Toward a Typology of Tone Sandhi
Author(s): Zhiming Bao
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Zhiming Bao
Ohio State University

Pike (1948) distinguishes between contour tone languages ('contour system') and level tone languages ('register systems'), and observes that contour is basic in the former, derivative in the latter. Furthermore, each syllable carries only one tone in contour tone languages, but one or more than one tone in level tone languages. Such typological difference will be manifested in the tone sandhi processes found in tone languages. In this paper I develop a formal model of tone sandhi typology that captures Pike's insight.[1]

1 Hierarchical Structure of Tone

At the core of the model is the structure of tone. I assume that tone consists of register, which specifies the relative pitch range of the tone and interacts with voicing, and contour, which specifies the pitch contour within a given register. It is shown in (1).

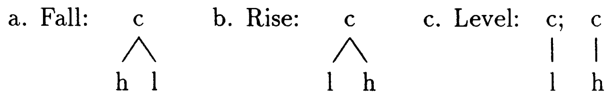
(1)
```
  t        t: tonal root node; r: register; c: contour
 / \
r   c
```

The structure is defended in Bao (1990a), and some of the sandhi processes that lend support to (1) will appear in this paper. Similar tone models have been proposed by a number of researchers, among them Hyman (1986, 1989), Inkelas (1987), Clements (1987), Yip (1989), Duanmu (1990) and Snider (1990). The register and contour will be specified with the features [stiff (vocal cords)] and [slack (vocal cords)] first proposed in Halle and Stevens (1971), as follows:

(2) r: H = [+stiff] L = [−stiff] c: h = [−slack] l = [+slack]

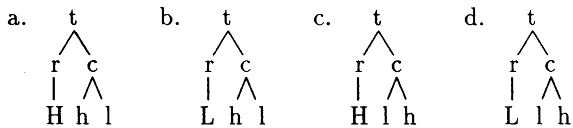
Following Yip (1980, 1989), I assume that the c node may branch, binary underlyingly. We thus have the following c node structures:

(3)

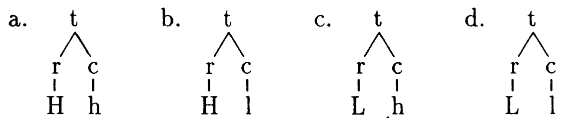


All told, we have four contour tones (5) and four level tones (4):

(4)



(5)



[Stiff] and [slack] are functionally equivalent to [upper] and [raised] of Yip (1980,1989) and Pulleyblank (1986); to row 1 and row 2 of Clements (1989) and tonal root node and tonal node of Hyman (1989).

2 The Model

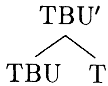
Tone languages may differ by the structure of tone they allow, and by the tone bearing unit (TBU) they choose. The model then consists of two parameters, TBU and Contour, as in (6), and a set of elementary operations, as in (7) (Clements 1989):

(6) a. TBU: prosodic categories such as mora, syllable, etc.
b. Contour: [+contour]: allows (3), i.e. tones in (4) and (5).
[−contour]: allows (3c), i.e. tones in (4).

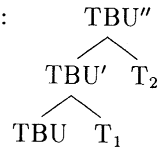
(7) Elementary Operations: spread, delink, permute, insert, etc.

Prosodic categories are the ones proposed in McCarthy and Prince (1986) and Pierrehumbert and Beckman (1989). In [+contour] languages, contour is encoded at c, internal to tone; in [−contour] languages contour is encoded at TBU, external to tone. I assume that the *Association Conventions* adjoin tone to TBU, creating structures shown in (8) (Bao 1990b, 1992); and there is no multiple encoding of contour: it is encoded either at c or TBU, but not both. The structure of High Fall in [+contour] languages is shown in (9a); that in [−contour] languages in (9b).

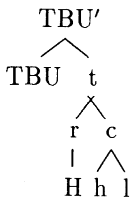
(8) a. One-one:



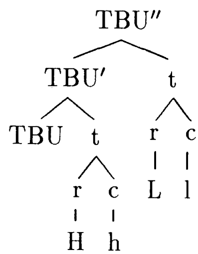
b. Multiple:



(9) a.



b.



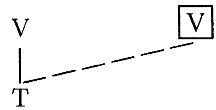
It has been observed that contour tones are distributed freely in contour tone languages, but not in level tone languages (Yip 1989). This follows from the model. If contour is encoded internal to tone, it is available underlyingly, prior to the operation of *Association Conventions*. This is not the case if contour is encoded at TBU, and derived through multiple association. With respect to tone sandhi processes, the model predicts that in [+contour] languages, rules may refer to contour (the c node), or be conditioned by contour; such rules do not exist in [−contour] languages. And in [+contour] languages, the overall pitch may change without change in contour. In what follows we will document the tone sandhi processes predicted by the proposed model.

3 Tone Sandhi Processes

3.1 Processes Affecting Tonal Root Node

The model predicts that in both types of language a tone may spread to a neighboring TBU. This is rather common in [−contour] languages (see, among others, Hyman and Schuh 1974). In Margi, for example, toneless suffixes assume the tone of the stem (Williams 1976, Pulleyblank 1986): *n`ərì* 'to tell a person'; *tsárí* 'to knock at'. Pulleyblank (1986) analyzes the facts in terms of the spreading rule shown in (10).

(10) Tone-spreading:



The same phenomenon can be observed in [+contour] languages as well. In Changzhi, a Mandarin dialect of Chinese, the suffix *ti* assumes the tone of the adjectival stem to which it is suffixed, as shown by the data in (11) (Hou 1983, Bao 1990a, Yip 1992):[2]

(11)	suaŋ 213 ti 213	'sour'	yaŋ 535 ti 535	'soft'
	xuaŋ 24 ti 24	'yellow'	iŋ 53 ti 53	'hard'

The facts can be derived by Tone-spreading given in (10).

3.2 Processes Affecting Register

Processes affecting the register are more complex in [+contour] languages than in [−contour] languages, due to the complex tonal structure in the former. Consider register dissimilation in Luoyang, a Mandarin dialect. Luoyang has four lexical tones, 33, 31, 53 and 412. In sequences of two 53s, the first 53 lowers to 31: *iaŋ 53 ma 53 > iaŋ 31 ma 53* 'raise horses'; *lɔ 53 mi 53 > lɔ 31 mi 53* 'old rice' (He 1984, Bao 1990a). Such facts can be handled in terms of the register dissimilation rule in (12):

(12) Register Dissimilation: H → L / [__,hl] [H,hl]

Note that the contour is not affected by *Register Dissimilation*; it remains falling as the register switches from H to L.

Wuyi provides data which suggest register assimilation. Wuyi has eight citation tones, as follows (Fu 1984):

(13)		H	[−voiced]	L	[+voiced]	
	a.	24	sa 'raw'	213	za 'tailor'	*ping*
	b.	55	pu 'beach'	13	bu 'part'	*shang*
	c.	53	t'ia 'supreme'	31	dia 'big'	*qu*
	d.	5	foʔ 'duplicate'	212	voʔ 'cloth'	*ru*

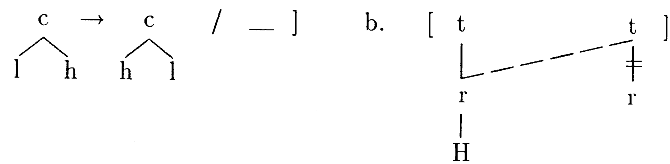
The H and L tones in (13) are derived from the same historical source, and H tones occur with voiceless initials, and L tones occur with voiced initials. In dissyllabic phrases with the tone melodies 24/213–24/213/53/31, we have the sandhi facts shown in (14):

(14)

	I	II	III	IV
	24	213	53	31
24	24–53	[24–53]	24–53	[24–53]
213	213–53	213–31	213–53	213–31

Observe that the rising tones 24/213 become falling when in phrase-final position (columns I and II). We can handle this fact with the rulle *Contour Change*, shown in (15a), which permutes the two branches of the c node. Observe further that low fall 31 in phrase final position is raised to high fall 53 when following high rise 24 (boxed patterns in columns I and IV). In other words, the low fall assimilates to the register of the preceding high rise. We account for this with the rule *Register Assimilation* shown in (15b).

(15) a. b.



As in Luoyang dissimilation, the contour remains unchanged.

One [−contour] language that displays register change is Mixteco, described and analyzed in Pike (1948), and in Goldsmith (1990) in the framework of autosegmental phonology. My analysis follows Pike's.

Mixteco has three surface tones, Hi, Mi and Lo. There are eight dissyllabic tone patterns in the language, shown in (16).

(16)

	Stable			Unstable	
1.	Hi-Hi	sana 'turkey'	5.	Mi-Mi	beʔe 'house'
2.	Hi-Mi	ñiʔi 'steam bath'	6.	Mi-Lo	kutu 'nose'
3.	Hi-Lo	baʔu 'coyote'	7.	Lo-Hi	suči 'child'
4.	Mi-Hi	kuči 'pig'	8.	Lo-Mi	mini 'puddle'

When preceded by a set of lexically determined, 'perturbing type' words, initial Mi or Lo of the unstable types are raised to Hi. For example, *sùčí* 'child' has the tone pattern Lo-Hi; but surfaces as Hi-Hi when following a perturbing word *kēē*: *kēē súčí* 'the child will eat'. Assuming that the tones have the structures as in (17a), we may derive the unstable types by *Register Raising* formulated in (17b):[3]

(17) a. Hi: [H,h] or [H,l] Mi: [L,h] Lo: [L,l]
b. $L \rightarrow H \ / \ W_p$ — where W_p is a perturbing type word.

The two H-registered tones [H,h] and [H,l] are phonetically neutralized. The stability of Type 4 is not unexpected if we invoke the OCP. Note that Mi-Hi pattern has the structure [L,h]–[H,h], to which *Register Raising* would apply to derive the ill-formed [H,h]–[H,h]. The rule is blocked by the OCP computing identity on the tonal root node (cf. McCarthy 1986, Yip 1988 and references cited therein). By contrast, the pattern Lo-Hi has the structure [L,l]–[H,h], to which *Register Raising* applies to derive [H,l]–[H,h]. Hence Lo-Hi is unstable; Mi-Hi is stable.

3.3 Processes Affecting Contour

Contour in [+contour] languages may classify tones into natural classes. This can be seen in the sandhi behavior in Luoyang reduplication data, given in (18) (He 1984):

(18) a. gong 33 gong 3 'grandpa' b. kan 412 kan 3 'take a look'
c. yi 31 yi 33 'move' d. nai 53 nai 33 'grandma'

The tone on the first syllable is the base tone. Note that the second tone in (18a,b) are reduced to the so-called 'light tone', denoted by a single digit 3. By contrast, the two falling tones 31/53 become the mid level tone 33, rather than the light tone 3. The falling contour here serves as a natural class.

Perhaps the most interesting sandhi property involving contour is contour dissimilation, whereby a fall becomes rise; and rise becomes fall. Consider Zhenjiang, a Mandarin dialect. This language has four citation tones, 42, 31, 35 and 55. The two falling tones become rise 35 when preceding another falling tone (Zhang 1985). This process can be accounted for by the rule *Contour Change*, which permutes the two branches of a fall into a rise:

(19)
```
 c  -->  c  / __  c
/\      /\       /\
h l     l h      h l
```

Contour tones in [+contour] languages may also be derived by rule. Consider Gao'an, another Mandarin dialect (Yan 1981). Gao'an has five citation tones: 55, 33, 11, 24 and 42. In this dialect, 55 becomes 53 when it precedes a 33 or 11: *siu 55 p'i 33* > *siu 53 p'i 33* 'repair', *ka 55 p'ɛi 11* > *ka 53 p'ɛi 11* 'double'. Assuming that the tones have the structures in (20a), the observed sandhi can be derived by the rule in (20b), which creates a fall contour:

(20) a. Tones: 55 [H,h]; 33 [H,l]; 11 [L,l]; 24 [L,lh]; 42 [L,lh]

b. Contour Formation:

```
c      c
|      |
h      l
```

Unlike [−contour] languages, contour tones are formed at the c node.

We have seen that contour tones in [+contour] languages may be underlying, or derived. In [−contour] languages, contour tones are derived, and their distribution is restricted (Yip 1989). We can see such phenonmenon in Margi (Williams 1976), Yoruba (Pulleyblank 1986), Keyang (Odden 1988), Kikuyu (Clements 1984), and Digo (Kisseberth 1984). Consider Digo, where contour tones occur on last two syllables of a phrase, derived through *Association Conventions* and Digo-specific rules. The derivation of *ku-fwinĭkâ* in (21) is due to Kisseberth (1984) (low tones are not marked):

(21)

Underlying	L H L $ku-fwinik-a$
High Tone Displacement	L HL $ku-fwinik-a$
Association Conventions	L HL $ku-fwinik-a$
Leftwards High Spread	L HL $ku-fwinik-a$
Surface:	ku-fwinĭkâ

One thing that is striking in [−contour] languages is the lack of sandhi processes which turn a fall to a rise, and vice versa (cf. Hyman and Schuh 1974), which are attested in [+contour] languages. This typological difference needs to be explained. One reason why contour dissimilation does not take place in [−contour] languages is due to the lack of applicable environment. Take Digo, where, as we have seen, *Association Conventions* and Digo-particular rules create a rise-fall sequence on the last two syllables of a phrase; but never a fall-fall (or rise-rise) sequence. Thus, in Digo contour dissimilation can not take place because its structural description is not met.

Perhaps the lack of contour dissimilation in [−contour] languages is due to some formal principle, rather than the accident of the rule system of a particular grammar. The intuitive idea towards an explanation is that the typological difference follows from the different formal mechanisms of encoding contour (see the structures in (9)). Suppose that the operation of permutation is so constrained as to apply to two nodes exhaustively dominated by a common node, then, in [−contour] languages the two tones forming a contour tone are not permutable, since they do not have a common mother node (cf. (9b)). By contrast, the two branches of a contour tone in [+contour] languages are permutable due to the fact that they have a common mother node, namely c (cf. (9a)).[4]

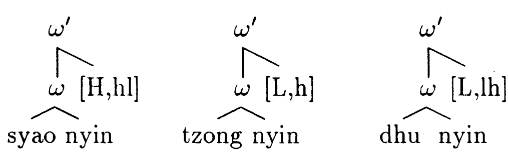
3.4 Prosodic Word as TBU

So far we have seen languages which take the syllable (by assumption) as TBU. Some languages may take a larger prosodic category as TBU. The Wu family of dialects typically have the following property: the entire phrase takes the shape of the first tone. Such languages include Shanghai (Zee and Maddieson 1979, Selkirk and Shen 1990) and Tangsic (Kennedy 1953, Leben 1980), and Grebo, which Newman (1986) shows to have phonemic contour tones, and yet exhibits some of the properties of Shanghai and Tangsic. Consider Tangsic (Kennedy 1953):

(22)	nyin 24 'man'		
	syao 51 'small'	tzong 33 'middle'	dhu 24 'large'
	syao-nyin 5001	tzong-nyin 3003	dhu-nyin 2004

The zeros indicate a graduate shift in pitch. Kennedy observes that the phrases surface with the tonal shape of the first tone. No further sandhi takes place. Suppose that Tangsic chooses the prosodic word ω as the TBU, *Association Conventions* adjoins tone to ω, creating the following structures:

(23)



The tone is realized over the entire tone bearing unit, which, in the case of Tangsic, is the entire phrase.

4 Conclusion

We have shown that some of the typological differences in sandhi processes are attributable to the parametric settings of tonal structure and tone bearing unit. The properties of tone sandhi in a language are determined in part by the structure of tone and by the prosodic category that the language chooses as TBU. We note that contour dissimilation is attested in [+contour] languages, but not in [−contour] languages, and explain the difference in terms of the formal mechanism of encoding contour. Furthermore, we note that register change may lower or raise a contour tone (such as 53 > 31 in Luoyang, cf. (12)); such process is not attested in [−contour] languages (Hyman and Schuh 1974). Again, this is due to the tonal structure: in [−contour] languages, contour tones are concatenations of level tones. Formally, register change of the start tone is not related to the end tone.

Notes

[1]I will ignore important issues concerning domains in which tone sandhi takes place. For this line of inquiry the reader is referred to Chen (1986, 1987), Selkirk and Shen (1990), and references cited there.

[2]When suffixed to a stem with the level tone 44, the suffix surfaces with its citation tone, 535. I assume that 44 is underlyingly unspecified, so *ti* assumes its citation tone when suffixed to the 44 stem. See Bao (1990a) and Yip (1992) for detailed analysis.

[3]Goldsmith (1990) assumes that perturbing words carry a lexically specified floating H, which spreads to the following Mi or Lo.

[4]Hyman and Tadadjeu (1976) and Pulleyblank (1986) discuss a rule in Dschang which metathesizes a HL sequence to LH, which surfaces as downstepped H (in some languages the metathesized sequence surfaces as a rise (Hyman, personal communication)). In the underlying sequence HL, L is floating. Therefore at the stage when metathesis takes place, there is no contour tone structure. This process is of different nature than contour dissimilation we saw in [+contour] languages.

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