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Tonally conditioned vowel raising in Shuijingping Mang

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Abstract In the Mang (Hmongic) dialect of Shuijingping, Guizhou, China, vowels are raised in certain tonal contexts. When a syllable bearing the historical A2 tone occurs in sandhi context, it surfaces with a low tone (historical S) and a raised vowel nucleus. When a syllable bearing the C2 tone occurs *out* of sandhi context, it also surfaces with a raised vowel. In most other documented cases of tone–vowel quality interactions, there is some factor, such as syllable structure, metrical structure, or vowel duration that mediates between tone and vowel quality. These earlier analyses cannot be straightforwardly extended to Shuijingping Mang since no synchronic mediating factor seems to be present. However, this paper shows that, historically, there was another mediating factor between tone and vowel quality, namely voice quality. It is common for tones in East and Southeast Asian languages to have characteristic phonation types. It is also common for phonation type to affect vowel quality. Comparative evidence shows that the tones that condition the vowel alternation in the present-day language historically underwent a tonally-driven breathy-modal voice alternation. Subsequently, the tonal grammar has changed; however, vowel raising remains as a synchronic alternation.

Keywords Mang · Hmong · Miao · Tone · Phonation type · Voice quality · Vowel quality · Tone–vowel interaction

1 Introduction

In Shuijingping Mang, a dialect of Mashan Mang, there is a vowel raising process that appears to be tonally conditioned. All of the factors that seem to govern this

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process are tonal: the vowel alternations occur when syllables with a specific set of underlying tones (A2 and C2) occur in specific tonal environments (following syllables bearing the tones A1, A1′, and A2) and are always accompanied by tone sandhi alternations.[1] The general shape of these alternations can be seen in examples (1–2):

(1)	a.	/ɬa^{A2}/	→	[ɬa^{A2}]	‘petal’
		/ʔɔ^{A1} ɬa^{A2}/	→	[ʔɔ^{A1} ɬ**e**^{S}]	‘two petals’
	b.	/tɕɔ^{A2}/	→	[tɕɔ^{A2}]	‘CLF (lengths)’
		/ʔei^{A1} tɕɔ^{A2}/	→	[ei^{A1}tɕ**o**^{S}]	‘one length’
(2)	a.	/ɳʈo^{C2}/	→	[ɳʈɔ^{C2}]	‘variegated’
		/hwei^{A1}ɳʈɔ^{C2}/	→	[hwei^{A1}ɳʈɔ^{S}]	‘muskmelon’
	b.	/ʐo^{C2}/	→	[ʐ**u**^{C2}]	‘labor’
		/toŋ^{A1}ʐo^{C2}/	→	[toŋ^{A1}ʐo^{S}]	‘worker’

This association between tone and vowel quality is typologically unusual. Tone–vowel interactions of various kinds have been reported earlier in the literature, but most of these interactions have been argued to be mediated by syllable structure (Hermans and van Oostendorp 2007), metrical facts (Wright 1983; Chan 1985; Jiang-King 1999), or vowel duration (Gussenhoven and Driessen 2004). In some cases, notably Fuzhou vowel alternations, intrinsic pitch has also been invoked as a phonetic factor (Yip 1980; Myers and Tsay 2003). What makes Shuijingping Mang interesting is the fact that, like only a handful of other cases, including Turkana and Slovenian (Dimmendaal 1983; Dimmendaal and Breedveld 1986; Becker and Jurgec forthcoming), it does not seem possible to attribute the vowel alternation to such factors. There is no consistent change in syllable structure and no evidence for a relationship with duration, and the raising of vowels is associated with relatively low tones and therefore is the opposite of what we would expect from a hypothesis based around intrinsic pitch. From a synchronic point of view, this alternation seems unusual, requiring the interaction of phonological features that do not commonly interact (Hombert 1977; de Lacy 2007).

From a diachronic point of view, however, this alternation can be explained in a relatively straightforward way. I will show that it emerges from the interaction of two very natural relationships: the historical breathiness of two of the tones and the lowering effect of breathy voice on F1.[2] The vowel raising process has a clear phonetic motivation, but the connection between the phonetic motivations of this pattern and the synchronic phonology of the language lies in history.

[1] Because it is the historical identity of the tones and not their synchronic contours that are relevant to the generalization here, only the abstract historical labels (A1, A2, etc.) are used. The synchronic phonological values of the tones are given in Table 3.

[2] This is similar to what has happened in Turkana with tone, voice quality, and [ATR] but different in that the correlation between tone and voice quality remains in Turkana (Dimmendaal 1983; Dimmendaal and Breedveld 1986).

1.1 A historical introduction to tone in Mashan Mang

A complete understanding of the problematic data that will be presented below requires knowing some basic facts about tone in Hmongic. The Hmong-Mien protolanguage had four tones (like Proto-Tai-Kradai and Middle Chinese), which are conventionally called *A, *B, *C, and *D (Chang 1947, 1953, 1972; Ratliff 2010).[3] Like the tones of Vietnamese, these tones are believed to have originated from final laryngeal consonants (Ratliff 2010, p. 184). The best evidence suggests that this pathway was not direct (Thurgood 2002; Michaud 2012, p. 122). Instead, the final laryngeals first gave rise to phonatory "registers"—voice quality distinctions—which developed secondarily into tones. In the case of Hmong-Mien, the characteristic voice quality of some of the tones persists in some languages. In particular, the C tone (from final **-h) is frequently breathy and the B tone (from final **-ʔ) is sometimes creaky (Ratliff 2010, p. 194).

A second phase of "registrogenesis" (and then, secondarily, tonogenesis) affected most Hmong-Mien languages. This arose from the voicing contrast in onset consonants and split each of the existing tones into two. From voiced onsets came breathy voice quality, which affected pitch and ultimately gave rise to a tone split. This split is indicated with "1" and "2" in the literature on the topic, where "1" stands for the historically voiceless register, and "2" stands for the historically voiced register. Presently, for most tone categories in most Hmong-Mien languages, it is pitch that serves as the primary phonemic cue. However, there are cases in which tones are more "register like" and voice quality still plays a dominant role in perception (Andruski and Ratliff 2000). When a Hmongic language has characteristically breathy tones, these tend to be in the lower pitch register ("2"). This breathiness is attributed by Ratliff (Ratliff 1992, p. 76; 2010, pp. 195–196) to the historical voicing of the onsets.

As shown in Fig. 1, Shuijingping is part of the Mashan Mang subgroup. This subgroup has undergone a third phase of tone splits. This time, the upper register was split according to the aspiration of onsets (with voiceless sonorants patterning as aspirated). This distinction is notated in the present paper with a prime for the historically aspirated series and no prime for the historically unaspirated series. As a result of this split, Mashan dialects have a large number of tones with a fairly complex phonological patterning, only part of which is of concern here. This patterning is best expressed in terms of historical categories and best understood in historical terms. An illustration of these historical categories, using cognates from two Mashan dialects (Shuijingping and Zongdi) and another Western Hmongic variety (Mong Leng) is given in Table 1. A summary of the tonal correspondences is given in Table 2. Note that Mong Leng, a non-Mashan variety, has not undergone the tertiary split between the 1 and 1′ series.

Starting with Downer (1967), it has been noted that tone sandhi rules in Hmong are easily expressed in terms of historical categories but difficult to compare when expressed phonetically. Niederer's (1998, p. 214) comparison of the tone sandhi

[3] On the need for abstract tone categories and the difficulty involved in reconstructing and using phonetic values for Hmong-Mien tones, see Ratliff (2010, p. 185).

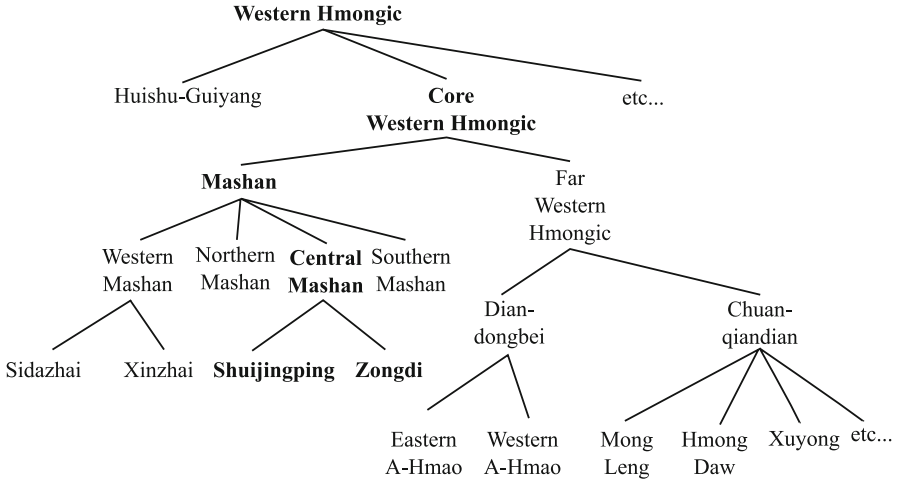

Fig. 1 Partial subgrouping of Western Hmongic languages including the Mashan dialect group (author's classification)

alternations of Western Hmongic (arranged by historical tone categories) shows that four tone sandhi patterns are widely attested within this subgroup:

(3) a. B1 → C1 / {A1,A2}_
b. C1 → D1 / {A1,A2}_
c. **A2 → C2 / {A1,A2}_**
d. **B2 → C2 / {A1,A2}_**

The first two alternations are found only in Core-Western Hmong (including the Mashan languages). The second two, which are of greater interest, are found more widely in Western Hmongic, in the Guiyang and Huishui subgroups, and in all branches of Core-Western Hmongic except for A-Hmao. Both of these alternations must be reconstructed for the tonal grammar of Proto-Core-Western Hmongic and for the superordinate grouping within Western Hmongic that includes Core-Western Hmongic, Guiyang, and Huishui. They are projected by Downer (1967) back to Proto-Western-Hmongic ("Proto-West-Miao"). Within Mashan, both of these alternations are attested in Xinzhai Mang (Xian 1990):

(4) A2 → C2

a.	/to^{A2}/	→	[to^{A2}]	'come'
	/nɔu$^{A1'}$to^{A2}/	→	[nɔu$^{A1'}$**tʰ**o^{C2}]	'sunrise'
b.	/tsɑo^{A2}/	→	[tsɑo^{A2}]	'step'
	/ou^{A1}tsɑo^{A2}/	→	[ou^{A1}**tsʰ**ɑo^{C2}]	'two steps'

Table 1 Cognates illustrating the tonal correspondences among Shuijingping, Zongdi, and Mong Leng

Category	Shuijingping	Zongdi	Mong Leng	Gloss
A1	ʔɔ^{33}	ʔɔ^{32}	ó	‘two’
	ʔei^{33}	ʔei^{32}	í	‘one’
	hwei^{33}	hwɪ^{32}	tlí	‘melon’
	ʐei^{33}	ʐɻ^{32}	ʒí	‘honey’
A1′	ŋkɑ^{22}	ŋka^{22}	^{n}qhúa	‘dry’
	məŋ^{22}	məŋ^{22}	móŋ	‘person’
	nɑ^{22}	na^{22}	ná	‘ear of grain’
	prɑ^{22}	pʐa^{22}	tʃ^{h}úa	‘blow’
A2	hɑ^{42}	ha^{53}	qûa	‘call, shout’
	ntoŋ^{42}	ntoŋ^{53}	^{n}tû	‘sky’
	mplɑŋ^{42}	mplaŋ^{53}	^{n}plôŋ	‘leaf’
	tɕoŋ^{42}	tɕaŋ^{53}	cô	‘lead (v.)’
B1	tɕə^{53}	tɕə^{42}	că̱	‘liquor’
	nɑ^{53}	na^{42}	nŭa	‘this’
	pra^{53}	pʐa^{42}	tʃĕ	‘house’
	ka^{53}	kæ^{42}	kĕ	‘road’
B1′	ntsɔ^{232}	ntsɔ^{232}	ntʃău	‘head lice’
	hoŋ^{232}	hoŋ^{232}	q^{h}ŏ	‘cave’
B2	ʂe^{11}	ʂe^{11}	tę̱	‘hand’
	hei^{11}	hɪ^{11}	qę̱	‘short (height)’
	tə^{11}	tɯ^{11}	tậ̱	‘fire’
	lo^{11}	lo^{11}	lậu	‘old’
C1	hɑ^{55}	ha^{55}	qua	‘crow (v.)’
	ha^{55}	hæ^{55}	qe	‘egg’
	ʐu^{55}	ʐu^{55}	jau	‘small’
	pɑŋ^{55}	paŋ^{55}	paŋ	‘air’
C1’	li^{24}	l̥i^{35}	l̥i	‘moon’
	mɔ^{4}	mɔ^{35}	mo	‘night’
C2	ʈə^{13}	ʈɯ^{13}	ʈậ̱	‘chopstick’
	tu^{13}	tu^{13}	tậ̱	‘which’
	məŋ^{13}	məŋ^{13}	mộ	‘wheat’
	ʐu^{13}	ʐu^{13}	ʒộ	‘labor’
D1	–	l̥e^{44}	tlài	‘bear’
	–	ntu^{44}	^{n}tàu	‘beat (v.)’
	–	ti^{44}	tì	‘wing’
D1′	–	naŋ^{13}	nòŋ	‘cough’
	–	le^{13}	l̥ài	‘cut’
	–	mpje^{13}	^{n}tsài	‘daughter’
D2	–	ku^{21}	kậu	‘ten’
	–	hu^{21}	qậu	‘back’
	–	mplə^{21}	^{n}plậ̱	‘whip’

Table 1 continued

Category	Shuijingping	Zongdi	Mong Leng	Gloss
S	ʔei^{33}ntei^{22}	ei^{32}ntɪ^{33}	–	'(one) instance'

Shuijingping data are from Xian (1990). Zongdi data are from Wang (1994) and Li (2001). Mong Leng data are from the author's observations. Shuijingping data for the D categories are not available

(5) B2 → C2

a.	/sɑ^{B2}/	→ [sɑ^{B2}]	'hand'
	/sei^{A1}sɑ^{B2}/	→ [sei^{A1}**s^{h}**ɑ^{C2}]	'palm (hand)'
b.	/tɛɑo^{B2}/	→ [tɛɑo^{B2}]	'pestle'
	/tlaŋ^{A1}tɛɑo^{B2}/	→ [tlaŋ^{A1}**tɛ^{h}**ɑo^{C2}]	'mortar (pestle trough)'

This shows that these old tone sandhi alternations survived into Proto-Mashan. Xinzhai Mang also displays the third (newer) alternation that is relevant to the vowel-raising problem. In tone sandhi context, C2 surfaces as S (a sandhi or replacement tone):

(6) C2 → S

a.	/pɑ^{C2}/	→ [**p^{h}**ɑ^{C2}]	'legbone'
	/ʔei^{A1}pɑ^{C2}/	→ [ʔei^{A1}pɑ^{S}]	'one legbone'
b.	/tsɑ^{C2}/	→ [**ts^{h}**ɑ^{C2}]	'chopstick'
	/tsɑŋ^{A2}tsɑ^{C2}/	→ [tsɑŋ^{A2}tsɑ^{S}]	'chopstick container'

This same alternation exists in all of the Mashan languages, so it too must be reconstructed as part of the tonal grammar of Proto-Mashan. On the basis of comparative evidence, it appears that Xinzhai Mang preserves the pattern of tone sandhi alternations that was present in Proto-Mashan while Shuijingping Mang, to be discussed below, has innovated. In summary, the tone sandhi pattern in Proto-Mashan most likely included the following alternations:

(7) a. A2 → C2 / {A1, A1′, A2}_
b. B2 → C2 / {A1, A1′, A2}_
c. C2 → S / {A1, A1′, A2}_

There is something even more interesting about the tone sandhi alternations in Xinzhai, namely that they are accompanied by what Xian (1990) describes as an aspirated/unaspirated alternation (an alternation between *songqi de* and *bu songqi de*), without specifying whether plain aspiration or "voiced aspiration" (*zhuo songqi*; breathy voice) is intended. Regardless of their underlying tone, obstruents in syllables surfacing with the tones B2 and C2 are aspirated while those surfacing with the tones A2 and S are not. This suggests a historical situation in which B2 and C2 were associated with a laryngeal setting different from that for A2 and S. From the comparative evidence, this marked laryngeal feature was likely to have been breathy phonation.

Of 24 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 (also called Jiaotuo), which is included in the survey but for which Niederer gives 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 dialect). 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 modal voiced. This is the same pattern that can be observed in Zongdi and is also the pattern that most likely preceded the development of the tonally-conditioned aspiration alternation in Xinzhai.

The Xinzhai aspiration alternation also provides crucial evidence that S was modal voiced 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 S tone even though they would become aspirated if they occurred out of sandhi context (and thus surfaced with their underlying tone, C2). In Zongdi, as we will see next, vowels are raised when they carry the C2 tone but not when they carry the S tone.

1.2 Zongdi Mang

Before looking in detail at Shuijingping itself, it will be helpful to examine a close relative. Zongdi Mang is a Mang dialect belonging to the Mashan group, like Shuijingping Mang. It is largely identical to Shuijingping, differing primarily in small details of vocalism and tone. In Zongdi Mang there is a breathy/modal difference in phonation (which is correlated with tonal contrasts). 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 becomes Zongdi /o/ in modal-voiced syllables but /u/ in breathy-voiced syllables. Likewise, historical *ɔ > modal /ɔ/ but breathy /o/. For example, *lo^{C1} > lo^{C1} ‘mouth’ but *lo̤^{B2} > lṳ^{B2} ‘come (back)’; *ntsɔ$^{B1'}$ > *ntsɔ^{B1} but *ntsɔ̤^{C2} > *ntsɔ̤^{C2}

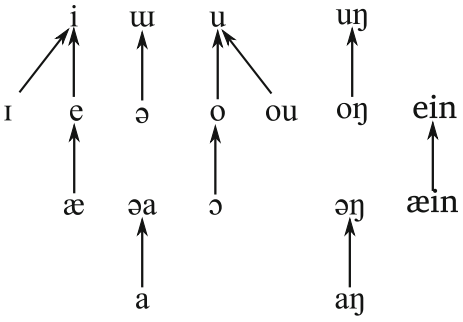

Fig. 2 Relationships between modal and breathy-voiced rhymes in Zongdi

Table 2 Tonal correspondences and historical labels for the tones of Shuijingping Mang, Zongdi Mang, and Mong Leng

Historical Categories		Shuijingping	Zongdi	Mong Leng
A1	A1	33	32	x́
	A1′	22	22	
A2		42	53	x̂
B1	B1	53	42	x̌
	B1′	232	232	
B2		11	11	x̤̂
C1	C1	55	55	x
	C1′	24	35	
C2		13	13	x̤̂
D1	D1	44	44	x̀
	D1′	13	13	
D2		21	21	x̰̂
S		22	33	—

Historically breathy tones are shaded in gray

'thin'; *mpa^{A2} > mpa^{A2} 'clap (hands)' but *wa̤^{B2} > wə̤ə̤^{B2} 'tile'. The whole set of relationships is illustrated in Fig. 2, with arrows pointing from the rhymes reflected in modal syllables to the rhymes reflected in breathy syllables (Wang 1994; Li 2001).

In most cases, 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 1994). The similarity between the set of relationships described here and the vowel alternations that are found in Shuijingping Mang, as illustrated in Fig. 4, is difficult to escape. It would be very surprising if these two patterns were not related. I will later show that the vowel quality alternations in Shuijingping Mang 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.

As mentioned above, 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 modal (clear) phonation, as demonstrated in the survey made by Niederer (1998, p. 249). This is also the case in Zongdi, where tones B2 and C2 are breathy, but tones A2 and S are modal voiced[4] (Wang 1994; Li 2001).

Tonal alternations in Zongdi regularly trigger alternations in phonation type (between modal and breathy voice). In Zongdi, the whole panoply of vowel changes described above can be triggered by tonal alternations. Vowel raising always occurs in syllables that surface with the C2 tone (and are therefore breathy-voiced) but does

[4] Historically, it appears that the syllables bearing other tones were modal voiced as well. However, in the variety described by Wang (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 reliably show this, however.

not occur in the same morphemes when they surface with the S tone due to tone sandhi (and are therefore modal voiced)[5]:

(8) Zongdi vowels failing to be raised in S toned syllables (Li 2001)

a.	/sæi^{C2}/	→ [s**e̤i**^{C2}]	‘smart’
	/mɦəŋ$^{A1'}$sæi^{C2}/	→ [mə̤ŋ$^{A1'}$sæi^{S}]	‘smart person’
b.	/ntɪ^{C2}/	→ [nt**i̤**^{C2}]	‘instance’
	/ei^{A1}ntɪ^{C2}/	→ [ei^{A1}ntɪ^{S}]	‘one instance’
c.	/ɳʈɔ^{C2}/	→ [ɳʈ**o̤**^{C2}]	‘variegated’
	/ntɔ^{A1}ɳʈɔ^{C2}/	→ [ntɔ^{A1}ɳʈɔ^{S}]	‘variegated cloth’
d.	/mpɻa^{C2}/	→ [mpɻ**ə̤a̤**^{C2}]	‘bereft’
	/po^{A2}mpɻa^{C2}/	→ [po^{A2}mpɻa^{S}]	‘widow’

Even more crucially, syllables bearing underlying A2 (a modal-voiced tone) become breathy in sandhi context, where they surface with the C2 tone. While vowel raising does not occur when such syllables surface with the modal-voiced A2 tone, it always occurs in syllables bearing the breathy C2 tone:

(9) Zongdi vowels raised in C2 syllables (Li 2001)

a.	/mplaŋ^{A2}/	→ [mplaŋ^{A2}]	‘leaf’
	/ʑen^{A1}mplaŋ^{A2}/	→ [ʑen^{A1}mplə̤ŋ^{C2}]	‘cured tobacco leaves’
b.	/soŋ^{A2}/	→ [soŋ^{A2}]	‘silk’
	/kua^{A1}soŋ^{A2}/	→ [kua^{A1}s**ṳ**ŋ^{C2}]	‘silk worm’
c.	/tæ^{A2}/	→ [tæ^{A2}]	‘matter’
	/ei^{A1}tæ^{A2}/	→ [ei^{A1}t**e̤**^{C2}]	‘one matter’
d.	/ɭe^{A2}/	→ [ɭe^{A2}]	‘plow’
	/ʈua^{A1}ɭe^{A2}/	→ [ʈua^{A1}ɭ**i̤**^{C2}]	‘plow’

As will be demonstrated, this is significant for the Shuijingping Mang case. There, vowel raising also occurs when underlying A2 syllables occur in sandhi context. The difference is that A2 becomes S in Shuijingping Mang and thus surfaces with modal phonation, rather than becoming the breathy tone C2 as in Zongdi.

2 Shuijingping Mang

2.1 Preliminaries

With adequate background now in place, we now turn to the principal problem addressed by this paper: the vowel-raising in Shuijingping. All available data for Shuijingping come from a single short article by Xian (1990), a professional fieldworker having extensive experience with the Hmongic languages of Guizhou. While this is not expressed explicitly, it appears to report fieldwork done by Xian himself as part of a dialect survey. The intent of the article is to contrast tone sandhi in Shuijingping Mang, in which Xian claims tone sandhi is accompanied by changes

[5] The S tone occurs primarily as the sandhi tone for C2. For more information, see Sect. 2.1 below.

Fig. 3 Shuijingping onset and rhyme inventories

Onsets

p	t	ts	ʈ	tɕ	k	ʔ
mp	nt	nts	ɳʈ	ɳʧɕ	ŋk	
m	n		ɳ		ŋ	
hw	ɬ		ʂ			h
			ʐ	ʑ		ɦ
w	l					
	pl		pr	pj		
	mpl		mpr	mpj		
			mr	mj		

Rhymes

i		u	ei	əu				
e	ə	o			aiŋ	əŋ	oŋ	
a	ɑ	ɔ	əɑ	uɑ		ɑŋ		

in the rhyme, with the closely related Xinzhai variety, in which he claims tone sandhi is accompanied by changes in the onset (see Sect. 1.1). The article consists primarily of data.

As shown in Fig. 1, Shuijingping Mang is a dialect of the Mashan Hmong language, which belongs to the Western Hmongic branch of the Hmong-Mien language family. Shuijingping Mang is spoken in the Shuijingping community of Xinzhai village, Zongdi township, Shuikuang District, Ziyun Miao-Buyi Autonomous County, Guizhou Province, China. It appears to be mutually intelligible with (indeed, almost identical to) Zongdi Mang and probably with other dialects within the Mashan group. It is very different from the better-known Western Hmongic language varieties like Hmong Daw (White Hmong), Mong Leng (Green Hmong),[6] and A-Hmao and is not mutually intelligible with these dialects. 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.[7] As stated above, I will refer to the group containing these two subgroups as "Core-Western Hmongic" (see, again, Fig. 1).

Shuijingping Mang has relatively simple consonant and vowel inventories for a Hmongic language. These are given in Fig. 3. Prenasalized segments are transcribed as in Xian (1990) with a homorganic nasal before the stop or affricate. The symbol

[6] Mong Leng and Hmong Daw should be treated as dialects of one language, given their high level of mutual intelligibility and their broad similarities in lexicon, syntax, morphology, and phonology.

[7] Chief among these are the tone sandhi alternations given in (3a–b). See Niederer (1998, p. 214).

Table 3 Shuijingping tones, adapted from Xian (1990)

Historical categories		Chao Tone numbers	Description
A1	A1	33	Mid level
	A1′	22	Low
A2		42	Mid falling
B1	B1	53	High falling
	B1′	232	Rising-falling
B2		11	Very low
C1	C1	55	Very high
	C1′	24	Mid rising
C2		13	Low rising
D1	D1	44	High level
	D1′	13	Low rising
D2		21	Low falling
S		22	Low level

"ɳ" is used to represent an alveo-palatal nasal (homorganic with /ɕ/). /aiŋ/ is phonetically [ã~ĩ]. "a" may actually be /æ/ or /ɐ/. "ɑ" may represent /a/. Other symbols have their IPA values.

The tonal inventory of Shuijingping Mang consists of eleven contrasting melodies. This tonal inventory, like those of other dialects belonging to the Mashan group, is large even by Hmongic standards. Table 3 summarizes the relevant historical categories and their synchronic realizations in Shuijingping Mang. In (10), the Shuijingping Mang tones are summarized by type (level, rising, falling, etc.).

(10) Shuijingping Mang Tones

Five level tones[8]	55, 44, 33, 22, 11
Three falling tones	53, 42, 21
Two rising tones	24, 13
One rising-falling tone	232

S is a "sandhi tone." Originally, this tone only appeared as the changed tone of C2 syllables in sandhi context; that is, it existed in the surface tonal inventory but not in the underlying tonal inventory. In the language currently, certain syllables do bear S as their underlying tone. Historically, these were part of the C2 category but were reinterpreted when a prefixed element acting as the sandhi trigger disappeared, a

[8] 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 affirmative 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-geometric 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 non-crucially assume this position here.

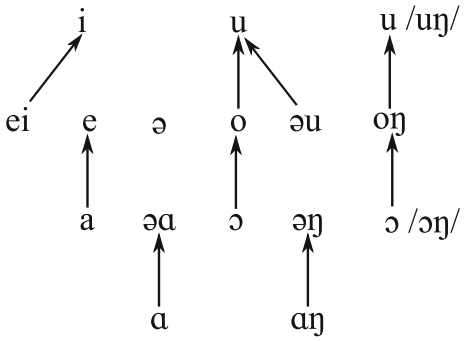

Fig. 4 Shuijingping vowel raising

phenomenon known as *sandhi form promotion* (Ratliff 1992, pp. 77–92). While this fact will not be important for the exposition here, S is realized on the surface as identical to A1′, but S and A1′ display different behaviors with reference to tone sandhi. A1′ acts as a tone sandhi trigger while S does not trigger 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 Mang occurs under the following conditions:

(11) Conditions for tone sandhi in Shuijingping Mang
   a. There is a trigger bearing one of the A tones (Shuijingping Mang /33/, /22/, and /42/).
   b. The trigger occurs immediately before the target within a prosodic word.
   c. The target bears one of the tones subject to sandhi alternations.

Under these conditions, a rather involved set of tonal alternations can be observed, which are detailed by Xian (1990). Of these tone rules,[9] three are of importance to the analysis that will be developed in Sect. 4. These are given in (12):

(12) a. /42/ → [22] (A2 → S)
   b. /13/ → [22] (C2 → S)
   c. /11/ → [13] (B2 → C2)

Given these pieces of background information, it is now possible to describe the generalization at issue and present the supporting data.

2.2 Shuijingping Mang vowel raising

In Shuijingping Mang, there are two conditions under which vowel raising can take place. The first is when a syllable surfaces with the C2 tone because it bears C2 underlying and it is not in sandhi context. The second case is when the underlying tone is A2 but the syllable surfaces with the S tone because it is in sandhi context. Under these conditions, three raising-like processes apply, as listed in (13):

[9] The word *rule* 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 rewrite rules is implied.

(13) Three vowel raising-like processes
   a. Mid and low monophthongs are raised.
   b. The initial portions of falling-sonority diphthongs are raised, yielding high monophthongal vowels.
   c. The initial portion of the low vowel /ɑ/ centralizes, producing the diphthong [əɑ].

These vowel raising processes are schematized in Fig. 4, where arrows point from underlying rhymes to surface rhymes.

The similarity between these alternations and the vowel raising pattern seen in Zongdi (Fig. 2) is difficult to escape.

With these generalizations in hand, it is possible to make sense of the data from Shuijingping. Examples of the relevant patterns are given in (14) and (15). The examples in (14) show that vowels fail to rise when the underlying tone is /C2/ and the syllables are placed in sandhi context (in all of these examples, following /A1/ tone syllables) and thus surface with the [S] tone. In isolation (and in other contexts) /C2/ surfaces as [C2] and vowel raising occurs:

(14) Vowel raising in [C2] tone syllables (Xian 1990)

a.	/plɔ^{A1}mɑŋ^{C2}/	→ [plɔ^{A1}mɑŋ^{S}]	‘awn of wheat’
	/mɑŋ^{C2}/	→ [məŋ^{C2}]	‘wheat’
b.	/hwei^{A1}ŋʧɔ^{C2}/	→ [hwei^{A1}ŋʧɔ^{S}]	‘muskmelon’
	/ŋʧɔ^{C2}/	→ [ŋʧ**o**^{C2}]	‘variegated’
c.	/toŋ^{A1}ʐo^{C2}/	→ [toŋ^{A1}ʐo^{S}]	‘worker’
	/ʐo^{C2}/	→ [ʐ**u**^{C2}]	‘work, strength’
d.	/toŋ^{A1}wo^{C2}/	→ [toŋ^{A1}wo^{S}]	‘Han nation’
	/ wo^{C2}/	→ [w**u**^{C2}]	‘Han’
e.	/ʔei^{A1}ntei^{C2}/	→ [ʔei^{A1}ntei^{S}]	‘one instance’
	/ntei^{C2}/	→ [nt**i**^{C2}]	‘instance’
f.	/nei^{A2}təu^{C2}/	→ [nei^{A2}təu^{S}]	‘which person’
	/təu^{C2}/	→ [t**u**^{C2}]	‘CLF (people)’

It might be tempting to analyze this process as a case of vowel lowering rather than vowel raising. After all, the putative vowel 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^{S}] and [wu^{C2}]) and the classifier for people (with the allomorphs [təu^{S}] and [tu^{C2}]) have [u] in their 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] while the /u/ in the classifier for people is mapped to [əu]). While it might be possible that this is a conditioned split, a claim for which there is no other evidence, it is conceptually simpler to label the observed process as vowel raising and to posit different underlying vowels for these two morphemes.

Assuming that the observed process is vowel raising also helps to unify the pattern observed in (14) with that in (15). Here, syllables with underlying /A2/ 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 [S]).

(15) Vowel raising in syllables where underlying /A2/ becomes surface [S] (Xian 1990). Note that surface [ɔŋ] and [uŋ] sequences are not allowed.

a.	/mplɑŋ^{A2}/	→ [mplɑŋ^{A2}]	‘leaf’
	/ʑain^{A1}mplɑŋ^{A2}/	→ [ʑain^{A1}mplə**ŋ**^{S}]	‘cured tobacco leaves’
b.	/kɑŋ^{A2}/	→ [kɑŋ^{A2}]	‘poor’
	/məŋ$^{A1'}$kɑŋ^{A2}/	→ [məŋ$^{A1'}$kə**ŋ**^{S}]	‘poor person’
c.	/nɔŋ^{A2}/	→ [nɔ^{A2}]	‘eat’
	/mu$^{A1'}$nɔŋ^{A2}/	→ [mu$^{A1'}$no**ŋ**^{S}]	‘not eat’
d.	/ŋoŋ^{A2}/	→ [noŋ^{A2}]	‘cattle’
	/ŋkɑ^{A2}ŋoŋ^{A2}/	→ [ŋkɑ^{A2}ŋ**u**^{S}]	‘cattle corral’
e.	/ɬa^{A2}/	→ [ɬa^{A2}]	‘petal’
	/ʔɔ^{A1}ɬa^{A2}/	→ [ʔɔ^{A1}ɬ**e**^{S}]	‘two petals’
f.	/tɕɔ^{A2}/	→ [tɕɔ^{A2}]	‘CLF (lengths)’
	/ʔei^{A1}tɕɔ^{A2}/	→ [ʔei^{A1}tɕ**o**^{S}]	‘one length’
g.	/hɑ^{A2}/	→ [hɑ^{A2}]	‘shout
	/kuɑ^{A1}hɑ^{A2}/	→ [kuɑ^{A1}hə**ɑ**^{S}]	‘insect sound’
	/so$^{A1'}$hɑ^{A2}/	→ [so$^{A1'}$hə**ɑ**^{S}]	‘thunder’
h.	/mɑ^{A2}/	→ [mɑ^{A2}]	‘maple’
	/wɑ$^{A1'}$mɑ^{A2}/	→ [wɑ$^{A1'}$mə**ɑ**^{S}]	‘maple tree’

Significantly, these processes cannot be driven solely by the output tone since, according to Xian (1990), the sandhi tones for /C2/ and /A2/ are both realized as [S] and are phonetically identical [22]. Since a surface [22] 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.

3 Phonation type, tone, and vowel quality

It is well known that there is an association between breathy phonation and vowel quality. On the one hand, breathy phonation requires the lowering of the larynx, which has the effect of lowering formants, especially F1 (Laver 1980; Fagan 1988; Ladefoged and Maddieson 1996; Gordon and Ladefoged 2001; Brunelle 2005a). On the other hand, producing breathy phonation involves a lack of contact between the anterior portions of the vocal folds. This allows for a partial coupling between the supraglottal and subglottal cavities, which has the effect of lowering resonances and therefore formants (Stevens 2000, p. 299).[10] These effects may give rise to either low-level allophonic splits or to more phonologically-significant developments.

[10] Thanks to an anonymous reviewer for pointing out this second effect.

Table 4 Development of registers in Eastern Cham, adapted from Brunelle (2005a, p. 60)

Proto-Chamic	Eastern Cham
*pa	> [pá]
*ba	> [pà̤]

In certain language families concentrated in Meso-America, Southeast Asia, and Southern China, an equally robust association is found between phonation type and tone. In Meso-America, this relationship is very complicated and is found primarily in Oto-Manguean languages (Silverman 1997). In Southeast Asia and Southern China, it is not unusual for syllables bearing certain tones to differ systematically in voice quality. This is unsurprising because the tonal systems of many of these languages emerged from "register" systems where phonation type was dominant (see Sect. 1.1 above). Recent phonetic research has provided a great deal of insight into the association between phonation type and pitch. Most relevant are findings about configuration of the larynx during the production of phonation. The larynx often raises during high pitch and is often actively lowered during the production of low pitch (Hirose 2010). As was noted above, production of breathy voice is often associated with laryngeal lowering, so it is reasonable that breathy phonation is often correlated with lower pitch (DiCanio 2008, p. 182).

3.1 Register in 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 2005a). Diachronically, this register distinction arose from a voicing distinction in onset consonants (Table 4).

Evidence from a word game shows that register in Eastern Cham is still a property of onsets phonologically (Brunelle 2005b). Phonetically, though, the contrast is realized primarily on the following vowel.

Brunelle (2005a) 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 displaying considerable inter-speaker variation. Brunelle's discussion raises two possibilities to account for this difference in vowel quality. Either this effect is directly caused by the difference between breathy and modal phonation or it is the result of the same historical cause as breathy phonation (voiced onsets). In either case, the difference may be due to the effect of laryngeal lowering, a strategy by which a speaker may suddenly increase the pressure differential across the glottis and thus facilitate voicing of stops and breathy voicing of vowels and other segments.

3.2 Register in 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 type. Breathy vowels are typically higher in the vowel space that their modal-voiced counterparts, though (historical) breathiness is also associated with diphthongization in some of these languages. Consider the vowel system of Kuy (also known as Souei) (Table 5).

Here, the initial portion of non-high vowels is raised in the low register. A related breaking pattern is seen in the low vowels of Shuijingping and Zongdi.

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 (including Kuy, Chaobon, Chong, Bru, and Mon). In many dialects of Khmer, the process has proceeded farther, and the phonatory difference has disappeared, leaving only the vowel quality contrast.

3.3 Tone, phonation type, and vowel quality in Burmese

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). These are presented systematically in Table 6.

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 (Bradley 1982). However, as an anonymous reviewer points out, perhaps it is best to treat pitch and voice quality as two coequal aspects of a single phonological system.

The differences in phonation type are correlated with differences in vowel quality. According to Bradley (1982), vowels in creaky syllables in standard Burmese are

Table 5 Vowels in Kuy, adapted from Ferlus (1980, p. 4); the low series was historically breathy

Vowel series in high register			Vowel series in low register		
i	ɨ	u	ì	ɨ̀	ù
e	ə	o	ìe	ɨ̀ə	ùo
ɛ	a	ɔ	èɛ	àa	òɔ

Table 6 Phonation-type distinctions in Burmese tones, adapted from Watkins (1997, 2001)

low	/ma/	[ma:^{22}]	‘hard’
high	/má/	[ma̤^{44}]	‘towering’
creaky	/ma̰/	[ma̰^{51}]	‘female’
stopped	/maʔ/	[maʔ^{51}]	‘March’

For the fourth tone, Watkins uses the term “killed” which is replaced here with “stopped”

articulated closer and farther back than those in modal-voiced syllables while vowels in breathy syllables are more open and more fronted. This contrasts somewhat with the Arakanese dialect where both non-modal phonation types are correlated with higher vowel allophones (Bradley 1982, p. 123).

3.4 Tone and phonation type in Vietnamese

Vietnamese tones, likewise, are characterized by particular phonation types (Nguyen and Edmondson 1997). Brunelle (2009) found that glottalization was one of the principal cues used by speakers of Northern Vietnamese in their perception of tones while Southern Vietnamese speakers relied more on pitch. 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).

3.5 Tone and phonation type in Tamang

In the Tibeto-Burman language Tamang, two of the four tones are characterized, "redundantly," by whispery phonation (Mazaudon and Michaud 2008). The two tones of Tamang's predecessor were split into the four tones of modern Tamang based upon the voicing of initial consonants. Mazaudon and Michaud (2008) argue, based on a detailed glottographic and acoustic study, that whispery voice and VOT in Tamang must be seen as cues to tone alongside of F_0 modulations. This parallels the situation in Hmongic where (i) the loss of an onset voicing contrast gave rise to a tonal split and (ii) the tones from the originally voiced onset series are accompanied by breathy phonation.

3.6 Tone and phonation type in A-Hmao

A similarly complex system can be found in the Western Hmongic language A-Hmao. In Western A-Hmao, phonation type is now somewhat independent of tone in that breathy voice can now occur with any of the tones (Johnson 1999), but in Eastern A-Hmao (Shimenkan dialect) tones still carry characteristic phonation types (Wang and Wang 1986). Tone sandhi alternations also drive alternations in voice quality (Wang and Wang 1986; Li 2001). Examples of this correlation from Li (2001) are given in (16) in the original transcription:

(16) Tone sandhi driving changes in voice quality in A-Hmao (Li 2001).

a.	/ŋ̊dz̥ɦau^{35}/	→	[ŋ̊dz̥ɦau^{35}]	'mouth'
	/au^{55}ŋ̊dz̥ɦau^{35}/	→	[au^{55}**ŋ̊tɕau^{55}**]	'saliva'
b.	/ŋ̊ɦu^{35}/	→	[ŋ̊ɦu^{35}]	'bovine'
	/ku^{55}ŋ̊ɦu^{35}/	→	[ku^{55}**ŋ̊u^{55}**]	'bovine horn'

Here, breathy phonation ("voiced aspiration") is indicated, as in the source, with "ɦ" after the onset. A similar tonally-driven change in voice quality underlies the account of Shuijingping vowel raising proposed in this article.

3.7 Tone and phonation type in Mong Leng

The case of Mong Leng, a Hmongic language belonging to the Far-Western group is particularly relevant to the situation in Shuijingping Mang. 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

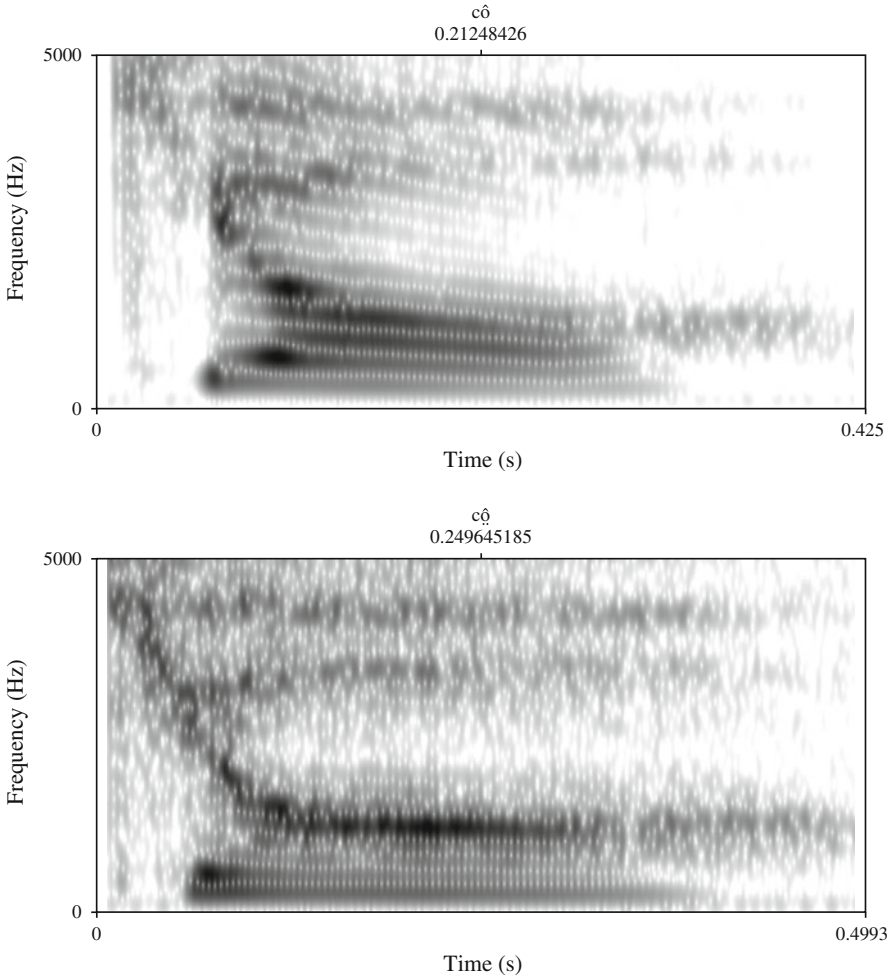

Fig. 5 Spectrograms of Mong Leng [cô] 'lead' (modal, *top*) and [cô̤] 'plant' (breathy, *bottom*)

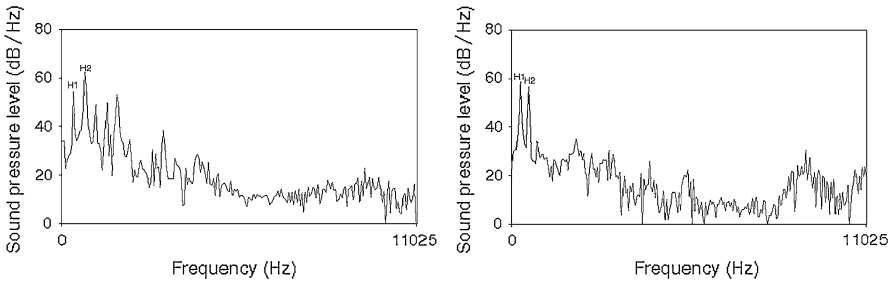

Fig. 6 Spectra from Mong Leng [cô] 'to lead' (modal, left) and [cô̰] 'to plant' (breathy, *right*)

(Lyman 1974; Andruski and Ratliff 2000). A similar pattern in Hmong Daw (White Hmong) has also been documented (Ratliff 1992, pp. 11–12) and investigated instrumentally (Huffman 1987).

The characteristic voice quality of the mid-falling tone in Mong Leng can be demonstrated by both qualitative and quantitative measures, as shown in Figs. 5 and 6. These illustrations were produced using Praat (Boersma and Weenink 2011) from the author's recordings of a female Mong Leng-English bilingual in her early twenties. The recordings were made with a Shure head-worn microphone and a Marantz solid state recorder in a quiet room. Items were spoken by the participant in the carrier phrase *hà X tṣua kŭ nə̂*. 'Say X to my mother.'

From inspection of the spectrogram in Fig. 5, it is apparent that the vowel in [cô̰] 'to plant' (bottom) includes a strong aperiodic component, suggestive of breathy phonation while the vowel in [cô] 'to lead' (top) does not.

Quantitative measures suggesting a voice quality difference between Mong Leng tones include H1–H2, the most common measurement of spectral tilt. H1–H2 correlates most strongly with open quotient, the percentage of the glottal cycle during which the vocal folds are open (DiCanio 2009; Kuang 2011). Differences in open quotient correspond with differences in glottal aperture duration, which are, in turn, correlated with differences in phonation type. Breathy phonation involves a greater open quotient than modal phonation. Therefore, breathy-voiced vowels will typically display a higher H1–H2 than corresponding modal-voiced vowels. 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 Fig. 6, where the spectrum for [cô̰] 'to plant' shows a much larger value for H1–H2 than the spectrum for [cô] 'to lead'.

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

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

(17) Mong Leng tone sandhi accompanied by alternation in phonation type.

a.	/^{n}tû/	→	[^{n}tû]	‘sky’
	/qáŋ ^{n}tû/	→	[qáŋ **^{n}tṳ**]	‘world (underside sky)’
b.	/tsâ/	→	[tsâ]	‘money’
	/ɲâ tsâ/	→	[ɲâ **tsa̤**]	‘riches (silver-money)’

It is of particular significance that the breathy tone in Mong Leng is cognate to the Shuijingping Mang C2 tone (the tone which always triggers vowel raising). Likewise, the modal-voiced high-falling tone with which it is contrasted in Figs. 5 and 6 is cognate to the Shuijingping Mang A2 tone. In Shuijingping Mang, vowels surfacing with the A2 tone never undergo vowel raising, as was indicated above.

4 The diachronic source of Shuijingping Mang vowel raising

4.1 Shuijingping vowel raising as evolution of grammar

At this point, the major pieces of the puzzle are in place and a plausible scenario for the origin of the tone–vowel interactions in Shuijingping Mang presents itself. A brief outline follows: Proto-Mashan had tone sandhi alternations similar to those seen in Xinzhai and Zongdi. As in Zongdi, phonation-type changes were part and parcel of these tone alternations. The vowel raising process occurred in breathy-voiced syllables, such that underlying /A2/ syllables were affected by vowel raising in sandhi context and underlying /C2/ syllables were affected by vowel raising out of sandhi context. In Shuijingping Mang, there was a change in the tonal grammar so that /A2/ came to surface as [S] in sandhi context rather than [C2]. Thus, in sandhi context, /A2/ is mapped to the same historically modal tone as /C2/. However, the vowel raising process continued to apply to underlying /A2/ syllables in sandhi context (despite the loss of the original conditioning environment). The apparent loss of voice-quality distinctions in Shuijingping Mang would render the original motivation for the vowel raising even more opaque, to the extent that vowel raising may have become a completely tonally-conditioned set of alternations. A summary of the proposed changes is given in Table 7.

Table 7 The historical derivation of Shuijingping Mang tonally-conditioned vowel raising

‘petal’	‘two petals’	‘strength’	‘laborer’	
*ɬa^{A2}	*ʔɔ^{A1}ɬa^{A2}	*ʐo̤^{C2}	*toŋ^{A1}ʐo̤^{C2}	Pre-Western Hmongic
–	ʔɔ^{A1}ɬa̤^{C2}	–	–	A2 > C2 / {A1, A2}__
–	–	–	toŋ^{A1}ʐo^{S}	C2 > S / {A1, A1′, A2}__
–	ʔɔ^{A1}ɬe̤^{C2}	ʐṳ^{C2}	–	Vowel raising in breathy syllables
–	ʔɔ^{A1}ɬe^{S}	–	–	/A2/ remapped to [S] in sandhi context
–	–	ʐu^{C2}	–	Loss of breathy phonation
ɬa^{A2}	ʔɔ^{A1}ɬe^{S}	ʐu^{C2}	toŋ^{A1}ʐo^{S}	Modern Shuijingping

Segmental reconstructions are approximate and are intended for illustrative purposes only

The foundation of this analysis is the proposition that the Proto-Mashan grammar generated the tone sandhi alternations A2 → C2 and C2 → S and that Proto-Mashan A2 and S were modal voiced while C2 was breathy voiced. The evidence thus far suggests that the tone system of Proto-Mashan (or the part that concerns us here) had the characteristics shown in Table 8 (with reconstructed contours based on Shuijingping Mang).

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 slightly higher in the vowel space (that is, had a slightly lower average 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 been seen in Zongdi (see Table 9), in which vowel quality changes accompanied changes in tone and phonation.

At that point, a minimal but crucial change took place in the grammar of Shuijingping Mang. A2, which previously had the breathy C2 as its sandhi tone (see Table 7), was re-mapped to the modal-voiced S in sandhi context (see Tables 9, 10).

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 A2 since such forms no longer alternated in phonation type. What seems to have happened, instead, is that learners of the language attributed the vowel quality alternations to purely tonal conditions. Based upon Xian's (1990) description, it appears that breathy phonation has now disappeared from B2 and C2. Xian does not give any positive indication that B2 and C2 are breathy voiced in Shuijingping Mang, and suggests that they are modal voiced by not transcribing onsets of syllables bearing these tones with marked laryngeal features. This

Table 8 Proto-Mashan tone system (partial)

Basic tone	Description	Phonation type	Sandhi tone	Description	Phonation type
A2	*falling	modal	C2	*low rising	breathy
B2	*very low	breathy	C2	*low rising	breathy
C2	*low rising	breathy	S	*low	modal
S	*low	modal			

Table 9 Illustration of the development of tonally-conditioned vowel raising in Shuijingping, using Zongdi to stand in for pre-Shuijingping

Proto-Mashan	Zongdi	Shuijingping	
*ntẹ̈i^{C2}	ntɨ̈^{C2}	ntɨ^{C2}	'instance'
*ʔei^{A1} ntei^{S}	ei^{A1} ntɪ^{S}	ʔei^{A1} ntei^{S}	'one instance'
*mplaŋ^{A2}	mplaŋ^{A2}	mplɑŋ^{A2}	'leaf'
*ʑain^{A1} mplạ̈ŋ^{C2}	ʑen^{A1} mplə̈ŋ^{C2}	ʑain^{A1} mpləŋ^{S}	'cured tobacco leaves'

Note that in *ei > Zongdi /ɪ/ but not in *ei* 'one'

Table 10 Pre-Shuijingping tone system (partial)

Basic tone	Description	Phonation type	Sandhi tone	Description	Phonation type
A2	*falling	modal	**S**	***low**	**modal**
B2	*very low	breathy	C2	*low rising	breathy
C2	*low rising	breathy	S	*low	modal
S	*low	modal			

contrasts with his treatment of Xinzhai, in which he transcribes historically breathy syllables with aspiration.[11] To establish the voice quality of Shuijingping Mang tones with a degree of certainty will require instrumental data that is not currently available. However, if it is in fact the case that these tones have lost breathy phonation, the original source of the vowel alternations has become even more obscure. Nevertheless, the vowel raising process remains robust, as seen in Table 9.

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 such as breathy voice. 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 deleting it before it could surface. However, if such a mediating factor is proposed, it must be a structure with which both tone and vowel quality features can interact. It appears, furthermore, that increasing the power of the grammar to the point that it can successfully model alternations of this type would weaken its restrictiveness. It is clear that patterns of this type are rare; undermining broad findings of conventional phonological theory in order to accommodate a few cases of this type might seem rash. Nevertheless, this phenomenon must be accounted for.

4.2 Allomorph selection: an alternative hypothesis

One possible explanation is to expurgate these alternations from the grammar altogether and to deny that the vowel raising process has any synchronic status at all, or that it ever had such a status. The observed pattern might be seen, instead, as the result of successive sound changes operating on frozen 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 would be situated entirely in the extra-grammatical realm of physical phonetics. The sound changes would result in allomorphy that would be maintained by phonologically conditioned allomorph selection, without any phonological operations whatsoever. The fact that there is an

[11] Chinese linguists working on Hmongic languages have typically treated breathy voice as a property of the onset ("voiced aspiration"). It is typically transcribed as "ɦ", as in the A-Hmao forms given above (Wang and Wang 1986; Wang 1994; Li 2001) but perhaps also as " ‘ ", as in Xian's (1990) transcription of Xinzhai Mang.

apparent interaction between tone and vowel quality would simply be an accidental byproduct of the available allomorphs.

This explanation finds some support in the tone sandhi system of Far Western Hmongic dialects like Hmong Daw and Mong Leng. Both Downer (1967) and Ratliff (1992, p. 76) have observed that tone sandhi in Hmong Daw is restricted not only to specific constructions but to specific instances of those constructions. It is a non-productive alternation on the decline and collocations subject to tone sandhi must be lexically listed. In some dialects of Mong Leng spoken in Thailand, tone sandhi alternations are disappearing altogether (Lyman 1974). But Downer (1967) notes that the non-productivity of Hmong Daw tone sandhi cannot be extended to all of Western Hmongic since the same basic tone sandhi system is fully productive in native vocabulary in Xuyong Hmong (a.k.a. Magpie Miao), a close relative of Hmong Daw and Mong Leng. Xian (1990, p. 72) suggests that Shuijingping tone sandhi does not apply in all contexts but is limited to certain constructions, primarily to attributive compounds. It also occurs between subjects and verbs, verbs and objects, and verbs and words of other classes. This is a somewhat wider range of environments than is found in Hmong Daw and Mong Leng, suggesting that Shuijingping Mang has somewhat more productive tone sandhi alternations than these other varieties. Regarding the vowel alternations, it is more difficult to judge their productivity since Xian makes no explicit statement about them. They are the result of a recent innovation and are therefore likely to be as productive as the older tone sandhi alternations. Nevertheless, the productivity facts for Shuijingping Mang vowel raising are consistent with an analysis that treats them as frozen forms or listed allomorphs selected according to context.

However, an allomorph selection analysis is problematic in at least two respects. In the first case, there is a technical difficulty: in sandhi context, the A2 tone had to have been mapped to two different tones at different historical periods. Currently, A2 is mapped to S in sandhi context, but at an earlier stage it must have been replaced by C2. This is demonstrated by both comparative evidence and internal evidence. In both Xinzhai and Zongdi Mang, the A2~S alternation persists, suggesting it was present in the forerunner of Shuijingping Mang as well. If it was not present, there would be nothing to condition vowel raising in underlying /A2/ syllables (since S is not breathy in any of the languages). So, at an early time we must have (18).

(18) A2 > C2 / {A1, A2}__

As noted, this change may date back to Proto-Western-Hmongic, if not earlier. It is problematic to go from an A2~C2 alternation to an A2~S alternation purely by the operation of regular sound change. We cannot have (19):

(19) A2 > S / {A1, A1′, A2}_

This would apply vacuously, since all instances of A2 in sandhi context would have already become C2. But we also cannot have the change in (20):

(20) C2 > S / {A1, A1′, A2}_

This change is not a possibility since not all instances of C2 in sandhi context become S (only those derived from A2). The only way to salvage such an analysis, in which the tonal alternations have no synchronic status, is to say that the A2~S alternation was lost through leveling—while all other tonal alternations were preserved—and that (19) subsequently applied. This is more complicated than proposing that there was a change in the tonal grammar that altered the mapping of A2 in the sandhi context.

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 the A tones were no longer a phonetically natural class by the time that the putative second C2 > S change occurred. This class most likely consisted of a *mid tone, a *low tone, and a *high falling tone. The only plausible explanation for the fact that the new alternation occurred in the same environments as the older alternations 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 Mang is generated by the grammar from a single set of underlying forms, or, at the very least, was so generated by the grammar at the time A2 gained S 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. It would make little sense, after all, for the grammar to be able to operate on one part of a representation but not another. 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 in the realm of diachrony.

5 Discussion

What does the example of vowel raising in Shuijingping establish? Is it a mere curiosity that does not, by itself, make a very significant contribution to our knowledge of language generally? I argue that this case is valuable in at least three respects: (1) It shows that direct tone–vowel interactions are possible, (2) it reiterates the important ways in which diachronic factors facilitate and constrain synchronic grammars, and (3) it provides evidence for a notion of phonological register: a phonological construct that relates vowel quality, voice quality, and pitch.

The claim has been made that tone and vowel quality cannot directly interact (Hombert 1977; de Lacy 2007). A great deal of the attention that has been devoted to vowel–tone interactions has been concentrated on explaining them away as well-behaved interactions between things that "should" interact. In most of these cases, the mediating factor between tone and vowel quality persists synchronically in the language, so it is plausible to give these cases synchronic analyses in which there is no direct interaction between tone and vowel quality. That does not mean, however,

that indirect interaction is the only or best analysis, only that it presents itself most obviously. In Shuijingping, however, one must acknowledge a direct interaction between tone and vowel quality even if it is still the case that tones B2 and C2 are breathy, since raising occurs in the environment of the historically non-breathy S tone and has thus been decoupled from the voice quality interaction.

If there is nothing in Universal Grammar preventing a direct tone–vowel interaction, why are these interactions so rare? The likely explanation is that the historical conditions which are necessary to introduce such alternations into the grammar are relatively rare. For example, relatively few languages have contrastive voice quality, and even fewer languages have contrastive voice quality as an aspect of "tone" or have pitch as a redundant aspect of voice quality distinctions. To establish a direct tone–vowel interaction, the mediating fact must also disappear or become obscured. Diachrony, then, is the limiting factor on the occurrence of effects of this kind.

What is needed, it seems, is a model of feature interactions in which the notion of register is easy to express, where voice, vowel quality, and pitch features can interact freely with one another. Such a scheme may be suggested by the laryngeal articulator model of Esling (2005), in which the laryngeal articulator is held to play a role not only in voice quality and pitch regulation, but also vowel quality.

6 Conclusion

The data and arguments presented here suggest that direct tone–vowel quality interactions are possible, a thesis also supported by the findings of Becker and Jurgec (forthcoming) for Slovenian. The materials presented here also suggest that the reason tone–vowel interactions are rare is that the diachronic prerequisites for the development of these interactions are rarely satisfied. They represent another case where a diachronic solution provides phonetic coherence to a synchronic picture that looks phonetically incoherent (Bach and Harms 1972; Anderson 1981; Hyman 2000). At the same time, the addition of a new tone sandhi rule in the same—unnatural—environment as the old tone sandhi rules suggests that synchronic grammatical patterns can channel diachrony.

Having resolved one question, the analysis presented here raises additional questions for future research, most notably, what is the role of phonation type in other tone–vowel quality interactions? The case of Turkana is already known (Dimmendaal 1983; Dimmendaal and Breedveld 1986). It seems not unlikely that the Fuzhou tone–vowel interaction, which has been analyzed in many different ways, is also connected to voice quality in a similar way to Shuijingping Mang. Future research should explore this connection and the role of phonation type as a mediating factor between tones and segments generally.

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