

## Diachronic Universals and Synchronic Parochialisms: Explaining Tone-Vowel Interactions

In Shuijingping Hmong, there is a vowel raising process that appears to be tonally conditioned. All of the factors that seem to govern this process are tonal: these alternations occur when syllables with a specific set of underlying tones (/HL/, and /ML) occur in specific tonal environments (following syllables bearing the tones /M/, /L/, and /HL) and are always accompanied by tone sandhi alternations. The general shape of these alternations can be seen in examples (1-2):

- (1) a. /ɬa<sup>HL</sup>/ → [ɬa<sup>HL</sup>] ‘petal’      /ʔɔ<sup>M</sup> ɬa<sup>HL</sup>/ → [ʔɔ<sup>M</sup> ɬe<sup>L</sup>] ‘two petals’  
b. /tɕɔ<sup>HL</sup>/ → [tɕɔ<sup>HL</sup>] ‘clf (lengths)’      /ʔei<sup>M</sup> tɕɔ<sup>HL</sup>/ → [ʔei<sup>M</sup> tɕo<sup>L</sup>] ‘one length’
- (2) a. /ɲɿɔ<sup>LM</sup>/ → [ɲɿo<sup>LM</sup>] ‘variegated’      /hwei<sup>M</sup> ɲɿɔ<sup>LM</sup>/ → [hwei<sup>M</sup> ɲɿɔ<sup>L</sup>] ‘muskmelon’  
b. /zɔ<sup>LM</sup>/ → [zu<sup>LM</sup>] ‘work, strength’      /toŋ<sup>M</sup> zɔ<sup>LM</sup>/ → [toŋ<sup>M</sup> zo<sup>L</sup>] ‘worker’

This association between tone and vowel quality is typologically unusual. In truth, tone-vowel interactions of various kinds of been reported earlier in the literature, but most of these interactions can be shown to be mediated by syllable structure, metrical facts, or vowel duration. What is interesting about this case is that, as I will show, it does not seem possible to attribute it to factors of this kind. From a synchronic point of view, this alternation seems aberrant, requiring the coupling of phonological features that do not normally interact.

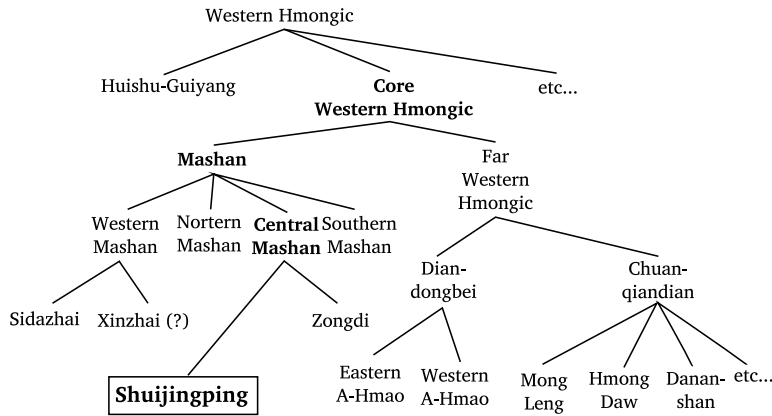
From a diachronic point of view, however, this alternation can be explained straightforwardly. I will show that it emerges from the interaction of two very natural relationships, the relationship between tone and voice-quality, on the one hand, and the relationship between voice-quality and vowel-quality on the other. The raising process has a clear phonetic motivation, but the connection between the phonetic motivations of this pattern and the synchronic phonology of the language seems to be mediated by diachrony. That is to say, the observed pattern is easiest to explain if we assume that phonetics influences phonology by affecting the transmission of phonological patterns between generations of language users.

## 1 The Language and the Problem

### 1.1 Preliminaries regarding the Language

Shuijingping Hmong is a dialect of the Mashan Hmong language, which belongs to the Western Hmongic branch of the Hmong-Mien language family. The location of Shuijingping in the Mashan group and the Western Hmongic branch is shown in (3).

(3) The position of Shuijingping in Mashan and Western Hmongic

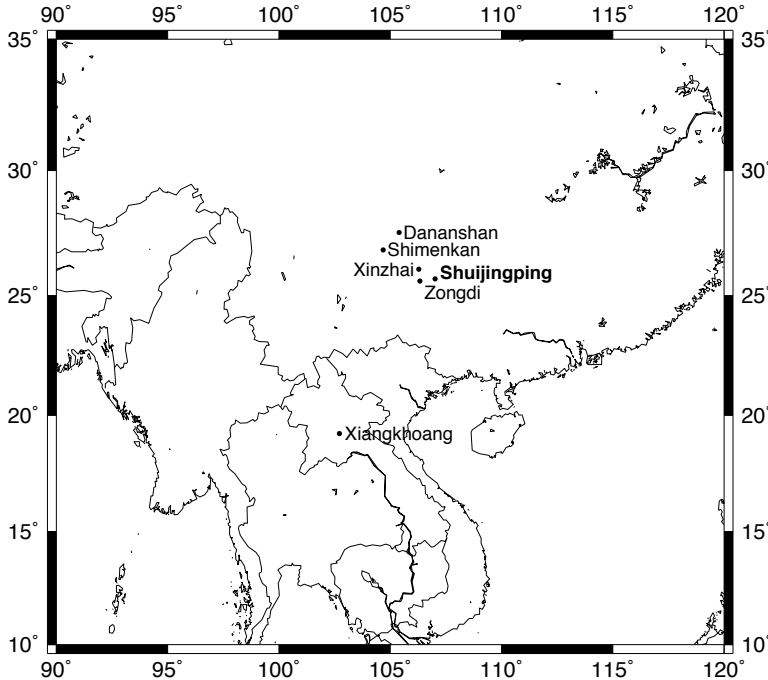


Shuijingping is mutually intelligible with Zongdi (Jiaotuo) Hmong, and probably with other dialects within the Mashan group. It is very different from the better-known Western Hmongic languages like Hmong Daw (White Hmong), Mong Leng (Green Hmong)<sup>1</sup>, and A-Hmao and is not mutually intelligible with these languages. However, the Mashan group to which Shuijingping belongs and the Far-Western Hmongic group to which these other languages belong are more closely allied than other subgroups within Western Hmongic, sharing a number of innovations. I refer to the group containing these two subgroups as “Core-Western Hmongic.” This relationship is important as the argument below will make reference to data from Far-Western Hmongic languages as a means of understanding the phonological history of Shuijingping Hmong.

Shuijingping Hmong 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. The location of Shuijingping village and other localities referenced in this study are shown in the map in (4):

(4) Map showing location of Shuijingping and other relevant localities

<sup>1</sup>Technically, Mong Leng and Hmong Daw should be treated as dialects of the same language, given their high level of mutual intelligibility and their broad similarities in lexicon, morphology, and phonology.



Shuijingping has a relatively simple segment inventory for a Hmongic language. These are given in (5). Prenasalized segments are transcribed as in Xian (1990) with a homorganic nasal before the stop or affricate. The symbol  $\text{ɲ}$  is used to represent a palato-alveolar nasal (homorganic with  $\text{ç}$ ). In coda position, /aiŋ/ is phonetically [āī]. /a/ may actually be [æ] or [ɛ]. /ɑ/ may represent [a]. Other symbols have their IPA values.

(5) *Segment inventories*

a. Onsets

p	t	ts	ʈ	tç	k	ʔ
mp	nt	nts	ɲʈ	ɲtç	ŋk	
m	n		ɲ		ŋ	
hw	ʈ		ç			h
			ʐ	ʑ		fi
w	l					
	pl		pr	pj		
	mpl		mpr	mpj		
			mr	mj		

b. Rhymes

i	u	ei	əu
e	ə	o	aiŋ
a	ɑ	ɔ	əŋ
	əa	ua	oŋ
			aŋ

The tonal inventory of Shuijingping consists of eleven contrasting tones (speaking in the Asianist sense, as contrasting contours that can occur on a syllable rather than as tonal features corresponding to a pitch target, as is the convention in discussions of African and Mesoamerican

tone languages). This tonal inventory, like those of other dialects belonging to the Mashan group, is large even by Hmongic standards.

(6) *Shuijingping Tones*

- a. Five level tones<sup>2</sup>: ↑H, H, M, L, ↓L
- b. Three falling tones: HL, HM, ML
- c. Two rising tones: LH, LM
- d. One rising-falling tone: LML

This large tonal inventory is the result of two historical splits conditioned by the laryngeal features of onsets. In Proto-Hmongic, there were four contrasting tones, which are conventionally labelled A, B, C, and D<sup>3</sup>. First, these tones split into two series based upon the voicing of onsets, with voiceless and preglottalized segments (including voiceless and preglottalized sonorants) serving as the conditioning environment for the high register (here indicated by the numeral 1) and the other onsets (voiced non-glottalized) serving as the conditioning environment for the lower register (here labeled with the numeral 2)<sup>4</sup>. The upper register was then affected by a second split on the basis of aspiration, with the tones of historically unaspirated syllables being indicated by the numeral 1 alone and the tones of historically aspirated syllables being indicated by 1'. The historical categories of the Shuijingping tones is summarized in (7):

(7) *Shuijingping tones by historical category*

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

<sup>2</sup>Relatively few languages have been claimed to have five level tones, and it has generally been pointed out that there is little or no phonological evidence to prove that some of the “level tones” in such languages are not, in fact, underlyingly contours. What is mentioned less often is that there is also often no positive linguistic evidence that such tones are underlyingly *contour tones*. The argument that they must be contour tones has been of a theory internal nature, drawing upon the predictions of feature-theoretic models like those of Yip (1980, 1989) and Bao (1999). Myers and Tsay (2003) argue that the relative rarity of such systems does not result from the impossibility of representing them in the phonology, but rather results from the difficulty of maintaining a five-level contrast in the perceptual domain. I will assume this position here.

<sup>3</sup>These are equivalent to the 平 *ping*, 上 *shang*, 去 *qu*, and 入 *ru* tones of Chinese historical phonology, which are sometimes labelled as I, II, III, and IV by tonologists working on Chinese languages (e.g. Ballard (1988) and Chen (2000)).

<sup>4</sup>These correspond to the 阴 *yin* and 阳 *yang* registers of Chinese phonology, which are sometimes indicated with the letters a and b (e.g. Ballard (1988) and Chen (2000)).

C2' is a “sandhi tone.” All syllables bearing this tone as their underlying tone historically were part of the C2 category but were reinterpreted when a prefixed element acting as the sandhi trigger disappeared. While this fact will not be important for the exposition here, C2' is realized on the surface as identical to A1', but they display different behaviors with reference to tone sandhi, A1' acting as a tone sandhi trigger and C2' not triggering alternations. What will be important to the exposition below is the definition of the tone sandhi environment. As in most Western Hmongic languages, tone sandhi in Shuijingping occurs under the following conditions:

(8) *Conditions for tone sandhi in Shuijingping*

- a. There is a trigger bearing one of the A tones (Shuijingping /M/, /L/, and /HL/).
- b. The trigger occurs before the target within a prosodic word<sup>5</sup>.
- c. The target bears one of the tones subject to sandhi.

Under these conditions, a rather involved set of tonal alternations can be observed, which are detailed in Xian (1990). Of these tone rules<sup>6</sup> three are of importance to the analysis that will be discussed below:

(9) *Three relevant tone rules*

- a. /HL/ → [L] (A2 → C2')
- b. /LM/ → [L] (C2 → C2')
- c. /↓L/ → [LM] (B2 → C2)

Given these pieces of background information, it is now possible to describe the problematic generalization for which we will later account.

## 1.2 The Generalization

In Shuijingping, there are two conditions under which vowel raising can take place. The first is when a syllable surfaces with the [ML] tone (either when the underlying tone is /ML/ and the

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<sup>5</sup>Depending upon the syntactic analysis which one applies to the Shuijingping DP, the domain for tone sandhi may or may not correspond to a syntactic or morphological constituent. Sequences consisting of a numeral followed by a classifier act as a domain for tone sandhi; sequences consisting of a classifier followed by a noun root do not act as a tone sandhi domain. If it is assumed that numerals and classifiers together head a ClfP or NumP, then the domains for tone sandhi would correspond to syntactic constituents. However, if it is assumed, as in some contemporary analyses of languages like Hmong, that both numerals and classifiers are heads and that the ClfP lies inside of the NumP, then the two elements would not form a syntactic constituent together and the domain must be seen as purely prosodic.

<sup>6</sup>The word *rules* will be used in this paper in a purely descriptive sense, describing the mappings between underlying forms and surface forms. No theoretical construct such as ordered string-rewrite rules is implied.

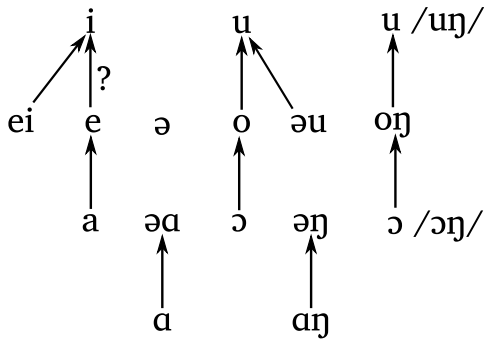
syllable is not in sandhi context or when the underlying tone is /↓L/ and the syllable is in sandhi context). The second case is when the underlying tone is /HL/ but the syllable surfaces with the [L] tone because it is in sandhi context. Under these conditions, three raising like processes apply, as listed in (10):

(10) *Three raising processes*

- a. Mid and low monophthongs are raised (12a–d, 13a–f).
- b. The first moras of falling-sonority diphthongs are raised, yielding high monophthongal vowels (12e–f).
- c. The first mora of the low vowel /a/ centralizes, producing the diphthong [əɑ] (13g–i).

These vowel raising processes are briefly schematized in (11), where arrows point from underlying vowels (actually, rhymes) to surface vowels:

(11) *Vowel raising in Shuijingping*



### 1.3 The Data

With these generalizations in hand, it is possible to make sense of the data. Examples of the relevant patterns are given in (12) and (13). The examples in (12) show that vowels fail to rise when the underlying tone is /ML/ but the syllables are placed in sandhi context (in all of these examples, following /M/ tone syllables) and thus surface with the [L] tone. However, in isolation (and in other contexts) /ML/ surfaces as [ML] and raising applies.

(12) *Vowel raising in [LM] tone syllables*

- |    |  |   |                  |                       |                        |                  |
|----|--|---|------------------|-----------------------|------------------------|------------------|
| a. | /plɔ <sup>M</sup> maŋ <sup>LM</sup> /  | → [plɔ <sup>M</sup> maŋ <sup>L</sup> ]  | ‘beard of wheat’ | /maŋ <sup>LM</sup> /  | → [məŋ <sup>LM</sup> ] | ‘wheat’          |
| b. | /hwei <sup>M</sup> ŋtɔ <sup>LM</sup> / | → [hwei <sup>M</sup> ŋtɔ <sup>L</sup> ] | ‘muskmelon’      | /ŋtɔ <sup>LM</sup> /  | → [ŋtɔ <sup>LM</sup> ] | ‘variegated’     |
| c. | /toŋ <sup>M</sup> zɔ <sup>LM</sup> /   | → [toŋ <sup>M</sup> zɔ <sup>L</sup> ]   | ‘worker’         | /zɔ <sup>LM</sup> /   | → [zɯ <sup>LM</sup> ]  | ‘work, strength’ |
| d. | /toŋ <sup>M</sup> wo <sup>LM</sup> /   | → [toŋ <sup>M</sup> wo <sup>L</sup> ]   | ‘Han nation’     | /wo <sup>LM</sup> /   | → [wu <sup>LM</sup> ]  | ‘Han’            |
| e. | /ʔei <sup>M</sup> ntei <sup>LM</sup> / | → [ʔei <sup>M</sup> ntei <sup>L</sup> ] | ‘one iteration’  | /ntei <sup>LM</sup> / | → [nti <sup>LM</sup> ] | ‘iteration’      |

- f. /nei<sup>HL</sup>təu<sup>LM</sup>/ →[nei<sup>HL</sup>təu<sup>L</sup>] ‘which person’ /təu<sup>LM</sup>/ →[tu<sup>LM</sup>] ‘clf (people)’

It might be tempting to analyze this process as a case of vowel lowering rather than vowel raising. After all, the putative raising process applies here only to the isolation forms and, as a general rule, these may be thought to be closer to underlying forms than those in sandhi context. However, it is clear from these data that this cannot be the case. Note that both the morpheme meaning ‘Han’ (with the allomorphs [wo<sup>LM</sup>] and [wu<sup>LM</sup>]) and the classifier for people (with the allomorphs [təu<sup>L</sup>] and [tu<sup>LM</sup>]) have [u] in the isolation forms (in these cases, the allomorphs with relatively higher vowels). Suppose, for the sake of contradiction, that both of these morphemes contain /u/ underlyingly. We then must posit that, in sandhi context, the /u/ in ‘Han’ is mapped to [o] and the /u/ in the classifier for people is mapped to [əu]). While it might be possible that this is a conditioned change, a claim for which there is no other evidence, it is conceptually simpler to label the observed process as vowel lowering and to posit different underlying vowels for these two morphemes.

Assuming that the observed process is raising also helps unify the pattern observed in (12) with that in (13). Here, syllables with underlying /HL/ are realized with their underlying vowels in non-sandhi context (e.g. isolation) but are realized with raised vowels in sandhi context (when the tone of the syllable surfaces as [L]).

(13) *Vowel raising in syllables where underlying /HL/ becomes [L]*

- |    |   |          |  |                 |
|----|---|----------|--|-----------------|
| a. | /mplaŋ <sup>HL</sup> / → [mplaŋ <sup>HL</sup> ] | ‘leaf’   | /zain <sup>M</sup> mplaŋ <sup>HL</sup> / → [zain <sup>M</sup> mpləŋ <sup>L</sup> ] | ‘tobacco’       |
| b. | /kaŋ <sup>HL</sup> / → [kaŋ <sup>HL</sup> ]     | ‘poor’   | /məŋ <sup>L</sup> kaŋ <sup>HL</sup> / → [məŋ <sup>L</sup> kəŋ <sup>L</sup> ]       | ‘poor person’   |
| c. | /nəŋ <sup>HL</sup> / → [nə <sup>HL</sup> ]      | ‘eat’    | /mu <sup>L</sup> nəŋ <sup>HL</sup> / → [mu <sup>L</sup> nəŋ <sup>L</sup> ]         | ‘not eat’       |
| d. | /ŋoŋ <sup>HL</sup> / → [ŋoŋ <sup>HL</sup> ]     | ‘cattle’ | /ŋka <sup>HL</sup> ŋoŋ <sup>HL</sup> / → [ŋka <sup>HL</sup> ŋu <sup>L</sup> ]      | ‘cattle corral’ |
| e. | /tə <sup>HL</sup> / → [tə <sup>HL</sup> ]       | ‘petal’  | /ʔə <sup>M</sup> tə <sup>HL</sup> / → [ʔə <sup>M</sup> tə <sup>L</sup> ]           | ‘two petals’    |
| f. | /tɕə <sup>HL</sup> / → [tɕə <sup>HL</sup> ]     | ‘length’ | /ʔei <sup>M</sup> tɕə <sup>HL</sup> / → [ʔei <sup>M</sup> tɕə <sup>L</sup> ]       | ‘one length’    |
| g. | /hɑ <sup>HL</sup> / → [hɑ <sup>HL</sup> ]       | ‘shout’  | /kua <sup>M</sup> hɑ <sup>HL</sup> / → [kua <sup>M</sup> həɑ <sup>L</sup> ]        | ‘bug sound’     |
| h. | /hɑ <sup>HL</sup> / → [hɑ <sup>HL</sup> ]       | ‘shout’  | /so <sup>L</sup> hɑ <sup>HL</sup> / → [so <sup>L</sup> həɑ <sup>L</sup> ]          | ‘thunder’       |
| i. | /mɑ <sup>HL</sup> / → [mɑ <sup>HL</sup> ]       | ‘maple’  | /wɑ <sup>L</sup> mɑ <sup>HL</sup> / → [wɑ <sup>L</sup> məɑ <sup>L</sup> ]          | ‘maple tree’    |

Significantly, these processes cannot be driven solely by the output tone since, if we may believe Xian (1990), the sandhi tones for /LM/ and /HL/ are both realized as [L] and are phonetically identical. Since a surface [L] is associated, in the second case, with vowel raising and, in the first case, with the preservation of the non-raised vowel, the crucial phonological generalization must take into account the underlying tone of the two categories of morphemes, not simply their surface realizations.

What we observe here, then, is a very unusual type of derived environment effect (DEE). In an ordinary DEE, a phonological process only applies in environments that did not exist in the underlying form. In the case of vowel raising where /HL/ becomes [L], the process applies just in case the environment is derived and the underlying tone has a specific value (/HL/). This is very significant. The apparent non-existence of effects of this kind has been taken by McCarthy (2002) as an argument against local constraint conjunction, which predicts the existence of effects of exactly this kind. In fact, of the mechanisms for capturing phonological opacity in two-level, strictly parallel Optimality Theory, local constraint conjunction seems to be the only mechanism capable of modeling these data. As will be discussed below, an analysis of this phenomenon in stratal models of Optimality Theory is possible as long as there is an intermediate stage of representation at which phonological structures that are found neither in the lexical inputs nor in the inventory of outputs may exist at an intermediate level of representation.

## **2 Comparison with Other Tone-Vowel Interactions**

The phenomenon described here is not completely unheard of in the phonological literature. While it has been widely claimed that there can be no directed interaction between vowel quality and tone (Hombert 1977, 1978; Hombert et al. 1979; Peeters and Shouten 1989; Gussenhoven and Driessen 2004), a number of instances of interactions between tone and vowel quality have been described and analyzed (Wang 1969; Hashimoto 1972; Matisoff 1973; Pilszczikowa-Chodak 1972, 1975; Newman 1975; Chan 1985; Wright 1983; Jiang-King 1999; Hermans and van Oostendorp 2000; Myers and Tsay 2003). In almost all of these cases, it has been argued that the interaction (if it is actually robust; see (Newman 1975)) is actually mediated by syllable structure (Hermans and van Oostendorp 2000) and metrical structure (Jiang-King 1999), or duration (Gussenhoven and Driessen 2004). Some investigators have also attributed certain tone-vowel interactions to functional factors related to the intrinsic pitch of vowels (Wang 1972; Yip 1980; Myers and Tsay 2003), though these arguments are the subject of some dispute (Maddieson 1976; Chan 1985; Jiang-King 1999). Here, I will argue that these various accounts cannot be extended to the Shuijingping case, that there must be some other mediating factor between tone and voice quality in this language, and that that factor is voice quality.

### **2.1 Tone-Vowel Interactions Mediated by Syllable Structure**

Hermans and van Oostendorp (2000) point to a set of cases where the relationship between vowel quality and tone. Comparing data from two Limburger dialects (Maasbracht and Sittard) they

show that a falling tone (HL) has triggered diphthongization in Sittard (14-15). Vowels bearing accent 1 (the HL tone) undergo a diphthongization process, as shown in (14). This process does not occur with vowels bearing accent 2 (the H(L)H tone) as demonstrated in (15).

(14) *Diphthongization with HL tone*

	<i>Maasbracht</i>	<i>Sittard</i>	
a.	[keeze]	[keize]	'to choose'
b.	[keezel]	[keizel]	'gravel'
c.	[bedreege]	[bedreige]	'to cheat'
d.	[vrøøtele]	[vruite]	'to grub'
e.	[bedrøøftj]	[bedruif]	'sad'
f.	[vrøøg]	[vruiɡ]	'early'
e.	[aalmooos]	[aalmooos]	'alms'
g.	[voot]	[vout]	'foot'
h.	[book]	[bouk]	'book'

(15) *No diphthongization with H(L)H tone*

	<i>Maasbracht</i>	<i>Sittard</i>	
a.	[beet]	[beet]	'bite'
b.	[smeet]	[sjmeet]	'smith'
c.	[streek]	[sjtreek]	'region'
d.	[døør]	[døør]	'door'
e.	[vøør]	[vøør]	'before'
f.	[røøk]	[røøk]	'smell'
g.	[toon]	[toon]	proper name
h.	[woos]	[woosj]	'sausage'
i.	[doon]	[doon]	'to do'

The essence of the analysis given by Hermans and van Oostendorp (2000) rests on the observation that more sonorous (and therefore lower) vowels are preferred in head positions and less sonorous (and therefore higher) vowels are preferred in non-head positions (Prince and Smolensky 1993; de Lacy 2002a). By the same token, they propose (following de Lacy (1999, 2002b)) that high tones are favored when they are linked to features that are linked to head positions, while low tones are preferred elsewhere. This means that, other things being equal, structures which are best for bearing HL falling tones are also best for bearing falling-sonority diphthongs. Thus, according to

their argument, there is no reason to propose a direct link between tone and vowel quality in this case because segmental headedness acts as a mediator between these two domains.

## 2.2 Tone-Vowel Interactions Mediated by Perceived Duration

Gussenhoven and Driessen (2004) examine data from another Limburger Dutch dialect, that of Weert, and conclude that the tone-vowel interaction in this dialect is mediated by duration, or more accurately, is the result of an attempt to enhance a tonal contrast by enhancing perceived differences in duration. Perceived duration, they argue, is increased by vowel raising. Example data are given in (16):

(16) *Height alternations in Weert*

- |    |                     |            |                    |            |
|----|---------------------|------------|--------------------|------------|
| a. | stæjn <sup>HL</sup> | ‘stone-PL’ | stein <sup>M</sup> | ‘stone-SG’ |
| b. | bœjm <sup>HL</sup>  | ‘tree-PL’  | bœym <sup>M</sup>  | ‘tree-SG’  |
| c. | aβx <sup>HL</sup>   | ‘eye’      | lux <sup>M</sup>   | ‘also’     |

The raised form of the diphthongs appear in syllables with accent 2 (M tone) while the lower form of the diphthongs appear in syllables bearing accent 1 (HL tone). Syllables bearing the relatively level accent 2 are characteristically longer than those bearing accent 1. Gussenhoven and Driessen (2004) present experimental evidence suggesting that higher vowels are, *ceteris paribus*, perceived as being longer in duration than lower vowels and argue that the raising of diphthongs bearing accent 2 is a way of leveraging this effect to perceptually enhance the existing duration difference between accent 1 and accent 2 syllables. In this case, too, there seems to be no reason to propose that tonal features and vowel features can interact directly.

## 2.3 Fuzhou Tone-Vowel Interaction

Probably the most intensely debated case of vowel quality-tone interaction is found in Fuzhou Chinese (Northern Min) described by (Wang 1969). In brief, there are two kinds of “finals” (or rimes) in Fuzhou, known conventionally as *tight* and *loose*. Each of these two categories is characterized by a particular set of tones and a particular set of vowels. When there are tone sandhi changes that result in changes of category along the tight/loose dimension, there are also vowel alternations. The relationships between tight and loose rhymes, tones, and vowels is given in (17), with alternating pairs displayed in the columns:

(17) Tone-vowel interaction in Fuzhou (adapted from Myers and Tsay (2003)):

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

Certain early analyses of this phenomenon, notably those of Wang (1968) and Yip (1980), attributed these alternations to a correlation between vowel height and pitch, observing that both the tones and vowels were relatively higher in the tight category. This observation was to be explained in terms of the correlation between the height of vowels (F1) and their intrinsic pitch (F0), F0 being in an inverse relationship with F1. This hypothesis, which Jiang-King (1999) labels the “high correlation hypothesis” was challenged by Maddieson (1976), who observed that many of the alternations could not be explained in terms of vowel height alone. Later analyses of this phenomenon (Wright 1983; Chan 1985; Jiang-King 1999) have explained the tonal alternations and vowel alternations in Fuzhou as results of alternations in prosodic or metrical structure. The relationship between tone and vowel quality, under such analyses, would thus be purely epiphenomenal. (Wright 1983) attributed the difference between tight and loose finals to a difference in stress (based on the argument that Fuzhou had an iambic stress pattern within words). Chan (1985) observed that the tones of loose syllables always include a rising contour, and related this fact to the widespread observation that rising contours are longer than level tones or falling contours. In strong positions, she argued, both tonal “lengthening” (change to a tone with a rising contour) and vowel lowering are triggered by stress. Jiang-King’s (1999) great innovation is to attribute the tight-loose distinction to a difference in syllable weight, arguing that loose syllables are bimoraic and tight syllables are monomoraic. In this analysis, too, metrical factors influence syllable structure and syllable structure affects tone and vowel quality independently. While Myers and Tsay (2003) object to these analyses on the grounds that they do not adequately explain the alternations where there is no change in syllable structure, arguing that the “height correlation hypothesis” is essentially correct, the case of Fuzhou is not an unambiguous example of the direct interaction between tone and vowel features. Indeed, even in the cases where tight vowels and their loose counterparts do not differ in structure, they should nevertheless differ in absolute duration, with the higher (and therefore shorter) vowels occurring in tight syllables (the tonal contours of which never include a rise) and the lower (and therefore longer) vowels occurring in loose syllables. In short, while it is not immediately clear what the proper analysis of this phenomenon is, there seems to be no compelling reason to believe that it involves a feature-to-feature interaction between vowel quality and tone.

## 2.4 The Inadequacy of these Accounts for Shuijingping Raising

This cases open a variety of analytic pathways for explaining vowel tone interactions. None of these pathways, however, seem to lead from the Shuijingping data to an insightful understanding of them. In fact, it appears—superficially, at least—that any surface-driven account of the vowel raising process in Shuijingping is bound to fail. The reason for this is quite simple, namely that the same output conditions, both in terms of the surrounding tonal environment and the tone of the affected syllable, lead to different outcomes depending upon the underlying identity of the tone of the affected syllable.

This is not the only obstacle to treating the Shuijingping tone-vowel interaction as mediated by metrical structure, syllable structure, or duration. It is true that certain of the tonally-triggered vowel alternations are accompanied by changes in syllable structure. Both /ei/ and /əu/ become monophthongs which they are raised (to [i] and [u]). Likewise, /ɑ/ surfaces as [əɑ] in raising context. It is significant, though, that the same environment seems to trigger opposite changes in syllable structure depending upon the characteristics of the input. There is a second set of syllable-structure alternations that are tied to the tone-vowel interaction. As shown above, /ɔŋ/ surfaces as [oŋ] in raising context but as [ɔ] in isolation; /oŋ/ surfaces as [u] in raising context, but as [oŋ] in isolation. This, however, must be attributed to a general ban on codas after [ɔ] and [u] (associated with a sound change that occurred in Shuijingping but which did not occur in Zongdi, as will be seen). That is to say, the deletion process is triggered by vowel quality features, not by tone, explaining why both deletion of the nasal coda and failure to delete it are associated with the raising process.

The height correlation hypothesis also seems to have no relevance to the Shuijingping pattern. Indeed, one of the triggers for raising is associated with the change from /HL/ to [L], which is in no way a raising process. Again, unlike the Fuzhou case, raised vowel variants are not associated with a particular set of output tones.

## 2.5 Vowel-Tone Interactions Mediated by Phonation Type

There is another possibility, however, which is noted by Gussenhoven and Driessen (2004), namely that the relationship between tone and vowel quality could be mediated by phonation type. They give the example of the Mon-Khmer language, where differences in laryngeal setting have given rise to vowel-quality differences in Khmer (and many other Mon-Khmer languages) but to tonal contrasts in Vietnamese. In that particular case, the relationship between tone and vowel quality is not manifest in any single languages, but across a family. However, there is no

principled reason that the same type of interaction could not arise within a single language. I will demonstrate that the tone-vowel interaction in Shuijingping is a relationship of exactly of this type.

### **3 Phonation and Vowel Quality**

It is well known that there is an association between phonation type and vowel quality. Specifically, breathy phonation requires a lowering of the larynx, which has the effect of lowering formants, especially F1 (Fagan 1988; Ladefoged and Maddieson 1996; Gordon and Ladefoged 2001; Brunelle 2005). This effect may give rise to either low-level allophonic splits or to more phonologically significant developments.

#### **3.1 Eastern Cham**

In Eastern Cham (an Austronesian language of Vietnam), there is a contrast between two “registers”: a “high” register characterized by high pitch and modal phonation and a “low” register characterized by breathy phonation and low pitch (Brunelle 2005). Brunelle shows that this contrast is also associated with a difference in vowel quality, particularly in the value of F1. The correlation between vowel quality and phonation in Cham, however, is a small subphonemic effect. Brunelle’s discussion raises the possibilities that the effect could either be directly caused by the difference between breathy and creaky phonation, or that breathy phonation and vowel-raising could result from the same historical cause (voiced onsets). In either case, the effect is likely due to the effect of laryngeal lowering, a strategy by which a speaker may suddenly increase the pressure drop across the glottis and thus facilitate voicing of stops and breathy voicing of vowels and other segments.

#### **3.2 Khmer and other Mon-Khmer Languages**

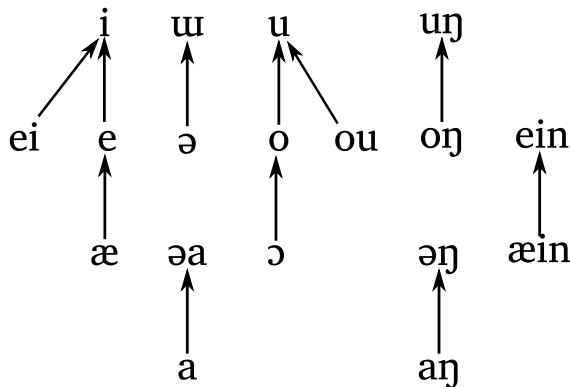
There is a more dramatic effect of breathy phonation on vowel quality in many Mon-Khmer languages (Huffman 1967, 1976). Like Eastern Cham, many Mon-Khmer languages have distinctions in vowel quality that are conditioned (either diachronically or synchronically) by differences in phonation. Breathless vowels are typically higher in the vowel space than their modal-voiced counterparts, though breathiness is also associated with diphthongization in some of these languages (conspicuously, Khmer). Most of these languages retain the breathy/modal register distinction, though according to Huffman (1976), phonation-conditioned vowel quality differences are now

contrastive in some of these languages (Kuy, Chaobon, Chong, Bru, Mon). In many dialects of Khmer, the process has proceeded farther, and the phonatory distinction has disappeared, leaving only the vowel quality contrast.

### 3.3 Zongdi

Much closer to Shuijingping is Zongdi, a Hmong dialect belonging to the Mashan group. In Zongdi there is a breathy/modal distinction in phonation (which, as will be seen later, is correlated with tonal contrasts). In Zongdi, different sets of vowels appear in breathy-voiced and modal-voiced syllables, with the breathy set being generally higher in the vowel space than the modal set. A single historical vowel will have two reflexes, split according to this criterion. Thus, Proto-Mashan \*o > Zongdi /o/ in modal-voiced syllables but /u/ in breathy-voiced syllables. Likewise, historical \*ɔ > modal /ɔ/ but breathy /o/. Concretely, \*lo<sup>C1</sup> > lo<sup>H</sup> ‘mouth’ but \*lo<sup>B2</sup> > lɥ<sup>L↓</sup> ‘come (back)’, \*ntsɔ<sup>B1</sup> > \*ntsɔ<sup>LML</sup> ‘but’ but \*ntsɔ<sup>C2</sup> > \*ntsɔ<sup>LM</sup> ‘thin’, \*mpa<sup>A2</sup> > mpa<sup>HM</sup> ‘clap (hands)’ but \*wə<sup>B2</sup> > wə<sup>L↓</sup> ‘tile’. The whole set of relationship is illustrated in (18), with arrows pointing from the vowels reflected in modal syllables to the vowels reflected in breathy syllables (Wang 1979, 1994; Li 2001).

(18) Relationships between modal and breathy-voiced vowels in Zongdi.



In most cases at least, the qualities of the modal voiced vowels are similar to those that must be reconstructed for the historical stage prior to the conditioned split (Wang 1979, 1994). The similarity between the set of relationships described here and the vowel alternations that are found in Shuijingping, as enumerated in (11) is obvious. It would be very surprising if these two patterns were not related. It will be shown that the vowel-quality alternations in Shuijingping originated as the same set of voice-quality conditioned splits that can be observed in Zongdi. The interaction between vowel quality and tone can be mediated by voice quality because voice quality is connected to tone as well as to vowel height.

## 4 Phonation Type and Tone

Many languages in both Mesoamerica and Southeast Asia display interactions between phonation type and tone. These vary greatly in their complexity, from the complex distributional restrictions found in many Otomanguean languages to the relatively simple tone-to-phonation-type relationships found in many Southeast Asian languages.

### 4.1 Burmese, Vietnamese, and Eastern A-Hmao

Burmese has a system of four tones, each of which is characterized by a particular type of phonation: a low, modal-voiced tone; a high, breathy tone; a high, creaky tone; and a very high, tense-voiced tone (Bradley 1982; Watkins 1997):

(19) *Phonation-type distinctions in Burmese tones* (adapted from (Watkins 1997, 2001))

<i>low</i>	/ma/	[ma: <sup>22</sup> ]	‘hard’
<i>high</i>	/má/	[má: <sup>44</sup> ]	‘towering’
<i>creaky</i>	/mǎ/	[mǎ: <sup>51</sup> ]	‘female’
<i>killed</i>	/ma?/	[ma? <sup>51</sup> ]	‘March’

Though in the traditional analysis (and the analysis given by Watkins) marked phonation is a secondary phonetic feature of particular tones, it would be possible to analyze the system such that voice quality was primary and pitch was secondary.

Vietnamese tones, likewise, are characterized by particular phonation types (Nguyen and Edmondson 1997). Voice quality is such a prominent acoustic and perceptual cue for Vietnamese tone categories that some researchers have argued that pitch is of secondary importance in the Vietnamese tone system (Pham 2003).

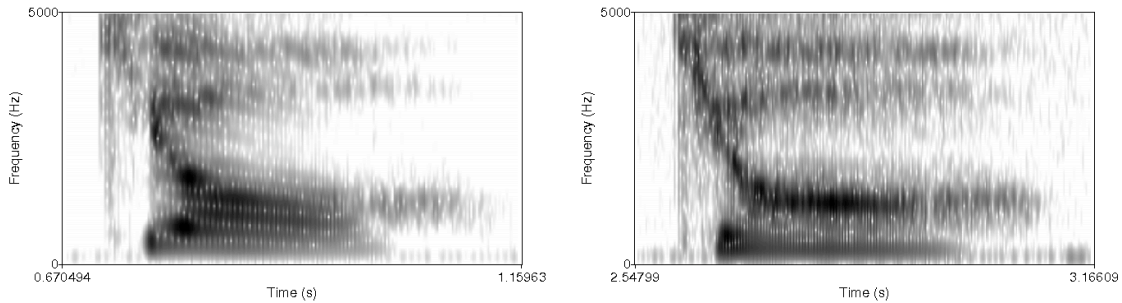
A similarly complex system can be found in the Western Hmongic language A-Hmao. In Western A-Hmao, phonation type is now independent of tone (Johnson 1999), but in Eastern A-Hmao tones still carry characteristic phonation types (Wang and Wang 1986). Tone sandhi alternations also drive alternations in voice quality.

### 4.2 Mong Leng

The case of Mong Leng, a Hmongic language belonging to the Far-Western group is particularly relevant to the situation in Shuijingping. In this language, the mid-falling tone (representing the merger of the historical tones B2 and C2) is characterized by strong breathy phonation, as has been

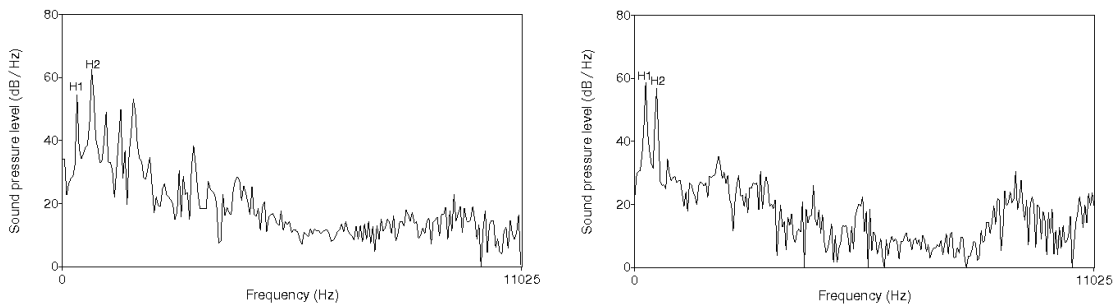
reported previously (Lyman 1974; Andruski and Ratliff 2000) and a similar pattern in Hmong Daw (White Hmong) has also been documented (Heimbach 1979; Ratliff 1992) and investigated instrumentally (Huffman 1987). The voice quality of the mid-falling tone in Mong Leng can be demonstrated by both qualitative and quantitative measures. From inspection of the spectrogram in (20), it is readily apparent that the vowel in [c̈ɔ̌] ‘plant’ (right) includes a strong aperiodic component, suggestive of breathy phonation while the vowel in [c̈ɔ̌] ‘lead’ (with the high falling tone, historical A2) does not.

(20) *Spectrograms of Mong Leng [c̈ɔ̌] ‘lead’ (modal, left) and [c̈ɔ̌] ‘plant’ (breathy, right)*



Likewise, measures of spectral tilt suggest that syllables bearing the mid-falling tone (B2/C2) display a larger open quotient than syllables bearing other tones (Andruski and Ratliff 2000). This is illustrated in (21), where the spectrum for [c̈ɔ̌] ‘plant’ shows a much higher ratio of H1 to H2 than the spectrum for [c̈ɔ̌] ‘lead’:

(21) *Spectra from Mong Leng [c̈ɔ̌] ‘lead’ (modal, left) and [c̈ɔ̌] ‘plant’ (breathy, right)*



Additionally, Andruski and Ratliff (2000) demonstrate that voice quality is the most important perceptual cue used to identify tone B2/C2 by speakers of Mong Leng.

In Mong Leng, as in Eastern A-Hmao, tonal alternations may be accompanied by alternations in phonation. For example, when the high-falling tone (A2) appears in sandhi context, it is replaced by the aforementioned falling-breathy tone (B2/C2):

(22) *Mong Leng tone sandhi accompanied by alternation in phonation type*

- a. /ntû → [ntû] ‘sky’ /qáŋ-ntû/ → [qá-ntû] ‘world (underside-sky)’  
b. /tsâ/ → [tsâ] ‘money’ /jâ-tsâ/ → [jâ-tsâ] ‘riches (silver-money)’

It is of particular significance that the breathy tone in Mong Leng is cognate to the Shuijingping /LM/ tone (the tone which always triggers vowel raising). Likewise, the modal-voiced high-falling tone with which it is contrasted in (20) and (21) is cognate to the Shuijingping /HL/ tone. In Shuijingping, vowels surfacing with the /HL/ tone never undergo raising, as was indicated above.

### 4.3 Zongdi

In fact, across Western Hmongic (and Eastern Hmongic as well), tones B2 and C2 are frequently characterized by breathy phonation while the other tones are characterized by clear phonation, as demonstrated by the survey made by Niederer (1998:249). This is also the case in Zongdi. The breathy/modal distinction described for Zongdi above is associated with tonal categories: /L↓/ (B2) and /LM/ (C2) are breathy and /HM/ (A2) and /M/ (C3) are clear<sup>7</sup> Wang (1979, 1994); Li (2001).

Just as in Mong Leng, tonal alternations in Zongdi regularly trigger alternations in phonation type. The difference between the two cases is significant. In Mong Leng, the vowel quality remains relatively constant when phonation type changes (with only small perturbations of F1, probably resulting from the lower position of the larynx during breathy phonation). In Zongdi, the whole panoply of vowel alternations described above can be triggered by tonal alternations. As in Shuijingping, vowel raising always occurs in syllables that surface with the [LM] tone (C2)—and are therefore breathy-voiced—but does not occur in the same morphemes when they surface with the [M] tone (C3) due to tone sandhi (and are therefore modal-voiced):

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

- a. /sæi<sup>LM</sup>/ → [sfiei<sup>LM</sup>] ‘smart’ /mfɛŋ<sup>L</sup>sæi<sup>LM</sup>/ → [mfɛŋ<sup>L</sup>sæi<sup>M</sup>] ‘smart person’  
b. /nti<sup>LM</sup>/ → [ntfi<sup>LM</sup>] ‘time’ /ei<sup>ML</sup>nti<sup>LM</sup>/ → [ei<sup>ML</sup>nti<sup>M</sup>] ‘one time’  
c. /ŋtɕ<sup>LM</sup>/ → [ŋtɕio<sup>LM</sup>] ‘variegated’ /ntɕ<sup>ML</sup>ŋtɕ<sup>LM</sup>/ → [ntɕ<sup>ML</sup>ŋtɕ<sup>M</sup>] ‘variegated cloth’  
d. /mpɿa<sup>LM</sup>/ → [mpɿɶa<sup>LM</sup>] ‘bereft’ /po<sup>ML</sup>mpɿa<sup>LM</sup>/ → [po<sup>ML</sup>mpɿɶa<sup>M</sup>] ‘widow’

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<sup>7</sup>It appears that, historically, the other tones were modal-voiced as well. However, in the dialect described by (Wang 1979, 1994), syllables bearing the 1' (historically aspirated) series of tones are now pronounced with a degree of breathiness. The data presented by (Li 2001) do not suggest this, however.

Even more crucially, in syllables bearing underlying /HL/ (a modal-voiced tone) become breathy in tone sandhi context, where they surface with the [LM] tone. While vowel raising does not occur when such syllables surface with the modal-voiced [HL] tone, it always occurs in syllables bearing the breathy [LM] tone:

(24) *Vowel raising in LM syllables in Zongdi* (Li 2001)

- |    |                        |   |                        |          |  |   |  |                |
|----|------------------------|---|------------------------|----------|--|---|--|----------------|
| a. | /mplaŋ <sup>HM</sup> / | → | [mplaŋ <sup>HM</sup> ] | ‘leaf’   | /ʒen <sup>ML</sup> mplaŋ <sup>HM</sup> / | → | [ʒen <sup>ML</sup> mpfiŋ <sup>LM</sup> ] | ‘tobacco leaf’ |
| b. | /soŋ <sup>HM</sup> /   | → | [soŋ <sup>HM</sup> ]   | ‘silk’   | /kua <sup>ML</sup> soŋ <sup>HM</sup> /   | → | [kua <sup>ML</sup> sfiŋ <sup>LM</sup> ]  | ‘silkworm’     |
| c. | /tæ <sup>HM</sup> /    | → | [tæ <sup>HM</sup> ]    | ‘matter’ | /ei <sup>ML</sup> tæ <sup>HM</sup> /     | → | [ei <sup>ML</sup> tfi <sup>LM</sup> ]    | ‘one matter’   |
| d. | /e <sup>HM</sup> /     | → | [e <sup>HM</sup> ]     | ‘plow’   | /tua <sup>ML</sup> e <sup>HM</sup> /     | → | [tua <sup>ML</sup> fi <sup>LM</sup> ]    | ‘plow’         |

This is significant for the Shuijingping case because (in that dialect) vowel raising also occurs when underlying /HL/ (A2) syllables occur in sandhi context. The difference is that /HL/ becomes [L] C3 in Shuijingping (which is cognate to Zongdi [M]) and thus surfaces with modal phonation, rather than becoming the breathy tone [LM] (C2) as in Zongdi.

## 5 The Diachronic Source of Shuijingping Vowel Raising

At this point, the major pieces of the puzzle are in place and a very plausible scenario for the origin of the tone-vowel interactions in Shuijingping presents itself. A brief outline is as follows: Proto-Mashan had tone sandhi alternations similar to those seen in Zongdi. As in Zongdi, phonation-type alternations accompanied these tone alternations. The vowel raising process occurred in breathy-voiced syllables, such that underlying /HL/ (A2) morphemes were affected by raising in sandhi context and underlying /LM/ (C2) morphemes were affected by raising out of sandhi context. In Shuijingping, there was a change in the tonal grammar so that /HL/ came to surface as [L] in sandhi context (just like /LM/) rather than [LM]. However, the vowel-raising process continued to apply to underlying /HL/ syllables in sandhi context (despite the loss of the original conditioning environment). The apparent loss of voice-quality distinctions in Shuijingping rendered the original motivation for the vowel raising even more opaque, to the extent that vowel raising came to be a completely tonally-conditioned set of alternations.

In order to establish this rigorously, it must be established that the Proto-Mashan grammar generated the tone sandhi alternations A2 → C2 and C2 → C3 and that Proto-Mashan A2 and C3 were modal-voiced while C2 was breathy voiced.



## 5.2 Phonation Type-Distinctions in Proto-Mashan

There is something even more interesting about the tone sandhi alternations in Xinzhai, namely that they are accompanied by alternations in what Xian (1990) describes as aspiration (between 送气的 *sòngqì de* and 不送气的 *bú sòngqì de*), without specifying whether plain aspiration or “voiced aspiration” (浊送气 *zhuó sòngqì*) is intended. Regardless of their underlying tone, obstruents in syllables surfacing with the tones [L] (B2) and [MHM] (C2) are aspirated, while those surfacing with the tones [H] (A2) and [HM] (C3) are not. This suggests strongly a historical situation in which B2 and C2 were associated with a laryngeal setting different than that for A2 and C3. This marked laryngeal feature is almost certainly breathy phonation.

Of twenty-four Hmongic languages surveyed by Niederer (1998), six are reported to have breathy voice accompanying tones B2 and C2 only. This is by far the most common pattern of tone-voice quality interaction in this family. This number does not include Zongdi (Jiaotuo) which is included in the survey but for which Niederer give no indication of characteristic phonation in her overview. There are four additional languages which are reported to have breathy phonation associated with tone C2 alone and two languages in which B2, C2, and D2 are all breathy. A2 is breathy in only one language, Eastern A-Hmao (Shimenkan). Given the wide distribution of these patterns within the family it appears necessary to reconstruct tone C2 and probably B2 as breathy and tone A2 as clear. This is the same pattern that can be observed in Zongdi, and is also the pattern that must have preceded the development of the tonally-conditioned aspiration alternation in Xinzhai.

The Xinzhai aspiration alternation also provides crucial evidence that C3 was voiceless in Proto-Mashan, as do both the phonetic descriptions of, and the vowel-raising process in, Zongdi. In Xinzhai, obstruent onsets fail to become aspirated in syllables bearing the [HM] tone (C3) even though they would become aspirated if they occurred out of sandhi context (and thus surfaced with their underlying tone, MHM). In Zongdi, vowels fail to rise in [M] (C3) syllables. Furthermore, there can be no question regarding the synchronic phonation type of [M]-tone syllables in Zongdi. Wang (1979, 1994) explicitly identifies the absence of “voiced aspiration” (that is, breathy phonation) as the most salient characteristic that distinguishes [L] from [LM].

## 5.3 Historical Scenario

The evidence thus far suggests that the tone system of proto-Mashan (or the part that concerns us here) had the following characteristics (using the Shuijingping tone values as labels):

(29) **Proto-Mashan tone system**

<i>underlying tone</i>	<i>phon. type</i>	<i>sandhi tone</i>	<i>phon. type</i>	
/HL/	A2	modal	/LM/ C2	breathy
/L↓/	B2	breathy	/LM/ C2	breathy
/LM/	C2	breathy	/L/ C3	modal
/L/	C3	modal	—	—

It was this state of affairs that held sway when the vowel-raising process came into being. Due to the acoustic side-effects of the production of breathy voice, vowels in breathy syllables were frequently slightly higher in the vowel space (that is, had a slightly lower F1) than the same phonemes in modal-voiced syllables. Language learners interpreted this accidental acoustic effect as an intentional, grammatical process in which (to a first approximation) vowels were raised one step in the vowel space. This resulted in a system similar to that which can be seen in Zongdi.

At that point, a minimal but crucial change took place in the grammar of Shuijingping: /HL/, which had previously had the breathy [LM] as its sandhi tone was mapped to the modal-voiced [L] in sandhi context:

(30) **Pre-Shuijingping tone system**

<i>underlying tone</i>	<i>phon. type</i>	<i>sandhi tone</i>	<i>phon. type</i>	
/HL/	A2	modal	/L/ <b>C3</b>	<b>modal</b>
/L↓/	B2	breathy	/LM/ C2	breathy
/LM/	C2	breathy	/L/ C3	modal
/L/	C3	modal	—	—

Were vowel raising a direct correlate of breathy phonation at this point, the vowel-quality alternation process would have ceased to apply to forms with underlying /HL/ since such forms did not alternate in phonation type any longer. What seems to have happened, instead, is that learners of the language attributed the vowel quality alternations to purely tonal conditions (rather than its root cause, breathy phonation). Based upon Xian's (1990) description, it appears that breathy phonation has now disappeared from [L↓] and [LM]. If this is in fact the case, then the original source of the vowel alternations has become even more obscure, yet the vowel-raising process remains robust.

This scenario has a striking implication, namely that language learners can encode tone-vowel quality interactions directly in their grammars, without any surface mediating factor. It is true that a model of phonology that allows for an intermediate level of representation between input and output could nevertheless capture this relationship indirectly by creating the mediating

structure at that intermediate level and destroying it at the surface. However, this would seem to require that the grammar can encode relationships directly between laryngeal features (the mediating factor) and vowel quality features. This is, in and of itself, problematic. It appears, furthermore, that increasing the power of the grammar to the point that it can successfully model alternations of this type would seriously weaken its restrictiveness. It is clear that patterns of this type are rare, and undermining the central goals of conventional phonological theory in order to accommodate a few cases of this type might seem rash. Nevertheless, this phenomenon must be explained.

One possible explanation is to avoid the grammar altogether and to deny that the vowel raising process has any status in the synchronic grammar at all, and that it ever had such a status. The observed pattern might be seen, instead, as the result of successive waves of sound change operating on surface forms. Both the vowel changes and tone changes that we have described thus far would be due only to sound changes of this type. This point of view is attractive in that it allows us to avoid the difficult question of how tone and other laryngeal features interact with vowel quality features—the interactions are situated entirely in the physical world.

This kind of explanation is problematic in at least two respects. In the first case, there is a technical difficulty: Suppose that morphemes that alternate between /HL/ (A2) and /L/ (C3) in Shuijingping do so because of a sound change. The environment for the sound change had to be sandhi context. It could not have applied to surface A2, because in that context all historical instances of A2 had become C2. This seems plausible, since C2 also alternates with C3, but it cannot be the case that instances of C2 from historical A2 became C3 by the same sound change that set up the alternation between historical C2 and C3, since that alternation is found in Xinzhai and Zongdi, without the A2/C3 alternation. Thus, A2 > C2 must have applied after C2 > C3. However, it is known that historical B2 also alternates with surface C2, and this change (B2 > C2) must have preceded the second C2 > C3 change, since the B2/C2 alternation is found throughout Western Hmongic. But if the second C2 > C3 change occurred after the B2 > C2 change, we would expect all instances of historical B2 to become C3 in sandhi context (since the first change would feed the second). This does not occur. We are thus caught in a paradox of relative chronology.

The only way to salvage such an analysis, in which the tonal alternations have no synchronic status, is to invoke a kind of phonetically-conditioned leveling whereby all morphs having the C2 tone and a co-allomorph with the A2 tone would change in tone to A2. This change would then be followed by A2 becoming C3 in sandhi context. Such a mechanism is undesirable, since it would make mergers reversible. Such a purely diachronic account also has no ready means

of explaining why sound changes continue to apply in the same environment (after the A tones) despite the fact that it was no longer a phonetically natural class by the time that the putative second C2 > C3 change occurred. The only plausible explanation for this fact is that speakers had grammatical knowledge of the environments in which tone sandhi alternations applied and that this knowledge constrained the scope of novel alternations as well. The upshot of these two sets of facts is that the tonal allomorphy observed in Shuijingping is generated by the grammar from a single set of underlying forms, or—at the very least—was generated by the grammar at the time A2 gained C3 as its sandhi tone. If the grammar has access to the underlying tone for each syllable affected by the tonal allomorphy, it should follow that the grammar also has access to the underlying vowels of such forms. In the absence of overwhelming evidence to the contrary, it seems that both the tonal alternations and the vowel raising process should be considered to be products of the synchronic phonological grammar, despite the fact that their coherence lies purely in the realm of diachrony.

## **6 Conclusion**

The case of tonally conditioned vowel raising in Shuijingping Hmong strongly suggests that neither diachrony nor synchrony can play an exclusive or even independent role in explaining phonological patterns. Both the existences of certain phonological phenomena, and their relative rarity, cannot be explained without reference to history and constraints on language change. However, aside from the computational limitations and characteristics of the human language faculty, it appears that the synchronic grammars of individual languages strongly influence the types of changes that are likely to occur in those languages.

### **6.1 Diachronic Explanation for Synchronic Patterns**

The pattern of tonally conditioned vowel raising seen in Shuijingping seems to flow with cool inevitability from verifiable facts about language change. Diachronically, it is possible to account for the observed pattern almost exhaustively. However, there is little in our knowledge of synchronic phonology that would lead us to expect the existence of patterns of this kind. Rather, much of phonological theory has been developed so as to avoid predicting the existence of apparently arbitrary interactions of the sort seen here. Feature-geometric models of phonological representation were developed, in large part, to constrain the interaction between features of different classes; the vowel raising process in Shuijingping seems, however, to require that vowel quality features and laryngeal features can interact directly. Models of phonological opacity like

comparative markedness (McCarthy 2002) have been advocated on the specific grounds that they rule out derived environment effects of the type exemplified by Shuijingping vowel raising; the evidence for the existence of such a case here is, however, quite compelling.

Cases of this type raise a series of significant questions: If generalizations of the type exemplified by Shuijingping vowel raising are learnable and computationally possible, why are they so rare? And if there are many possible but nearly unattested patterns, how many conceivable but unattested phonological relationships are part of possible human grammars, but accidentally missing from the typological sample? And if, as a number of scholars have suggested (?), human linguistic history has not yet played out the full range of typological possibilities, what can phonologists possibly learn about the limits of the human language faculty from typological studies of phonological phenomena of the type that are currently so important in evaluating phonological hypotheses?

Satisfying answers to all of these questions can be given, provided they are approached from a diachronic point of view. Whatever their theoretical stripe, linguists have to concede some role for history in defining how a given language behaves at a given point. If it is also conceded that not all historical developments are equally probable, and if it is possible to evaluate the relative probability of such developments through independently verifiable means, external to the linguistic competence proper, then it becomes possible to provide real explanations for statistical patterns in the grammars of human languages, removing the need to rely on purely circular models that rely heavily on appeals to negative evidence. Starting with such assumptions, we would predict tonally-vowel interactions of the Shuijingping type to be relatively rare simply because the prerequisites for their development are relatively rare, and are thus very unlikely to co-occur in the fashion necessary to give rise to them. There is no reason to construct the formal grammar to constraint interaction between laryngeal features and vowel quality features—thus ruling out the possibility of grammars like that of Shuijingping, since the ways in which they do and do not interact can be largely explained in terms of facts about the physical world (in the case of Shuijingping, facts of aerodynamics and acoustics).

In such a light, the cross-linguistic study of synchronic phonological patterns takes on a new purpose. While this is almost certainly the wrong place to look for definitive answers to questions about the absolute limits of the language faculty, it is the right place to look for the range of phonological patterns that are likely to develop given the physical constraints and social characteristics of the world in which we live (a question that is of no less importance). Such a pursuit necessarily has a diachronic component.

## 6.2 Synchronic Grammar in Diachronic Scenarios

The whole scenario is consistent with a picture of learners desperately seeking coherence in a code that—as it presents itself to them—is badly underdetermined. They are presented with variation of several types—phonetic variation introduced by articulatory missteps, aerodynamic constraints, acoustic coincidences, and perceptual errors, stylistic and sociolinguistic variation, and variation introduced by other speakers who themselves do not fully command the common medium of communication. In the face of this rampant ambiguity, speakers do their best to construct phonological grammars as internally consistent systems, using whatever tools are available to them. For example, the patterns of development and change in the tone sandhi systems of Western Hmongic languages implies that speakers of these languages were relying upon their existing grammatical knowledge when they posited new or modified tone alternations. New alternations were introduced in precisely the same environment as the existing alternations, despite the fact that the phonetic properties of that environment have varied widely over time and space to the extent that it lacks any phonetic coherence at all except in a few languages and dialects like Dananshan Hmong. It is unjustified, then, to view linguistic change as blind processes that operate over surface structures with no regard to the grammatical patterns that exist in the languages they would affect, just as it is unjustified to treat language change as wholly, or even largely, motivated by factors internal to the grammar. Rather, it appears that synchrony acts as a biasing factor that influences the way in which externally induced variation is rationalized in ever-evolving grammars.

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