

Semper Infidelis: Theoretical Dimensions of Tone Sandhi Chains in Jingpho and A–Hmao

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Abstract

Tone sandhi chains present several problems to classical Optimality Theory. Not only are they opaque, they often appear to be ill-motivated and may, not infrequently, be circular. As shown by Moreton (1999), such circular chain-shifts cannot be described in terms of Classical Optimality Theory (limited to only markedness and faithfulness constraints). But, as this paper argues, even given a more powerful theory which allows anti-faithfulness constraints, the discovery of representations which properly constrain and motivate such tone shifts is non-trivial. This is shown through case studies of A–Hmao and Jingpho tone sandhi. Some of the theoretical implications of admitting anti-faithfulness to optimality theory are also discussed.

East and Southeast Asian Tone sandhi chains present some interesting and important questions to phonological theory generally and to optimality theory specifically. To date, these issues have not been adequately addressed in the literature. There are three major aspects of these chain shifts which appear problematic:

1. *The alternations are poorly motivated.* While the tone changes under discussion here are typically highly predictable, there is often no readily apparent phonetic or phonological rationale governing what tones are potential triggers or targets and what sort of change is likely to be manifest in the target tone.
2. *The alternations are often opaque.* Not only are the synchronic motivations for the shifts usually unclear, the chain-shifts and mergers present in many such systems mean that they are difficult or impossible to implement in one-level phonological theories.
3. *The chains may be circular.* Like the best-known example of a tone sandhi chain, the Xiamen sandhi ring, many other tone sandhi chains include circular

chains where, in the same environment, $A \rightarrow B \rightarrow A$. As Moreton (1999) has demonstrated, such circular chain shifts are impossible to implement in Classical OT—his term for a OT framework in which all constraints are either faithfulness or markedness constraints.

To date, most of the theoretical discussion of tone sandhi chains has been confined to a few examples from Chinese, especially the Xiamen tone sandhi ring. If, indeed, the actual phenomenon of tone sandhi chains was as restricted as the data that has been brought to bear on the discussion of it, it might be justified to dismiss the whole system as a historical accident—a strange and illusory set of alternations existing in a few languages on the coast of Southeastern China. Moreton (1999:24) insinuates as much when outlining the various analyses that have been proposed for Xiamen tone sandhi:

Previous analyses have taken one of three lines on this phenomenon. One school of thought holds tones to be distinctive–feature matrices and treats the sandhi mechanism as an exchange rule operating on tonal features (Wang 1967, Cheng 1968, 1973, Shih 1986). Another views the tones as complexes of autosegments, and the sandhi process as an autosegmental rule affecting autosegments and association lines; the circular effect is achieved by having several different phonological representations for each phonetic tone (Yip 1980; Wright 1983; Du 1988). Finally Schuh (1978) argues that, whatever the representations may be, the tone–sandhi process treats each tones as an atomic unit, substituting one for another according to an arbitrary pattern of “paradigm replacement”. (For reasons to be explained below, I agree with him.) All researchers agree that something odd is going on, and all solution have a contrived look to them.

Given the arbitrary and capricious nature of most explanation of the Xiamen tone sandhi process, it might be supposed that the phenomenon seen there is highly uncommon, rather unlike other phonological phenomena, and, therefore, best relegated to some other part of the grammar (e.g. explained as “allomorph selection”).

However, tone sandhi chains are not terribly rare in Southeast Asia, even in languages which have never been in contact with the Min dialects of Chinese.¹The purpose of this paper is to bring to light additional data from two languages with chain tone sandhi—Jingpho and A–Hmao, to argue that these phenomena have parallels in other sorts of phonological phenomena—particularly polarity phenomena—that can be described in terms of anti–faithfulness (AF), and to provide a anti–faithfulness analysis of these data.

1 Anti–faithfulness

Classical Optimality Theory treats phonological alternations as the result of competition between two classes of constraints: faithfulness constraints which penalize outputs

¹However, they do seem to be rare outside of East and Southeast Asia. This may be associated with typological differences in tonal systems. Furthermore, the analysis presented in this paper suggests that the tonal polarity phenomena found in African languages may have an underlying affinity to the tone sandhi exchanges that appear in SEA tone sandhi chains.

that differ from corresponding inputs, and markedness constraints which penalize malformed outputs. There are a number of phonological phenomenon which cannot be described in terms of only these constraints. Alderete (2001:207) cites as an example consonant polarity in Luo (drawing data from Gregersen 1972 and Okoth-Okombo 1982):

(1)	<i>singular</i>	<i>plural</i>	
a.	bat	bed-e	‘arm’
	luθ	luð-e	‘walking stick’
b.	čogo	čok-e	‘bone’
	owadu	owet-e	‘brother’

The voicing of stem final consonants in plural forms must be opposite that of stem final consonants in singular forms. This type of exchange, Alderete notes, is impossible to formalize using only markedness and faithfulness constraints, since “if grammars are rankings of just these constraints, input–output mappings will either be faithful to the input or improve on markedness” (207). It is logically impossible for A to be more marked than B and for B to be simultaneously more marked than A. Since faithfulness constraints can only protect underlying identity and markedness constraints can only motivate shifts down the markedness scale, they are insufficient by themselves to explain exchanges like Luo consonant polarity. “The conclusion that can be draw from these observations,” Alderete continues, “is that phonological alternations can be motivated by constraints other than markedness. That is, Universal Grammar may have a set of constraints that trigger alternations for reasons other than markedness” (208).

Intuitively, alternations like Luo consonant polarity are easily described as an avoidance of identity. The grammar requires certain morphologically related words to be opposite in some parameter. Such phenomena seem to demand that the grammar is able to constrain morphologically related outputs so that they are different in some feature. These constraints have been dubbed *trans-derivational anti-faithfulness* constraints by Alderete (1999).²

There are several arguments that may be made against employing such a set of constraints in Optimality Theory analyses. The first is the apparent philosophical conflict between these constraints and the general principles of OT. A fundamental insight of OT seems to be that phonological alternations are the result of competition between pressures to maintain underlying contrasts and pressure to eliminate ill-formed (marked) structures. It seems counterintuitive, then, to include in such a theory constraints which motivate changes from underlying form which do not repair ill-formedness. Against this position, it could be argued that anti-faithfulness constraints are in fact a type of faithfulness constraints. Even though they motivate changes in feature values, they preserve underlying contrasts (in contrast to markedness constraints, which tend to neutralize underlying contrasts)³. But perhaps the most significant problem with anti-faithfulness constraints is the extent to which they limit the type of predictions that Optimality Theory can make. Given only markedness and faithfulness

²The analysis presented here is not explicitly trans-derivational (but could as easily be implemented trans-derivationally), assuming instead a somewhat different model of construction-specific phonology.

³Of course, this is not true to the extent that markedness constraints are used to model allophonic variation and possibly certain other aspects of post-lexical phonology.

constraints, a ranked–constraint grammar should be able to model any phonological alternation except for infinite chain shifts and circular chain shifts (Moreton 1999). With the addition anti–faithfulness constraints, the set of possible languages that can be modeled is even less constrained. Anti–faithfulness constraints are more powerful than either faithfulness or markedness constraints. Not only can they motivate changes (like markedness constraints but unlike faithfulness constraints), they also specify the repair for the target structure (unlike markedness constraints). As such, they are functionally a constrained subset of two–level correspondence constraints. However, it should not be assumed that admitting anti–faithfulness constraints to the grammar will add the same degree of power as unconstrained two–level correspondence constraints (which—as Moreton 1999 demonstrates through two trivial proofs—would prevent the theory of grammar from making any predictions whatsoever).

2 Case Study: Jingpho

The fact the tone sandhi can behave like consonant polarity (or other sorts of exchange rules) is not widely documented in the theoretical literature. However, a very clear example of this phenomenon is to be found in Jingpho. Jingpho (also called Kachin and Singpho) is a Tibeto–Burman language of Southern China, Northern Burma, and extreme eastern India. Altogether, there are approximately 645,000 speakers.

The dialect of Jingpho represented here is spoken in China and seems to be substantially identical to the dialect used there as the basis of the written standard.

2.1 The Jingpho tone system

Jingpho has four phonemic tones: /33/, /55/, /31/, and /51/. Tone /51/ appears primarily as a sandhi tone and occurs only on the last syllable in a word. For reasons that will be clarified below: I will represent these tones as the intersection of two features called [\pm high] and [\pm contour]:

	[–high]	[+high]
[–contour]	/33/	/55/
[+contour]	/31/	/51/

Tones /31/ and /55/ occur in both stopped and unstopped syllables. Tones /33/ and /51/ occur only in unstopped syllables⁴.

2.2 Tone Sandhi in Compounds

The principle Jingpho tone sandhi processes that will be discussed in this paper are those occurring in disyllabic nominal compounds. The whole system of tone sandhi processes is quite complex, and interacts with a number of factors, especially syllable structure. In their simplest form, the tone changes in disyllabic compounds affect the

⁴The tonal values for Jingpho as spoken in Burma may be slightly different. Matisoff (1974:159) describes our /55/ as HIGH, and our /33/ as mid, but calls our /31/ LOW. /51/ is described as FALLING.

first syllable only, but other intervening factors may cause the second syllable to change in tone as well⁵. The normal process can be analyzed into two components:⁶

1. The first syllable, regardless of the tone of the following syllable, changes its specification for the feature [\pm contour].
2. If possible, the first syllable assimilates to the second syllable in its specification for the feature [\pm high].

Other things being equal, then, we will observe the set of changes seen in Table 1. Of

	55	33	31
55	31-55	31-33	31-31
33	31-55	31-33	31-31
31 <i>stopped</i>	55-55	55-33	55-31
31 <i>unstopped</i>	55-55	33-33	33-31

Table 1: Basic tone changes in Jingpho disyllabic compounds.

course, other things are not equal, and the actual changes are heavily modulated. For example, stopped syllables cannot bear the tone /33/. Stopped syllables on which /33/ would be expected (based upon the chart above) will actually be realized with the tone /55/.

2.2.1 Data

Representative examples can be found in the following data, adapted from Dai (1990) (to which source the reader should refer for a comprehensive descriptive account of tone sandhi patterns in Jingpho):

- (2) a. tum⁵⁵ + khzak⁵⁵ → tum³¹ khzak⁵⁵
bamboo tube suitable 'small box'
- b. phun⁵⁵ + ku⁵⁵ → phun³¹ ku⁵⁵
tree branch crooked 'bent tree branch'
- (3) a. tum⁵⁵ + ka³³ → tum³¹ ka³³
bamboo tube picture 'bamboo tube with patterns'
- b. kat⁵⁵ + tsi³³ → kat³¹ tsi³³
'tree sp.'
- (4) a. pʒa⁵⁵ + mut³¹ → pʒa³¹ mut³¹
caterpillar gray 'gray caterpillar'

⁵These changes will not be discussed here, but the reader is referred to Dai (1990:207–211) for further details.

⁶This insight, and much of the foundation for the analysis below, is due ultimately to Lai (2002). All data are adapted from Dai (1990).

- (9) a. $\text{thiŋ}^{31} + \text{ka}^{33} \rightarrow \text{thiŋ}^{33} \text{ka}^{33}$
 ‘back basket’
- b. $\text{u}^{31} + \text{kh}\bar{z}\text{u}^{33} \rightarrow \text{u}^{33} \text{kh}\bar{z}\text{u}^{33}$
 bird dove ‘turtledove’

I cannot explain example (10a) in terms of my analysis, and believe it to be an exceptional form.

- (10) a. $\text{khum}^{31} + \text{t}\bar{f}\text{aŋ}^{33} \rightarrow \text{khum}^{55} \text{t}\bar{f}\text{aŋ}^{33}$
 ‘winter melon’
- b. $\text{mji}^{31} + \text{p}\bar{z}\text{ui}^{33} \rightarrow \text{mji}^{55} \text{p}\bar{z}\text{ui}^{33}$
 eye tear ‘tear’
- (11) a. $\text{na}^{?31} + \text{tham}^{31} \rightarrow \text{na}^{?55} \text{tham}^{31}$
 ‘a type of large tuber’
- b. $\text{wa}^{?31} + \text{k}\bar{z}\text{aŋ}^{31} \rightarrow \text{wa}^{?55} \text{k}\bar{z}\text{aŋ}^{31}$
 ‘bamboo washing basin’

2.3 Implications for tonal representation

Although a few practitioners of optimality theory have attempted to operate as if representations are irrelevant to the enterprise of phonological theory, arguing that the grammar should be constructed so as to produce well-formed outputs even under changing representation. However, it has become apparent that no theory phonology—no matter how grammar-centered—can be formulated without some notion of representation. Even variants of optimality theory which assume that constraints make direct reference to phonetic parameters require a way of formalizing the relationship between inputs and outputs and the parameters to which constraints can apply. Thus, it will be impossible to provide a replicable analysis of tone sandhi without making explicit the representational assumptions that underly it. The matter of tonal representations (and particularly the matter of representing East Asian tone systems like Jingpho) is still under intense debate and each paper on the subject seems to bring with it a slightly different notion of tonal representation. The current paper is no exception. In most controversial claim that will be made here is that Jingpho tone can be represented as a set of binary (equipollent) features, the internal structure of which is not important to the analysis. That is, the representation does not rely upon the critical ordering of features within tones along tiers or any other axis.

This may seem like a reactionary move—a return to the bad old days of SPE—derived tonology (as exemplified in Wang 1967). Most subsequent models of tone, including those for East Asian languages, have treated them as either autosegmental or feature-geometric structures (see, for example, Woo 1969, Yip 1980, Duanmu 1990, Bao 1999 and so forth)⁷. However, it is not always clear to what degree these representation are driven by the demands of the data for the particular languages under discussion

⁷An exception to this generalization is Shih (1986), which—if Bao (1999) is correct in his interpretation—bears some important affinities to the system employed here, especially for A–Hmao.

and to what extent they reflect a desire to devise a single formalism that can account for both “register” and “contour” tone languages (for which distinction, see Pike 1948) or, at very least, emphasize the commonalities between these two types of systems.

/55/	/33/	/51/	/31/
H	L	H	L
		/	/
h	h	h l	h l

Table 2: Representation of Jingpho tones under Yip’s system.

Unfortunately, it does not seem that these earlier models provide much insight into the nature of Jingpho tone sandhi. Take for example the possible representation of the Jingpho tones according to Yip’s (1980) system in Table 2. This representation makes modeling the alternations seen in Jingpho quite difficult. First of all, the only instances of Jingpho tone sandhi that seem to act like autosegmental spreading would have to be modeled (given the representations in Table 2) as cases of register spreading. The first case, in the compounding construction already mentioned, is exemplified when /31/ becomes as level tone and assimilates in register to the following tone:

- (12) a. 31 + 55 → 55–55
 b. 31 + 33 → 33–33
 c. 31 + 31 → 33–31

The second is exemplified in certain other constructions, where a /31/ tone following a /55/ tone becomes a high–falling tone /51/:

- (13) 55 + 31 → 55–51

Problematically, Yip’s representations are designed specifically to prevent this very possibility. Since the register acts as a node dominating the other (sequentially arranged) tonal features, it cannot be “spread” without spreading the whole tone.⁸

The representation is of even less help when modeling the polar alternation between falling and non–falling tones. While the process behaves as if “contourness” was a single parameter which the grammar can simply toggle, Yip’s style of representation would force the grammar to model such alternations as the insertion of a low tone (if the contour node only dominates a high tone) or the delinking of a low tone (if the contour node dominates a high tone and a low tone). Such statements are further complicated by the fact that, in this representation, contour itself does not function as a unitary constituent.

⁸Of course, within a declarative phonological framework such as OT, representations do not necessarily have the same implications that they would in a procedural framework. The fact that the register feature dominates any tones in a contour (in Yip’s representation) may prevent a spreading processes which resulted in the sharing of only the register feature, but would do nothing to prevent a constraint from motivating agreement between features in an output. In other words, in a declarative framework, Yip’s representation of tone only makes the predictions it is claimed to make regarding register spreading if constraints of the type AGREE apply not only to instances of the feature supplied as an argument to the constraint, but to any features dominated by specific instances of this feature.

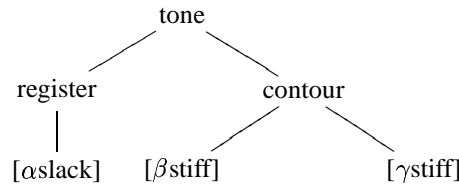


Figure 1: Representation of tone in Bao (1999).

Under Bao’s (1999) system, the situation is somewhat better. Taking the equivalent feature values and applying them to Bao’s formalism (see Figure 1), we are able to model the spreading of register observed in Jingpho. His system treats register as a feature–group sister to, and residing on a separate tier from, contour, so spreading of the register separate from contour is predicted. But while contour polarity is easier to formalize in this system than under Yip’s representations, its implementation is still unnecessarily complicated. Even if the grammar is able to refer to the contour as a unit, it still must make stipulations that would both force the feature values dominated by contour in the surface form to disagree with the feature values dominated by contour in the UR, at the same time preventing this change from avoiding identity by simply producing a rising contour from a falling contour, a low level from a high level, and so on.

In fact, to digress in a manner relative to the point at hand, most autosegmental representations of tone provide no structural mechanism for modeling the greater markedness of rising tones than of falling tones. In systems like those of Bao and Yip, rising and falling tones are equivalent in structural complexity. The preference for falling tones over rising tones seen in many tone change processes must, assuming Bao or Yip’s representation, be stipulated directly in the grammar⁹. The featural system used here, in contrast, can separate the existence of a contour from its realization as rising or falling, with falling as the default (or “unmarked”) type of contour. The greater markedness of rising tones is indicated by the participation of a separate feature [rise] in their representation. In the case of Jingpho, the feature [+rise] is so highly marked that it is banned altogether. This specific fact must be stated in the grammar, but the greater *relative* markedness of these tones emerges naturally from the featural representation.

While Bao’s system represents an improvement over that of Yip, it probably does not provide enough insight into systems like that of Jingpho to justify the conceptual complexity necessary to frame the analysis of such systems within it.

In short, any the generalizations that can be captured for Jingpho tone sandhi using either of these two representational schemes can be captured more elegantly by using the two equipollent features [\pm high] and [\pm contour]. This is especially true within a

⁹Given my own ontological assumptions, I am not averse to the encoding the greater “markedness” of rising contours relative to falling contours in the grammar *as a parochial parameter*. For both articulatory and perceptual reason—phonetics favor falling tones over rising tones and changes which remove rises are thus more likely to be phonologized than changes which create rises. Thus, this typological generalization need not be attributed to any innate characteristic of the language user. Thus, I am sceptical of the psychological reality of these features, but I feel that they are nevertheless useful for modeling some phonological behaviors.

declarative framework in which proximity on a tier is not a necessary precondition for enforcing agreement or co-occurrence restrictions between feature values.

2.4 Anti-faithfulness analysis of Jingpho tone sandhi in disyllabic compounds

2.4.1 Earlier analyses

The analysis given here builds upon the descriptive work of Dai (1990) and the earlier OT analysis of Lai (2002). The following analysis differs from that of Lai (2002) in several respects. However, it shares with that analysis the fundamental insight that anti-identity effects drive much of this sandhi process.

Lai calls her anti-identity constraint *LIGHT-SYLLABLE'S-TONAL-CONTOUR-DOES-NOT-CHANGE¹⁰ Despite the fact that this constraint is phrased as a markedness constraint, it is evaluated as an anti-faithfulness constraint (and is basically a context-specific equivalent of \neg IDENT-CONTOUR as defined below; see 2.4.2). This constraint dominates the height agreement constraint TONE-OF-STRESSED-SYLLABLE-SPREADS-TO-UNSTRESSED-SYLLABLE¹¹ which is co-ranked with contour faithfulness¹². These two constraints dominate faithfulness to tone height¹³. Lai is not clear about the type of representation she employs for tone, but it is clear from the evaluation of her constraints that the variables to which her constraints make reference are equivalent to the features employed in my analysis (my [\pm high] and [contour]).

It is not clear that Lai's (2002) ranking of constraints can predict all of the outputs documented for this type of construction. For example, given a /33/ + /55/ or /55/ + /55/ sequence, her analysis would seem to predict a /51/ contour, but the actual output is always /31/. Lai's analysis could account for these outputs through the use of additional constraints, but she does not seem to be primarily concerned with handling all of the data relevant to this compounding construction. Instead, she focuses more attention upon fitting this pattern into a single constraint-ranking grammar that will generate all of the possible tone sandhi patterns in Jingpho, especially those appearing in constructions consisting of a minor-syllable prefix affixed to a root. The tonal phonology of these words is quite different than that of the compounds listed above and it is the position of the current author that these constructions belong to different co-phonologies, and that relatively little insight is to be gained by treating these very distinct alternations as manifestations of the same underlying patterns¹⁴.

¹⁰Chinese: *輕音節調形不變.

¹¹Chinese: 重音節調高延伸至輕音節

¹²Chinese: 調形不變.

¹³Chinese: 調高不變.

¹⁴It should be noted that my analyses have some philosophical underpinnings that differ from "mainstream" OT. These assumptions may be grouped together under the rubric CONSTRUCTION PHONOLOGY. Briefly, my notion of CONSTRUCTION PHONOLOGY holds that the morphophonological grammar consists of a set of grammars, each of them describing a specific CONSTRUCTION (leaf nodes) or CONSTRUCTIONS CLASSES (parent nodes), ordered according to an inheritance hierarchy. The topmost grammar in the hierarchy describes all generalizations that can be made over the whole lexicon of the language, and each daughter grammar describes a subset of the lexicon, which is successively smaller as one moves down the tree. To place the abstraction in more concrete terms, in an OT implementation of a Construction Phonology grammar, the parent construction class would consist of constraint rankings that are shared by all daughter

Be that as it may, differences between Lai’s analysis and that presented here are relatively slight. Nevertheless, Lai did not note the extent to which the phenomena captured by the constraint *LIGHT-SYLLABLE’S-TONAL-CONTOUR-DOES-NOT-CHANGE is different from both markedness and faithfulness as they are typically understood with OT. She also does not carry the implications of these phenomena for the representation of tone in Jingpho to their logical conclusion, namely that contour functions as a unitary feature rather than being a derivative of autosegmental structure.

2.4.2 Constraint definitions

The following constraints are employed in my analysis of this phenomenon:

Anti-faithfulness

- \neg IDENT-CONTOUR¹⁵ The feature [contour] must have a different specification in output than in input. This could be translated into a transderivational anti-faithfulness constraints à la Alderete (1999, 2001). However, it is not clear that Jingpho construction we are modeling here follows the prediction made by transderivational anti-faithfulness, namely that such alternations should be confined to bases or stems.

Faithfulness

- IDENT-T-STRESSED The feature specifications of a tone associated in the output with a TBU bearing stress must be identical to the corresponding feature specifications in the input. In practical terms, this constraint penalizes changes in the tone of the second syllable of compounds, since in Jingpho compounds, the second syllable is stressed and the first is unstressed (Lai 2002).
- IDENT-HIGH The specification for the feature high must be the same for corresponding tones in the input and the output.

Markedness

- AGREE-HIGH Tones within a word should share the same specification for [high].¹⁶

constructions and construction classes, and are thus consistent with the entire lexicon. Constructions themselves describe lexical classes, morphological constructions, and other subsets of the lexicon. They encode only productive phonological generalizations (i.e. morphophonemic processes, phonotactic generalizations, and so on)—generalizations that cannot be employed productively are treated as properties of the lexicon, not properties of the grammar. In their formalization, a construction does not aim to relate an abstract underlying forms to surface forms (or outputs from related constructions) so much as to relate old items from outside the lexical scope of the construction to new items lying within the lexical scope of the construction. The large role of the lexicon in Construction Phonology is incompatible with the richness of the base hypothesis, and certain other ideas commonly associated with Optimality Theory. Constraints, in construction phonology, are not assumed to be either universal or innate.

¹⁵I prefer to refer to this family of constraints as SCHMIDENT, in honor of its role in echo-word constructions. However, I have used the more conventional term in this paper in order to avoid excessive flippancy.

¹⁶This could be implemented one of two ways: (1) The OCP could be assumed and the constraint could be seen as enforcing the sharing of a single [high] feature among two or more TBUs. (2) The OCP could

- *HIGH-CONTOUR Tones which are both [+high] and [+contour] are banned. In effect, this constraint penalizes the tone /51/.
- *LOW-LEVEL-STOPPED (or *LLS) This constraint is violated when [–high, –contour] tones occur in syllables ending with a stop coda¹⁷.

2.4.3 Contour Anti-faithfulness

At its simplest, the alternation seen in the data provided in Section 2.2.1, can be seen as a competition between IDENT-T-STRESSED and ¬IDENT-CONTOUR (as seen in (14) ‘turtledove’ below):

		u ³¹ + khɔ̃u ³³	ID-T-STR	¬ID-C
(14)	☞ (a)	u ³³ khɔ̃u ³³		*
	(b)	u ³¹ khɔ̃u ³³		**!
	(c)	u ³¹ khɔ̃u ³¹	*!	

The mirror image of this tone shift (of /31/ to /33/ before /33/) is seen in ‘cotton field’ (as shown in (15) below). Given this constraint ranking, these two mutually inverse input–output pairs are formally identical:

		si ³³ + phɔ̃a ³³	ID-T-STR	¬ID-C
(15)	☞ (a)	si ³¹ phɔ̃a ³³		*
	(b)	si ³³ phɔ̃a ³³		**!
	(c)	si ³¹ phɔ̃a ³¹	*!	

While these two constraints form the kernel of this interaction, they are not sufficient to account for the full range of alternations seen in the data (simply because there are additional markedness–related factors which constrain possible outputs).

2.4.4 Ban on high falling tones

This construction seems to be characterized by a fairly high–ranked ban on high falling tones (tones with the feature specification [+high, +contour]). This is evidenced by the non–occurrence of /51/, even in contexts where it would be predicted to occur (other things being equal). In (16) ‘sleeve’, there is no apparent reason, except for a ban on /51/, that would make the winning candidate (a) more optimal than candidate (c).

be ignored and the constraint could be treated as simply enforcing agreement in the specification for this feature. These two definitions make somewhat different predictions. In this paper, I will be assuming the latter definition.

¹⁷In Jingpho, this constraint’s diachronic phonological origins are not clearly related to its synchronic phonological formulation. According to Matisoff (1974), two tones in Jingpho stopped syllables are the reflexes of a single proto–tone which split according to the voicing of the onset. Because the split was only binary, only the reflexes of these two tones (which now pattern with tones in open syllables) are allowed in stopped syllables.

loŋ ³³ + taʔ ⁵⁵		*HC	ID-T-STR	¬ID-C
(16)	(a) loŋ ³¹ taʔ ⁵⁵			*
	(b) loŋ ³³ taʔ ⁵⁵			**!
	(c) loŋ ³¹ taʔ ³¹		*!*	
	(d) loŋ ⁵¹ taʔ ⁵⁵	*!		*

Furthermore, in (17) ‘bamboo tube with patterns’, one would expect candidate (d) to win—to be the most optimal candidate—if there were not a high-ranked constraint banning /51/:

tum ⁵⁵ + ka ³³		*HC	ID-T-STR	¬ID-C	ID-H
(17)	(a) tum ³¹ ka ³³			*	*
	(b) tum ⁵⁵ ka ³³			**!	
	(c) tum ³¹ ka ³¹		*!		*
	(d) tum ⁵¹ ka ³³	*!			

Likewise, in (18) ‘crooked branch’, it seems readily evident that candidate (e) is most favorably evaluated by the kernel anti-faithfulness and faithfulness constraints. It appears, then, that even though the contour /51/ can occur in certain contexts, it is banned in this construction.

phun ⁵⁵ + kuʔ ⁵⁵		*HC	ID-T-STR	¬ID-C	ID-H
(18)	(a) phun ³¹ kuʔ ⁵⁵			*	*
	(b) phun ⁵⁵ kuʔ ⁵⁵			**!	
	(c) phun ³¹ kuʔ ³³		*!	*	*
	(d) phun ³¹ kuʔ ³⁵		*!*		*
	(e) phun ⁵¹ kuʔ ⁵⁵	*!		*	

It is not clear, however, that this ban can be said to be phonetically well motivated. Intuitively, a high falling tone should be more desirable than a low falling tone since it provides a greater pitch range over which the contour to be realized and therefore should be more salient perceptually. The explanation for the pattern seems to lie in history rather than synchronic phonetics. As Matisoff (1974:160) points out, tone /51/ is a “johnny-come-lately.” If it emerged after the tone sandhi system was established, it may simply have been missing from the lexical subset associated with this construction, and thus is not yet licensed for participation in it.

2.4.5 Register assimilation

The constraint ranking established up to this point does not explain the fact that, *ceteris paribus*, the tones of syllables in a disyllabic compound agree in their specifications for the feature [high]. Without a constraint enforcing such agreement and dominating IDENT-HIGH, one would predict the victory of the more faithful candidate (b), rather than the assimilating candidate (a):

	thiŋ ³¹ + ʒoʔ ⁵⁵	*HC	ID-T-STR	¬ID-C	AGR-H	ID-H
(19)	(a) thiŋ ⁵⁵ ʒoʔ ⁵⁵			*		*
	(b) thiŋ ³³ ʒoʔ ⁵⁵			*	*!	
	(c) thiŋ ³¹ ʒoʔ ⁵⁵			*!*	*	
	(d) thiŋ ³¹ ʒoʔ ³¹		*!	*		*
	(e) thiŋ ³¹ ʒoʔ ³³		*!	**		
	(f) thiŋ ⁵⁵ ʒoʔ ⁵¹	*!	*			*

It has already been noted that this relationship is functionally equivalent to “register spreading.” If this analysis is correct, it has important implications for theories of tonal representation that predict the non-occurrence of this type of effect.

2.4.6 Syllable type–tone co-occurrence restriction

A complete analysis of tone sandhi in this construction requires the consideration of one other characteristic of the general tonal grammar of Jingpho—the fact that /33/ and /51/ tones cannot occur in syllables ending in an oral stop consonant. Given the high-ranked ban on /51/ tones, this constraint is only evaluated as violated when a /31/ tone occurs in a stopped syllable and is called *LOW-LEVEL-STOPPED. However, the constraint could equally well be formalized so that it was violated whenever a tone with the features [α high, α contour] was associated with a stopped syllable.

This constraint comes into play in forms like ‘tear’ shown in (20). In this case, the agreement and identity constraints would favor candidate (e). However, this candidate is phonotactically impossible. Thus, candidate (a) wins even though it violates both AGREE-HIGH and IDENT-HIGHT.

	mjiʔ ³¹ + pʒui ³³	*LLS	*HC	ID-T-STR	¬ID-C	AGR-H	ID-H
(20)	(a) mjiʔ ⁵⁵ pʒui ³³				*	*	*
	(b) mjiʔ ³¹ pʒui ³³				**!		
	(c) mjiʔ ³¹ pʒui ³¹			*!	*		
	(d) mjiʔ ⁵⁵ pʒui ⁵¹		*!	**			**
	(e) mjiʔ ³³ pʒui ³³	*!			*		

Inasmuch as this constraint, *HC and *ID-TONE-STRESS, are never violated in the construction under discussion, it does not appear that they are crucially ranked relative to one another. However, they clearly are ranked very high in the constraint hierarchy.

3 Case Study: A-Hmao

A-Hmao is a Western Hmongic language spoken in parts of Guizhou and Yunnan provinces in China¹⁸. On the basis of shared lexicon and shared phonological innovations, it appears to be closely related to the Hmongic dialects of Mainland Southeast Asia (Hmong Daw and Mong Leng, as well as the varieties of Hmong spoken in

¹⁸Like many people groups in Southeast Asia, the A-Hmao are cursed with an incredible profusion of names. Roughly equivalent appellations include *Shimen Hmong*, *Shimenkan Miao*, *Weining Miao*, *(Da) Hua Miao*, *(Big) Flowery Miao*, *A-Hmau* and probably others.

Dananshan and *Xuyong* (Wang 1994; Wang and Mao 1995; Niederer 1998). However, it is highly innovative and is not mutually intelligible with any of these speech varieties. The literature recognizes two main dialect groups for A–Hmao: Western A–Hmao (WAM) and Eastern A–Hmao (EAM). Most of the available publications on this language document the Eastern Dialect as exemplified by the speech of the inhabitants of Shimenkan village, Weining county, Guizhou province. For a comprehensive bibliography of literature on this dialect, see Johnson 1999.

3.1 The A–Hmao tone system

3.1.1 Historical background

A real understanding of the tonal patterns of A–Hmao is not possible without a historical and comparative perspective on the development of A–Hmao tones. It has long been established that Proto–Hmongic had four contrasting tones, each of which had two important allotones—one occurring in syllables with voiceless and preglottalized onsets and the other occurring in syllables with modal voiced onsets (Chang 1953). The four proto–tones have typically been identified with the *ping*, *shang*, *ru*, and *qu* tones of traditional Chinese historical phonology and are usually identified by the letters A, B, C, and D respectively. At the proto–Western Hmong stage, the voicing–conditioned proto–allotones mentioned (here designated 1 and 2 respectively and traditionally called *yin* and *yang* after their Chinese equivalents) had not yet undergone the transition from predictable variants to phonologically distinct tones. However, most (but not all) of the modern Western Hmongic dialects have replaced the previously existing voicing distinctions with tonal distinctions.

But even before this contrast was completely rephonologized, the proto–allotones were already displaying different phonological behavior. A system of tone sandhi processes can be reconstructed for proto–Western–Hmongic in which the *yin* and *yang* allotones of each toneme behave differently from one another (Ratliff 1992). This tone sandhi system is most clearly understood as a phonologized categorial system, rather than a system of shared repairs to phonetic or phonological ill–formedness. The tone sandhi system of the *Dananshan* dialect (represented in Figure 2) provides a representative example of one of these systems. The changes represented are those that occur in syllables following syllables bearing one of the *ping* tones (A1 and A2). Despite differences in pitches and voice qualities, identical systems can be found in the *Dashanjiao* dialect and *Hmong Daw*; less perfect reflexes of these systems can be found in *Mong Leng* and the *Xuyong* dialect (Ratliff 1992; Niederer 1998). The fact that what appear to be predictable allotones of the same toneme display rather different phonological behavior in tone sandhi may have important implications for theories of phonological representation and assumptions about the relationship between onset voicing and tone. Unfortunately, these issues cannot be fully explored here. A–Hmao preserves some of the features of the older tone system, including some of the tone sandhi rules, but it has, through innovation, introduced some unique properties of its own.

	A	B	C	D
1	43	55	44	33
2	31	21fi	13fi	24

Figure 2: Dananshan *ping*-triggered tone sandhi.

3.1.2 Western A-Hmao tone system

Although there is a great deal of literature available on Eastern A-Hmao, including a good deal of work on the phonology of tones Wang and Wang (1984), adverbs, demonstratives, and nominal reduplication, little specific information is available on the phonetics of the tone system. While only one article on Western A-Hmao is available (Johnson 1999), this article details specifically the phonetic properties of Western A-Hmao tone. A basic outline of the contrasts can be found in Table 3.1.2. In addition to

<i>category</i>	<i>contour</i>	<i>example</i>	<i>gloss</i>
A1	52	tau ⁵²	‘gourd’
A2	13	ts ^h ai ³¹	‘that side’
B1	45	tu ⁴⁵	‘flea’
B2, D1	22	tau ²²	‘axe’
C1	33	tau ³³	‘get’
C2	21	tau ²¹	‘poke’
D2	11	ty ¹¹	‘fart’

Table 3: The tones of Western A-Hmao (adapted from Johnson 1999:229)

this outline, a few notes are in order:

- The tones of Western A-Hmao, like those of many other East and Southeast Asian languages, are associated with characteristic lengths. Syllables bearing falling tones tend to be short, while those bearing rising or level tones tend to be longer (see Johnson 1999:230).
- B1 is described by Johnson (1999) as rising, but his pitch plots show it to be almost level, with a slight upward taper and a drop at the end.
- Tone C2 has a clear phonetic fall Johnson (1999:230), but I will treat it as a phonologically level tone (for reasons that will become apparent). This decision is problematic both in terms of phonetic realism and phonological representation (since it would imply that this system, phonologically, has five levels of contrasting pitch). However, it appears to be justified for analytic reasons. Namely, C2 does not pattern with other contour tones but does pattern with the low, level tones.

- Tones B2 and D1 have an identical surface realization, but they display different patterns of phonological behavior and so must be given distinct representations.

Tone and phonoation Western A–Hmao preserves, to a large extent, the voicing distinctions of Proto–Western Hmong. However, tone has become dissociated from the voice and voice quality of obstruents so that any tone contour can occur with almost any of the consonant types (when these are categorized according to voicing). This subject is treated at length by Johnson (1999) (see especially Table 4 on page 242). The reflexes of preglottalized sonorants are characterized by modal voicing, while the reflexes of modal voiced obstruents and sonorants are characterized by breathy phonation (which seems to be associated with the onset, but which affects the syllable as a whole). The distinctions *yin* and *yang* register tones still exists in a phonological sense (it is essential to any understanding of the tone sandhi patterns) but it is not linked to the actual voicing of the obstruents.

Because of the detailed information available on its tones, and because of the relative simplicity of its tone and tone sandhi system, the analysis given here will center upon Western A–Hmao (even though the volume of available tone sandhi data is much smaller). Extensive information on Eastern A–Hmao is provided for comparison.

3.1.3 Eastern A–Hmao tone system

There are two major differences between the Eastern A–Hmao tone system and that of Western A–Hmao (as well other Western Hmongic languages):

1. The voicing distinction between modal voiced and preglottalized sonorants was collapsed (like most other Western Hmongic languages but unlike Western A–Hmao). The other voicing distinctions in onsets are retained, and still retain their historical relationship to tone categories (Niederer 1998).
2. There was an additional tonal split along grammatical lines, possibly conditioned by a now–lost prefix.¹⁹ Tones B2, C2, and D2 split according to whether the morpheme bearing the tone was nominal (I) or non–nominal (II) (Wang and Wang 1984; Ratliff 1991, 1992). This change is confined to the Shimenkan dialect (Eastern A–Hmao) (Wang and Wang 1984:6 and Ratliff 1991:277).

<i>Register</i>		A	B	C	D
1 (voiceless)		55	55'	33	11
2 (voiced)	I (nom)		33'	53	53'
	II (non–nom)	35fi	11fi	31	31fi

Table 4: The tonal inventory of Eastern A–Hmao by historical category (adapted from Wang and Wang 1984).

Table 4 gives the pitch values for each of the tones as they are given by Wang and Wang (1984). These values are idealized so as to employ only three levels. The data

¹⁹The idea that this tonal split was conditioned by a prefix was proposed and defended in Ratliff (1991).

given later in this section is transcribed with these values. Phonetically more realistic values are given in Table 5. It should be observed that there are only six contrastive

<i>Register</i>		A	B	C	D
1 (voiceless)		55	55'	44	22
2 (voiced)	I (nom)		44'	53	53'
	II (non-nom)	24fi	12fi	21	31fi

Table 5: The tonal inventory of Eastern A–Hmao with phonetic tone values (adapted from Wang and Wang 1984:91 and Enwall 1994:33–34).

pitch contours and eight contrasting combinations of pitch and phonation. However, as will be seen, the sandhi behavior of tones—as both triggers and targets—is dependent upon their historical category and not upon their surface phonetics. In other words, it is necessary to posit different underlying representations for at least ten of these eleven categories even though only eight contrasting categories are represented on the surface.

Tone and phonation In Eastern A–Hmao, by way of contrast with WAH, not all of the voicing distinctions from the proto–language are preserved. In particular, the distinction between preglottalized and modal voice sonorants has been lost (so there are a few minimal pairs that separate *yin* register tones from *yang* register tones). However, tone and phonation are still closely associated. Three of the tones (A1, B1, and D1) are characterized by breathy phonations (which Wang and Wang transcribe as a segmental distinction). When a tone sandhi process changes a tone in one of these categories to another category, the voice quality of the associated syllable changes. Likewise, when a syllable with an obstruent initial bearing the tone A2 changes to tone A1, the onset becomes voiceless (Li 2001:145). Thus, in contrast to Western A–Hmao, voice quality in Eastern A–Hmao should be treated as an integral part of tone, with some apparent segmental distinctions in voice quality being conditioned by these tonal features.

3.2 A–Hmao general *ping*–triggered tone sandhi

3.2.1 Western A–Hmao

Western A–Hmao preserves what appears to have been the proto–A–Hmao *ping*–triggered tone sandhi system. All of these changes occur when a *ping* (A) tone syllable occurs before a syllable of the targeted tone. From the proto–Western–Hmong tone sandhi system, it preserves the B1 → C1 → D1 chain. The other changes are innovations peculiar to A–Hmao. The whole set of changes is schematized in Figure 3. The relatively few examples of Western A–Hmao tone sandhi that are available are from Johnson (1999:241). All of these are nominal compounds, and it is thus unclear how general these tone sandhi patterns are:

- (21) a. $\text{kau}_{(A1)}^{52} + \text{ki}_{(B1)}^{45} \rightarrow [\text{kau}_{(A1)}^{52} \text{ki}_{(C1)}^{33}]$
 line road ‘custom; Christianity’

	A	B	C	D
1	52	45	33	22
2	13	22	21	11

Figure 3: Western A–Hmao *ping*-triggered tone sandhi.

- b. $dfi_{(A2)}^{13} + mpa_{(C1)}^{33} \rightarrow [dfi_{(A2)}^{13} mpa_{(D1)}^{22}]$
oil pig ‘lard’
- c. $ndfiu_{(A2)}^{13} + dzfie_{(B2)}^{22} \rightarrow [ndfiu_{(A2)}^{13} dzfie_{(C2)}^{21}]$
sky/season cold ‘autumn’
- d. $?au_{(A1)}^{52} + nfiaw_{(C2)}^{21} \rightarrow [?au_{(A1)}^{52} nfiaw_{(B2)}^{22}]$
water rain ‘rain water’
- e. $ndfili_{(A2)}^{13} + ndfilau_{(D2)}^{11} \rightarrow [ndfili_{(A2)}^{13} ndfilau_{(B2)}^{22}]$
rice glutinous ‘glutinous rice’
- f. $ngfiai_{(A2)}^{13} + zfiaw_{(A2)}^{13} \rightarrow [ngfiai_{(A2)}^{13} zfiaw_{(A1)}^{52}]$
meat sheep ‘mutton’

3.2.2 Eastern A–Hmao

In Eastern A–Hmao, the tone sandhi situation is far more complicated. While it seems apparent that this (the *ping*-driven) system developed from a complex one like that of Western A–Hmao, the nominal/non-nominal splits in the *yang* tones have produced a much more complicated system, represented in Figure 4, (based upon data and analysis from Wang and Wang 1984). This does not represent all of the tone changes that can

	A	B	C	D
1	55	55'	33	11
2 I		33'	53	53'
2 II	35fi	11fi	31	31fi

Figure 4: Eastern A–Hmao *ping*-triggered tone sandhi.

occur in Eastern A–Hmao. In the same types of syntactic and morphological contexts, tone B1 can trigger a different set of changes. Furthermore, the nominal tones also

merge with their non-nominal counterparts under certain tonal conditions. And this is only the beginning of the complications, as certain other constructions, like numeral-classifier constructions, exhibit yet another—subtly different—pattern of tone sandhi (Wang 1958, 1986).

Their is a fairly copious set of tone sandhi data for EAH. The following data are taken from Wang and Wang (1984:100–109):

- (22) a. $\text{tu}_{(A1)}^{55} + \text{ki}_{(B1)}^{55} \rightarrow [\text{tu}_{(A1)}^{55} \text{ki}_{(C1)}^{33}]$
 ‘son’ ‘grandson’ ‘descendants’
- b. $\text{mau}_{(A1)}^{55} + \text{sa}_{(B1)}^{55} \rightarrow [\text{mau}_{(A1)}^{55} \text{sa}_{(C1)}^{33}]$
 ‘A-Hmau’ ‘Chinese’ ‘populace’
- c. $\text{gfiu}_{(A2)}^{35} + \text{su}_{(B1)}^{55} \rightarrow [\text{gfiu}_{(A2)}^{35} \text{su}_{(C1)}^{33}]$
 ‘lusheng’ ‘sound’ ‘sound of lusheng’
- d. $\text{lfi}_{(A2)}^{35} + \text{nti}_{(B1)}^{55} \rightarrow [\text{lfi}_{(A2)}^{35} \text{nti}_{(C1)}^{33}]$
 ‘long time’ + ‘long’ ‘for a long time’
- (23) a. $\text{ti}_{(A1)}^{55} + \text{t\check{c}hey}_{(C1)}^{33} \rightarrow [\text{ti}_{(A1)}^{55} \text{t\check{c}hey}_{(D1)}^{11}]$
 ‘land’ ‘place’ ‘location’
- b. $\text{qu}_{(A1)}^{55} + \text{t\check{s}ho}_{(C1)}^{33} \rightarrow [\text{qu}_{(A1)}^{55} \text{t\check{s}ho}_{(D1)}^{11}]$
 ‘old’ ‘clothing’ ‘old clothing’
- c. $\text{nfi}_{(A2)}^{35} + \text{cau}_{(C1)}^{33} \rightarrow [\text{nfi}_{(A2)}^{35} \text{cau}_{(D1)}^{11}]$
 ‘year’ ‘year’ ‘age’
- d. $\text{dzfi}_{(A2)}^{35} + \text{mpa}_{(C1)}^{33} \rightarrow [\text{dzfi}_{(A2)}^{35} \text{mpa}_{(D1)}^{11}]$
 ‘animal’ ‘pig’ ‘beast of burden’
- (24) a. $\text{lu}_{(A1)}^{55} + \text{za}_{(C2I)}^{53} \rightarrow [\text{lu}_{(A1)}^{55} \text{zfi}_{(B2II)}^{11}]$
 ‘CLF’ ‘comb’ ‘the comb’
- b. $\text{au}_{(A1)}^{55} + \text{nau}_{(C2I)}^{53} \rightarrow [\text{au}_{(A1)}^{55} \text{nfi}_{(B2II)}^{11}]$
 ‘water’ ‘rain’ ‘rain water’
- c. $\text{dlfi}_{(A2)}^{35} + \text{zo}_{(C2I)}^{53} \rightarrow [\text{dlfi}_{(A2)}^{35} \text{zfi}_{(B2II)}^{11}]$
 ‘spirit’ ‘strength’ ‘vigor’
- d. $\text{dzfi}_{(A2)}^{35} + \text{nau}_{(C2I)}^{53} \rightarrow [\text{dzfi}_{(A2)}^{35} \text{nfi}_{(B2II)}^{11}]$
 ‘time’ ‘time’ ‘time’
- e. $\text{tu}_{(A1)}^{55} + \text{bfia}_{(C2I)}^{31} \rightarrow [\text{tu}_{(A1)}^{55} \text{ba}_{(B2II)}^{11}]$
 ‘son’ ‘embrace’ ‘adopted son’
- f. $\text{qai}_{(A1)}^{55} + \text{dlo}_{(C2II)}^{31} \rightarrow [\text{qai}_{(A1)}^{55} \text{dlfi}_{(B2II)}^{11}]$
 ‘chicken’ ‘fat’ ‘fat chicken’

- g. $\eta\text{fiu}_{(2)}^{35} + \text{dlo}_{(C2II)}^{31} \rightarrow [\eta\text{fiu}_{(2)}^{35} \text{dlfi}_{(B2II)}^{11}]$
‘cattle’ ‘fat’ ‘fat cattle’
- h. $\text{zfiaw}_{(A2)}^{35} + \text{da}_{(C2II)}^{31} \rightarrow [\text{zfiaw}_{(A2)}^{35} \text{dfia}_{(B2II)}^{11}]$
‘sheep’ ‘die’ ‘dead sheep’
- i. $\text{qu}_{(A1)}^{55} + \text{va}_{(D2I)}^{53} \rightarrow [\text{qu}_{(A1)}^{55} \text{vfi}_{(B2II)}^{11}]$
‘old’ ‘rice’ ‘leftover rice’
- j. $\text{i}_{(A1)}^{55} + \eta\text{gey}_{(D2I)}^{53} \rightarrow [\text{i}_{(A1)}^{55} \eta\text{gfiey}_{(B2II)}^{11}]$
‘one’ ‘pair’ ‘one pair’
- k. $\text{ti}_{(A1)}^{55} + \text{ndlfiaw}_{(D2II)}^{31} \rightarrow [\text{ti}_{(A1)}^{55} \text{ndlfiaw}_{(B2II)}^{11}]$
‘land’ ‘sticky’ ‘sticky ground’
- l. $\text{dlfi}_{(A2)}^{35} + \text{dau}_{(D2II)}^{53} \rightarrow [\text{dlfi}_{(A2)}^{35} \text{dfia}_{(B2II)}^{11}]$
‘oil’ ‘bean’ ‘bean oil’
- m. $\text{dzfia}_{(A2)}^{35} + \eta\text{gey}_{(D2I)}^{53} \rightarrow [\text{dzfia}_{(A2)}^{35} \eta\text{gfiey}_{(B2II)}^{11}]$
‘nine’ ‘pair’ ‘nine pairs’
- (25) a. $\text{lu}_{(A1)}^{55} + \text{zo}_{(B2I)}^{33} \rightarrow [\text{lu}_{(A1)}^{55} \text{zo}_{(C2I)}^{53}]$
‘CLF’ ‘village’ ‘the village’
- b. $\text{t\textsubscript{0}lau}_{(A1)}^{53} + \text{nu}_{(B2I)}^{33} \rightarrow [\text{t\textsubscript{0}lau}_{(A1)}^{55} \text{nu}_{(2I)}^{53}]$
‘hair’ ‘horse’ ‘horse hair’
- c. $\text{NGfiai}_{(A2)}^{35} + \text{nu}_{(B2I)}^{33} \rightarrow [\text{NGfiai}_{(A2)}^{35} \text{nu}_{(C2I)}^{53}]$
‘meat’ ‘horse’ ‘horse meat’
- d. $\text{dlfi}_{(A2)}^{35} + \text{mb\textsubscript{0}}_{(B2I)}^{33} \rightarrow [\text{dlfi}_{(A2)}^{35} \text{mb\textsubscript{0}}_{(C2I)}^{53}]$
‘oil’ ‘fish’ ‘fish oil’
- e. $\text{tu}_{(A1)}^{55} + \eta\text{gf\textsubscript{0}w}_{(B2II)}^{11} \rightarrow [\text{tu}_{(A1)}^{55} \eta\text{kw}_{(C2I)}^{53}]$
‘son’ ‘lazy’ ‘lazy person’
- f. $\text{au}_{(A1)}^{55} + \text{dzfie}_{(B2II)}^{11} \rightarrow [\text{au}_{(A1)}^{55} \text{dzie}_{(B2II)}^{53}]$
‘water’ ‘cool’ ‘cool water’
- g. $\eta\text{fiu}_{(A2)}^{35} + \text{lfiaw}_{(B2II)}^{11} \rightarrow [\eta\text{fiu}_{(A2)}^{35} \text{lau}_{(C2II)}^{53}]$
‘cattle’ ‘old’ ‘old cattle’
- h. $\text{NGfiai}_{(A2)}^{35} + \text{dzfie}_{(B2II)}^{11} \rightarrow [\text{NGfiai}_{(A2)}^{35} \text{dzfie}_{(C2II)}^{53}]$
‘meat’ ‘cool’ ‘cool meat’

These data present some incredible complexities, and until these problems can be resolved, a complete analysis will not be possible. They are presented here for comparison with the WAH data.

3.3 Anti-faithfulness analysis of Western A–Hmao *ping*–triggered tone sandhi in compounds

3.3.1 Featural representation of tones

As the tonal system of A–Hmao, even Western A–Hmao, is far more complex than that of Jingpho, a far more complicated featural representation will be required. It must be observed, first of all, that the tones of WAH fall into three distinct classes:

1. *The ping tones.* Tones A1 and A2 are the triggers for all of the changes seen here. A2 may become A1, but neither tone may shift to a non-*ping* tone, nor may any other tone shift to become a *ping* tone.
2. *The yin tones B–D.* Tones B1, C1, and D1 are all part of one chain. There are neither shifts into this category, nor out of it.
3. *The yang tones B–D.* Tones B2, C2, and D2, are all part of the same chain/circle. There, again, is no movement into or out of this discreet group.

Each of these classes will be identified by means of a single featural specification. The *ping* tones will be called [+contour]. The *yin* tones will be called [+voice] (a tone feature that should not be confused with the segmental voicing feature, from which it is independent), and the *yang* tones will be called [–voice]²⁰.

Within each of these categories, there is a clear pattern of “markedness” (given the types of changes that occur):

- A1 /52/ < A2 /31/
- D1 /22/ < C1 /33/ < B1 /45/
- B2 /22/ < C2 /21/ < D2 /11/

The change /52/ → /31/ represents the common change of a rising tone into a falling tone. A2 is thus treated as [+rise] and A1 as [–rise]. The markedness of the *yin* and *yang* tones is directly proportional to their distance from /22/²¹, and this kind of scale will be represented here with three height features: [±high], [±low], and [±extreme]. The most marked members have positive specifications for both [±high] or [±low] and [±extreme]. The least marked *yin* and *yang* tones do not have positive specifications for [±high] or [±low], which excludes the possibility of a positive specification for [±extreme]. The whole set of tone features can be conceived of as in Figure 5, where the specification of a positive feature value lower in the tree implies the featural specifications found higher in the tree. For purely opportunistic reasons, the *ping* tones are treated as if underspecified for [voice]. The *yin* and *yang* tones are treated as [–contour].

²⁰This tone feature [±voice] is, in fact, entirely an abstraction postulated for the purposes of analysis. Tones B2 /22/ and D1 /22/ are in fact homophonous, but since they display different phonological behavior, a representational device is needed to distinguish them.

²¹It is the right, indeed the duty, of any thoughtful tonologist to question the treatment of a /22/ as the midpoint of the phonological scale. It should be noted, however, that the tone transcribed as /22/ by Johnson (1999) is not far from the middle of the vocal range. Furthermore, the claim being made here is not that /22/ is universally an unmarked pitch level, but that it functions as such in WAM.

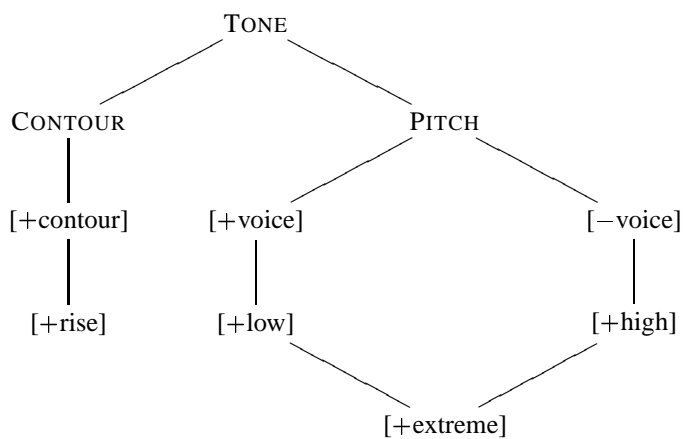


Figure 5: Tone features of Western A-Hmao

		[contour]	[rise]	[voice]	[low]	[high]	[extreme]
A1	52	+	-				
A2	13	+	+				
B1	45	-		-		+	+
C1	33	-		-		+	-
D1	22	-		-		-	-
B2	22	-		+	-	-	-
C2	21	-		+	+	-	-
D2	11	-		+	+	-	+

Table 6: Featural specifications for Western A-Hmao tones.

3.3.2 Constraints

Anti-faithfulness

- **–IDENT–TONE** This constraint is violated when a tone in the output shares all of the same tone features as the corresponding tone in the input and is preceded in the output by a [+contour] tone.

Faithfulness

- **IDENT–CONTOUR** Violated when an output tone’s specification for the feature [contour] is different than that of the corresponding tone in the input.
- **IDENT–VOICE** Violated when an output tone’s specification for the feature [voice] is different from that of the corresponding tone in the input.
- **IDENT–PITCH** Counts as a violation each difference in pitch–governing featural specifications between corresponding tones in the input and output.
- **PITCH–VL–DISTANCE \leq 1** This constraint is violated when any input tone having the specification [–voice] in the input differs by more than one pitch feature specification from the corresponding output form. This constraint is essentially a DISTANTIAL FAITHFULNESS constraint, as formulated by Kirchner (1996). The difference between this constraint and Kirchner’s constraints is that this constraint is feature specific, and uses the number of features altered as the criteria for determining whether the threshold of distance has been crossed.

Markedness The markedness constraints described here are, in all cases, complex. That is, they do not penalize a single ill–formed structure but rather militate against the juxtaposition of two or more structures. Reducing each of these constraints to the conjunction of two or more simpler constraints is trivial, and is left as an exercise for the reader.

- ***NONMID** Counts as a violation each positive specification for a pitch feature occurring in a tone B that is immediately preceded by a [+contour] tone A.
- ***NONMID–VL** Counts as a violation each positive specification for a pitch feature occurring in a [–voice] tone B that is immediately preceded by a [+contour] tone A.
- ***CONTOUR+RISING** Violated when a tone bearing the specification [+contour] is immediately followed by a tone bearing the specification [+rise].

3.3.3 Anti-identity

The fundamental driving force behind most (four of six) of the tone changes, in this analysis of A–Hmao tone sandhi, is the imperative that all tones change after a [+contour] tone. This imperative is overruled by the forces of faithfulness that penalize changes in features like [contour], as shown in (26) ‘mutton’, below.

		NGfi ¹³ _(A2) + zfi ¹³ _(A2)	ID-C	¬ID-T
(26)	☞ (a)	NGfi ¹³ _(A2) zfi ⁵² _(A1)		
	(b)	NGfi ¹³ _(A2) zfi ¹³ _(A2)		*!
	(c)	NGfi ¹³ _(A2) zfi ²² _(D1)	*!	
	(d)	NGfi ²² _(D1) zfi ⁵² _(A2)	*!	

That is to say, the same force that motivates the change from A1 to A2 after a *ping* tone, motivates the other changes that occur after *ping* tones. However, given only these constraints, it would be expected that A1 and A2 would form a ring (like the rings in Jingpho). What is needed is a markedness constraint that penalizes the sequences 51(A1)–13(A2) and 13(A2)–13(A2), which must be ranked above ANTI-IDENT-TONE. The (admittedly rather arbitrary) *CONTOUR+RISING defined above serves this function, as seen in (27)

		52(A1) + 52(A1)	ID-C	*C+R	¬ID-T
(27)	☞ (a)	52(A1)–52(A1)			*
	(b)	52(A1)–13(A2)		*!	
	(c)	22(D1)–52(A1)	*!		

3.3.4 The yang exchange

The ranking so far will account for the alternation in the *ping* tones. What follows is far more complex. In the case of the [+voice] tones, tones which are not /22/ in contour must become /22/ in contour—that is, they must lose all of their pitch features. This is motivated by the special constraint *NonMid, as demonstrated in (28) ‘glutinous rice’ and (29) ‘rain water’. This constraint must dominate IDENT-PITCH.

		ndfili ¹³ _(A2) + ndfilau ¹¹ _(D2)	ID-C	ID-V	¬ID-T	*NONMID	ID-P
(28)	☞ (a)	ndfili ¹³ _(A2) ndfilau ²² _(B2)					**
	(b)	ndfili ¹³ _(A2) ndfilau ²¹ _(C2)				*!	*
	(c)	ndfili ¹³ _(A2) ndfilau ¹¹ _(D2)			*!	**	
	(d)	ndfili ¹³ _(A2) ndfilau ²² _(D1)		*!			**
	(e)	ndfili ²² _(D1) ndfilau ¹¹ _(D2)	*!				

		?au ⁵² _(A1) + nfi ²¹ _(C2)	ID-C	ID-V	¬ID-T	*NONMID	ID-P
(29)	☞ (a)	?au ⁵² _(A1) nfi ²² _(B2)					*
	(b)	?au ⁵² _(A1) nfi ¹¹ _(D2)				*!*	*
	(c)	?au ⁵² _(A1) nfi ²¹ _(C2)			*!	*	
	(d)	?au ⁵² _(A1) nfi ²² _(D1)		*!			*
	(e)	?au ²² _(D1) nfi ²¹ _(C2)	*!			*	

These tableaux also demonstrate the need for a high-ranked IDENT-VOICE, in order to rule out candidates with the wrong [voice] specification.²²

That *NONMID is crucially ranked below ANTI-IDENT-TONE is demonstrated by the case shown in (30) ‘autumn’. Were it not so, the need to achieve a /22/ pitch would overpower the forces of anti-faithfulness and no change in pitch would occur.

²²Actually, this is not particularly important, since tones D1 and B2 have the same surface realization.

		ndfiu ¹³ _(A2) + dzfiie ²² _(B2)	ID-C	ID-V	¬ID-T	*NONMID	ID-P
(30)	■	(a) ndfiu ¹³ _(A2) dzfiie ²¹ _(C2)				*	*
		(b) ndfiu ¹³ _(A2) dzfiie ¹¹ _(D2)				**!	**
		(c) ndfiu ¹³ _(A2) dzfiie ²² _(B2)			*!		
		(d) ndfiu ¹³ _(A2) dzfiie ²² _(D1)		*!			
		(e) ndfiu ²² _(D1) dzfiie ²² _(B2)	*!				
		(f) ndfiu ¹³ _(A2) dzfiie ⁵² _(A1)	*!				

Instead, this ranking of constraints provides the desired B2 ↔ C2 exchange.

3.3.5 Preventing a *yin* circle

But just as we must provide for the tone circle among the *yang* tones, we must prevent the occurrence of an equivalent circle in the *yin* tones (cycling back from D1 /22/ to C1 /33/). This is done, here, with the aesthetically unpleasant constraint *NONMID-VL, which mandates—via its domination of ANTI-IDENT-TONE—that it is more important for [–voice] tones to be mid than to be unfaithful.

		52(A1) + 22(D1)	ID-C	*NONMID-VL	¬ID-T
(31)	■	(a) 52(A1)–22(D1)			*
		(b) 52(A1)–33(C1)		*!	
		(c) 22(D1)–22(D1)	*!		

3.3.6 The *yin* chain

The *NONMID-VL constraint is the immediate motivation for the *yin* tone sandhi chain. This is demonstrated in (32) ‘lard’:

		dfiŋ ¹³ _(A2) + mpa ³³ _(C1)	ID-C	*NONMID-VL	¬ID-T	*NONMID	ID-P
(32)	■	(a) dfiŋ ¹³ _(A2) mpa ²² _(D1)					*
		(b) dfiŋ ¹³ _(A2) mpa ³³ _(C1)		*!	*	*	
		(c) dfiŋ ²² _(D1) mpa ³³ _(C1)	*!				

But given just this constraint, we would expect all [–voice] tones to become D1 /22/ after [+contour] tones. With only the constraint rankings introduced so far, the winning candidate in (33) ‘custom, Christianity’ would be (e). The constraint PITCH-VL-DISTANCE ≤ 1, crucially ranked above *NONMID-VL, prevents this by penalizing candidates in which more than one pitch feature differs between input and output in the target tone.

		kau ⁵² _(A1) + ki ⁴⁵ _(B1)	ID-C	ID-V	P-DIS ≤ 1	*NONMID-VL	¬ID-T	*NONMID
(33)	■	(a) kau ⁵² _(A1) ki ³³ _(C1)						*
		(b) kau ⁵² _(A1) ki ⁴⁵ _(B1)				*!*	*	**
		(c) kau ⁵² _(A1) ki ²² _(D1)			*!			
		(d) kau ⁵² _(A1) ki ²² _(B2)		*!	*			
		(e) kau ²² _(A1) ki ³³ _(C1)	*!			*		*

While this analysis rests upon some rather tenuous assumptions about the representation of Western A-Hmao tones, cannot be applied to Eastern A-Hmao, and is lacking in elegance, it does demonstrate an important point: that the analysis of tone

sandhi rings in terms of a ranked–constraint grammar can be quite difficult even without a concept such as anti–faithfulness, and is almost certainly impossible without anti–faithfulness, or some other instrument of equivalent formal power.

4 Implications

The tone sandhi systems examined here have important implications for both theories of phonological representation and theories of grammar. While I have concentrated primarily upon the grammatical implications of this construction—in particular, upon the ability of the linguistic faculty to encode anti–identity relationships—I have felt it necessary to bring up certain of the representational issues as well, as these were essential to the grammatical analysis.

4.1 Representation

The feature [contour] The Jingpho data and analysis provide convincing reasons to treat the presence or absence of a contour (in Jingpho, at least) as a single parameter to which the grammar has direct access, rather than a temporally structured sequence of autosegments. This analysis is extended to WAM, where the feature value [+contour] acts as the conditioning factor for the tone sandhi alternations we have analyzed.

Five pitch levels Perhaps even more controversially, the WAM data have argued for the use of five phonological tone levels, arranged in two symmetrical scales so that the midpoint is least “marked” and the end margins are most “marked”. This approach provides a convenient explanation for both the participants in exchanges (the least marked and second least marked categories) and chains (where the changes reduce the markedness of the tone—in context—but target tones are constrained from reducing themselves to the unmarked tone in one fell swoop down the markedness scale). This second analysis also suggests the existence of DISTANTIAL FAITHFULNESS.

4.2 Grammar

Markedness scales and DISTANCE The idea of DISTANTIAL FAITHFULNESS was articulated by Kirchner (1996), where he applies this analysis to vowel chain shifts. The data analyzed here show that it is of some utility in formalizing some chain tone shifts as well.

The need for anti–faithfulness But perhaps the most important implication of these findings is the additional evidence they provide for anti–faithfulness. It has been suggested earlier in this paper that all of the interactions that have been modeled through anti–faithfulness could be modeled easily, indeed much more economically, through the use of two level constraints (or the formally equivalent reinterpretation of phonological rules as logical implications evaluating the well–formedness of input–output pairs, see Goldsmith 1993; Karttunen 1993; Lakoff 1993). In fact, such analyses seem to correspond to the informal descriptions given of East and Southeast Asian tone sandhi

by scholars working in the Sino–American Structuralist tradition. But, allowing for such constraints, one can model any input–output relationship. Furthermore, all relationships can be described in terms of a kind of atomic mapping. This is not desirable within a theoretical framework like OT, which seeks to elucidate the “motivations” for phonological processes²³.

The problem, then, is capturing the very odd types of alternations that occur in real languages (including circular chains, exchange rules, and echo–word dissimilation at a distance) without making the theory so powerful that all phonological processes can be trivially described by parochial mappings. The most economical solution to several of these problems is the use of anti–faithfulness, if it is indeed found to have the formal power to model the attested patterns. The current study suggests that it may be the weakest formal mechanism capable of describing the tonal alternations here analyzed.

But in some sense, this type of constraint is at odds with the philosophical underpinnings of Optimality Theory, at least as it is conventionally understood. It is clear that grammars involve more than the interaction between “markedness” and “faithfulness”, as conventional Optimality Theory would lead us to believe, but it may be hard to part with apparent insight gained through this formulation of the theory. If these are the not bounds the may be placed upon phonological generalization, what are those bounds? At this stage, it is still unclear exactly what the limits of phonological generalization are. It may yet be seen that “markedness” and “faithfulness” effects, like anti–faithfulness, are merely epiphenomena emerging from more general linguistic and extra–linguistic principles.

²³In the view of the current author, phonological processes are motivated by attempts to maintain patterns that already exist in the lexicon, and not to achieve well–formedness in any teleological sense (that is, phonology is more about “keeping up appearances” than “building a better mousetrap.” Nevertheless, I believe that modeling phonological processes *as if* they were motivated by synchronic goals can provide insight into the diachronic origins of productive patterns within the lexicon and their cross–linguistic correlates. Thus, the ability to model such motivations is a *desideratum* of a theory of phonological grammar.

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