

Tonally conditioned vowel raising in Shuijingping Hmong

David Mortensen

University of California, Berkeley

mortensen@berkeley.edu

January 6, 2006

1 Introduction

- (1) In Shuijingping Hmong, there is a vowel raising process that appears to be tonally conditioned.
- Occurs in syllables following the tones M, L and HL.
 - Occurs in syllables bearing the underlying tones HL and LM.
 - Always accompanied by tonal alternations.
- (2) a. /ɬa^{HL}/ → [ɬa^{HL}] ‘petal’ /ʔɔ^M ɬa^{HL}/ → [ʔɔ^M ɬe^L] ‘two petals’
 b. /tɕɔ^{HL}/ → [tɕɔ^{HL}] ‘clf (lengths)’ /ʔei^M tɕɔ^{HL}/ → [ʔei^M tɕo^L] ‘one length’
- (3) **Claims**
- This typologically unusual association between tone and vowel quality arose from the interaction of two more natural relationships:
 - Tone and phonation¹ type
 - Phonation type and vowel quality
 - When analyzed correctly, this phenomenon is a clear example of phonetic factors directly shaping phonology, in spite of its apparent phonetic arbitrariness.

¹In this paper, *phonation type* and *voice quality* will be used largely interchangeably, but with the understanding that *phonation type* refers to the actual state of the glottis while *voice quality* refers to its perceived correlate.

2 The Language and the Problem

2.1 Preliminaries

- (4) Shuijingping Hmong² is spoken in Shuijingping 水井坪 community, Xinzhai 新寨 village, Zongdi 宗地 township, Shuikuang 水坑 District, Ziyun 紫云 Miao-Buyi Autonomous County, Guizhou 贵州 Province, China.
- (5) The location of Shuijingping village is shown in Figure (1).

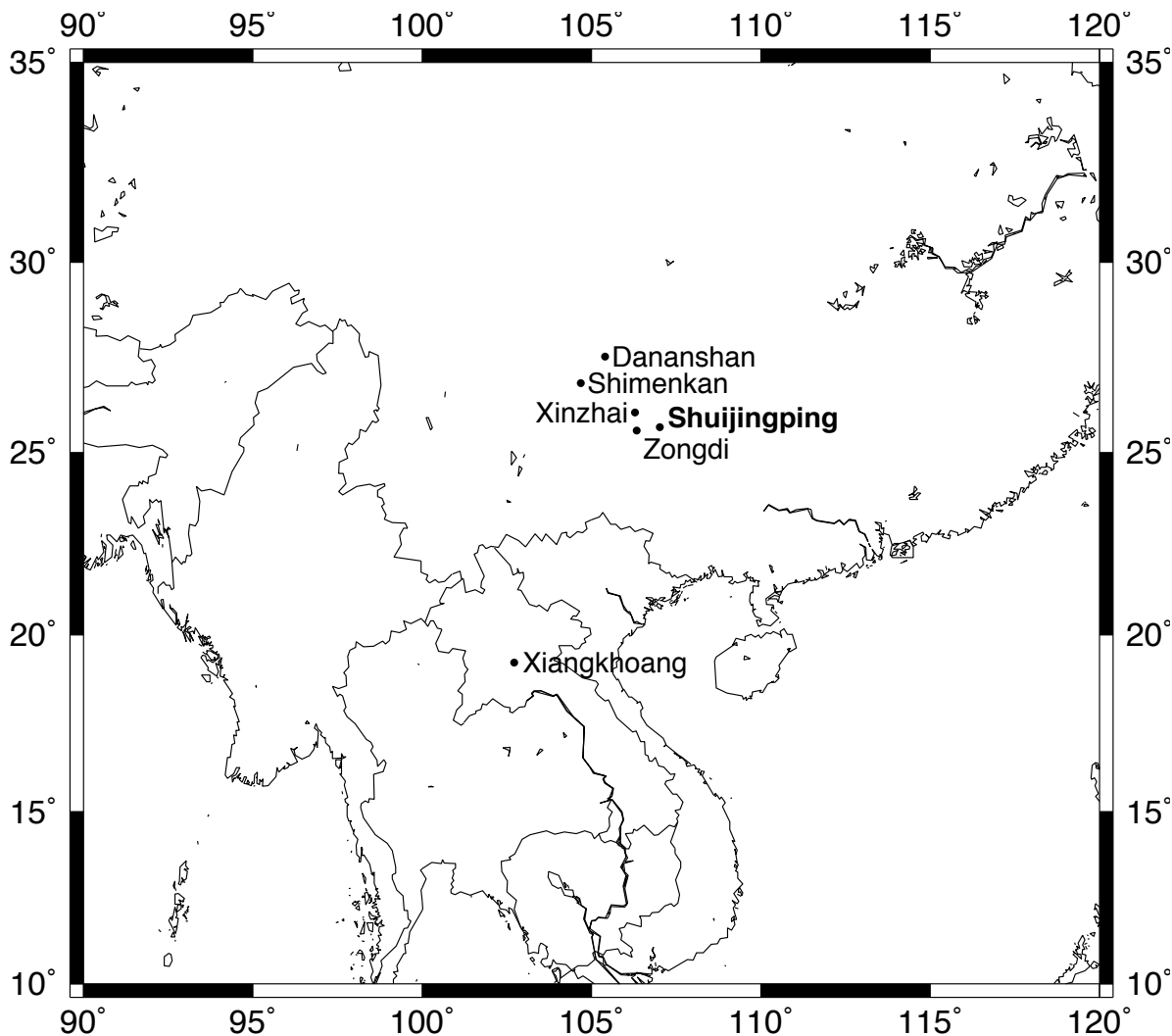


Figure 1: Map indicating the location where Shuijingping Hmong and several of the other languages mentioned in this paper are spoken.

²All Shuijingping data is taken from Xian (1990).

- (6) Shuijingping Hmong is a dialect of the Mashan Hmong group which belongs to the Western branch of the Hmongic family.
- (7) The Mashan group lies outside the subgroup called Far-Western Hmongic (which includes the best-known Western Hmongic languages; see Johnson (2002)) but shares innovations with that group³, as implied in (2).

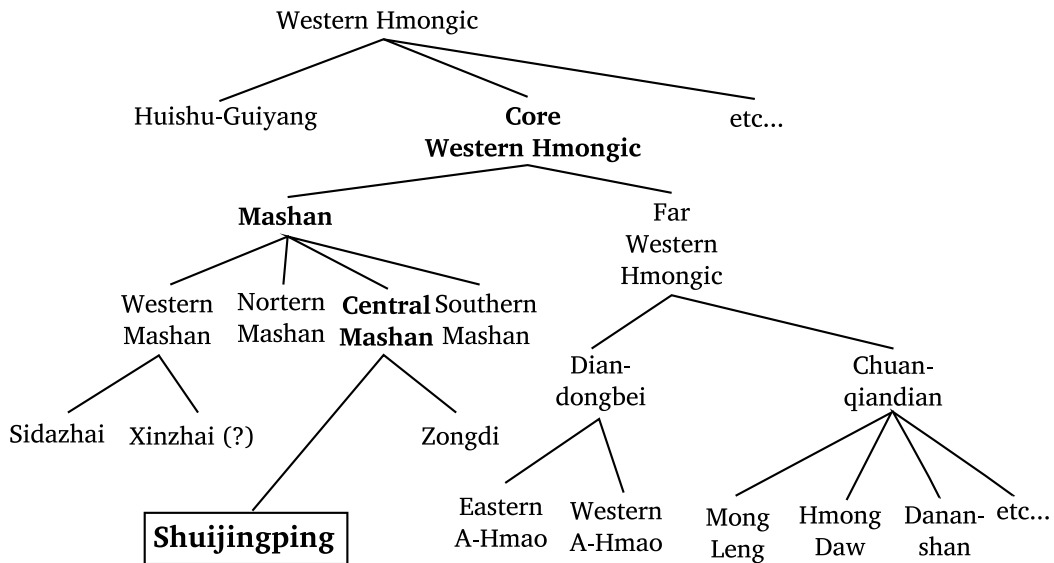


Figure 2: The place of Shuijingping in Western Hmongic.

(8) *Segment inventories*

a. Simple onsets

p	t	ts	tʃ	tɕ	k	ʔ
mp	nt	nts	ntʃ	ntɕ	ŋk	
m	n		ɲ		ŋ	
hw	ɬ		ɕ			h
			ʒ	ʐ		ɦ
w	l					

b. Clusters

pr	pl	pj
mpr	mpl	mpj
mr		mj

c. Rhymes

i	u	ei	əu		
e	ə	o		ain	əŋ oŋ
a	ɑ	ɔ	əɑ	ua	ɑŋ

³These innovations include the development of a tone sandhi chain in the higher (*yin*) register and a sound change *a > i. For the relevant data, see Wang (1979, 1994); Niederer (1998); Mortensen (2005).

(9) Tones

a. Eleven Tones

- i. Five level tones: ↑H, H, M, L, ↓L
- ii. Three falling tones: HL, HM, ML
- iii. Two rising tones: LH, LM
- iv. One rising-falling tone: LML

b. Tones by historical category

	A	B	C	D	
1	M	HM	↑H	H	(plain voiceless or preglottalized)
1'	L	LML	LH	LM	(aspirated)
2	HL	↓L	LM	ML	L (= C2') (voiced, non-glottalized)

- i. Four tones in Proto-Hmongic (A, B, C, D)
- ii. Tones split into “registers” based on consonant voicing
 - Voiceless and preglottalized onsets: A1, B1, C1, D1 (high register)
 - Voiced onsets: A2, B2, C2, D2 (low register)
- iii. High register tones split based upon aspiration of onsets
 - Unaspirated onsets: A1, B1, C1, D1
 - Aspirated onsets: A1', B1', C1', D1'
- iv. **C2' developed as “sandhi tone’ from C2.**

c. Two historical tones (D1' and C2) have merged as LM.

d. The sandhi tone C2' and the A1' are both realized as [L]. However, they behave differently with regard to tone sandi; should be treated as different phonologically.

e. **Tone Sandhi Context:** Tone sandhi occurs. . .

- i. Immediately following “A” tones (M, L, and HL)
- ii. In the same prosodic word
- iii. In a domain that need not correspond to a syntactic or morphological constituent⁴

⁴This statement relies crucially upon the attestation of tonal alternations in noun classifiers triggered by the tones of numerals but the non-attestation of tonal alternations in nouns following classifiers bearing the appropriate tones. While some syntactic analyses of Asian languages that are structurally similar to Hmong treat the numeral and classifier as together heading a ClfP or NumP, much recent work on this subject assumes that the ClfP is nested inside of the NumP and that the classifier and numeral each act as heads of the respective phrases.

- iv. Tone sandhi alternations are quite complex (include three different chain shifts, etc.)

2.2 The Generalization

- (10) In Shuijingping, vowel raising occurs under two circumstances (superficially):
- The surface tone of the syllable is [LM].
 - The underlying tone of the syllable is /HL/ but the syllable is in sandhi context and so surfaces with the [L] tone.

c. **Conditions for vowel changes:**

<i>Underlying Tone</i>	<i>In Non-Sandhi Context</i>	<i>In Sandhi Context</i>
/LM/	raising	no change
/HL/	no change	raising

- In sandhi context, both /LM/ and /HL/ → [L]
- (11) Under these conditions, three raising-like processes can be observed:
- Mid and low monophthongs are raised (14a–d, 15a–f).
 - The first moras of falling-sonority diphthongs are raised, yielding high monophthongal vowels (14e–f).
 - The first mora of the low vowel /a/ centralizes, producing the diphthong [əa] (15g–i).
- (12) These processes are depicted schematically in Figure 3 (arrows point from underlying vowels to surface vowels).

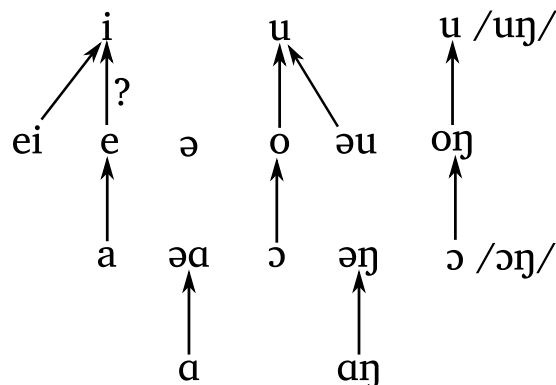


Figure 3: Synchronic vowel raising in Shuijingping.

- (13) For arguments regarding the development and synchronic analysis of chain shifts, like the vowel raising chain shift seen here, see Mortensen (in progress).

2.3 Basic Data

- (14) Vowel raising in [LM] tone syllables

a.	/plo ^M maŋ ^{LM} /	→[plo ^M maŋ ^L]	‘beard of wheat’	/maŋ ^{LM} /	→[məŋ ^{LM}]	‘wheat’
b.	/hwei ^M ŋtɔ ^{LM} /	→[hwei ^M ŋtɔ ^L]	‘muskmelon’	/ŋtɔ ^{LM} /	→[ŋtɔ ^{LM}]	‘variegated’
c.	/toŋ ^M zɔ ^{LM} /	→[toŋ ^M zɔ ^L]	‘worker’	/zɔ ^{LM} /	→[zu ^{LM}]	‘work, strength’
d.	/toŋ ^M wo ^{LM} /	→[toŋ ^M wo ^L]	‘Han nation’	/wo ^{LM} /	→[wu ^{LM}]	‘Han’
e.	/ʔei ^M nte ^{LM} /	→[ʔei ^M nte ^L]	‘one iteration’	/nte ^{LM} /	→[nti ^{LM}]	‘iteration’
f.	/nei ^{HL} təu ^{LM} /	→[nei ^{HL} təu ^L]	‘which person’	/təu ^{LM} /	→[tu ^{LM}]	‘clf (people)’

- (15) Vowel raising in syllables where underlying /HL/ becomes [L]

a.	/mplaŋ ^{HL} /	→[mplaŋ ^{HL}]	‘leaf’	/zain ^M mplaŋ ^{HL} /	→[zain ^M mpləŋ ^L]	‘tobacco’
b.	/kaŋ ^{HL} /	→[kaŋ ^{HL}]	‘poor’	/məŋ ^L kaŋ ^{HL} /	→[məŋ ^L kəŋ ^L]	‘poor person’
c.	/nɔŋ ^{HL} /	→[nɔ ^{HL}]	‘eat’	/mu ^L nɔŋ ^{HL} /	→[mu ^L noŋ ^L]	‘not eat’
d.	/ŋoŋ ^{HL} /	→[ŋoŋ ^{HL}]	‘cattle’	/ŋka ^{HL} ŋoŋ ^{HL} /	→[ŋka ^{HL} ŋu ^L]	‘cattle corral’
e.	/ʔa ^{HL} /	→[ʔa ^{HL}]	‘petal’	/ʔɔ ^M ʔa ^{HL} /	→[ʔɔ ^M ʔe ^L]	‘two petals’
f.	/tɕɔ ^{HL} /	→[tɕɔ ^{HL}]	‘length’	/ʔei ^M tɕɔ ^{HL} /	→[ʔei ^M tɕɔ ^L]	‘one length’
g.	/hɑ ^{HL} /	→[hɑ ^{HL}]	‘shout’	/kuɑ ^M hɑ ^{HL} /	→[kuɑ ^M həɑ ^L]	‘bug sound’
h.	/hɑ ^{HL} /	→[hɑ ^{HL}]	‘shout’	/so ^L hɑ ^{HL} /	→[so ^L həɑ ^L]	‘thunder’
i.	/ma ^{HL} /	→[ma ^{HL}]	‘maple’	/wɑ ^L ma ^{HL} /	→[wɑ ^L məɑ ^L]	‘maple tree’

- (16) In examples (15c,d) the raising process is associated with a ŋ/∅ alternation.

- Codas are banned after both [ɔ] and [u].
- Underlying /ŋ/ deletes when preceded in the syllable by one of these two vowels, but surfaces after [o].
- Diachronically speaking, sound changes deleted [ŋ] after [ɔ], [u].
- Thus tone changes trigger vowel raising which affects consonant deletion.
- No consistent link between vowel raising and syllable structure in Shuijingping.**

2.4 Shuijingping Raising Compared to Other Tone-Vowel Quality Interactions

- (17) Previous claim: most or all tone-vowel quality interactions are tied to syllable structure (quantity, weight, etc.) (Hermans and van Oostendorp 2000).
- (18) Duration also implicated as a mediator between vowel quality and tone, as in the case of Limburg Dutch (Gussenhoven and Driessen 2004)
- (19) There are, however, certain cases of tone-vowel interaction that cannot be easily explained in these terms, such as Fuzhou (Chinese): tone sandhi alternations trigger vowel alternations.
- (20) Tone-vowel interaction in Fuzhou (Myers and Tsay 2003):

Tones	Vowel alternations									
LM, LML	æ	ai	au	ay	ei	ou	œ	ieu	uoi	
H, HL, M	ɛ	ei	ou	oy	i	u	y	iu	ui	

- (21) The proper analysis of this set of alternations remains controversial.
- (22) Most investigators have tried to explain this relationship by positing that metrical structure or syllable structure mediates between tone and vowel quality (Wright 1983; Chan 1985; Jiang-King 1999).
- (23) However, **some of the alternations involve no change in quantity, number of segments, etc.**
- (24) Myers and Tsay (2003) have argued that these alternations are grounded in the relationship between tone pitch and the intrinsic pitch of vowels.
- The higher a vowel, the higher its intrinsic pitch.
 - The higher series of vowels occurs with the higher tones.
 - The lower series of vowels occurs with the lower tones.
- (25) **These various proposals seem not to explain the Shuijingping case:**
- Many of the alternations do not involve changes in syllable structure.
 - Sometimes contour-simplification is associated with raising, sometimes with the failure to raise.
 - Likewise, intrinsic pitch seems not to be correlated with the observed changes. **Vowels that surface with [L] show both raising and failure to be raised** depending upon the underlying tone.

- (26) Gussenhoven and Driessen (2004) note another possibility, which is that the relationship between tone and vowel quality may be mediated by phonation type.
- a. On the surface, this also seems unworkable—no synchronic evidence.
 - b. I will argue, however, that it is the proper diachronic account of this phenomenon.
 - i. Tone sandhi alternations drove alternations in phonation type which conditioned, in turn, the vowel alternations.
 - ii. Changes in the tone system and tone sandhi system then removed these alternations in voice quality without affecting the vowel quality alternations.
 - iii. The vowel alternations had been reinterpreted as having a tonal conditioning environment.

3 Phonation and Vowel Quality

- (27) **Fact:** phonation type has an effect upon vowel quality.
- (28) Acoustic effect (Thurgood 2000; Gordon and Ladefoged 2001).
- a. Breathy voice associated with lowering of the larynx.
 - b. Makes the vocal tract longer, making F1 (and F2) lower.
- (29) In Khmer two sets of vowels have developed in each of the two historical “registers” (Henderson 1952).
- a. (Generally) higher vowels appear in the breathy register.
 - b. Their (generally) lower counterparts appear in the clear⁵ register.
- (30) Likewise, in Jingpho (Tibeto-Burman) there are differences in vowel quality associated with phonation type
- a. Tense vowels are relatively lower in the vowel space.
 - b. Modal vowels are relatively higher.
- (31) In Zongdi (a.k.a. Jiaotuo), like Shuijingping a dialect of Central Mashan (see Figure (2)), a similar type of register effect exists (Wang 1994; Niederer 1998; Li 2001).
- a. Clear and breathy voiced vowels
 - b. On the balance, higher vowels in breathy syllables and lower vowels in clear-voiced syllables.

⁵*Clear* and *modal* are used here as synonyms. That is to say *clear voice* is to be interpreted as the voice quality resulting from modal phonation.

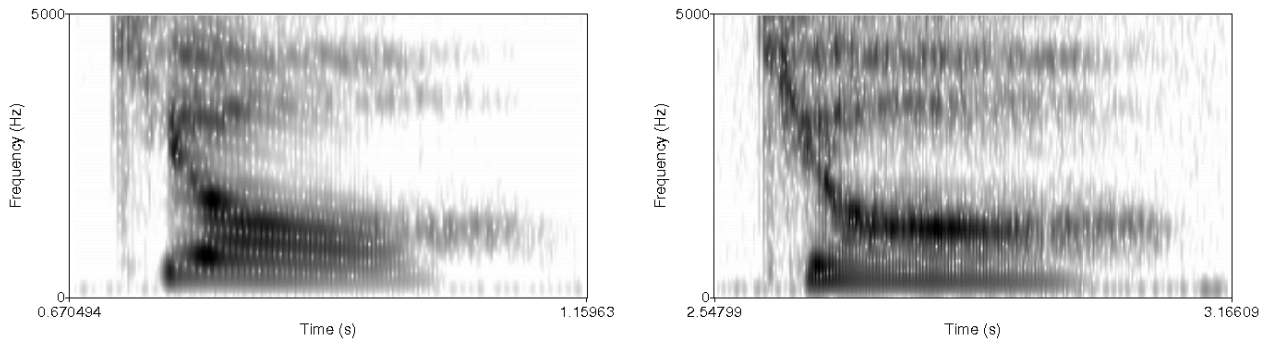


Figure 5: Spectrograms of Mong Leng (Xiangkhoang variety) *cô* ‘to lead’ (left) and *cộ* ‘to plant’ (right). Note the “ragged” appearance of the vowel formants in the spectrogram on the left, an indicator of breathy voice. (Spectrogram produced in Praat, 0.5 ms window length, 0.2 ms time step, 20 Hz frequency step, gaussian widow shape).

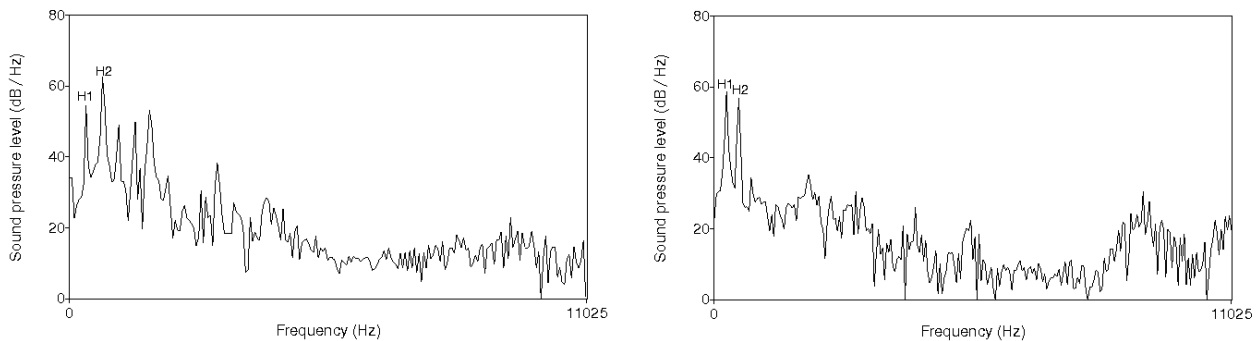


Figure 6: Spectra of Mong Leng (Xiangkhoang variety) *cô* ‘to lead’ (left) and *cộ* ‘to plant’ (right). Note that H1 is much higher relative to H2 in the spectrum on the right. This number is one measure of *spectral tilt*, and a high value for this measure is a reliable indicator of breathy phonation. (Spectra extracted and plotted using Praat)

e. **Foreshadowing:** Mong Leng /ML/ is tone C2, **cognate to Shuijingping LM**⁶.

(35) Similarly, certain tones in Zongdi are characteristically breathy (Wang 1979, 1994; Niederer 1998; Li 2001).

a. The affected tones are ↓L (B2) and LM (C2).

b. Many Chinese sources (e.g. Li (2001)) indicate breathiness by the symbol <fi> in the onset, reflecting an assumption that breathiness is a property of consonants.⁷

⁶This is significant because, in Shuijingping, vowels are raised when they occur in syllables bearing the LM tone.

⁷A similar argument has been made for the Far-Western Hmongic language Western A-Hmao by Johnson

- c. However, the phonation type of the syllable is predictable from the tone and is affected by tone sandhi rules⁸.
- i. When /HM/ becomes [LM] due to tone sandhi rules, the syllable becomes breathy.
 - ii. When /LM/ becomes [L] due to tone sandhi rules, the syllable is realized with clear voice (modal phonation).
- d. It was earlier observed that breathy voice results in raised vowels in Zongdi.
- e. These tonal alternations (and the associated alternations in phonation type) feed that vowel raising process.

(36) Vowel raising in LM syllable in Zongdi (Li 2001)

- a. /mplaŋ^{HM}/ → [mplaŋ^{HM}] ‘leaf’ /zen^{ML}mplaŋ^{HM}/ → [zen^{ML}mpfiŋ^{LM}] ‘tobacco leaf’
- b. /soŋ^{HM}/ → [soŋ^{HM}] ‘silk’ /kua^{ML}soŋ^{HM}/ → [kua^{ML}sfiuŋ^{LM}] ‘silkworm’
- c. /tæ^{HM}/ → [tæ^{HM}] ‘matter’ /ei^{ML}tæ^{HM}/ → [ei^{ML}tfi^{LM}] ‘one matter’
- d. /le^{HM}/ → [le^{HM}] ‘plow’ /tua^{ML}le^{HM}/ → [tua^{ML}fi^{LM}] ‘plow’

(37) Vowels failing to raise in M syllables in Zongdi (Li 2001)

- a. /sæi^{LM}/ → [sfi^{LM}] ‘smart’ /mfəŋ^Lsæi^{LM}/ → [mfəŋ^Lsæi^M] ‘smart person’
- b. /nti^{LM}/ → [ntfi^{LM}] ‘time’ /ei^{ML}nti^{LM}/ → [ei^{ML}nti^M] ‘one time’
- c. /ŋtɔ^{LM}/ → [ŋtɔ^{LM}] ‘variegated’ /ntɔ^{ML}ŋtɔ^{LM}/ → [ntɔ^{ML}ŋtɔ^M] ‘variegated cloth’
- d. /mpɿa^{LM}/ → [mpfiɿa^{LM}] ‘bereft’ /po^{ML}mpɿa^{LM}/ → [po^{ML}mpfiɿa^M] ‘widow’

(38) From the standpoint of historical categories, these alternations are related to those in Shuijingping.

(39) Comparison of tonal alternations in Shuijingping and Zongdi

<i>Shuijingping</i>	<i>Zongdi</i>
HL → L (A2 → C2')	HM → LM (A2 → C2) clear → breathy
LM → L (C2 → C2')	LM → M (C2 → C2') breathy → clear

(1999).

⁸Rule, as I am employing the term, is a strictly descriptive label for a particular mapping. It is not meant to imply that these mappings are generated by a rule ordered grammar. Indeed, a two-level, constraint-based grammar (with no rule ordering) actually accounts better for many of the mappings pertinent to this paper.

5 Putting things together

- (40) In Proto-Mashan, there were three tone sandhi rules relevant to our account. Stated in terms of Shuijingping tone values, they are
- HL → LM (clear → breathy, A2 → C2)
 - ↓L → LM (breathy → breathy, B2 → C2)
 - LM → L (breathy → clear, C2 → C2')

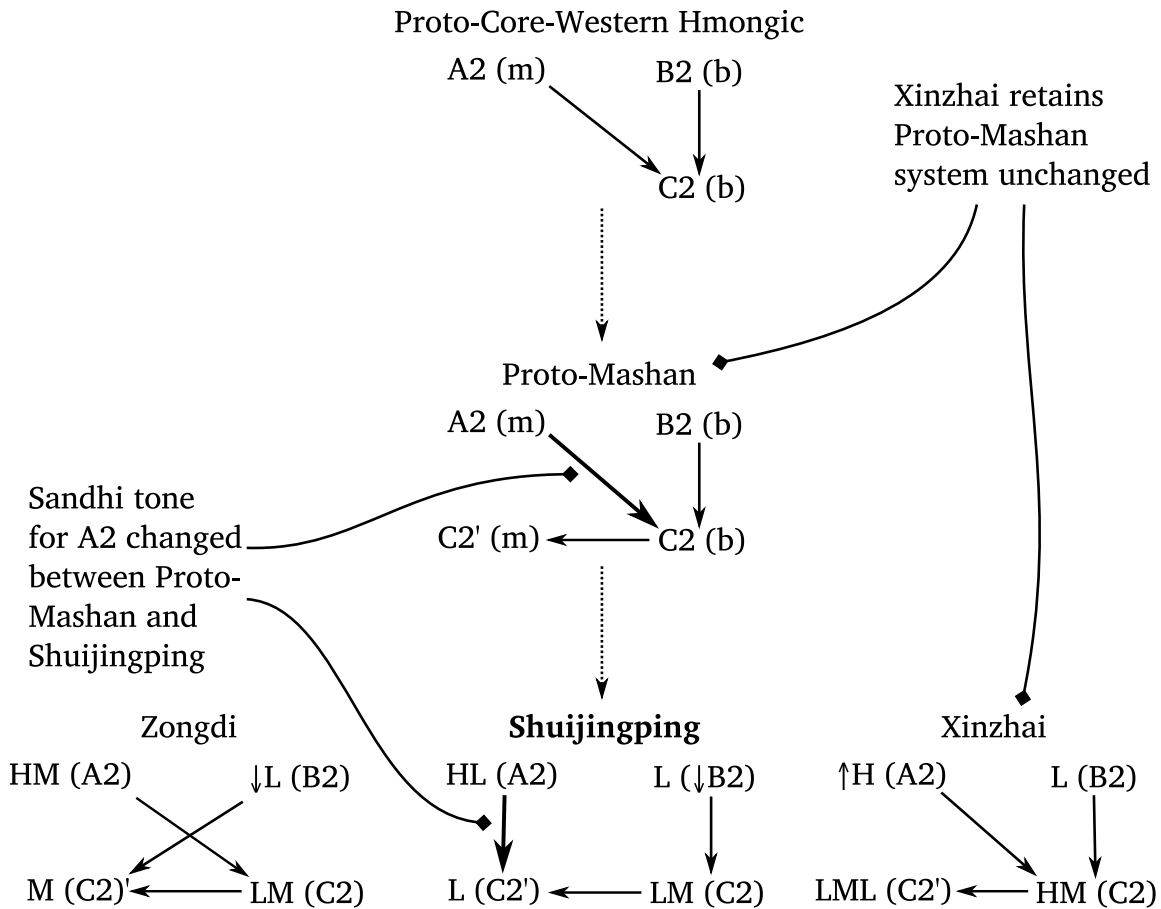


Figure 7: The development of tone sandhi from Proto-Core-Western Hmongic to Shuijingping. Clear-voiced and breathy-voiced tones are indicated by “m” and “b” respectively. When the vowel raising process developed, the tone sandhi pattern was like that of Proto-Mashan.

- (41) The first two rules (stated in terms of historical categories, as shown in Figure 7) are attested throughout most of Western Hmongic (e.g. Dananshan (Wang 1985) and Guiyang-Huishui Niederer (1998)) and so must be reconstructed at least for Proto-Core-Western-Hmongic.

- (42) The final rule is found in all Mashan languages, and so is to be reconstructed for Proto-Mashan (Figure 7).
- (43) Breathy-clear distinction is posited on the basis of the pattern found in the majority of languages throughout Western Hmongic (cognates of Shuijingping LM and ↓L are almost always breathy; cognates of HL and L are clear voiced).
- (44) The historical process
- a. Tone sandhi rules produced voice quality alternations.
 - b. Breathy voiced vowels were misperceived as being higher in the vowel space than their phonetic targets.
 - c. Learners mistakenly posited a vowel alternation based upon this misperception.
 - d. The rule HL → LM (clear → breathy) was replaced with HL → L (clear → clear), as illustrated in Figure 7.
 - e. **This change was a change in the grammar**⁹
 - f. Vowel raising still applied in sandhi context, despite the disappearance of the original conditioning environment; that is, a voice quality/vowel quality interaction was reinterpreted as a tone/vowel quality interaction.
 - g. Vowels with underlying /HL/ are raised in sandhi context because the historical sandhi tone for /HL/ (A2) was the breathy [LM] (C2) (rather than the clear-voiced [L] (C2')).
 - h. When [LM] and [↓L] lost their breathiness, the vowel quality/voice quality relationship was further obscured.

⁹Treating the tone sandhi rules as simple sound changes with no counterpart in the grammar runs into problems at two fronts. First, it seems unlikely that sound change after sound change affecting tone should occur with fortuitous consistency in the same conditioning environment (after the A tones) when the phonetics of this environment have varied widely in time. More significantly, the replacement of “A2 → C2” with A2 → C2’” cannot have simply been a sound change since this would require the reversal of a merger (between A2 and B2 in sandhi context). We could get around this fact only by positing the leveling of all morphemes in the A2 category (to HL) and an additional sound-change where HL > L. Such phonologically-conditioned leveling seems improbable. It is far simpler to posit that A2 words are still /HL/ underlyingly and are mapped to [L] in sandhi context by the grammar. This entails, likewise, that the vowel alternations are also present in the grammar since speakers are treating the sandhi/non-sandhi allomorphy as if it is governed by phonological “rules.”

6 Conclusion

- (45) Shuijingping vowel raising results (diachronically) from the effect of breathy phonation upon vowel quality.
- (46) Now (on the surface, at least) it is tonally conditioned.
- (47) Small changes in the phonological grammar of a language can change phonetically natural alternations into phonetically arbitrary alternations.
- (48) **Synchronic Status?**
- a. Considerable evidence that vowel-raising is/was encoded in the grammar (at least at the time when sandhi tone for /HL/ changed to [L]).
 - b. Implications for the modelling of tone-vowel interactions
 - i. Deep associations between vowel quality and tone?
 - ii. Arbitrary associations between unrelated features (à la constraint conjunction)?
 - iii. Abstract intermediate level including mediating features?
- (49) In this case at least, the interface between phonetics and phonology lies in diachrony—as interference in the transmission of a phonological pattern.

Bibliography

- Andruski, Jean E., and Martha Ratliff. 2000. Use of phonation types in distinguishing tone: The case of Green Mong. *Journal of the International Phonetic Association* 30:29–62.
- Chan, Marjorie K. M. 1985. Fuzhou phonology. Doctoral Dissertation, University of Washington.
- Gordon, Matthew, and Peter Ladefoged. 2001. Phonation types: a cross-linguistic overview. *Journal of Phonetics* 29:383–406.
- Gussenhoven, Carlos, and Wilske Driessen. 2004. Explaining two correlations between vowel quality and tone: The duration connection. URL http://www.isca-speech.org/archive/sp2004/sp04_179.pdf, paper presented at Speech Prosody 2004, March 23-26, 2004, Nara Japan.
- Henderson, Eugenie J. A. 1952. The main features of Cambodian pronunciation. *Bulletin of the School of Oriental and African Studies* 14:149–174.

- Hermans, Ben, and Marc van Oostendorp. 2000. On the interaction between vowel quality and tone in limburg dutch dialects. Handout from a talk given at the Tromsø Tone Symposium, 7 June 2000.
- Jiang-King, Ping. 1999. *Tone-vowel interaction in optimality theory*, volume 16 of *LINCOM studies in theoretical linguistics*. München: LINCOM Europa.
- Johnson, Michael. 1999. Tone and phonation in Western A-Hmao. *SOAS Working Papers in Linguistics* 9:227–251.
- Johnson, Michael. 2002. The reconstruction of labial stop-consonant clusters in Proto-Far-Western Hmongic. *Transactions of the Philological Society* 100:25–58.
- Li Yunbing 李云兵. 2001. 苗语方言比较中的几个问题 *Miaoyu fangyan bijiao zhong de ji ge yuyin wenti* [some phonetic issues in the comparison of Miao dialects]. *Guizhou Minzu Yanjiu* 21:141–149.
- Mortensen, David. 2005. The development of tone sandhi in Western Hmongic: an abstract approach to diachronic morphophonology. Ms. University of California, Berkeley.
- Mortensen, David. in progress. Logical and substantial scales in phonology. Doctoral Dissertation, University of California, Berkeley.
- Myers, James, and Jane Tsay. 2003. A formal functional model of tone. *Language and Linguistics* 4:105–138.
- Nguyễn, Dihn-Hoá. 1997. *Vietnamese*. Amsterdam: John Benjamins.
- Niederer, Barbara. 1998. *Les langues Hmong-Mjen (Miáo-Yáo)*. Number 07 in *Lincom Studies in Asian Linguistics*. München: Lincom Europa.
- Ratliff, Martha. 1992. *Meaningful tone: A study of tonal morphology in compounds, form classes, and expressive phrases in White Hmong*. Number 27 in *Monograph Series on Southeast Asia*. DeKalb Illinois: Northern Illinois University Center for Southeast Asian Studies.
- Thompson, Laurence C. 1965. *A vietnamese grammar*. Seattle: University of Washington Press.
- Thurgood, Graham. 2000. Voice quality differences and the origin of diphthongs. In *BLS* 25.
- Wang Fushi 王辅世. 1979. 苗语方言声韵母比较 *Miaoyu fangyan sheng yun mu bijiao*. Beijing: Zhongguo Shehui Kexue Yuan Minzu Yanjiushi.

- Wang Fushi 王辅世. 1985. 苗语简直 *miao yu jianzhi [sketch grammar of the miao language]*. Beijing: Minzu Chubanshe.
- Wang Fushi 王辅世. 1994. 苗语古音构拟 *Miaoyu guyin gouni [reconstruction of Proto-Miao]*. Tokyo: Institute for the Study of Languages and Cultures of Asia and Africa.
- Wang Fushi 王辅世, and Wang Deguang 王德光. 1986. 贵州威宁苗语声调 Guizhou Weining Miaoyu shengdiao. In *Zhongguo minzu yuyan lunwen ji [collect of papers on chinese national minority languages]*, ed. Maoji Fu, 91–134. Chengdu: Sichuan Minzu Chubanshe.
- Wright, Martha. 1983. A metrical approach to tone sandhi in Chinese dialects. Doctoral Dissertation, University of Massachusetts, Amherst.
- Xian Songkui 鲜松奎. 1990. 贵州紫云水井坪苗语和望谟新寨苗语的连读变调 Guizhou Ziyun Shuijingping Miaoyu he Wangmo Xinzhai Miaoyu de liandu biandiao [tone sandhi in the Miao speech of Shuijiping, Ziyun and the Miao speech of Xinzhai, Wangmo in Guizhou]. *Minzu Yuwen* 71–77.
- Yip, Moira. 2002. *Tone*. Cambridge: Cambridge University Press.