our knowledge expands.

There is evidence, however, that even the three cases in (86) are questionable. I have already argued that there is no evidence of contour tones. We now look at the other two cases.

3.7.1. Affricates

Steriade (1989) has extensively argued that affricates are stops, i.e. [-cont], not [-cont, +cont]. I will not repeat Steriade's arguments, but limit our discussion to Sagey's argument that affricates are [+cont] to the right and [-cont] to the left..

Sagey discusses four languages: in Zoque, affricates are [-cont] to the left, while in English, Kutep, and Sierra Popoluca, affricates are [+cont] to the right. Since there is no disagreement that affricates are [-cont] to the left, I only review the latter three languages. I will show that there is no evidence that affricates are [+cont] to the right.

Consider English first. Sagey (p94) argues that the English plural is realized as /iz/ after strident fricatives and affricates, but not after simple stops or non-strident fricatives

(88)   box   boxes
        church   churches
        hat   hats
        booth   booths

She concludes that English affricates are [+cont] to the right, like fricatives. However, this argument is inconclusive. If we assume that the trigger for /iz/ is [+str], and not [+cont], and the same distribution follows.

We next consider Kutep, where there is a consonant labialization process (Ladefoged 1968:31, 62), as shown below (Sagey p95, from Ladefoged)

(89)   a.   Fricatives   basfa   'they kneel'
                            nsazvakkwa   'the water is hot'
                            baZve   'they washed'
                            baZvam   'they begged'
                            açfapang   'groundnuts'
       b.   Affricates   ba¢fap   'they chose'
                            batçfak   'they sleep'
       c.   Stops   bapwa   'they grind'
                            bambwa   'they tasted
                            batwap   'they picked up'
                            bandwap   'they wove'
                            nsazvakkwa   'the water is hot'
                            bangwa   'they drink'
                            baskwap   'they are foolish'

What is of interest to us is that the labialization is realized as /f, v/ after fricatives and affricates, but /w/ after stops. Sagey takes the pattern as evidence that affricates <mark>are</mark> [+cont] to the right, like fricatives. This argument, again, is inconclusive. We see that the difference between (89a, b) on the one hand and (89c) on the other is not just one of [cont], but also one of [str]. The question then is, which is the triggering feature? To find the answer, we want to look at [-str] fricatives or affricates: if the labialization after them is /f, v/, we know that [str] plays no role, but if the labialization is /w/, we know that [cont] plays no role. <mark>Unfortunately</mark>, Kutep does not have [-str] fricatives or affricates. There is, nevertheless, evidence that [cont] plays no role, as shown below (Ladefoged p62)

(90)   barwa 'they greeted'

/r/ is [+cont]. If [+cont] triggers /f, v/, as Sagey claims, /r/ should, too. But /r/ does not trigger /f, v/, so what triggers /f, v/ cannot be [+cont]. Moreover, [son] cannot be the triggering feature either, since the stops in (89c) are [-son] while /r/ is [+son], yet both trigger /w/. Thus, the only possible triggering feature is [+str].[18] Therefore, Kutep labialization gives no evidence that affricates are [+cont] to the right.

We finally look at Sierra Popoluca. Here, stops are aspirated syllable finally, but fricatives and <mark>affricates</mark> are not, as Sagey shows them (p95)

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[18]. I ignore the possibility that what triggers /f, v/ is the combination [+cont, -son], since this is not the null hypothesis.

(91)   a. Stops   /hʌp/   [hʌph]   'mouth'
                        /ʔampat/   [ʔampath]   'I met'
                        /mʌk/   [mʌkh]   'fog'
        b. Affricates /maȼ/   [maȼ]   'grasp' (*maȼh)
                        /ʔapiC/   [ʔapiC]   'thorn' (*ʔapiCh)
        c. Fricatives /wəsten/   [wəsten]   'two'   (*wəshten)
                        /piStək/   [piStək]   'flee'   (*piShtək)
                        (/ȼ/ = 'hits', /C/ = 'church', /S/ = 'fish')

In (91a), the codas [p t k] are aspirated (no word is said about the coda [m] in [ʔampath]); in (91b, c), the codas [ȼ C s S] are not, as the starred patterns show. Sagey argues that affricates and fricatives form a group because both are [+cont] to the right.

There are two problems with this argument. First, the difference between [p t k] and [ȼ C s S] need not be in [cont], but may be in [strident]. Therefore, (91) cannot show whether affricates are [+cont] to the right. Second, (91) is taken from Foster & Foster (1948:4), but a comparison with the original shows that (91) is not exactly what was given. In particular, Foster & Foster only said that stops are aspirated syllable finally, but DID NOT say that affricates and fricatives are unaspirated. The starred patterns in (91b, c) are added by Sagey. To see why this addition is misleading, we take a look at all the Sierra Popoluca stops, fricatives and affricates, given below (Foster & Foster p4)

(92)   p   t   T   k   ?   (/T D N/ = palatal /t d n/)
            b   d   D   g
                    ȼ   C
                    s   S   h
            m   n   N   ŋ

The fricatives /s S h/ are [-voice], and so must be [+asp]. Foster & Foster also say that /ȼ/ is as in the English word 'hits', and /C/ as in 'church', so they too are [+asp]. Thus, all fricatives and affricates are aspirated in Sierra Popoluca. There is therefore no reason to assume that fricatives and affricates are unaspirated, as Sagey does in (91). In other words, Sierra Popoluca gives no evidence that affricates are [+cont] to the right.[19]

In conclusion, I have shown that there is no good evidence that affricates have contour features [-cont, +cont].[20]

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[19]. What seems to me to be the case in Sierra Popoluca final aspiration is devoicing. As Foster & Foster (p4) points out, voiced stops do not occur finally, and the glide /y/ is aspirated and voiceless when occurring finally. Final nasals are aspirated, too, though Foster & Foster do not say if they are devoiced. Since Foster & Foster's discussion is too brief, and the issue is irrelevant to our point, we do not pursue it further.

[20]. How we should represent affricates is a separate issue. For most cases, it seem to suffice if we consider affricates as strident stops ([-cont, +strident]), as suggested in Chomsky & Halle (1968), pending the only claim of [-strident] affricates in F.K. Li (1946).

3.7.2. Pre- and Post-nasalized Stops

The issue of pre- and post-nasalized consonants is too large to be reviewed here (cf. Campbell 1974; Anderson 1976; Sasse 1976; Herbert 1975, 1986, Sagey 1986). I will, therefore, focus on just one point: whether any language has underlying pre- and/or post-nasalized stops. I will survey the UCLA Phonological Segment Inventory Database (UPSID, Maddieson 1985) and show that no language has underlying pre- or post-nasalized stops.

Herbert (1986) argues, rightly, that a surface pre- or post-nasalized stop need not be considered underlyingly as such, if it meets one of the following

(93)   a.   Its distribution is completely predictable from the nasality of its neighboring
               segments.
       b.   It freely varies or does not contrast with a voiced stop, or it freely varies or does
               not contrast with a nasal.
       c.   Its nasal and stop parts belong to separate syllables, as a cluster.

A typical case of (93a) is found in Kaingang (Wiesemann 1972), which has the following patterns ($\tilde{V}$ = nasal V, m = nasals, b = stops, etc.):

(94)   VbV $\tilde{V}$mbV   Vbm$\tilde{V}$ $\tilde{V}$mbm$\tilde{V}$
       VbmbV $\tilde{V}$mbV   Vbm$\tilde{V}$ $\tilde{V}$m$\tilde{V}$

(95)   b --> b / V __ V   m --> bmb / V __ V
       b --> mb / $\tilde{V}$__ V   m --> mb / $\tilde{V}$__ V
       b --> bm / V __ $\tilde{V}$ m --> bm / V __ $\tilde{V}$
       b --> mbm / $\tilde{V}$__ $\tilde{V}$ m --> m / $\tilde{V}$__ $\tilde{V}$

Kaingang contrasts oral and nasalized vowels. Pre-nasalized stops occur only in /$\tilde{V}$__V/, post nasalized stops only in /V__$\tilde{V}$/, and pre- and post-nasalized stops only in /$\tilde{V}$__$\tilde{V}$/. Similarly, pre-stopped nasals occur only in /V__$\tilde{V}$/, post-stopped nasals in /$\tilde{V}$__V/, and pre- and post-stopped nasals in /V__V/. The ==distribution== in (94) is completely predictable by the rules in (95), whereby if a cluster of CV or VC differ in nasality, a short epenthetic sound appears between them. In Kaingang this sound agrees in nasality with the vowel, and in other features with the consonant. Herbert uses the notion 'shielding' for the effects in (95). The 'shielding' effect is also seen in English

(96)   /prins/-->[prints]   'prince'
       /lenz/-->[lendz]   'lens'

where [t] shields the [+nas] /n/ from the [-nas] /s/, and [d] shields /n/ from /z/. Phonetically, the 'shielding' effect may be due to mis-alignment of time between the soft palate and the place articulators, as illustrated below

(97)   a. Kaingang: b --> mb / Ṽ__ V

          Labial: open   close   open

          Soft Palate: lowered   raised

Ṽ	ᵐ	b	V

          b. English: s --> ᵗs / n __

          Apico-alveolar: closed   open

          Soft Palate: lowered   raised

n	ᵗ	S

In (97a) the soft palate closes too late, and in (97b) it closes too early. Herbert points out, rightly, that as a matter of phonological practice, such epenthetic sounds have no underlying status. Shielding mostly occurs in languages that contrast /V/ and /Ṽ/.

The case of (93b) also concerns a standard phonological practice. As Pike (1947) and Ladefoged (1968) point out, to postulate nasalized vowels in a language, it is necessary for three of the following four syllable types to be distinctively opposed

(98)   CV   CṼ   NV   NṼ

    a.   CV   CṼ   NṼ
    b.   CV   NV   NṼ
    c.   CV   CṼ   NV
    d.   CṼ   NV   NṼ

In the same fashion, Herbert argues that a ==phonetically== pre-nasalized stop alone does not justify the ==existence== of an underlying pre-nasalized stop. Instead, in order to posit underlying pre-nasalized stops in a language, it must contain all the following four sets of consonants

(99)   voiceless stops
       voiced stops
       pre-nasalized stops
       nasals

Many languages, typically Austronesian and Indo-Pacific languages, have a pre-nasalized series but not a voiced stop series. In such a case, we must check if the prenasalized series is in fact the voiced series ==in== disguise. For example, Nambakaengö of the Reef Islands-Santa Cruz Family has the following consonants (Herbert pp16-17, citing Wurm 1972a, b)

(100)   Nambakaengö

p	p^w	t	t^w		k	k^w
ph		th			kh	
mb	mb^w	nd	nd^w		Ng	Ng^w
m	m^w	n	n^w	ñ	N	N^w
v	w	s/ty		y		
l					(N = velar nasal)	

There are prenasalized stops, but no voiced stops. In a related language, Nea, we find the following consonants

(101) Nea

p	p^w	t	t^w		k	k^w
ph		th			k^h	
(m)b	$(m)b^w$	(n)d	$(n)d^w$	$(ñ)d^y$	(N)g	$(N)g^w$
m	m^w	n	n^w	ñ	N	N^w
v	w	s/t^y		y		
l					(N = velar nasal)	

where except the sound /$(ñ)d^y$/, the inventory is identical to (100). However, in Nea, the third line of stops are prenasalized only optionally. Thus, underlyingly we may posit either voiced stops or prenasalized stops. Positing the former will add no extra cost to UG; yet, without other evidence, positing the latter will. Similarly, in Nambakaengö we may simply posit underlying voiced stops, rather than prenasalized stops; whatever relates underlying voiced stops to surface pre-nasalized stops in Nea will do the same in Nambakaengö. The free variation between prenasalized and voiced stops are not restricted to Pacific languages, but are also found in some dialects of Malay (Hendon 1966), many Melanesian languages (Ray 1926), many non-Austronesian languages of New Guinea (Capell 1969), and some Austronesian languages (Dyen 1971). Herbert (p19) cites Capell (1969:29) about this variation in Austronesian languages

> Prenasalization occurs in some areas as normal process or as a local peculiarity. In Tuna, some speakers have /b, d, g/, other /mb, nd, ng/, according to geographical distribution of villages. While the pre-nasalization is normal in some areas of insular MN [Malenesia] - Fijian has only /mb, nd, ng/, it is either optional in or missing from others, e.g. Central Malaita (optional), Nguna-Efate (New Hebrides - present in the north, absent in the south).

In short, prenasalized stops do vary with voiced stops. Whatever the reason for the variation, if the two sets do not contrast underlyingly, there is no reason to posit underlying prenasalized stops.

Finally, we look at (93c), where surface prenasalized stops are underlying clusters. This would be the case, for example, if initially, the nasal part bears a mora or a tone, constituting a syllable by itself, and medially, the nasal part may be the coda of the preceding syllable, for languages that allow CVC syllables. Herbert (1975) considers Luganda to be such a case.

Let us now look at the languages in UPSID. Of the 317 languages, only one, Aranda, has postnasalized stops. Seventeen have prenasalized stops, which fall into four categories

(102) a. Without voiced stops (9 languages): Luvale, Sedang, Washkuk, Selepet, Kewa, Wantoat, Nambakaengö, Paez, Apinaye.
  b. Without nasals (2 languages): Hakka, Siriono.
  c. Without voiceless stops (2 languages): Berta, Alawa.
  d. With voiceless and voiced stops and nasals (4 languages): Gbeya, Sara, Yulu, Ngizim.

(102a) has already been discussed. We look at Aranda and (102b-d) in turn.

Aranda There are two series of stops, voiceless and postnasalized, and a series of nasals. There are no voiced stops. One may wonder if the postnasalized stops are underlyingly voiced stops. However, K. Hale (p.c.) points out that the postnasalized stops, or 'pre-stopped nasals' as he calls them, behave like nasals rather than oral stops. For example, in Anmatjera, an Aranda dialect, we find long nasals in place of pre-stopped nasals. If so we must distinguish two nasal series. There are several possible distinctions, e.g. in length, in [tense], or [cont][21]. I was unable to get the original references on Aranda, and Wilkins (1989)'s account of a neighbouring language, Mparntwe Arrernte, which has a similar consonant inventory, is brief. I will therefore leave the problem open.

Hakka There is no contrast between prenasalized stops and nasals in Hakka. In fact, some transcriptions write the series as nasals (Yuan 1960).

Siriono Priest (1968, Maddieson's source on Siriono) notes that stops may become prenasalized after a nasal vowel, and that nasals become post-stopped when preceding an oral vowel (104-105). Thus, the prenasalized stops are due to what Herbert calls 'shielding'. In fact, in Priest's own transcription, there are no underlying prenasalized stops.

Berta and Alawa In both languages, there is a voiced stop series and a prenasalized series, but no voiceless series. In particular, in Alawa, there are no aspirated consonants nor fricatives at all

(103) Alawa

```
b    ᵐb    d    ⁿd    d̲    ⁿd̲    d.    ⁿ.d.         g    ᴺg
m          n          n̲          n.
           r
           l          l̲          l.
w          R                           j
```

It is likely that the underlying contrast is between voiceless and voiced stops, both unaspirated. The former would sound like a voiced stop in English, and is probably so transcribed. For the latter, to maintain voicing during closure, without making an implosive, one must either expand the vocal cavity or leave the nasal passage open; Alawa seems to have chosen the latter way, giving a prenasalized stops.

---

[21]. Nasals are considered [-cont] in Chomsky and Halle (1968), but they behave like [+cont] in some Chinese language games (Chao 1931).

Another possibility is that the prenasalized stops are clusters, rather than segments. Triulzi et al (1976), Maddieson's source on Berta, report that Berta has geminate consonants

(104)   àmmá   'mother'
         bèllè   'this stone' (< bèlè+lè)

In Triulzi et al's sketchy report, there is little discussion on the syllabic structure of Berta, except the following words (p521)[22]

> Consonant clusters seem not to occur other than long (geminate) consonants. Homorganic nasal plus stop, as in ^{m}*bè*, 'this, this one which', ^{n}*dé*, 'person', ^{N}*gole*, 'tree, wood' are best <mark>thought</mark> of as units. Across syllable boundaries, Fadashi tolerates consonant sequences more than Undu and Undu in turn more than Mayu, e.g. F(adashi): *bùbdà*, 'ashes', U(ndu), M(ayu): *bùb^{ù}dà*; U(nda): *sùrNí*, 'long', M(ayu): *sùr^{i}Ní*.

What we can infer is that the syllable structure may be CV or CVC, with some restrictions on coda consonants; thus, prenasalized stops could be clusters inter-vocalically. Initially, they seem to be clusters, too. As Triulzi et al note, Berta bisyllabic nouns may be HL, LH, HH, and LL, but monosyllabic nouns generally are L. However, a monosyllabic noun with a prenasalized stop may be H, as in ^{n}*dé* 'person'. In our view, if the [n] in ^{n}*dé* is syllabic (with a H or L which Triulzi et al do not mark), the exceptions disappear. There is, therefore, little evidence that Berta has underlying prenasalized stops.

Gbeya, Sara, Yulu, and Ngizim   All of these four languages have four series of stops and nasals: <mark>voiceless</mark> stops, <mark>voiced</mark> stops, prenasalized stops, and nasals. We look at them in turn.

Gbeya   Maddieson (p229, citing Samarin 1966) gives the following stops and nasals in Gbeya, together with all the vowels (N = velar nasal)

(105) Gbeya

Stops & Nasals				Oral Vowels		Nasal Vowels	
p	t	k	kp	i	u	ĩ	ũ
b	d	g	gb	e	o		
^{m}b	^{n}d	^{N}g	^{mN}gb	E	O		Õ
m	n	N	mN	a		$\tilde{æ}$ ã	

If the four series of stops and nasals contrast with each other, they constitute a case for underlying prenasalized stops.

We note, however, that Gbeya has both oral and nasal vowels, and so before prenasalized stops are postulated, we must examine the 'shielding' effect first. Unfortunately, I was unable to obtain original references on Gbeya. Instead, I looked at Sango (Samarin 1967), a language closely related to Gbeya. Both languages are described by the same author (W.J. Samarin), and during about the same period (1966-1967). So the analysis of Sango should be indicative to the analysis of Gbeya as well.

---

[22]. Fadashi, Undu and Mayu are three Berta dialects on which Trulzi et al's report is based.

Like Gbeya, Sango has both oral and nasal vowels. Songa also has four series of stops and nasals (Samarin p31)

(106) Songa Stops and Nasals: p   t   k   kp

                                           b   d   g   gb

                                         mb   nd   ng   ngb

                                         m   n

Samarin particularly points out that prenasalized stops are single segments, and that their nasal parts 'never appear to figure as the end of a preceding phonetic syllable' (p32). So a cluster analysis is not available (assuming that no onset cluster is allowed). In addition, Samarin provides the following minimal contrasts between voiced stops and prenasalized stops (p32)

(107)   Voiced Stops   Prenasalized Stops
       bi 'to throw'   mbi 'I'
       dé 'cold'   ndé 'different'
       da 'house'   nda 'end'
       dú 'hole'   ndú 'to touch'
       gá 'to come'   ngá 'also'
       gó 'neck'   ngó 'canoe'
       gbá 'in vain'   ngbá 'to remain'

However, the minimal contrasts between voiced stops and prenasalized stops, as given in (107), are only apparent. Samarin gives no discussion of the contrasts between prenasalized stops and nasals, nor between voiced stops and nasals. This omission is suspicious, since Sango has both oral and nasal vowels, and we expect to see the 'shielding' effect. In particular, we want to see whether the prenasalized stops are realizations of nasals before oral vowels, as is the case in Kaingang.

In order to find out the answer, I checked the complete Sango lexicon (Samarin pp259-267), and observed the following distributions

(108) a.   Prenasalized stops do not occur before nasal vowels.
       b.   Nasals do not occur before nasal vowels.

(108b) is puzzling, since we would expect the opposite. The answer lies in the fact that vowels after nasals are always nasalized for some people, as Samarin (p38) points out, and as he alternatingly transcribes the word for 'to grow' as [mái] (p38) and [mã́ĩ] (p263). To put it in another way, all vowels after nasals are nasal vowels, which Samarin does not mark in this environment. In contrast, stops occur before both oral and nasal vowels (Samarin p38)

(109) kẼ   'to refuse'
       kE   'to be'

Putting the above observations together, we have the following distributions

(110)   a.   Stops may occur before oral and nasal vowels.
        b.   Nasals occur before nasal vowels only.
        c.   Prenasalized stops occur before oral vowels only.

This is just what we would expect for the 'shielding' effect: nasals are shielded from a following oral vowel by an epenthetic homorganic stop.

Sara   I was unable to obtain references on Sara. However, like Sango, Sara has both oral and nasal vowels, and so the 'shielding' effect is possible.

Yulu   I was unable to obtain references on Yulu. In addition, unlike Sara, Yulu does not have nasal vowels, although they are closely related languages, both belonging to the Central Sudanic family. I can offer no analysis here.

Ngizim   Ngizim (Maddieson p320, citing Schuh 1972) has voiceless stops, voiced stops, prenasalized stops, and nasals, yet no nasal vowels. So the 'shielding' analysis is not available, nor can we reduce prenasalized stops to voiced stops or nasals. However, the following comment of Schuh (1981:xi) is revealing
        [Prenasalized] sounds function as unit phonemes only in word initial positions; medially, a nasal followed by a homorganic stop is always treated as a sequence.

Thus, it may well be possible that all Ngizim prenasalized stop are underlyingly nasal-stop clusters, since it is easier to explain the 'contraction' of two segments than the 'split' of one.

We have seen that, as far as facts are clear, there is no compelling evidence that any language has underlying pre- or post-nasalized stops. This conclusion, if correct, should not be taken lightly. It is possible that, even if there are no underlying pre- and post-nasalized stops, such segments exist at surface. Phonological arguments for surface pre- and post-nasalized stops include compensatory lengthening, phonotactics, rhythmic counting, and language games (cf. Herbert 1986 for controversies). But if no language has underlying pre- and post-nasalized stops, it may well be the case that such forms are universally excluded, and that surface pre- and post-nasalized stops, whatever their origins, should be reanalyzed.

3.7.3. The No Contour Principle (NCP)
I have argued that there is no clear evidence for any of the three contour segments (contour tones, affricates, and pre- and post-nasalized consonants) which Sagey (1986) has proposed. Since arguments for other contour segments (such as 'short diphthongs') are still weaker, I will maintain the strongest hypothesis that no contour segment exists. I will call the universal con-straint the 'No Contour Principle' (NCP)

(111)   The No Contour Principle (NCP):
        *X   X = any node
        / \   F = any feature
    [αF][-αF]

Let me speculate on the physiological motivations for the NCP. It is well-know that neurological information is sent in discrete units. For example, the human eye receives information in about twelve frames per second. If the human speech faculty functions in a similar fashion, then it will take some threshold interval of time to generate and perceive a speech sound, say about 80ms. This threshold interval may very well be what phonologists have been calling the 'timing slot' or the 'X-slot', and the content of speech activities during this interval 'the segment'. Although articulators may move at different speeds, it is likely that at some planning level all parallel activities are synchronized, so that in each timing unit, each activity can take place at most once.

The NCP not only constrains feature theories, but may account for some well-known autosegmental phenomena. I will discuss one example, the association conventions.

3.7.3.1. Association Conventions
One of the most important components in autosegmental tonology is what has come to be called association conventions (AC) (Williams 1976, Goldsmith 1976, Clements & Ford 1979, D. Pulleyblank 1986, and others). As D. Pulleyblank (1986) argues, earlier formulations of the AC are too strong, and that the AC have just the following two elements (p11)

(112)   Association Conventions:
        Map a sequence of tones onto a sequence of tone-bearing units,
        a.   from left to right
        b.   in a one to one fashion.

There is evidence, however, that (112a) is not universal. We will take two example, Tonga (e.g. Goldsmith 1981, 1984; Halle & Vergnaud 1982) and Shanghai (Xu et al 1981-1983, Selkirk & Shen 1988, Duanmu 1988).

In Tonga, a nominal form may have underlying HL, HLHL, etc. These tones do not associate to TBUs from left to right; rather, each L is associated to an accented V, as shown below (Goldsmith 1984:20-21)

```
(113)  a.     i-bu-si --> i-bu-si --> i-bu-si 'smoke'     (boldface=accent)
                             |      | /    |
              HL           H    L    H      L


       b.     acisya --> acisya --> acisya --> acisya 'uncle'
                           |   |     | | |      | | |
              HLHL         HL  H  L   HL H  L    L  H   L
```

In each case, L is first associated to an accented V. Then other association and spreading apply. Finally, unassociated H is deleted.

In Shanghai, association is from left to right for most patterns, but there is one pattern where it is not

```
(114)  a. za? 'ten'    b. za? se 'thirteen'    c. za? se ti 'thirteen o'clock'
             |\              |  |                    | /    |
             LH             L  H                    L      H
```

d. za? se   ti çi çi ge? 'foolishly' (Lit.: thirteen-o'clockish)

L   H

In each of (114), the underlying tones are LH (coming from the first word sa?). Here association is not from left to right, but from the two ends, then there is spreading to the right.

If (112a) is not universal, what is left of the AC is just (112b). But (112b) need not be stated. It simply follows from the NCP.

3.8. Summary

In this chapter I have argued for the universal tonal model given in (1), in which tone is part of segmental feature geometry. I have also argued that the TBU is the segment in the rime (or the mora carrying segment), that there is no CTU (contour tone unit), that there is a direct relation between the TBA (tone bearing ability) and rime length, and that a TBU can carry at most one tone. In a broader theoretical framework, our treatment of tone suggests that there are no longer any autosegment (an entity that is detached from the segment), and our conclusion of one tone per TBU leads us to the hypothesis of the No Contour Principle (NCP), stated in (111).

CHAPTER FOUR

STRESS

4.0. Introduction

In this chapter I discuss mechanisms for stress assignment. I will basically follow the metrics of Halle & Vergnaud (1987) and Halle (1989). In addition, like Chen (1987), I will emphasize that in order to account for certain stress patterns, the stress mechanism must have full access to syntactic information.

4.1. Halle & Vergnaud (1987)

In Halle & Vergnaud (1987), the stress system of a language is determined by a set of parameters, such as left/right headedness and boundedness. The parameters, in addition, may be set differently at various lines, so that, for example, a language may have [left headed] on line one and [right headed] on line two. This system can account for stress patterns in a wide range of languages in a very simple manner.

4.2. Halle (1989)

Halle (1989) extends the system of Halle & Vergnaud (1987) by allowing a language to insert constituent boundaries at certain points, such as the left or right edge of a syllable. This extension explains the fact that in some languages, stress is based on mora counting, yet the syllable is never broken into two stress domains.

4.3. Syntactic Information and Nonhead Stress

In Halle & Vergnaud (1987) and Halle (1989), stress may be sensitive both to phonological entities, such as syllable and the rime segment, and to syntactic entities, such as word and phrase boundaries. This agrees with Chomsky's (1981) model of grammar, in which the phonological component takes as its input the output of the syntactic component. Naturally, all syntactic information is available for the phonological component. There is much evidence for this analysis. For example, the English Main Stress Rule makes use of syntactic bracketing (Chomsky & Halle 1968), and in Xiamen, the main stress is assigned to the last (non-weak) syllable in every XP that is not an adjunct (Chen 1987). As Chen puts it, 'phonology cannot be syntax-blind' but must make much more use of syntactic information than has been suggested in Selkirk (1984). Moreover, although Selkirk & Shen (1988) argue that the syntax-phonology mapping has 'extremely limited sensitivity to syntactic structure', and that 'no syntactic relations govern the mapping at all, be they dominance, sisterhood, or c-command', yet their analysis of phonological domains makes specific use of both syntactic bracketing and syntactic labeling, as we will see in Chapter 5.

In this section I will discuss a further stress pattern that requires the full use of syntactic informa-

tion. I will call the pattern 'non-head stress' (NHS),[1] whereby in a syntactic head-nonhead rela-
tion, the stress is assigned to the non-head. The relation between head and non-head is defined as
follows:

(1)   In X^{n+1} Y is the non-head and X^n is the head.
              /\
            Y X^n (Y = any projection)

By this definition, the head need not be X^0 but could be any projection of X. Similarly, by this
definition, non-head covers what may be called modifier, complement, etc. Note also that (1)
does not distinguish adjunct v. argument nonheads, unlike the case of Xiamen discussed in Chen
(1987). The NHS rule, which is cyclic, is given below

(2)   In a head-nonhead structure, stress the nonhead.

Let us illustrate (1) and (2) with data from Chengdu, based on my own work. Consider the stress
patterns in NPs (boldface = main stress)[2]

(3)   NP: [**niu** nai]   [**chao** fan]   [**ji**   dan]
                 cow milk   fry rice   chicken egg
                 cow's milk   fried rice   chicken's egg

                [**xian** [niu nai]]   [[**you** chao] fan]   [**re** [[you chao] fan]]
                fresh cow milk   oil fry rice   warm oil fry rice
                fresh cow milk   oil-fried rice   warm oil-fried rice

(4)   Verb: [**hong** shao]   [**qing** duen]   [**shou** xie]
                  red cook   plain stew   hand write
                to red-cook   to plain-stew   to hand-write

(5)   Adj: [**bing** leng]   [[**shen** lu]
                 ice cold   dark green

The above examples may give one the impression that the stress pattern is left headed. But
further patterns show that it is not so

(6)   VP: [chao **fan**]   [pao **cai**]   [he [**xian** [niu nai]]]
                 fry rice   pickle veg   drink fresh cow milk
                to fry rice   to pickle veg   to drink fresh cow milk

---

[1]. Thanks to M. Yip for suggesting this term to me. As she rightly points out, my earlier term
'complement stress' is a little confusing.
[2]. The transcription is given in Pinyin, a Romanized alphabetical system for Mandarin, although
the pronunciation of Chengdu differs somewhat from Mandarin. The following stress markings
are based on normal speech, i.e. without contrast or focus. The manifestation of stress is mainly
in length, so that the stressed syllable is markedly longer.

(7)   PP: [zai [**wai** mian]]   [yan [**he** bian]]   [cao   [**er** lou]]
                at outside side   along river side   toward second floor

The above patterns may be derived by cyclically applying the NHS rule and the stress clash rule (Halle & Vergnaud 1987). Let us look at a few examples. Consider the following stress patterns

(8)   [[**xian** [niu nai]]
          fresh cow milk   'fresh milk'
            2   1 1

(9)   [[he [**niu** nai]]
          drink cow milk   'to drink milk'
            1   2   1

(10)   [[[**xing** mai] de] [**shu** bao]]
           new   buy   book bag   '(a) newly bought school-bag'
            2   1   0   2   1

where 2 is stronger than 1, and 1 stronger than 0. The derivation of (8) is as follows (*=stress, following Halle & Vergnaud 1987)

(11)   [[**xian** [niu nai]
          fresh   cow milk
            2   1 1

```
                                  *
    [* [* *]]   ---->     [* [* *]]   ---->
    lex. stress           NHS-1

     *   *                    *
    [* [* *]]   ---->     [* [* *]]
     NHS-2                stress clash
```

In (11), all the three words are lexically stressed. On the first cycle (NHS-1), the nonhead is second syllable, which received an NHS assignment. On the second cycle (NHS-2), the nonhead is the first syllable, which gets an NHS assignment. Now the first two syllables have equal additional stress, so the stress clash rule applies, removing one of the NHS assignments. I assume that, as a general rule, later assignments override earlier ones, so that the NHS assignment is deleted from the second syllable. The result is that the first syllable has stronger stress, while the other two have lexical stress alone.

Next, consider the derivation of (10), which is shown below

(12)   [[he [**niu** nai]]
          drink cow milk
            1   2   1

```
                                    *
[* [* *]]   ---->      [* [* *]]   ---->
lex. stress            NHS-1

    *                      *
    * *                    *                      *
[* [* *]]   ---->      [* [* *]] ---->    [* [* *]]
 NHS-2                 stress clash       reduction
```
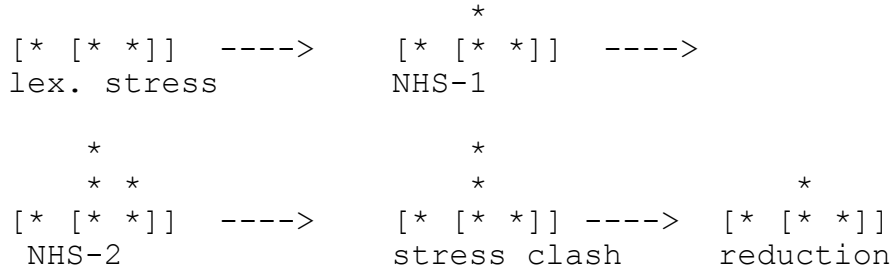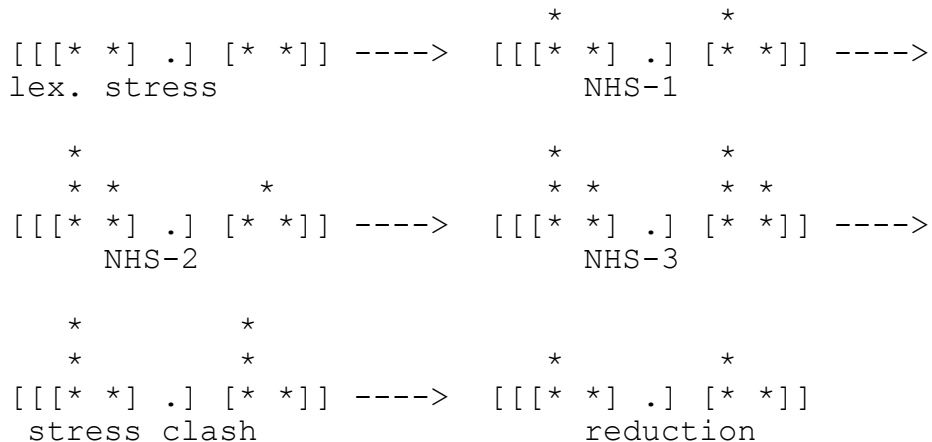
Again all the three words are lexically stressed. On the first cycle, the nonhead is the second syllable, which gets an asterisk. On the second cycle, the nonhead is the last two syllables, each of which receives an asterisk. Then, the stress clash rule applies, removing the NHS from the third syllable. At this point, we have the stress pattern [1 3 1]. Since to may knowledge, [1 3 1] never contrasts with [1 2 1], I assume there to be a stress reduction rule that changes [1 3 1] to [1 2 1], as stated below

(13)   Stress Reduction: Reduce stress levels whenever possible, as long as relevant
                               prominence is maintained.

Intuitively, what (13) says is that stress is relative, and not absolute. This is reminiscent of our discussion of pitch in Chapter 3, where I suggested that what matters is relative pitch and not absolute pitch. The final result of (12) is that the second syllable has stronger stress, while the other two have just lexical stress.

Finally, consider the more complicated (10), whose derivation is given below

(14)   [[[**xing** mai] de] [**shu** bao]]
           new   buy   book bag   '(a) newly bought school-bag'
            2   1   0   2   1

```
                                        *           *
[[[* *] .] [* *]]  ---->     [[[* *] .] [* *]]  ---->
lex. stress                      NHS-1

    *                            *           *
    * *           *             * *         * *
[[[* *] .] [* *]]  ---->     [[[* *] .] [* *]]  ---->
    NHS-2                        NHS-3

    *           *
    *           *                *           *
[[[* *] .] [* *]]  ---->     [[[* *] .] [* *]]
 stress clash                    reduction
```

First, the functional word <u>de</u> does not have lexical stress (indicated by '.'), while the other four syllables do. On the first cycle, the two pairs of inner brackets independently undergo NHS, and the two nonheads, the first and the fourth syllables, receive an asterisk each. On the second cycle, the nonhead is the first two syllables, each of which receives an asterisk. On the third

cycle, the nonhead is the last two syllables, each of which gets an asterisk. Now the stress clash rule removes the NHS from the second and the last syllables. Finally, stress reduction applies, giving the expected result.

In the above examples, we have not mentioned whether the stress clash rule and the stress reduction rule apply after every cycle, of postcyclically. There is some indicate that they apply after each cycle. Consider

```
(15)   [NP  re   [[dan chao] fan]]]
            warm  egg fry   rice              'warm  egg-fried rice'
            2     1   1      1
```

```
(16)   [VP  chi [[dan chao] fan]]]
            eat    egg fry   rice             'to eat egg-fried rice'
            1      2   1      1
```

The derivation of (15) is as follows

```
(17)   [NP  re   [[dan chao] fan]]]
            warm  egg fry   rice                 'warm  egg-fried rice'
            2     1   1      1

                                     *
       [* [[* *] *]]] ----> [* [[* *] *]]] ---->
       lexical stress              NHS-1

            *                        *
            * *                      *
       [* [[* *] *]]] ----> [* [[* *] *]]] ---->
            NHS-2                stress clash

            *                    *   *                      *
       [* [[* *] *]]] ----> [* [[* *] *]]] ----> [* [[* *] *]]]
            reduction            NHS-3            stress clash
```

First, all the syllables in (17) have lexical stress. On the first cycle, the nonhead is the second syllable, which gets an asterisk. On the second cycle, the nonhead is the second and third syllables, each of which gets an asterisk. Now stress clash and reduction rules apply, leaving just one NHS asterisk on the second syllable. On the third cycle, the nonhead is the first syllable, which gets an asterisk. The stress clash rule applies again, giving [2 1 1 1].

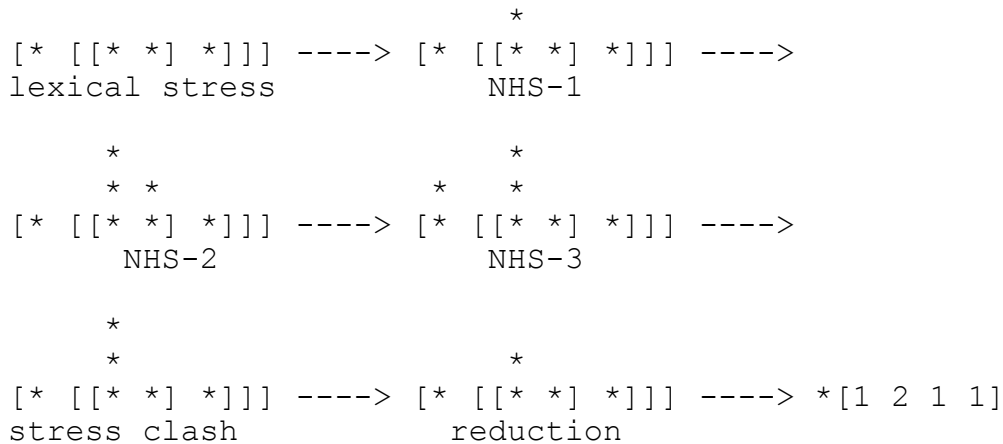Finally, consider the derivation of (16), which is given below

```
(18)   [VP  chi [[dan chao] fan]]]
            eat    egg fry   rice             'to eat egg-fried rice'
            1      2   1      1
```

```
                                  *
[* [[* *] *]]] ----> [* [[* *] *]]] ---->
lexical stress            NHS-1

        *                     *
      * *                     *
[* [[* *] *]]] ----> [* [[* *] *]]] ---->
    NHS-2            stress clash

                                  *
      *                     *                         *
[* [[* *] *]]] ----> [* [[* *] *]]] ----> [* [[* *] *]]]
    reduction            NHS-3                 stress clash
```
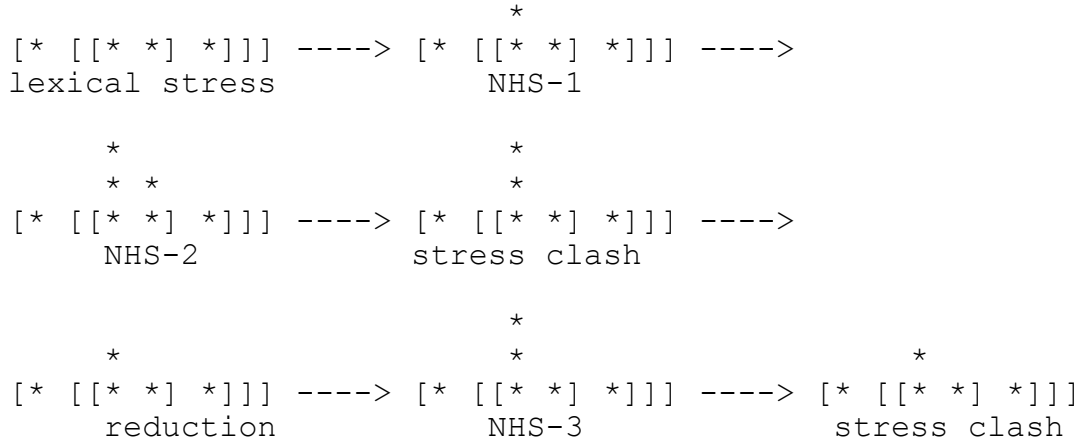
All the steps in (18) are the same as in (17), until the third cycle (NHS-3), where here the nonhead is the second syllable, which gets another asterisk. Finally stress clash rule applies, giving [1 2 1 1].

If the stress clash and reduction rules do not apply after each cycle, we will get the different results. Take (15) for example, derived below

(19)   [NP **re** [[dan chao] fan]]]
            warm   egg fry   rice   'warm egg-fried rice'
             2   1   1   1

```
                                  *
[* [[* *] *]]] ----> [* [[* *] *]]] ---->
lexical stress            NHS-1

        *                     *
      * *                   *   *
[* [[* *] *]]] ----> [* [[* *] *]]] ---->
    NHS-2                NHS-3

        *
      *                     *
[* [[* *] *]]] ----> [* [[* *] *]]] ----> *[1 2 1 1]
stress clash            reduction
```

The problem in (19) may be solved by employing the Stress Equalization Convention (Halle& Vergnaud 1987:265). But this measure will complicate the analysis of other cases we discussed earlier, such as (10).

One may attempt to derive (3)-(7) by setting [left headed] for NP, V, A, etc., and [right headed] for VP, PP, etc. To compare this analysis and mine, we have to look for cases where the two analyses make different predictions. Such examples are not rare. Consider

(20)   a.   V   b.   V
              / \   / \
            A   V   V   A
            gan-chao   chao-**gan**
             dry fry   fry dry
            to dry-fry (i.e.fry without oil)   to fry-till-dry

(21)   a.   ta gan-chao le yi wan cai
                he dry fry ASP a bowl veg
                'He dry-fried a bowl of vegetable'

        b.   ta chao-gan le yi wan cai
                he fry dry ASP a bowl veg
                'He fried-till-dry a bowl of vegetable'
                ('He fried a bowl of vegetable till it was dry')

(20a, b) are both compound transitive verbs, as shown in (21a,b). But (20a,b) have different structures: in the former the head is on the right, and in the latter the head is on the left. My analysis correctly predict that (20a) has stress on the left, and (20b) on the right. In contrast, the alternative analysis wrongly predicts that both (20a,b) have the stress on the right.

The NHS is not only found in Chengdu, but also in Shanghai, as we will see in Chapter 5. The NHS also provide us with a cue to otherwise unclear syntactic structures. The following are some examples

(22)   [**Li** xiansheng]   [**Wang** jiaoshou]
          Li mister   Wang professor

(23)   [Li **Hao**]   [xiao **Wang**]   [Lao **Li**]
        (surname given-name)   Little Wang   Old Li

(24)   [chi **bao**]   [da **lan**]
          eat full   hit break
        to eat till full

        [da lan   [**hua** ping]]
        hit break flower vase
        to hit till breaking the vase

(25)   [**jin** qu]   [**zou** jin qu]   [**chi** le]   [**lai** guo]
        enter go   walk enter go   eat ASP   come ASP
        to go in   to go in by walking

(26)   [bu **lai**]
        not come

(27)   [shi **wu**]   [**wu** shi]   [[wu shi] **wu**]
         ten five   five ten   five ten five
         fifteen   fifty   fifty-five

(22) shows that the head is the title, not the name. This agrees with the fact that such phrases may often be shortened to <mark>the</mark> title only, but not the name only. For example, 'Professor Wang' may be shortened to 'Professor' but not 'Wang'. (23) shows that of a person's names, the surname is the head; so are prefixes like 'Old' and 'Little' in friendly addresses. (24) shows that in Verb-Resultative compounds, the resultative is the head. And so on. Clearly, using the NHS to help clarify syntactic issues is a promising area of research, but that is beyond our scope here.

CHAPTER FIVE

DOMAIN

5.0. Introduction

In this chapter I discuss the determination of tonal domains. I will argue that the tonal domain is
the same as the stress domain, as Yip (1980) and Wright (1983) suggest. I will discuss two
languages, Mandarin and Shanghai. I will also discuss syntax-phonology mismatches and show
that they are also stress dependent. Specifically, I will show that, with a proper analysis of
Chinese syntax, all mismatches are accountable with stress rules alone, and no other prosodic
accessories are needed.

5.1. Mandarin

Mandarin has two kinds of syllables, stressed and unstressed. Unstressed syllables, also called
'neutral-tone syllables', are toneless and monomoraic, and are mostly marked lexically (Woo
1969, C. Cheng 1973, Chao 1968, M. Lin & Yan 1988). In contrast, stressed syllables, which
comprise the overwhelming majority, always have tones and are bimoraic (or sometimes
trimoraic finally) in length (cf. Chapter 2).[1]

The fact that most Mandarin syllables are stressed may explain why there is little tone shifting
going on, i.e. why the ACs ('association conventions', e.g. D. Pulleyblank 1986) do not seem to
apply. For example, consider

```
(1)      55        35          * 53          55
      q i ng--t a i -->   q i ng--t a i            'moss'
        | |      | |            | |      | |
      Rt Rt    Rt Rt         Rt Rt    Rt Rt
                              | |      |/
        H        MH            H M      H
```

---

[1]. Among stressed syllables, some may bear greater stress than others. Hoa (1983) suggests that
such additional stress is at least partly marked in the lexicon, while Meredith (1990) suggests
that it is predictable from the tones of the syllables. My own experience with native Peking
Mandarin speakers suggests that while there is never confusion between stressed and unstressed
syllables, judgments on the relative prominence of stressed syllables are less clear. In any case,
additional stress will not be our concern here.

```
(2)        55         35              55         35
      q i ng--t a i --> * q i ng--t a i
      | |       | |             | |       | |
      Rt Rt    Rt Rt          Rt Rt    Rt Rt
                               |/        | |
       H        MH              H        M H
```

The word for 'moss' has two syllables; underlyingly, qing is [55] or [H], and tai is [35] or [MH]. If the ACs apply, as in (1), we expect the output [HM H] or [53 55]. But the actual pattern is [H MH] or [55 35], as in (2), i.e. each syllable keeps its underlying tones.[2] Similarly, consider another example

```
(3)      214          21              214
      b e i -->  b e i     or    b e i
      | |        | |              | /\          'north'
      Rt Rt      Rt Rt          Rt Rt Rt
                 | |             |  |  |
       MLH        M L            M  L  H
```

```
(4)      214    35          21          35
      b e i j i ---> b e i     j i           'north pole'
      | |  / \        | |      / \
      Rt Rt Rt Rt    Rt Rt    Rt Rt
                      | |       | |
       MLH    MH       M L H    M H
```

```
(5)      214    35       * 21       53          * 21          535
      b e i j i ---> b e i     j i     or    b e i     j  i
      | |  / \        | |      / \            | |      / | \
      Rt Rt Rt Rt    Rt Rt    Rt Rt          Rt Rt    Rt Rt Rt
                      | |      | |            | |      | | |
       MLH    MH       M L    H M H            M L    H M  H
```

bei 'north' is underlyingly [214], which we assume to be [MLH]. In final positions, shown in (3), it may surface as [21] with the regular length, or as [214] with a longer length. In bei ji 'north pole', bei is [21], and cannot be [214]. We assume that a syllable may be lengthened only in final positions, where it may carry three tones. The question is, if bei in (4) has an extra H, why does

---

[2]. The problem cannot be solved by assuming that each syllable has just one TBU, as the following shows

```
      51 51 51           *55 11  5(151)        (correct: [51 51 51])
      xü-li-ya  -->   xü-li-ya                 'Syria'
                       |   |   |
      HL HL HL         H   L  H(LHL)
```

If each syllable has one TBU, we expect [55 11 5...], which is wrong. The right pattern is [51 51 51], i.e. each syllable again keeps its own tones.

it not realize on ji, to give [ML HM] or [ML HMH], as we would expect from the ACs shown in (5)? The fact, again, is that each syllable keeps its own tones, and the ACs seem to fail to apply.

The apparent failure of the ACs to apply to Mandarin is explained if we assume that the tonal domain is the stress domain. In particular, since most syllables are stressed, the tonal domain is in effect the syllable, as we have seen above. This is not a surprising fact, since most Chinese syllables are words themselves. We do predict, however, that if a stressed syllable is followed by one (or more) unstressed syllable(s), there will be just one domain. This prediction is borne out, as the following shows

```
(6)      214                    21    5
      m a i  l e  ---> m a i  l e          'bought'
       | |    |          | |    |
      Rt Rt  Rt         Rt Rt  Rt
                         | |    |
       MLH               M L    H
```

mai 'buy' is [214] or [MLH]. When followed by the unstressed and toneless le 'PAST', mai shifts its H to the latter. This is just what we expect from the ACs. In other words, the apparent failure of the application of the ACs in Mandarin and most other Chinese languages is due to the fact that in these languages most syllables are stressed, so each syllable forms a tonal domain.

The final question we want to find out is whether Mandarin stress is left-headed or right-headed. (6) gives some evidence that it is left-headed. Below is further evidence

```
(7)    a.    buy    ASP  wine    'bought wine'
            m a i  l e  j i u  ---> m a i  l e  j i u
             | |    |    | |          | |    |    | | \
            Rt Rt  Rt   Rt Rt        Rt Rt  Rt   Rt Rt Rt
                                      | |    |    | | |
            (MLH      ) (MLH )        (M L    H)  (M L  H)  [21 5 214]

       b.   m a i  l e  j i u  ---> *m a i  l e  j i u
             | |    |    | |           | |    |    | |
            Rt Rt  Rt   Rt Rt         Rt Rt  Rt   Rt Rt
                                       | |    |    | |
            (MLH  ) (      MLH)        (M L H) (M    L H)   *[21 2 14]
```

In mai le jiu, le is stressless and must merge mai or jiu. If the Mandarin stress domain is left-headed, le should merge with mai as in (7a), which is correct. On the other hand, if the Mandarin stress domain is right-headed, le should merge with jiu as in (7b), which is wrong. We conclude, therefore, that the Mandarin stress domain is left-headed. Below is the summary of Mandarin stress rules (in the framework of Halle & Vergnaud 1987)

(8)   Mandarin Stress Domains:
       a.   Mark all regular syllables.
       b.   Construct left-headed, unbounded constituents.

We will see later that (8) may account for some syntax-phonology mismatches in Mandarin.

5.2. Shanghai

In sharp contrast to Mandarin, tones in Shanghai are not syllable bound. In addition, it is well-known that in Shanghai (as in many other Wu dialects) the tonal pattern of a phrase (we will clarify 'phrase' shortly) is determined by the underlying tones of the first syllable (Xu et al 1981-1983, Selkirk & Shen 1988, among others). Consider (ignoring register)

```
(9)    zã he zi --> zã he zi --> zã he zi          'Shanghai City'
                                  |  |  |
       LH LH LH        LH         L  H (L)
```

All the three syllables are underlyingly [LH]. After deleting tones from noninitial syllables, tones are associated to TBUs left to right and one-to-one, then the toneless zi gets L as default. Note that Shanghai syllables are monomoraic in nonfinal positions, as I have argued in Chapter 2, so that each syllable has one TBU.

If the phrase for 'Shanghai City' is spoken in Mandarin, each of the three syllables will keep its own tones; there will be no tone deletion on noninitial syllables, nor tone shifting cross syllable boundaries. What makes Shanghai different from Mandarin? I suggest that it is stress, as proposed in Yip (1980) and Wright (1983). Recall that in Mandarin, most syllables are stressed, and so the tone domain is essentially the syllable. In Shanghai, however, only the phrase initial syllable is stressed, and this gives the two consequences we saw: first, noninitial syllables lose their underlying tones, and second, the tone domain is the entire phrase.[3] In other words, two conditions hold for both Mandarin and Shanghai

(10)   a.   Stressless syllables lose their underlying tones.
       b.   The tonal domain is the stress domain.

These two conditions are likely to have a more general nature, which I will not pursue further here.

Let us now consider how a 'phrase' or tonal domain is determined in Shanghai. I suggest the following rules (in terms of Halle & Vergnaud 1987)

(11)   Shanghai Stress Domains:
       a.   Mark the initial syllable of every XP, if it is not lexically weak.
       b.   Construct left-headed, unbounded constituents.

We will see what happens if the XP initial syllable is weak in section 5.3. (11) is similar to the

---

[3]. Selkirk & Shen (1988) argue that unlike the often claimed initial stress in Shanghai, the native speaker does not feel that the initial syllable is more prominent. I am not sure whether Selkirk & Shen are right. However, what Halle & Vergnaud (1987) calls 'stress' need not mean physically longer or louder; retaining the underlying tones of a syllable suffices to be a manifestation of stress.

rules proposed in Selkirk & Shen (1988, hence S&S), rephrased below

(12) a.   Mark the initial syllable of every lexical word, i.e. V, N, and A. Ignore functional
             words, e.g. I, P, pronouns, etc.
      b.   Mark the initial syllable of every lexical XP, i.e. VP, NP, and AP, but not PP, IP,
             etc.
      c.   Mark the sentence initial syllable, if it is unmarked.
      d.   A sandhi domain starts from a marked syllable and ends before the next marked
             syllable.

Both (11) and (12) assume that certain weak syllables cannot start a domain. The main difference
between (11) and (12) is that while (12) marks both X^0s and XPs, (11) marks XPs only. This
difference is mainly due to different analyses of Chinese nominals. For example, consider

```
(13)                    (du      ge?)    (fi-ji)          () = tone domain
                         big               plane
        Duanmu:    [[[XP    ][  ]] [NP      ]]     'the plane that is big'
        S&S   :    [[AP           ][N       ]]     'big plane'
```

Both analyses correctly predict (13) to form two domains, but for different reasons. For me, it is
because the particle ge? (same as the famous de in Mandarin) has its own projection and must be
flanked by XPs, as sown below

```
(14)        DeP         a. [[ong ge? [ho      ge?  tsz]]
           / \                  red      flower      seed
        De'  XP2              'flower seeds that are red'
       / \
     XP1  ge?         b. [[[yi ma] ge?] [ge?-nge ma?-z]]
                              he buy        these   thing
                         'these things which he bought'
```

So in (13), both du and fi-ji are XPs, giving two domains. In contrast, for S&S, ge? has no
projection; it may be followed by N, as in (13), or by XP, as in (14a,b). Although for S&S fi-ji in
(13) is N, by (12a) it may still start a domain. In addition, ge? is lexically weak and cannot start a
domain, so (13) forms two domains. Next consider

```
(15)  a.            (so?-lio    fi-ji)
                     plastic    plane
             [[AP          ][N      ]]:      Duanmu
             [N                     ]:       S&S

      b.          (çio-ying       fi-ji)
                   small-sized     plane
             [[AP              ][N     ]]:     Duanmu
             [N                       ]:       S&S
```

Each of (15a,b) forms one domain. Both S&S and I predict it, but again for different reasons. For

me, (15a,b) are NPs; since <u>fi-ji</u> is not XP, there is just one domain. For S&S, (15a,b) are compound nouns. This is because S&S (and many others, such as B. Lu 1990) hold the view that whether a nominal is NP or N depends on the presence of <u>ge?</u>. With <u>ge?</u>, it is an NP; without <u>ge?</u>, it is a (compound) N. (15a,b) have no <u>ge?</u>, so they are not NPs, but compounds. Since a compound is a single word, (15a,b) each forms one domain.

S&S and I do not always make the same predictions, though. Consider

```
(16)                  (çio-ying)      (so?-lio    fi-ji)
                       small-sized     plastic     plane
       Duanmu: [[AP             ][AP          ][N        ]]
       S&S   : [N                                         ]

       a.    /\          b.    /\
            /\ \              / /\
         AP AP N          AP AP N
```

This phrase forms two domains. In my analysis, <u>çio-ying</u> and <u>so?-lio</u> are APs, and <u>fi-ji</u> is N, so whether the structure is (16a) or (16b), there will two two domains, which is correct. In S&S's analysis, since there is no <u>ge?</u>, (16) is a compound, and so should form one domain, which is wrong.

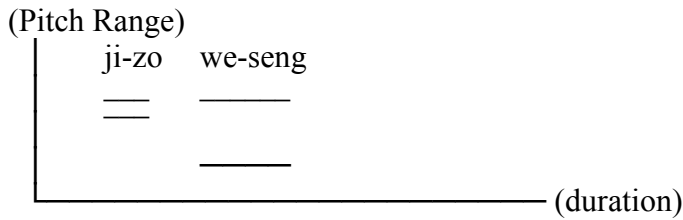A major argument S&S give for marking both X^0s and XPs is based on focused phrases. This is illustrated below

```
(17)    red       horse      tail          'tails of red horses'
        [[ong ge?  mo]   ge? nʸi-po]]
         (         ) (          ) (        )    Normal speech
         (*                        )            Focus on ong
```

```
(18)    red        horse      tail          'red tails of horses'
        [[ong ge?] [[mo   ge?] nʸi-po]]
         (         ) (        ) (        )     Normal speech
         (*         ) (        ) (        )     Focus on ong
```

In normal speech, both (17) and (18) form three domains. For me, it is because <u>ge?</u> is flanked by XPs; in particular, <u>ong</u>, <u>mo</u> and <u>nʸi-po</u> each is an XP and starts a domain. For S&S, <u>mo</u> and <u>nʸi-po</u> in (17) and <u>nʸi-po</u> in (18) are Ns, but since both XP and X^0 may start a domain, (17) and (18) each has three domains (excluding the weak <u>ge?</u>).

Now, when we focus <u>ong</u>, (17) and (18) differ. According to S&S, (17) becomes one domain (or the last two domains lose their tones), but (18) remains three domains. The question is why. For S&S', the difference is due to a distinction between the XP boundary and the X^0 boundary. In particular, S&S suggest that the focused syllable causes tone deletion in the syllables to its right, unless the syllables are separated by an XP. In (17), <u>mo</u> and <u>nʸi-po</u> are not separated by an XP from <u>ong</u>, so their tones delete. In (18), <u>mo</u> starts a new XP, which blocks tone deletion.

My analysis is quite different. To me the contrast between (17) and (18) is due to NHS ('non-head stress', cf. Chapter 4). Consider

(19)

```
            w ┌──────┴────┐ s          s = stress on nonhead
        s ┌────┴──┐ w                  w = lack of stress on head
      w ┌──┴─┐ s
    s ┌─┴┐ w
```

```
   ong   ge?  mo  ge?  nYi-po     'tails of red horses'
   (2        )(2       )(1    ):   Focus ong
   (3        )(2       )(1    ):   Focus ong
```

(20)

```
       w ┌─────┴───┐ s
            w ┌────┴──┐ s
      s ┌─┴┐ w   s ┌─┴┐ w
```

```
   ong   ge?  mo  ge?  nYi-po     'red tails of horses'
   (1        )(2    )(2      ):    Normal
   (2        )(2    )(2      ):    Focus ong
```

I have marked NHS in (19) and (20) (cf. our analysis of ge? in (14), where between XP$_1$ and ge?, XP$_1$ is the nonhead, and between De' and XP$_2$, XP$_2$ is the nonhead). In (19)=(17), ong gets two ==assignments== of NHS, ho gets two, and tsz gets one. In (20)=(18), the order is one, two and two. Now to focus ong is to add more stress to it, say another degree. In (19), the effect is for ong to ==overshadow== mo and nYi-po in stress, but in (20), the effect does not make ong stronger than others. Whether or not there is tone deletion in (19)=(17) I am not sure, but my prediction of relative prominence among different domains agree with S&S's observations. The effect of focusing mo can be explained in the same way.

That Shanghai has NHS is independently reflected in the transcriptions of Xu et al (1981-1983). For example, in [V NP] phrases, Xu et al give a narrower pitch range for the tones on V than for the tones on NP. Consider

(21)
```
         investigate      problems        'to investigate problems'
      [VP dio-zo   [NP weng-ti]]
        (  L   H )  (  L    H )            ( ) = tonal domains
           22  33        22   44
```

(21) has two domains, each with the same tones. Xu et al writes [22 33] for the verb but [22 44] for the object. This is in agreement with our view that the object is the nonhead, and so has additional stress. My own acoustic study yield the same result, as the following example shows

(22)   inspect   hygiene   'to inspect hygiene'
        [VP ji-zo   [NP we-seng]]
            (L H)   (L H)

        (Pitch Range)
                ji-zo   we-seng
        |
        | ——   ———
        |
        | ———
        |
        |_____— (duration)

	ji-zo	we-seng
Pitch range	20Hz	100Hz
Duration	240ms	420ms

The VP phrase has two domains. As is shown, in normal speech, the object domain has both a wider pitch range, as Xu et al note, and a longer duration.

I have given a stress-based account of tonal domains in Shanghai, rather than a category-based account, as S&S propose. I will now show that a stress-based account can also explain many otherwise puzzling syntax-phonology mismatches.

5.3. Syntax-Phonology Mismatches

Syntax-phonology mismatches (SPM) have attracted much recent attention (e.g. Selkirk 1984, Hayes 1984, Klavans 1985, Nespor & Vogel 1986, Shih 1986, Chen 1987, Marantz 1988, Selkirk & Shen 1988). Some consider SPMs to be accountable by syntactic relations, such as dominance, sisterhood and c-command (e.g. Hayes 1984, Nespor & Vogel 1986); some attribute SPMs to largely independent prosodic operations (e.g. Selkirk & Shen 1988). In this section, however, I will offer a stress-based account of SPMs. I will discuss two languages, Shanghai and Mandarin, and show that the stress-based account is superior to other accounts.

The essence of a stressed-based account of SPM is schematically shown below

(23)   a.   Syntax: [*   ][*   ]
            Phonology: [   ][   ]

       b.   Syntax: [*   ][*   ]
            Stress Deletion: [*   ][   ]
            Mismatch: [   ]

In (23a), two syntactic domains map to two phonological domains; there is no mismatch. In (23b), since one of the stresses is deleted, a phonological domain is lost; the two syntactic domains now map to one phonological domain, giving a mismatch. Let us now look at real cases.

5.3.1. Shanghai

S&S discuss a rich body of SPMs in Shanghai. Most examples below will be taken from S&S.
Consider first

```
(24)          I     read ASP    he      book    'I read his book'
          [ngu [kö    ku    [yi ge? sz]]]
     a.    (    )(              )(      )(    )
     b.    (    )(                     )(    )
```

If we mark the boundaries at every XP, (24) forms four domains, as in (24a). In particular, since
ge? is followed by XP, sz is NP and forms a domain. In addition, I follow S&S and assume that
ku does not start an XP. (24a) is a possible tonal pattern, in which there is no SPM. Now, as S&S
point out, (24b) is also a possible pattern, which mismatches the syntactic partition in (24a). The
question is why. According to S&S, pronouns are optionally weak, hence may fail to start a
domain; this explains the loss of the domain yi ge?. On the other hand, the initial pronoun ngu
cannot lose its domain, since if it does, it will remain un-partitioned to any constituent, which
S&S assume to violate some well-formedness constraint.

My analysis is only slightly different from that of S&S's. For me, a pronoun may optionally lose
its stress, and when it does, the constituent headed by it will be headless and cease to exist (Halle
& Vergnaud 1987); in this particular case it will automatically merge with the constituent on its
left, due to left-headedness. In addition, I follow S&S and assume that all elements must belong
to some constituent, so that the initial pronoun cannot lose its stress (since it cannot merge with
the domain to its right). For me, therefore, the SPM in (24b) is a result of stress deletion.

Before we consider further examples, it is necessary to look at Chinese 'classifier phrases' (ClP).
I assume that ClP has the following structure

```
(25)       ClP          ?i? que [yi ma  ge? bi-zo]
            /\           a   cake he buy      soap
        Cl'  XP₂         'a cake of soap which he bought'
         /\
      XP₁ Cl
```

What is of interest to us is that the classifier (Cl) is followed by XP, such as a relative clause, as
the example shows. Now consider the case below

```
(26)           buy      a/one   cup     tea
          [VP ma [ClP ?i?    pe [NP zo]]
     a.       (   )(               )(        )        'to buy one cup of tea'
     b.       (                    )(        )        'to buy  a  cup of tea'
```

?i? may mean 'one' or 'a'. When it means 'one', there are three tonal domains, as in (26a), which
agree with the syntactic domains. However, when ?i? means 'a', there are just two tonal domains,
mismatching the syntactic domains. Our explanation for the SPM in (26b) is simple: ?i? 'a' does
not carry stress, so it cannot head a domain, so its domain merges with the one on its left.

S&S call a domain that contains a stressed word followed by one or more weak words the 'Phonological Word' (PWd), which they consider to be similar to what Hayes (1984) and Nespor & Vogel (1986) call the 'Clitic Group'. S&S point out, rightly, that, unlike what Hayes (1984) and Nespor & Vogel (1986) suggest, the formation of a PWd does not require that the weak word c-command the stressed word. For example, in (26b), ?i? does not c-command ma, yet the two words form a domain. In my analysis, however, not only is c-command unneeded, but the notion PWd is also superfluous. It suffices to assume, as everyone does, that certain words do not carry stress, and that every constituent must have a head, as independently argued for by Halle & Vergnaud.

As a final example, consider the following

```
(27)    he        live      at    Shanghai           'He lives in Shanghai.'
        yi [VP  z      [PP  le?  zang-he]]
        (    ) (                    ) (         )
```

```
(28)    he               at    Shanghai   live        'He lives in Shanghai.'
        yi [VP  [PP  le?  zang-he ]   z     ]
        (    ) (                ) (            ) (        )
```

The point of interest to us is that the word le?, which S&S consider to be a preposition, does not start a domain in (27), but does in (28). The ==dilemma== is that, if le? is strong, it should start a domain in both cases, and if it is weak, it should not start a domain in either. S&S's account is as follows. Prepositions are weak and so neither P nor PP may start a domain; this is the case in (27). In (28), le? lies at the beginning of both PP and VP. S&S propose a rule by which every 'lexical' XP, i.e. VP, AP and NP, must begin a domain, so that le? is forced by the VP boundary to start a domain in (28).

Although S&S's account may explain (27) and (28), it raises questions about other cases. Consider

```
(29)          I     read ASP   he      book               'I read his book'
        [ngu [kö    ku    [yi ge? sz]]]
    a.      (    ) (                   ) (     )
    b.      (    ) (              ) (        ) (     )
```

For S&S, the pronoun yi 'he' is weak, and so may fail to start a domain. The question is, what is the category of the object, of which yi is at the beginning? If the object is NP, it should force yi to start a domain. S&S suggest that the object is DP (determiner phrase), which is weak and cannot start a domain; there is, however, no independent argument for this suggestion.

In my analysis, P is not weak. This accounts for (28). In (27), my analysis differs from that of S&S, as shown below

```
(30)    he        live-at  Shanghai            'He lives in Shanghai.'
        yi [VP  z-le?      zang-he]]
        (    ) (             ) (                 )
```

The VP structure is not [V PP] but [V-P NP], where V-P is an incorporated compound. There are two reasons for this analysis. First, [V P NP] is not a productive structure in Chinese. Generally, post-verbal PPs are not allowed, as the following show

(31)   a.   *yi [o?-yi? [le? zang-he]]
                      he   study at Shanghai   'He studies in Shanghai.'

       b.   *yi [fi [zong zang-he]]
                      he   fly from Shanghai   'He flies from Shanghai.'

Second, if [V PP] is the correct structure, we expect verbal aspect markers to occur before P. On the other hand, if [V-P NP] is the structure, verbal aspect markers should appear after P. Consider

(32)   a.   yi tsou to ku zang-he
                      he walk to ASP Shanghai   'He (once) walked to Shanghai.'

       b.   *yi tsou ku to zang-he
                      he walk ASP to Shanghai   'He (once) walked to Shanghai.'

As is shown, the aspect ku must follow the P, confirming that V-P is an incorporated compound. Thus, the fact that le? 'at' in (27) does not start a domain is expected, because it forms a compound with the verb, as sown in (30).

In summary, I have shown that a purely stress-based analysis gives a simple account of both tonal domains and syntax-phonology mismatches in Shanghai, without employing notions like c-command, nor notions like lexical v. functional categories, Phonological Word, etc.

5.3.2. Mandarin T3S
Let us now look at a slightly different case of SPM in Mandarin. The case we discuss is related to the well-known 'third tone sandhi' (T3S), which is stated as follows

(33)   T3 --> T2 / __ T3
       (or simply: 3 --> 2 /__ 3)

The values of the tones need not concern us. We are interested in how T3S applies. First of all, it should be noted that T3S is not bound to a stress domain, nor to any category domain, as the following show

(34)   3 3 --> 2 3   3 3 --> 2 3   3 3 --> 2 3
       ma-ji   mai jiu   ni you
       ant   buy wine   you have
       'ant'   'to buy wine'   'you have'

Since all syllables have underlying tones, they all must be stressed; each phrase, therefore, is two stress domains (cf. section 5.1.). Yet, T3S applies to all the phrases. This means that T3S is not

bound by stress domains. We also see that T3S applies whether the phrase is a morpheme ma-ji 'ant', or a sentence ni you 'you have'.

In long phrases, there is much debate on how T3S should apply, but in short phrases, and in normal speech, most people agree that T3S applies cyclically (e.g. C. Cheng 1973, Shih 1986, Duanmu 1989b). For example,

```
(35)  a.  3    3    3  --> 2 2 3    b. 3     3    3 --> 3 2 3
         [[li   pin] chang]             [xiao [li   pin]]
          gift item factory             small gift item
```

In each case, T3S applies from the innermost brackets out, two syllables at a time. In (35a) the first two syllables change, while in (35b), only the second syllable changes. We will not discuss the behavior of T3S in long phrases. It suffices to note that, in short phrases, and in normal speech, T3S operates on structural bracketing, and that left- and right-branching structures yield different outputs.

In (35), T3S follows the syntactic bracketing. There is no SPM. Sometimes, however, T3S does not follow the syntactic bracketing. Consider

```
(36)    3    3    3  --->   2 2 3 (*3 2 3)
       [[      ]   ]
       [ mai [wan jiu]]
         buy  bowl wine       '(to) buy a bowl of wine'
```

The syntax is right branching. If T3S follows the syntax, we expect the output [3 2 3], same as in (35b). Yet the correct output is [2 2 3], as if (36) is left branching, like (35a). The question is why there is SPM in (36).

Shih (1986, 149-151) suggests that classifiers like wan may cliticize to the preceding verb, so that (36) will change from right branching to left branching

```
(37)        /\                      /\
           / /\      cliticization  /\ \
        mai wan jiu  ------------>  mai-wan jiu
        buy bowl wine
```

Although it may be true that some cliticization is going on, there are three problems with the analysis in (37). First, clitics are usually unstressed. In Mandarin unstressed syllables lose their underlying tones (cf. section 5.1.). However, wan retains its underlying tones, which means that it is stressed. Second, we have argued that the tonal domain is the stress domain. If wan has stress, it should start a domain, and so it is not clear how it can merge with the preceding domain, as implied in (37). Third, as Marantz (1988) points out, a clitic may merge with a word either to its left or to its right. It is not clear in (37) why wan should merge with mai rather than with jiu.

In my analysis, (36) is again accountable in terms of stress. This may seem surprising, since we

mentioned earlier that T3S is not bound to stress domains. Let us see how the stress solution works. First, consider the structure of (36) again. As I have argued, the Chinese ClP has the following structure

(38)   ClP
             $/\backslash$
          Cl' XP_2
          $/\backslash$
       XP_1 Cl

Although what corresponds to XP_1 does not phonetically appear in (36), I will assume that it is underlyingly present as yi 'a', for the following evidence

(39) a.   mai yi wan jiu   b.   mai   wan jiu
            buy a bowl wine   buy   bowl wine
            'to buy a bowl of wine'   'to buy a bowl of wine'

Whether yi phonetically realizes or not, (39a,b) are synonymous, in agreement with our assumption. Apparently, yi is optionally deleted. Thus, (36) underlyingly has the following structure

(40)   [VP mai   [ClP yi wan [NP jiu]]]]

where yi may surface, giving (39a), or fail to to surface, giving (39b). Now. if yi does not surface, it surely cannot carry stress, and so should merge with, or cliticize onto mai.

But what exactly is going on when we say that A merges with (or cliticizes onto) B? Here I will formally characterize the process as follows

(41)   The Merger Convention: When two adjacent constituents merge, delete all boundaries
                               between them.

In (40), merging yi with mai will give the following result

(42)   Underlying: [VP mai [ClP yi wan [NP jiu]]]
       After merger: [VP mai-yi   wan [NP jiu]]
       Deleting yi: [VP mai   wan [NP jiu]]

After the merger, a [V ClP] phrase is changed to a [V NP] phrase. At this point, wan is closer to mai than to jiu; this is because between mai and wan there is no intervening bracketing, but between wan and jiu there is an NP boundary. When we apply T3S here, it will operate on mai wan first, and then on wan jiu, giving the output [2 2 3], as shown below

```
(43)                    [VP   mai    wan    [NP   jiu ]]
        Underlying:           3      3            3
        Cycle 1:              2      3
        Cycle 2:                     2            3
        Output:               2      2            3
```

The output of (43) is the same as one from a left branching structure, as we expect.

5.4. Summary

I have argued that in both Mandarin and Shanghai, the tonal domain is the stress domain. Although in Mandarin stress is assigned to regular syllables, and in Shanghai it is assigned to XPs, both languages have left headed domains (cf. (8) and (11)). In addition, I have shown that a stress-based analysis, shown in (23), may explain a wide range of syntax-phonology mismatches, whether the mismatches appear with stress sensitive rules, such as in Shanghai tone sandhi, or with rules unbounded by stress domains, such as the Mandarin T3S.

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