

**A SYSTEM OF TONE FEATURES
AND ITS IMPLICATIONS FOR THE REPRESENTATION OF TONE**

by

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A System of Tone Features And Its
Implications For The Representation of Tone

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Abstract

The construction of a new system of tone features is the principal focus of this study. This system is intended to account for the following observations:

- i). Tonogenetic studies suggest that three types of syllable endings give rise to three tone heights.
- ii). Tonal split studies show that three types of syllable initials can induce tonal tripartition, i.e. the split of an original tone in three ways.
- iii). Historical studies show that register overlapping frequently arises as a result of register split.
- iv). Typological studies show that the maximum number of tone heights any language can distinguish is five.
- v). Phonetic studies show that tone space varies with the number of tone heights within a system.

While previously proposed systems of tone features can capture some of these observations, none can capture all. In particular, tonal tripartition has never before formally incorporated in a system of tone features. The major contributions of the present study are the incorporation of tonal tripartition and a unified account of all the above observations in a simple, historically motivated and phonetically verified system of tone features.

Data in support of the proposed system are drawn from synchronic and diachronic studies of Chinese, Tai, Kam-Sui, Vietnamese, Miao-Yao, and some other Southeast Asian languages, with special reference to tonogenesis and tonal tripartition, and the interactions between tone and consonants. Evidence from phonetic and typological studies are also brought in to further strengthen the new feature system.

The implications of the new feature system to the representation of tone in general are discussed in the last chapter of this dissertation. The main aspects of this issue to be addressed include: i) the tone-bearing unit (i.e. whether the tone-bearing unit should be the syllable, the rhyme, or the mora); ii) the nature of tone features (i.e. whether they are defined perceptually, acoustically, or articulatorily); and iii) the value of tone features (i.e. whether they are binary or privative).

It is concluded that an optimal system of tone features should consists of two perceptually defined, privative features, with the function of specifying up to five degrees of tone height and three tonal registers, and the optimal tone-bearing unit is the mora.

This work is dedicated to my parents

Fu Langhuan

Cao Xiutian

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Chapter One

Introduction

This thesis is a study on the distinctive features of tone. Embodying four research areas, *viz.* contemporary phonological theories, historical tonal development, typological classification, and phonetic observations, this thesis introduces a new system of distinctive features to handle a wide range of tonal phenomena, including a maximum number of three registers, a maximum number of five distinctive tone heights, tone space variation, register overlapping, and historical correlation of register with syllable initials and tone with syllable finals.¹ Phonologically, the new system is based on an analysis of twenty previously proposed systems of tone features, and incorporates some recent developments in the study of feature geometry and underspecification, such that only two features are used to handle all the tonal phenomena mentioned above.

1.1. The scope of the study

This thesis consists of six chapters. In Chapter One, I first introduce the central arguments and the scope of the present study. I then briefly review the development of tonal distinctive features in the literature.

In Chapter Two, I discuss the relationship between register features and tone features. I demonstrate that this relationship determines the representation of many other tonal phenomena, including, for example, how many registers and tone heights a feature system is capable to handle, and what types of contour tones a system can deal with. In addition, this relationship also determines the overall economy of a feature system. I conclude that an optimal register-tone relationship should be such that the existence of the tone feature should not be dependent upon the existence of the register feature, or vice versa, and that both register and tone features should be able to represent contour tones.

¹ Tone space is the pitch range within which all the tonal contours of a language are confined. Tone space is smaller than the whole voice range, the latter being used for other purposes as well, such as intonation. For a fuller discussion of tone space, see § 5.3. 'Register' and 'tone height' (or 'tone level') refer to two different notions in this thesis. Register is defined as the subdivision of the tone space, while tone height further divides register. In this sense, tone space, register, and tone height enter a relationship of three hierarchies. For details, see § 2.1.

In Chapter Three, the core of this thesis, I propose a new system of tone features. This new system offers a unified account of the following observations, which none of the previous proposals is able to capture all at once:

(1) Tonal phenomena dealt with in previous systems of tone features

- i. The number of tone heights: the maximum number of tone heights any language can distinguish is five (Wang 1967; Woo 1969; Anderson 1978; Maddieson 1978b; Edmondson 1992b).
- ii. Register bipartition: historically, voiceless syllable initials induce a higher pitch on the following vowel, while voiced syllable initials induce a lower pitch. Such consonant effect on vowels may result in a bifurcation of the tone space, known as register bipartition (Yip 1980; Clements 1981b; Hyman 1986; Bao 1990).
- iii. Register overlapping: the upper and lower register tones often overlap in pitch (Duanmu 1990).
- iv. Tone-height compression: with the increase of the number of tone heights, the overall tone space tends to stay the same with the space between each tone height compressed (Pike 1948; Wang 1967).
- v. Tone-space expansion: a system with a larger number of tone heights tends to have a wider tone space than a system with a smaller number of tone heights (Maddieson 1970; 1978b).²
- vi. The markedness of tone: the mid tone is the least marked (Maddieson 1970; Hyman 1986; Pulleyblank 1986).

This thesis is intended not only to offer a unified account the above phenomena, it also takes into consideration some other phenomena which have never been incorporated in any previous system of tone features. These additional phenomena are:

(2) Additional phenomena dealt with in this thesis

- i. Register tripartition: in some Southeast Asian languages, tone space can split into three registers (Haudricourt 1961; Edmondson 1990a).

² Note that iv. and v. state different observations on the relationship between the number of tone height and the width of tone space. For more on this relationship, see Chapter Five.

- ii. Tonogenesis from syllable final consonants: not only can syllable-initial consonants induce pitch changes on the following vowel, syllable-final consonants can also give rise to pitch changes on the preceding vowel (Haudricourt 1954a,b). In particular, -h gives rise to a falling pitch; -ʔ gives rise to a rising pitch; sonorant endings give rise to a mid pitch.
- iii. Simultaneous tone-space expansion and tone-height compression: while tone-space tends to be larger in a system with a larger number of tone heights than in a system with a smaller number of tone heights, the distance between each adjacent tone height tends to be smaller (Hombert 1978b).
- iv. Tone merger: tone-height compression results in the reduction of the perceptual distance between adjacent tones, which may ultimately lead to the merger of originally distinct tones (Haudricourt 1961; Hombert 1978b).

To account for the phenomena listed in (1) and (2), the new system I propose has the following properties:

(3) Aspects of a new feature system

- i. The system contains two features [high] and [low].
- ii. These features are privative features.
- iii. These features are perceptually defined.
- iv. Register and tone are represented by the same set of features.
- v. A maximum number of three registers is identified.
- vi. Each register consists of a maximum number of three tone heights.
- vii. Register overlapping is incorporated.
- viii. The total number of distinctive tone heights is five.
- ix. Both tone-space expansion and tone-height compression are allowed.
- x. The mid register and mid tone are unspecified.

The evidence for the new system is discussed in detail in Chapter Four and Chapter Five.

In Chapter Four, I introduce historical evidence for the new system. I survey various historical studies, covering such topics as tonogenesis, tone split, and tone merger. I demonstrate that although there are considerable disagreements in the literature concerning the mechanisms of both tonogenesis

and tone split, there is overwhelming agreement on the pattern of tonal development, in particular, three-way register split with each register further divisible into three tone heights. This agreement strongly supports the fifth and sixth properties of the new system, i.e., the identification of three registers and three tones. Historical evidence also clearly demonstrates that register split does not produce clear-cut divisions among registers, as is commonly assumed in previous tone systems, but rather, it is often the case that registers partially overlap with each other as a result of register split. This overlap may develop into a total merger of tone, as is often seen in the history of tonal development.

In Chapter Five, I provide typological and phonetic evidence for the new system. The most important issues are the following three. First, there is overwhelming agreement in the literature that the maximum number of tone heights any language can distinguish is five. This observation strongly supports the eighth property of the new system, i.e., the identification of five tone heights. It also gives further support to the seventh property of the new system, i.e., register overlapping. In other words, it is register overlapping that accounts for the fact that the maximum number of registers is three, with each register further divisible into three tone heights, but there is no language that distinguishes nine tone heights. Second, there is evidence that more tone heights tend to require a larger tone-space, but at the same time the distances between adjacent tone heights tend to decrease. That is, tone-space expands while tone height compresses as the number of tone levels increases in a system. This observation supports the ninth property of the new system, i.e., tone-space expansion and tone-height compression. Third, tone-space expansion can be formulated in two different ways, either starting from the center and expanding outwards, or starting from one border of the tone space and expanding beyond the other. Various studies have shown that it is the former that is true. This observation entails that there is need to employ the notion of the neutral mid pitch,³ and that featurally this pitch is best treated as unmarked, supporting the tenth property of the new system, i.e., the mid is unspecified. In the last section of this chapter, I discuss cover features for voice and tone. Ever since Halle and Stevens (1971), there have been several proposals of tone in which tone and consonant voice are represented by the same set of features. Such a theoretical stand stems from the observation that voiceless consonants tend to induce a high pitch while voiced consonants tend to

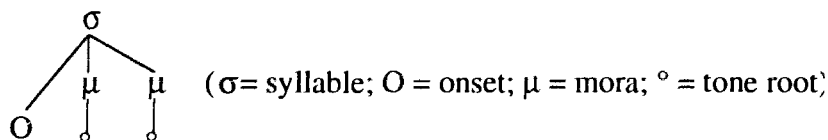
³ Note that not all tone-feature systems employ this notion. See § 1.2.

induce a low pitch on the following vowel. I argue that since there are other consonant types that also have the same effect on the pitch of the following vowel, the Halle-Stevens' cover features are not adequate. For this reason, cover features for voice and tone are not adopted in this thesis.

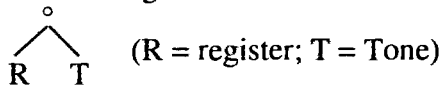
In Chapter Six, I discuss the implications of the new system to the formal representation of tone. The following issues will be discussed: i) the representation of contour tones and the tone-bearing unit (TBU); ii) the nature of tone features (i.e. whether they are defined perceptually, acoustically, or articulatorily); and iii) the value of tone feature (i.e. whether they are binary or privative). I argue for the following model of tonal representation:

(4) Tonal representation

i) The relationship between tone root and other prosodic units



ii) Tone and register



(4i) is based on two hypotheses: i) The standard moraic theory (Hyman 1985; McCarthy and Prince 1986; Hayes 1989), which assumes that the prosodic anchor is the mora. ii) The CTU hypothesis (contour tone unit hypothesis) (Yip 1989), which represents contour tones as units at one level, but concatenations of level tones at another. Under the CTU hypothesis, the tonal root node is the register. In (4i), a further assumption is made to the effect that only the head mora is allowed to branch. Yip's original CTU hypothesis, which takes the syllable as the TBU, is incompatible with the moraic theory. By taking the mora as the TBU, (4i) has the advantage of capturing the interactions between syllable weight and the complexity of tone (Duanmu 1990, 1992, 1993, 1994a,b), and tone-vowel interaction (Jiang-King 1994, 1995), both of which cannot be accounted for by Yip's original CTU hypothesis. By retaining the CTU under the head mora, (4i) can account for the free occurrence of short contour tones (see § 6.1.4), which cannot be captured without CTU.

(4ii) says that the relationship between register and tone is parallel. In the literature, register-tone relationship has been represented in two different ways. Yip (1980), Bao (1990) and Duanmu (1990)

argue that this relationship should be parallel; Yip (1989) argues that this relationship should be hierarchical, i.e. register dominates tone. I will argue in Chapter Two that the existence of tone features should not be dependent on the existence of register features, or vice versa, and therefore the register-tone relationship should be parallel.

As to the issue of the nature of tone features, I demonstrate that the articulatory and acoustic tone features proposed so far cannot account for five contrastive tone heights and three registers. For this and other reasons, they are not adopted in this thesis. As to the value of the tone features, I follow Dikken and Hulst (1988), Hulst (1989), Avery and Rice (1989), Lombardi (1991) and many others, arguing that privative features allows for the maximum economical system, while the binary systems are more costly.

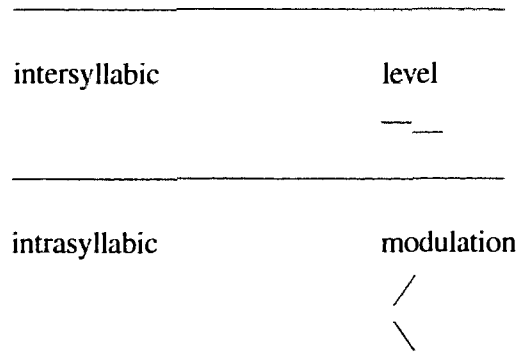
1.2. The development of tone features

In this section, we outline the development of the theory of tone features by examining previous models of tone. The following issues will be discussed: i) the representation of multiple tone heights; ii) the representation of tonal register; iii) the representation of contour tones; iv) the relationship between tone space and the number of tone heights; v) the relationship between different features within a system; vi) the nature of tone features, i.e. whether tone features should be defined in terms of glottal tension and constriction (articulatory features), in terms of fundamental frequency (acoustic features), or in terms of perceptual pitch (perceptual features); and vii) the overall economy of tone-feature systems.

1.2.1. Jakobson and Halle (1956)

The Jakobson and Halle's tone-feature system (1956) is perhaps the first ever proposed. The authors distinguish two types of tone features: intersyllabic and intrasyllabic. The intersyllabic features are level features, which contrast different syllable crests within a sequence by their register. The intrasyllabic features are called modulation features, which contrast the two portions of the same syllable by their relative pitch height. Thus, a modulation feature can be either rising or falling. Fischer-Jørgensen (1975) illustrates these two types of tone features as below:

(5) Jakobson and Halle (1956), illustrated by Fischer-Jørgensen (1975)



In this system, the level feature involves a basic opposition between high and low registers, each of which could further split into 'raised' and 'diminished' variants. Jakobson and Halle write (1956:22-23):

The level feature may be split in two: either a neutral register is contrasted with an elevated register, on the one hand, and with a lowered one, on the other, or, finally, each of the two opposite registers, high and low, may appear in two varieties, raised and diminished.

This system can therefore distinguish a total number of four tone heights, resulting from successive splits of the tone space. In this aspect, Jakobson and Halle's system antedates bi-registral systems championed by Yip (1980) by two decades.

1.2.2. Wang (1967)

Wang's system (1967) is the first full-fledged system of tone features. It touches upon many theoretical issues, and lays the foundation for the subsequent development of the theory of tone features. The theoretical issues discussed in Wang's paper include: a) the representation of tone heights; b) the representation of tone contours; c) the relationship between tone space and the number of tone heights; d) the domain of tone features (which is held to be the syllable); e) the restriction of redundancies; and f) the marking convention. Here we restrict our discussion to the first three issues.

Wang uses seven binary features to specify a total number of thirteen tones. These tones are given in tone letters⁴ in the second row in (6).

(6) Wang (1967)

	1	2	3	4	5	6	7	8	9	10	11	12	13
	˥	˨	˧	˦	˩	˪	˫	ˬ	˭	ˮ	˯	˰	˱
[contour]	–	–	–	–	–	+	+	+	+	+	+	+	+
[high]	+	–	+	–	–	+	–	+	–	+	–	+	–
[central]	–	–	+	+	+	–	–	–	–	–	–	–	–
[mid]	–	–	–	–	+	–	–	–	–	–	–	–	–
[rising]	–	–	–	–	–	+	+	–	–	+	+	+	+
[falling]	–	–	–	–	–	–	–	+	+	+	+	+	+
[convex]	–	–	–	–	–	–	–	–	–	–	–	+	+

The three level features [high], [central] and [mid] together specify up to five tone heights, matching exactly with the typological observation that the maximum number of tone heights any language can distinguish is five. In Wang's system, these three level features do not have equal functions. For a language distinguishing two levels of tone, only [high] is distinctive; [central] and [mid] are redundant. For a language with three or four levels, only [high] and [central] are distinctive. [mid] becomes distinctive only in a system with five tone heights (see (7)). Although the rare use of [mid] is intended to reflect the fact that languages with five distinctive levels are extremely rare, in Wang's formulation the mid tone is the most marked among the five level tones, which is later found to be incorrect (see Maddieson 1970; Hyman 1986).

The biggest difference between Wang's system and most later systems is that there is a set of contour features for the description of contour tones. Apparently, Wang takes the position that contours should be regarded as basic units, at least in the type of languages of the East Asian area. He writes (1967:97):

⁴ The system of tone letters was introduced in Chao (1930). It consists of two sets of symbols, as illustrated below:

straight tones		circumflex tones		short tones	
˥	11	˨˨	131	˥	1
˦	13	˨˩	153	˦	2
˧	15	˨˪	242	˧	3
˦˥	22	˨˫	313	˦˥	4
˦˩	24	˨ˬ	315	˦˩	5

In 1989, this system of tonal transcription was sanctioned by the International Phonetic Association.

The recognition of contour tones is crucial in the analysis of certain types of tone systems if we are to capture all the only the consistent characteristics in the phonological structure. If it turns out that FALLING is the only relevant feature for a particular tone, then over-differentiation would only lead to chaos when we try to mark what pitch levels the tone falls from or what level it falls to.

Thus, in his system the only relevant level feature in the description of contour tones is [high]. As shown in (6), no tonal contour varies across the mid-pitch line. This characteristic of the system is reminiscent of the register feature [Upper] of Yip (1980) (§ 1.2.10), although the notion of register is not explicitly incorporated in Wang's system.

Wang's system is explicitly based on Pike's 'tone-height compression' view (§ 5.3). He says, 'No matter how many tones a language has, the voice pitch traverses approximately the same overall range... The greater the number of distinct tones in the paradigm, the narrower the phonetic range of each tone would be' (1967:100). This can be illustrated with the following figure, which is based on figure 2 in Wang's paper (1967:101):

(7) Tone-height compression expressed in terms of distinctive features

2 levels	3 levels	4 levels	5 levels
+high	+high -central	+high -central	+high -central -mid
		+high +central	+high +central -mid
-high	+central	-high +central	-high +central +mid
		-high +central	-high +central -mid
	-high -central	-high -central	-high -central -mid

The immediate consequence of this formulation is that the same features cover different pitch ranges in different paradigms. The range covered by [+central] grows with the increase of the

number of tone heights within a paradigm. The feature [+high] covers half of the total range in paradigms with two and four levels, but less than half in paradigms with three and five levels. In other words, the features [high] and [central] do not have fixed values with respect to tone space. It is unclear how the variation of [high] can be reconciled with the fact that this feature functions to restrict all the tonal contours within half of the tonal tone space in (6).

1.2.3. Sampson (1969)

Accepting Wang's contour features, Sampson (1969) aims at modifying Wang's level features. The main purpose of the modification is to achieve a more or less equal use of the features, as can be seen from a comparison of the relevant features in (6) and (8). Thus, Wang's feature [mid] is dropped; [central] is renamed as [mid]; and a feature parallel to [high], i.e. [low], is adopted. Sampson's three level features are illustrated in (8).

(8) Sampson (1969)

	[high]	[mid]	[low]
[5]	+	–	–
[4]	+	+	–
[3]	–	+	–
[2]	–	+	+
[1]	–	–	+

As shown in (8), the feature [high] can no longer be defined as covering half of the total pitch range. Instead, it is redefined as 'pitch at level 4 or above'. Correspondingly, [low] is defined as 'pitch at level 2 or below'. This modification, however, overlooks the relationship between Wang's level and contour features. As noted above, in Wang's system all the contour tones are confined within half of the total pitch range, due to the use of the feature [high]. By redefining [high] as 'pitch at level 4 or above', Sampson is no longer able to specify half of the pitch range with this feature. In fact, none of Sampson's features nor any combinations of his features can have this function. It is therefore unclear how the system as a whole would function.

1.2.4. Woo (1969)

Woo's biggest contribution is the proposal that unitary contour tones be represented by concatenations of level tone features. Here we discuss two issues: a) the representation of unitary contour tones; and b) the feature [modify].

Woo observes that there is a major difference in the literature regarding the representation of the contour tones in African languages on the one hand, and the contour tones in Asian languages on the other. As tone clusters, the former type of contour tone is usually represented as concatenations of level features. The latter type, being branching contour tones, is represented with unitary contour features, such as those suggested in Wang (1967). Woo questions the validity of the different treatments of these two types of contour tones, proposing instead that the Asian type of contour tones be also represented with level tone features. Woo suggests that all tone features be assigned to the tone-bearing segments, rather than to the syllable as Wang and Sampson do.

Compared to earlier feature systems, Woo's proposal has two advantages. First, by representing contours as sequences of levels, it eliminates all the contour features from the system, thus achieving a dramatic gain of economy. Because of this, Woo's whole system consists of only three features as in (9):

(9) Woo (1969)

	[high tone]	[low tone]	[modify]
high	+	–	–
high-mid	+	–	+
mid	–	–	–
low-mid	–	+	+
low	–	+	–

The second advantage of the system is that it captures certain correlations between the complexity of the tone and the length of the tone-bearing portion of the syllable, which is defined as the nuclear vowel plus any number of sonorant segments following the nucleus (Woo 1969:31), i.e. the rhyme. Woo provides measurements of the duration of the four Beijing tones, demonstrating that the most complex tone, [214], is indeed longer than the other three tones [55], [35], and [51]. In Wang

(1967) and Sampson (1969), since the TBU is the syllable, the correlation between the length of the rhyme and the complexity of the tone cannot be expressed.

There are two major problems with Woo's tonal study. First, like Sampson (1969), Woo also employs the features [high] and [low], but she rejects the feature [mid], on the ground that it is 'difficult to see what the articulatory correlate to the feature specification [+mid] could be, other than the redundant one also given by the feature matrix [-high tone, -low tone].' (:70). She feels that levels 4 and 2 in a five-level system are more marked than levels 5, 3 and 1, being 'the result of a secondary articulatory mechanism imposed on the primary mechanisms.' (:69). Thus, she invents the feature [modify] to specify levels 4 and 2, and reflects the unmarked status of level 3 with negative specifications of all the three features. However, the claim that levels 4 and 2 are more marked than levels 5 and 1 is not backed up. As we shall see in § 1.2.5, this claim is incorrect, and hence the feature [modify] is untenable.

The second problem is that by matching tonal complexity directly with the length of the rhyme, Woo's proposal cannot represent short contour tones, as exemplified in (10).

(10) Buyang short contour tones (M. Liang 1990)

i) short contour tone

hot⁵³ 'tree'

lak⁵³ 'son'

ii) long contour tone

bo:t⁵³ 'to pull out (grass)'

he⁵⁵ ta:k⁵³ 'loom'

Thus, although Woo's proposal captures the correlation between tonal complexity and rhyme length in certain circumstances, the requirement that there be always a perfect match between the two is nevertheless too strong (Anderson 1978).

1.2.5. Maddieson (1970)

Feature systems prior to Maddieson (1970) are based on what we have called the 'tone-height compression view', which assumes that with the increase of the number of tone heights, the overall tone space tends to stay the same with the distance between adjacent tone heights compressed. Maddieson argues against this assumption. His feature system, presented in (11), embodies the

‘tone-space expansion view’, which says that a system with a larger number of tone heights tends to have a wider tone space than a system with a smaller number of tone heights (Maddieson 1978b):

(11) Maddieson (1970)

	[Raised]	[Lowered]	[Extreme]
extra high	+	–	+
high	+	–	–
mid	–	–	–
low	–	+	–
extra low	–	+	+

In Maddieson system, the least marked tone is the mid tone, while the most marked tones are the peripheral tones (highest and lowest tones). His system thus makes a claim completely opposite to that made by Wang’s system, where the least marked are the peripheral tones while the most marked tone is the mid. It is interesting to note that Woo’s system makes a third claim, where the most marked tones are neither the mid nor the peripheral.

1.2.6. Maran (1971)

In studies prior to Maran, tone features are typically defined in perceptual terms. For Maran, this approach is ‘seriously wrong’ because it fails to incorporate tonal features into a system of universal phonetic features, where most of the segmental features are defined in articulatory terms, and it fails to bring about any understanding of the articulatory correlates of tone (Maran 1971:9).

Maran adopts the acoustically-defined tone features as in (12) for two reasons. In the first place, it is a reaction to the failure of the perceptual approach in its explanation of tone production. In the second place, he feels that the precise articulatory mechanism for tone production is still unknown. But since the articulation of tone is reflected in F_0 variations, the acoustic features can be taken as substitutes for the more difficult articulatory tonal features.

(12) Maran (1971)

	[Raised F ₀]	[Lowered F ₀]
high	+	–
mid	–	–
low	–	+

Maran's system has a major problem: it cannot specify more than three levels of tone. Since there do exist languages with four or five distinctive tone heights, Maran's system cannot be used as a universal system of tone features.

1.2.7. Halle and Stevens (1971)

In the same year as Maran proposed the above acoustically defined tone features, Halle and Stevens (1971) proposed a set of laryngeal features to handle, among other things, tones and the interaction between tone and voicing.

(13) Halle and Stevens (1971)

		[stiff]	[slack]
p	\acute{V}	+	–
w	V	–	–
b	\grave{V}	–	+

Most common objection to the features [stiff] and [slack] is that they can only specify up to three levels of tone height (Fromkin 1972; Anderson 1978; Yip 1980). In this aspect, Halle and Stevens (1971) is equally inadequate as Maran (1971). For more discussions of Halle and Stevens (1971), see § 5.6.

1.2.8. Fromkin (1972)

Fromkin (1972) addresses three issues. First, she argues against Woo and Maddieson's systems, where the mid tone is always represented as the least marked tone. Since in three-tone systems, the mid tone is not always the least marked (see Chapter Three, (74)), Fromkin argues, Sampson's system captures the variations better. In systems where the mid is the least marked, [high] and [low]

can be used; in systems where the mid is the most marked, [high] and [mid], or [low] and [mid] can be used. A system with downstep, for example, can be represented as below:

(14) The representation of downstep (Fromkin 1972:58)

	high	downstep	low
[high]	+	+	–
[mid]	–	+	–

Secondly, Fromkin argues for the contour features. She says that if in every language a succession of two tones is always realized as a contour tone, then contour tone features can be dispensed with. But this is not always the case. In Nupe, there is a contrast between a low-high sequence and a low-rising sequence:

(15) Nupe (Fromkin 1972:63)⁵

- a. ètú ‘parasite’
èdǔ ‘taxes’
- b. èkpá ‘length’
ègbǎ ‘a garment border’

Fromkin concludes that for descriptively adequate phonetic representations, at least the feature [contour] must be retained (see below).

Third, Fromkin argues against Leben’s (1971) suprasegmental representation of tone. Instead, she argues for Woo’s segmental approach where there is always a one-to-one match between tone and the segment. As shown above, the biggest problem with Woo’s approach is the representation short contour tones. The solution Fromkin proposes is to use the feature [–segment]. Short contour tones can be represented underlyingly as in (16i), and surface phonetically as in (16ii):

⁵ Hyman and Schuh (1974:106) has an alternative analysis of the Nupe data. They argue that contour tone formation is due to a process of tone spreading, and that the intervocalic voiceless consonants block the spread of the low tone on the first vowel, while voiced consonants do not.

(16) Fromkin's representation of short contour tones (Fromkin 1972:72)

i. falling tone	$\begin{bmatrix} +h \\ +seg \end{bmatrix} \begin{bmatrix} -h \\ -seg \end{bmatrix}$
rising tone	$\begin{bmatrix} -h \\ +seg \end{bmatrix} \begin{bmatrix} +h \\ -seg \end{bmatrix}$
rising-falling tone	$\begin{bmatrix} -h \\ +seg \end{bmatrix} \begin{bmatrix} +h \\ -seg \end{bmatrix} \begin{bmatrix} -h \\ -seg \end{bmatrix}$
ii. falling tone	$\{+low, +contour\}$
rising tone	$\{+high, +contour\}$
rising-falling tone	$\{+high, -high, +contour\}$

1.2.9. Goldsmith (1976)

Goldsmith's feature system is different from any of the previous systems in that it allows the combination of $\{+high\}$ and $\{+low\}$, while disallows the combination of $\{-high\}$ and $\{-low\}$. Such a system is possible if $\{high\}$ means 'pitch from the mid and above' and $\{low\}$ means 'pitch from the mid and below'. In this definition, the two features do not refer to the two poles of the pitch range. Compare Goldsmith's definition of the features with the traditional definition:

(17) Definitions of $\{high\}$ and $\{low\}$

i) Traditional

high	$+H$	
		$-L$
mid		
	$-H$	
low		$+L$

ii) Goldsmith (1976)

high		$-L$
	$+H$	
mid		
		$+L$
low	$-H$	

An obvious disadvantage of Goldsmith's system is that it can only represent three tone heights:

(18) Goldsmith's feature system (1976)

	[high]	[low]
high	+	-
mid	+	+
low	-	+

Besides, it cannot give a natural expression of tonogenesis from syllable final consonants. As mentioned above, syllable-final -ʔ gives rise to a rising tone, and syllable-final -h gives rise to a falling tone in a number of languages (for details, see Chapter Four). Such tonogenesis processes can be simply captured in traditional features as the addition of [high] and [low] to the system. In Goldsmith's system, the tonogenesis processes have to be expressed in the opposite way: the genesis of the rising tone would be expressed as the addition of [-low], and the genesis of the falling tone as the addition of [-high]. Such expressions are obviously counter-intuitive.

1.2.10. Yip (1980)

The major contribution of Yip (1980) is the introduction of tonal register into a system of tone features. She first bisects the whole tone-space by the register feature [Upper], and then further divides each register by the tone feature [High]. Formulated in this way, Yip's system departs from the traditional configuration of tone features (Sampson 1969; Woo 1969; Maddieson 1970; Maran 1971; Halle and Stevens 1971; Fromkin 1972; Goldsmith 1976) in that the only relationship between the features is one of inclusion, i.e. the pitch range specified by [High] is completely included in the pitch range specified by [Upper]:

(19) Yip's feature system (1980)

+ Upper Register	+ High Tone
	– High Tone
– Upper Register	+ High Tone
	– High Tone

With this configuration, Yip is able to specify up to four degrees of tone height and two registers, with only two features. These two features have different functions: [Upper] is used to specify register only, while [High] is used to specify the fine-tuning of pitch within each register, i.e. tone. Yip also accepts Woo's analysis of contour tones as concatenations of level features, so that no contour features are needed. For a full discussion of Yip (1980), see Chapter Two.

1.2.11. Clements (1981b)

Clements (1981b) is the first tone-feature system that incorporates underspecification. Based on Yip (1980), it also identifies a maximum of four tone levels and two registers, as shown in (20), where the four levels are illustrated as H (= high), LH (= lowered high), RL (= raised low), and L (= low):

(20) Clements (1981b)

	H	LH	RL	L
row 1	h	h	l	l
row 2	h	l	h	l

The main purpose of the modification is to address the following two issues. Firstly, since both register and tone level belong to 'an acoustically homogenous phonetic dimension, that of pitch' (Clements 1981b:58), it is more desirable to describe them with the same features, rather than with different features as Yip does. Clements therefore uses [h] and [l] for both register and tone, and defines them as 'relatively high pitch' and 'relatively low pitch', respectively. Secondly, in Yip's system all tones must be fully specified. In contrast, Clements introduces underspecification into the representation of tone. This is done by assuming that tones are represented as matrices of tone

features. Each matrix consists of two rows of [h], [l], or Ø. The top row is equivalent to Yip's [Upper]; the second row is equivalent to Yip's [High]. The advantage of underspecification can be demonstrated by Ewe, a language with three tone levels. In Ewe, the low and mid tones frequently alternate with each other, but not with the high tone, suggesting that there has been a split in the lower register, while the upper register has remained unified. In Clements' system, these three tones are represented as:

(21) The representation of Ewe (Clements 1981b:59)

	H	RL	L
row 1	h	l	l
row 2		h	l

That is, the high tone does not have to be specified on row 2. In Yip's system, the high tone must be fully specified as either [+Upper, +High], or [+Upper, –High].

1.2.12. *Pulleyblank (1986)*

Pulleyblank (1986) incorporates Yip's tonal system into the framework of lexical phonology proposed by Mohanan (1982) and Kiparsky (1982b,c). First, he renames the feature [High] as [raised], so as to 'distinguish it clearly from the segmental feature [high] and to avoid any suggestion that [+high tone] implies a H autosegment.' Now the system can still distinguish four tone heights, which are named as H, HM, M, and L, respectively. The revised system is shown in (22):

(22) Revision of Yip (1980) by Pulleyblank (1986)

+ upper	+ raised	H
	– raised	HM
– upper	+ raised	M
	– raised	L

Secondly, Pulleyblank introduces underspecification into the revised tonal system. In Yip's original system, since underspecification is not available, all tones must be fully specified with the two features. In the framework of lexical phonology, however, predicable information is excluded

from the underlying representation, and unmarked feature specifications are supplied by universal default rules. In keeping with this strategy, Pulleyblank proposes the following two default rules, where the \textcircled{V} indicates a vowel unspecified for tone:

(23) Pulleyblank's default rules (1986:126)

- i) $\textcircled{V} \rightarrow \begin{array}{c} V \\ | \\ [-\text{upper}] \end{array}$
- ii) $\textcircled{V} \rightarrow \begin{array}{c} V \\ | \\ [+raised] \end{array}$

That is, for the feature [upper] the default value is minus; for the feature [raised] the default value is plus. In systems with four or three tones, the M tone is unmarked; in systems with two tones, the L tone is unmarked. The four tone levels are minimally specified underlyingly as below:

(24) Underlying representation (Pulleyblank 1986:126)

- H = [+upper]
- HM = $\begin{bmatrix} +\text{upper} \\ -\text{raised} \end{bmatrix}$
- M = \emptyset
- L = [-raised]

In a three-tone system such as Yoruba and Yala, for example, the underlying specifications are given in (25i), and the full specification filled out by the default rules (23i, ii) is given in (25ii).

(25) The application of default rules (Pulleyblank 1986:131)

- | | |
|-----------------|---|
| i) H = [+upper] | ii) H = $\begin{bmatrix} +\text{upper} \\ +\text{raised} \end{bmatrix}$ |
| M = \emptyset | M = $\begin{bmatrix} -\text{upper} \\ +\text{raised} \end{bmatrix}$ |
| L = [-raised] | L = $\begin{bmatrix} -\text{upper} \\ -\text{raised} \end{bmatrix}$ |

1.2.13. Hyman (1986)

Just as Clements (1981b) is a modification of Yip (1980), Hyman (1986) is a modification of Clements (1981b). Hyman points out that if tone features are grouped into matrices as Clements does, then it is impossible to express partial spreading which involves only one row of features but not the other. He therefore arranges tone features on two tiers, without grouping them into matrices. He accepts Clements' argument that register and tone should be represented by the same features, but differs from the latter in that he uses a single feature T, meaning to effect pitch height by one step from some notional mid. Thus, [+T] means 'go up one step', while [-T] means 'go down one step' (Hyman 1986:146). Hyman's system is shown below:

(26) Hyman (1986)

	A	B	C	D
Primary tier	+T	+T	-T	-T
Secondary tier	+T			-T

Under Hyman's system, further underspecification is made possible. The Ewe system would be represented as (27) rather than (21):

(27) A marked three-level system (Hyman 1986:114)

	H	RL	L
primary tier	+T	-T	-T
secondary tier		+T	

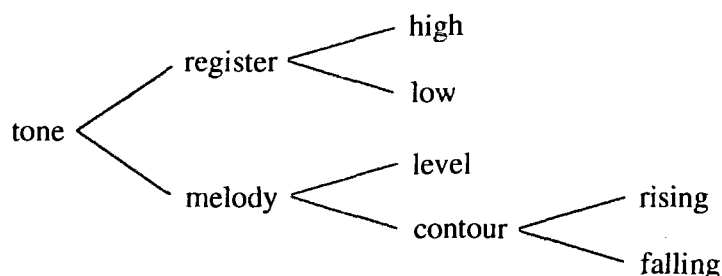
That is, in contrast to (21) where the L tone is marked [l] on row 2, the same tone is unspecified on the secondary tier in (27). This is because in Hyman's system two [-T]'s would mean to go down two steps from the mid, which is not what we normally see in a three-level system (Hyman 1986:115).

Since Hyman's feature is defined with reference to the notional mid pitch, his system is similar to Maddieson (1970) in that it can also distinguish five tone heights, and that the peripheral tones are also more marked than the inner tones. Hyman, however, does not discuss the representation of five tone heights in his system.

1.2.14. Shih (1986)

Shih's feature system seems to be a combination of part of Wang's system (1967) with part of Yip's system (1980). On the one hand, she accepts Wang's contour features ([contour], [rising], and [falling]), but rejects his level features ([high], [central] and [mid]). On the other hand, she accepts Yip's register feature [Upper], but rejects Yip's sequential representation of contour tones by concatenations of the tone feature [High]. The Shih's system is given in (28):

(28) Shih's feature system (Shih 1986:22)



Since the focus of Shih's study is tone sandhi in East Asian languages (Chinese, Tibetan and Tai), she does not elaborate on the implications of her feature system. We do not know, for example, if her system identifies two or three registers, nor if each register is further divisible into two or three tone heights. In fact, the combination of Wang (1967) with Yip (1980) is unnecessary. Take for example her analysis of Lhasa-Tibetan, which has six tones: [54], [24], [52], [12], [113] and [132]. Her analysis is given in (29):

(29) Shih's analysis of Lhasa (1986:19)

Melody		Level	Rising	Falling
Syllable Structure		-V	-VC	-VC
Register	H	[54]	[24]	[52]
	L	[12]	[113]	[132]

Shih takes the Lhasa tones as the evidence for the feature [register] (p.31), which accounts for her combination of Wang's system with Yip's system. But this is unnecessary, since Wang's feature [high] has the same function as Yip's register feature (see § 1.2.2). In other words, Wang's feature

system along can handle the Lhasa data. There is therefore no compelling motivation for the combination of Wang's system with Yip's system.

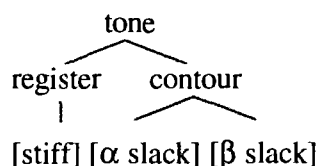
1.2.15. *Bao (1990)*

Bao (1990) also distinguishes four levels of tone, much in the same fashion as Yip (1980). But his model is different from Yip's in the following aspects: i) following Halle and Stevens (1971), Bao uses articulatory features [stiff] and [slack], in place of Yip's perceptual features [Upper] and [High], respectively; ii) he replaces Yip's notion of Tone with his own innovation 'contour'; iii) following Sagey (1990), he suggests that register and voicing are controlled by the articulator 'cricothyroid', while contour by the articulator 'vocalis'. In his model, tone levels are defined as in (30), and tone geometry is represented as in (31):

(30) Bao's feature system (1990)

+ Stiff	- Slack
	+ Slack
- Stiff	- Slack
	+ Slack

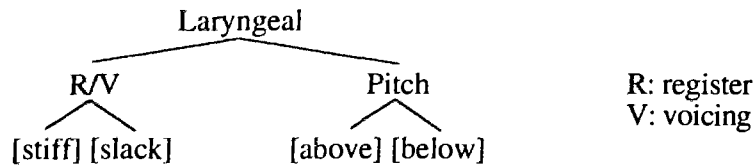
(31) The geometry of tone in Bao (1990)



1.2.16. *Duanmu (1990)*

Following Halle and Stevens (1971), Duanmu uses articulatory tone features. His system consists of four binary features, given in (32):

(32) Duanmu's model (1990)



The features [stiff] and [slack] specify three voicing states (voiced, sonorant, and voiceless). Since the voicing states are identified with registers, the model also identifies three registers. Each register is further specified by the features [above] and [below], producing three degrees of tone height within each register. In this way Duanmu's model produces a maximum number of nine tone heights, which although effectively overcomes the three-height limitation of the Halle-Stevens' model, is nevertheless not attested in any language (§ 5.5).

Besides identifying three registers, Duanmu also allows for register overlapping. In this respect, Duanmu's system is similar to Hyman's proposal (1992, § 1.2.17). But unlike Hyman (1992), Duanmu's three registers are not designed for the representation of downstep and upstep. They are not designed for the representation of register tripartition either. In fact, register tripartition is not mentioned in Duanmu's thesis. The three registers in Duanmu's system are only an artifact of identifying registers with voicing. For the disadvantages of identifying register with voicing, see § 5.6.

1.2.17. Hyman (1992)

Hyman (1992) identifies three registers, with each register further divisible into three degrees of tone height. A single set of features are used for both register and tone. These features, H and L, are defined as 'at or above a neutral reference tone height', and 'at or below a neutral reference tone height' (1992:76). Combinations of features (LH or HL) represent a mid tone, rather than contour tones. This definition of tone features is similar to that of Goldsmith (1976),⁶ and thus suffers similar drawbacks. Hyman's system (1992) is given in (33):

⁶ Although Hyman (1992) intends to retain the feature of Hyman (1986), i.e. a single binary feature [T] ([+T] = [H], [-T] = [L]), his 1992 definition is different from his 1986 definition.

(33) Hyman (1992)

	H	L	M	[!] H	[!] L	[!] M	[!] H	[!] L	[!] M
R-plane	Ø	Ø	Ø	L	L	L	H	H	H
T-plane	H	L	LH	H	L	LH	H	L	LH

Since Hyman's main concern is the downstep and upstep phenomena in African languages, his system can only handle up to three discrete tone heights.⁷ In this respect, his system is similar to Maran (1971) and Halle and Stevens (1971).

1.2.18. Peng (1992)

The theme of Peng (1992) is to apply the theory of Grounded Phonology (Archangeli and Pulleyblank 1994) to the study of the relationship between tone and consonant voicing, and his account of tone features takes only a minor section of his work. Here we only discuss his feature system and its consequence on the representation of tone.

Peng's feature system is a combination of Maran (1971) with Yip (1980). He distinguishes four tone heights with two binary features, [HI] and [LO], which are functionally equivalent to Yip's [Upper] and [High] respectively. Peng follows Maran in defining the features in terms of F₀. His definition is as follows (Peng 1992:44):

suppose that on a scale of 0 to 10, [+HI] represents 10 and [-HI] represents 0. Further suppose that [+LO] indicates -5 while [-LO] refers to 0. The resolution of any pairing of two tonal features can be thought of as deducting the F₀ value of [HI] from that of [LO].⁸ Under this interpretation, the above matrix translates into:

⁷ Hyman (1992:79) writes, 'there are languages that have more than three discrete tone heights... By "discrete" is meant that the language allows a maximum of four tone heights. Particularly troublesome would be a case where there were four such levels and no particular redundancies or restrictions on their distribution. If the four heights are symmetric in this way, i.e. no one of them is derived from one of the other three, then this would require revision of the tone features..., perhaps along the lines of the features [upper] and [raised] adopted by Yip (1980) and Pulleyblank (1986).'

⁸ Probably it should be 'deducting the F₀ value of [LO] from that of [HI].'

	H	HM	M	L
F ₀	10	5	0	-5

The reason for not defining features in articulatory terms is that Peng does not want to rule out the feature combination of [+HI] and [+LO].⁹ With all the logically possible feature combinations, Peng argues that the two features can represent four tone heights as follows:

(34) Peng's feature system (Peng 1992)

	H	HM	M	L
HI	+	+	-	-
LO	-	+	-	+

The problem with Peng's features is that the features [HI] and [LO] are neither in an intersecting relationship, nor do they refer to different phonetic parameters so that they can be ordered hierarchically as in Duanmu (1990). In Peng's system, they refer to different sections of a single scale, one being the extension of the other, as below:

+				-
—— HI ——				
10	5	0		-5
			—— LO ——	
			-	+

Defined in this way, they can be combined at most as follows:

	H	HM	M	L
HI	+	-	-	
LO			-	+

It is therefore unclear how these two features can yield the four tone heights as in (34).

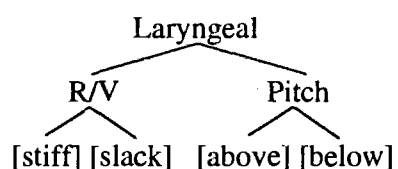
⁹ Peng writes (1992:44), 'If [+HI] and [+LO] represent two opposing physiological gestures, it appears to make some intuitive sense to prohibit this combination on the grounds that they cannot be executed simultaneously. However, once their physical correlates are F₀, there appears to be little reason to rule out a priori the combination of [+HI] and [+LO].'

1.2.19. Chang (1992)

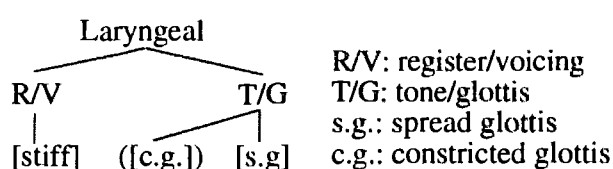
Chang's feature system (1992) is a modification of Duanmu (1990). In Duanmu's framework, since the two articulators R/V and Pitch both dominate two binary features, a maximum number of nine tone levels can be produced (§ 1.2.16). Chang proposes that each articulator can only dominate one binary feature, such that only four basic levels can be produced. Compare:

(35) A comparison of Duanmu (1990) with Chang (1992):

i) Duanmu (1990)



ii) Chang (1992)



Chang further proposes that the feature [c.g.] is unspecified in normal circumstances. In rare exceptional cases, [c.g.] may be specified, provided [stiff] and [c.g.] share the same value. In other words, [stiff] enhances [c.g.]. Under Chang's proposal, then, a maximum number of six tone heights can be produced, in contrast to Duanmu's nine:

(36) Tone heights produced by Chang's system (Chang 1992:49)

[+stiff]/[–spread glottis]	Hh
[+stiff]/[+spread glottis]	Hl
[–stiff]/[–spread glottis]	Lh
[–stiff]/[+spread glottis]	Ll
[αstiff]/[αc.g.] [–αs.g.]	Hh↑/Ll ↓(marked)

1.2.20. McHugh (1993b)

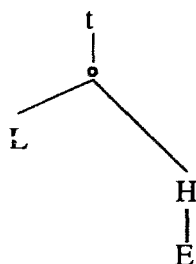
McHugh (1993b) differs from Yip (1980) in the following aspects. i) Instead of using two features, McHugh uses three features [High], [Low], and [elevated]. The first two features are functionally equivalent to Yip's [+Upper] and [–High], respectively. The feature [elevated] is hierarchically dependent on [High], and is responsible for the contrast between the high tone and superhigh tone in KiVunjo Chaga spoken in Northern Tanzania. Theoretically speaking, McHugh's

system can distinguish five tone levels. ii) Instead of using binary features, all the three features are privative. iii) Instead of defining features in perceptual terms, McHugh claims that [High] and [Low] 'represent fundamentally distinct laryngeal gestures or configurations that are universally available to the language learner' (p.2). Compare:

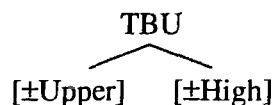
(37) A comparison of McHugh (1993b) with Yip (1980)

i) McHugh

timing
tonal root
[Low] tier
[High] tier
[elevated]



ii) Yip



Although McHugh takes [High] and [Low] as representing laryngeal configurations, he does not identify them with specific laryngeal activities. With the addition of the third feature [elevated], which is neither defined articulatorily nor perceptually, the status of the feature system is unclear.

1.3. Summary

As seen in § 1.2, the key issues in the construction of a system of tone features include the following: i) the representation of multiple tone heights; ii) the representation of tonal register; iii) the representation of contour tones; iv) the relationship between tone space and the number of tone heights; v) the relationship between different features within a system; vi) the nature of tone features; and vii) the economy of tone-feature systems. These issues are interrelated such that the decision on one issue may influence the functions of the others. Take for example, two binary features in an intersecting relationship can only specify up to three degrees of tone height (Maran 1971; Halle and Stevens 1971; Goldsmith 1976). To specify more than three tone heights, another feature must be added. But since three binary features can have a maximum number of eight combinations, while the maximum number of tone heights is five, systems with three binary features (Woo 1969 and Maddieson 1970) are not maximally economical. If the features are hierarchically related, then two binary features can specify up to four tone heights (Yip 1980, Clements 1981b, Bao 1990). Since

there is no redundancy in such systems, the economy is improved; but the functionality is reduced, since these systems cannot account for languages with five tone heights.

The new feature system to be proposed in Chapter Three differs from the previous systems mainly in the recognition of register tripartition, which has occurred in Kam-Sui, Tai, Miao-Yao and some Chinese dialects. Although some of the previous proposals have the potential to treat register tripartition, this potential is usually regarded as redundant (Duanmu 1990), or used for other purposes, such as the treatment of terracing tones (Hyman 1992). In other words, register tripartition has never been formally incorporated into the representation of tone. Previous proposals that incorporate the notion of register usually identifies only two registers with a maximum number of four or six tone heights (Yip 1980; Clements 1981b; Chang 1992). Previous proposals that have the potential to treat register tripartition usually identify nine tone heights (Duanmu 1990; Hyman 1992). Previous proposals that identify five tone heights usually do not recognize register. In short, no proposal up to now captures both of the following observations: i) the maximum number of tone heights any language can distinguish is five; ii) the maximum number of registers is three. One of the purposes of this thesis is to account for both of these two observations in a simple, historically motivated and phonetically verified system of tone features.

Chapter Two

Register and Tone

This chapter investigates how the relationship between the two notions ‘register’ and ‘tone’ should be represented in a system of tone features. This relationship determines the overall economy of a feature system and its capability to handle a number of important tonal issues, such as the number of registers, the number of tone heights, and the types of contour tones. Since the initial incorporation of ‘register’ in a tone-feature system is inspired by the historical register split (Yip 1980, see below), a feature system’s capability to handle such historical events will also be examined. Through the discussion of these issues, this chapter lays the foundation for the establishment of a new feature system in the next chapter.

2.1. The notion of register

In phonological studies, the term ‘register’ has at least two distinct meanings. The first meaning refers to what Henderson calls ‘voice quality’, such as creaky, breathy, and plain voicing, of the non-tonal Southeast Asian languages like Mon and Khmer (Henderson 1952). These features are also known as phonation types (Catford 1964), and accordingly a distinction has been made by some writers between phonation-type-based register languages and pitch-based tone languages.¹⁰ The other meaning of ‘register’ refers to voice pitch. Under this meaning, three different uses can be further identified. First, ‘register’ refers to the shape of tone, meaning ‘level’. In this sense, it is used in opposition to ‘glide’ or ‘contour’. Pike (1948), for example, distinguishes register tone languages from contour tone languages. Second, ‘register’ refers to degrees of tone heights. This meaning is used, for example, in Pike (1948), and Jakobson and Halle (1956), for whom a maximum number of four registers (= four degrees of tone heights) are identified. Third, Maspéro (1912) and

¹⁰ Henderson (1965:404) states, “‘tone’ is seldom, if ever, a matter of pitch alone. There are very frequently concomitant features of phonation-type, glottal constriction, stress, etc. which pose problems of interpretation and definition. Similarly, the characteristic phonation-types of ‘register’ languages such as Mon and Khmer may be accompanied by, or perceived as being accompanied by, concomitant pitch features. It is necessary, therefore, to be more precise and to define the feature we are examining as ‘lexically contrastive pitch’ rather than ‘tone’, or as ‘lexically contrastive phonation-type’ rather than ‘register’”.

Haudricourt (1954a) use the term to refer to the subdivisions of tone-space, and associate register with syllable initials, stating that while syllable endings affect the pitch contours of the preceding vowel, syllable initials affect the pitch height of the whole syllable, i.e. register.¹¹ This usage corresponds to the traditional Chinese notion of ‘yin’ and ‘yang’ (see Chapter Four), and is inherited by Yip (1980). Note that for Pike (1948) and Jakobson and Halle (1956), register is not further divisible, while for Yip (1980) it is further divisible by the tone feature [High]. Thus, Pike, Jakobson and Halle identify two pitch hierarchies, i.e., tone-space and register, while Yip identifies three, i.e., tone-space, register, and tone.¹² The different meanings of ‘register’ are summarized in (38):

(38) The meanings of register

- i. voice quality: creaky voice, breathy voice, modal voice, etc.
- ii. voice pitch:
 - a. tone shape (= non-contour or even tone)
 - b. tone height (= a certain pitch level in the tone space)
 - c. subdivisions of the tone space (= a certain pitch range within the tone space)

Although ‘register’ has been used for different notions, it has been known for some time that there is a certain correlation between voice quality and voice pitch. Creaky voice and breathy voice, for instance, are known to correlate with low pitch. In this sense, the different notions of ‘register’ are related.

When carried over into the study of distinctive features, the various notions of ‘register’ are reflected in the different uses of the term ‘register feature’. ‘Register features’ may refer to the features that specify pitch heights or level pitches as opposed to contour pitches (Lin 1992:21), or it may refer to the subdivisions of the tone space (Yip 1980).

In this thesis, ‘register’ means the subdivisions of the tone space (38iic). Two types of features will be used: the register feature specifies registers; the tone feature specifies tone heights.

¹¹ Maspéro (1912:88): ‘Les tons chinois n’étaient pas des phénomènes simples; ils se décomposaient en deux éléments, la hauteur et l’inflexion. La hauteur dépendait de l’initiale, tandis que l’inflexion dépendait dans une certaine mesure au moins, de la finale, le timbre et la quantité de la voyelle étant indifférent.’

¹² Since tone space is smaller than the general voice pitch range, there is need to identify four pitch hierarchies: voice pitch range, tone space, register, and tone levels. For further discussion, see Chapter Five.

Following Woo (1969) and Yip (1989b), I assume that contour tones can be represented by register and tone features, and that no contour features are needed.

2.2. Register-tone relationships

In previous feature systems, the register-tone relationship fall into four types. In the first type, register and tone are represented by different features, and no register overlapping is allowed. This relationship is first formulated by Yip (1980), and later adopted in a number of studies (Pulleyblank 1986; Packard 1989; Yip 1989; Clark 1990; Bao 1990; Yip 1992a; Yip 1992b; McHugh 1993b). In the second type of relationship, register and tone are represented by the same features. Again, no register overlapping is allowed. Clements (1981b) and Hyman (1986) adopt this relationship. In the third type of relationship, register and tone are represented by the same features, and register overlapping is allowed. Hyman (1992) adopts this relationship. In the last type of relationship, register and tone are represented by different features, and register overlapping is allowed. Duanmu (1990) adopts this relationship (cf. Chapter One).

Of these four types of register-tone relationship, the first type is the most influential. Accordingly, we are going to analyze this type in greater detail. Since this relationship is best embodied in Yip (1980), we choose her study as a representative.

2.3. Yip (1980)

Yip's feature system is an important development in the study of tone. Its impact can be seen from the following two facts. First, proposals on tone features after Yip (1980) can no longer ignore historical register split. These proposals (Clements 1981b; Hyman 1986; Bao 1990; Duanmu 1990; Hyman 1992; Peng 1992) either directly borrow Yip's mechanism or implement a different mechanism to deal with register split. Second, under Yip's usage, tone space, register, and tone height enter a relationship of three hierarchies, i.e., register divides tone space while tone height subdivides register (see (39)). This usage has now been widely accepted. In feature systems prior to Yip (1980), the intermediate hierarchy—register—does not exist.

Several problems of Yip's model have been discussed in previous studies. Clements (1981b) and Hyman (1986) point out that languages with five genuine level tones pose a potential problem to Yip's model. Pulleyblank (1984) argues that a model with only two registers cannot handle three-way register splits that have occurred to some tonal systems of Tai, Miao-Yao, and also Middle Chinese. Packard (1989) argues against Yip's hypothesis that pitch contours are restricted within half of the tone space; he proposes that all tones are given two values for register in the underlying form. Clements (1981b) and Hyman (1992) reject the notion that one tone feature defines tone height and the other tone register, proposing instead that tone and register are represented by the same set of features. Bao (1990) suggests that since no ultracomplex tone of the shape HLHL occurs, a restriction should be added to Yip's model to limit the co-occurrence of the feature [High], so that sequences like HLHL would not be allowed.¹³ Duanmu (1990:104) points out the five level notation of the tone letters cannot be translated unambiguously into Yip's four level representation.

In the rest of this section, I present my own analysis of Yip's system. I first analyze the theoretical considerations upon which Yip's model is based, i.e., typological considerations, redundancy considerations, and historical considerations (§ 2.3.2). Then I examine the typological considerations, and demonstrate that these considerations are not accurately interpreted in Yip's model (§ 2.3.3; § 2.3.4). Finally, I analyze the organization of the mechanisms that address these considerations (§ 2.3.5; § 2.3.6).

2.3.1. Introduction

Yip (1980) is characterized by a system of hierarchically ordered perceptual features. The two features are in a dominant-dominated relationship, in the sense that the pitch range specified by tone is completely included in the pitch range specified by register. This system has already been illustrated in (19), repeated here in (39):

¹³ We do find reports of ultracomplex tones in the literature. Yuan (1960:10) gives three examples from Shangxian, Shaanxi Province of China: [tsq³²³¹] 'to grab', [puə⁵²³¹] 'to winnow', [p'æ²¹⁴¹] 'to lose money'. Edmondson (1991) reports that Nalun Kam has a tone of the shape [4512].

(39) Yip's feature system (1980:24)

+ Upper Register	+ High Tone
	- High Tone
- Upper Register	+ High Tone
	- High Tone

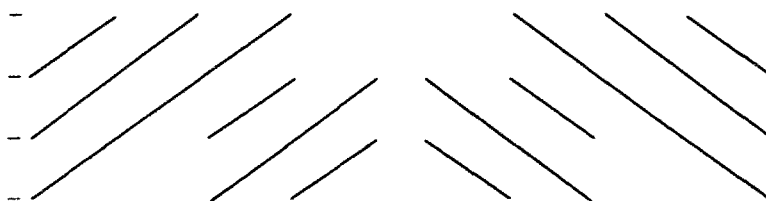
This system is based on the following typological observations (Yip 1980:23/126):

(40) Typological observations of Yip (1980)

- a) The maximum number of level tones most languages can distinguish is four.
- b) The maximum number of contour tones of each direction is two (i.e. two rising tones, two falling tones).

Yip further observes that there is a mismatch between (40a) and (40b). That is, although the maximum number of actual occurring contours is only two, a four-level system produces a maximum number of six logically possible contours of each direction (Yip 1980:23), as shown in (41):

(41) Possible contours in four-level systems (Yip 1980:127)



To curtail the redundancy, Yip proposes the 'one morpheme one register hypothesis', henceforth 'uni-register hypothesis':

(42) Uni-register hypothesis (Yip 1980)

[Upper] remains constant over the morpheme, while [High] may vary.

(42) is crucial in Yip's system: it functions as a filter on (39) by limiting the number of contour tones of each direction to two, as shown in (43):

(43) Contour tones in Yip (1980:24)

+ Upper	L H	Rising
	H L	Falling
– Upper	L H	Rising
	H L	Falling

Yip also discusses two types of potential counter-examples to the system. The first type concerns the number of tone heights. Yip acknowledges the existence of languages with five level tones, but she observes that such languages are extremely rare,¹⁴ and that even in these few languages, there is still doubt whether the five level tones are truly in contrast with each other. She suggests that for languages with true five level tones, an additional feature akin to [\pm Modify] of Woo (1969) might be introduced.

The second type of potential counter-example concerns the uni-register restriction. Yip is aware of the fact that many languages have more than two rising or falling tones, and some of the contour tones involve both the upper and the lower registers. In defense of the uni-register restriction, Yip suggests that [Upper] can vary on the surface, but underlyingly it must remain constant over the morpheme. Yip quotes, for example, Pike's study (1948) of Mazateco, which has at least the following three rising tones:

(44) Mazateco rising tones (Yip 1980:128)¹⁵

ški ⁴³	'medicine'
ti ⁴²	'bowl'
the ³²	'our (inclusive) forehead'

The third contour tone in Mazateco, Yip suggests, should be analyzed as arising from multiple association due to vowel contraction, as shown below:

¹⁴ For languages with five contrastive tone levels, see § 5.5.

¹⁵ Pike (1948) identifies a maximum number of four tone levels. His transcriptional system differs from that of Chao (1930. see fn. 7) in that 1 indicates the highest tone level, while 4 indicates the lowest. Compare Pike and Chao's systems:

Pike (1948)	Chao (1930)
_____ 1	_____ 5
_____ 2	_____ 4
_____ 3	_____ 3
_____ 4	_____ 2
	_____ 1

(45) Mazateco contour formation (Yip 1980:129)

- i. $th\epsilon^3 + a^2 \rightarrow th\epsilon^{32}$ 'forehead + 1st pl. incl. possessive pronoun'
- ii. $[-Upper] \quad [+Upper] \rightarrow [-Upper] \quad [+Upper]$
- | | | | |
|-----------------------------|-----------------|-----------------------------|-------|
|
th ϵ

H |
a

L |
th ϵ

H |
L |
|-----------------------------|-----------------|-----------------------------|-------|
- (Dashed lines connect the H of the second syllable to the H and L of the third syllable in the final form.)

In other words, this type of contour tone is treated as the result of a morphophonemic process, rather than an underlying contrast.

In many languages, especially languages of the East and Southeast Asia, contour tones are not subject to the kink of morphophonemic analysis as in the Mazateco case. For such languages, Yip offers three solutions. The first solution is downdrift. Yip cites, for example, Norman's study (1973) of a Chinese Min dialect spoken in Kienyang, Fujian Province of China, which has the following tonal inventory:

(46) Kienyang dialect (Yip 1980:132) ¹⁶

Level:	33				
Rising:	35				
Falling:	53	31	43	32	21

She says, 'it seems highly likely that the last three falling tones, which have a rather slight fall, may be phonologically level but surface phonetically with a slight downdrift giving the appearance of falling tones' (p.132). That is, the last three tones of Kienyang ([43], [32], and [21]) are analyzed as phonologically level, but on the surface they are falling due to downdrift. Yip therefore concludes that Kienyang does not constitute a true counter-example to the uni-register restriction.

Yip's second solution to the counter-examples to the uni-register restriction is tone sandhi. The Beijing Mandarin falling tone [51], for example, covers the whole tone space, and cannot be explained in terms of either morphological process or surface downdrift. But in an unstressed syllable, [51] becomes [53] if it occurs before another [51], as below:

(47) Tone sandhi in Beijing Mandarin (Chao 1968)

$xu^{51}t\varsigma u^{51} \rightarrow xu^{53}t\varsigma u^{51}$ 'help each other'

¹⁶ The tones are transcribed in 'tone letters'. See Note 4.

Yip therefore analyzes Beijing Mandarin [51] as underlyingly /53/. The further fall to [1] is 'a phonetic detail possible in a language that has only one falling tone' (Yip 1980:183).

With the two solutions above, there are still many counter-examples to the uni-register restriction that cannot be accounted for. Yip's last solution is to re-analyze the surface pitch. Thus, [24] can be re-analyzed as belonging to either the upper or the lower register (i.e., either [35] or [13]), depending on the specific tonal system. The Fuzhou tonal system, for example, is analyzed as follows:

(48) Fuzhou tones (Yip 1980:225)

[+Upper]		[-Upper]	
[44]	HH	[12]	LH
[52]	HL	[13]	LL
[22]	LL	[242]	LHL
[35]	LH		

Notice that the tone [242] is analyzed as underlyingly belonging to the lower register. Yip argues that such a re-analysis is justified by the fact that there are considerable inconsistencies in the transcription of tones, different field workers frequently transcribing the same tonal system differently. What is transcribed as [24] by one person may well be transcribed as [13] by another. Thus, a strict interpretation of the transcription is undesirable (Yip 1980:17/224).

2.3.2. *Theoretical basis*

Yip's system is built on three types of theoretical considerations as given in (49). These considerations determine the relationship between the two features (i.e., [Upper] dominates [High]) and the restriction (i.e., uni-register hypothesis) that is imposed on the system.

(49) Theoretical considerations of Yip (1980)

(i) Typological considerations (see (40))

(a) Tone heights: Since languages with five distinctive tone heights are extremely rare, there is no need to distinguish five tone heights. In a universal model of tone, a maximum number of four heights is needed.

- (b) Tone contours: The maximum number of contour tones of each direction is two (i.e. two rising tones, two falling tones).

(ii) Redundancy considerations

- (a) Tone heights: If tone features stay in an intersecting relationship (as in Halle and Stevens 1971), then two binary features can only specify three tone heights. This means that for a model that distinguishes four heights, at least three binary features are needed. Since three binary features can specify eight objects, a large amount of redundancy will be built into the system. But if features are in a dominant-dominated relationship (as between [Upper] and [High]), then only two binary features are needed for four distinctive heights. This not only reduces the redundancy, but also appears to be able to capture historical register split.
- (b) Contour tones: If contour features are used (such as those of Wang 1967), then the number of theoretical primes will be greatly increased. In order to reduce the number of theoretical primes, contour tones are represented by level tone features.
- (c) The mismatch between the number of tone heights and tone contours (see (41)): This problem is dealt with by the uni-register restriction, i.e., [High] can vary over a morpheme while [Upper] cannot. This restriction reduces the number of possible contour tones of each direction to two.

(iii) Historical considerations

- (a) Contour tones: Contour tones existed prior to the split of the tone-space. Contour tones are represented by concatenations of the feature [High].
- (b) Register split: Register is represented by the feature [Upper]. Since register split occurred late, [Upper] is a relatively new feature added to the grammar.

2.3.3. *The uni-register restriction*

The uni-register restriction is perhaps the most controversial aspect of Yip's system. Pulleyblank (1984) points out that there is no principled reason for the uni-register restriction—except the pragmatic reason that it produces about the right number of possible contours. Based on a typological review, Packard (1989) attempts to remove the uni-register restriction from Yip's model. He observes that typological surveys do not support the claim that contours are confined within half of the tone space. He reports a survey of Chinese dialects and finds that about 20% of all tones, or 33% of all contour tones, cross the mid pitch line. His observation is supported by a much more extensive survey reported in Cheng (1973b), which covers the tonal systems of 737 Chinese dialect locations, with a total number of 3433 individual tones and 2347 contour tones. Cheng's survey shows that the total number of contour tones involving two registers is 734, or 21.38% of all tones, and 31.27% of all contour tones.¹⁷

Packard (1989) proposes that the uni-register hypothesis be removed. Instead, all tones, except for checked and neutral tones, are given two values for register in the underlying form. The two registers may or may not have the same value. Under this proposal, contours involving two registers would no longer be an anomaly. Packard further suggests the following register collapse rule:

(50) Register collapse rule (Packard 1989)

If the two register values are identical, then they are collapsed. Otherwise, they are branching.

In the following examples, a) shows the register collapse rule, b) a branching register, c) a neutral tone, and d) a checked tone.¹⁸

¹⁷ The calculation in these surveys is based on a strict interpretation of the tone-letter notation, i.e., any tone which crosses level [3] is counted as bi-registral. Freer interpretation may reduce the number of bi-registral tones, but it can increase the number as well.

¹⁸ Consider the following data:

a) Mandarin:

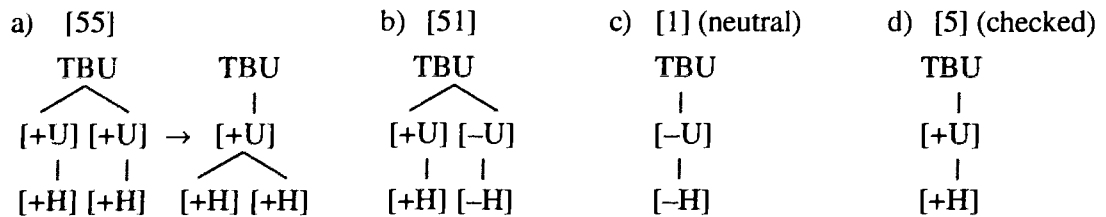
[fan ⁵⁵]	'location'	(11a)
[ti ⁵¹]	'earth'	(11b)
[ti ⁵¹ fan ¹]	'place'	(11c)

b) Amoy

[tɛk ⁵]	'enemy'	(11d)
---------------------	---------	-------

[fan¹] in [ti⁵¹ fan¹] 'place' is neutralized from [fan⁵⁵] 'location'.

(51) Tonal representations in Packard (1989)



In addition to Pulleyblank and Packard's objections, there is a stronger objection to the uni-register restriction. When analyzing Mende tones, Yip observes (1980:132):

Most African languages, for example, have less than four level tones, and two tone systems are very common. If there are only two contrastive level tones only one feature is needed to distinguish them, and we might reasonably ask which feature is used in such cases, and whether the unused feature is used in any other way. As to which feature is used, this can normally be settled quite simply by noting whether or not the language allows sequences of tones on a single morpheme; if it does, the tones must be distinguished by the feature \pm High, since only H and L tones occur in underlying sequences. If it does not, we have a system using \pm Upper only. Most African languages fall into the first category: for example, Mende has H and L tones, and permits the following sequences on morphemes:

H pɛ́lɛ	HL kényà	LHL nyàhâ
L bèlɛ	LH nìká	

More Mende data are taken from Leben (1973/1980; 1978). Notice that Yip's transcription is slightly different from Leben's.

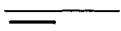
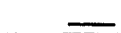
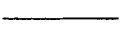

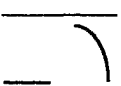

(52) Mende contour tones

pɛ́lɛ	'house'	mbû	'owl'
bèlɛ	'trousers'	mbǎ	'rice'
kényà	'uncle'	mbǎ	'companion'
nìká	'cow'	njégùlû	'tarantula'
nyàhâ	'woman'	kónùgû	'centipede'
		dúmbèékà	'star'

If in the Mende case the H's and L's refer to the feature tone [High] rather than the register [Upper], then it is claimed that in this language only half of the tone-space is used while the other half plays no part for tone purposes. Obviously, this claim is self-contradictory by definition. If, on the other hand, Mende uses the whole tone-space, then the H's and L's cannot refer to [High].

To put it in another way, if we assume that no language uses only half of the tone-space for tone purposes, then two elements in Yip's model, i.e. i) contour tones are represented by level tone features and ii) pitch variations are confined within half of the tone-space, predict that languages with two tone heights cannot have underlying contour tones. But the Nigerian language of Etsako has two level tones, high and low, and a falling tone from high to low. Laver (1994:467) illustrates them as follows:

(53) The tones of Etsako (Laver 1994)

		
[ǐgbà]		'fences/thorns'
		
[ǐgbà]		'chins'
		
[ǐgbâ]		'locust beans/gathering(s)'

The problem with the uni-register restriction is caused by a conflict between the two mechanisms which address the redundancy considerations (49iib) and (49iic). According to (49iib), contour tones are represented by level features, and therefore both [High] and [Upper] should have this function. But according to the uni-register restriction (49iic), [Upper] is deprived of this function. (49iic) is therefore a restriction on (49iib). But the purpose of (49iic) is to restrict the number of contour tones, not contour types (whether pitch varies across the mid pitch line). In other words, the uni-register restriction is not the proper mechanism for the reduction of the number of contour tones, and it leads to an illogical analysis with regard to the Mende tones. If the uni-register restriction is not imposed, the two Mende tones can then be represented by [Upper], and no inconsistency would arise.

In fact, the typological observation on contour tones (49ib) is not accurate. It says that in a single tonal system the maximum number of rising tones is two, and so is the maximum number of falling tones. But as we will see below, there do exist languages with three rising or three falling tones. Since (49ib) is not accurate, the uni-register restriction, which is designed to achieve (49ib), is therefore unnecessary.

2.3.4. Tone contours

With respect to contour tones, the uni-restriction has the consequence that no language can have more than two underlying contour tones of each direction, and underlying contours are not allowed to cross the mid pitch line. Exceptions are treated in the following ways (see § 2.3.1):

(54) The treatments of exceptions to the uni-register restriction in (Yip 1980)

- i) The Kienyang [43, 32, 21] are interpreted as underlyingly [44, 33, 22] (46).
- ii) The Beijing [51] is interpreted as underlyingly [53] (47).
- iii) The Fuzhou [242] is interpreted as belonging to the lower register (48).

That is, a slight fall is interpreted as underlyingly level (54i), while a full fall is interpreted as underlyingly half fall, with the rest of the pitch movement taken care of by declination (54ii). Where (54i) and (54ii) fail, the surface pitch contour is re-interpreted as belonging either to the upper register or the lower register, depending on the specific tonal systems (54iii).

These treatments, however, do not enable the system to represent all the observed contour types. One key problem is that the typological observation on contour tones given in (40b) says nothing about the bipartition of the tone-space. Although this observation claims that no language can have more than two rising or two falling tones, it does not rule out the possibility that one contour covers half the tone-space while the second covers the whole (see (55), (57), and (59) below). It therefore does not support the uni-register restriction which confines tonal contours within half of the tone space. In fact, the claim made in (40b) is too strong, since there do exist languages with more than two rising or falling tones that cannot be explained in any of the ways listed in (54).

First, let us examine the tone system of Xiaomiaozi, of Guizhou Province of China, which has the following tones:

(55) Xiaomiaozi (Li, *et al.* 1959)

35 15 31 53 213 55 42 24

The Xiaomiaozi system has three rising tones, [35], [15], and [24]. The second rising tone [15] cannot be explained in terms of declination. Since rising tones generally require a larger articulatory effort (Ohala 1978), [15] cannot be explained in terms of any natural surface pitch

spreading.¹⁹ The Xiaomiaozhai system also has three falling tones, [31], [53] and [42]. While [31] and [53] are confined within half the tone-space, [42] straddles right on the mid pitch line. This tone can neither be explained away by (54i) or (54ii), since it is not qualified for such interpretations, nor can it be re-interpreted by (54iii), since such a re-interpretation clashes with the other two existing falling tones, [31] or [53].

The second example is Khün, a Tai language of the Burmese Shan State:

(56) Khün (Egerod 1959)

35 55 13 31 42 51

There are three falling tones in this language, [31], [42] and [51]. By using (54ii) [51] can be interpreted as [53]. But when this is done, [42] cannot be interpreted as [53] (54iii) any more, and it cannot be interpreted as [31] either, since the reinterpretation of [42] would result in the collapse of this tone with either of the other two falling tones. Since none of the three tones can be re-interpreted by (54), the fact that there are three fallings in this language cannot be explained away.

In the following three examples, the first two show that (54) fails even in the treatment of simple tonal systems, i.e., the Mandarin type. Linfen and Shenxian are two Mandarin dialects spoken in Shanxi and Hebei Provinces of China, respectively. The last example has a more complex system. Duchang is spoken in Jiangxi Province of China.

(57) Linfen (J. Hou, *et al.* 1986)

22 24 51 55 53

(58) Shenxian (W. He, *et al.* 1986)

33 53 214 51

(59) Duchang (C. Chen 1983)

33 35 351 15 313

In Linfen and Shenxian, since there is a [53] falling tone already, the [51] falling tone cannot be interpreted as underlyingly [53] by (54ii). In Duchang, there are only two rising tones, but one is

¹⁹ Rising spreading in sequences is conceivable, but not in citation forms.

[15], which Yip offers no solution. These three examples show that the uni-register restriction fails even in cases involving only two contour tones of the same direction.

2.3.5. *Tone heights*

Since Yip's model identifies only four tone heights, it cannot handle languages with five contrastive heights. Yip suggests that the issue of five tone heights be treated in the following manner:

(60) The treatment of five contrastive tone heights in Yip (1980)

- a) Since languages with five contrastive levels are rare, feature systems should not provide more than a four-way contrast. Five-level models are wrong in that they treat the rare cases as the common cases, while four-level models avoid this error.²⁰
- b) For genuine five-level languages, a feature akin to [\pm Modify] of Woo (1969) might be introduced.

Neither treatment, however, endures close scrutiny. Treatment a) is invalidated by the fact languages that distinguish four levels of tone are also rare.²¹ If languages with five contrastive levels should be excluded because of their small number, languages with four levels should also be excluded by the same token. If the issue of tone levels should be decided by the number of tones the vast majority of tone languages distinguish, then the universal model should distinguish only two levels.

Treatment b) is only suggested but never developed in Yip's model. It is likewise undesirable. As we have seen in Chapter One, Woo distinguishes two kinds of features: primary and secondary. The primary features [high tone] and [low tone] give rise to three tone levels: high, mid, and low. The

²⁰ Yip (1980:131): 'in the vast majority of cases the feature system should not provide for more than a four-way contrast, and that if a fifth is needed it should be achieved by addition of an extra feature to the system. Previous approaches have on the contrary assumed that the rare need for a five-way contrast should be allowed to determine the features in general use....'

²¹ Anderson (1978:145): 'Systems of two and three distinct level tones are abundantly attested from all of the major groups of tone languages in the world.... Systems of four distinct tone levels are somewhat less common, but still firmly established.' Maddieson (1978:338) 'Languages with three tone levels are commonplace, while those with only two are the most frequently encountered type of tone language.'

feature [modify] is secondary, in the sense that it interacts only with the plus value of the two primary features, producing two additional intermediate levels: high-mid and low-mid.²²

The three features of Woo (1969) are thus in two kinds of relationships. Features [high tone] and [low tone] are in an intersecting relationship, and they both dominate the feature [modify]. [modify] is dominated in the sense that its very existence depends on the existence of the other two features. It does not independently specify any pitch value; rather it only ‘modifies’ the pitch values specified by [high tone] and [low tone].

Unlike the two primary features of Woo (1969), the two features of Yip (1980)—[Upper] and [High]—are already in a hierarchical relationship. If [modify] is introduced, the three features would be in three hierarchies. Here two problems arise. First, as Pulleyblank (1984:37) points out, there is nothing in the theory of tonogenesis to account for the feature [modify]. Since Yip’s model is based on a historical principle, it is unclear how [modify] would fit into such a model. Second, with the addition of an extra hierarchy, Yip’s model can now specify at least six levels,²³ and there does not seem to be any principled way to reduce the number to five. In this respect, Yip’s model would be clearly inferior to Woo’s, since the latter does not generate more than five levels.

A more serious problem concerns the validity of the feature [modify]. As pointed out by Pulleyblank (1984) and Maddieson (1970), this feature is neither historically plausible nor phonetically verified. For more discussion, see § 1.2.4.

²² Woo (1969:70): ‘With the set of features we purpose, this would be reflected by the fact that these languages would have to make distinctive use of a secondary feature which is normally non-distinctive.’

²³ [Modify] can be introduced to a) the lowest hierarchy, or b) the intermediate hierarchy. Assuming, following Woo (1969), that [modify] applies only to the plus value of a dominant feature, then in the case of a), there will be two registers, with each register containing three levels; in the case b), there will be three registers, with each register containing two levels. Whichever way, there will be six tone levels.

a) [Upper]	[High]	[Modify]	b) [Upper]	[Modify]	[High]	
+	+	–	+	–	+	6
+	+	+	+	–	–	5
+	–	–	+	+	+	4
–	+	–	+	+	–	3
–	+	+	–	–	+	2
–	–	–	–	–	–	1

2.3.6. *Historical register split*

Yip's register is inspired by the Chinese traditional distinction between yin and yang tones. She says (Yip 1980:135, 136):

One of the most wide-spread changes in tone languages, at least in Asia, was a process of register splitting that effectively doubled the number of tones: every tone present before the split gave rise to two variants, one lower and one higher, but with contours essentially unchanged. The complicated subsequent development of the tones has frequently obscured the picture, but there is little doubt that this is what happened, and in some languages, such as Cantonese, it can be seen quite clearly...

Now consider how such a development is to be dealt with phonologically. It appears likely that an additional binary feature has come into play, and indeed as we shall see this is exactly what can be stated very simply given a register system: **the feature $[\pm\text{Upper}]$ is now being used for tones in addition to the original $[\pm\text{High}]$.**

In order to capture the historical split of tone, Yip constructs her feature system in the following way (Yip 1980:24):

...the two binary features which together define four levels are hierarchical: one of them, the Register feature, is 'dominant' and splits the pitch range of the voice into two halves. The second feature, Tone (with an upper-case T), then further subdivides each half to give a total of four levels...

It is claimed that each of these features is independently autosegmental (just as different vowel features may form separate tiers). However, only the feature Tone may occur in sequences underlyingly: Register remains constant over the syllable. The main effect of this is to restrict the basic inventory of tones to no more than two of any given contour....²⁴

It is not hard to see that a conflict between the historical and theoretical implementations of the two features is built into the system. Historically, $[\text{High}]$ must exist prior to the implementation of $[\text{Upper}]$ in order to account for the contour tones. $[\text{Upper}]$ is a later addition to the system to account for register split. But theoretically, since $[\text{Upper}]$ dominates $[\text{High}]$ and $[\text{High}]$ divides $[\text{Upper}]$, $[\text{High}]$ cannot be implemented until $[\text{Upper}]$ is already in place. That is, historically $[\text{Upper}]$ should be a later addition but theoretically $[\text{Upper}]$ cannot be a later addition. With respect to the $[\text{Upper}]$ - $[\text{High}]$ relationship, Pulleyblank (1986:123) has a similar observation:

²⁴ The above boldface emphases are mine.

One cannot assign a vowel to the top or bottom of a *sub-register* if the vowel has not been assigned to a register. That is, one cannot make fine distinctions in pitch without first making a gross distinction. Hence by virtue of the hierarchical organization of the features [upper] and [raised], if only one feature is assigned it must be [upper].²⁵

Another consequence of the [Upper]-[High] is that it can only express tone-height compression (§ 1.2.2), but not tone-space expansion (§ 1.2.5). The dominant feature [Upper] defines the width of the whole tone space, and the dominated feature [High] compresses the tone height specified by [Upper]. The two features are thus configured to work inwardly from the border of the tone space toward the center. Such a configuration runs counter to the process of register split, which frequently results in the expansion of the tone space from the center (see Chapter Five).

In sum, the theoretical configuration of [Upper]-[High] relationship makes it doubtful whether the system can account for historical register split. For more on this issue, see § 3.3.1.

2.4. Summary

I have shown in this chapter that the uni-register restriction is unwarranted. It conflicts with the principle that contour tones are represented by level tone features, and it may lead to the illogical conclusion that in some languages only half of the tone space is used for tone purposes. It also limits a system's capability to represent contour tones. For this reason, the uni-register restriction must be abandoned.

I have also shown that it is doubtful whether the register-tone relationship as in Yip (1980) enables the system to correctly account for historical register split, due to a conflict between theoretical and historical implementations of the two features, and due to the system's failure to express tone-space expansion. Since contour tones existed before the historical register split, and since tone features are used to represent contour tones, the existence of tone features must not depend on the existence of the register features. In other words, tone and register features should be in a parallel relationship and independent of each other.

²⁵ Yip's [High] is renamed by Pulleyblank as [raised]. See § 1.2.12.

Chapter Three

A New System of Tone Features

In this chapter I propose a new system of tone features. This system is built on three types of evidence: historical, phonetic and typological. The details of the evidence are left to the following two chapters. Here we discuss the formulation of the new system, and then compare this system with some previous systems.

3.1. Issues to be addressed

The new feature system is designed to address the following issues. First, since Yip's (1980) initial incorporation of register into a system of tone features, all the subsequent feature systems make use of the interactions between register and tone features to account for historical register split. The question is how to characterize this interaction so that the historical register split can be correctly accounted for.

Second, while register split induced by syllable initials has been a central issue in the construction of tone features (Jakobson and Halle 1956; Halle and Stevens 1971; Yip 1980; Clements 1981b; Hyman 1986, 1992; Bao 1990; Duanmu 1990), tonogenesis induced by syllable finals has not been incorporated in any tone-feature system. The question is how to give a unified account of both syllable-initial induced register split and syllable-final induced tonogenesis.

Third, since there is clear evidence that each register can contain up to three tone levels and there can be up to three registers in a single language (§ 4.1, § 4.2, § 5.1, § 5.2), statistically tone languages with as many as nine tone levels should exist. The fact that no such language has ever been found suggests that during register split, some of the levels merged with others, which explains why the maximum number of tone levels is five. The question is how to handle three-way register split without duplicating nine levels of tone.

Fourth, there is evidence that more tone levels tend to require a larger tone-space, but at the same time the distances between adjacent tone levels tend to decrease. That is, tone-space expands while tone heights compresses as the number of tone levels increases in a system. The question is how to incorporate tone-space expansion and tone-height compression in a system of tone features that distinguishes three registers and five levels.

The last question is how to achieve the maximum economy in the feature system, in particular, how to capture five tone levels, three registers, register overlapping, tone-space expansion, tone-height compression, historical tonogenesis and register tripartition, without dramatically complicating the feature system.

3.2. The formulation of a new system

The new system is formulated in the following way. Starting first with tonogenesis, Haudricourt (1954a) observes that three types of syllable ending gave rise to three tones in Vietnamese, changing that language from a non-tonal language into a tonal language. The three types of syllable ending and their functions are the following: -ʔ gave rise to a rising tone; -h gave rise to a falling tone; sonorant endings gave rise to a mid tone.

The tonogenesis process thus suggests that at the time when all three tones had developed from different syllable endings, three levels of tone were also generated. If these levels are designated as high, mid and low, the three tones can be described as mid level (generated from syllables ending in a sonorant), mid-to-high rising (generated from -ʔ), and mid-to-low falling (generated from -h). Assuming the mid level carries a neutral reference pitch, it can be left unspecified, and the other two levels can be represented by using two features, [high] and [low], which are defined in (61):

(61) The definition of tone features

[high] = to raise the pitch by one and only one step.

[low] = to lower the pitch by one and only one step.

The representation of the three levels is illustrated in (62), where 'n' refers to the unspecified neutral reference level.

(62) Three basic tone levels



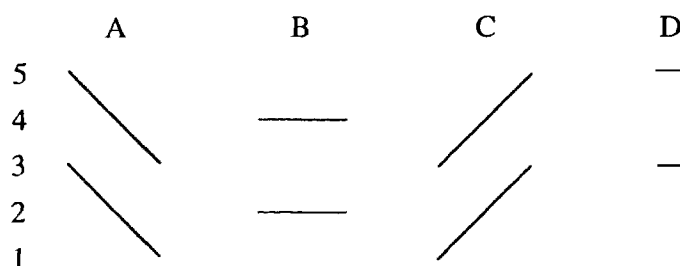
The three levels in (62) represent the tone space before register split. Tone space can split into either two or three registers. Two-way register split is well known, and as we have seen in Chapter Two, Yip (1980) is an attempt to capture this type of split. An ideal system with a two-way split is represented by the Songjiang dialect spoken in a suburb of Shanghai, where no register overlapping nor tone merger occurs. In (63), A, B, C, and D represent four historically older tones, each of which has split into two tones in modern Songjiang, conditioned by different types of syllable initials. I and II represent the two registers.

(63) An ideal case of two-way register split (Bao 1990:318)²⁶

i) Tone values

	A	B	C	D
I	53	44	35	5
II	31	22	13	3

ii) Tone pattern



Ideal cases of three-way register split are extremely rare, since the greater number of times the register splits, the more vulnerable the pitch patterns become. Other processes, such as tone merging, or the development of concave or convex tones, may obscure the pattern of register split. But still, an ideal case is found in Category B of the Baisuo Miao dialect, where the three modern tones in Category B have managed to maintain the same shape. They also clearly show register overlapping:

²⁶ The Fengxian dialect, also spoken near Shanghai, has a very similar tonal system (Pan 1982:368):

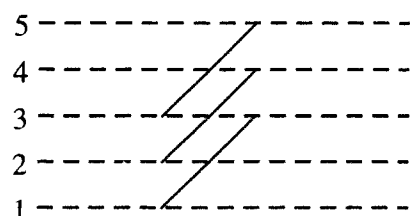
	A	B	C	D
I	53	44	35	<u>45</u>
II	31	22	13	<u>23</u>

(64) Three-way register split in Baisuo (Li, *et al.* 1959)²⁷

i) Tone values

	A	B	C	D
I	33	35	13	54
II	23	24		31
III	55	13	43	53

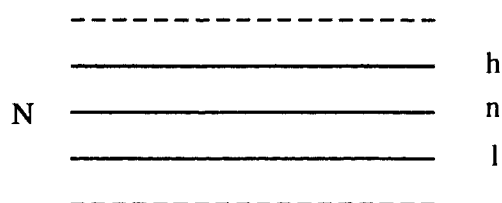
ii) Register overlapping in category B



In terms of tone features, the splitting process can be represented as an expansion of the original tone space either upwards or downwards. Since register can split in as many as three ways, it can be represented in the same fashion as tone by using the same set of features. That is, the neutral mid register is unspecified (marked with 'N'), and the other two registers are specified as [high] and [low], respectively. Here again the features are interpreted as raising or lowering the pitch level by one and only one step.

(65) The three registers

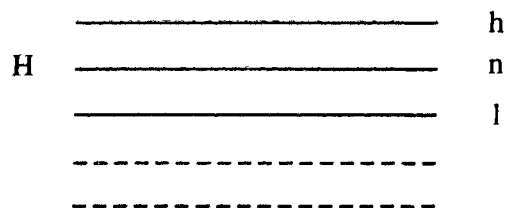
i) The neutral register



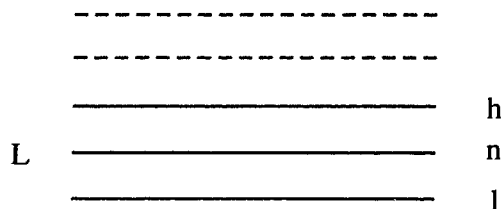
²⁷ i) As we shall see later, the three registers in (40) may be better represented as Ia, Ib, II. That is, historically there have been two successive register splits; the first gave rise to the distinction between upper (including mid) and lower; the second gave rise to the distinction between upper and mid. Since our present purpose is to show that register split have given rise to three registers, rather than how the registers have derived, we illustrate these three registers with I, II, and III.

ii) The C category split only in two ways.

ii) The upper register



iii) The lower register



3.3. A comparison

In this section, we compare the formulation of the new system with that of some previous systems. The following aspects are compared: i) register-tone relationship, ii) the definition of tone features; iii) register, register overlapping, and register tripartition; iv) the markedness of tones.

3.3.1. The register-tone relationship

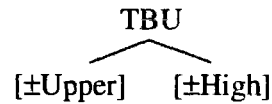
In the literature, the register-tone relationship has been formulated in various ways. In feature systems like Yip (1980), Bao (1990) and McHugh (1993b), register and tone features are in two types of relationship. In terms of feature definition, they are in a hierarchical relationship, register dominating tone. In terms of tonal representation, they are in a parallel relationship, both being associated with TBU or tonal root node as sister nodes. Take Yip (1980) as an example (66):

(66) Register-tone relationship in Yip (1980)

i) Definition

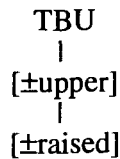
+ Upper Register	+ High Tone
	– High Tone
– Upper Register	+ High Tone
	– High Tone

ii) Representation



In Yip (1989), the parallel relationship is abandoned, such that the two features can only be hierarchically related, both in terms of feature definition and tonal representation:

(67) Tone-register relationship (Yip 1989)



I argued in Chapter Two that in order to account for historical register split, the existence of tone features should not depend on the existence of register features, and that tone and register should be in a parallel relationship. This argument is further strengthened when we associate tonogenesis from syllable finals with the tone feature, in parallel with the association of the register feature with register split induced by syllable initial consonants. As will be shown in the next chapter, tonogenesis from syllable finals preceded register split induced by syllable initials. This is true in many Southeast Asian languages. Although this does not exclude the possibility that tonal development induced by syllable initials precedes those induced by syllable finals in some languages, it does show that tone features should not depend on register features.

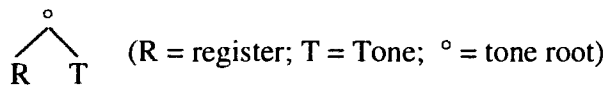
The parallel relationship, however, cannot be achieved in the feature configuration initiated in Yip (1980). By virtue of the successive splits of the tone space, first by the feature [Upper] and then by the feature [High], the feature system is based on the notion of the tone space. In this way, three tonal hierarchies are established: the tone space, the register, the tone. Since tone is on the lowest hierarchy, its existence is always dependent on the existence of register. In the same way, the

existence of register depends on the existence of tone space. Thus, by definition, the register-tone relationship in this kind of feature configuration can only be a hierarchical relationship.

The system proposed in this chapter is based on the notion of the mid neutral reference pitch, rather than the notion of tone space. Since both register and tone features are defined with respect to the neutral reference pitch, they are in a parallel relationship. The existence of one does not depend on the existence of the other; both depend on the mid pitch. And this makes sense: the mid reference pitch is needed anyway, either in tonal languages or in non-tonal languages. Before tonogenesis, there was no tone, but there was the mid pitch. Tonogenesis and register split can be regarded as the addition of the tone and register features to the phonological system. Tone space can be regarded the result of the addition of the features. The line of events is thus the following: mid pitch → addition of features → genesis of the tone space.

To be consistent with the definition of features, I assume that register and tone are also in a parallel relationship in terms of tonal representation (cf. (4)):

(68) Tone and register



3.3.2. *The definition of tone features*

As stated above, this system uses a single set of features ([high] and [low]) to specify both register and tone. When applied to the register node, the features move the pitch range by one and only one step. When applied to the tonal node, the features move the tone level by one and only one step.²⁸ Thus, the same features may occur twice on different nodes. Such a definition of tone features is not unprecedented. Recall (Chapter One) that Clements (1981b), Hyman (1986), and Hyman (1992) reject Yip's original formulation of the register-tone relationship, in which one feature defines tone level and the other register. Instead, they use the same features for both tone and register. Furthermore, in Hyman (1986) a single binary feature is used, [+T] meaning 'go up one

²⁸ This follows naturally from the difference between register and tone: register is pitch range, while tone is pitch level.

step', and [-T] meaning 'go down one step'. Thus, when applied to the register tier, [T] moves the pitch range up or down by one step; when applied to the tonal tier, [T] moves pitch level up or down by one step.²⁹ Clements and Hyman's systems are repeated below for a quick comparison:

(69) Clements (1981b)

	H	LH	RL	L
row 1	h	h	l	l
row 2	h	l	h	l

(70) Hyman (1986)

	A	B	C	D
Primary tier	+T	+T	-T	-T
Secondary tier	+T			-T

(71) Hyman (1992)

	H	L	M	!H	!L	!M	'H	'L	'M
R-plane	Ø	Ø	Ø	L	L	L	H	H	H
T-plane	H	L	LH	H	L	LH	H	L	LH

3.3.3. *Register, register overlapping, and register tripartition*

In feature systems that can only handle a simple register bipartition between H and L (Yip 1980, Clements 1981b, and Bao 1990), register overlapping is not allowed. In the feature system proposed here, it is precisely register overlapping that accounts for the fact that there are languages with register tripartition, but there is no language with nine distinctive tone levels.

In Duanmu (1990) and Hyman (1992), register overlapping is allowed, and their systems are capable of accounting for three registers. But rather than being motivated by historical register tripartition, the identification of three registers in Duanmu (1990) is an artifact of relating register to the three states of voicing (voiced, voiceless, and sonorant). As we will see in Chapter Four, the

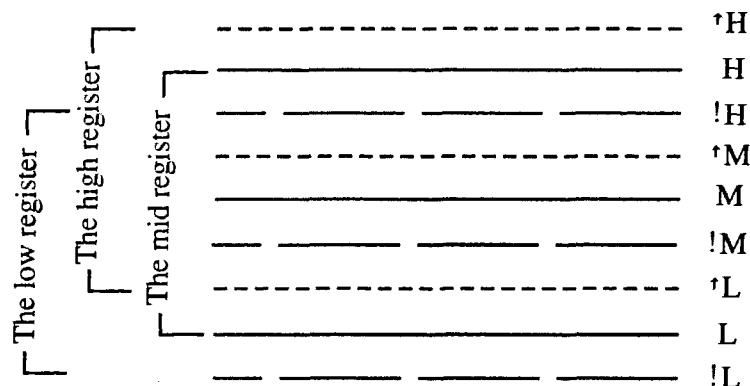
²⁹ Consider Hyman's definition of the tone feature (1986:115): 'we can assume that a tone-bearing unit may have no tone associated with it underlyingly and perhaps even on the surface, in which case the TBU will be interpreted as having no instruction for pitch from the phonology. In this case it will be open to interpretation solely from the phonetics. The assumption here is that an untuned TBU is a M tone.... The "h"... says "go up 1 step" and hence we get a H tone one step higher than M; the "l"... says "go down 1 step", and hence we get a L tone one step lower than M.'

tripartition of register may be due to factors other than the contrasts between voiced, voiceless and sonorant syllable initials. Thus, the three registers in Duanmu's system is different from the historical register tripartition dealt with in the system proposed in this thesis.

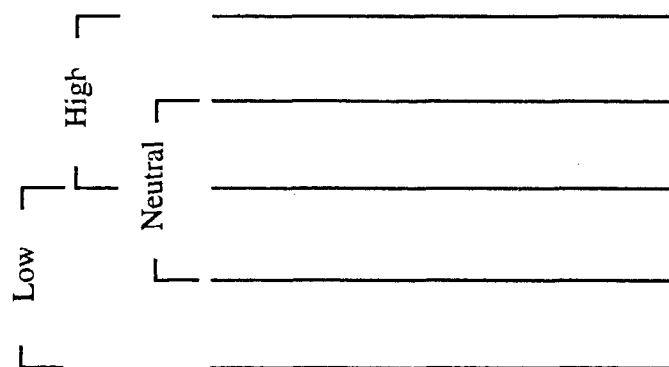
Hyman's system (1992) is designed for the purpose of accounting for downstep and upstep in African languages. Although it recognizes nine tone heights, they are not all contrastive. In fact, Hyman's system cannot account for languages with five contrastive tone heights (see § 1.2.17). One key difference between Hyman's system and the system proposed in this thesis is the manner in which register overlapping is formulated. Compare:

(72) A comparison of register overlapping

i) Register overlapping in Hyman (1992)



ii) Register overlapping in this thesis



The register overlapping in this thesis is determined by the definition of the features, i.e. to raise or lower the register by one step. Such a formulation enables the system to give a unified account of

three contrastive registers and five contrastive tone heights, while Duanmu and Hyman's systems fail to account for both.

A question arises at this point as to how to account for upstep and downstep in the system proposed in this chapter. I suggest a parametric solution whereby Hyman's system is incorporated into the system proposed in this thesis. Under this solution, languages are regarded as differing in how registers overlap with each other. In languages with three registers and five contrastive tone heights, the three registers overlap in the manner as illustrated in (72ii). In languages with upstep and downstep, the three registers overlap in the manner as illustrated in (72i). In the latter case, the register features can be redefined as 'to move the pitch range by half a step', which enables an easy incorporation of Hyman's system into the system proposed here. Such a redefinition will not affect the relationship between contrastive registers and tone heights, since in dealing upstep and downstep we are not concerned with contrastive tone heights.

3.3.4. The markedness of tones

The feature system proposed in this chapter allows for three types of bipartition and three types of tripartition. They are:

(73) Types of register split

- a) N and H;
- b) N and L;
- c) H and L;
- d) a single triple split, i.e., [H N L];
- e) a primary split into upper and lower registers plus a secondary split in the upper register, i.e., [[H M] L];
- f) a primary split into upper and lower registers plus a secondary split in the lower register, i.e., [H [M L]].

In (73a), the lower of the two registers is less marked. In (73b), the reverse is true. In (73c), the two registers have the same status with respect to markedness. In (73d), the N is unmarked. In (73e)

and (73f), the middle tone is not neutral at all, and thus it is labeled as M. M is different from the N in (73d) in that it shares a closer relationship with H in (73e), but with L in (73f).

Recall that Fromkin (1972) states that the mid tone is not always the least marked. Sometimes, it can be the most marked tone (§ 1.2.8). Compare for example, the treatments of three types of three-tone African languages in Clements (1981b), Hyman (1986), and the system proposed here. In the first type, the mid tone is the unmarked tone. In the second type, the mid tone results from a split in the original high tone. In the third type, the mid tone results from a split in the original low tone. The different representations of these three tonal systems are given in (74), where LH = lowered high, and RL = raised low:

(74) Three-tone systems³⁰

i) Clements (1981b)

	a) H	M	L	b) H	LH	L	c) H	RL	L
row 1	h		l	h	h	l	h	l	l
row 2				h	l			h	l

ii) Hyman (1986)

	a) H	M	L	b) H	LH	L	c) H	RL	L
primary tier	+T		-T	+T	+T	-T	+T	-T	-T
secondary tier					-T			+T	

iii) This thesis

	a) H	M	L	b) H	LH	L	c) H	RL	L
register	H		L	H	H	L	H	L	L
register					L			H	

Since Clements' system identifies four tone heights, it does not employ the notion of the mid reference pitch. Therefore it has no natural expression for the unmarkedness of the mid (see more in § 5.4). Hyman's system is equal to the system proposed here, except that the former has to use two tiers, both register and tone, while the latter uses only the register. In other words, in the system

³⁰ (74i) is appropriate for Yoruba, (74ii) for Kom, and (74iii) for Ewe. See Clements (1981), Hyman (1986), and Pulleyblank (1986).

proposed here, H and L tones are produced by applying [high] and [low] to M, respectively. LH is produced by applying [low] to H, and RL is produced by applying [high] to L. In this way the re-application of features accounts for the fact that LH and RL, being different from a neutral tone, result from further splits from original H and L, respectively. Thus, the register feature itself is enough to account for the three systems, and the tonal feature need not be activated.

3.4. *Summary*

As formulated in § 3.2, the new system can now be used to answer the five questions raised in § 3.1. First, since in this system tone and register share the same set of features, and since they are both defined with reference to the mid neutral pitch, in no sense does the existence of tone features depend on the existence of register features. The conflict between the theoretical and historical implementations of features in Yip (1980) does not arise. This guarantees a correct characterization of the historical register split.

Second, by relating tonogenesis induced by syllable finals to the tone feature and register split induced by syllable initials to the register feature, and by using the same features for both tone and register, this system offers a unified account of both tonogenesis and register split, which none of the previous systems of tone features is able to achieve.

Third, by defining [high] and [low] as raising or lowering the pitch by one and only one step from the neutral reference pitch, this system can generate no more than three tone levels within each register. Since register is specified by the same set of features, the maximum number of registers is also three, and the maximum register shift is also one step in both directions. Since no further shift is allowed, no further expansion of the tone space is allowed, and no more than five tone levels can be generated.³¹ The system thus satisfies the observations that the maximum number of tone levels is five and the maximum number of registers is three.

³¹ Conceptually it may be argued that since each register can contain three levels and there can be three registers, there is a chance that nine tone levels can be generated, and that the five maximum levels are a result of merging back from nine levels. The feature system proposed here excludes this possibility. Since the maximum register shift is one step in both directions, no more than five levels can be generated in the first place.

Fourth, by using the notion of the mid reference pitch, and by defining the two features as raising or lowering the pitch from the mid, the system represents both tonogenesis and register split (i.e., the addition of tone and register features) as expansions of the tone space, satisfying the observation that more tonal levels require larger tone space.

Lastly, in this system there are only two features, [high] and [low], applied to both register and tone. With underspecification, no feature specification to the neutral tone or the neutral register is necessary. Since enough distinctions are made, the features do not have to be binary. By using privative features, the number of theoretical primes are kept at the minimum, and the system achieves maximum economy.³²

³² There is a major difference between the underspecification proposed here and that proposed in Pulleyblank (1986). The fact that the mid is unspecified in the present system is a direct result of the way in which the system is set up. The underspecification in Pulleyblank (1986) cannot be predicted from the feature system itself (§ 1.2.12).

Chapter Four

Historical Evidence

This chapter provides historical evidence for the new feature system of tone formulated in the previous chapter. Three topics involving three different stages of tonal development are discussed. These are: the origin of tone, tone split, and tone merger.

In this chapter, tonogenesis and tone split are dealt with under separate headings (§ 4.1 and § 4.2, respectively). They differ in that tonogenesis concerns the issue of the origin of tone (i.e., the emergence of tone in languages not yet tonal), while tone split concerns the issue of tonal proliferation (i.e., the multiplication of tone in languages already tonal). In the literature, these two issues are usually not separated, but are both dealt with as tonogenesis (Matisoff 1973; Henderson 1982).

4.1. The origin of tone

4.1.1. Tonogenesis

In modern linguistics, the view that tone is a secondary development is becoming more and more popular under the tonogenesis hypothesis. Originally referring to processes whereby tonal contrasts arise through the decaying of the consonantal system (Matisoff 1973), the term ‘tonogenesis’ has recently been extended to include cases of tonal development from stress contrast and language contact.

Although the term ‘tonogenesis’ was not coined until 1970,³³ this line of study has a much longer history. F.-K. Li (1980:32) mentions that Duan Yucai (1735-1815) brought up, in effect, the issue of consonant-induced origin of tone by hypothesizing that the OC departing tone was a secondary development. In the 1850s, Heymann Steinthal discovered the voiced-low principle (Edmondson 1988).³⁴ In 1912, Maspéro noted the effect of syllable initial voicing on the pitch height

³³ ‘Tonogenesis’ was first used in Matisoff (1970).

³⁴ The yin-yang split of the Chinese tones was recorded as early as in 1324 by Zhou Deqing. According to him, the yin tones were induced by qing initials, and the yang tones were induced by zhao initials. In modern linguistics, yin

of the following vowel, and reconstructed the falling tone of Old Vietnamese as originating from *-h, which had itself developed from an earlier *-s. In 1954, Haudricourt reconstructed the Vietnamese and tones from *-ʔ and open syllables, respectively. He explained that the emergence of the falling tone was due to the sudden relaxation of the larynx associated with the articulation of [h], and that the emergence of the rising tone was due to the increase in tension of the glottis. Haudricourt summarized the schema of Vietnamese tonogenesis from *-h and *-ʔ as follows:

(75) Schematic table of the origin of tone (Haudricourt 1954a:81)³⁵

beginning of Christian era (no tone)	sixth century (three tones)
pa sla > hla ba la	pà hlà bà là
pas > pah slas > hlah bas > bah las > lah	pá hlá bá lá
paX > paʔ slaX > hlaʔ baX > baʔ laX > laʔ	pá hlá bá lá

Since 1954, this schema of tonogenesis has been applied to Chinese in a number of studies, and has also been modified in various ways. Haudricourt (1954b) argues that the OC departing tone, like the Vietnamese counterpart *hỏi-ngã* tone, was marked by an -s. Based his argument mainly on analogy with Vietnamese, Pulleyblank (1962) posits an earlier -ʔ as the source of the MC Rising tone. He also provides evidence further substantiating the -s hypothesis of Haudricourt (1954b), and proposes that the MC level tone arose through the loss of syllable endings -fi and -ð. Focusing on the MC Rising tone, Mei (1970) agrees that the antecedent for this tone was a syllable ending -ʔ, and he shows that a -ʔ is still preserved in some modern Min and Wu dialects where it is associated with a high rising tone. He argues that by the time of Early Middle Chinese (EMC), syllable endings -ʔ and

and yang are interpreted as high and low pitch respectively; and qing and zhuo are interpreted as voiceless and voiced, respectively. But as we will see later, such interpretations themselves are subject to debate.

³⁵ The X in the table represents unspecified oral stops.

-h had dropped from the majority of dialects, so that the tones of EMC can be described ‘in terms of pitch and contour and length’ (p.86). Pulleyblank (1978) thinks that Mei’s conclusion about the shapes of MC tones is ‘excessively cautious’ (p.174). Instead, he believes that syllable endings -ʔ and -h were preserved until the eighth century, and in the ninth century -h was assimilated to -fi due to the influence from syllable-initial -fi, i.e., pfi--h → pfi--fi, etc. Since different types of syllable endings were preserved throughout the MC period, Pulleyblank argues, the MC categories of *sheng* were not tonal, or quasi-tonal at best. Rejecting Pulleyblank’s conclusion, Mei (1982) forcefully argues that final -ʔ was dropped from the northern (standard) dialect no later than the second century A.D., so that the MC tones could not have been marked by syllable-final consonants. As a by-product of his paper, Mei demonstrates that tonal system can remain stable over a long period of time. The MC Rising tone has remained high in the ‘central plain’³⁶ for no less than six centuries, in Loyang for at least nine hundred years, and in Xi’an for more than a millennium. This conclusion challenges the traditional wisdom that tonal system is the most vulnerable aspect of phonology, being subject to great temporal changes and wide regional variations.

Further support for reconstructing -ʔ as the direct precursor of the rising tone comes from Lahu, a member of the Loloish branch of the Lolo-Burmese sub-group of the Tibeto-Burman family. Matisoff (1970) shows that the Proto-Tibeto-Burman (PTB) causative prefix *s- fused with the initial consonant of the verb-root in Proto-Lolo-Burmese (PLB), imparting to it a glottal coarticulation. By that time, PLB syllable-final -p, -t, and -k had reduced to -ʔ. These two separate processes thus created two ʔ’s, one at the beginning and the other at the end, of the syllable. For Lahu, this was more than the phonology could bear, thus prompting a process which Matisoff calls ‘glottal dissimilation’, whereby the final -ʔ disappeared, leaving behind a compensatory high rising tone, as shown in the following examples:

³⁶ In a broad definition, ‘central plain’ refers to the vast area encompassing southern Hebei, northern Hunan, western Shandong, and northern Anhui provinces, traditionally regarded as the heart of China. In a narrow definition, ‘central plain’ refers to the Henan province. Mei in his article uses the broad definition.

(76) Glottal dissimilation and the Lahu high-rising tone (Matisoff 1970)

PLB	Old Burmese	Lahu	
*ʔkyak	khyak	cá	'cause to boil'
*ʔwak	hwak	fá	'cause to be hidden'
*ʔtuk		tú	'set fire to'
*ʔlyak		*ʔlɛʔ > lɛ́	'cause to lick'
*ʔwat		*ʔwəʔ > fɿ	'cause to wear'

Glottal stop is also known to have a pitch-lowering effect on the preceding vowel in some languages. The falling tone in certain words of Hopi, a Uto-Aztecan language spoken in Arizona, is believed to have derived historically from an earlier glottal stop. Compare, for example, an earlier *soʔ-*, presuffixal allomorph of *soʔa* 'to die' (pl. subj.), with a later *sòðni* future of same (Manaster-Ramer 1986).³⁷

The different pitch-changing effect of the glottal stop in different languages may be explained by the fact that what is commonly transcribed as [ʔ] may in fact represent different speech sounds in different languages. Ladefoged has been quoted as suggesting that the pitch-lowering effect may be attributed to creaky voice, rather than glottal stop per se (Hombert, *et al* 1979). In contrast, the [ʔ] in Chinese and Southeast Asian languages is commonly unaspirated and without noticeable release.'

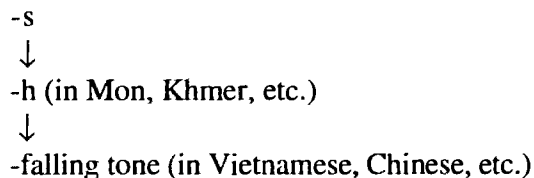
Just as the reconstruction of [ʔ] has generated a great amount of discussion, the reconstruction of -h as the source of the falling tone has also induced some scholarly work. Sagart (1986) argues that while more and more evidence has been found for an -s state in the evolution of the MC Departing tone, there is little evidence suggesting an -h stage, and there is no modern dialect that has ever been reported to have the -h feature. The reconstruction is further weakened by the fact that the syllable-final laryngeal spirant of Sanskrit (-h) was not transcribed by MC Departing-tone words, as would be expected by the hypothesis that -h was preserved in MC. Sagart therefore suggests that MC Departing tone was not characterized by an -h, but by a high degree of glottal constriction throughout the final,³⁸ i.e., a creaky phonation, while the MC Rising tone was characterized by a clear, modal

³⁷ Professor Edmondson points to me that in Tibetan ʔ have either falling or rising effect. In Burmese, ʔ is the source of a falling tone. He suggests that slow closure causes lowering while rapid closure causes rising pitches in Burmese.

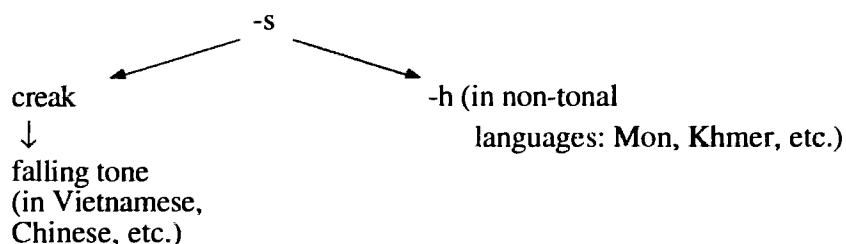
³⁸ In the literature, a Chinese syllable like [m i ɛ n³⁵] 'cotton' is said to have the following structure:

voice and a final glottal stop. Taking one step further, Sagart suggests that not only MC but OC Rising and Departing Tones were also characterized by these features (p.99). In a follow-up paper, Sagart (1988) directly challenges Haudricourt's tonogenetic hypothesis of the falling tone, arguing that most -h preserving languages are either non-tonal or tone languages in which the final -h played no tonogenetic role. In his view, the cognate relationship between -h in non-tonal languages like Mon-Khmer and the falling tone in tone languages like Vietnamese cannot be taken as evidence that the falling tone derived from -h. The common origin of the falling tone in Chinese and Southeast Asian languages, Sagart argues, should be creaky phonation, in which 'the effective mass of the vocal folds is increased, which results in a slowing down of the vibrations, in other words, a pitch fall' (Sagart 1988: 84). Haudricourt's model (77) is then amended as in (78):

(77) Haudricourt's model of the emergence of the falling tone



(78) Sagart's amendment



The -h hypothesis, however, is supported by data from languages outside the East and Southeast Asian area. In Hopi an earlier preaspiration or preconsonantal *h* is lost, leaving behind a lengthened

Tone			
	Final		
		Rhyme	
		Nucleus	Ending
Initial	Medial	Nucleus	Ending
m	i	ε	n

In this sense, 'the final' refers to the part of the syllable minus the initial consonant. 'Final' may also be used to refer to the syllable ending, as in the expressions 'the final position', 'syllable-final consonant', etc. Here, it is the former meaning that is being used.

vowel with a falling tone. According to Manaster-Ramer (1986), this development is quite recent, since the tonal system was absent in the language in the 1930s:

(79) Genesis of Hopi falling tone from aspiration (Manaster-Ramer 1986)

<u>1930s</u>	<u>1970s/1980s</u>	
wi ^h ti	wîiti	‘woman’
le ^h pe	léèpe	‘to fall’
ki ^h ki	kîiki	‘foot’
hahlaya	háàlayi	‘to be happy’
momoht	momóòt	‘bees’
sowiht	sowîit	‘rabbits’

Hopi is unique in that earlier postvocalic voiceless semivowels or sonorants (transcribed in capital letters in the following data) also gave rise to a falling tone, while this kind of tonogenesis is virtually unknown in other languages:

(80) Hopi falling tone from voiceless semivowels/sonorants (Manaster-Ramer 1986)

<u>1930s</u>	<u>1970s/1980s</u>	
waLpi	wálpî	name of a village
sik ^y uòpî	sik ^y yáñpî	‘yellow’
naWki	náwki	‘to snatch’
soMta	sómîta	‘to tie’

Not only can tonogenesis be conditioned from syllable-final consonants, it can also be induced from syllable-initial consonants. One common type of tonogenetic condition is the neutralization of voicing contrast in prevocalic consonants. Haudricourt (1961) mentions that voicing neutralization is believed to be the source of tonogenesis in Lamet and Riang, two Austroasiatic languages spoken in Burma and Laos respectively, and in Cham, an Austronesian language spoken in Vietnam.³⁹ Qu (1988) reconstructs two proto-tones for Tibetan, *A and *B. *A derived from earlier voiceless initial, and *B from earlier voiced initial. The values of *A and *B are reconstructed as [44] and [22], respectively. (81) shows a comparison of Classical Written Tibetan, a non-tonal language, with two modern Tibetan tonal dialects Muya and Yajiang.

³⁹ Professor Edmondson points to me that Cham shows tonogenetic effects from both syllable initials and finals.

(81) Tonogenesis from syllable-initial voicing contrast in Tibetan (Qu 1988:322)

Written Tibetan	Muya	Yajiang	
A *sa	sa ⁵³	sa ⁵³	'earth, land'
A *kha	kha ⁵³	kha ⁵³	'mouth'
A *gnam	na ⁵³	nō ⁵³	'sky'
A *sñiŋ	ñin ⁵³	ñi ⁵³	'heart'
B *dza	tɕa ¹³	tɕa ¹³	'tea'
B *bal	pe ¹³	pe ¹³	'wool'
B *rdo	do ¹³	do ¹³	'stone'
B *sgo	go ¹³	go ¹³	'door'

Tonogenesis can also result from language contact and extensive borrowing. According to Benedict, Tai and Miao-Yao, two branches of the Austro-Thai family, and Vietnamese, an Austro-Asiatic language, developed their own tonal systems from the Chinese system through area diffusion (Benedict 1972b, 1973).⁴⁰ Baonan, a Mongolian language spoken in Qinghai Province of China, is in the process of acquiring tones through contact with the Chinese dialect of Linxia (Li 1986). Since tone borrowing is not our major concern, we will not go into the details here.

4.1.2. *Tonogenesis: summary and implications*

As we have seen in this section, there have been considerable disagreements in the literature regarding the hypothesis of tonogenesis. For example, the time of tone emergence in Chinese has been suggested to be as early as in the eleventh century B.C., or as late as the ninth century A.D., with a difference of two thousand years. The source of the Departing tone has been posited as -h in some studies, but as creaky phonation in others. Glottal stop is known to have conditioned the development of rising tone in Asian languages, but falling tone in American languages. Creaky voice is found to correlate with high pitch in languages like Burmese, but with low pitch in languages like Mam. The falling pitch is believed to have been conditioned by -h, -fi, -ʔ, creaky voice, voiceless sonorants, semi-vowels, and breathy voice. But in spite of the disagreements regarding the exact TIME and CONDITIONS of tonogenesis, the PATTERN of Haudricourt's original three-tone schema (1954a), i.e., rising, level and falling, is left intact.

⁴⁰ Benedict's theory of the origin of tone in East-Southeast Asian languages is different from that of Haudricourt (1954a).

The tonogenesis process thus suggests that at the time when all the three tones had developed from different syllable endings, three tone heights were also generated. It is apparent that these three tone heights can be matched with the three basic tone levels in the new feature system proposed in the previous chapter in (62), repeated here in (82):

(82) The match between the pattern of tonogenesis and the new feature system

_____	h
_____	n
_____	l

Under this system, the genesis of the three tones can be represented as resulting from the application of the two features [high] and [low] to the neutral reference pitch, [high] and [low] being defined in (61) as ‘raising or lowering the pitch level by one and only one step’, respectively. The three tones in Haudricourt’s schema can therefore be represented as [mh], [m] and [ml], with [m] being a default value. In this way, the new feature system captures the pattern of tonal development suggested by tonogenesis studies.

The type of tonogenesis from syllable initial consonants shown in (81) should not be handled by (82). As we will see in § 4.1, this type of tonogenesis shares some property with register split, and can be handled accordingly.

4.2. *Tone split*

It is typical of languages in China and Southeast Asia that a single earlier tone has often split into two tones. This process was recorded as early as in the ninth century for Chinese in both Japanese and Chinese documents (Mei 1970; Pulleyblank 1978; X. Li 1983; Hirayama 1987), and swept across Southeast Asia in the first half of the second millennium A.D., affecting Thai, Burmese, Loloish, Vietnamese, Miao-Yao, and many other languages (Gedney 1985).⁴¹ Dwarfing the ‘Great

⁴¹ According to Gedney (1985), tonal split occurred to Tai around 1000 A.D. Based on Japanese and Vietnamese transliterations of ancient Chinese texts, C. Shi (1981) believes that the splitting process started in Chinese no later than the Tang Dynasty (618-907 A.D.).

A similar process also occurred to the non-tonal Mon-Khmer family in that area, affecting the vowel systems (Jenner 1974a). Gedney (1985) states: ‘The non-tonal Mon-Khmer languages underwent a similar set of changes, making splits in vocalic nuclei conditioned by the phonetic nature of the preceding consonant, and sometimes even developing two registers of voice quality. This happened in the two major languages of the group, Khmer or Cambodian and Mon.’

Vowel Shift' of English in its immensity of influence, this process is also known as the 'Great Tone Split' (Brown 1975). Unlike tonogenesis from syllable-final consonants which generally affects the pitch contour of a syllable, tonal split is in most cases conditioned by syllable-initial consonants and typically affects the pitch range. That is, voiceless initials give rise to a higher pitch, while voiced initials give rise to a lower pitch. For this reason, tonal split is also known as register split (Yip 1980).⁴² After the split, the original voicing contrast is lost in some languages, a common phenomenon known as consonant leveling. In some languages of the area, the tone-space splits not just in two but in three ways, yielding a total number of three registers.

Another type tone split is conditioned by the long : short contrast in vowels, especially in checked syllables in Asian languages. Combined with register split, a single earlier checked tone may split in six possible ways. In this section, the implication of this type of tone split to the new feature system is also considered.

4.2.1. Two-way register split

In traditional Chinese phonology, two-way register split is known as 'yin-yang' split. It is believed that such split is conditioned by a major distinction between voiced and voiceless initial obstruents, traditionally known as *qing* and *zhuo*. A third class of syllable initials—*cizhuo* (sonorants)—also plays a part.⁴³ If we label the four MC tone categories with A, B, C and D, then the development of tone in Chinese can be illustrated with two dialects—Jinan and Wenzhou.

Jinan is a Mandarin dialect, spoken in Shandong Province. In the majority of the Mandarin dialects, MC Tone A split into yin and yang varieties, part of the MC Tone B merged into Tone C, and MC Tone D merged with other categories. As a result, there are four new tone categories, which are labeled in (83) as AI, AII, B and C, respectively. The development of MC Tone D is not regular across Mandarin. In Jinan, it merged with AI, AII and C; in Beijing, it merged with AI, AII, B, and C; in Xi'an, it merged with AI and AII; in Chengdu, it merged with AII (Yuan 1960).

⁴² Other names for the same process are 'register bifurcation' (Clements 1981:62) and 'tonomitosi' (Duanmu 1990:113).

⁴³ For the interpretation of the traditional terms, see Luo (1954).

Wenzhou is spoken in Zhejiang Province. While the yin-yang split occurred only in MC Tone A in the majority of the Mandarin dialects, in many Wu dialects, the yin-yang split occurred to all the four MC categories, yielding a total number of eight tones. These eight tones are labeled as AI, AII, BI, BII, CI, CII, DI and DII in (83).

(83) Development of tone in Jinan and Wenzhou (Beijing University 1959)⁴⁴

MC		Jinan		Wenzhou		
A	vl.	AI	tā ²¹³	AI	ta ⁴⁴	‘to carry’
	son.	AII	lā ⁴²	AII	la ³¹	‘blue’
	vd.		t‘ā ⁴²	da ³¹	‘to talk’	
B	vl.	B	tā ⁵⁵	BI	ta ⁵⁴	‘gallbladder’
	son.		lā ⁵⁵	BII	la ²⁴	‘to see’
	vd.	C	tā ³¹	da ²⁴	‘thin, light’	
vl.	t‘ā ³¹		CI	t‘ø ⁴²	‘to explore’	
son.	lā ³¹		CII	la ¹¹	‘flood’	
	vd.	tā ³¹	da ¹¹	‘egg’		
D	vl.	(AI)	ta ²¹³	DI	tø ²³	‘to answer’
	son.	(C)	la ³¹	DII	la ¹²	‘cured meat’
	vd.	(AII)	ta ⁴²		da ¹²	‘to extend’

The traditional account of the Great Tone Split—the ‘voiceless-high, voiced-low’ principle—has been questioned in a number of studies. It has been known for some time that in the Wu dialect group of Chinese, the only dialect group where the traditional *zhuo* category of initials is systematically preserved, the *zhuo* initials are in fact not voiced. Chao (1928:xii) reports that the *zhuo* obstruents of Wu have a voiceless onset and closure, but are released with a voiced aspiration; the only truly voiced consonants in Wu are the nasals, laterals and [ɦ]. J. Yuan (1960:61) observes that sonorants as well as the *zhuo* obstruents in Wu are released with breathy voice, and he transcribes these initials as [pɦ, tɦ, kɦ, tʃɦ, tʂɦ, fɦ, sɦ, ʃɦ, mɦ, nɦ, ɲɦ, ɳɦ, ɳɦ, ɳɦ, lɦ], etc. Recent acoustic and aerodynamic studies have confirmed the breathy quality in Wu initials (Cao and Maddieson 1992). Based on the Wu evidence, C. Shi (1981) reconstructs MC *zhuo* initials as [pɦ, tɦ, kɦ], etc., rather

⁴⁴ Since voicing contrast in initial consonants is still preserved in Wenzhou, register differences are not fully phonemic. If we maintain that tone must be phonemic, we would reach the conclusion that Wenzhou has only three tones, i.e., ping, shang, and qu, since the ru category would also be non-tonal (see fn. 4). But traditionally, Wenzhou is said to have eight tones.

than [b, d, g], etc. This entails that the lowering of pitch could not have been caused by plain voice. Based on a comparison with Mon-Khmer and Punjabi, as well as from evidence in modern Wu dialects of Chinese, Pulleyblank (1978) argues that register split in Chinese was conditioned by breathy voice. He reconstructs EMC *zhuo* initials as voiced, but they became breathy-voiced in Late Middle Chinese (LMC). He remarks that the different reconstructions of *zhuo* as either plain voice or breathy voice do not contradict each other, but rather they refer to different historical periods, with plain voice antedates breathy voice. This is in line with reconstructions of the origin of phonation types in phonation-type languages, typically of the Austroasiatic family, where it is believed that the development of phonation types is conditioned by the voicing characteristics of the syllable-initial consonant. If the initial was voiced, a breathy voice might develop for the entire syllable; if voiceless, a creaky phonation might develop (Bradley 1982b:118).

Register split is also found in African languages. Clements (1981b) discusses a case in two Bantu languages, Cuka and Kamba, where the proto-Bantu two-way opposition between high and low expands into a four-way opposition word-finally. These four tones are marked in (84) as * (raised-high), ´ (high), ¯ (low), and ` (lowered-low). ˘ designates low to lowered-low falling, and ˆ designates raised-high to lowered-low falling. In (84) Tharaka is another Bantu language where no register split has occurred.

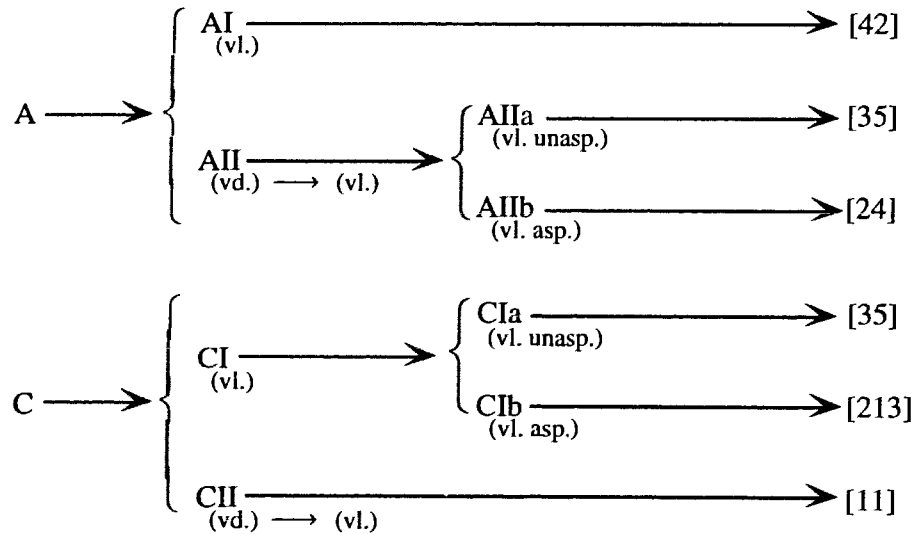
(84) Register split in two African languages (Clements 1981b:63)

<u>Tharaka</u>	<u>Cuka</u>	<u>Kamba</u>	
ɲō:ntō	ɲō:ntò	nō:ndò	‘breast’
ṁtō	mō:ntò	mō:ndò	‘person’
ŋkórō	ŋkórò	ŋgǒǒ	‘heart’
māyútā	māyútà	māūtā	‘oil’
ēmwe	ēmwe	ēmwe	‘one’
kē:ndá	kē:ndā	kē:ndā	‘nine’
ŋkí:ŋgó	ŋkí:ŋgó	ŋgí:ŋgó	‘neck’

4.2.2. Three-way register split

Compared with two-way register split, three-way register split is relatively rare and less well-known. Y. Chao (1928) reports that MC Tone C and Tone D in modern Lili, and MC Tone B in modern Jiaxing, both spoken in Jiangsu Province of China, have split into three tones. Hirayama (1987) mentions that there is evidence showing a tripartition of MC Tone A in the Tang Dynasty. Y. Liang (1986) reports that in the Min dialect of Wenchang, spoken on the Hainan island, MC Tone C has split into three tones, with the values [11], [42] and [53], respectively, e.g., [ʔbua¹¹] ‘half’, [ʔban⁴²] ‘do’, [ʔbua⁵³] ‘dustpan’. Xiong (1979) discusses a tripartition example in the Gan dialect of Nanchang, spoken in Jiangxi Province of China. In this dialect, tripartition occurred only in MC Tone A and Tone C. Xiong proposes that the tripartition is in fact consists of two successive double splits, the first conditioned by voiceless : voiced contrast, the second by aspirated : unaspirated contrast, as shown below:

(85) Successive splits in Nanchang (Xiong 1979):



Li, *et al* (1959) reports a survey of the Miao language in twenty locations in Hunan and Guizhou Provinces of China. Out of the twenty locations, one shows no register split, seven have two-way register split, and twelve have three-way register split. Ancient Miao had four tones, named A, B, C, and D respectively. In locations where two-way split has occurred, each of the four earlier tones split into two registers, yin (upper) and yang (lower), conditioned by the voicing feature of the initials. In locations where three-way split has occurred, the yin (upper) register has further split into two,

conditioned by aspiration. (86) gives data from two locations, Zongdi and Shuiwei. The primary split is indicated by I and II; the secondary split by a and b. In Zongdi, voiced initial obstruents have become voiceless, a common leveling phenomenon. In Shuiwei, no register split has occurred; it is included for comparison.

(86) Three-way register split of Miao (Y. Li, *et al* 1959)⁴⁵

Ancient		Modern Dialects	
Categories		Zongdi	Shuiwei
A	Ia	plo ³²	plu ³¹ 'hair, feather'
		to ³²	tu ³¹ 'deep'
		mpz ³²	mʔpa ³¹ 'green'
		maŋ ³²	ʔmoŋ ³¹ 'ache, pain'
		lan ³²	ʔleŋ ³¹ 'red'
		zɒ ³²	ʔwju ³¹ 'tea'
	Ib	pz ³²	p ³¹ 'blow'
		tɕ ³²	tɕ ³¹ 'thread a needle'
		m ³²	m ³¹ 'Miao nationality'
		n ³²	n ³¹ 'sun'
		l ³²	l ³¹ 'brains'
		z ³²	seŋ ³¹ 'high'
	II	ʂaŋ ⁴²	z ⁴²
		tɕ ⁴²	z ⁴²
		ntɕ ⁴²	ntɕ ³¹ 'mouth'
		len ⁴²	leŋ ³¹ 'field'
		zaŋ ⁴²	wjoŋ ³¹ 'dragon'
B	Ia	pz ⁴³	pi ⁵⁵ 'house'
		tɕ ⁴³	tɕo ⁵⁵ 'wine'
		ka ⁴³	tɕi ⁵⁵ 'road'
		nta ⁴³	nʔti ⁵⁵ 'long'
		ha ⁴³	qa ⁵⁵ 'excrement'
		loŋ ⁴³	ʔlaŋ ⁵⁵ 'short'
	Ib	s ⁴³	ts ⁵⁵ 'bone'
		h ⁴³	qw ⁵⁵ 'ginger root'
		h ⁴³	q ⁵⁵ 'hole'
		ɸ ⁴³	xu ⁵⁵ 'head'

⁴⁵ As the data show, the actual pitch values of the lower register may *higher* than the pitch values of the upper register. This, however, can be regarded as a later development (see below). What is important for now is to show that the register can split in three ways.

		$\tilde{n}^h\text{ɒ}^{243}$	$\tilde{n}\text{ɔŋ}^{55}$	'heavy'
		$\tilde{n}^h\text{ɔŋ}^{243}$	$\tilde{n}^h\text{eŋ}^{55}$	'intestines'
	II	$t^h\gamma^{11}$	$\delta^d\text{o}^{55}$	'fire'
		$t^h\text{ɔŋ}^{11}$	$\delta^d\text{ɔŋ}^{55}$	'wait'
		$mpz\zeta^h\text{e}^{11}$	mpi^{55}	'fish'
		$m^h\text{en}^{11}$	ma^{55}	'horse'
		$z^h\text{ɔŋ}^{11}$	$wjaŋ^{55}$	'warehouse'
C	Ia	$t\text{ɔ}^{45}$	$t\text{o}^{35}$	'foot'
		$t\text{ɒ}^{45}$	$t\text{u}^{35}$	'ax'
		$mp\text{ɔŋ}^{45}$	$m\text{ʔpaŋ}^{35}$	'snow'
		mpa^{45}	$m\text{ʔpi}^{35}$	'name'
		ha^{45}	qwe^{35}	'egg'
		$z\text{aŋ}^{45}$	ʔwioŋ^{35}	'good'
	Ib	$k^h\text{ɒ}^{24}$	$k^h\text{u}^{35}$	'shoe'
		$t^h\text{an}^{24}$	$t^h\text{aŋ}^{35}$	'charcoal'
		$\tilde{n}t\zeta^h\text{ɔ}^{24}$	$\tilde{n}\text{ʔt}\zeta^h\text{u}^{35}$	'fumigate'
		$m^h\text{ɔŋ}^{24}$	$m\text{ɔŋ}^{35}$	'night'
		$mj^h\text{en}^{24}$	$m\text{eŋ}^{35}$	'to smell'
		$l^h\text{j}^{24}$	$l^h\text{a}^{35}$	'moon'
	II	$t^h\text{a}^{13}$	$\delta^d\text{a}^{35}$	'to die'
		$p^h\text{a}^{13}$	$v^b\text{a}^{35}$	'embrace'
		$nt^h\text{a}^{13}$	$nt\text{a}^{35}$	'hemp'
		$n^h\text{ɔŋ}^{13}$	$n\text{o}^{35}$	'bird'
		$z^h\text{u}^{13}$	$wj\text{u}^{35}$	'strength'
	Ia	$t\text{e}^{33}$	$t\text{a}^{31}$	'wing'
		$pz\text{u}^{33}$	$p\text{ø}^{31}$	'dark'
		ʃo^{33}	$t\text{u}^{31}$	'laugh, smile'
		$l\text{ɔ}^{33}$	ʔlo^{31}	'to peel, to skin'
		$s\text{a}^{33}$	$t\text{se}^{31}$	'connect, join'
	Ib	$mpj^h\text{e}^{13}$	$m\text{ʔp}^h\text{e}^{31}$	'daughter'
		$s^h\text{e}^{13}$	$t\text{s}^h\text{e}^{31}$	'paint'
		$n^h\text{aŋ}^{13}$	$\eta^h\text{o}^{31}$	'cough'
		$l^h\text{e}^{13}$	$j^h\text{e}^{31}$	'cut'
		$w^h\text{o}^{13}$	$x\text{o}^{31}$	'to drink'
		$k^h\text{o}^{13}$	$k^h\text{o}^{31}$	'itch'
D	II	$k\text{u}^{31}$	$\gamma^g\text{o}^{31}$	'ten'
		$t\text{o}^{31}$	$\delta^d\text{u}^{31}$	'to bite'
		$\eta k\text{e}^{31}$	$NG^h\text{ac}^{31}$	'narrow'

The Miao data also show that the secondary split in the upper register can also be conditioned by prenasalized stops/affricates, as in (87), where 'Dongtouzhai' and 'Jiwei' are the names of two locations. In Jiwei, the secondary split does not occur. Again, it is included for comparison.

(87) Split conditioned by prenasalized stops/affricates (Y. Li, *et al*)

Ancient		Modern Dialects		
Categories		Dongtouzhai	Jiwei	
A	Ia	tɔ ⁵³	to ³⁵	‘deep’
		pɔ ⁵³	pu ³⁵	‘three’
		qwe ⁵³	qwei ³⁵	‘ghost’
	Ib	ñɬu ³³	ɲtuŋ ³⁵	‘middle’
		ndzi ³³	ñtɕi ³⁵	‘to shear’
		nde ³³	nteɪ ³⁵	‘wet’
B	Ia	ku ⁵⁵	ku ⁴⁴	‘road’
		pe ⁵⁵	pe ⁴⁴	‘full’
		li ⁵⁵	le ⁴⁴	‘short’
	Ib	ndu ⁴⁴	ntu ⁴⁴	‘long’
		mba ⁴⁴	mpa ⁴⁴	‘mend’
		ndzo ⁴⁴	ntsɔ ⁴⁴	‘morning’
C	Ia	tso ³³	tɕu ⁵³	‘year’
		la ³³	la ⁵³	‘moon’
		kʰɔ ³³	ɕɔ ⁵³	‘shoe’
	Ib	mba ²²	mpa ⁵³	‘pig’
		ñdʒi ²²	ntsei ⁵³	‘thin, skinny’
		ndzo ²²	ñtɕi ⁵³	‘to ride’
D	Ia	ti ³⁴	tɣ ⁴⁴	‘wing’
		la ³⁴	lʰa ⁴⁴	‘cut’
		ɬɔ ³⁴	tɔ ⁴⁴	‘laugh, smile’
	Ib	nda ²⁴	ntu ⁴⁴	‘navel’
		ndɔ ²⁴	ntɔ ⁴⁴	‘weave’
		ñdʒa ²⁴	ñtɕa ⁴⁴	‘to peck’

The existence of register tripartition is most forcefully argued for by Haudricourt (1961). Haudricourt (1961) extends his earlier observation on three-way tonogenesis from features of voice, aspiration and glottalization in syllable-final position, arguing that three-way register split can be

conditioned by the same features but in syllable-initial positions. In Kam (also known as Dong or Tung), spoken in the eastern Guizhou Province of China, for example, each of the earlier A, B, C tones are divided into three tones conditioned by syllable-initial differences, as evident from a comparison with other two languages of the same family—Sui and Mak:⁴⁶

(88) Three-way register split in Kam (Haudricourt 1961)

Category A	Sui	Mak	Kam	
glottalized	ʔnaa ¹¹	naa ²⁴	naa ⁵⁵	‘épais’
	ʔbaaŋ ¹¹	ʔbaan ²⁴	maaŋ ⁵⁵	‘mince’
	ʔdaai ¹¹	ʔdaai ²⁴	laai ⁵⁵	‘bien’
aspirated	hmaa ¹¹	maa ¹³	ɲwaa ³⁵	‘chien’
	...	maa ¹³	maa ³⁵	‘venir’
	hɲai ¹¹	hai ¹³	ai ³⁵	‘ouvrir’
voiced	mya ¹¹	mii ¹³	mya ²¹²	‘main’
	lee ¹¹	lee ¹³	lee ²¹²	‘lettres, caractère’
	Raan ¹¹	ʒaan ¹³	yaan ²¹²	‘maison’
Category B				
glottalized	ʔnan ³⁵	ʔdan ³⁵	nan ⁵³	‘salé’
	ʔdaai ³⁵	ʔdaai ³⁵	laai ⁵³	‘sanglier’
	ʔbya ³⁵	ʔbii ³⁵	myaa ⁵³	‘ennuyé’
aspirated	hmuu ³⁵	məu ³⁵	muu ⁴⁵³	‘porc’
voiced	lyaan ³⁵	liin ³⁵	lyaan ³³	‘poivré’
	naai ⁵⁵	naai ²⁴	naai ³³	‘ceci’
Category C				
glottalized	ʔnaa ³³	naa ⁴⁴	naa ³²³	‘face’
	ʔmaa ³³	maa ⁴⁴	maa ³²³	‘mou’
	ʔdai ³³	ʔdai ⁴⁴	lii ³²³	‘obtenir’
aspirated	hnaa ³³	...	naa ¹³	‘arc, arbalète’
	hnoo ³³	noo ⁴⁴	noo ¹³	‘rat’
	khau ³³	lau ⁴⁴	khwaau ¹³	‘alcool’
voiced	naam ³³	nam ⁴⁴	nam ³¹	‘eau’
	mai ⁵¹	mai ⁵¹	mai ³¹	‘arbre’
	nu ⁵¹	nun ⁵¹	non ³¹	‘cadet’

⁴⁶ In Haudricourt’s paper, Category D is not included.

According to F-K. Li (1965), the Kam-Sui group consists of four languages, Kam, Sui (also known as Shui), Mak (also known as Mo), and T’en (also known as Yanghuang). They are related to, but sufficiently different from the Tai languages as to form a distinct group.

The Kam data not only demonstrate that register split can result from the same features that condition tonogenesis, they also show that these features function differently in different positions. Syllable-finally, voiceless aspiration induces the lowest tone (falling); syllable-initially, voiceless aspiration does not induce the lowest register. The Kam register split is summarized by Haudricourt (1961) as below:

(89) Summary of register split in Kam (Haudricourt 1961:170)

	A	B	C
$\text{ʔb} > \text{m}, \text{ʔm} > \text{m}, \text{ʔn} > \text{n}, \text{ʔd} > \text{l}, \text{ʔR} > \text{y}, \text{k}, \text{t}, \text{p}$	55	53	323
$\text{hm} > \text{m}, \text{hn} > \text{n}, \text{hñ} > \text{ñy}, \text{hñ} > \text{O}, \text{kh}, \text{th}, \text{ph}$	35	453	13
$\text{m}, \text{n}, \text{ñ}, \text{l}, \text{b} > \text{p}, \text{d} > \text{t}, \text{g} > \text{k}, \text{R} > \text{y}$	212	33	31

Edmondson (1990a) presents a different explanation of the Kam triple split. He suggests that the triple division of the register results from two temporarily distinct bipartitions rather than one simultaneous tripartition, and that the real cause of the second split was not aspiration, but rather breathy voice. He argues that there has been a complex interaction among three factors in Kam: breathy voice, aspiration, and deaspiration. After conditioning the second split, breathy voice was lost in favor of aspiration, which later became deaspirated in some locations, further obscuring the real cause of the second split. Assuming that voiceless nonaspiration is the most unmarked state for syllable-initial stops, and that breathy voicing is more marked than aspiration, Edmondson is able to achieve a uniform explanation of the changes in Kam initials after the two temporally distinct tonal splits. He argues that these changes can be seen as a series of unmarking processes. That is, after the primary split, the change $\text{m}/\text{ŋ} > \text{m}/\text{n}$ is a manifestation of [m voice, m continuant] > [u voice, m continuant]; and the change $\text{ʔb}/\text{ʔd} > \text{m}/\text{n}$ or l is a manifestation of [m voice, u continuant] > [u voice, m continuant]. After the secondary split, breathy voice > aspiration > deaspiration is also a process of unmarking.

Pulleyblank (1978) discusses a triple-split case in Chinese. He argues that in LMC, the consonantal system of EMC had undergone three types of changes: 1) Voiced initial obstruents became devoiced but with breathy phonation, i.e., $\text{b} \rightarrow \text{pfi}$, etc. 2) The final -h of the Departing tone was assimilated to -fi under the influence from syllable initials, i.e., $\text{pfi--h} \rightarrow \text{pfi--fi}$, etc. 3) The final

oral stops of the entering category had undergone some degree of lenition, with -p alternating with $-\overset{?}{v}$, a continuant accompanied by a glottal stop, -t with $-\overset{?}{r}$, and -k with $-\overset{?}{y}$. The ninth century Chinese tonal categories are therefore reconstructed as having the following variants:

(90) Tones of ninth century Chinese (Pulleyblank 1978)⁴⁷

Level	Rising	Departing	Entering
p_{H--}	$\left\{ \begin{array}{l} p_{H--}\overset{?}{} \\ m_{L--}\overset{?}{} \end{array} \right.$	$\left\{ \begin{array}{l} p_{H--}\overset{?}{f} \\ m_{L--}\overset{?}{f} \\ p\overset{?}{h}_{L--}\overset{?}{f} \end{array} \right.$	$p_{H--}\overset{?}{y}/k$
$\left\{ \begin{array}{l} m_{L--} \\ p\overset{?}{h}_{L--} \end{array} \right.$	$(p\overset{?}{h}--\overset{?}{} \rightarrow)$		$m_{L--}\overset{?}{y}/k$
			$p\overset{?}{h}_{L--}\overset{?}{y}/k$

In this schema, the Rising tone had only two variants, the third having merged with the Departing tone by the ninth century. This schema accounts for, Pulleyblank argues, the later double split of the Level tone, and triple split of the Entering tone. Pulleyblank (1978:194) observes:

The triple division itself is not really so extraordinary. What we have is, first, a division corresponding to that between upper and lower entering tone, as found in many modern dialects, and then a further division within lower entering tone corresponding to the difference between LMC voiced aspirate and sonorant initials which, as we have seen, had other effects on the development of the tones.

Another example of three-way register split is found in the Wu dialect of Wujiang, spoken in Jiangsu Province west of Shanghai. The Wujiang triple split was discussed by Y-R. Chao as early as in 1928, and later by J. Yuan (1960), X. Ye (1983) and F. Shi (1992). They all seem to indicate that the three registers in Wujiang result from two successive double splits. J. Yuan (1960), for example, says that Wu dialects usually have eight or seven tones. In some dialects like Shanghai, the tone systems are simplified, but in others like Wujiang, the number of tones are more than eight. 'This [the Wujiang case] is a development in another direction.' (p.59).

⁴⁷ p = any voiceless obstruent; m = any sonorant; k = any oral voiceless stop; $-\overset{?}{y}$ = either $-\overset{?}{v}$, $-\overset{?}{r}$, or $-\overset{?}{y}$; H = high pitch; L = low pitch)

The following Wujiang data is taken from X. Ye (1983). Ye identifies six slightly different local variants, which are named as Songling-Tongli, Pingwang, Lili, Luxu, Shengze and Zhenze, respectively. They have the following tonal systems:

(91) Wujiang tonal systems (Ye 1983)⁴⁸

MC categories		Modern Wujiang					
		Songling-Tongli	Pingwang	Lili	Luxu	Shengze	Zhenze
A	vl-u	55	55	55	55	55	55
	vl-a	33	33		33		33
	vd	13	24	24	13	24	13
B	vl-u	51	51	51	51	51	51
	vl-a	42	34	34	312	34	
	vd	31	23	21	212	23	31
C	vl-u	412	513	412	412	513	412
	vl-a	312	313	313	312	313	312
	vd	212	213	213	212	212	212
D	vl-u	5	5	5	5	5	5
	vl-a	3	3	3	3		3
	vd	2	2	2	2	2	2

Some of Songling-Tongli data are given below:

⁴⁸ vl-u = voiceless unaspirated initials; vl-a = voiceless aspirated initials.

MC Categories		Modern Songling-Tongli					
A	vl-u	kā ⁵⁵	'just now'	pi ⁵⁵	'border'	tir ⁵⁵	'summit'
	vl-a	k'ā ³³	'chaff'	p'ir ³³	'slang'	t'ir ³³	'sky'
	vd	fiyən ¹³	'cloud'	dʒioŋ ¹³	'poor'	z á ¹³	'time'
B	vl-u	tsiəu ⁵¹	'walk'	tsir ⁵¹	'scissors'	siəu ⁵¹	'hand'
	vl-a	ts' iəu ⁴²	'second'	ts'ir ⁴²	'shallow'	ts' E ⁴²	'color'
	vd	ñy ³¹	'daughter'	vE ³¹	'model'	z á ³¹	'similar'
C	vl-u	fā ⁴¹²	'release'	pi ⁴¹²	'change'	tsE ⁴¹²	'drunk'
	vl-a	k'ā ³¹²	'resist'	ts' ā ³¹²	'sing'	ts' E ³¹²	'vegetable'
	vd	dəu ²¹²	'large'	vE ²¹²	'meal'	nəu ²¹²	'angry'
D	vl-u	tsiəʔ ⁵	'connect'	səʔ ⁵	'say'	pəʔ ⁵	'hundred'
	vl-a	ts' iəʔ ³	'cut'	ts' əʔ ³	'rule'	p' əʔ ³	'clap'
	vd	hiəʔ ²	'medicine'	dʒioʔ ²	'office'	bəʔ ²	'white'

The Wujiang data show, among other things, i) the register induced by voiceless unaspirated consonants is systematically higher than that induced by voiceless aspirated consonants; ii) voiceless fricatives pattern with the unaspirated stops/affricates, rather than with aspirated stops/affricates; iii) sonorants pattern with voiced obstruents, rather than inducing a fourth register. Compared with Jinan (83), the Wujiang data also show that although consonant classes can pattern differently, register can only split in as many as three ways.

4.2.3. Tone split: summary and counterexamples

Two-way register split has been known for a long time. Traditionally, it is believed that register split is conditioned by the simple opposition between voiced and voiceless initial consonants. Later studies show, however, that in many languages the situation is much more complicated. Register can split not just in two ways, and the conditioning factor is not just limited to the simple

⁴⁹ [E] is the 'middle e' proposed by Chao (1928; 1931). It is a spread, front vowel, with the tongue position between cardinal [e] and [ɛ]. [á] and [à] are known as 'apical vowels', proposed by Karlgren (1915-26). [á] occurs only after dental/alveolar obstruents; [à] occurs only after retroflex obstruents. Later studies show that they are best analyzed as syllabic alveolar fricative [ʒ] and syllabic retroflex fricative [ǯ], respectively (Chao 1968; Pulleyblank 1984). For different analyses of [á] and [à], see L. M. Hartman (1944), C. Hockett (1947), P. Kratochvíl (1968) and J. M. Howie (1976).

voiced : voiceless opposition. The following is a summary of some of the issues in the current study of register split.

The first issue concerns whether register tripartition consists of one simultaneous three-way split, or two successive double splits. Recent writers tend to believe that register tripartition results from two successive double splits rather than one single triple split (Pulleyblank 1978; Xiong 1979; Hirayama 1987; Edmondson 1990a; F. Shi 1992), while earlier writers are not explicit about the diachronic significance of register tripartition. One writer (Haudricourt 1961:169), at least, seems to indicate that tripartition is simultaneous,⁵⁰ but no evidence is provided to show that this is the case.

The second issue concerns the identification of the conditioning factors of register split. Although the traditional 'voiceless high, voiced low' principle has been verified in a great number of cross-linguistic phonetic studies (Lehiste and Peterson 1961; Lehiste 1970; Mohr 1971; Ohala 1973; Hombert 1977b, 1978a; Hombert, Ohala and Ewan 1979), recent historical studies tend to attribute the real cause of pitch lowering to breathy voice rather than plain voice (Pulleyblank 1978; C. Shi 1981; Edmondson 1990a). Since both plain voice and breathy voice are known to have a pitch-lowering effect (Painter 1978), phonetic studies seem to be indecisive in this case. An even more difficult case is aspiration in relation to pitch lowering. Historical and dialectal studies tend to attribute the cause of some cases of primary and secondary split to aspiration (Haudricourt 1961; Brown 1975; Henderson 1982; Ye 1983; to mention just a few), but phonetic studies have so far failed to confirm that aspiration has a definite pitch-lowering effect (Hombert and Ladefoged 1976). Hirayama (1987:9) suggests that the transition from initial aspiration to the following vowel may produce a [h] sound, which he believes is the real cause of some cases of secondary split. Again, then, the cause of split is attributed to breathy voice.

The third issue concerns how to explain the voiceless-low and voiced-high correlation, that is, in some languages initial voiceless consonants correlate with low tone, while initial voiced consonants correlate with high tone. Such correlation is not unusual cross-linguistically (Maddieson 1978a). Brown (1975), for example, surveys six branches of the Tai language (Shan, Phuan, Northern Thai,

⁵⁰ 'Mais dans d'autres langues du même groupe, en Tong et en Mak il y a disparition simultanée des glottalisations et des aspirations des sonantes. Alors que la confusion de deux sortes de phonème produit une bipartition, la confusion de trois sortes de phonèmes produit une tripartition du système tonal.'

Central Thai, Lao, and Phu Thai), and finds that 75% of the dialects are voiced-high. In the literature, several types of explanation of this phenomenon have been offered. Brown explains the existence of both voiced-low (V-L) and voiced-high (V-H) languages by the different strategies listeners use to process linguistic signals. He argues that the pitch in syllables with voiced initial consonants is lower at the beginning but higher throughout the rest of the syllable, while the syllables with voiceless initial consonants is higher at the beginning but lower in the remaining part. If the listener concentrates on the initial portion of the syllable, the voiced initials in his own speech will correlate with low register; if he concentrates on the median portion of the syllable, the voiced initials will correlate with high register. Aided by other factors such as fashion and prestige, the whole linguistic community will either develop a V-L language or a V-H language. He further suggests that there have been two great tone splits in Tai, V-H and V-L, with V-H split antedating V-L split by 400 years. A second explanation of the V-H phenomenon is tonal flip-flop, which assumes that all register-splits start as V-L, and the V-H correlation is caused by a later development whereby high tones become low and low tones become high. Those who endorse this explanation include W. Wang (1967; 1969), Matisoff (1973), Hashimoto (1972), and Yue-Hashimoto (1986). A third explanation assumes that consonants had changed before register split. Hombert, *et al.* (1979), for example, suggests that if the initial [b] had changed to an implosive [ɓ] before the time of register split, then V-H development would be expected. A fourth explanation invokes the reverse argument, that is, 'voiceless-low' and 'voiced-high' are regarded as resulting from the effects of tone on consonants. Maddieson (1978a) shows that tonal effects on consonants is not just limited to syllable-initial voicing contrast; changes in syllable-final voicing contrast, places or manner of articulation, as well as the insertion of consonantal segments, may all be attributable to tonal effects. A fifth explanation is by positing more consonant types for the phonological systems before register split. Norman (1973, 1974), for example, posits a series of voiceless sonorants for Proto-Min to account for the fact that in modern Min dialects some words with sonorant initials in MC are pronounced with upper register tones.

In spite of the different views concerning the above issues, tripartition as a current state-of-affairs has been confirmed in a number of tonal systems. Note that as the examples in § 4.2.2 show, secondary split occurs only in one of the registers produced by the primary split. Thus, in the

Nanchang case (85), while the lower register further splits into two, no further split occurs in the upper register. Miao (86, 87), Kam (88) and Songling-Tongli (92) show the opposite: once the upper register splits, the lower register remains unified. In short, no four-way split occurs.

One apparent counterexample is the split of the checked tones in a number of languages in China and Southeast Asia. A single earlier checked tone may split in six possible ways in two steps, the first conditioned by the voicing features of the initials, the second by vowel length. In the Cantonese dialects spoken in Hengxian (Bi 1982), Yulin and Bobai (Yang, *et al.* 1985) of Guangxi Province of China, the earlier checked tone has split in four ways, labeled in (93) as DIa, DIb, DIIa, and DIIb, respectively. The upper ru tones (DIa and DIIa) co-occur with short vowels while the lower ru tones with long vowels:

(93) Vowel-length-induced tone split in Hengxian, Yulin and Bobai

	DIa	DIb	DIIa	DIIb
Hengxian	44	33	11	21
Yulin	5	33	12	11
Bobai	5	33	23	21

(94) Hengxian data (Bi 1982:21)

DIa		DIb		DIIa		DIIb	
kəp ⁴⁴	‘urgent’	ka:p ³³	‘first’	tɕuk ¹¹	‘yesterday’	tɕɔ:k ²¹	‘muddy’
tɕət ⁴⁴	‘quality’	tɕa:t ³³	‘prick’	tɕik ¹¹	‘straight’	tɕe:k ²¹	‘touch’
hək ⁴⁴	‘black’	ha:k ³³	‘guest’	muk ¹¹	‘eye’	mɔ:k ²¹	‘no’
kik ⁴⁴	‘attack’	ke:k ³³	‘foot’	ləp ¹¹	‘stand’	la:p ²¹	‘bacon’
kuk ⁴⁴	‘valley’	kɔ:k ³³	‘country’	fət ¹¹	‘Buddha’	fa:t ²¹	‘punish’

Compared with consonant-induced tone split, vowel-duration-induced tone split is less well studied. Hirayama (1987:19) offers a tentative explanation: Suppose there is a checked tone with two allotones, [55], which co-occurs with long vowels, and [5], which co-occurs with short vowels. Since they have similar pitch values, they constitute one tone. But due to its length, the [55] allotone is more susceptible to downdrift than the [5] allotone. Thus, [55] may change to [53] while [5] remains unchanged. In this way, a single earlier tone splits into two tones due to differences in length.

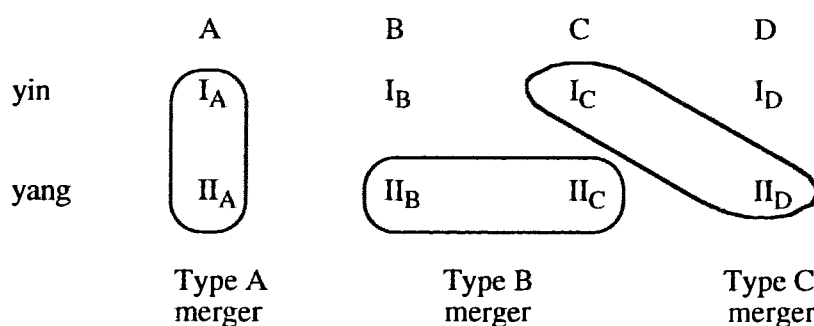
4.3. Tone merger

Tone merger has received much less attention in the literature than tone split, probably due to the fact that although there are disagreements on the exact conditions of register split, the patterns of split are clear and obvious (§ 4.2.3). In contrast, both the conditions and the patterns of tone merger are much more difficult to pinpoint. It has been pointed out by many scholars that tonal systems have a life of their own; once established, they develop without regard to their etymological values (Haudricourt 1961; Hombert 1978b), and there seem to be no guide-lines for development after tone split, with different dialects changing in different directions (Henderson 1982). But in spite of the difficulties, several patterns of tone merger have begun to be formulated.

4.3.1. Patterns of merger

Pan (1982) identifies three types of tone merger. Type A occurs between the upper and lower varieties within a tonal category, which Lien (1986) calls vertical merger. Type B occurs across tone categories but is confined within the upper or lower ranges, which Lien (1986) calls horizontal merger. Type C occurs across both tone categories and sub-pitch-ranges. These three types of merger are illustrated in the following diagram.

(96) Types of tone merger (Pan 1982)



Pan observes that type A and C do not occur in languages where voicing distinction in initial obstruents is still preserved, and that type B does not occur in languages where obstruent endings are still preserved. Type C is a combination of A and B, presumably subject to both restrictions. Type B can be illustrated by Shanghai, Suzhou and Yongkang, and type C by Danyang, all given in (97). In

Danyang, the voicing contrast in initial obstruents is lost, making type C merger possible. In Yongkang, obstruent endings are lost, making type B merger possible.

(97) Tone merger in Wu dialects⁵¹

i) Shanghai (Pan 1982)

	A	B	C	D
yin	41	<u>3^b2^b2</u>	<u>2^b2^b3</u>	4#
yang	<u>1^b3^b</u>	<u>1^b3^b</u>	<u>1^b3^b</u>	<u>23</u>

ii) Suzhou (Yuan 1960)

	A	B	C	D
yin	44	41	513	4
yang	24	<u>331</u>	<u>331</u>	<u>23</u>

iii) Danyang (Lü 1980)

	A	B	C	D
yin	33	55	<u>24</u>	3
yang	<u>24</u>	<u>24</u>	11	4

iv) Yongkang (Yuan 1960)

	A	B	C	D
yin	44	<u>35</u>	<u>52</u>	
yang	22	<u>13</u>	<u>24</u>	

A true type A merger must be carefully distinguished from lack of split. An example to be discussed is given by Haudricourt (1961). Haudricourt observes that it is rare for tonal systems with register tripartition to retain all its tonal contrasts; tone merger is expected. Thus in Man-Yao, spoken in northern Vietnam, mergers have occurred both within a single tone category and across different categories, as shown in (98). These mergers are clearly demonstrated in a comparison with other two

⁵¹ The tones are transcribed in the numbered musical notation, from which the tone letter system developed. The musical notation is used in Chao (1928).

related languages, Western Miao, spoken in the border area between Sichuan, Guizhou and Yunnan Provinces of China, and Central Miao, spoken in eastern Guizhou Province, as in (99).

(98) Merger in Man-Yao (Haudricourt 1961)

	A	B	C
ʔm > m, ʔn > n, ʔr > gy, p, t, k	413	13	35
hm > m, hn > n, hn > n, hl > l	413	21	31
m, n, n, l, r > gy, b > p, d > t, g > k	33	31	21

(99) Comparison of Man-Yao with W. Miao and C. Miao (Haudricourt 1961)

Category A	W. Miao	C. Miao	Man-Yao	
	nañ ⁴³	nañ ³³	nañ ⁴¹³	'serpent'
	kañ ⁴³	kañ ³³	keñ ⁴¹³	'ver'
	hno ⁴³	hnai ³³	noy ⁴¹³	'jour, soleil'
	pañ ³²	pañ ⁵⁵	pien ³³	'fleur'
	mua ³²	mai ⁵⁵	naay ³³	'avoir'
	tua ³²	ta ⁵⁵	taay ³³	'venir'
Category B				
	tle ⁵⁴	tla ³⁵	klo ⁱ³	'chien'
	tlañ ⁵⁴	tlañ ³⁵	klañ ¹³	'milan'
	tu ⁵⁴	tai ³⁵	tuoy ¹³	'queue'
	nč hañ ⁵⁴	ś hañ ³⁵	sam ²¹	'sang'
	hnao ⁵⁴	hnañ ³⁵	nom ²¹	'entendre'
	təu ²¹	tu ¹¹	təw ³¹	'feu'
	re ²¹	Ri ¹¹	gyaw ³¹	'nid'
	nje ²¹	nai ¹¹	byaw ³¹	'poisson'
Category C				
	ua ⁴⁴	ai ⁴⁴	aay ³⁵	'faire'
	tua ⁴⁴	...	tay ³⁵	'tuer'
	hli ⁴⁴	hla ⁴⁴	la ³¹	'lune'
	...	hñyu ⁴⁴	ñyañ ³¹	'année'
	hnao ⁴⁴	...	naañ ³¹	'riz cuit'
	mua ¹³	mai ¹³	mey ²¹	'œil'
	tua ¹³	tai ¹³	tay ²¹	'mourir'

Haudricourt, however, does not give enough evidence to show the [413] tone in Category A of Man-Yao (98) is a result of merger, but not lack of split. Since we do not have evidence to prove either way, we will put this particular example aside,⁵² but accept Haudricourt's observation that the more tones split, the more likely merger would happen, especially mergers of type B and C. This is probably due to the fact that as a result of tone split, the distance between tones within a single system will be reduced, so that similar tone shapes will be produced. This renders the tone system vulnerable, leading eventually to the collapse of the originally distinct tones. In Chapter Five, phonetic evidence will be provided to support this observation.

The types of merger listed in (96) are all total mergers, where both the height and contour of two or more previous tones have become the same. Since two distinct aspects of tone (height and contour) can be identified, it is expected that in many cases tone merger involves only one aspect. Such cases can be called partial merger. Partial mergers have not been given much attention in the literature, probably due to the fact that register overlapping has not been incorporated in previous theoretical frameworks. In the remainder of this section, I discuss two types of partial merger.

The first type is exemplified by the Yongkang system, given in (97), repeated here in (100). In Yongkang, the two A tones are parallel, with no overlapping. The same is true of the two B tones, both being rising, with no overlapping between them. The parallel pattern is the C tones, one being rising, another falling. Assuming that before tone split, the three tones A, B, and C were level, rising, and falling, respectively (see fn. 26), tone CII must have resulted from a further development, i.e., in addition to register shift, tone contour is also changed. Although the intermediate stages of the CII development cannot be reconstructed, the result of the development is clear: CII now shares the same contour with the two B tones, and partially overlaps with both of them. Since CII and the two B tones came from two historically older categories, the overlapping is undoubted due to tone merger.

⁵² For a clear example of type A merger, see (107v).

(«Yongkang») The Yongkang system

	A	B	C
I	44	35	52
II	22	13	24

The second type of partial merger is exemplified by Taiping, spoken in Anhui Province of China. («Taiping») shows the tonal system of Taiping:

(«Taiping») Taiping (S. Zhang 1983)

	A	B	C
I	32	45	33
II	13	11	24

We now focus on the A tones of Taiping. In Taiping there is a sandhi process whereby tone AI [32] shifts upwards, becoming [34]. This happens whenever the upper A tone occurs in a non-phrase-final position. For example:

(102) Tone sandhi in Taiping⁵³

fɔ ^{32→34}	xo ⁴	tiɛ ³³	‘second-hand store’
sɛ ²⁴	sá ^{32→34}	ki ³¹	‘to whisper’
p‘i ^{32→34}	foŋ ⁴		‘cloak’
ioŋ ²⁴	ɕiŋ ^{32→34}	sá ³¹	‘to worry about’

Previous studies have shown that historically older forms of tone are often preserved in sandhi forms.⁵⁴ If this is true in Taiping, then the sandhi form of AI must represent the older form, i.e., the A tones must have developed from a stage when the two tones shared the same contour (both being rising), but differ in terms of tone height, to the present stage when tone height distinction is given up in favor of distinction in contour (one rising, one falling). This order of development has been observed in a number of studies, including, for example, Pan (1982).

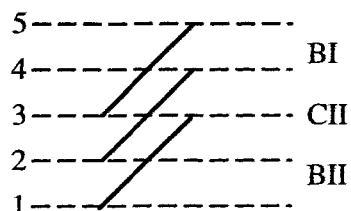
⁵³ The single-digit tones are neutral tones. All the six citation tones can be neutralized, the values of which depends on the values of the immediately preceding tone.

⁵⁴ See W. Pan (1982); P. Ting (1982, 1984). Court (1985) also advances the thesis that sandhi forms foreshadows the future changes in citation forms.

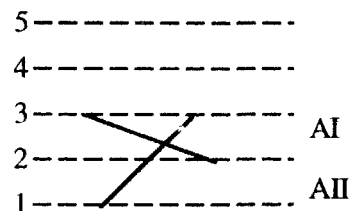
The Taiping case differs from the Yongkang case in that in Yongkang the partially merged tones share the same contour, differing only in height, while in Taiping the two tones partially merged in terms of height, but differ in terms of contour. The two types of partial merger are illustrated in (103):

(103) Types of partial merger

i) Yongkang



ii) Taiping



4.3.2. Register Overlapping

The Yongkang and Taiping examples show unambiguously register overlapping due to tone merger. But as seen earlier, in many cases it is unclear whether overlapping is due to merger or split. This is true not only in cases of total merger, but also in cases of partial merger. Take for example, the three Wu dialects, Kaihua, Shangrao, and Guangfeng, spoken in Zhejiang and Jiangxi Provinces of China. They are closely related, Wu in Jiangxi being extensions of Wu from Zhejiang (Yan, *et al.* 1984). The three dialects have the following tonal systems:

(104) The tonal systems of three Wu dialects (Fang, *et al.* 1984)

i) Kaihua

	A	B	C	D
yin	44	53	434	5
yang	42	13	13	2

ii) Shangrao

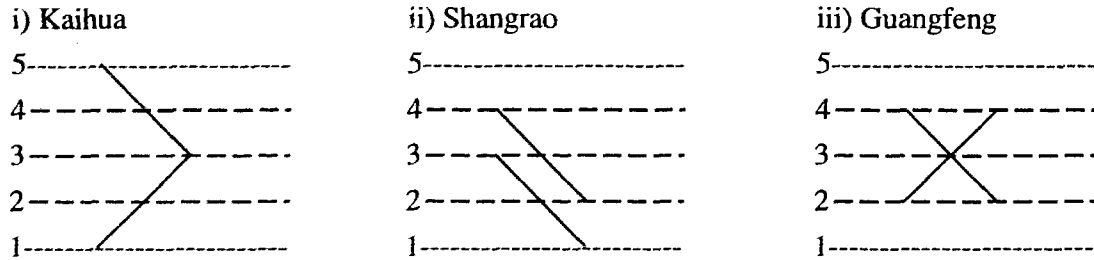
yin	55	42	523	5
yang	312	31	212	3

iii) Guangfeng

yin	55	42	423	5
yang	31	24	212	3

Let us now focus on the B tones of these three dialects. In Kaihua, the two B tones have different contours and heights, so that no merger occurs. In Shangrao, the two B tones have the same contour, and the two registers partially overlap with each other. In Guangfeng, the two registers completely overlap, but the contours of the two tones are different. Schematically, the patterns of tone B are illustrated in (105):

(105) The B tones of three Wu dialects



The evidence available to me is not enough to determine whether the present tone pattern in Shangrao is directly due to tone split, or directly due to tone merger. If the former is true, then the simplest scenario is the assumption that before tone split the tone value was [42], and that the split yielded a parallel tone [31]. If the latter is true, then the simplest scenario is the assumption that after the initial split, the [42] tone shifted upwards to become [53]. At this intermediate stage, there was no overlapping between the two tones, one being [13], the other [53]. In the next stage, i.e. the present stage, [53] tone shifted downwards to [42] again. (106) shows the different stages involved in the two scenarios:

(106) Shangrao tone overlapping: two scenarios

i) [42] > [42], [31]

ii) [42] > [42], [31] > [53], [31] > [42], [31]

There might be other intermediate stages involved in either of these two scenarios, but the details cannot be reconstructed without further evidence. But no matter which scenario we assume, it is clear that tone split is the prerequisite for tone merger, and that register overlapping can be produced by tone split as well as tone merger.

In Kaihua and Guangfeng, the development of the B tones involves not only register shifts but also contour reversal. Guangfeng is similar to Taiping (101) in that once the two B tones are

distinguished by contour, the register distinction is no longer needed. Kaihua represents a different development: the two B tones are distinguished by both contour and tone height. If we assume that the pre-split B tone in Kaihua was also [42] as in Shangrao, then the present-day Kaihua B tones [53] and [13] must have resulted from register shift both upwards and downwards. It is important to notice that this two-way register shift did not produce three registers, no matter whether the two shifts were simultaneous or sequential.

While systems with two registers may or may not involve register overlapping, in systems with three registers, overlapping seems inevitable, so long as there exist contour tones in the system. In (107) are listed nine Miao dialect locations reported in Y. Li, *et al.* (1959), which has been discussed in (86) and (87). Here we limit our discussion to tone C only. In Shuiwei (107i), tone C did not split. In Baijin, Tuanpo (107ii), and Xianjin, Kaitang (107iii), tone C split into two tones; the upper tone is labeled as CI; the lower tone as CII. In Zongdi, Xiguan (107iv), and Pingyan, Xiaomiaozhai (107v), the upper tone further split into two tones, labeled as CIa and CIb, respectively. According to Li, *et al.* (p.67), the further split in the upper tone in all these four locations is conditioned by the aspirated : unaspirated contrast.

(107) The C tones of nine Miao dialect locations (Y. Li, *et al* 1959)

i) Shuiwei

C	35
---	----

ii) Baijin

CI	44
----	----

CII	33
-----	----

iii) Xianjin

CI	44
----	----

CII	13
-----	----

iv) Zongdi

CIa	45
-----	----

CIb	24
-----	----

CII	13
-----	----

v) Pingyan

CIa	53
-----	----

CIb	31
-----	----

CII	31
-----	----

Tuanpo

CI	33
----	----

CII	21
-----	----

Yangsong

CI	44
----	----

CII	13
-----	----

Xiguan

CIa	44
-----	----

CIb	24
-----	----

CII	13
-----	----

In (107) the nine dialect locations are arranged in five groups, which seem to represent different stages of tonal development. In stage i), there is no split. In stage ii), the tone splits into two varieties, but the distance between the two is very close. In stage iii), the distance is enlarged. In stage iv), the upper tone further splits into two tones; but instead of moving further up, the upper tone splits downwards, so that the lower variety of the upper tone occupies the mid range. In stage v), C1b moves further downwards; since it has the same contour as CII, the result is a type-A total merger.

4.3.3. Tone merger: summary and implications

In this section we follow W. Pan (1982) in identifying three types of total merger (96). Type B and C are straight-forward. Since they involve tones of two or more previously distinct categories, no confusion with lack of split can arise. Type A, however, is more difficult. Without enough evidence, type A merger is indistinguishable from lack of split (98, 99). A clear example of type A merger is given in (107v), where as type B and C, the merger also involves two previously distinct categories. In addition to the three types of total merger, I further identify two types of partial merger, as illustrated in (103).

Partial merger of the type (103i) clearly demonstrates register overlapping, but merger is not the only way whereby register overlapping can result. Contrary to the traditional belief that register split always results in two non-overlapping registers, a belief which has been reflected in many feature systems of tone where register overlapping is prohibited (see Chapter Six), it is argued in § 4.3.3 that register split frequently, if not always, produces overlapping registers. Non-overlapping registers can be seen as a result of a further development. This is line with the fact that non-overlapping registers are comparatively rare. Opponents of this conclusion may argue that register split always produces non-overlapping registers, while overlapping registers are results of tone merger. This argument, however, overlooks the fact that tone merger is the mirror image of tone split. If register overlapping is possible in tone merger, it is also possible in tone split.

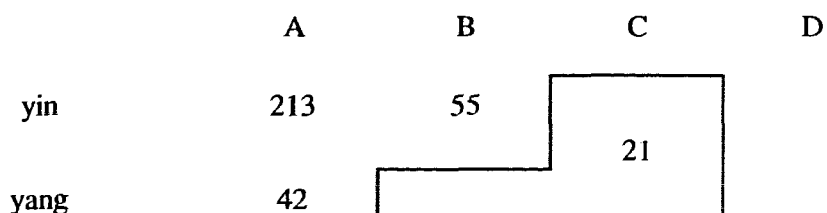
Acceptance of register overlapping is the key to understand why there are languages with three registers, but there is no language that distinguishes nine tone heights. As shown in (107), the

addition of a third register to a two-register system does not result in a further expansion of the whole tone-space; instead, the third register turns inwards, so to speak, and overlaps with the first two. (107) also shows evidence that before the addition of the third register, the first two registers tend to move away from each other, so as to leave room for an additional register.

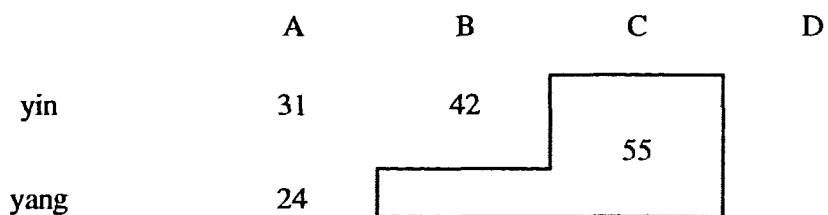
Register shifts, either upwards or downwards, may or may not lead to the addition of another register. Thus in Kaihua category B (105i), the two tones have moved away from each other as can be seen from a comparison with the corresponding tones in Shangrao (105ii) and Guangfeng (105iii), but no extra tone has been added to this category. This process is mirrored in Pingyan (107v), where the middle tone has moved downwards and merged with the lower tone, but without causing split in the original middle tone. As a further example, compare the C tone in Jinan and Xi'an (108).

(108) The development of MC C tone in two Mandarin dialects

i) Jinan (Qian, *et al.* 1985)



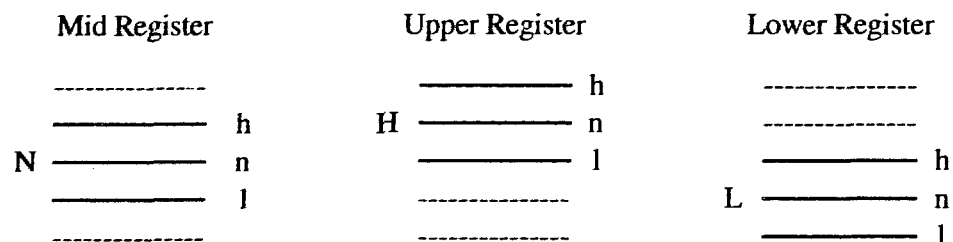
ii) Xi'an (Yuan 1960)



Whatever the original value of this tone might have been, it is clear that this tone has moved in opposite directions in these two dialects, but in neither the tone has split. In all these examples, register shift is not (directly) caused by a contrast in syllable initials, but may be due to the balance of the distribution of all tones within each system, or due to sociolinguistic factors. To sum up then, register split must result in register shift, but register shift may not result in register split.

The discussion in this section further demonstrates that the tone feature system proposed in Chapter Three is essentially correct. More exactly, the discussion strongly supports one particular aspect of the feature system, i.e., register overlapping, as shown below (also in (65) and (95)):

(109) Register overlapping represented by the new feature system



Incidentally, the discussion leads to another conclusion, that is, as a universal model a feature system needs to distinguish five contrastive levels, whether or not there exist languages with five level tones. This subject will be discussed again in the next chapter.

Chapter Five

Phonetic and Typological Evidence

This chapter discusses phonetic and typological evidence for the new feature system proposed in Chapter Three. The topics to be discussed are i) pitch in relation to syllable-final -h and -ʔ; ii) register tripartition; iii) the expansion, compression, and limit of tone space; iv) the mid tone; v) the number of tone heights; and vi) cover features for voice and tone. Some of these topics have been discussed in Chapter Four, but there they are treated from a different perspective. The purposes of the present chapter are the following. First, by verifying from the phonetic perspective some of the claims made on the historical ground, such as tonogenesis and register tripartition, it is hoped that this chapter will further strengthen those aspects of the new feature system which capture these historical observations. Second, this chapter goes beyond Chapter Four by providing further evidence for the new feature system, such as tone space and the number of tone heights. Third, through the discussion of the conditioning factors of register split, this chapter explains why the new feature system proposed in Chapter Three does not adopt a set of cover features for both voice and tones, along the lines of the features [stiff] and [slack] proposed by Halle and Stevens (1971).

5.1. Syllable final -h and -ʔ

It has been shown in Chapter Four that tonogenesis in a number of languages is attributable to syllable-final -h and -ʔ. This pattern of tonogenesis is suggested by Haudricourt (1954a), who explains the pitch-changing effect of -ʔ and -h in terms of their effects on the tenseness of the vocal folds:

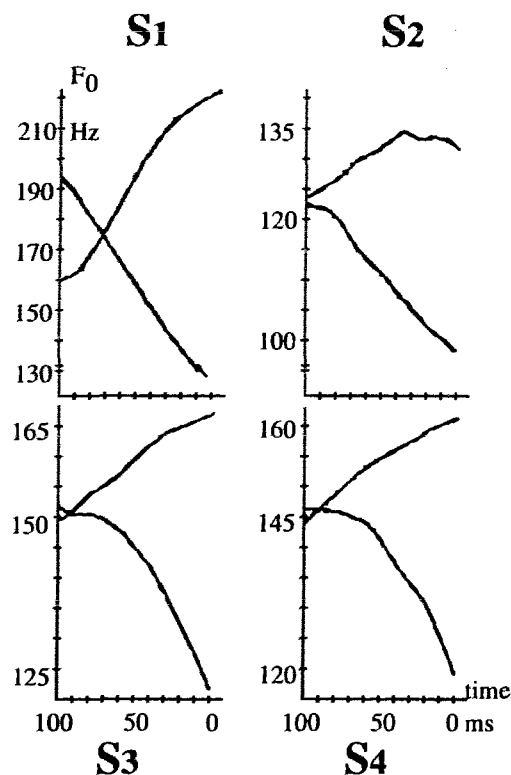
la spirante finale est devenue un *h* laryngal produit par un relâchement brusque du larynx. Le relâchement des cordes vocales produit une baisse de la hauteur musicale de la voyelle qui précède, c'est-à-dire un tone descendant; ce ton descendant qui n'est d'abord que la conséquence phonétique du *h* final, devient un ton phonologiquement pertinent, caractéristique du mot, lorsque le *h* final disparaît au cours de l'évolution (p.80).

Or une occlusion du larynx suivant une voyelle est produite par une augmentation de la tension des cordes vocales... Pendant la durée de la voyelle, l'augmentation de tension des

cordes vocales préparant l'occlusion finale produit un ton montant; ce ton, conséquence phonétique de l'occlusion glottale, devient un véritable ton phonologiquement pertinent servant à distinguer le mot lorsque l'occlusion glottale disparaît (p.81).

Haudricourt's impressionistic observations have been verified in phonetic experiments. Ohala (1970) suggests that it is perhaps the inhibition of the lateral cricoarytenoid muscle during the production of [h] that decreases the vocal fold tension and lowers the F_0 . Hombert, Ohala, and Ewan (1979) report an experiment on the pitch curves on vowels immediately preceding [ʔ] and [h] in the speech of four Arabic speakers. The experiment shows that [ʔ] induces a rising pitch, and [h] induces a falling pitch. The rising curve varies from 9 to 48 Hz; the falling curve varies from 25 to 50 Hz. The two curves become significantly different at least 70 msec before vowel offset. The authors also report a perceptual experiment which shows that synthesized F_0 perturbations simulating the effects of [ʔ] and [h] can be perceived even when the perturbations are much smaller ($\Delta F = \pm 10$ Hz and $\Delta t = 40$ Hz). (110) shows the averaged F_0 curves on vowels immediately preceding [ʔ] and [h] produced by the four Arabic speakers.

(110) F_0 curves on vowels preceding [ʔ] and [h] (Hombert, Ohala, and Ewan 1979)



In terms of the new feature system proposed in Chapter Three, the importance of (110) lies not so much in the fact that it verifies the genesis of two contour tones from syllable-final glottal consonants, but that it verifies the genesis of three tone levels. By matching to these three levels, the mid register of the new feature system thus captures this pattern of tonogenesis.

The verification of three-level tonogenesis from syllable finals also points to one of the inadequacies of most previous tone models. As will be shown in Chapter Six, these models usually distinguish only two levels within a single register, which is not enough to capture the pattern of tonogenesis discussed above.

5.2. Register tripartition

Since register bipartition is well known, it need not to be considered. In this section, we discuss two case studies of register tripartition. The first is the Wu dialect of Lili spoken in East China; the other is the Kam language spoken in South China. The phonological descriptions of both these languages have been given in Chapter Four in (91) and (88).

5.2.1. *Lili*

F. Shi (1992) reports a phonetic study on the tones of Lili, the values of which are given in (111). According to Shi, the tone system of Lili is the result of two successive events: the first is the split between the odd- and even-numbered tones, which is known as the Great Tone Split; the second is between the prime and the non-prime (odd) tones. Shi believes that the second split is due to aspiration, which is in line with the most common explanation of secondary tone split. But as we will see in § 5.6, there is another explanation.

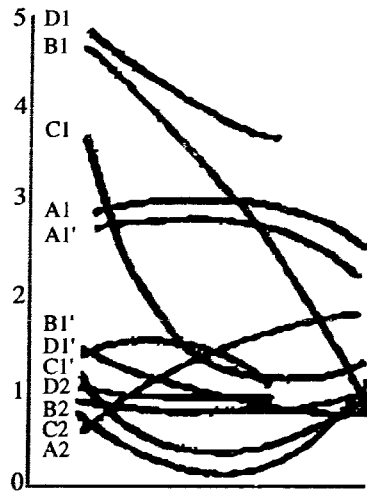
(111) Lili tones (F. Shi 1992:193)

	A	B	C	D
1	33	51	42	5
1'	33	22	212	2
2	13	11	12	1

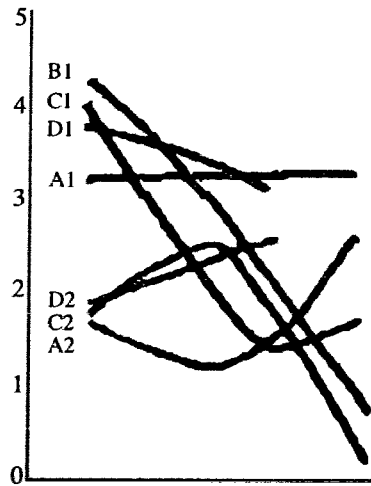
As shown in (111), each of the MC tone categories B, C, and D has split in three-ways, while category A has split only in two. This description of register split by Shi is in agreement with the description by X. Ye (1983; see (91)), but the transcriptional values of some of the tones given in these two studies are different. This is because while Ye's transcription is based on auditory impressions, Shi's transcription is based on F_0 plots.

(112) The distribution of Lili and Suzhou tones in the tone space (F. Shi 1992)

(i) Lili



(ii) Suzhou



(112) shows the F_0 plots of Lili and Suzhou tones. Suzhou is another Wu dialect closely related to Lili. The biggest difference between the two tone systems, as can be seen from the above figure, is that register tripartition has occurred in Lili but not in Suzhou. Shi reports that tripartition is still under way in dialects located between Lili and Suzhou, and that tripartition tends to be more pervasive (i.e., across all tonal categories) in dialects closer to Lili than to Suzhou. Thus, these dialects constitute a chain with varying degrees of tripartition, with Lili and Suzhou representing the two ends of this chain. Lili and Suzhou can therefore be regarded as representing two stages in the historical development of a single tonal system.

The tone patterns in (112i) illustrate many tonal behaviors discussed in Chapter Four. First of all, it clearly demonstrates the existence of three registers. The non-prime odd tones all start in the higher pitch range, the prime tones all start in the mid range, while the even tones all start in the lower range. Secondly, since the contours marked as A1 and A1' have similar shapes and heights, they do not constitute separate tones. This illustrates the lack of tone split in this category. Thirdly, the values of the non-prime odd tones of Lili are very close to the corresponding tones of Suzhou, but the even-numbered tones of Lili are much lower. This shows that the whole lower register of Lili has moved downwards to make room for the prime tones. This kind of movement has been called register shift in Chapter Four. Fourthly, although the shapes of the non-prime odd tones of the two dialects are

very similar, the shapes of the even-numbered tones are quite different. An obvious explanation is that while the even-numbered tones moved downwards, the shapes of these tones were also altered. This shows the impact on the even-numbered tones induced by the split of the odd tones. Lastly, tone C1' and tone C2 are very close. Since historically C1' was closer to C1 than C2, the present distance between C1' and C2 shows the tendency that they are about to merge. This type of merger has been called vertical merger in Chapter Four.

5.2.2. *Kam*

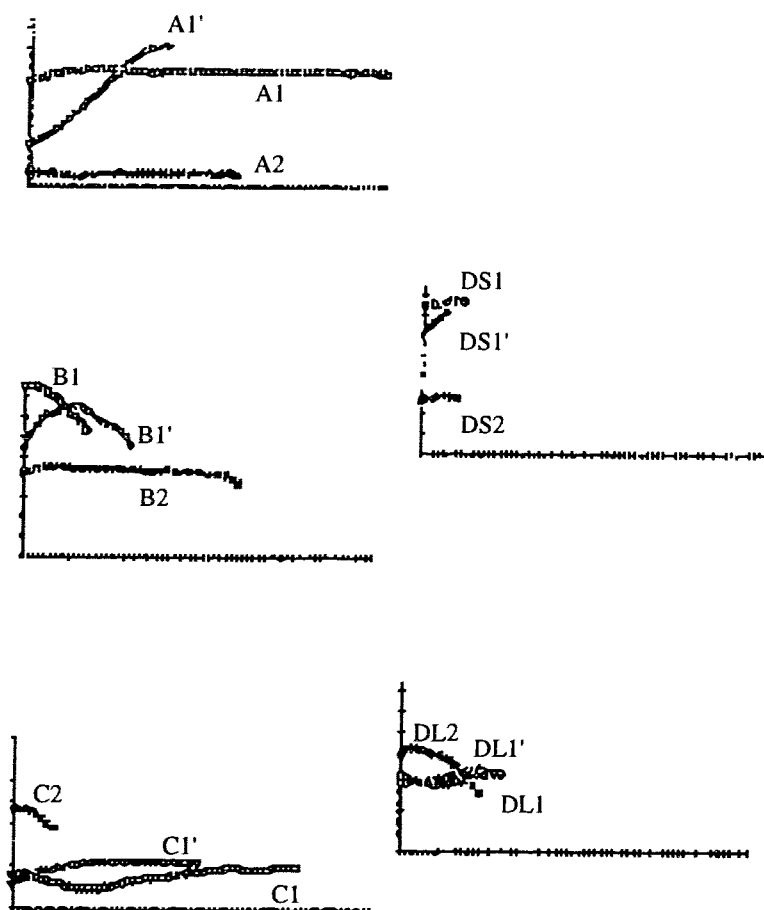
Edmondson (1992) reports a phonetic study on Kam. Kam has become famous after Haudricourt's study (1961), where, however, only the unchecked tones were discussed (see (88)). Edmondson (1992) produces the time course of all Kam tones, including both the checked and unchecked tones. The values of these tones are given in (89):

(113) Kam tones

	A	B	C	DS	DL
1	55	53	323	55	24
1'	35	453	13	35	13
2	11	33	31	21	31

In Kam, tone D (checked) have split in six ways, conditioned by syllable initials and vowel length (S = short; L = long). The time course of these tones are given in (114), where the vertical lines represent frequency in semitones, and the horizontal lines represent time in centiseconds. Dark plots signify tones following the originally voiced consonants.

(114) Kam tone plots (Edmondson 1992)



As far as the tone plots in (114) are concerned, Edmondson (1992:91) concludes 'it is easy to ascertain that a tonal tripartition has, indeed, taken place.' In addition, tonal reversal has occurred to tone C and tone DL, such that the tones corresponding to the originally voiced initials are now higher than the tones corresponding to the originally voiceless initials. Such reversals are not seen in the Lili example (112).

5.2.3. *Tripartition: summary*

Although register tripartition has been known for some time (Chao 1928; Haudricourt 1961), instrumental study of this phenomenon has just begun. The significance of the above two studies lies in the fact that they verify the existence of three registers within single tonal systems, and hence

highlight the need for the recognition of three registers in the phonological representation. They also verify many tonal behaviors discussed in Chapter Four, such as register shift and tone merger. All these provide solid evidence for the feature system proposed in Chapter Three.

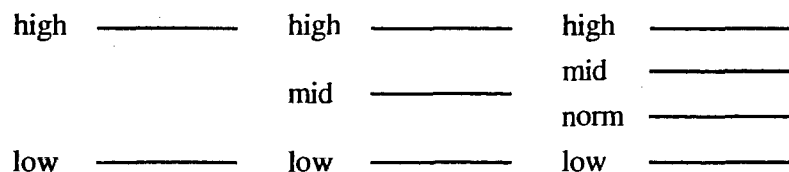
5.3. *Tone space*

All feature systems of tone depend on the notion of tone space, either explicitly or implicitly. Whether a system identifies three, four, or five tone heights, it is the tone space that is equally divided into these numbers.⁵⁵ The notion of tone space, therefore, plays an important role in the theory of tone features. In this section, two issues will be discussed. The first is the number of tone heights in relation to the width of tone space. The second is the limit to the width of tone space.

5.3.1. *Tone space in relation to the number of tone heights*

There are two opposing hypotheses in the literature regarding the relationship between the overall tone space and the number of tone levels in a system. The older hypothesis holds that a language with two levels tends to have a wider space between the two than the space between each of the levels in a four-level system. In other words, with the increase of the number of tone heights, the overall tone space tends to stay the same with the space between each level compacted. This can be called the 'tone-height compression' view. Pike (1948), for example, holds this view. He illustrates the relationship between the overall tone space and the number of tone heights with the following figure:

(115) Tone-height compression (Pike 1948:6):



⁵⁵ The division of tone space we are talking about here is the phonological division. In this sense, it is an equal division. In physical terms, adjacent tones in a single system with three or more tones may not be equidistant from each other. In this respect, tone space is compatible with vowel space.

A more recent hypothesis holds that the overall tone space is smaller in a system with a smaller number of tone heights than a system with a larger number of tone heights. In other words, tone space tends to expand with the increase of the number of tone heights. This view can be called the 'tone-space expansion' view. Maddieson (1978b) illustrates this view with the measurement of the tone space in six tone languages as shown below:

(116) Tone space as a function of the number of tone heights (Maddieson 1978b:339)

TWO LEVELS		THREE LEVELS					FOUR LEVELS
SISWATI	KIOWA	YORUBA I	THAI I	THAI II	TAIWANESE	YORUBA II	TOURA
							+50
		+26	+28	+32	+32	+52	+30
+18	+22	+16	+16	+16	+18	+27	+10
+0	+0	+0	+0	+0	+0	+0	+0

(116) shows the difference in Hz between each tone and the lowest tone in each system. This difference demonstrates that tone space tends to expand as the number of tone heights increases. From this, Maddieson concludes that 'A larger number of tone levels occupy a larger pitch range than a smaller number.'

Maddieson's conclusion is supported by Painter (1978). Painter compares the F_0 plots for Sindhi, a non-tone language, with the F_0 plots for two tone languages, Yoruba and Gã, and finds that the Sindhi plots show a small variation about the mean (± 5 Hz), while the Yoruba and Gã plots show considerably more variation (20-30 Hz).

Maddieson's conclusion is partly supported and partly refuted by Hombert's study (1978b). Hombert develops a model in which the notion of minimum articulatory difficulty and maximum perceptual distance is used quantitatively to predict the phonetically optimal tone systems from

universal phonetic considerations.⁵⁶ Based on this model, a perceptual experiment is carried out to determine the perceptual distance between the two closest tones as a function of the number of tones in a system. The number of tones ranges from two to eight. The following two findings are of particular interest to our discussion here (p.140). i) the distance between high and low is smaller in a two-tone system than in a system with a greater number of tones, suggesting tone-space expansion. ii) Tone space does not expand with the same rate as the number of tones increases from three to four, or from four to five. Rather, as the number of tones increases, the perceptual distance between tones tends to decrease, suggesting tone-height compression. Hombert observes (p.139):

The fact that the minimum distance is much larger in the case of two tone systems than for other systems suggests that we were wrong in assuming that when a system has two level tones, these two tones are 11 and 55. These data seem to indicate that these two tones should be closer to each other.

He then concludes that 'the spacing between the top and the bottom of the fundamental frequency range is smaller for two tone systems than for systems with greater number of tones' (p.139).⁵⁷

The result of Hombert's experiment thus suggests that both tone-space expansion and tone-height compression are at work when the number of tones increases in a system. This result is in line with historical evidence which shows that languages with a large number of tones are unstable and that merger between tones is likely to occur (Haudricourt 1961). In a system of tone features, then, both expansion and compression should be incorporated.

Hombert points out (p.140) that his study does not support Maddieson's claim that the same increase in tone space is found between three and four or four and five tone heights. Hombert's findings, nonetheless, may not constitute a strong partial refutation of Maddieson's claim, since Hombert uses not only level tones but also contour tones in his study. He observes that 90% of two tone systems are constituted by high and low tones. 65% of three tone systems are constituted by

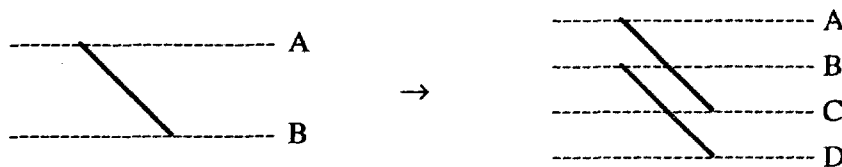
⁵⁶ 'A system was considered perceptually optimum for a given set of input parameters (i.e. number of tones and set of weighting factors) when it was found to have the greatest DMIN [minimal distance] after all possible tone systems with N tones were compared. In other words, the chosen perceptual criteria was to keep the two closest tones of a given system maximally apart.' (Hombert 1978:135).

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high, mid, and low tones, while 20% by high, low, and falling tones. The two most common types of four tone systems are constituted by high, low, falling, and rising tones (40%), and by high, mid, low and falling tones (30%). High, mid, low, falling, and rising tones constitute the most common five tone systems (60%). For six tone systems, two level tones, two rising tones, and two falling tones constitute the most common type (60%). For seven and eight tone systems, no clear patterns are found. The inclusion of contour tones in Hombert's study makes it unclear how many tone heights can be identified for systems with higher number of tones. Systems with three or four tones may distinguish only two heights, while systems with eight tones may distinguish only three heights. Thus, the fact that the minimum perceptual distance is much smaller in cases of systems with higher number of tones does not necessarily refute the claim that tone space is a function of the number of tone heights in a system.

By representing both tonogenesis and register split as expansions of the tone space, the feature system proposed in Chapter Three captures the observation that a larger number of tone levels requires a larger tone space. But by allowing register overlapping, this system also allows tone-level compression. In fact, this system constitutes a third claim regarding the relationship between the overall tone space and the number of tone heights. It claims that tone-space expansion and tone-level compression are not mutually exclusive. They may be both at work when the number of tone heights increases. The simplest scenario where both compression and expansion occur can be illustrated in (117), where the distance between the two nearest surface tone heights indicated by A and B is compressed after register split, but the whole tone space is enlarged:

(117) Simultaneous tone-height compression and tone-space expansion



In the new feature system, then, the scenario of simultaneous tone-height compression and tone-space expansion can be captured by register overlapping.

As we have seen in Chapter One, some previous tone models endorse only the tone-height compression hypothesis, while others endorse only the tone-space expansion hypothesis. The present feature system differs from them by endorsing both hypotheses. This new position is in fact supported by the surveys discussed above. In Maddieson (1978b), although the data supports tone-space expansion, they do not exclude the possibility of simultaneous tone-height compression, as can be seen by a comparison of the first five tonal systems in the survey (Siswati and Kiowa, on the one hand, and Yoruba I, Thai I, and Thai II, on the other (see (116)). Similarly, Hombert's study (1978b) not only verifies (partially) tone-space expansion, it also shows the reduction of the perceptual distance as the number of tones increases. Finally, stronger evidence for both tone-space expansion and tone-height compression is perhaps provided by the Lili-Suzhou example discussed by F. Shi (1992) (see in (112)). Unlike the tonal systems discussed by Maddieson and Hombert, Lili and Suzhou are closely related, representing two stages of the development of a single tonal system. (112) shows that as the result of the further split in the original upper register, the lower register tones (the even-numbered tones) are pushed downward, and the distances between them are reduced. Here we see that both tone-space expansion and tone-height compression are at work.

In view of the above observations, we conclude that a feature system of tone recognizing only expansion or only compression does not capture all possible types of tonal behavior. A more powerful system should be able to capture both tone-space expansion and tone-height compression.

5.3.2. *The limit of tone space*

One of the findings of Hombert's study (1978b) discussed above is that as the number of tones in a system increases, the minimum perceptual distance between each tone decreases. With respect to this tendency, Hombert remarks:

The flattening of the curve obtained for seven and eight tone systems indicates some sort of saturation in the tone space. A huge number of tone systems are then found to be perceptually equivalent. This implies high instability. These data are in agreement with the fact that it is extremely rare to find tone languages with seven or eight tones using only F_0 to distinguish these tones.

The saturation of the tone space suggests that there is a limit as to how far tone space can expand. Without such a limit, there will be no saturation, no instability, and no merger; the number of tone heights will not be limited to five, and the number of registers will not be limited to three. In fact, the idea that tone space is limited is assumed in almost all the works dealing with tone. As early as in 1930 Chao wrote with respect to his famous tone-letter notation which divides the tone space into five levels, 'As the intervals of speech-tones are only relative intervals, the range 1-5 is taken to represent only ordinary range of speech intonation, to include cases of moderate variation for logical expression, but not to include cases of extreme emotional expression.' Here, a clear distinction is made between tone space and the voice pitch range. But although the limit to tone space is generally assumed in the literature, the reason for such a limit, as far as I know, has not been explicitly explained. This section explores this issue.

In the study of the interrelationship between tone and intonation, it is well known that only part of the voice range is used for tone purposes. J. Shen (1985) points out that intonation affects tonal pitch indirectly through successive tonal ranges. Thus, although tonal range varies constantly, the relationship between successive tones remain constant. X. S. Shen (1990b) argues that in Mandarin the intonation baseline as well as the topline is movable, and that the major cue differentiating statement intonation from question intonation does not only lie in the final section of the intonation contour, but rather it is the pitch range of the sentence as a whole moves upwards. The following table shows the means of tonal values in Hz of six informants in statements and questions at sentence-initial, highest peak, and sentence-final positions:

(118) Mandarin tone values in statements and questions (X. S. Shen 1990b:35)⁵⁸

Tones	Types	Sentence-initial	Highest peak	Sentence-final
1st	A	257.3 - 259.4	276.5 - 277.7	241.5 - 228.6
	B	319.7 - 327.6	348.3 - 346.8	332.5 - 352.9
2nd	A	228.5 - 257.4	265.7 - 282.4	180.8 - 201.9
	B	261.8 - 311.8	332.4 - 353.1	237.6 - 315.5
3rd	A	205.7 - 230.5		199.3 - 128.7 - 171.5
	B	249.9 - 307.2		232.7 - 189.2 - 241.4
4th	A	285.8 - 244.7	281.9 - 227.3	242.3 - 175.4
	B	352.1 - 332.5	312.9 - 298.7	343.1 - 272.8

A = statement; B = question.

The figures in (118) shows that the question intonation uses a higher overall pitch than the statement intonation. In other words, the tone space as a whole is raised in questions. From this, X. S. Shen suggests that there exist two layers of intonation in Mandarin, an upper layer for questions and a lower layer for statements.

In addition to the raising or lowering the tone space as a whole, the tone space can also expand or shrink due to different emotions of speech. This phenomenon is observed in N-C T. Chang's study of Chengdu Mandarin (1958). Chengdu has four citation tones. Tone I starts between mid-high and mid and rises to high, roughly [35]. Tone II starts somewhere lower than mid and ends between mid-low and low, roughly [31]. In emphatic sentences, Tone I 'remains high-rising and ends yet higher than its normal pitch in an ordinary statement'; Tone II 'falls yet lower.' In sentences implying a dismissal of the topic, 'The range is narrow; therefore the rising and falling of the tones are very slight.' From this, Chang concludes:

The range of the pitch varies with the types of sentences. Sentences containing a protest and sentences implying dismissal of the topic have completely different pitch levels, yet both have a narrow range. On the other hand, emphatic sentences and sentences expressing contempt, for example, both have a wide range. Ordinary statements and questions have a medium range.

⁵⁸ Shen did not give the values for the third tone at the highest peak, because 'due to tone sandhi, the tonal contours were different at the highest peak.'

It is clear from the discussion of tone-intonation relationship that the limit of the tone space is different from the voice pitch range used in speech (60-250 Hz for men, and 150-350 Hz for women (Hombert 1975b:119)). Since register split is conditioned by syllable initials, the limit of the tone-space expansion can be explained in terms of the pitch-affecting limit of the initials. Data from various phonetic experiments can be interpreted as supporting the existence of such a limit.

Hombert (1975b) studies the effect of voicing on F_0 at different frequency ranges in Yoruba. Yoruba is a tone language with three contrasting tones: high, mid, and low. (119) shows the time course of F_0 variation after voiced and voiceless unaspirated velar stops produced by two Yoruba speakers.

(119) Pitch variations after [k] and [g] in Yoruba (Hombert 1975b:44)

	TIME IN MSEC							
	0	20	40	60	80	100	150	200
HIGH TONE								
after [k]	186.1	176.3	174.7	175.4	175.8	175.2	174.0	172.7
after [g]	142.6	159.0	166.1	171.0	173.8	175.6	175.2	172.3
MID TONE								
after [k]	164.9	151.6	149.2	149.0	148.4	148.8	148.4	147.8
after [g]	134.3	145.1	148.3	149.5	150.6	151.5	150.7	149.6
LOW TONE								
after [k]	153.0	137.0	132.6	128.2	123.9	120.2	115.0	106.6
after [g]	121.6	130.7	130.9	129.7	126.3	122.4	117.8	113.6

This experiment shows, 'The perturbation caused by a voiced consonant on a following high tone or by a voiceless consonant on a following low tone is greater than the effect of these two series of consonants on a mid tone' (Hombert 1977b:178). This means that the more the tone space expands, the stronger the opposite forces to balance the expansion.

A similar tendency exists in Siamese (Gandour 1974), where it is found that the raising effect of the voiceless consonants is at its weakest at the top of the tone space, and the lowering effect of the voiced consonants is at its weakest at the bottom of the tone space. Siamese has five tones, High, Mid, Low, Rising, and Falling. (6) shows the averaged F_0 values after voiceless and voiced stops

for three tones. The onset value refers to the initial fundamental frequency value after the release of the stops; the peak value refers to the highest fundamental frequency value after the release of voiced stops. The result shows that 'The distance of the fall in pitch...varies depending on the initial height on the following vowel. The longer falls in pitch tend to occur before lower pitch heights, the shorter falls in pitch before higher pitch heights' (Gandour 1974:343).

(120) Pitch values after voiced and voiceless stops in Siamese (Gandour 1974:342)

	[p t]	[b d]	
	onset	onset	peak
High	146	123	132
Mid	136	120	126
Low	136	109	114

The Yoruba and Siamese examples show that although the impact of initial voicing on the F_0 of the following vowel is evident at different frequency ranges, the effectiveness of such an impact differs according to the pitch height of the vowel. The raising effect of the voiceless consonants is weaker on a higher tone than on a lower tone; conversely, the lowering effect of the voiced consonants is weaker on a lower tone than on a higher tone. Such correlations between pitch and voice clearly suggest the existence of a limit beyond which a voiceless/voiced distinction ceases to affect pitch.

Not only does a voicing distinction affects pitch, pitch variation also affects the perception of voicing. Experimental studies of the latter also suggest that pitch variation caused by a voicing distinction is limited.

Haggard, *et al.* (1970) conduct a perceptual experiment to determine the effect of F_0 on the perception of the voiced/voiceless distinction. The test material is a synthesized syllable ambiguous between [bi] and [pi]. Superimposed on the initial 55 msec of this syllable are three F_0 trajectories, falling, level, and rising. These trajectories start at 308, 201, and 145 Hz, respectively, and all terminate at 201 Hz. The initial section is followed by the steady-state vowel, the F_0 of which is at 201 Hz for 50 msec and then gradually falls to 165 Hz. The perceptual experiment shows that the

high falling trajectory generates more [p] responses, the low rising trajectory more [b] responses, and the level pitch an equal frequency of [b] and [p].

Massaro and Cohen (1977) conduct a series of perceptual tests to evaluate the effects of frication duration, voice onset time, and F_0 on the perception of voicing. In their experiments, synthesized [si] and [zi] are presented to a number of subjects. Massaro and Cohen demonstrate that as the F_0 value at the vowel onset increases, there is an increased chance that the synthesized sounds are perceived as starting with [s]. (121) shows the result of their 1977 experiment.

(121) The effect of F_0 values on the perception of voicing (Massaro and Cohen 1977:379)

Subject	F_0 (Hz)			
	163	183	206	224
1	.33	.40	.58	.69
2	.27	.43	.61	.73
3	.24	.44	.56	.69
4	.34	.45	.56	.64
5	.31	.43	.55	.72
6	.28	.39	.55	.80
Average	.30	.42	.57	.71

These two perceptual experiments demonstrate that given a wide-enough range, pitch variation can help to determine the status of voicing or even override a voicing distinction. The significance of this is that the effect of consonants on pitch can be counterbalanced by the effect of pitch on consonants.

Such a balancing force has both diachronic and synchronic consequences on the phonological systems cross-linguistically. Maddieson (1978a) has a summary of consonantal changes conditioned by pitch. The following are some examples taken from that study. In Korana spoken in South Africa */g/ and perhaps other voiced consonants have become devoiced when followed by high tones. In Kuwaa spoken in Liberia, /kp/ is realized as [gb] before a low tone. In Tankhur Naga spoken in North-Eastern India, /p, t, k/ become voiced intervocalically especially before a low tone.

To summarize, the above cited studies all point to the fact that the effect of consonants on the pitch of vowels is limited to a narrow range. Thus, if we accept the hypothesis that the maximum

tone space is decided by register split and that register split is due to the effect of consonants, then it follows naturally that tone space is limited. But to explain the limit of tone space in terms of the limit of consonant effect is not to deny that tone space can also be affected by active pitch control. Since different emotions may either expand or reduce the width of tone space, the actual tone space varies constantly in actual speech. But since this kind of variation is synchronic and does not permanently affect tone space, it should not be considered as a determining factor of the limit to tone space.

5.4. *The mid tone*

In the feature system proposed in Chapter Three, the mid tone is to be treated as carrying the neutral reference pitch. It is argued that phonologically this tone is unspecified. This position is in fact commonly adopted in phonological studies dealing with tones of both the African type and the Asian type. Pulleyblank (1986), for example, argues that the mid tone in Yala and Yoruba is underlyingly unspecified. Hyman and Schuh (1974) observe that contour tones are most likely to develop where the interval between two successive tones is greatest. Thus, in a tone system with three level tones, L-H sequence is more likely to develop into L-R (low and rising) than L-M or M-H; similarly, H-L sequence is more likely to develop into H-F (high and falling) than H-M or M-L. This means that the farther apart the two adjacent tones, the more likely a centralizing glide is to develop. Maddieson (1970) suggests that in Mandarin there are several neutral toned syllables that do not have corresponding full toned articulations. In sequence, their pitch values are decided by the preceding tone; in isolation, they are said with a mid pitch with a slight tendency to fall. Maddieson argues that 'Both their pitch in isolation and the fact that their pitch in sequence is contextually determined fit in with the view that a mid point in the voice range is the neutral unmarked point' (p.11).

In order to capture the phonological facts such as the above, a number of previously proposed feature systems are designed in such a way that the mid tone is represented as the unmarked or unspecified. These systems include Sampson (1969), Woo (1969), Maddieson (1970), Maran (1971), Halle and Steven (1971), Hyman (1986), Duanmu (1990), and Hyman (1992).⁵⁹ In these studies, we find some phonetic justifications for treating the mid as the norm. Maddieson (1970)

⁵⁹ For these feature systems, see the Appendix.

cites Longacre's study (1952) of Trique, which has five phonemic pitch levels. Longacre observes that there is an ascending onglide for tones 1, 2 and 3, and a descending onglide for tones 4 and 5.⁶⁰ Thus, there seems to exist a phonetic norm, lying somewhere between tone 3 and 4, which can be regarded as the point of origin for both higher and lower tones. Longacre writes (1952:80), 'The centre level, lying quite close to the phonetic norm, may be considered the structural norm of the system. The highest level represents one pole of the bi-directional tendency, the lowest level represents the other pole.' Halle and Stevens (1971) justify the representation of the mid as the unmarked in terms of the tenseness of the vocal cords. They identify three states in vocal-cord tenseness, represented in their system as [+stiff, -slack], [-stiff, -slack], and [-stiff, +slack], respectively. The neutral state [-stiff, -slack] represents the mid tone.

Further evidence for treating the mid as the norm comes from the phenomenon of tone-space expansion. Tone-space expansion can be represented in two different ways, either starting from the center and expanding outwards, or starting from one border of the space and expanding beyond the other. If the former is the case, then it naturally entails that the mid tone carries the neutral reference pitch. Phonetic evidence seems to support the former representation.

Let us first examine the pattern of tonogenesis from syllable finals suggested by Haudricourt (1954a). As we have seen in § 5.1, there is phonetic evidence that syllable-final -h induces a falling tone, and syllable-final -ʔ induces a rising tone. These two tones contrasted with each other, and with syllables ending in sonorants. Since syllables with sonorant endings acquired tone only by contrasting with the former two types of syllables, rather than by active pitch movement, this type of syllables carry the non-high, non-low, neutral pitch. Phonologically, this pitch can be regarded as a default tone.

The same analysis can be applied to pitch movement due to syllable initial consonants. As shown in § 5.3 above and § 5.6 below, it is a common practice in phonetics to identify a class of pitch raisers and a class of pitch depressors. When neither the raisers nor the depressors are involved, the pitch value is said to be intrinsic (Lehiste and Peterson 1961; Lehiste 1970). Phonologically, this intrinsic pitch can be identified with the mid tone.

⁶⁰ In keeping with the American tradition, tone 1 is the highest tone while tone 5 is the lowest.

To sum up, there is abundant phonetic evidence suggesting that the center of the tone space should be regarded as the neutral reference pitch. Phonologically, this pitch is best represented as the unspecified default pitch. This observation is naturally expressed in the feature system proposed in the Chapter Three.

5.5. *The number of tone levels*

It has been shown in the last chapter that in order to account for all the available tonal data, at least five contrastive tone heights should be distinguished. It has also been shown that due to the overlapping of registers, the existence of three registers does not call for more than five contrastive tone heights. In other words, the number of tone heights required in a phonological representation of tone is five. This number matches exactly with a frequently-made hypothesis in the study of tone that 'a phonological feature system must provide for the description of at least (and apparently at most) five levels of tone' (Anderson 1978:146).

In the phonological literature, the five-level hypothesis is not based on the observation of register tripartition nor register overlapping. It is based on the typological observation that the maximum number of tone heights any language can distinguish is five (Wang 1967; Anderson 1978; Maddieson 1978b). Languages that distinguish five tone heights include the following (Maddieson 1978b):

(122) Languages with five contrastive levels

African languages:

Dan
Kporo
Ashuku
Ngamambo

Asian languages:

Black Miao
Tahua Yao
some dialects of Puyi

American languages:

Trique
Ticuna
Usila Chinantec

To some extent, the calculation of tonal heights depends on where we draw the distinction between level and contour tones. Pike (1948:5) defines a contour tone as 'one in which during the pronunciation of the syllable on which it occurs there is a perceptible rise or fall, or some combination of rise and fall, such as rising-falling or falling-rising.' In contrast, a level tone is 'one in which, within the limits of perception, the pitch of a syllable does not rise or fall during its

production.’ But since pitch fluctuates continuously in speech, it is quite natural to find that in what is called a level tone there is usually a gliding onset and/or offset. Thus although the emphasis on perception enables us to make a rough distinction between level and contour tones, difficulty frequently arise when a decision must be made as to whether a particular onset or offset should be included in the phonological description of tone. It is partly due to this difficulty that the five-level hypothesis has not been firmly established in the literature. Frequently we find attempts to reduce the maximum number to four, by re-interpreting one of the five levels in terms of downdrift or transcriptional inaccuracy (see for example, Chapter Two). Such re-interpretation strategy, however, works in both ways, since it can also be used to argue for the existence of five contrastive levels. Take for example the Chiu-chou dialect of Miao, which has the following tonal system: [22], [33], [44], [55], [13], [53], and [21] (K. Chang 1972). While [13] and [53] have distinct tonal contours, the status of [21] is not very clear. Commenting on Chang (1972), Anderson (1978) remarks, ‘it would seem perfectly plausible to treat the tone [21] as phonologically a low level tone /11/, with the [2] element considered a nondistinctive onglide,’ since ‘it is indeed quite frequent for the "extreme" tones of a system to be preceded by a central onglide.’⁶¹ According to Anderson, then, Chiu-chou Miao is another language which distinguishes five tone heights.⁶²

The second difficulty in the re-interpretation strategy is that not all tonal data are subject to the downdrift interpretation. The Black Miao data that are cited in Anderson (1978:145) show that the five levels of tone in this language are minimally contrastive:

(123) Black Miao

a.	lɑ ¹¹	‘candle’	e.	lɑ ⁵⁵	‘short’
	tju ¹¹	‘waist’		tju ⁵⁵	‘heart’
	va ¹¹	‘I, me’		tɑ ⁵⁵	‘to take, use’
	ljɔŋ ¹¹	‘green’		nhɑŋ ⁵⁵	‘to listen, hear’
b.	lɑ ²²	‘to move away’	f.	lɑ ³⁵	‘to squeeze’
	tɔ ²²	‘far’		tɑ ³⁵	‘to break, to kill’

⁶¹ The extreme tones in a system that distinguish five levels of tone are the highest (level 5) and the lowest (level 2) tones.

⁶² As the Chiu-chou Miao example illustrates, the issue of the maximum number of tone levels is usually decided by examining the maximum number of level tones any language can distinguish, although tone level and level tone are two different notions. One of the reasons why level tones are used is perhaps attributable to the nature of the tone letter notation (Chao 1930), which has been used extensively in the description of Asian languages. In this notation, the five degrees refer to the perceptually equidistant divisions of the pitch range. These divisions are not based on a phonological principle, and therefore are not automatically equitable to phonologically distinctive levels.

	ɬai ²²	'to enter'		ɬhai ³⁵	'moon'
	ji ²²	'eight'		yau ³⁵	'good'
c.	la ³³	'cave'	g.	ɬju ¹³	'to save, rescue'
	tjo ³³	'broom'		to ¹³	'not'
	khau ³³ (na ¹³)	'to kiss'		ɬaŋ ¹³	'to lose'
	xe ³³	'tall, high'		sho ¹³	'to close'
d.	la ⁴⁴	a classifier	h.	la ⁵¹ qa ⁴⁴	'to mow'
	ɬjo ⁴⁴	'squirrel'		ta ⁵¹ (no ³³ 'fall')	'to rain'
	xan ⁴⁴	'to walk'		ɬaŋ ⁵¹	'wall'
	ɬhja ⁴⁴	'to miss, think of'		yu ⁵¹	'cage'

According to L. Shi (1992), the Kam dialects of Gaoba and Shidong also have five contrastive level tones. Gaoba, for example, has the following tones:

(124) Gaoba Kam (L. Shi 1992)

a.	ta ¹¹	'grab'	b.	ta ²²	a classifier
c.	ta ³³	'mountain forest'	d.	ta ⁴⁴	'to pass'
e.	ta ⁵⁵	'middle'	f.	ta ¹³	'male (animal)'
g.	ta ²⁴	'peg'	h.	ta ⁴⁵	'father's sister's husband'
i.	ta ³¹	'to measure'			

The above examples show that we need at least five tone heights to account for all the available data. But do we need more than five contrastive tone heights? In his study of the Zulu language, Clement M. Doke (1926) uses musical staff to record Zulu tone. He claims that nine levels are needed to account for Zulu tones adequately. These nine tones are designated as F#⁺, E⁺, D#, D⁺, C, Bb, A#, Ab, F⁺, respectively (+ means slightly higher than the note indicated). Before him, as Doke reports (1926:199), K. E. Laman has recorded nine separate tone-points for Kongo as below: F#, F, E, D#, C#, C, B, Bb. Later studies show, however, that the nine levels in these cases are not all minimally contrastive (Anderson 1978). Now, there seems to be universal agreement in the literature that the maximum number of tone heights in a phonological representation should not be more than five.

5.6. Cover features for voice and tone

It is well-known that prevocalic voiceless initial consonants induce a higher pitch in the following vowel, while voiced initial consonants induce a lower pitch. Such consonantal effects on vowels seem to be universal, since they occur not only in tone languages, but also in non-tone languages. Phonetic studies on such effects have been done on a variety of languages, including English (House and Fairbanks 1952, Lehiste and Perterson 1961, and Hombert 1978a); Siamese (Gandour 1974); Swedish (Löfqvist 1975); Yoruba (Hombert 1977b, Painter 1978); Tibetan (Kjellin 1977); Sindhi (Painter 1978); Gã (Painter 1978); Burmese (Maddieson 1984), and also on nonsense syllables read by speakers of different languages (Mohr 1971). In all these studies, it is found that the maximum difference in F_0 values induced by different initials occurs at the vowel onset, and that the F_0 value after voiceless consonants reaches its peak right after the release of the consonants, while F_0 value after voiced consonants reaches its peak near the middle of the vowel.

The cover features [stiff] and [slack] suggested by Halle and Stevens (1971) are intended to capture the interactions between consonant types and tone. Since then these features have been accepted by some (Lieber 1987; Sagey 1990; Bao 1990; Duanmu 1990), but rejected by others (Fromkin 1972; Anderson 1978). In this section we review several studies on the conditioning factors of register split and discuss their significance to the cover features [stiff] and [slack].

Among the conditioning factors of register split we are going to discuss are aspiration and murmur. Phonetic studies have shown that aspirated and unaspirated voiceless stops may induce different F_0 perturbations in different languages. In Korean (Kim 1968), for example, the aspirated series induces a higher F_0 perturbation in the following vowel than the unaspirated series. In English and French (Hombert and Ladefoged 1976), there is no appreciable difference between the effects of voiceless aspirated and unaspirated stops. In many East and Southeast Asian languages (Chapter Four), aspirated stops induce lower F_0 values. After examining various parameters controlling pitch vibration, such as the horizontal tension of the vocal folds, the height of the larynx, and the subglottal air pressure, Hombert (1978a) concludes that these parameters are not significantly different at the onset of a vowel following a voiceless aspirated stop versus a voiceless unaspirated

stop, and this, Hombert believes, explains why there are diverse tendencies of pitch perturbations in different languages following these two series of consonants.

In contrast to aspiration, murmur is generally believed to be a more reliable depressor of pitch. As we have seen in Chapter Four, more and more people are now trying to explain historical register split in terms of murmur, rather than plain voice or plain aspiration.

The last type of consonants are implosives and velar-labials. They are known as the most reliable pitch-raisers.

5.6.1. Lhasa

Kjellin (1977) reports an experimental study of the consonant types and tone in Lhasa Tibetan. In this language, every syllable must begin with a consonant. In terms of phonation, initial consonants fall into three groups, i.e., i) voiceless unaspirated, ii) voiceless aspirated, and iii) voiced. There are two tones, high and low, and they can co-occur with both voiceless and voiced initials.⁶³ The co-occurrence relationship between tone and initial consonants is exemplified in the following table:

(125) Initials and tones in Lhasa Tibetan (Kjellin 1977)

High		Low	
p	ph	b	ph
	s		s
m		m	
ʔ	h	ɦ	

In Lhasa, the F_0 following voiceless aspirated stops (*PHA*) is lower (166 Hz) at vowel onset than voiceless unaspirated stops (*PA*) (178 Hz). A more interesting pattern is found in *phA*, which at the vowel onset induces the lowest F_0 value (126 Hz), even lower than the voiced *bA* (131 Hz). A fiberoptic inspection reveals no significant differences between the glottal opening gestures of *PH* and *ph*, but the timing of complete adduction relative to voice onset time is about 10 msec. later for *ph* than for *PH*. An electromyographic inspection shows that the cricothyroid muscle activity for *phA*

⁶³ Kjellin is of the view that Lhasa is, strictly speaking, not tonal, since the tones can be derived phonologically from the consonant environment.

is similar to *bA* rather than *PHA*. Similarly, the vocalis muscle activity for *phA* is characteristic of the activities for *bA*. In other words, articulatorily *phA* is closer to *bA* rather than to *PHA*. Based on these observations, Kjellin suggests that the Lhasa *phA* may be regarded as a devoiced variant of *bA*.

Kjellin does not give an explanation of the development from an unaspirated *bA* to an aspirated *phA*. But judging from the experiment report, the aspiration in *phA* may not be a 'plain' aspiration. Kjellin states (p.322):

The envelope of the amplitude [in *phA*] did not rise rapidly for the vowel, and periodic waves emerged only gradually from the aspiration noise. It seemed possible that voicing began before the cessation of aspiration...

Thus although [p^h] is not explicitly posited for Lhasa, what is designated as *phA* may in fact involve murmured aspiration.

5.6.2. Siamese

[p^h] is posited for Siamese in Gandour (1974), and an explanation of the historical development of [p^h] is also provided. Siamese has five tones. These are designated in Gandour (1974) as HIGH, MID, LOW, FALLING, and RISING. In terms of phonation, Siamese initial stops fall into three groups, i) voiceless unaspirated, ii) voiceless aspirated, and iii) voiced. The second group further splits into two subgroups, a plain and a breathy variant. The average F₀ values at vowel onset after bilabial stops are given in (126):⁶⁴

(126) F₀ values for bilabial stops in Siamese (Gandour 1974:342)

	[p t]	[p ^h t ^h]	[p ^{h̥} t ^{h̥}]	[b d]
HIGH	146	—	128	123
MID	136	132	123	120
LOW	136	116	114	109
FALLING	148	140	136	133
RISING	137	124	113	114

⁶⁴ No value is given for the high tone after plain aspirated stops because of lack of data.

These data show, first of all, that in Siamese initial voicing contrast ([p t] vs. [b d]) affects the F_0 of the following vowel in the same way as it does in Lhasa, i.e., voiceless consonants raise the F_0 , while voiced consonants lower the F_0 . Secondly, the pitch-changing effect is not just limited to a plain voicing contrast ([p,t] vs. [b d]); two more classes ([p^h t^h] and [p^{h̥} t^{h̥}]) also regularly affect the F_0 , but to a lesser extent. Thirdly, these consonant classes not only affect the F_0 of the mid tone, they also affect the F_0 of the high and the low tones. In other words, they affect F_0 in different frequency ranges. This issue will be taken up again in § 5.6.

With respect to Siamese aspirated stops, Gandour suggests that they came from earlier murmured stops ([b̥ d̥]), through a stage of murmured aspirated voiceless stops ([p^{h̥} t^{h̥}]). In other words, the development of the Siamese consonantal system follows the route *b̥ > p^{h̥} > p^h > p. Gandour also finds an interesting correlation between the occurrence of the murmured variety of the aspirated stops and tone heights (1974:345):

The “breathy” allophone occurs more frequently before tones that start at higher pitch heights. The higher the tone, the more likely it is to occur. Ranking the tones of Siamese—RISING LOW MID HIGH FALLING—in order from lowest to highest initial pitch height...agrees closely with a ranking of the tones in order from lowest to highest percentage of “breathy” allophones of the aspirated stops.

Gandour, however, does not discuss the significance of this correlation.

5.6.3. *Kam*

A different kind of correlation is found between the occurrence of murmured aspiration and pitch height in Kam. Edmondson (1990a) studies the relationship between the occurrence of murmur and the occurrence of tone split in eighteen locations of the Kam speaking area. He finds that tone splits are much more closely associated with dialects showing murmur than those showing only aspiration. Every dialect with murmur shows secondary tone split, but many dialects with aspiration do not show secondary split. Thus, there seems to be little correlation between tone split and aspiration. From this, Edmondson concludes that ‘aspiration is largely independent of splitting in Kam.’ (p.196).

In another study, Edmondson (1992:94) compares the spectrograms of the prime tones (with ‘aspirated’ initials) and non-prime tones (with unaspirated initials) of Kam. He finds that the contour, location, number, and distributions of formants for the two types of tones are virtually identical. Since the VOT of the prime tones is not markedly and consistently longer than that of the non-prime tones, Edmondson argues that the major difference between the two types is not a difference in the presence or absence of aspiration. Rather, it is a difference of murmur. Edmondson writes:

The RISING register syllables (that is, those called “aspirated”) evidence irregular glottal vibration as is seen in the formant striations. In stops these began before release and lasted well into the vocalic part of the syllable. Moreover, the formants were often superimposed upon a background bottom-to-top white noise, the sign of friction that lasted for the first third to half of the syllable. Both of these are consistent with a phonatory quality of breathiness or murmur, a sound produced by vocal chords characterized as flapping in the airstream without touching and thus having an irregular component in their oscillation. The heightened airstream flow also produces some friction of the sides of the folds. By contrast, initials from non-prime (HIGH) syllables showed formant bands with the regular striations of glottal pulsing and a lack of accompanying acoustic friction.

From this, Edmondson concludes that the real cause of the secondary split in Kam is murmured phonation.

5.6.4. Wu

While Edmondson’s papers (1990a; 1992) concern mainly the condition for the secondary split, Cao and Maddieson’s paper (1992) discusses the condition for the primary split. The languages Cao and Maddieson investigate are four Wu dialects of Chinese, spoken in east China at Changyinsha, Shanghai, Wenzhou, and Ningbo. The tested syllables include oral stops followed by an assortment of vowels. Phonemically, these stops can be transcribed as /p, t, k, b, d, g/. /p, t, k/ are voiceless unaspirated stops; the nature of /b, d, g/ is the subject of investigation of the paper.

The results of Cao and Maddieson’s study show that what are transcribed phonemically as /b, d, g/ are only truly voiced at utterance-medial positions. At utterance initial positions, there is no significant difference between /b, d, g/ and /p, t, k/ in terms of voicing, the VOT value being

essentially zero for both classes. The major differences between the two at utterance initial positions are manifested in H2-H1 (the difference between the amplitude of the first harmonic and the second harmonic), F1-H1 (the difference between the amplitude of the first harmonic and the strongest harmonic in the first formant), and AF/AP (the ratio of airflow to air pressure) measurements. The authors find that the mean energy difference in both the H2-H1 and the F1-H1 measurements is less after /b, d, g/ than after /p, t, k/. In other words, the first harmonic at vowel onset after /b, d, g/ has relatively higher energy than after /p, t, k/. Furthermore, the AF/AP ratio is greater in the case of /b, d, g/ than in /p, t, k/. All these indicate that the glottis is relatively more open at vowel onset for /b, d, g/ than for /p, t, k/, so that there is greater airflow through the glottis in the syllables beginning with /b, d, g/. Since such effect is significant only at the onset of the vowel, phonologically murmured phonation can be regarded as a property of /b, d, g/, rather than the whole syllable. The authors therefore conclude that the contrast between /b, d, g/ and /p, t, k/ in Wu is not related to the presence vs. absence of voicing, but to a difference in glottal configuration which causes a murmured phonation following /b, d, g/. Clearly, the value of /b, d, g/, according to the authors, is [p^h, t^h, k^h].

The significance of this study is summarized by the authors in the following quotation:

Our study has confirmed the observations of others to the effect that the “voiced” consonants in Wu dialects are only truly voiced in unstressed intervocalic positions. Interestingly, it is precisely in unstressed positions that the tonal contrasts between Yin and Yang tones are entirely or largely neutralized in many of the Wu dialects. This is also the position in which a contrast in terms of the factor we have labeled breathiness is not found. Since phonetic voicing without breathiness does not preserve or create tonal differences, we have an indication that the breathiness contrast may be a more powerful influence on pitch than plain voicing is. Since the tone split is pervasive across Chinese dialects, such a strong influence might be more plausibly assumed to be its cause, and breathiness should be reconstructed as a feature of the “voiced” category of Middle Chinese. Pulleyblank (1984) and others have made this proposal before, but there is now stronger phonetic motivation for it.

5.6.5. *Implosives and labial-velars*

Painter (1978) studies the pitch-changing effect of eleven consonants ([kp̚, gb̚, pʔ, ɓ, ph, p, ɓ̥, p^h, bʔ, b, b^h]), and finds that at the release of the oral closure, [kp̚, gb̚, pʔ, ɓ] have the highest

frequencies among the eleven. Common to these four sounds is that they all have a double release. Painter explains the pitch-raising effect of implosives as follows (p.254):⁶⁵

In an implosive the vocal folds are brought together before the larynx is lowered, and they remain fairly tightly together throughout the articulation so that air will not pass through the glottis in such volume as to destroy the negative P_{ph} [pharyngeal pressure] necessary for an implosive. Since the larynx lowers only after the vocal folds are adducted, the lips brought together and the velopharyngeal port closed, the pressure in the oral-pharyngeal air chamber falls and as a consequence, the pressure drop increases (i.e. P_{ph} gets smaller and smaller than P_{sg} [subglottal pressure]) which in its turn raises the pitch since decreasing the P_{ph} has the same effect as raising the P_{sg} .

Painter explains the pitch-raising effect of $[\widehat{gb}]$ in terms of pressure change in the pharyngeal cavity. Roughly, in $[\widehat{gb}]$ labial and velar closures are made simultaneously and voicing begins immediately. Before the release of the velar closure, pulmonic airflow responsible for voicing increases P_{ph} . At the velar release, the P_{ph} drops and empties into the negative oral pressure. This pressure drop results in the increase of F_0 .⁶⁶

5.6.6. Consonants and tone: summary

In sections § 5.6.1-5.6.4, we discussed four case studies which have a bearing on the relationship between aspiration, murmur, voice, and register split. In the first case, although Kjellin (1976) does not mention murmured stops such as $[p^h]$, there is evidence in the experiment report suggesting there might exist such stops in Lhasa. In the second case, Gandour (1974) demonstrates that murmured stops, such as $[p^h]$, do exist in Siamese, and that they regularly correlate with a lower F_0 at vowel onset than aspirated stops such as $[p^h]$. Gandour also suggests that Siamese consonants developed through the stages $*b > p^h > p^h > p$, but he does not relate murmur to register split. In the third case, Edmondson (1990a; 1992) argues forcefully that the ultimate cause of both primary and secondary register split in Kam is murmur. He also suggests that Kam consonants developed through the stages of murmur > aspiration > deaspiration, which is remarkably similar to Gandour's

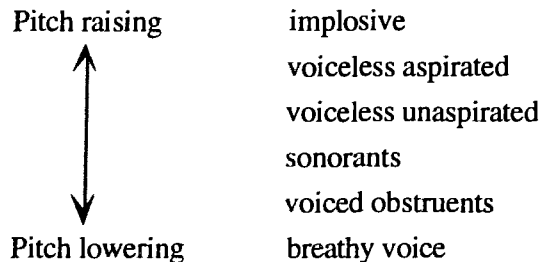
⁶⁵ Implosives is known to raise the pitch in Xhosa, Ngizim, and Kru. See Greenberg (1970); Hyman and Schuh (1974); and Painter (1978).

⁶⁶ But before the labial release, P_{sg} also drops. Thus $[\widehat{gb}]$ is not a reliable pitch-raiser. According to Painter, $[\widehat{gb}]$ raises the pitch in Gã, but not in Yoruba.

suggestion for the development of Siamese consonants. Edmondson further suggests that the real condition for register split is often obscured by the development in the consonants themselves. In the last case, Cao and Maddieson (1992) demonstrate that what are commonly assumed to be voiced stops in Wu are in fact voiceless stops with murmured aspiration, i.e., [p^h, t^h, k^h]. They argue that since register distinction in Wu is usually neutralized where truly voiced stops [b, d, g] occur, but not where murmur occurs, murmur is even more reliable than voice as a condition for register split.

The above hypothesized order of consonant development (b > p^h > p^h > p) is very close, though not identical, to the phonetic scale proposed by Hyman and Schuh (1974), in which breathy voice or murmur is also regarded as a more reliable pitch depressor than plain voice:

(127) A pitch-affecting hierarchy (Hyman and Schuh 1974)



This hierarchy agrees with Painter (1978) in that implosives induce the highest pitch.

The major difference between this hierarchy and Gandour's hypothesis is that the phonetic scale in (127) does not represent a single chain of development. The second difference lies in the order of the aspirated-unaspirated consonants. As we have seen at the beginning of this section, the relationship between aspiration and pitch height remains one of the controversies in the study of tone.

5.6.7. *Halle and Stevens (1971)*

Consider now the significance of the above studies to the theory of cover features for both voice and tone. In 1971, Halle and Stevens proposed the following set of laryngeal features:

(128) Laryngeal features (Halle and Stevens 1971)

	1	2	3	4	5	6	7	8	9
Obstruents	b _l	b	p	p _k	b ^h	p ^h	ɓ	ʔ	pʔ
Glides	w, y				ɸ	h, W, Y		ʔ	ʔ, ʔw, ʔy
vowel	V	V̂	V̇	Voiceless vowels	Breathy vowels			Creaky voice vowels	Glottalized vowels
Spread glottis	–	–	–	+	+	+	–	–	–
Constricted glottis	–	–	–	–	–	–	+	+	+
Stiff vocal cords	–	–	+	–	–	+	–	–	+
Slack vocal cords	–	+	–	–	+	–	–	+	–

In this system, two semi-independent parameters are identified, i.e. glottal constriction and vocal-cord tension. As far as the parameter of constriction is concerned, three states are identified: the neutral state (columns 1, 2, 3), the spread state (columns 4, 5, 6), and the constricted state (columns 7, 8, 9). Within each of these states, the variation in the tenseness of the vocal cords brings about three degrees of pitch, i.e., high, mid and low. In this system, therefore, the pitch raising and lowering mechanisms are identified with the parameter of tension, while the parameter of constriction is considered neutral with respect to pitch change. Since the second parameter, vocal-cord tension, is correlated with voice, the traditional voice features and tone features are covered by a single set of features – [stiff] and [slack].

This system captures in a straightforward way the traditional view of the interaction between voice and tone: historically voiceless consonants may induce a high tone and synchronically they block the spread of low tone; voiced consonants may induce a low tone and block the spread of high tone. But this system does not seem to fit very well with the more recent view of register split in Asian languages. Since the four languages discussed in § 5.6.1-5.6.4 belong to different branches of a huge language family (Sino-Tibetan), murmur as a conditioning factor of register split must be a general areal phenomenon. Notice in particular that in Wu the real conditioning factor is said to be

murmur rather than voice. This means that besides vocal-cord tension, glottal constriction also plays a major role in pitch regulation.

In addition to glottal tension and constriction, transglottal air pressure drop is another major factor in pitch control. The behaviors of implosives and $[\widehat{gb}]$ observed in Painter's study (1978) suggest that under certain circumstances the effect of pressure drop can override the effect of vocal-cord tension, such that these special voiced consonants function to raise the pitch instead of lowering it. These consonants therefore pose another problem for the cover features [stiff] and [slack].

A third and most common objection to the cover features [stiff] and [slack] is that they can only specify up to three levels of tone height (Fromkin 1972; Anderson 1978; Yip 1980). Since there is ample evidence showing the existence of languages with four or five tone levels (§ 5.4), the cover features are also inadequate in this respect.

The three-level limit of the Halle-Steven's proposal has other consequences. First, it predicts that voiceless consonants have no raising effect on a following high tone, and voiced consonants have no lowering effect on a following low tone (Gandour 1974:346). But as we have seen in the Yoruba and Siamese examples that in languages with three tone levels voiceless initials still raise the pitch and (breathy) voiced consonants still lower the pitch. Second, the cover features can only raise or lower a single level of pitch. Since the register mechanism is not installed, there is no way to raise or lower two or three levels in a single application of the features. As such, the features can only capture historical tonogenesis from syllable initials (81), but not register split, where two or three levels are shifted in a single step (63, 64).

5.6.8. Bao (1990)

Some of the drawbacks of the Halle-Stevens' cover features have been rectified in later studies. Bao (1990) redefines the cover features in such a way that [+stiff] and [+slack] are not mutually exclusive. In Halle-Stevens' model, since [stiff] and [slack] refer to the two polar states of a single dimension, i.e. vocal-cord tension, the configuration [+stiff, +slack] is both logically and physiologically impossible. Bao argues that since vocal-cord tension is not controlled by a single set

of muscles, [stiff] and [slack] do not have to refer to the two ends of a single dimension. He therefore identifies the feature [stiff] with the cricothyroid muscle and the feature [slack] with the vocalis muscle, suggesting that they have different linguistic functions (Bao 1990:155):

The feature [stiff] provides the articulatory instructions to the relevant laryngeal muscles to increase or decrease the overall tension of the vocal cords, which we take to be the tonal register. Within the register, the feature [slack] acts over time to micro-adjust the physical properties of the vocal cords which result in modification of the acoustic realization of tone.

In Bao's framework, the cover features can specify not only register distinctions, but also a maximum number of four levels (§ 1.2.15).

5.6.9. *Duanmu (1990)*

Duanmu (1990:119) finds that Bao's identification of register with the cricothyroid muscle and tone with the vocalis muscle is unconvincing. He suggests instead that register be identified with the vocalis muscle and tone with the cricothyroid muscle. In Duanmu's model, the features [stiff] and [slack] do not cover implosives and aspiration. Duanmu writes (1990:102):

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.

5.6.10. *Cover features: summary*

To sum up, although the features [stiff] and [slack] proposed by Halle and Stevens (1971) capture an important interaction between consonant voicing and tone, they fail to capture the interaction between murmur and tone, and between implosives/voiced-velar-labials and tone. Bao and Duanmu's modifications give Halle-Stevens' features the capacity to represent registers and more than three tone levels, but the features still do not cover murmur, implosives, and voiced velar-labials. By relating only to voice, the features as used in Bao (1990) and Duanmu (1990) imply that register split can only be induced by a distinction between voiced and voiceless consonants, which however, is far from being the case.

Due to the failure of the features [stiff] and [slack] in capturing all the possible types of register split, these features are not adopted in the new feature system developed in this thesis.

Chapter Six

Tonal Representation

In Chapters Four and Five, I provide historical, typological, and phonetic evidence to support the new feature system proposed in Chapter Three. To recapitulate, these characteristics include the following: a) a match of tone levels with tonogenesis induced by syllable final-consonants; b) a match of registers with register split induced by syllable initial consonants; c) a maximum number of five tone levels; d) a maximum number of three registers; e) register overlapping; f) tone-height compression and tone-space expansion; g) underspecification of the mid. In Chapter Five we also provide arguments against cover features for tone and voice.

This chapter concerns mainly with the issues pertinent to the representation of tone, in particular the representation of contour tones and TBU. Other issues to be discussed are the nature of tone features, i.e. whether they should be defined in articulatory, acoustic or perceptual terms, and the value of tone features, i.e. whether they are optimally binary or privative.

6.1. The TBU and contour tones

6.1.1. Contour tones

Modern treatments of contour tones can be traced back to Pike (1948). Pike distinguishes two types of contour tones. The first type is formed by the juxtaposition of two or more level tones. These level tones must exist independently of the contour tones in the same language. The contour formed in this way is itself non-significant, being a mere transition from one level component to another without forming an independent toneme. Furthermore, the contour may be part of a single morpheme, as in the Mixteco word *nàà* 'mother', or may represent two morphemes, as in the Mazateco word *ti*²⁻⁴ 'we, but not you, burn' (Pike 1948:7). Yip (1989) refers to this type of contour tones as 'tone clusters'.

The second type of contour tones differs from the first type in the following way (Pike 1948:8).

- i) The basic tonal unit is contour instead of level.
- ii) The contours cannot be interrupted by morpheme boundaries.
- iii) The beginning, ending and reversal points of a contour cannot be equated with the level tones in the same language.
- iv) Languages with this type of contour have only one toneme per syllable.

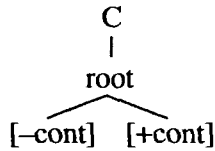
Yip (1989) refers to this type of contour tones as ‘branching tones’. It has been observed in various studies (Pike 1948; Wang 1967; Yip 1989; Kenstowicz 1994; Duanmu 1994b) that contour tones in American and African languages are mainly of the first type, while contour tones in Asian languages are mainly of the second type.

Pike’s classification of contour tones has left a far-reaching impact on the study of tonal features in modern phonology. While tone clusters can definitely be represented by concatenations of level-tone features, the representation of branching contour tones has been a major controversy in tonal studies. In the literature, branching tones has been analyzed in three different ways. Wang (1967), Fromkin (1972), Gandour and Fromkin (1978), Newman (1986), and Shih (1986) advocate unitary contour features (such as $[\pm\text{rising}]$, $[\pm\text{falling}]$). The major disadvantage of this approach is that it requires a large number of distinctive features, which inevitably reduces the economy in the feature system. To argue against the unitary approach, Woo (1969) strongly advocates the decomposition approach, where branching contour tones are decomposed into sequences of level tone features, and represented in the same way as tone clusters. Since Woo demands a one-to-one match between tone and TBU, which is equivalent to the mora, her decomposition approach has been criticized for its incapability to represent short contour tones (Leben 1973; Anderson 1978; Yip 1980), as in *pak*³⁵ ‘mouth’ in the Li-Ngam dialect of Sui (F. Li 1965)).

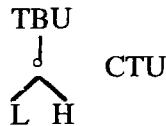
The third type of analysis is proposed by Yip (1989), who compromises the above two approaches, by representing contour features as units at one level but as concatenations of level tones at another. This new analysis parallels Sagey’s (1990) analysis of affricates, in that both affricates and contour tones are explained in terms of edge effects, i.e., they exhibit different properties on the left and right edges, while simultaneously they are identified as single melodic units. Yip names such tonal unit as Contour Tone Units (CTU). These two analyses are shown in (129):

(129) Edge effects

i) Affricates (Sagey 1990)



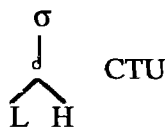
ii) Contour tones (Yip 1989)



In Yip's framework (1989), CTU exists on the register level. That is, contour tones are analyzed as sequences of levels on the tonal level, but melodic units on the register level. The TBU in this case is the syllable. This new analysis of contour tones has the advantage of capturing the difference between branching tones (single contour tones) and tone clusters, without the use of contour features such as [rising] and [falling]:

(130) Branching tones vs. tone clusters (Yip 1989:150)

i) Branching tone



ii) Tone cluster



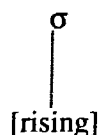
This effect cannot be achieved in previous models that treat contour tones as concatenations of level features, such as Woo (1969) (§ 1.2.4).

The main objection to Yip's analysis (1989) is that CTU depends on the uni-register restriction (§ 2.3.3). Since the TBU is the syllable, CTU predicts that within the domain of the syllable there cannot be two register values. A syllable with two register values is possible only in tone clusters (130ii), not branching tones (130i). This prediction, however, is false (§ 2.3.4).

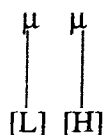
The three representative approaches to branching contour tones are illustrated below:

(131) Three analyses of the branching contour tone

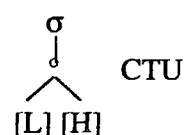
i) Wang (1967)



ii) Woo (1969)



iii) Yip (1989)

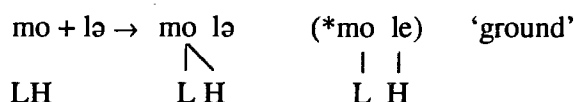
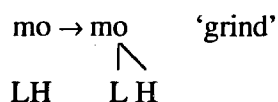


6.1.2. Tonal complexity and syllable weight

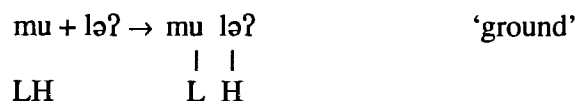
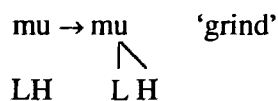
Yip's CTU is challenged by Duanmu (1990, 1992, 1993, 1994a,b). Duanmu argues that this approach obscures an important correlation between the complexity of tone and the weight of the syllable. Consider, for example, the Beijing Mandarin word *mǒ* 'to grind' and its Shanghai cognate *mǔ*.⁶⁷ When *mo* is followed by the toneless aspect marker *le*, *mo* still carries the rising tone and *le* is still toneless. But when *mu* is followed by the toneless aspect marker *le?*, the rising tone splits into an L and an H. The L is carried by *mu*, but the H is carried by *le?*. Thus, although the splitting of the contour tone does not occur in Beijing, it does occur in Shanghai:

(132) Contour tones in Beijing and Shanghai

i) Mandarin



ii) Shanghai



Such examples show that Shanghai tones tend to behave more like the African tones than the tones in Mandarin. The same tendency is also found in some other Wu languages (Chen 1991). Since the Shanghai contour tones break into sequences of level tones, Duanmu argues that they do not behave like units and hence there is no CTU in this language.

⁶⁷ Here Duanmu uses the Africanist system of tonal transcription. ˥ indicates a rising tone.

But is there a CTU in Mandarin? Duanmu's answer is no. His central argument is that there is a direct correlation between syllable weight and the tone-bearing ability of the syllable. He argues that all Beijing full syllables are heavy (with two rhyme slots or moraic units), and hence they carry two level tones. Since there is already a one-to-one correlation between TBU and tone, no tone shift occurs in sandhi positions, giving the appearance of contour tone stability. All Shanghai full syllables are light (with one rhyme slot or moraic unit), and hence they can only carry one level tone, shifting the rest (if there is any) to the following syllables in the sandhi domain. But in monosyllabic domains, full syllables in Shanghai are lengthened, due to the metrical constraint against degenerated feet (feet consisting of single light syllables, McCarthy and Prince 1990). In other words, in non-monosyllabic domains, a full syllable in Beijing has three segment slots, CVX, and all underlying syllables in Shanghai have two segmental slots, CV. Duanmu therefore argues that (132) should be re-analyzed as (133):

(133) Syllable weight and tone in Beijing and Shanghai (Duanmu 1994b)

i) Beijing

mo → moo	'grind'	mo + lə → moo lə	'ground'
LH LH		LH LH	

ii) Shanghai

mu → muu	'grind'	mu + lə? → mu lə?	'ground'
LH LH		LH L H	

This analysis suggests that the differences of tonal behavior between Beijing and Shanghai are more apparent than real. The real difference, Duanmu argues, lies in syllable weight. The difference in tonal behavior is but a trivial consequence of the difference in the weight of the syllable. To support this claim, Duanmu (1994b) measures the syllable duration of Beijing and Shanghai, and finds that the Beijing syllable is significantly longer than the Shanghai syllable. This result, Duanmu contends, supports his claim about the syllable weight of Beijing and Shanghai.

Duanmu further extends his analysis of contour tones to all Chinese languages. He classifies Chinese languages into two types. Languages which are similar to Mandarin are called M-languages. In M-languages, there are contrasts in the coda position, there are diphthongs, and in sandhi

positions contour tones do not break into sequences of level tones (132i). All major branches of Chinese other than Wu fall into the M-language type. Languages which are similar to Shanghai are called S-languages. In S-languages, there is no contrast in the coda position, there are no diphthongs, and in sandhi positions contour tones break into sequences of level tones and shift to the following syllables in the sandhi domain. All S-languages listed by Duanmu are from the Wu branch of Chinese. The difference between S-languages and M-languages can be summarized below:

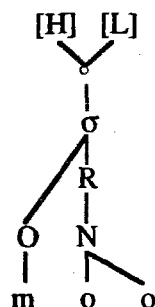
(134) M-languages and S-languages in China (Duanmu 1994a,b)

	Coda contrast	Diphthongs	Tone sandhi
Mandarin	+	+	contours do not break
Cantonese	+	+	contours do not break
Xiamen (Amoy)	+	+	contours do not break
Meixian (Hakka)	+	+	contours do not break
Fuzhou	+	+	contours do not break
New Shanghai	–	–	contours break
Old Shanghai	–	–	contours break
Suzhou	–	–	contours break
Danyang	–	–	contours break
Shaoxing	–	–	contours break
Nantong	–	–	contours break

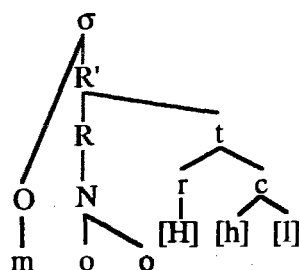
Duanmu's proposal has the advantage of bringing out the correlation between the complexity of the tone and the weight of the syllable. Such a correlation is obscured if the TBU is taken as the syllable (Yip 1989) or the rhyme (Bao 1990). Compare the representation of *mo* in these three proposals:

(135) A comparison of Yip (1989), Bao (1990), and Duanmu (1990)

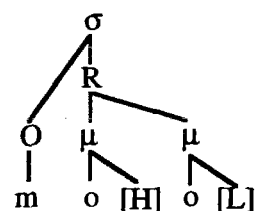
i) Yip (1989b)



ii) Bao (1990)



iii) Duanmu (1990)



6.1.3. Complex contour tones

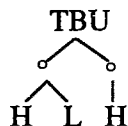
Duanmu's approach to contour tones is essentially an updated version of Woo (1969), and hence suffers similar criticisms as its predecessor. One problem is the complex contour tones in what Duanmu calls the S-languages. Suzhou is a Wu dialect closely related to Shanghai. Although the transcriptions of Suzhou tones vary from one author to another, it is generally agreed that there are seven tones in this language. Here we compare three transcriptions:

(136) The transcriptions of Suzhou tones

	I	II	III	IV	V	VI	VII
i) J. Yuan (1960)	44	24	41	513	331	4	<u>23</u>
ii) Z. Xie (1982)	44	23	52	412	31	<u>55</u>	<u>23</u>
iii) P. Wang (1983)	44	113	41	523	242	<u>43</u>	<u>23</u>

From these transcriptions, at least one tone—Tone IV—can be established as a complex contour tone. Yip (1989:167) represents this tone as in (137):

(137) Suzhou complex contour tone:



Now, according to Duanmu, the major difference between M-languages and S-languages is in the weight of the syllable. In M-languages there are diphthongs and codas; all regular syllables are heavy, and they become extra heavy when they occur in the phrase-final position. By contrast, there are no diphthongs and no coda in S-languages; all syllables are light and they become heavy only in the phrase-final position. Since the maximum number of moras in M-languages is three, and since syllables of S-languages are always one mora less than those of M-languages, the inevitable conclusion is that complex contour tones can never occur in S-languages. This prediction, however, is proved false by the Suzhou example.

6.1.4. *Short contour tones*

The second problem of Duanmu's approach concerns the short contour tones. Since Duanmu's framework requires a one-to-one correlation between tone and TBU, it predicts that short contour tones do not exist in any language. The same prediction has been made in Woo's framework (1969), but later proved to be too strong (Leben 1973; Anderson 1978), evidence of short contour tones having been found in both African and Asian languages. Anticipating criticisms, Duanmu treats short contour tones in two different ways. In Duanmu (1990), he analyzes checked syllables such as *tat* as bimoraic, i.e. the final obstruent is analyzed as an independent mora. Under this analysis, short checked syllables are thus qualified for bearing contour tones. In his later studies (Duanmu 1994a, b), he argues that the TBU's of short contour tones must fall on lengthened vowels (hence bimoraic), but because of the phonemic tradition whereby predictable duration is not transcribed, the two moras are represented as one. In essence, both of these analyses imply that short contour tones are in fact not short. This is tantamount to saying that there are no short contour tones. Here we discuss these two claims.

First, let us look at the stipulation that syllable finals in checked syllables are tone bearers. Take Shanghai for instance. Traditionally Shanghai is analyzed as having three types of rhyme. They are i) vocalic rhymes, which consist of vowels only; ii) nasal rhymes, which consist of a vowel and a nasal; and iii) checked rhymes, which consist of a vowel and a [ʔ]. As noted above in § 6.1.2, Duanmu argues that all Shanghai rhymes are light: vocalic rhymes consist of a single vowel, nasal rhymes consist of a nasalized vowel, and checked rhymes consist of a glottalized vowel. In other words, the glottal stop in checked rhymes does not constitute an independent timing unit.

As seen in Chapter Four, checked syllables in Asian languages usually end in one of the voiceless stops [p, t, k, ʔ]. It is generally true that all these stops are very short, just like the Shanghai [ʔ]. They are articulated 'with neither distinct hold nor release' (Xu 1984:437). It is therefore inappropriate to analyze them as independent timing units on a par with vowels and sonorant consonants. Hence final obstruents in checked syllables cannot be tone bearers.⁶⁸

⁶⁸ Duanmu (1990) has already argued that Shanghai rhymes are light, but in the same work he also argues that [ʔ] is a tone bearer in Shanghai. The analysis is obvious inconsistent.

Let us now look at the claim that short contour tones can only fall on lengthened vowels. F-K. Li (1965) compares eight dialects of the Tai and Kam-Sui languages. In two of these dialects, T'en and Mak, the checked tone D1 has split into two variants conditioned by vocalic length. 'The long vowels give 44 in Mak and 22 in T'en, short vowels give 35 in both' (Li 1965:151). In the dialects Li-Ngam, Jungchiang, and Pyo, Tone D1 does not split, but the tone still has a rising pitch. For example:

(138) Contour tones in short checked syllables (Li 1965:176-7)

Mak	T'en	Li-Ngam	Jungchiang	Pyo	
taap ⁴⁴	taap ²²	tap ³⁵	tap ³⁵	tap ³⁵	'to carry loads on a pole'
tap ³⁵	tap ³⁵	tăp ³⁵	tăp ³⁵	tăp ³⁵	'liver'

Further examples of short contour tones are shown in (139):

(139) Further examples of short contour tones (Li 1965:176-7)

Mak	T'en	Li-Ngam	Jungchiang	Pyo	
put ³⁵	put ³⁵	put ³⁵	put ³⁵	put ³⁵	'lung'
ʔdāk ³⁵	dāk ³⁵	ʔdāk ³⁵	ʔdāk ³⁵	lāk ³⁵	'deaf'
ʔbit ³⁵	bjət ³⁵	ʔbjət ³⁵	ʔbit ³⁵	mit ³⁵	'to pick flowers'
măt ³⁵	măt ³⁵	măt ³⁵	măt ³⁵	măt ³⁵	'flea'
tət ³⁵	tət ³⁵	tət ³⁵	tut ³⁵	tet ³⁵	'to break wind'
tok ³⁵	tok ³⁵	tok ³⁵	tok ³⁵	tok ³⁵	'to drop down'

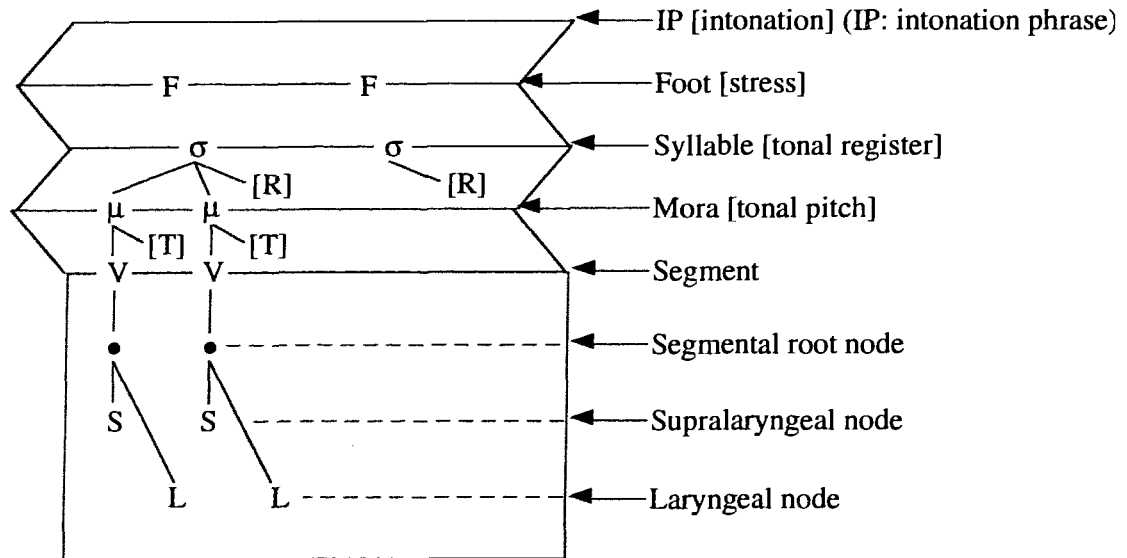
These data show unequivocally that contour tones do co-exist with short vowels. In short, both the above two analyses of the short contour tone require a one-to-one match between tone and TBU. Such a match, however, is untenable.

6.1.5. Double TBU

As shown in § 6.1.3 and § 6.1.4, the selection of TBU as either the syllable or the mora has direct consequences to the analysis of contour tones and the relationship between syllable weight and tonal complexity. In this section we discuss two proposals in which the TBU resides on two levels of representation, i.e. both the syllable and the mora.

Chang (1992) proposes to retain CTU, and to take both the syllable and the mora as the TBU. This proposal is embodied in the following tonal representation:

(140) Tonal representation (Chang 1992)



In this representation, there are four prosodic levels: the IP, the foot, the syllable, and the mora. They serve as the anchors for intonation, stress, register, and tone, respectively. Unique in this proposal is that register and tone are anchored at different prosodic levels. They then undergo a process of percolation, which 'facilitates the coordination of all features into articulatory reality' (P.46). Chang's principle of percolation is given in (141) and exemplified in (142):

(141) Principle of percolation (Chang 1992: 46)

Prosodic features (e.g. tone features) at a certain level in the prosodic structure must percolate through elements on each subsequent level until they reach the laryngeal node under a segmental root node.

(142) Processes of percolation



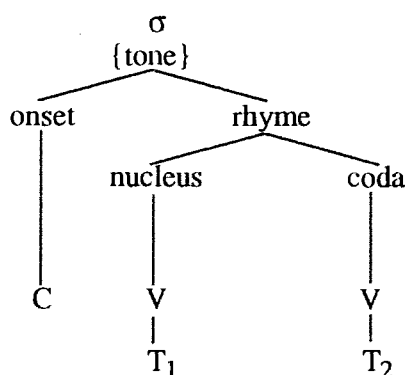
In (142) the register feature [upper] percolates down to the moraic segments but not to the onsets, 'because no elements is available at the mora level to carry out the percolation for the onset segment'

(p.46). This treatment is in line with moraic theory, which allows only the moraic elements to carry tone.

The biggest advantage of Chang's model is that by taking both the syllable and the mora as the TBU, it captures the advantages of contour features (Wang 1967; Shih 1986) and CTU (Yip 1989) on the one hand, and it also captures the correlation between the length of the rhyme and the complexity of the tone (Woo 1969; Duanmu 1990, 1992, 1993, 1994a,b). But Chang's model also has a problem: this model depends on the uni-register hypothesis. As shown in (142), the register value at the syllable level can only be one, either [+upper] or [-upper]. But as argued in § 2.3.3, the uni-register restriction is untenable.

Chang's representation is similar to the hypothesis of autosegmental licensing proposed by Goldsmith (1990), in that in both proposals the TBU resides on two levels of prosodic representation. Under autosegmental licensing, both the syllable node and coda node are taken as licensers. The syllable node is the primary licenser and is language universal. The coda node is secondary and is language specific. All autosegmental material must be licensed by either the syllable node or the coda node; elements not licensed will be deleted. In terms of tone, the licensing process can be represented as below:

(143) Autosegmental licensing (Goldsmith 1990)



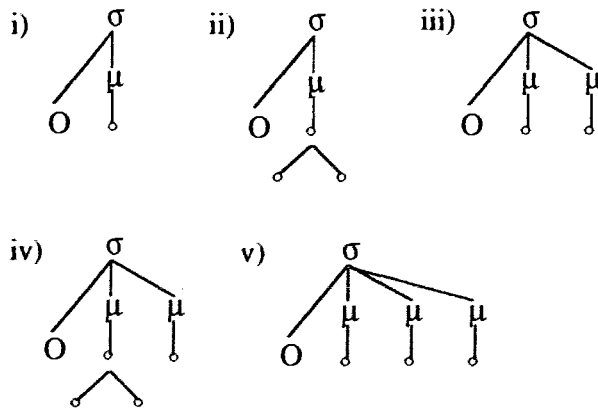
If we take the syllable to license the register feature, and the coda to license the tone feature, then the autosegmental licensing hypothesis is remarkably compatible with the feature system I proposed in Chapter Three, i.e., codas induce tonogenesis and onsets induce register split. There are, however, two problems. First, if the syllable node licenses the register feature, then under

Goldsmith's proposal each syllable can have only one register value. Similar to Yip's CTU analysis, this position also depends on the uni-register hypothesis, which I have argued against in Chapter Two. Second, under Goldsmith's formulation, only heavy syllables are allowed to have contour tones. He says, 'If the coda of a language licenses association to tone, then the syllable will give the appearance of associating to one tone when it is light, and to two when it is heavy' (Goldsmith 1990:127). In other words, short contour tones cannot be represented.

6.1.6. An alternative analysis

To overcome the difficulties encountered by previous analyses, I adopt the following representation:

(144) Tonal Representation



(144) is built on two hypotheses, namely, the moraic hypothesis (Hyman 1985, McCarthy and Prince 1986, Hayes 1989), and the contour-tone-unit hypothesis (Yip 1989b). In this representation, CTU is retained, but its occurrence is restricted on the head mora. In monomoraic syllables (144i, ii), the tonal root node may or may not branch. In bimoraic syllables (144iii, iv), only the head mora can branch. (144v) represents a trimoraic syllable, which normally occurs at the end of the phonological phrase (Yip 1989; Duanmu 1994a,b). (144ii) is the representation of short contour tones as in (138) and (139). (144iv) is the representation of bimoraic contour tones as in (136).⁶⁹

⁶⁹ In Yip and Duanmu's discussions of trimoraic syllables, there are no examples of ultracomplex tones. Since we have allowed the branching of the head mora, there is no *a priori* reason to rule out (144vi) which can be used to represent ultracomplex tones (Edmondson 1991) (see fn. 13, p. 33):

(144) takes the advantages of the moraic approach (Hyman 1985, McCarthy and Prince 1986/1993, and Hayes 1989), where closed syllables can be analyzed as either heavy or light depending on language-specific differences:

(145) Closed syllables in moraic theory

i) light syllable



ii) heavy syllable

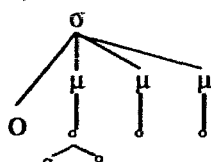


Such a freedom of analysis is not available in approaches that do not recognize the mora, such as the autosegmental licensing hypothesis, where closed syllables always have two timing units.

The representation in (144) has been adopted in King-Jiang (1994, 1995). It is shown there that in order to account for the interaction between tone and vowels there is need to allow the head mora to branch. As we have seen above, short contour tones also call for the branching of the head mora.

By adopting the representations in (144), the following can be achieved. First, by associating two tonal root nodes independently to two moras (144iii, iv), the uni-register restriction as required by Yip (1989), Goldsmith (1990) and Chang (1992), can be avoided. Second, short contour tones can be represented (144ii). Third, the observation by Woo and Duanmu that there is a certain correlation between syllable weight and tonal complexity can be accounted for, i.e. a complex tone needs at least two moras.

(144vi)



However, it is unclear to me at this point whether syllables with ultracomplex tones are extra heavy and thus subject to trimoraic analysis. Further study in this issue is needed.

6.2. *The nature of tone features*

In the Jakobsonian theory of distinctive features (Jakobson, Fant, and Halle 1952; Jakobson and Halle 1956), a feature can be defined in either articulatory, acoustic or auditory/perceptual terms. Jakobson, however, attaches special importance to the perceptual aspect of speech. He writes:

the specification of phonemic oppositions may be made in respect to any stage of the speech event from articulation to perception and decoding, on the sole condition that the variables of any antecedent stage be selected and correlated in terms of the subsequent stages, given the evident fact that we speak to be heard in order to be understood (Jakobson, Fant and Halle 1952:13).

The closer we are in our investigation to the destination of the message, the more accurately can we gauge the information conveyed by the sound-chain. This determines the operational hierarchy of levels in their decreasing pertinence: perceptual, aural, acoustical and motor (the latter carrying no direct information to the receiver except for the sporadic help of lip-reading). The auditory experience is the only aspect of the encoded message actually shared by the sender and the receiver since the speaker normally hears himself (Jakobson and Halle 1956:33-34).⁷⁰

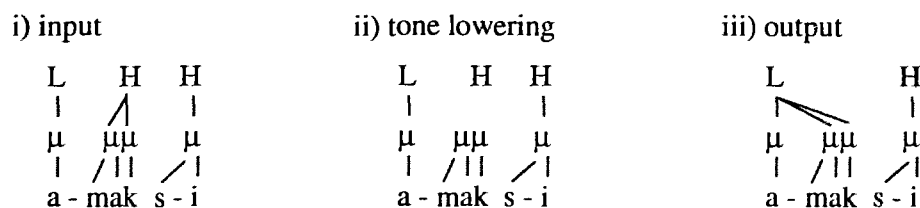
In early studies of tone features, such as Jakobson and Halle (1956), Wang (1967), Sampson (1969) and Woo (1969), the nature of tone features is not a major issue; in these studies, tone features are typically defined in perceptual terms (Fromkin 1972:50). In later studies, the issue of tonal correlates becomes a major concern. Ladefoged (1971b, 1972) and Maran (1971) bring up the issue of quantifiability and falsifiability, arguing that if a feature system is viewed as a theory about the innate phonetic capabilities of man, it should be measurable and quantifiable, and therefore there is no place for features which invoke the unfalsifiable notion of perceptual reality. Maran (1971) and Peng (1992) define their features in terms of F_0 variation; their features can be called acoustic features. Halle and Stevens (1971), Bao (1990), Duanmu (1990), Chang (1992), and McHugh (1993b) define their features in terms of laryngeal configurations; their features can be called articulatory features.

The representation of tone is determined to a large extent by the nature of tone features. Generally speaking, perceptual tone features are less restricted in terms of association with other phonological

⁷⁰ Jakobson distinguishes the perceptual aspect of speech from the auditory aspect. In this thesis, however, the term 'perceptual' is used in a broader sense to cover both the perceptual and auditory aspects of speech.

elements; they can be associated with either the syllable (Yip 1989), the mora (Hyman 1992), the vowel (Goldsmith 1976) and/or the consonant. Acoustic features by definition cannot be associated with voiceless consonants, since voiceless consonants do not have F_0 . Hence the following representation from Peng (1992:76-7) is incomprehensible, where a tone is associated with a voiceless consonant:

(146) A mismatch between feature definition and tonal representation



By definition articulatory tone features have to be associated with the laryngeal node (Bao 1990, Duanmu 1990, Chang 1992). If associated with a prosodic unit (mora, rhyme, or syllable), additional mechanisms have to be invoked to justify such an association (Bao 1990; Chang 1992).

A big problem with Halle and Stevens' (1971) articulatory approach is that it can only distinguish three tone heights. Later proponents of this approach (Bao 1990, Duanmu 1990, Chang 1992, and McHugh 1993b) try to incorporate more tone heights into their articulatory models, but they fail to pinpoint the exact articulatory mechanisms which are responsible for the additional tone heights, and they make conflicting and sometimes unsustained claims about the human laryngeal functions. Commenting on Bao (1990) and Duanmu (1990), Chang (1992) remarks,

It is not clear to me if their decisions on the articulators were based on precise phonetic evidence, or simply due to a theoretical need to correlate their proposed features to some plausible articulators in the realization of tone.

Unfortunately, such a state of affairs has not been improved in the latest developments in the articulatory approach (Chang 1992; McHugh 1993b).

The acoustic approach has similar problems with respect to the number of tone heights specifiable by the feature system. Maran's model (1971) is limited to three tone heights, and Peng's modification (1992) fails its own purpose (§ 1.2.18).

Articulatory features can capture the interactions between consonant voicing and tone in a straight-forward way. This is one of the reasons that they are adopted in some of the previous tone models. But since similar pitch movement can be induced by different types of consonantal contrast, rather than just the simple voiced:voiceless contrast, articulatory features cannot achieve the maximum generalization (§ 5.6). Besides being problematic with tonal representation, articulatory features are also problematic with segmental representation (Lombardi 1991). In fact, Halle and Stevens' system (1971) has never been generally accepted in segmental representation, where the most common practice has been to use [voice], sometimes along with [spread glottis] and [constricted glottis] to indicate aspiration and glottalization, respectively (Kenstowicz 1994).

In view of the above difficulties with articulatory and acoustic features, no attempt is made in this thesis to define the features proposed in Chapter Three in either articulatory or acoustic terms. The new features are not correlated with any single or groups of laryngeal muscles. Rather, they can be regarded as designating the perceptual effect of pitch movement induced by a variety of articulatory mechanisms, some are laryngeal, some are not (Chapter Five). From a historical point of view, they designate pitch movement induced by syllable-initial and syllable-final consonants, and by the interactions between different suprasegmental features (Chapter Four). I believe that only when tone features are defined in perceptual terms, can they achieve the maximum generality.

This leads us back to the issue of quantifiability and falsifiability of perceptual features. This is a pseudo issue. First, the linguistic notions of tone, such as level and contour, have always been defined in perceptual terms. Take, for instance, Pike's definition of level and gliding tones (Pike 1948:5):

A LEVEL toneme is one in which, within the limits of perception, the pitch of a syllable does not rise or fall during its production.

A GLIDING toneme is one in which during the pronunciation of the syllable on which it occurs there is a perceptible rise or fall, or some combination of rise and fall, such as rising-falling or falling-rising.

In terms of F_0 plot, what is called a level tone may not be level at all. If the acoustic features are meant literally, there would be practically no level tones to represent, because pitch production

always involves F_0 fluctuation. Acoustic tone features, if they are used at all, cannot be taken literally as referring to some actual F_0 specifications. What they actually represent, paradoxically, are the perceived tone patterns.

Second, Halle and Stevens' articulatory system (1971) is developed using modeling of the vocal tract, rather than the actual measurement of articulatory muscle movement. Their tonal features and all the subsequent articulatory features based on theirs, have the same problem of measurability and quantifiability as the perceptual features.

Third, with the exception of some acoustic recordings of tone, the majority of the tonal data that are used as the input of articulatory or acoustic tone models are perceptual transcriptions. That is, all the available articulatory and acoustic tonal features are used mainly to represent perceptual data. There is therefore a discrepancy between what is claimed in articulatory and acoustic approaches and what is actually done in practice. Perceptual features of tone do not have this problem.

6.3. The value of tone features

The issue of tone feature values (binary or privative) is closely related to such issues as the number of tone features, the relationships between tone features, the redundancy in a feature system, the number of tone heights and the number of registers specifiable by a system. As shown in § 1.2, most researchers of tone use binary features. Although Clements' features (1981b) are in effect privative, he does not explicitly say so. Hyman (1986, 1992) defines his features as binary, but they are functionally privative, since nowhere in the papers is the minus value of the two features used. Only McHugh (1993b) explicitly uses a privative system.

The use of privative features is not new. Trubetzkoy (1969) allows for three types of opposition: privative, gradual, and equipollent. A privative opposition refers to a difference in the presence or absence of a certain property. A gradual opposition refers to a difference in degree of the same property. An equipollent opposition refers to a difference in the presence of one property and the presence of another property, the two being logically equivalent. In Trubetzkoy's system, an equipollent opposition is binary only in cases where a single dimension is involved.

In the Jakobsonian theory of distinctive features, the distinctions between privative, gradual and equipollent oppositions are abandoned, and all distinctive features are strictly binary. For Jakobson, the binarity principle is inherent in the structure of the human mind, in the language-acquisition process, and in the communication process itself; it therefore allows for an optimal and most economical description of language (Jakobson, Fant and Halle 1952; Jakobson and Halle 1956). The binarity principle is so influential that it is still the dominant view in contemporary phonology.

In recent years there has been a renewed interest in privative features, inspired in part by the study of underspecification (Kiparsky 1982b; Pulleyblank 1986; Archangeli 1988b; Ringen 1988). Archangeli (1988a) distinguishes three types of underspecification. In contrastive underspecification, non-contrastive feature values, i.e. values that are predictable from the values of other features in the underlying representation, are left unspecified. In radical underspecification, all feature values predictable either in the underlying representation or from later derivations, are left unspecified. Under the first two types of underspecification, features are formally binary. In the last type of underspecification, inherent underspecification, some or all the features are privative.

The privative approach has been taken in the analysis of vowel features (Hulst 1988), supralaryngeal features (Avery and Rice 1989), laryngeal features (Lombardi 1991), and nasal feature (Trigo 1993; Steriade 1993a,b).

Hulst (1989) summarizes three arguments for the privative approach. First, both the privative and the binary approaches divide the set of segments in two. Under the binary approach, both of the two sets (specified as [+F] and [-F]) are accessible to phonological representations and rules. Under the privative approach only one of the two sets is accessible. The other set, lacking any feature specification, cannot spread, delete, or be inserted. The privative system thus reduces a large number of possible natural classes, phonological systems, and processes. Second, to address the issue of which the two values of binary features are more common or natural, the binary approach has to resort to such mechanisms as the markedness convention (*SPE*) or the default values and rules (Radical Underspecification). Under the privative approach, such mechanisms are unnecessary. In short, the privative approach 'not only leads to a reduction of the phonological machinery, but it also

reduces the amount of phonological computation. Most importantly, however, it leads to a more constrained theory.’ (Dikken and Hulst 1988:45).

The relationships between tone features can be of three types, i.e. intersecting, hierarchical, and parallel. The most common type of relationship in early tone-feature systems is intersecting. In Sampson (1969), Woo (1969), Maddieson (1970), Maran (1971), Fromkin (1972) and Hyman (1986), it is the minus value of the two features [high] (or [raised]) and [low] (or [lowered]) that intersects. In Goldsmith (1976) and Hyman (1992), it is the plus value that intersects. In systems that distinguish five tone heights, a third feature ([mid] or [extreme]) further intersects with the first two. The second type of relationship, the hierarchical relationship, has also been in use for a long time. In Wang (1967), [mid] is completely dominated by [central]. In Woo (1969), [modify] is dominated by both [high] and [low]. Since Yip (1980), hierarchical dominance has become the major type of relationship that holds between different tone features (Clements 1981b; Yip 1989; Bao 1990; Chang 1992; McHugh 1993b). The third type of relationship, the parallel relationship, is as common as the intersecting relationship. In systems where an intersecting relationship holds between the minus value of two features, a parallel relationship holds between the plus value of the two features, and vice versa. The only exception is the feature system proposed in Chapter Three, where the only relationship between the two features [high] and [low] is parallel. There is no intersecting relationship between the two features, because they are not binary.

The restriction of redundancy has always been used as one of the major criteria in evaluating a tone-feature system. With seven binary features, Wang’s system (1967) can yield 128 different tone patterns, far exceeding the number of tones any language can distinguish. To reduce the redundancy built in Wang’s system is one of the major objectives of Woo (1969), who uses three binary level-tone features to specify five tone heights. Since three binary features can specify eight objects, there is still a redundancy of three in Woo’s system. Yip (1980) further reduces the number of binary features to two, thus eliminating all the redundancy from the system. The key to achieve this elimination is to change the intersecting relationship between features to a hierarchical relationship. But Yip’s system is too restrictive in that it cannot represent languages with five tone heights. Subsequent attempts to incorporate five tone heights, however, have ended up in overgeneration. Using four binary features, Duanmu (1990) can specify up to nine tone heights; using three binary

features, Chang (1992) can specify six. It thus seems that binary features either end up in overgeneration or undergeneration, no matter what kind of relationship holds between the features. This problem is solved in McHugh (1993b), who, by using three privative features, achieves five tone heights while eliminating all redundancy.

The feature system I propose in Chapter Three also uses privative features. It differs from McHugh's system in the following aspects. First, it uses two features, one fewer than McHugh's system. Second, McHugh's three features are defined in three different ways, and three different relationships hold between the features. In contrast, the two features in the new system are defined in the same way (61), no matter whether they specify register or tone, and a simple parallel relationship holds between the two features. This simple relationship guarantees the overall simplicity of the new system.

Chapter Seven

Conclusion

In this study, I proposed a feature system to represent five tone heights and three registers, and to offer a unified account of both syllable-initial induced register split and syllable-final induced tonogenesis. A number of other issues are also examined, including the interactions between the number of tone heights and the tone space, the relationship between tone features and register features, the representation of contour tones and the TBU, and the value and nature of tone features.

To conclude the thesis, twenty previous systems of tone features are compared with the new system proposed in Chapter Three. Thirteen aspects are compared, which are indexed in (147). The result of the comparison is shown in (148), where the blanks indicate that either the items are irrelevant to the system being compared, or the treatment of the issues is unclear within the system being compared.

(147) Index for (148)

- A** = number of features
- B** = type of features (2 = binary; 1 = privative)
- C** = number of levels
- D** = I-R match (initial-register match)
- E** = number of registers
- F** = register tripartition
- G** = F-T match (final-tone match)
- H** = same features for register and tone
- I** = register overlapping
- J** = mid is the least marked
- K** = cover features for consonant and tone
- L** = contour features
- M** = TBU (σ = syllable; R = rhyme; μ = mora; S = segment)

(148) A summary of proposals

	A	B	C	D	E	F	G	H	I	J	K	L	M
1. Jakobson and Halle (1956)	4	2	4		2		-	-	-		-	+	σ
2. Wang (1967)	7	2	5				-			-	-	+	σ
3. Sampson (1969)	7	2	5				-			-	-	+	σ
4. Woo (1969)	3	2	5				-			+	-	-	S
5. Maddieson (1970)	3	2	5				-			+	-	-	S
6. Maran (1971)	2	2	3				-			+	-	-	S
7. Halle and Stevens (1971)	2	2	3				-			+	+	-	S
8. Fromkin (1972)	4	2	5				-			+	-	+	S
9. Goldsmith (1976)	2	2	3				-			-	-	-	σ
10. Yip (1980)	2	2	4	+	2	-	-	-	-	-	-	-	σ
11. Clements (1981b)	2	1	4	+	2	-	-	+	-	-	-	-	
12. Hyman (1986)	1	2	5	+	2	-	-	+	-	-	-	-	μ
13. Shih (1986)	8	2		+	2	-	-	-	-		-	+	
14. Yip (1989b)	2	2	4	+	2	-	-	-	-	-	-	-	σ
15. Bao (1990)	2	2	4	+	2	-	-	-	-	-	+	-	R
16. Duanmu (1990)	4	2	9	+	3	-	-	-	+	+	+	-	μ
17. Hyman (1992)	1	2	9	+	3	-	-	+	+	+	-	-	μ
18. Peng (1992)	2	2	4	+	2	-	-	+	-	-	-	-	μ
19. Chang (1992)	3	2	6	+	2	-	-	-	-	-	+	-	σ/μ
20. McHugh (1993)	3	1	5	+	2	-	-	-	-	-	-	-	
21. Fu (Chapter Three)	2	1	5	+	3	+	+	+	+	+	-	-	μ

Although the comparison is limited, the advantage of the new proposal is obvious. First, the new proposal has some properties that none of the previous proposals has, such as items F and G. Second, the new proposal incorporates many advantages of the previous proposals, such as items D, H, I, and J. Third, with all these functions, the new proposal is not complex, as can be seen from items A and B. Last, the new proposal can handle five distinctive tone heights and three registers, which I believe are the maximum any language can distinguish. In contrast, no previous model can

handle both of them. With register overlapping, the new proposal successfully answers the question why there is three-way register split, but there is no language that distinguishes nine discrete tone levels.

Bibliography

Abbreviations

<i>ALH</i>	<i>Acta Linguistica Hafniensia</i> . Copenhagen.
<i>ALS</i>	<i>African Language Studies</i> . London.
<i>AO</i>	<i>Acta Orientalia</i>
<i>BEFEO</i>	<i>Bulletin de l'Ecole Française d'Extrême-Orient</i> . Paris.
<i>BIHP</i>	<i>Bulletin of the Institute of History and Philology, Academica Sinica</i> . Taiwan.
<i>BLS</i>	<i>Proceedings of the Annual Meeting of the Berkeley Linguistics Society</i> .
<i>BMFEA</i>	<i>Bulletin of the Museum of Far Eastern Antiquities</i> . Stockholm.
<i>BSOAS</i>	<i>Bulletin of the School of Oriental and African Studies</i> . London.
<i>BSLP</i>	<i>Bulletin de la Société de Linguistique de Paris</i> .
<i>CAAL</i>	<i>Computational Analyses of Asian and African Languages</i> . Tokyo.
<i>CAAL</i>	<i>Current Approaches to African Linguistics</i> .
<i>CJL</i>	<i>Canadian Journal of Linguistics</i> . Toronto.
<i>CLS</i>	<i>Papers from the Regional Meeting of Chicago Linguistic Society</i> .
<i>Fangyan</i>	<i>Dialect. Quarterly journal</i> . Beijing.
<i>GL</i>	<i>General linguistics</i>
<i>HJAS</i>	<i>Harvard Journal of Asian Studies</i>
<i>IJAL</i>	<i>International Journal of American Linguistics</i>
<i>JA</i>	<i>Journal Asiatique</i>
<i>JAOS</i>	<i>Journal of the American Oriental Society</i> . New Haven.
<i>JAS</i>	<i>Journal of Asian Studies</i> . New York.
<i>JASA</i>	<i>Journal of the Acoustical Society of America</i>
<i>JCL</i>	<i>Journal of Chinese Linguistics</i> . Berkeley.
<i>JEAL</i>	<i>Journal of East Asian Linguistics</i> .
<i>JICS</i>	<i>Journal of the Institute of Chinese Studies of the Chinese University of Hong Kong</i> .
<i>JIPA</i>	<i>Journal of the International Phonetic Association</i>
<i>JL</i>	<i>Journal of Linguistics</i>
<i>JP</i>	<i>Journal of Phonetics</i>
<i>JSHR</i>	<i>Journal of Speech and Hearing Research</i>
<i>Lg</i>	<i>Language</i> . Baltimore.
<i>LI</i>	<i>Linguistic inquiry</i> .
<i>LTBA</i>	<i>Linguistics of the Tibeto-Burman Area</i>
<i>MP</i>	<i>Le Maître Phonétique</i>
<i>MIT WPL</i>	<i>MIT Working Papers in Linguistics</i>
<i>MZYW</i>	<i>Minzu Yuwen</i> . Beijing.
<i>NLLT</i>	<i>Natural Language and Linguistic Theory</i>
<i>OPWSTBL</i>	<i>Occasional Papers of the Wolfenden Society on Tibeto-Burman Linguistics</i>
<i>PL</i>	<i>Pacific Linguistics</i> . Canberra.
<i>PP</i>	<i>Perception & Psychophysics</i>
<i>PY</i>	<i>Phonology Yearbook</i> .
<i>SAL</i>	<i>Studies in African Linguistics</i>
<i>THJCS</i>	<i>Tsing Hua Journal of Chinese Studies</i> . Taiwan.
<i>TPS</i>	<i>Transactions of the Philological Society</i> . London.
<i>TWPL</i>	<i>Toronto Working Papers in Linguistics</i>
<i>WPP</i>	<i>UCLA Working Papers in Phonetics</i>
<i>WPPL</i>	<i>Working Papers from the Phonology Laboratory, UC Berkeley</i>
<i>YYWZX</i>	<i>Yuyan Wenzhi Xue</i> . Beijing.
<i>YYYJ</i>	<i>Yuyan Yanjiu (Language Study)</i> .
<i>YYYJLC</i>	<i>Yuyan yanjiu luncong</i> . (Collected papers in linguistic studies.) Journal of Nankai University, Tianjin, China.
<i>ZGYYXB</i>	<i>Zhongguo Yuyan Xuebao (Chinese linguistics)</i> . Journal of the linguistic society of China.

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