LINGUISTICS OF THE TIBETO-BURMAN AREA
VOLUME 15:1 — SPRING 1992

An autosegmental analysis of tone in four Tibetan languages*

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0. Introduction. This paper applies an autosegmental analysis to tone in four Tibetan languages: Lhasa Tibetan (LS), Gar Tibetan (GR), Gërzê Tibetan (GZ), and Zedang Tibetan (ZD).[1] [2] I will discuss the representations of underlying tones on monosyllables, and the derivation of tonal patterns in multisyllabic expressions. Our discussion is intended to make three points. First, autosegmental phonology can be successfully applied to Tibetan tone. Second, an autosegmental analysis is superior to a non-autosegmental approach. Third, an autosegmental analysis brings out important similarities between Tibetan tone and tone in other parts of the world, such as Africa and east China, while the traditional approach misses these similarities. In addition, we will discuss what Tibetan tone tells us about the generality of the Association Conventions, rules that govern the linking between tones and segments.

This paper is organized as follows. In Section I, I provide a background for the autosegmental phonology of tone. In Section II, I analyze LS, GR, GZ, and ZD respectively in an autosegmental framework, drawing data mostly from recent publications that appeared in the People's Republic of China in the past decade. In Section III, I compare the proposed analysis with the non-autosegmental approach. In Section IV, I make a few concluding remarks.

1. Background. Autosegmental phonology, which first appeared in the early 1970s, has led to many fruitful results. Of interest to the present discussion are two insights (Williams 1971/6, Yip 1980):

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* A draft of this paper was written in 1989. Since then I have benefited from discussions with M. Halle, Z. M. Bao, and S. Meredith.

1 I follow the tradition of using the name of a place for the language spoken in that place. In addition, many of the names will be spelled in the Pinyin system.

2 Tone in Tibetan languages is a recent phenomenon. In the seventh century, when Tibetan orthography was created, there was no marking for tone. In addition, one of the three modern Tibetan dialect families is still toneless (Hu 1980, Qu 1981, Zhang 1981). The emergence of tone in Tibetan is a result of the loss of contrasts in the consonants surrounding the vowel. Typically, a historical contrast in onset voicing is replaced by a contrast in tone. Thus, historical [kʰo] 'he' and [go] 'hear', which were both toneless, have respectively become [kʰo] with a high tone and [kʰo] with a low rise in Lhasa Tibetan. This process, or **tonogenesis**, to borrow a term from Matisoff (1973), is widely observed in Southeast Asia. For an analysis of tonogenesis in a distinctive feature theory, cf. Duanmu 1991a.

(1) Tones lie on a tier separate from other segmental features, and may freely spread across segments.[3]

(2) Contour tones are composed of clusters of level tones. For example, a rising tone is made up of LH (i.e., a low tone L followed by a high tone H), a falling tone is made up of HL, a fall-rise is made up of HLH, and so on.[4]

For illustration, consider some classic examples from the African language Margi (Williams 1971/6, Hoffman 1963; ˇ = rising tone, ` = low tone, ´ = high tone):

(3) a. vě̀l to jump b. ani causative c. vèlání to make jump

In isolation, the morpheme *vel* shows a rising tone. The morpheme *ani* has no tone. When the two morphemes are put together, the three syllables are respectively L, H, and H. Intuitively, we feel that the rising contour on *vel* in (3a) matches the overall rising contour on *velani* in (3c). In other words, the tones in *velani* must have come from the root *vel*. Specifically, the rising contour on *vel* must have split into a L on the first syllable and a H on the second and third syllables in *velani*. However, this intuitive relation cannot be captured in the framework of Chomsky & Halle (1968), since in that framework, there is no easy way to allow distinctive features to freely move from one syllable to another. In addition, if 'rise' is a single feature, how can it split into two? And if 'rise' is made of two features, how can they both stay on the same vowel in *vel* in (3a) (assuming that tone is carried by the vowel)?

To solve the problem, Williams makes three proposals. First, a contour tone is composed of level tones, following the idea of Woo (1969). Second, tones lie on a special tier, separate from the segments. Third, the relation between tones and segments are governed by a set of **Mapping Rules**. Below is Williams' analysis:

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[3] In the theory of feature geometry, a segment has the structure of a tree, with nodes and branches. Features generally lie on terminal nodes. Each node is on an independent tier, with its own path of spreading. In this view, tone features should also lie on terminal nodes, just as other features do, as suggested by Clements (1985:247). For exposition, we continue to use the notations of Williams, where tones are drawn away from segments.

[4] For proposals that some contour tones, typically those in Chinese languages, may behave as units, cf. Wang 1967, Yip 1989 and Bao 1990.

(4) The Mapping Rules:[5]

a. Associate tones to syllables one-to-one, from left to right
b. If there are more syllables, spread the last tone to excess syllables
c. If there are more tones, link excess tones to the last syllable.

(5) a.

```
          4a      4c
vel  -->  vel --> vel          : segmental tier
          |       |\
LH        LH      L H          : tonal tier
```

b.

```
                4a          4b
vel + ani  -->  velani  -->  velani   : segmental tier
                | |          | | /
LH              L H          L  H     : tonal tier
```

Underlyingly, *vel* lies on the **segmental tier**; its tones LH lie on the **tonal tier**. When there is no suffix, both tones link to *vel*, which surfaces with a rising tone, as shown in (5a). When the suffix *ani* is added, then the tones are linked to the syllables one-to-one, from left to right. Finally, the last tone H spreads to the excess vowel [ɪ], as shown in (5b).

The same analysis applies to more complicated cases, where tone spreading interacts with vowel reduction. In Margi, [i] changes to a glide [y] before [a] and ceases to be a tone bearer, as in:

(6) a. fǐ 'to swell' b. fyànǐ 'to make swell'

The morpheme *fi* has a rising tone in isolation. When the toneless suffix *ani* is added, [ɪ] in *fi* becomes [y]. At the same time, the rising tone of *fi* appears as L and H on *ani*. The derivation can be accounted for if we assume that the Mapping Rules apply after [ɪ]-->[y], as shown below:

(7) a.

```
          4a    4c
fî  -->   fi --> fî
          |     |\
LH        LH    LH
```

b.

```
fi + ani  -->  fyani  -->  fyani
               LH          LH      | |
                                   L H
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As Williams argues, if the rising tones in (3a) and (6a) are an unanalyzable unit, then it is hard to account for the above patterns. Similarly, if tones do not lie on a separate tier, it is hard to explain how they

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5 There is evidence that tones are associated with segments in the rime, instead of the syllable as a whole. For exposition, however, we will follow Williams in assuming that tones are associated with syllables.

can move across segments, e.g., how H from *fi* can move all the way to the last vowel in *ant*.

Autosegmental phonology has been successfully applied to many African tone languages. The Mapping Rules, however, may differ in each language. For example, in Tiv, (4c) does not apply, and excess toneless syllables will take on L as the default tone (Pulleyblank 1986). Autosegmental phonology has also been applied to Chinese languages, especially to the Wu dialect family, spoken in east China. For illustration, let us consider some data in New Shanghai, spoken by the younger generation in Shanghai City. Like many other Wu languages, New Shanghai has what may be called **initial prominence**, by which in a multisyllabic domain, the pitch pattern of the domain is solely determined by the tones from the initial syllable.[6] Consider

(8)	ço	çi	wã	du	ŋ
	MH	HL	LH	LH	LH
	small	fresh	yellow	big	fish

(9)	a.	ço	+	ŋ	-->	ço	+	ŋ		'small fish'
		MH		LH		M		H		
	b.	çi	+	ŋ	-->	çi	+	ŋ		'fresh fish'
		HL		LH		H		L		
	c.	wã	+	ŋ	-->	wã	+	ŋ		'yellow fish'
		LH		LH		L		H		
(10)	a.	ço	+	wã	+	ŋ	-->	ço	+ wã +	ŋ 'small yellow fish'
		MH		LH		LH		M	H	L
	b.	du	+	wã	+	ŋ	-->	du	+ wã +	ŋ 'big yellow fish'
		LH		LH		LH		L	H	L
	c.	çi	+	wã	+	ŋ	-->	çi	+ wã +	ŋ 'fresh yellow fish'
		HL		LH		LH		H	L	L

According to Selkirk & Shen (1990), New Shanghai has three syllable tones,[7] HL, MH, and LH[8], which surface as fall, high-rise, and low-rise

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6 For a discussion of how a domain is determined, cf. Selkirk & Shen 1990, Duanmu 1991b.

7 Since Chinese is a monosyllabic language, a syllable tone may also be considered a morpheme tone, in line with African tonology.

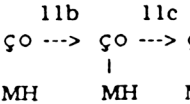
8 For exposition, I will follow Selkirk & Shen and omit the discussion of 'register' in New Shanghai.

respectively on monosyllables; some examples are shown in (8). From (9) and (10), we can make three observations. First, input tones on noninitial syllables have no effect on the output. Second, input tones from the initial syllable are taken one each by the first two syllables in the output. Third, excess syllables get L as the default tone.[9] The above data can be derived by the following rules:

(11) New Shanghai Tone Rules:
- a. Delete tones from noninitial syllables.
- b. Associate tones to syllables one-to-one, left to right.
- c. If there are more tones, link excess tones to the last syllable.
- d. If there are more syllables, excess syllables get L as default.

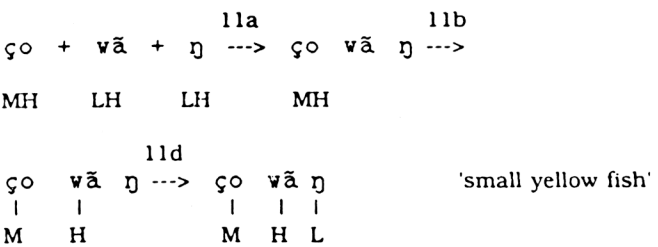
(11a) reflects **initial dominance** in the Wu family. (11b, c), which are the same as (4a, c) in Margi, make sure that when there is just one syllable, it carries all its tones, but when there are more syllables, the initial syllable keeps just one tone and shifts the rest to others. (11d) says that, unlike (4b) in Margi, there is no automatic tone spreading to excess syllables in New Shanghai. Below we show two derivational examples:

(12) a.



'small'

b.



'small yellow fish'

To summarize, we have seen that there are striking similarities between African and Asian tone languages,[10] namely, that a contour tone is

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9 The phonetic values of the excess syllables are mid or low pitch, with a slight drop on the final syllable. One may suggest, as an alternative, that excess syllables remain toneless even at the surface level, along the lines of Keating 1988.

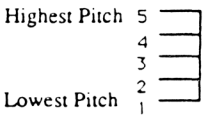
10 [Ed.] I feel that it is a vast overgeneralization to imply that this sort of analysis holds for all "Asian tone languages." In language families like Hmong-Mien, Tai, Lolo-Burmese, and

made of level tones, and that tones lie on an independent tier and may spread across segments. We will now show that the above generalizations also hold for tone in Tibetan languages.

2. Tone in Tibetan Languages. In this section we will apply autosegmental phonology to tone in four Tibetan languages. Before we proceed, a few comments are needed about *Chao letters*, a tone marking system created by Y. R. Chao (1930). Chao letters are the most widely used system in Asian phonology, and most of my sources on Tibetan follow it.

In Chao letters, a speaker's pitch range is divided into five levels, from the highest 5 to the lowest 1:

(13) Chao Letters



Each syllable is usually given two or three letters (i.e. numbers) for its tone. For example, 55 marks a high level tone, 11 a low level, 35 a mid-to-high rise, 13 a low-to-mid rise, 131 a low-mid-low rise-fall, and so on.

Chao letters have a graphic variety, which have been adopted by the International Phonetic Association (1989). In the graphic form, a tone is represented by a vertical bar, which shows the speaker's pitch range, and a short line, which shows the pitch movement on a syllable. For example,

(14) Chao letters: 55 11 33 35 13 53
Graphic:

high level	low level	mid level	high rise	low rise	high fall

When one interprets Chao letters, it is crucial to keep two points in mind. First, Chao letters have a certain degree of flexibility, due partly to the relative nature of pitch height, and partly to the dubious question of whether Chao letters are a phonetic or a phonemic system.[11] As Chao (1930) points out, a variation of one degree between two transcriptions (e.g. between 44 and 55, between 24 and 35, etc.) should not always be taken

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Viet-Muong, it buys one nothing (and flies in the face of known historical developments and synchronic Sprachgefühl) to treat contour tones as anything but indivisible units.

[11] This dubious status haunts the International Phonetic Alphabet, too.

seriously. In fact, Chao himself transcribed the Mandarin (nonfinal) third tone as 11 in one analysis and 21 in another (Chao 1931, 1968).[12] What is more, a transcriber will often modify the actual values of Chao letters for 'visual clarity' (especially when s/he is using the graphic variety) or for other purposes. For example, in transcribing Old Shanghai,[13] Shen (1981:132) says that:

> *The real value of Yin Ping is 52; this paper marks it as 53. The real value of Yin Qu is 33 or 24; this paper marks it as 35. The real value of Yang Qu is 113 or 13; this paper marks it as 13. The real value of Yang Ru is a short tone 23, this paper marks it as 13.*[14]

Similarly, in transcribing New Shanghai, Xu et al. (1981:145) say that

> *Yin Ping is 34; for visual clarity, this paper writes it as 24. Yang Ru is 12; for visual clarity, this paper writes it as 13.*

And in transcribing Lhasa Tibetan, Hu (1980:25) says that

> *(the high level tone) is 44. For visual clarity, it is written as 55.*

The practice of modifying the actual values of Chao letters is extremely common, and is often done without acknowledgement.

The second point to keep in mind is that Chao letters are often used to record the phonetic pitch of a syllable, and not the phonemic nature of a tone. For example, phonemic LH will realize differently on a 'smooth' syllable (e.g. one with a sonorant coda) and a 'checked' syllable (e.g. one with a short vowel and a glottal stop coda).[15] On the former, the pitch contour is a clear rise; on the latter the pitch may not rise as high, or the final pitch may even drop a little due to the glottal closure. Despite the fact that the two syllables may carry the same phonemic tones (which may be demonstrated by evidence from tone spreading, for example), a transcriber will normally give different Chao letters to the two syllables, for example 14 for the smooth syllable and 12 or 121 for the checked syllable. We will soon see this when we look at Tibetan tones below.

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12 This is not due to a change in Mandarin.

13 Old Shanghai is spoken by the older generation in Shanghai City and by people of all ages in some suburbs of Shanghai.

14 Yin Ping, Yin Qu, etc., are traditional names of the tones.

15 [Ed.] Many specialists in Asian tone languages would argue that 'smooth' and 'checked' tones constitute quite separate subsystems, so that it is not fruitful to identify a particular checked tone as being the same phonemically as a particular smooth tone in a given language.

2.1. Lhasa Tibetan (LS).[16] It has been debated whether LS has two, four, or six syllable tones. Sprigg (1981), among others, suggest that LS has two syllable tones (or word tones), which we may call high and low (not to be confused with the tone features H and L, as we will explain below). Qu and Tan (1983) suggest that there are two kinds of high tones and two kind of low tones, depending on the length of the syllable. Thus, Qu and Tan propose four syllable tones, A, B, C, and D:

(15)	High	High	Low	Low
	A	B	C	D
	53	55	12	14
	short	long	short	long
	pa^{53}	$pa:^{55}$	pa^{12}	$pa:^{14}$
	ape	to light	tent	neck tumour

As is shown, A and B are in complementary distribution, as are C and D. A and B are high tones, while C and D are low tones. In addition, A and C occur on short syllables, while B and D occur on long syllables.

Based on an instrumental study, Hu et al. (1982) further distinguish two kinds of short syllables and thus propose six syllable tones:

(16)		High	Low			
	-VN	55	13	long		
	-VP	52	121	short		
	-V	54	12	short		
	$ka:^{55}$	$ka?^{52}$	ka^{53}	$ka:^{13}$	$ka?^{121}$	ka^{12}
	column	prevent	order	install	clog	saddle

[-VN] represents a long syllable, whose rime either is a long vowel, or a short vowel followed by a sonorant segment. Both [-VP] and [-V] are short syllables. [-VP] represents a rime with a short vowel and a stop coda, including a glottal stop. [-V] represents an open rime with a short vowel. Again, [-VN], [-VP], and [-V] are in complementary distribution.

From a phonemic point of view, however, one would like to reduce the underlying syllable tones, as Sprigg points out. The question is how. In particular, we want to support the reduction with phonetic and phonological

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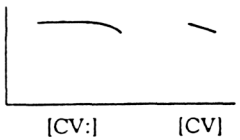
[16] The variety of Lhasa Tibetan in my sources (Hu 1980, Hu et al. 1982, Qu 1981, Qu and Tan 1983) is based on speakers from Lhasa City in the late 1970s. It may differ somewhat from other varieties, such as the one described in Chang & Shefts 1964.

justifications. Comparing the system of Qu and Tan with that of Hu et al., we notice several differences. Some differences need not worry us. For example, the long low tone is 14 in the former and 13 in the latter, but this is within the intrinsic flexibility of Chao letters. Other differences need explanations. For example, [-VP] low is a rise-fall in (16), but this pattern is not found in (15). Let us look at those differences in detail.

Consider [-VP] first. Phonetically, a glottal coda is marked by a sharp drop in pitch, due probably to the sudden closure of the glottis and so reducing the vocal cord vibration to zero (cf. Zee & Maddieson 1979:99-100). In addition, in Chinese languages, stop codas are glottalized. The same is probably true in LS (cf. Hu et al. 1982:28-30). Phonetically Hu et al. correctly recorded this glottal drop. But phonemically one would want to exclude it from the underlying representation. This is probably why Qu and Tan have merged [-VP] 121 and [-V] 12 to give C 12. Similarly, if we discount the glottal drop on [-VP] 52, we would merge it with [-V] 54 to give A 54. But why do Qu and Tan mark A as 53 instead of 54? Qu and Tan give no explanation in their book. However, Tan, a co-author, points out in another paper that "the experimental value (of A) in Lhasa Tibetan is 43 or 54..., for convenience and visual clarity, it is usually marked as 53" (Tan 1987:25).

Let us now look at [-V]. Since this is a short syllable, it is natural that in the Low column, it does not rise all the way to 3 or 4, but stops short at 2. Now in the High column, why does [-V] not hold steady as 55, but tilt down a *little? The reason, I suggest, is again phonetic. From the data of Hu et al.*, we can see that the vowel of a checked syllable (e.g. [kaʔ] 'to prevent') is about 100ms, while the vowel of a smooth syllable (e.g. [ka:] 'pillar') is about 300ms, both being considerably longer than in normal speech. This suggests that the sample syllables must have been spoken either in isolation, or in an environment where the surrounding syllables were unstressed (Hu et al. do not describe the environment in which the syllables were spoken). In either case, we may expect a drop in the final pitch, due to the domain-final intonation, perhaps. This in fact seems to be the case. Compare the following schematic pitch contours of high [-V:] and [-V] syllables (adapted from Hu et al. 1982:35):

(17) Pitch Contours on Isolated High Syllables



On both syllables, the final pitch is lowered. On [CV:], this lowering does not affect overall level contour, but on [CV] the lowering does make the contour look like a fall. That is perhaps why Hu et al. write 55 for the former and 54 for the latter.[17]

The above considerations suggest that there are just two underlying syllable tones, a high level H, which includes A and B of Qu and Tan, and a rise LH, which includes C and D of Qu and Tan. We will see immediately that this view is justified in multisyllabic patterns.

Consider bisyllabic phrases first. According to Qu and Tan (1983:35), there are sixteen combinations (cf. also Hu 1980, Qu 1981):

(18) Bisyllabic Patterns in LS[18]

1.	AA:	53 53 --> 55 53	ɕu? pa	'cypress'
2.	AC:	53 12 --> 55 53	na ma	'bride'
3.	AB:	53 55 --> 55 55	tɕ'u ɕel	'crystal'
4.	AD:	53 14 --> 55 55	ha jaŋ	'aluminum'
5.	CA:	12 53 --> 11 53	ta? po	'master'
6.	CC:	12 12 --> 11 53	to ro	'pile of rocks'
7.	CB:	12 55 --> 11 14	me por	'fire pan'
8.	CD:	12 14 --> 11 14	tça ril	'bowl shaped tea brick'
9.	BA:	55 53 --> 55 53	k'aŋ pa	'house'
10.	BC:	55 12 --> 55 53	laŋ ŋa	'earthenware pot'
11.	BB:	55 55 --> 55 55	sam tçar	'opinion'
12.	BD:	55 14 --> 55 55	çiŋ toŋ	'tree'
13.	DA:	14 53 --> 11 53	sam pa	'bridge'
14.	DC:	14 12 --> 11 53	tuŋ ma	'roof beam'
15.	DB:	14 55 --> 11 14	ŋal tsø	'labor'
16.	DD:	14 14 --> 11 14	ɲam ɲuŋ	'experience'

It can be seen that, if we consider 53 as a variant of 55, and 12 as a variant of 14, conditioned by the phonetic effects we discussed above, then there are just three patterns, [55 55], [11 55], and [11 14]. [55 55] occurs when the first syllable is 55 (or 53). [11 55] occurs when the first syllable

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17 On the high syllables [ka:m] 'do' and [pa:r] 'picture', the pitch contours do not show a final drop (Hu et al. 1982:35). This is probably because Hu et al. have not included the pitch contour on the sonorant coda, since they consider tone to be the the pitch contour 'on the vowel' (pp. 20, 25).

18 Nearly all Tibetan expressions we cite are composed of (strings of) monosyllabic morphemes (L. Gomez personal communication, 1991). For example, in [ɕu? pa] 'cypress', [ɕu?] is the root and [pa] is the nominal suffix. For simplicity I follow Qu and Tan and only give a single gloss to each expression. In addition, Qu and Tan write all vowels before a sonorant coda as long, but Qu (1981) does not. I follow Qu and omit the length marking in [-VN] syllables.

is 14 (or 12) and the second syllable is short. [11 14] occurs when the first syllable is 14 (or 12) and the second syllable is long.

There is a question, however. Why is H on a short syllable 53 in final positions but 55 in nonfinal positions? The answer, I suggest, is twofold. First, as we mentioned above, on final [-V] 53 syllables, the slight pitch drop is due to the domain-final effect; this effect is absent on nonfinal syllables. Second, on final [-VP] 52 syllables, the pitch drop is due to the glottal coda. If the glottal coda is deleted, the pitch dropping effect will also be lost. In Chinese languages, [ʔ] coda is deleted in nonfinal positions (Chao 1928, Xu et al. 1981), and its pitch dropping effect is lost. Although in the transcriptions of Qu and Tan, it is not shown whether Tibetan [ʔ] coda is deleted in nonfinal positions, Hu (1980:36) points out that this is indeed the case.

Given the above considerations, we are able to analyze LS tone in the same way we analyzed Margi and New Shanghai. Below are the rules and some derivations.

(19) *LS Tone Rules:*

a. Delete tones from noninitial syllables.
b. Associate tone to syllables one-to-one, left to right.
c. If there are more syllables, spread the last tone to excess syllables.
d. If there are more tones, link excess tones to the last syllable.
e. If a L precedes a final long syllable with a H, spread L to the latter:

(20)

Underlying tones:	**H**	**LH**	
Realizations:	55	13 (or 14)	-VN
	52	121	-VP
	54	12	-V

(21)

	19b		19d		
ka:	--->	ka:	--->	ka:[14]	'to install'
		|		|\	
LH		LH		LH	

(22) a.=(AC)

	19a		19b		
na ma	--->	na ma	--->		
H LH		H			
	19c				
na ma	--->	na[55] ma[53]			'bride'
|		|			
H		H			

```
                    19a          19b
b. =(CA)   ta? po --> ta? po --> ta?11 po53   'master'
                                    |     |
           LH  H      LH           L     H

                    19a          19b
c.=(CB)    me por ---> me por --->

           LH  H        LH

                    19d
           me por ---> me11  por14            'fire pan'
            |  |          |  /  |
            L  H          L     H
```

The rule (19a) is similar to **initial prominence** in New Shanghai. (19b, c, d) were seen in Margi. (19e) is also found in some African languages (cf. Hyman & Schuh 1974).

Let us now consider trisyllabic expressions. Qu and Tan (1983:36-37) and Qu (1981:24) give the following patterns:

(23)

Initial		Pattern	Last Syllable
A:	53 X X -->	a. 55 55 53	short
		b. 55 55 55	long
B:	55 X X -->	a. 55 55 53	short
		b. 55 55 55	long
C:	12 X X -->	a. 11 55 53	short
		b. 11 55 55	long
D:	14 X X -->	a. 11 55 53	short
		b. 11 55 55	long

(X=any syllable)

Again, if we discount the variation between 53 and 55 (which are short and long respectively on the last syllable), then there are just two patterns, [H H H] and [L H H]. Both patterns follow from our previous rules. Below we show the derivations of (24A, D)[19]

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19 In the expression for 'moth', Qu (1981:24) marks the output tone on [lep] as 55. I consider this to be a typographical error, since [lep] is a short syllable and should be 53 in Qu's analysis.

(24) a

	19a	19b, c
tç'e ma lep	---> tç'e ma lep	---> tç'e^{55} ma^{55} lep^{53}
H LH LH	H	H

'moth'

b.

	19a	19b,c
kã ma tça	---> kã ma tça	----> kã^{11} ma^{55} tça^{55}
LH LH LH	LH	L H

'sleet'

To summarize, LS has two underlying syllable tones, H and LH. Tonal patterns in multisyllabic phrases are derived by first deleting tones from noninitial syllables, and then linking and spreading the tone(s) from the initial syllable to the entire domain.

2.2. Gar Tibetan (GR). According to Qu and Tan (1983:33-35), GR has the same four syllable tones (A, B, C, and D) as LS:

(25)

A	B	C	D
53	55	12	14
pa^{53}	pa:^{55}	pa^{12}	pa:-^{14}
ape	to light	tent	neck tumour

In addition, bisyllabic patterns in GR are very close to those in LS, except in four places indicated by boldface below:

(26) Bisyllabic Patterns in GR

1.	AA:	53 53 --> 55 53	ɕu? pa	'cypress'
2.	AC:	53 12 --> 55 53	na ma	'bride'
3.	AB:	53 55 --> 55 55	tç'u ɕel	'crystal'
4.	AD:	53 14 --> 55 55	ha jaŋ	'aluminum'
5.	CA:	12 53 --> 11 53	ta? po	'master'
6.	CC:	12 12 --> 11 53	ntso mo	'female *pien niu*'[20]
7.	CB:	12 55 --> 11 **55**	me por	'fire pan'
8.	CD:	12 14 --> 11 **55**	tça ril	'round tea brick'
9.	BA:	55 53 --> 55 53	k'aŋ pa	'house'

20 A *pien niu* is the offspring of a bull and a female yak.

10.	BC:	55 12 --> 55 53	aŋ ŋa	'earthenware pot'
11.	BB:	55 55 --> 55 55	ɔam tçar	'opinion'
12.	BD:	55 14 --> 55 55	çiŋ toŋ	'tree'
13.	DA:	14 53 --> 11 53	sam pa	'bridge'
14.	DC:	14 12 --> 11 53	tuŋ ma	'roof beam'
15.	DB:	14 55 --> 11 **55**	ŋal tsø	'labor'
16.	DD:	14 14 --> 11 **55**	ɲam ɲuŋ	'experience'

While in LS the last syllables in CB, CD, DB, and DD surface as 14, those in GR surface as 55. In our analysis, the reason is simple: GR simply lacks the rule (19e). Below are GR tone rules, and the derivation of (26.7) CB (cf. CB of LS in 18.7, 22c):

(27) GR Tone Rules:

a. Delete tones from noninitial syllables.
b. Associate tone to syllables one-to-one, left to right.
c. If there are more syllables, spread the last tone to excess syllables.
d. If there are more tones, link excess tones to the last syllable.

(28)

	27a		27b	
me por	--->	me por	--->	me^{11} por^{55}
LH H		LH		L H

'fire pan'

Trisyllabic patterns in GR are exactly the same as in LS. No new rules are needed to account for them, and so we will omit the derivations. In addition, of the eight Tibetan languages Qu and Tan surveyed, five others, Ritu, Zhada, Geje, and Cuoqin, resemble Gar in monosyllabic, bisyllabic, and trisyllabic patterns. This may be taken as evidence that languages tend to adopt simpler rule systems, a tendency that is reflected in our analysis.

2.3. Gêrzê (GZ). GZ also has four citation tones, corresponding to A, B, C, and D in LS and GR. In addition, bisyllabic and trisyllabic patterns in GZ resemble those of GR (Qu and Tan 1983:36). If we again discount the variation between 53 and 55 on the final syllable, GZ has the following patterns:

(29) GZ Bisyllabic Patterns:

a.	A X --> H H	t'e po	'thumb'
b.	B X --> H H	am tço?	'ear'
c.	C X --> L H	nba ra	'palm'
d.	D X --> L H	der ma	'saucer'

(30) GZ Trisyllabic Patterns:

a. A X X --> H H H
b. B X X --> H H H
c. C X X --> L H H
d. D X X --> L H H (X=any tone)

As can be seen, like in LS and GR, noninitial syllables in GZ have no effect on the output. In other words, output tones must have come entirely from the initial syllable. We will therefore give the same analysis to GZ as we did to LS and GR:

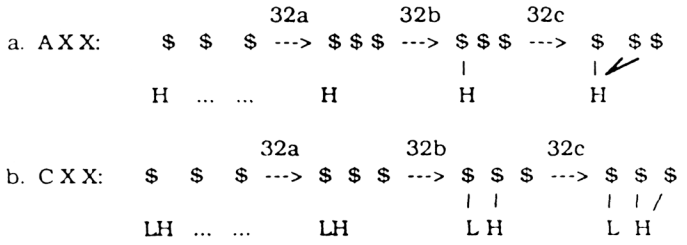
(31) GZ Syllable tones:

A	B	C	D
H	H	LH	LH

(32) GZ Multisyllabic Tone Rules:

a. Delete tones from noninitial syllables.
b. Associate tone to syllables one-to-one, left to right.
c. If there are more syllables, spread the last tone to excess syllables.

(33) GZ Trisyllabic derivations (... = any tone):



However, this analysis has a problem with syllable tones. If GZ has the same syllable tones as LS and GR, namely, A=H, B=H, C=LH, and D=LH, then we expect GZ syllable tones to have the same pitch values as those in LS and GR, namely, A=53, B=55, C=12, D=14. But this is not the case. Compare the predicted syllable tones with the actual pitch values in GZ (Qu and Tan 1983:33, 35):

(34)

	GZ				LS & GR			
Syllable Tones:	A	B	C	D	A	B	C	D
Predicted:	H	H	LH	LH	H	H	LH	LH
Actual:	53	51	31	22	53	55	12	14

While the actual value in LS and GR agree with the prediction, the difference between the predicted tones and the actual values is big in GZ. Specifically, C and D are predicted to be a rise, but they turn out to be a low fall and a low level. In addition, B is predicted to be H, but it turns out to be a fall. How, then, can we relate the predicted tones to the actual values?

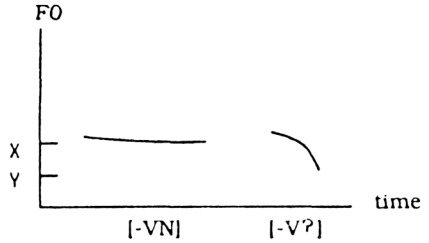
It can be seen that all GZ syllable tones end in L (with the possible exception of A 53, which is too short to tell). I suggest, therefore, that in GZ, a L is added to the end of the syllable when it is in isolation, and that the H in C and D stay unlinked (shown in parentheses below):

(35)

GZ Syllable Tones:	A	B	C	D
Underlying:	H	H	LH	LH
L-insertion:	H**L**	H**L**	L(H)**L**	L(H)**L**
Actual:	53	51	31	22
	short	long	short	long

The exact way to insert L, and not linking H to C and D will be discussed shortly. Let us now see what effects our proposal has. First, L-insertion makes both A and B a fall, which, in view of the shortness of A, agrees with the actual values. Second, without linking to H, both C and D will be L (or LL). The value of D 22 nearly agrees with our expectation. But what about the value of C 31? Here again we have to consider phonetic effects and the nature of Chao letters. Recall that C is a short syllable with a glottal or glottalized coda. Recall also that a glottal coda sharply drops the final pitch. Below is a schematic representation of how L may be realized on different syllables:

(36) Realizations of L on different syllables



In a language where L only falls on [-VN] syllables, the point X will be the lowest, and will be marked 11 in Chao letters. In a language where L falls on both [-VN] and [-V?] syllables, the point Y is the lowest and will be marked 11, while the point X will be marked 22 or 33. This, I suggest, is what happens to Qu and Tan's analysis of GZ, where L on [-VN] is marked 22 and L on [-VP] is marked 31. If we use Chao letters phonemically, however, we would disregard the point Y and transcribe both [-VN] and [-V?] as 11.

From the above considerations, I suggest the following analysis of GZ:

(37) GZ Syllable Tones:

A	B	C	D
H	H	LH	LH

(38) GZ Tone Rules:

a. Delete tones from noninitial syllables.
b. Associate tones to syllables one-to-one, left to right.
c. If there are more syllables, spread last tone to excess syllables.
d. On a monosyllable, add L to the right.

We have already shown two derivations on trisyllabic syllables. Below we show derivations of monosyllabic B and C:

(39) a.

	38b		38d	
kør	--->	kør	--->	kør^{51}
		|		|\
H		H		H L

'to send'

b.

	38b		38d	
tar	--->	tar	--->	tar^{22}
		|		/ \
LH		LH		L(H)L

'popular'

The fact that H remains unlinked in [tar] 'popular' may be because GZ allows at most two tones on a syllable.[21] In a footnote, Qu and Tan note that GZ B 51 may alternate with 55, and C 31 may alternate with 12. It is not clear, however, whether D 22 alternates with 14 in GZ. If so, then L-

[21] If there is no restriction on two tones per long syllable, then after the final L-insertion, D would surface as a rise-fall LHL. I guess this is the case in the speech of Mr. Nawang Nornang, described in Chang & Shefts 1964, where, domain-finally, B may appear as what Chang & Shefts call 'high-falling' (which we call HL), and D may appear as what Chang & Shefts call 'low-falling' (which we call LHL). In fact, L-insertion is a fairly general phenomenon. In New Shanghai, for example, [ho] 'good' is MH, but under emphasis, it can become MHL.

insertion in GZ is optional. When L-insertion does not apply, GZ syllable tones are exactly like those in LS and GR:

(40) GZ Syllable Tones:	A	B	C	D
Underlying:	H	H	LH	LH
	53	55	12	14
After L-insertion:	HL	HL	L(H)L	L(H)L
	53	51	11	11

Multisyllabic phrases are derived in the same way as in previously discussed Tibetan languages. Below we show the derivations of BD and CB patterns:

(41) a

	38a		38b	
kaŋ tuŋ	--->	kaŋ tuŋ	--->	
H LH		H		

	38c		
kaŋ tuŋ	--->	kaŋ^{55} tuŋ^{55}	'marrow'
H		H	

b.

	38a		38b		
sa kaŋ	--->	sa kaŋ	--->	sa^{11} kaŋ^{55}	'dining room'
LH H		LH		L H	

In the output of (41b), L from the first syllable does not spread to the second syllable, even though the second syllable is long. In this respect, GZ is like GR and unlike LS (cf. the CB pattern in LS and GR).

2.4. Zedang (ZD). ZD has the same four syllable tones as LS and GR, namely, A=53, B=55, C=12, and D=14 (Qu 1981:25):

(42)

A	B	C	D
la^{53}	la:^{55}	la^{12}	la:^{14}
pay	musk deer	mountain	wool sweater

Following our analysis of LS and GR, we assume that ZD has the same underlying syllable tones:

(43)

A	B	C	D
H	H	LH	LH

According to Qu (1981:25), bisyllabic patterns in ZD "are basically the same as in LS," with a few peculiarities which we will not go into. In trisyllabic patterns, ZD shows an interesting difference. Compare the schematic representations of ZD with LS and GR below (omitting the variation between 53 and 55 on the final syllable):

(44)

Pattern	LS & GR	ZD
AXX	55 55 55	55 55 55
BXX	55 55 55	55 55 55
CXX	11 55 55	**11 11 55**
DXX	11 55 55	**11 11 55**

While in LS and GR, [C X X] and [D X X] are [11 55 55], in ZD they are [11 11 55]. In other words, the H from the initial syllable is shifted to the final syllable, instead of the second. We will account for this difference by proposing the following rules for ZD:

(45) ZD Tone Rules:

a. Delete tones from noninitial syllables.
b. Associate the first tone to the first syllable, and the last tone to the last syllable.
c. If there are free syllables in between, spread the first tone to them.

The rule (45a) is the same as in the previous languages. Although (45c) looks new, it is essentially the same as the spreading rule in Margi, LS, GR, and GZ in that there is rightward spreading to toneless syllables. (45b) is like what Yip (1988) calls '**edge-in**' association, which, as she suggests, has considerable generality. An example of (45b) is seen in New Shanghai below:

(46) a

ba?	ço?	koŋ	tsz	--->	ba?	ço?	koŋ	tsz	--->
LH	MH	HL	MH		LH				

ba?	ço?	koŋ	tsz	--->	ba?	ço?	koŋ	tsz
|	|			|	|	|	|
L	H				L	H	L	L

b. ba? ço? koŋ tsz ---> ba? ço? koŋ tsz --->

LH MH HL MH LH

ba? ço? koŋ tsz ---> ba? ço? koŋ tsz

| | | | |

L H L H

'Snow White' (Lit.: white snow princess)

The expression for 'Snow White' has two freely alternating patterns, [L H L L] or [L L L H] (Xu et al. 1983). The first can be derived by left to right association, followed by default L insertion (cf. 11). The second pattern, however, must be derived by edge-in association (followed either by spreading or by L insertion, which we will leave open). This alternation happens only with expressions that begin with a [CV?] syllable that is underlyingly LH. Whatever the reason for [CV?] with LH to trigger edge-in association, it seems that edge-in association must be available as an alternative to left to right association.[22]

Below we give the derivations of some ZD expressions:

45b

(47) a la: ---> la: 'wool sweater'

|\

LH LH

45a 45b

b. tç'e mu le? ---> tç'e mu le? --->

H LH LH H

45c

tç'e mu le? ---> tç'e mu le? 'moth'

| |

H H

45a 45b

c. le tçe pa ---> le tçe pa --->

LH LH H LH

22 One may suggest other alternatives to edge-in association, such as right to left association. The point here is that there must be more than one way of association available.

45c

```
le   tçe   pa  ---> le   tçe   pa          'cadre'
 |          |        |  /     |
 L          H        L        H
```

The results of (47a,b) are the same as what we would get in LS, GR and GZ, even though we have applied edge-in association. The result of (47c) shows the real effect of edge-in association, which gives the characteristic color of ZD 'accent'.

2.5. Summary. In our analysis of LS, GR, GZ, and ZD above, we have shown that tonal variations among mono- and multisyllabic expressions, and among different Tibetan languages, can be explained by assuming that all tones are composed of level tones. In addition, the relation between tones and syllables are regulated by general rules. Moreover, we have seen that Tibetan languages share tonal similarities with other tone languages, such as Margi and New Shanghai.

3. The Non-autosegmental Approach. Let us now compare our analysis with the non-autosegmental approach. For exposition, we will focus on Qu and Tan's analysis of LS.

Qu and Tan's approach represents a long tradition in Asian phonology.[23] In this tradition, tone is viewed as a property of the syllable. Given a tone language, one first determines how many syllable tones there are by looking at syllables in isolation. Then one looks at multisyllabic expressions, and determines whether each syllable maintains its syllable tones. If not, then one considers there to be 'tone sandhi'. To describe 'tone sandhi', one enumerates all possible combinations of syllable tones in bisyllabic, trisyllabic, and longer expressions, and observes how each syllable tone changes in each environment. Finally, one gives a set of 'sandhi rules' that list such changes.

Below we repeat Qu and Tan's analysis of LS syllable tones and the exhaustive bisyllabic patterns, together with their 'sandhi rules':

(48) LS Syllable Tones	A	B	C	D
	53	55	12	14

[23] Xiong 1984 nicely summarizes the essential steps of this approach.

(49) LS Bisyllabic Patterns

1.	AA:	53 53 --> 55 53	ʂu? pa	'cypress'
2.	AC:	53 12 --> 55 53	na ma	'bride'
3.	AB:	53 55 --> 55 55	tʂ'u ʂel	'crystal'
4.	AD:	53 14 --> 55 55	ha jaŋ	'aluminum'
5.	CA:	12 53 --> 11 53	ta? po	'master'
6.	CC:	12 12 --> 11 53	to ro	'pile of rocks'
7.	CB:	12 55 --> 11 14	me por	'fire pan'
8.	CD:	12 14 --> 11 14	tʂa ril	'round tea brick'
9.	BA:	55 53 --> 55 53	k'aŋ pa	'house'
10.	BC:	55 12 --> 55 53	laŋ ŋa	'earthenware pot'
11.	BB:	55 55 --> 55 55	sam tʂar	'opinion'
12.	BD:	55 14 --> 55 55	ʂiŋ toŋ	'tree'
13.	DA:	14 53 --> 11 53	sam pa	'bridge'
14.	DC:	14 12 --> 11 53	tuŋ ma	'roof beam'
15.	DB:	14 55 --> 11 14	ŋal tsø	'labor'
16.	DD:	14 14 --> 11 14	ɲam ɲuŋ	'experience'

(50) LS Bisyllabic Sandhi Rules (Qu and Tan 1983:3)

a. 53 (A) changes to 55 on the first syllable, and does not change on the second syllable.
b. 55 (B) does not change on the initial syllable. On the final syllable, 55 does not change after 55 and 53, and changes to 14 after 12 and 14.
c. 12 (C) changes to 11 on the first syllable, and to 53 on the second.
d. 14 (D) changes to 11 on the first syllable. On the second syllable, 14 does not change after 12 and 14, and changes to 55 after 53 and 55.

There are important differences between Qu and Tan's analysis and ours. For example, in our analysis, all noninitial syllables lose their underlying tones; their surface tones come from the initial syllable. Thus, in both DA and DC, the surface H of the second syllable comes from the first syllable. In contrast, in Qu and Tan's analysis, the surface 53 on the second syllable of DA does not come from the first syllable but is its orignal tone, since according to their (50a) "53 (A) does not change on the second syllable." Similarly, the surface 53 on the second syllable of DC does not come from the first syllable; instead, C directly changes into 53 on the second syllable by the rule (50c).

Although Qu and Tan's sandhi rules can derive the correct results, they offer no insight into why LS tone should behave the way it does. For example, there is no explanation why 55 can change to 14 on the second

syllable, but not on the first. Similarly, we do not understand why sometimes there is no change (as in BA), sometimes the first syllable changes (as in DA), sometimes the second syllable changes (as in BD), and sometimes both syllables change (as in DB). In other words, in Qu and Tan's sandhi rules, there is no constraint at all.

Qu and Tan's analysis also makes wrong predictions. For example, if any syllable tone can change to any other, we can imagine the following possibility for a language with the same four syllable tones as LS:

(51) a. 53 changes to 11 on the first syllable.
b. 55 changes to 51 on the first syllable.
c. 12 changes to 11 on the first syllable.
d. 14 changes to 51 on the first syllable.

This alternative says that, in initial positions, short syllables change to 11, and long syllables change to 51. On the second syllable, no change takes place. This process is simpler than that in LS, and one would expect it to occur in some languages, had tone sandhi been a process of free tone change. However, no such language is reported. In our view, (51) is impossible. In particular, if the high tone 53 should change to L, as in (51a), then 55 should change to L, too, and not to 51. Similarly, since 12 and 14 are both LH, they should change in the same way.

Let us now consider trisyllabic patterns. Recall that in our analysis, trisyllabic patterns follow from the same rules as bisyllabic patterns (cf. section 2.1, above). In contrast, in the traditional analysis, two new rules have to be added

(52) LS Trisyllabic Sandhi Rules (Qu and Tan 1983:36-7; Qu 1981:24)

a. The first and the third syllables change according to bisyllabic rules, except that when the first syllable is 12 or 14, and when the third is 55, the latter does not change to 14.
b. All tones on the second syllable change to 55.

Again, these rules tell us nothing about why the changes should be as they are. In addition, one hardly sees any relation between bisyllabic and trisyllabic patterns.[24]

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[24] The same might be said about Sprigg's (1981) analysis of Lhasa Tibetan. Sprigg proposes two syllable tones, tone1 (corresponding to the high tones A and B) and tone2 (corresponding to the low tones C and D). In multisyllabic expressions (without emphatic words), the tonal output is derived by switching noninitial tone2 to tone1 (pp.57-58). For example, in a trisyllabic sequence [T1 T2 T1], we apply [T2]-->[T1] to get [T1 T1 T1]. It is unexplained why initial tones do not switch, nor why noninitial T1 does not switch. For Sprigg, it should be

In sum, the non-autosegmental analysis offers no insight to why Tibetan tone behaves the way it does. In addition, the non-autosegmental analysis predicts possible sandhi patterns that are never found. Moreover, an autosegmental analysis brings out significant generalities among tones in Tibetan, Chinese, and African languages, whereas a non-autosegmental approach completely miss them.

4. Conclusions. Our analysis of Tibetan tone sandhi shows that autosegmental phonology not only can be applied to Tibetan but is also superior to the non-autosegmental approach. The latter offers little insight into the behavior of tone, makes wrong predictions, and reveals no generality between Tibetan and other tone languages. By contrast, the autosegmental approach brings out important similarities among Tibetan, Chinese, and African tone languages, namely, contour tones are made of level tones, and that tones may move across segments in a rule governed way.

Our analysis also shows that languages may have different 'mapping rules' (or association conventions). Consider the 'mapping rules' below, rephrased from Williams (1971/6):

(53) a. Associate tones to syllables one-to-one.
b. Associate tones to syllables left to right.
c. If there are more syllables, spread the last tone to excess syllables.
d. If there are more tones, link excess tones to the last syllable.

We have seen that New Shanghai and Zedang Tibetan (ZD) do not always follow (53b); instead, they seem to show edge-in association in some cases. Similarly, New Shanghai does not follow (53c); instead, excess syllables get L as default (or possibly remain toneless throughout). Finally, we saw that in Gêrzê Tibetan (GZ), an underlying H may remain unlinked in C and D syllables, so that (53d) is not observed.

Our analysis of Tibetan is preliminary, and several issues remain untouched. First, we said nothing about what the tone-bearing unit is (e.g. syllable, rime, or the nuclear segment in the rime). Second, we said nothing about how a tonal domain is determined. For example, some trisyllabic expressions form one domain, such as [ko ko ja?] 'cross-bred ox', while others form two domains, such as [tçeã | ka ra] 'sugar' and [sa tsa | npu] 'centipede' (Qu and Tan 1983:36-37, vertical bar indicating domain break). Third, there are certain 'weak' syllables that do not have tone in isolation, nor do they receive tone from other syllables (Qu and Tan

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possible to find a process (in a language like Lhasa) where, in a trisyllabic domain (without emphatic words), noninitial T1 switches to T2, and nonitial T2 switches to T1, so that we get [T1 T1 T2]-->[T1 T2 T1]. For us, such a process is not possible under initial dominance.

1983:33-34), and this remains to be explained. Finally, Sprigg (1981:57) notes that an emphatic stress may change the tonal pattern of the following syllables, and we have not looked at such cases. Nevertheless, since these issues are separate from our present topic, namely, how tones move in a given domain, I will leave them for further studies.[25]

[25] The fact that tone rules are sensitive to syllabic weight (e.g. 'weak' syllables do not carry or attract tones, and long syllables may trigger L spreading in LS) and that emphatic stress may alter tonal patterns, strongly suggests an interaction between tonology and metrical phonology. Cf. Meredith 1990 for a metrical approach to Tibetan tone, which differs from the present proposal in a few ways. Cf. Duanmu 1991b, c for a discussion of the relation between metrical structures and tonal domains.

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