# Phonetics and function in diachronic conflict: the case of rising tones

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# 1 Introduction

Both Ohala and Ewen (1979), and Sundberg (1973, 1979) have demonstrated that experimental subjects can lower their pitch *faster* than they can raise their pitch when asked to do so at maximum speed. In other words, pitch-raising takes more time than pitch-lowering. While it's true that no phonological system ever demands of speakers that they encounter their physiological limits during speech production, physiological limitations may yet be reflected phonologically in a number of ways. In this paper I show that languages often evolve strategies which, while accommodating to physiological pressures, nonetheless maintain contrastive rising pitch patterns.

Broadly, there are three patterns that seem to be cross-linguistically prevalent. In **Pattern (A)** the pitch peak may spread/displace on to the following vowel, whereas *falling* contours do not spread/displace their troughs. In **Pattern (B)** the rising contour occurs only on *longer* vowels/sonorous rimes, in comparison to vowels/sonorous rimes associated with falling contours (Zhang 2001). Finally, the rise in pitch of a rising contour may be somewhat smaller than the fall in pitch of a falling contour. This is **Pattern (C)**. Each of these patterns may be due to a lexical distributional property of the language, or may result from alternation. They are schematized in (1).

(1)	Pattern (A):	$[V_{\Lambda}V^{\gamma}]$ or $[V_{J}V^{\gamma}]$	but	[V\V-]]
	Pattern (B):	[Vː/] or [V <sup>.</sup> /]	but	[V\]
	Pattern (C):	[V]	but	[V\]

All three of these phonological patterns may be seen as ultimately related when considering how physiological and functional factors may diachronically interact with each other. After outlining the phonetic motivation for these disparate diachronic routes to the survival of the higher pitch, I consider a number of languages that exemplify the patterns.

# 2 Phonetic underpinnings

As already noted, pitch rises take longer to implement than do pitch falls. This is shown schematically in (2).



Now, given the sluggishness of pitch rises in comparison to pitch falls, a following consonant might be implemented *before* the pitch rise is fully achieved: after release, the pitch peak is hit. This is **Pattern (A)**. By contrast, as suggested by Ohala (1978:31), "...[S]ince falling tones can be produced faster than rising tones...they might be less likely to 'spill over' onto the next syllable." In (3) I overlay the pitch schematic with an oral CVCV sequence. The 'spill-over' effect becomes apparent.

(3)



Alternatively, high tones may be limited in their distribution to long vowels/sonorous rimes (either phonemically or subphonemically). This is **Pattern (B)**, which is schematized in (4).



Alternatively again, the pitch rise may be curtailed. **Pattern (C)** is schematized in (5).





In all the schematics, observe that speed of pitch increase is equivalent. What varies is the timing of the pitch increase with respect to the overlaid oral gestures, and, for **Pattern (C)**, the duration (and consequent extent) of the pitch increase. While these are, of course, only schematics, they are intended to capture the proposed intimate relation among the three patterns, i.e. that the three patterns represent different responses to an identical phonetic limitation.

# 3 Exemplification of Pattern (A)

# 3.1 Zulu (Cope 1960, 1966, Traill et al. 1987, Russell 2000, Silverman 2000)

In Zulu, "depressor" consonants have been characterized as phonetically and/or historically breathy-voiced. They induce significant pitch lowering during the first portion of the immediately following vowel. Following depressor consonants, high tones on short vowels are displaced from their vowel of origin to a following vowel. In (6) are some examples from Cope's 1966 paper; relevant strings are underlined for clarity; relevant depressors are italicized.

(6)	i-l <u>si†ła:-l</u> lo-l	'chair'	$\rightarrow$	i-l <u>zi] ła:∖</u> lo-l	'chairs'
	<u>i†↓ nsi: </u> zwaJ	'young man'	$\rightarrow$	<u>jiJnsir\</u> zwaJ	'by a young man'
	<u>i1 no:-l</u> ni-l	'bird'	$\rightarrow$	<u>nel porl</u> ni-l	'with a bird'

So, moving from the depressor-induced low pitch to the lexical high tone results in a delay in pitch peaking, and high tone displacement is the result.

## 3.2 Digo (Kisseberth 1984, Yip 2002)

In Digo, high tone verbs spill their high component into the suffix domain, except when a voiced obstruent blocks its propagation. (Actually, *any* preceding high tone migrates to the penult-final border region.)

(7)	"toneless" verbs:	high-toned verbs:
	ku_ri_ma_1 'to cultivate'	ku_la_lr <u>u_lka\</u> 'to begin'
	ku_am_bi_ra_ 'to tell'	ku_fu_ru_ <u>ku/ta\</u> 'to move restlessly'
	ku_lgan_lda_lmi_lza_l 'to press'	ku_fu_ki-za_1 'to apply heat'

#### 3.3 Quiotepec Chinantec (Robbins 1968, Gardner and Merrifield 1990)

In Quiotepec Chinantec, an arbitrary set of open, "ballistic" syllables possessing M or LM tones is raised to H in the context of a preceding LH or MH contour. "Ballistic" is largely a cover term for a number of distinct phonetic configurations. In certain Chinantec, Zapotec, and Amuzgo dialects, it involves post-vocalic aspiration. In certain Mazatec and Trique dialects it involves vowel length (Hollenbach 1984, Silverman 1995, 1997, Silverman et al. 1995, Holsinger 1998, Herrera Z. 2000). In Quiotepec, the contrast is characterized by Robbins as a combination of pitch, energy, and aspiration. Some examples are provided in (8) ("´ " = ballistic syllable).

(8)	non-sandhi context:	sandhi context:	gloss:
	tữ́-	k <sup>w</sup> ó∤ tấ́ ๅ	'give (me) two'
	t <sup>j</sup> ý į	cý:∤t <sup>j</sup> ý⊺	'good earthen jar'
	d <sup>j</sup> á-j	siː/ d <sup>j</sup> á7	'shave down ten'
	t <sup>j</sup> új-j	∫ý?႔ t <sup>j</sup> új⊺	'good armadillo'
	bố-	∫ý?႔ bố́ๅ	'stupid armadillo'

# **3.4 Comaltepec Chinantec (Anderson, Martinez, and Pace 1990, Pace 1989, Silverman 1997, to appear)**

In Comaltepec Chinantec, higher pitch spreads rightward from rising-toned syllables, as exemplified in (9).

(9) non-sandhi context: sandhi context: gloss:

toː]	kwa∥ to:∖	'give a banana'
ŋɨh」	kwa∥ ŋɨh∖	'give a chayote'
kuː-	kwaj ku:Y	'give money'
<sup>n</sup> dʒuː-	kwa/ <sup>n</sup> dzur	'give a jug'

Notice that low tones become high-to-low falls, and mid tones become high-tomid falls, in the context of a preceding low-to-high rise. The pattern is actually significantly more complicated, but the examples in (9) do indeed capture its gist. Briefly, Silverman (1997) suggests that the pattern has its phonetic and diachronic origins in this context, but the pattern came to be generalized to include all high toned vowels which lacked post-vocalic laryngeals. The "spreading" of the high tone was maintained even after these level high tones lowered to mid at a later point in time (\*V(:) $\gamma > V(:)-\gamma$ ). Reconstructions (those of Rensch 1968, 1976, 1989) are exemplified in (10), along with their modern reflexes. In (11) are some present-day examples. In the final example in (11), the trigger has itself been subject to morphological sandhi, and is realized as a high-to-mid contour, having been derived from level mid; it consequently triggers rightward sandhi.

present-day Comaltepec:	reconstructed Proto-Chinantec:	gloss:
ku:-	kuːˈ	'money'
ndzœː-	dʒuː]	'earthen jar/jug'
?wiŋ4	?wi:7	'Ojitlán' (a village)
non-sandhi context:	sandhi context:	gloss:
hij	mir-  hi∖	'I ask for a book'
moh?]	mir-  moh?∖	'I ask for squash'
ku:-	mir-1 kur)	'I ask for money'
?oː-l	mi:-1 Sor	'I ask for papaya'
?õː∖ teh-	mmi₁ ?õ:\ teh]	'sticky soot'
	present-day Comaltepec: ku:-  <sup>n</sup> dʒœ:-  ?wi:ŋ-  non-sandhi context: hiJ moh?J ku:-  ?o:-  ?o:-  ?õ:`\ teh-	present-dayreconstructedComaltepec:Proto-Chinantec:ku:ku:"d3œ::ku:"d3œ::d3u:?wi::?wi:non-sandhi context:sandhi context:hijmi:moh?jmi:ku:mi:?o:fteh?o:mi:?o:mi:?o:fteh

So, as the pattern aged, its original phonetic motivation became obscured by subsequent changes.

#### 3.5 Chiquihuitlan Mazatec (Jamieson 1977)

The main tone sandhi patterns in Chiquihuitlan Mazatec are schematized in (12): rising and higher tones spread their high(er) component rightward. In (12), sandhi outputs are indicated in the table interior. So, for example, when a 41 rising pattern comes to precede a 34 falling pattern, the 34 is changed to a 14 fall, the leftward high component having spread rightward on to the first portion of the rightward vowel, overwriting the 3. (According to American tradition, 1=highest,

5=lowest; IPA font limitations preclude my using the proper symbols here. Also the complex tones (214, 314, 414) are found only in very limited phonological contexts [p.112]).

(12)					
target→ trigger↓	31	3	34	target→ trigger↓	4
1	1	1	14	1(4)	14
21				21(4)	
31				31(4)	
41				41(4)	
2	2	2	24	(A)2(A)	24
42	2	2	24	(4)2(4)	24
				3(4)	34

(12)

Examples of several of these patterns are provided in (13).

(13) <u>sua<sup>1</sup></u> 'I give' + <u>rki<sup>3</sup></u> 'medicine'  $\rightarrow$  <u>sua<sup>1</sup> rki<sup>1</sup></u> <u>kih<sup>31</sup></u> 'went' + <u>-nka<sup>3</sup></u> 'again' + <u>mu<sup>3</sup></u>su<sup>14</sup> 'hired worker'  $\rightarrow$  <u>kih<sup>31</sup>nka<sup>1</sup>mu<sup>1</sup></sub>su<sup>14</sup></u> nku<sup>2</sup> <u>?pu<sup>2</sup></u> 'rapidly' + <u>hbæ<sup>3</sup></u> 'it finishes'  $\rightarrow$  nku<sup>2</sup> <u>?pu<sup>2</sup> hbæ<sup>2</sup></u> <u>nku<sup>2</sup></u> 'one' + <u>nta<sup>3</sup>?nka<sup>34</sup></u> 'corncrib'  $\rightarrow$  <u>nku<sup>2</sup> nta<sup>2</sup>?nka<sup>24</sup></u> <u>ho<sup>1</sup></u> 'two' + <u>khua<sup>4</sup></u> 'word'  $\rightarrow$  <u>ho<sup>1</sup> khua<sup>14</sup></u> le<sup>4</sup><u>?ba<sup>14</sup></u> 'hoe' + <u>ne<sup>4</sup></u> 'uh'  $\rightarrow$  le<sup>4</sup><u>?ba<sup>14</sup></u> <u>ne<sup>14</sup></u> <u>nu<sup>2</sup></u> 'year' + <u>ne<sup>4</sup></u> uh  $\rightarrow$  <u>nu<sup>2</sup> ne<sup>24</sup></u> <u>kui?<sup>42</sup></u> 'will drink' + <u>me<sup>4</sup></u> 'they'  $\rightarrow$  <u>kui?<sup>42</sup> me<sup>24</sup></u> <u>koh<sup>3</sup></u> 'with' + <u>me<sup>4</sup></u> 'they'  $\rightarrow$  <u>koh<sup>3</sup> me<sup>34</sup></u> <sub>ju<sup>3</sup>ma<sup>34</sup></sub> 'poor' + <u>hnu<sup>4</sup></u> 'corn plant'  $\rightarrow$  ju<sup>3</sup>ma<sup>34</sup> hnu<sup>34</sup>

It's interesting to note that downdrift is found between adjacent level tones in Chiquihuitlan Mazatec, except upon tone spread, where downdrift is blocked, especially when the spreading tone is high. This is suggestive of the intimate phonetic relationship between the pitch values which flank the consonant, and—if the case of Comaltepec Chinantec is any guide—further suggests the fairly shallow diachronic origin of this sandhi pattern.

#### 3.6 Beijing Mandarin (Xu 1997, Xu and Wang 2001)

In Beijing Mandarin, Xu (/Wang) shows that tones with rising-to-high offsets typically peak only after the following consonant has been implemented; level high tones peak slightly earlier than rising-to-high tones. Tones with low offsets show a significantly lesser effect in these same contexts. Note that this sort of "low level" process is not typically reported in standard grammatical statements, instead requiring instrumental investigation to be detected. Indeed, as previously

discussed, the cross-linguistic tendency toward high spread/displacement after a rise is quite likely to have its diachronic origins in this low-level tendency, and may become conventionalized over time. As such low level processes are not typically reported, studies like Xu (and Wang)'s make one suspect that these low level effects are far more prevalent than the phonological literature would suggest.

### 3.7 Zagreb Croation (Lehiste and lvic 1986)

In Zagreb Croation, syllables characterized as possessing a high pitch accent actually possess a rising pitch contour, pitch peaks being realized on the posttonic syllable rather than on the accented syllable itself. Indeed, the prevalence of high pitch accent displacement would seem especially likely, since displacement here runs little risk of neutralizing lexical distinctions. That is, given the sparse distribution of tones in stress and pitch accent systems, displacement would seem an evolutionarily natural response.

# 3.8 Spanish (Navarro-Tomás 1944, Fant 1984, Prieto, van Santen, and Hirschberg 1995, Kim and Avelino, to appear)

A similar pattern is found in both Peninsular and Mexican Spanish. A number of phonetic studies show that stressed syllables in Spanish typically possess a pitch rise, with the pitch peak being realized on the post-stressed syllable.

#### 3.9 Interim summary

We have now considered quite a number of languages which exemplify **Pattern** (A). Indeed, there are likely to be many more examples at various stages of diachronic development, from the shallow, "phoneticky" pattern found in Beijing Mandarin, to the deeper, older, and consequently more idiosyncratic patterns found in Comaltepec Chinantec. The prevalence of **Pattern** (A) in stress and pitch accent languages systems such as Croation and Spanish is further suggestive of its phonetic naturalness. It is reasonable to assume that in the absence of systemic, functional pressures inhibiting a delayed achievement of a pitch peak—in particular, in the absence of other tonal values that might be neutralized upon high tone spreading/displacement—the more likely that **Pattern** (A) will evolve and take hold in a system. Indeed, one of the main observations of Silverman's (1997) analysis of high tone spread Comaltepec Chinantec is that it is very rarely neutralizing, and instead usually produces an allophonic output.

## 4 Exemplification of Pattern (B)

Observing subphonemic lengthening of vowels with rising tones often requires a phonetic investigation. Consequently, this pattern is not likely to be noted in phonological descriptions. However, it is probably quite common. I now consider a number of documented cases.

### 4.1 Cantonese (Yu, to appear)

In a recent study on Cantonese, Yu shows that checked syllables with (derived) rising tones are significantly longer than checked syllables with level tones. Examples are in (14).

(14)	"morphologically-derived"	"sandhi-derived" rising
	rising tones on checked syllables:	tones on checked syllables:
	sa:אסיk (a type of food)	tsharty tshaty 'to brush a little'
	tsʊk¬ๅ ts <sup>h</sup> a't¬ן 'a bamboo brush'	p <sup>h</sup> a'k¬1 p <sup>h</sup> ak¬1 'to hit a little'
	pסן p <sup>h</sup> a'k ויז ball racket'	kɛ'p¬⁴ kɛp¬+ 'to clip a little'
	pujๅ tɔ'k¬ן 'a cup stand'	thɔ'k¬ı thɔk¬ı 'to support a little'
	fɔŋๅ ka'k¬ٳ 'a square'	ka'k¬1 kak¬1 'to separate a little'
	kʌːmๅ t∫ʰaːp¬≬ 'a golden insert'	t∫harp¬   t∫hap¬+ 'to insert a little'
	kʌːmๅ tsɔ'k¬≬ 'a golden chisel'	tsɔ'k¬4 tsɔk¬4 'to chisel a little'
	kɛjๅ ji'p¬Į 'propeller'	ti <sup>·</sup> p <sup>-</sup> 1 tip <sup>-1</sup> 'to pile up a little'

# 4.2 Mitla Zapotec (Briggs 1961)

Briggs reports that Mitla Zopatec has four tones, high, low, rising, falling: "The vowel of a stem-final syllable having a low-high glide is somewhat lengthened." (p.2).

# 4.3 Thai (Gandour 1977)

Gandour reports that vowels with rising tones in Thai are longer than other vowels.

## 4.4 Zulu again (Russell 2000)

Russell finds that vowels with rising tones flanked by depressor consonants which do not displace the high component—are subphonemically lengthened. An example is provided in (15).

(15)  $i \perp \underline{zir} \underline{p!h} o \perp ko \perp$  'hats'

Here, the rightward depressor blocks the propagation of the pitch rise. Perhaps for this reason, the language has passively evolved these longer vowels which serve to maintain the contrastive tonal pattern.

# 4.5 Zhang's report (2001): Ga (Paster 1999), Konni (Cahill 1999), and Tiv (Pulleyblank 1986)

Zhang's central thesis is that contour tones are far more likely to reside on longer sonorous rimes than shorter ones. He considers a large number of languages that possess limitations on the distribution of contour tones. In a subset of this group, rising tones have a more limited distribution than falling tones. For example, in Ga, rising tones on final vowels trigger lengthening. Also, rising tones in Konni can only occur on final CVN or CVVN syllables, whereas falling tones may be found on final CV syllables. Similarly, in Tiv, contour tones are restricted to word-final position. Especially relevant is the fact that HL may occur on CV, but LH may occur only on CVR (R=resonant).

### 4.6 Interim summary

We've now considered seven languages which exemplify **Pattern (B)**. It should be noted that vowel lengthening is not an automatic, physiologically-rooted consequence of moving from lower pitch to higher pitch. Instead, we might characterize **Pattern (B)** as less natural than **Pattern (A)**; it is more likely to evolve when systemic, functional pressures might inhibit spread/displacement, though it remains to be investigated whether spread/displacement in **Pattern (B)** languages would have indeed resulted in a significant amount of neutralization.

# 5 Pattern (C)

As mentioned in the context of Beijing Mandarin, it is quite possible that certain low-level phenomena are underreported in standard grammatical statements, requiring instead instrumental investigation. In this light, consider the possibility that reduced pitch rises might require a phonetic investigation. But although this pattern is not likely to be noted in phonological descriptions, it is likely to be quite common, For example, in Mandarin Chinese.

## **6** Conclusion

In this paper I have considered how physical properties of the speech mechanism—phonetic factors—may induce a delay in achieving higher pitch in the context of preceding lower pitch. But independent functional factors may induce one of three results: **Pattern (A)** high tone spread or displacement, **Pattern (B)** lengthening of the associated vowel, or **Pattern (C)** a reduction in the pitch change in comparison to falling tones. All of these patterns may salvage the otherwise jeopardized pitch rise. These three patterns may be seen as intimately related by considering the diachronic interaction of phonetic and functional forces on phonological systems. Also, all of these patterns are likely to be far more prevalent than the standard phonological literature would suggest, as they typically require instrumental investigation.

I have suggested that **Pattern (A)** is the most phonetically "natural" of the three patterns, and that the more subtle realization of high tone spread/displacement suggests the diachronic shallowness of the pattern. Over time, however, the pattern may take on a more "categorical" character, and further, may stray from its phonetic origins due to pattern generalization, and further phonological innovations that might render the pattern phonetically opaque.

Regarding the direction of future work, the question to be pursued is: are **Patterns (B)** and **(C)** more likely to be found when **Pattern (A)** would jeopardize lexical distinction? I am investigating this issue now.

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