

97 Tonogenesis

JOHN KINGSTON

1 Introduction

Tones have frequently appeared and multiplied under the influence of the laryngeal articulations of adjacent consonants (§§2–4), but much more rarely under the influence of the vowels that bear them (§6). The laryngeal articulations of following consonants readily introduce tones into previously toneless languages, but those of preceding consonants far more often split existing tones than introduce them where there were none before (§5). Opposite tones can arise from the same ostensible phonological source, apparently because the source can be pronounced so as to raise or lower F₀ (§§3.2.2 and 4). Finally, tone can arise from prosodic as well as segmental sources (§7). In all these sound changes, a predictable or redundant F₀ difference becomes contrastive – i.e. is “phonologized” – once the contrast that introduced it neutralizes. These changes show how easily languages blur the distinction between phonetics and phonology and undermine their autonomy over time.

2 From consonants to tone

2.1 Introduction

The first two examples, Yabem and Korean (§2.2), show how tone can remain redundant on phonation contrasts in preceding consonants, and the next two, Kammu and Cham (§2.3), show how the contrast transfers from phonation contrasts to tone. This section closes with discussion of how redundant F₀ differences are phonologized (§2.4), why voiced obstruents lower F₀ (§2.5), how consonants’ influence on F₀ is represented phonologically (§2.6), and whether a consonant’s phonological specification or its phonetic properties determine its tonogenetic effects (§2.7).

2.2 *Yabem and Korean: Contrastive phonation and redundant tone*

In Yabem, an Oceanic Austronesian language of the North Huon Gulf (Bradshaw 1979; Ross 1993) and Korean (Jun 1996; Silva 2006; Kang & Guion 2008), tone remains redundant on phonation contrasts in preceding consonants (CHAPTER 2: CONTRAST).

2.2.1 *Yabem*

In Yabem (Ross 1993), tonogenesis is the product of tone–voicing harmony. The weak syllable of a two-syllable iambic foot acquired the tone and voicing of the strong syllable when the strong syllable began with a stop in Proto-Huon Gulf (PHG), and a strong syllable not beginning with a stop acquired the tone and voicing of the weak syllable when it began with a voiced stop in PHG,¹ as illustrated by the alternations in the three realis/irrealis verb paradigms in Table 97.1:

Table 97.1 Realis and irrealis paradigm of three Yabem verb stems. The irrealis morpheme is realized by prenasalizing the first voiced stop in the root, if it has one, but otherwise by selecting distinct allomorphs of the singular subject prefixes.

	-dèn 'move towards'		-tán 'weep'		-lu? 'vomit'	
	realis	irrealis	realis	irrealis	realis	irrealis
1 sg	gà-dèn	jà- ⁿ dèn	ká-tán	já-tán	gà-lù?	já-lú?
2 sg	gò-dèn	ò- ⁿ dèn	kó-tán	ó-tán	gò-lù?	ó-lú?
3 sg	gè-dèn	è- ⁿ dèn	ké-tán	é-tán	gè-lù?	é-lú?
1 plincl	dà-dèn	dà- ⁿ dèn	tá-tán	tá-tán	tá-lú?	tá-lú?
1 plexcl, 2 pl.	à-dèn	à- ⁿ dèn	á-tán	á-tán	á-lú?	á-lú?
3 pl	sè-dèn	sè- ⁿ dèn	sé-tán	sé-tán	sé-lú?	sé-lú?

The voiced and voiceless stems /-dèn/ and /-tán/ show the covariation of stop voicing and tone within the strong syllable of the foot. No tone is marked on /-lu?/ 'vomit,' because it varies between low when the prefix stop is voiced (after realis singular [gà-, gò-, gè-]), and high otherwise (after 1st plural inclusive [tá-] and 3rd plural [sé-] and in all irrealis forms). As this stem is high after pre-fixes that do not contain stops, high must be the default tone value for tone, with low occurring only when a voiced stop appears somewhere in the foot. Neither voicing nor its absence can be the default value, as alternations occur in both directions: 1st singular /gà-/ → [ká-] and 1st plural inclusive /tá-/ → [dà-]. These observations indicate that voicing is the source of low tone (as well as voicing any stop in a weak syllable's onset), and that high tone and the absence of voicing developed elsewhere.

In other examples, tone is contrastive, e.g. /áwé/ 'outside' vs. /àwè/ 'woman' and /ólí/ 'body' vs. /òlí/ 'wages.' The source of the tones in these and similar

¹ Generally, Proto-Oceanic (PO) *b, *g > PHG *b, *g > Proto-North Huon Gulf (PNHG) *b, *g > Yabem /b g/ and low tone, and in some morphemes, PO *p, *k unpredictably voiced and lenited to PHG *v, *y > PNHG zero reflexes in Yabem with low tone.

examples is apparently the PHG *v, *y which derive via voicing and lenition from PO **p, **k.

2.2.2 Korean

Following an aspirated [spread glottis] or tense [constricted glottis] stop (CHAPTER 69: FINAL DEVOICING AND FINAL LARYNGEAL NEUTRALIZATION), the initial L of the accentual phrase's LHL melody found after a laryngeally unspecified lax stop is raised to H in Seoul and Chonnam Korean (Jun 1996) – elsewhere in the word, the F0 elevation is smaller and shorter lasting. Silva (2006) and Kang and Guion (2008) argue that tone is becoming contrastive after consonants that are not [constricted glottis] as the duration of aspiration in lax stops has lengthened in younger people's speech to match that of aspirated stops.

2.3 Kammu and Cham: Contrastive tone and loss of phonation contrasts

Kammu and Cham illustrate the transfer from phonation to tone contrasts.

2.3.1 Kammu

Table 97.2 shows that in two western dialects of the Mon-Khmer language, Kammu, low tones (“à”) appear where syllables begin with voiced stops and sonorants

Table 97.2 Correspondences of tone and register in three western dialects of Kammu to the phonation contrast on initial stops (a) and sonorants (b) in the eastern dialect. Examples from Suwilai (2003). E. Kammu = Svantesson's (1989) “Southern” Kammu, the first tonal W. Kammu dialect = his “Northern Kammu” and the register dialect of W. Kammu resembles his Lamet.

	<i>E. Kammu</i>	<i>W. Kammu</i> Tone 1	<i>W. Kammu</i> Tone 2	<i>W. Kammu</i> Register	
a.	bu:c	pù:c	p ^h ù:c	pụ:c	‘rice wine’
	pu:c	pû:c	pú:c	pû:c	‘to take off clothes’
	bok	pòk	p ^h òk	pọk	‘to cut down a tree’
	pok	pók	pók	pók	‘to take a bite’
	bu:m	pù:m	p ^h ù:m	pụ:m	‘to chew’
	pu:m	pû:m	pú:m	pû:m	‘to fart’
	gla:ŋ	klà:ŋ	k ^h là:ŋ	klạ:ŋ	‘stone’
	kla:ŋ	klâ:ŋ	klá:ŋ	klâ:ŋ	‘eagle’
	jaŋ	càŋ	c ^h àŋ	cạŋ	‘to weigh’
	caŋ	câŋ	cáŋ	câŋ	‘astringent’
b.	ŋə?	ŋə?	ŋə?	ŋə?	‘to fear’
	^h ŋə?	ŋó?	ŋó?	ŋó?	‘paddy rice’
	ra:ŋ	rà:ŋ	rà:ŋ	rạ:ŋ	‘flower’
	^h ra:ŋ	râ:ŋ	rá:ŋ	râ:ŋ	‘tooth’
	wa?	wà?	wà?	wạ?	‘to chase’
	^h wa?	wá?	wá?	wá?	‘monkey’

in the eastern dialect and a higher tone (high “á” or rising-falling “â”) where those syllables begin with voiceless stops and sonorants; the other western dialect shows a contrast in voice quality (also known as “register”) instead (Svantesson 1989; Suwilai 2003). Whether the higher tone is high or rising-falling in the first tonal dialect depends on whether the vowel is short or long.

In both tonal dialects, voiceless sonorants have become voiced, and in the first, voiced stops have become voiceless unaspirated. These mergers *transfer* the contrast from phonation in the initial consonant to tone in the following vowel (cf. Hyman 2008 on “trans-phonologization”). In the second tonal dialect, voiceless aspirated stops correspond to voiced stops in the eastern dialect, so the tone difference remains redundant in syllables beginning with stops. In the register dialect, a clear or tense voice quality and high tone (“â” or “á”) corresponds to voiceless initials in the non-tonal dialect, while a breathy voice quality and low pitch “ã” corresponds to voiced initials.² In this dialect, too, the contrast has been transferred completely from the initial consonant to the following vowel. Tone is rising-falling or high after [spread glottis] consonants (= voiceless aspirated stops, /s h/) and [constricted glottis] consonants (= /ʔ j w b d/ – the implosives correspond to glottalized nasals /ʔ m n/ in the non-tonal dialect). Surprisingly, tone is low following /ʔ/ itself.

2.3.2 Cham

Two Chamic languages, Eastern Cham (Phu *et al.* 1992) and Utsat (Maddieson & Pang 1993) have also developed tone from preceding consonants (see also Thurgood 1999; but cf. Brunelle 2005, for arguments that Eastern Cham is not tonal), while Western Cham has developed a register contrast instead. These developments are much like those observed in the Western Kammu dialects, except that proto-Cham did not distinguish sonorants for phonation. Low tone emerged after voiced sonorants, unless the syllable ended in glottal stop, in which case high tone emerged.

2.4 Exaggeration and then transfer

In Yabem and Korean, the F₀ differences remain largely predictable from the phonation differences in the consonants, yet they are exaggerated in both size and extent in both languages, so they cannot still be described as mere phonetic perturbations. The tonal Western Kammu dialects, Eastern Cham and Utsat have taken the next step and transferred the contrast from these exaggerated but still redundant F₀ differences to tone by no longer pronouncing at least some of the preceding consonants with distinct phonation. Jun (1996) shows that exaggerated F₀ differences may coexist with phonation differences, so exaggeration of one phonetic difference does not necessarily trade off at first with diminution of another,³ but Silva (2006) and Kang and Guion (2008) show that such a trade-off may eventually occur and thereby transfer the contrast.

² “Register” refers to breathy or lax *vs.* tense, clear or modal voice quality, low *vs.* high F₀ and higher *vs.* lower vowel qualities, which may occur singly or in combination (Gregerson 1976; Huffman 1976; Thongkum 1987; Denning 1989). In many Mon-Khmer languages, the first value appears in words that began with voiced obstruents and sonorants in an earlier form of the language, while the second appears in words that began with voiceless consonants. The first values may all be concomitants of expanding the pharynx by advancing the tongue root and lowering the larynx (Lindau 1979; Edmondson & Esling 2006).

³ Phonation properties vary in their probability of occurrence, not in their value; for example, a stop may occur more or less often with aspiration but not with a greater or lesser degree.

2.5 The phonetics of low tone from voiced stops

In Yabem, Western Kammu, Eastern Cham and Utsat, low tones developed on vowels following voiced stops and non-low tones elsewhere. These tones could have arisen from exaggerating the F0 lowering that is an automatic phonetic side-effect of an articulation whose purpose is to resolve the aerodynamic conflict between voicing and obstruency. On the one hand, producing the noise characteristic of obstruents requires that intraoral air pressure (P_o) rise, but, on the other hand, maintaining voicing requires that P_o remain enough below subglottal air pressure (P_s) that air continues to flow up through the glottis. An articulation that both maintains the pressure drop across the glottis and also lowers F0 is larynx lowering (Hombert 1978; Hombert *et al.* 1979), which slows the rise in P_o by enlarging the oral cavity (Westbury 1983) and slackens the vocal folds by tilting the cricoid cartilage forward relative to the thyroid cartilage (Honda *et al.* 1999). This slackening could be an automatic, unintended mechanical consequence of larynx lowering, because this articulation's purpose in voiced obstruents is to expand the oral cavity and keep the rise in P_o in check. Yet Honda *et al.* (1999) as well as Collier (1975), Ewan (1976), and Erickson *et al.* (1994), show that larynx lowering is also one of the maneuvers which speakers use to lower F0 deliberately. Their results suggest that larynx lowering in a voiced obstruent could also be intended to lower F0.

Why would a speaker wish to lower F0 when producing a voiced obstruent? Kingston and Diehl (1994, 1995) and Kingston *et al.* (2008) argue that a low F0 in vowels flanking a voiced stop integrates perceptually with voicing in the stop closure itself to enhance the percept of the presence of low-frequency energy in and near the stop (see also Stevens & Blumstein 1981). The percept of low-frequency energy (among other auditory qualities) rather than either voicing or low F0 individually may be what conveys that the stop is [voice]. Integration unifies the stop's phonation and the adjacent vowel's pitch phonetically, at a stage in perception between the signal's raw acoustics and the listener's recognition of the stop's value for an abstract distinctive feature [voice]. This line of reasoning suggests that the lower F0 next to voiced obstruents may be as deliberate a consequence of larynx lowering as keeping P_o from rising too fast.

This account extends naturally to the register differences that have developed from the [voice] contrast in Western Kammu, Lamet, Western Cham and elsewhere (see also Henderson 1967, Matisoff 1973, Denning 1989, and Thurgood 2002 for recognition of this link). In breathy voice, the first harmonic is far more intense than higher harmonics compared to modal or tense voice, and in higher vowels, the first formant (F1) is lower than in lower vowels. While both differences can be interpreted as automatic concomitants of producing voicing in an adjacent stop, their exaggeration and phonologization in the development of register contrasts in these languages can equally easily be construed as an attempt to strengthen the percept of low-frequency energy next to the stop.⁴

⁴ F0 is usually lower in breathy voice, as in tonal Western Kammu and Eastern Cham compared to registral Western Kammu and Western Cham. Obstruents that are sometimes described as breathy voiced also "depress" tone in many Southern Bantu languages (Rycroft 1980, 1983; Traill *et al.* 1987; Traill 1990; Cassimjee 1998; Cassimjee & Kisseberth 1998; Donnelly 2009). However, the depressors are often no longer breathy nor even voiced (Schachter 1976; Traill 1990; Jessen & Roux 2002; Maddieson 2003; Strazny 2003; Downing & Gick 2005; Downing 2009), so depression has become autonomous from the original laryngeal articulation that first introduced it into the languages (Traill *et al.* 1987; Traill 1990; Maddieson 2003), like other transfers of contrast from phonation to tone.

2.6 *Stiff and slack*

Halle and Stevens (1971) propose a different unification, which substitutes features used to represent tone contrasts in vowels, [stiff] and [slack] vocal folds, for [voice] in obstruents (see also Löfqvist *et al.* 1989 for phonetic evidence, and Avery & Idsardi 2001 for a dramatic extension of Halle & Stevens' proposals). A stop specified for [slack] vocal folds would be pronounced with voicing and would lower F0 on the following vowel, while one specified for [stiff] would be pronounced without voicing and with higher F0 on the following vowel. Voicing in obstruents is thus a side-effect of the vocal folds being slack enough.

The reduction in vocal fold tension represented by [slack] both helps and hinders keeping P_o enough below P_s : slacker folds vibrate for a smaller pressure drop across the glottis than stiffer ones, but they also let a larger volume of air pass through the glottis per unit of time and thereby accelerate the rise in P_o . Speakers apparently rely instead on slowing the rise in P_o by expanding the oral cavity both actively (Bell-Berti & Hirose 1975; Westbury 1983) and passively (Ohala & Riordan 1979). Halle and Stevens's features do not therefore abstract away from the phonetic realization of the phonation and tone contrasts so much as subsume them under a single contrast, whose phonetic realization differs systematically as a function of the segment's value for other features (cf. Kingston & Diehl 1994; see also CHAPTER 17: DISTINCTIVE FEATURES).

The Korean facts show that obstruents with other phonation types than [voice] raise rather than lower F0. Jun (1996) attributes this difference to the [spread glottis] and [constricted glottis] stops also being [stiff], apparently as a byproduct of stronger thyroarytenoid (also known as vocalis) contraction compared to the lax stops – cricothyroid contraction does not differ between the three classes of stops (Hirose *et al.* 1974; Hirose *et al.* 1981). The differences in the amount and timing of thyroarytenoid contraction are intended to contribute to differences between these stops in the glottal opening's size and timing (see also Kagaya 1974) and in the [constricted glottis] stops to the firmness with which the vocal folds are pressed against one another, but they clearly affect F0 too.

2.7 *Phonetics or phonology?*

The discussion in §2.5 treats F0 lowering next to voiced obstruents as one of the intended correlates of an abstract [voice] contrast. F0 raising next to [spread glottis] and [constricted glottis] could be treated as a similarly deliberate correlate of these contrasts. Yet we have seen two clear instances of tonogenesis from phonetically predictable rather than contrastive properties, namely, predictably voiced sonorants induced a low tone in the tonal Western Kammu dialects and in Eastern Cham, and the predictably spread glottis voiceless fricative [s] induced a high tone in the tonal Western Kammu dialects. The low tone that emerged after voiced sonorants in the tonal Western Kammu dialects could be attributed to their contrasting with voiceless sonorants in their ancestor (and the Eastern Kammu dialect). However, sonorants did not contrast for [voice] in proto-Cham, so the low tone that emerged in Eastern Cham after voiced sonorants cannot derive from a correlate of the [voice] contrast in that language. Similarly, voiceless fricatives do not contrast for [spread glottis] with voiced ones in Western Kammu. The participation of voiced sonorants and /s/ suggest that their tonogenetic effects are determined by their being pronounced with voicing or the

glottis wide open (Löfqvist & Yoshioka 1980; Yoshioka *et al.* 1981) and not by their phonological specification (see also CHAPTER 8: SONORANTS).

The quandary here is this: if the F0 differences next to consonants contrasting the phonation features [voice], [spread glottis], and [constricted glottis] are the product of articulations that are controlled so as to produce those differences, why do the differences also appear next to consonants that do not contrast for any of these features? Their appearance next to this latter group of consonants suggests that they are instead automatic consequences of voicing, opening the glottis wide, etc., and that it is only the articulations which produce these properties that are controlled. Producing voicing in a sonorant, however, does not require any articulation such as larynx lowering to keep the rise in P_0 in check, because no appreciable amount of air is trapped inside the oral cavity during their pronunciation. In the absence of such an articulation, F0 would also not be automatically lowered next to sonorants, however reliably voiced they would be. These facts suggest that voiced sonorants pattern with voiced obstruents because voicing makes them phonetically similar, and that F0 is deliberately lowered next to them to enhance this phonetic similarity.

The case of voiceless fricatives apparently differs: the glottis must be opened wide to provide a volume of airflow through the oral constriction downstream sufficient to produce turbulent, noisy airflow. Opening the glottis wide in voiceless aspirated stops is presumably also intended to produce turbulent, noisy airflow after the stop release, so both non-contrastive and contrastive glottal spreading have a common purpose. Even so, glottal spreading does not automatically raise F0 (Hombert *et al.* 1979; Kingston & Diehl 1994), and to do so would require deliberate stiffening of the folds next to both classes of consonants. In short, what looked like evidence that the F0 differences must be automatic turns out to be evidence that they must instead be controlled.

3 Tonogenesis from following consonants

The strikingly similar tonogenetic behavior of following consonants in Vietnamese and Chinese (§3.1) is presented first, followed by the discussion of Athabaskan (§3.2). The Athabaskan data are the first to show that opposite tones can evolve from the same ostensible phonological source (§3.2.2).

3.1 Vietnamese and Chinese

According to Haudricourt (1954b), the tone contrasts of present-day Vietnamese developed in two stages. First, a final stop induced a rising tone, a final voiceless fricative a falling tone, and a level tone developed in other syllables, which were either open or ended in a nasal (see the columns in Table 97.3). A considerable time later, each of these tones then split in two under the influence of a [voice] contrast in syllable-initial stops, with words beginning with voiced stops developing lower pitches than those beginning with voiceless ones (see the rows in Table 97.3). The resulting six-way tone contrast displayed in Table 97.3 can be observed today in the Vietnamese spoken in the northern part of Vietnam.

Thurgood (2002) argues that the tones attributed to final and initial stops in Vietnamese did not arise directly from the stops themselves but instead from differences in voice quality that perturbed F0. The distinction between a rising

Table 97.3 Tonogenesis in Vietnamese: “k” = any following stop. The italicized words are the Vietnamese names for each of the tones.

		Following consonants		
		CV, CVN	CVk, CVP	CVs, CVh
Preceding consonants	voiceless	*pa > pa high level (<i>ngang</i>)	*pak > pak high rising (<i>sac</i>)	pas > pa high falling (<i>hoi</i>)
	voiced	*ba > pa low level (<i>huyen</i>)	bak > pak low rising (<i>nang</i>)	bas > pa low falling (<i>nga</i>)

and level tone initially arose from a contrast between creaky and modal voice in syllables not ending in stops or fricatives in Proto-Vietic (Diffloth 1989). Tones in syllables ending in stops subsequently merged with those arising in creaky voice syllables because final stops were pronounced with a simultaneous glottal closure. Similarly, the subsequent tone split arose from an earlier difference between a breathy and a modal voice quality induced by preceding voiced and voiceless stops and not directly from the [voice] contrast itself. Only the falling tones that developed in syllables that ended in voiceless fricatives are attributed directly to the consonants themselves (Thurgood 2002: 336).⁵

Haudricourt (1954a), Pulleyblank (1962), Mei (1970), Baxter (1982), and Sagart (1999) propose that tones developed in much the same way in the evolution from Old Chinese (500 BCE) to Middle Chinese (500 CE). Between Old and Middle Chinese, the *ping* ‘level’ or A tone arose in syllables ending in vowels or sonorants, the *shang* ‘rising’ or B tone in syllables ending in a glottal stop, and the *qu* ‘departing’ or C tone in syllables ending in originally in /s/, which had become /h/ by the time the tones developed. A fourth tone, *ru* ‘entering’ or D, arose in syllables ending in an oral stop. Between Middle Chinese and the present-day languages, these tones split into lower and higher reflexes when the voiced stops merged with the voiceless unaspirated stops. There is little disagreement about this second stage in the development of the present-day tones, but considerable controversy about the transition from Old to Middle Chinese; for alternative analyses see Wang (1958), Benedict (1972), and Ballard (1988). Lack of space prevents me from doing more here than mention the fact of this controversy.

3.2 Athabaskan

The Athabaskan languages in northwestern Canada, southeastern Alaska and the Apachean subgroup are tonal, while those in southwestern Alaska and along the Pacific Coast of Oregon and northern California are not (Leer 1979, 1999, 2001; Kingston 2005; Krauss 2005). Most of the latter retain a contrast between glottalic and non-glottalic stops at the ends of stems that has been replaced by tones in the tonal languages.

⁵ The Tamang languages, a group of closely related Tibeto-Burman languages spoken in Nepal, synchronically illustrate the covariation of tone, voice quality and voicing in preceding obstruents that was the hypothesized precursor to present-day Vietnamese (Mazaudon 1978, forthcoming; Mazaudon & Michaud 2008).

3.2.1 Stem rime contents

Three contrasts between stem-final consonants (1a–c) and two contrasts between stem nuclei (1d–e) interacted in tonogenesis:

- (1) a. Glottalic *vs.* non-glottalic stops (K' *vs.* K), sonorants ($'R$ *vs.* R), and fricatives ($'X$ *vs.* X)
- b. Stops *vs.* sonorants (K *vs.* R)
- c. Stops *vs.* fricatives (K *vs.* X)
- d. Full *vs.* reduced (or long *vs.* short) nuclei (VV and VP *vs.* V)
- e. Full vowel nuclei ending with glottal constriction ($V^?$) *vs.* those not ending with glottal constriction (VV).

(The difference in the position of the glottalic diacritic (K' *vs.* $'R$ and $'X$) is explained below.)

If a stem rime lacked a coda consonant, the nucleus had to be full (VV or $V^?$), but reduced as well as full vowel nuclei occurred in rimes ending in a consonant (VC , VVC). A rime ending in a glottalic sonorant or fricative with a non-glottalic full vowel nucleus did not contrast with one with a glottalic full vowel nucleus, i.e. $VV'R$ and $VV'X = V^?R$ and $V^?X$. Otherwise, all possible combinations of rimes and nuclei occurred. Anticipating §3.2.2, the tones are referred to as the “marked” and “unmarked” (see also CHAPTER 4: MARKEDNESS).

When the vowel was reduced, marked tone developed in stems ending in a glottalic stop or sonorant (VK' , $V'R$), while unmarked tone developed in those ending in a non-glottalic stop or sonorant (VK , VR). When the vowel was full and non-glottalic, however, marked tone only developed in stems ending in glottalic sonorants ($VV'R$); otherwise, the unmarked tone developed (VVK' as well as VVK , VVR). The glottalic articulation was thus lost without a trace in VVK' stems in the tonal languages. Marked tone also developed in all stems with a glottalic full vowel ($V^?$, $V^?K$, $V^?K'$). Glottalic fricatives are derived in certain stem allomorphs by spirantizing glottalic stops ($VK' > V'X$, $VVK' > VV'X$), and they behave like glottalic sonorants in producing marked tone on preceding full as well as reduced vowel nuclei in the tonal languages.

Much as Thurgood (2002) did for Vietnamese (§3.1), Leer (1979, 1999) argued that marked tone did not develop directly from any glottalic articulation on a stem-final consonant; glottalic consonants instead introduced a voice quality he called “constriction” on the preceding vowel, which was subsequently replaced by the marked tone. As in the ancestor of Vietnamese, some stem nuclei already contrasted for constriction in Proto-Athabaskan, i.e. $*V^?$ *vs.* $*VV$, and stems ending in glottalic consonants merged tonogenetically with those whose nuclei were constricted.

Kingston (1985, 1990, 2005) argues that sonorants and fricatives behaved differently from stops because they lacked a stop burst with which the laryngeal articulation could be coordinated (CHAPTER 8: SONORANTS; CHAPTER 28: THE REPRESENTATION OF FRICATIVES). The laryngeal articulation in sonorants and fricatives could therefore shift more easily to the beginning of the consonantal articulation than in a stop, where it remains bound to the release at the end of the closure. This timing difference would also explain why no contrast was possible in Proto-Athabaskan between VV and $V^?$ nuclei in stems ending in glottalic sonorants or fricatives: the glottal constriction at the beginning of a sonorant or

fricative consonant would coincide with that at the end of a glottalic full vowel and render VV'R and VV'X rimes indistinguishable from V?R and V?X rimes.

The coordination of the glottalic articulation with the release of a stop was not enough to prevent it from constricting all or most of a preceding reduced vowel, so marked tone developed in such stems, but in stems with full vowels, only a portion of the vowel would be constricted by co-articulation with the final consonant – too little for marked tone to develop on them.

3.2.2 *Opposite tones from the same source*

The marked tone differs in level between languages, for example, it is high in Chipewyan, but low in Gwich'in. Kingston (2005) argues that both high and low tones could have developed from stem-final glottalic consonants because their laryngeal articulation could have been pronounced so as to raise or lower F₀. If the glottal constriction was achieved by contracting the thyroarytenoid muscle alone, then the voice quality of adjacent vowels would be creaky and F₀ would be characteristically low; however, if the cricothyroid muscle was also contracted at the same time, the adjacent vowel's voice quality would instead be tense and its F₀ would be characteristically high.

According to Leer (1999), the languages with the high-marked tone are found on the Canadian Cordillera's east side and those with the low-marked tone on the Cordillera's west side. Yet within each of these two geographical ranges are found closely related languages with the opposite tone, e.g. low-marked Dogrib is spoken among otherwise high-marked and closely related languages on the east side, while on the low-marked west side, Northern Tutchone is high-marked next to its close relative, low-marked Southern Tutchone and similarly Tanacross is high-marked next to its close relatives, low-marked Upper and Lower Tanana.

The glottalic *vs.* non-glottalic contrast must have been lost very early in stem-final stops in the tonal languages, as none of them retain any vestige of it in the consonants themselves. How then could these recent reversals come about? The answer probably lies in the retention of the contrast in stem-final sonorants as well as between glottalic and non-glottalic full vowels in these languages down to the present day. If the ancestor of the tonal languages originally split into a high-marked and a low-marked dialect when some of its speakers chose to pronounce all the glottalic consonants with cricothyroid as well as thyroarytenoid contraction, while others chose to do so with thyroarytenoid contraction alone, then there is no reason why speakers should have lost this freedom to choose how to pronounce glottalic consonants in the subsequent history of the family. Speakers of Dogrib, Northern Tutchone and Tanacross could have exercised this choice quite recently in words ending in glottalic sonorants or whose nucleus was glottalic, where tone remained redundant on the laryngeal articulation of the stem-final consonant or the nucleus. The contrastive tones in what were once stop-final stems must have switched value at the same time as those in the stems where the tones were predictable. That is, all high and low tones were treated alike regardless of whether they were contrastive or redundant.

Athabaskan is by no means unique in developing the opposite tone values from ostensibly the same source. Glottal stop produced a rising tone in Vietnamese (Table 97.3) and Chinese, but a falling tone in Lhasa Tibetan (Mazaudon 1977). An [h] produced a falling tone in Vietnamese (Table 97.3), but a high tone in Utsat.

A high tone also emerged after voiceless aspirated stops, [s] and [h] in Korean, and on Punjabi vowels followed by [h] or breathy voiced stops in Middle Indic (Ohala 1973).

3.3 *Summary*

In this section, I have described how tone emerged from the laryngeal articulations of following consonants in the earliest ancestors of present-day Vietnamese, the Chinese languages and the tonal Athabaskan languages – [constricted glottis] in all three families and [spread glottis] in Vietnamese and Chinese. In more recent ancestors of present-day Vietnamese and Chinese, the [voice] contrast in preceding consonants split the tones that arose from this source. Tonogenesis in Athabaskan shows that a glottal constriction can be pronounced so as to either raise or lower F₀, depending on whether the cricothyroid as well as the thyroarytenoid is contracted. Other examples show that F₀ can be both raised and lowered while the glottis is constricted or spread. The next section shows that such cross-linguistic variability is pervasive. This variability is another, strong clue that the so-called “perturbations” of F₀ caused by these various laryngeal articulations may instead be controlled.

4 **Tone splitting in East and Southeast Asia**

Examples presented in this section show that languages can differ in whether higher or lower tonal reflexes arise after [voice], [constricted glottis] or [spread glottis] consonants. This cross-linguistic variability is attributed to the freedom to raise or lower F₀ next to sonorants of any phonation type.

4.1 *Two- and three-way splits and cross-linguistic variability*

Tone splitting under the influence of onset consonants is characteristic of the Sino-Tibetan, Hmong, Tai and Kam-Sui families of languages in East and Southeast Asia. A two-way split induced by an earlier [voice] contrast in initial consonants has already been illustrated with Vietnamese; many other examples of two-way splits induced by [voice] can be found in this linguistic area (Haudricourt 1972; Matisoff 1972, 1973; Mazaudon 1977). Three-way splits (Table 97.4), in which [spread glottis] and [constricted glottis] induce distinct tones, are also not uncommon.

In Yung-chiang Kam (Table 97.4a), higher tones have evolved after [constricted glottis] than [spread glottis] consonants, while in Nakhorn Sithammarat Thai (Table 97.4b), it is the reflexes after [spread glottis] consonants that are higher. These outcomes are referred to henceforth as “Constricted High” and “Spread High” splits.

In all examples so far, reflexes after [voice] consonants have been lower than those after other phonation types, but some languages exhibit higher reflexes instead, both when tones split two ways (Table 97.5a) and three ways (Table 97.5b). These outcomes are “Voiced High” splits, as compared to the “Voiced Low” splits in Tables 97.3 and 97.4.

Table 97.4 Three-way tone splitting: “ $x > y$ ” indicates that “ x ” changed into “ y ” in the course of the split. Labial symbols are used to represent the various phonation types. Commas separate distinct reconstructed sounds or their reflexes.

<i>b mv ≠ p^hmf(p) ≠ ?b?m(p)</i>		A	B	C
<i>voice ≠ spread ≠ constricted</i>				
a.	Constricted High: Yung-chiang Kam			
High	p, ?b > m, ?m > m	55	53	323
Mid	p ^h , ^h m > m	35	453	13
Low	b > p, m	212	33	31
b.	Spread High: NakhornSithammarat Thai			
High	p ^h , ^h m > m	53	53	55
Mid	?b, p	24	24	33
Low	b > p ^h , m	31	35	11

Table 97.5 Voiced High two-way and three-way splits in Shan and Szu ta chai. Slashes indicate multiple reflexes of the same reconstructed sound.

<i>b mv ≠ p^hmf(p) ≠ ?b?m(p)</i>		A	B	C	D
<i>voice ≠ spread ≠ constricted</i>					
a.	Two-way: Shan				
High	b > p, m	55	22	44	
Low	p, ^h m > m, ?b > m/w	334	11	22	
b.	Three-way: Szu ta chai				
High	b > p, m	35	33	44	33
Mid	(m)p, ?m > m	33	44	13	31
Low	p ^h , mp ^h > mp ^h , s > z ^h , ^h m > ^h m	13	34	11	11

In the face of such dramatic cross-linguistic variation, it's perhaps easy to ignore the three outcomes that are consistent across all these examples (and the many others that could be presented): (i) distinct reflexes emerged after original [voice] consonants than consonants of other specified phonation types;⁶ (ii) distinct reflexes emerged after the one series of obstruents that is unspecified for phonation type, the voiceless unaspirated stops, than the [voice] obstruents; (iii) sonorants and obstruents of a given phonation type produce the same reflexes.

The cross-linguistic variation is limited to the differences in level between the tonal reflexes observed after consonants of each phonation type.

⁶ None of the examples presented here show comprehensively how fricatives behave in tone splits, although a hint is provided by Szu ta chai, where [s] patterns with the voiceless aspirated stops. For the purposes of tonogenesis, fricatives are analyzed as contrasting for [spread glottis] rather than [voice], with voicing differences being redundant, like sonorants. Both [f] and [p^hm] are [spread glottis] and redundantly voiceless, while both [v] and [m] are unspecified for [spread glottis] and redundantly voiced.

4.2 An explanation

The traditional explanation for the Voiced High developments has been that these languages were originally Voiced Low, in conformity with phonetic expectations, but after the initial [voice] contrast neutralized and the tone split became contrastive, the tones' values were no longer constrained phonetically, and the tones that had evolved after the original [voice] consonants exchanged values with those that evolved after consonants with other phonation types. A similar story might be devised for the Spread High *vs.* Constricted High difference: either [spread glottis] or [constricted glottis] consonants first induced higher tone reflexes in the three-way splits, and the higher reflexes later exchanged values with the lower ones.

Kingston and Solnit (1989) give three arguments against such post-merger exchange processes. First, exchange processes otherwise do not occur but would have to apply frequently in this linguistic area to this linguistic property (see also Alderete 2001 and Moreton 2004 for formal objections). Second, since it is the tone features that have developed on the vowels that apparently invert their values, inversion should apply across all proto-tones. But once inversion occurred, the prior, uninverted stage would no longer be detectable, and there would be no way to know it had ever happened. If the mechanism that inverted tones could apply to individual proto-tones, inversion would be observable in that some proto-tones would exhibit post-inversion Voiced High reflexes, while others would retain the prior Voiced Low reflexes. However, such mixed languages do not occur (see Brown 1975 for further elaboration of this argument). Third, the difference between Spread High and Constricted High splits is observable prior to the merger of the laryngeal contrasts in the consonants, in a Spread High language in Table 97.4b, and for the Constricted High Karenic language, Pwo, in Table 97.6. If languages can differ while the tone reflexes still remain predictable from the consonants' laryngeal articulations, then there is no need to assume that one development is original and the other a later inversion. In the Voiced Low language, Shih men k'an (Hmong) and many others, consonants contrasting for [voice] remain unmerged, but I have not found any cases of a Voiced High split in which this contrast has not merged (CHAPTER 80: MERGERS AND NEUTRALIZATION).

Solnit and Kingston (1988) and Kingston and Solnit (1989) argue that the freedom to pronounce sonorants of any phonation type with a higher or lower F0 (but cf. Maddieson 1984) accounts for both Voiced High *vs.* Voiced Low and Spread High *vs.* Constricted High developments. The development of opposite tones from the same phonological sources in different Athabaskan languages was explained in §3.2.2 by appealing to the same freedom to pronounce sonorants differently

Table 97.6 Three-way Constricted High tone split in Pwo.

	A	B
ʔb, p	33	41
p ^h , ^h m > m	11	41
b > p ^h , m	33	24

across languages. As in Athabaskan, once the sonorants' pronunciation and its effect on F0 had been determined in the East and Southeast Asian languages, the corresponding obstruents would be pronounced and affect F0 in the same way, even if that pronunciation would conflict with the obstruent's phonetic proclivity to perturb F0 in the opposite direction. A phonetic conflict may in fact only arise with [voice] obstruents, which lower F0, as both [spread glottis] and [constricted glottis] obstruents can be pronounced so as to raise or lower F0. Solnit and Kingston (1988) and Kingston and Solnit (1989) formalize this hypothesis by specifying first sonorants and then the corresponding obstruents for tones, using Halle and Stevens's (1971) features [stiff] and [slack], as well as for phonation type. The tone features are not substituted for [voice] in this analysis. Instead, a consonant's value for [stiff] and/or [slack] is predictable from/redundant in its value for [voice], [spread glottis], or [constricted glottis] within a language, but not cross-linguistically.

This proposal does not account for entire language families or substantial sub-groups being either Constricted High or Spread High, while Voiced Low and Voiced High developments are found within the same families, sub-groups, and even between closely related languages. As only voiced obstruents are expected on phonetic grounds to have a consistent (lowering) effect on F0, we would expect them to constrain these changes, yet they are the most labile in tone splits.

5 Tones from preceding *vs.* following consonants: Splits *vs.* tonogenesis

Tones rarely arise *de novo* from phonation contrasts in preceding consonants, as they have done in Western Kammu dialects, Eastern Cham, Utsat, Yabem, and Korean; they are more likely to split existing tones, as they have frequently done in the Vietic, Sino-Tibetan, Hmong, Tai and Kam-Sui families.

There is actually a paradox here. Hombert (1977) showed that the F0 perturbations induced by an initial [voice] contrast were much smaller and shorter lasting in Yoruba, where high, mid, and low tones contrast, than in English, where no contrasts between morphemes are carried by tone. The perturbations may be constrained in size and extent in Yoruba to prevent confusion of one tone with another. If the perturbations induced by initial consonants' laryngeal articulations are generally constrained in tone languages, then how could they ever bring about the splits just described? The answer must be that speakers of these languages have been sensitized to F0 differences between previously existing tones, and they would be more likely to attend to, rely on, and eventually transfer the contrast to the systematic F0 differences after preceding consonants, too, even if those differences were at first small and brief.

How then could tone have developed from an initial [voice] contrast in the Western Kammu dialects, Eastern Cham or Utsat, where there was no tone before? Extensive contact with other languages whose tones have split under the influence of an initial [voice] contrast is the most likely explanation.⁷ Contact

⁷ Brunelle (2005) presents extensive sociolinguistic evidence that speakers of Eastern Cham did not have sufficient contact with Vietnamese, the most likely language to have provided a model for its tonogenesis.

with tone-splitting languages, however, cannot explain tonogenesis from preceding consonants in Yabem or Korean. Yabem is apparently not in contact with any other tonal languages, aside from its close relative Bukuwa. Close similarities between their tone systems indicate that tone must have developed in their immediate common ancestor, rather than Bukuwa being the source of Yabem's tones. Korean has, of course, been in prolonged contact with Chinese, but the phonologization of the F₀ differences after [spread glottis] and [constricted glottis] *vs.* unspecified consonants is too recent to be explained by that contact, and too different from the tone split occasioned by the much earlier merger of the [voice] contrast in Chinese – many Chinese languages also maintain the contrast between voiceless unaspirated and aspirated stops that is about to be transferred to a tone contrast in Korean. These languages and perhaps Eastern Cham (cf. Brunelle 2005) are at least incipient exceptions to the generalization that contrastive tone does not develop in non-tonal languages from laryngeal articulations in preceding consonants.

6 Tones from uncommon sources

While consonants have often induced or split tones on neighboring vowels, the vowels' own articulations have split tones in just two languages. The rarity of this development is surprising because F₀ is higher in vowels in which the tongue is higher than in vowels in which the tongue is lower. This variation in the vowels' "intrinsic" F₀ is so pervasive that it is thought to be a universal, mechanical consequence of raising the tongue, which pulls the larynx up via the hyoid bone (Ohala & Eukel 1987; Whalen & Levitt 1995; Whalen *et al.* 1999), but see Ladd and Silverman (1984), Steele (1986), and Kingston (1991, 1992) for contrary evidence. Despite these intrinsic F₀ differences' ubiquity and apparently automatic character, it appears that vowel height has only split tones in the Angkuic language, U, a not-too-distant relative of the Kammu languages discussed in §2.3.1 above (Svantesson 1989), and Lugbara, a Moru-Madi language of the Central Sudanic branch of Nilo-Saharan (Andersen 1986) – other putative cases have been argued not to be products of vowel height differences (Hombert 1978; Maddieson 1978; Schuh 1978).

6.1 Tone from vowel height: U

In U, the high level tone in the closely related language Hu has split: it remains high in syllables with high vowels (CHAPTER 19: VOWEL PLACE), but became low in syllables with non-high vowels (Table 97.7a *vs.* b; forms from U's and Hu's close non-tonal relative, Lamet, are given when there is no Hu cognate showing the original vowel height).

6.2 Tone from advanced tongue root: Lugbara

Western Lugbara contrasts four tones: low [fi] 'it exploded,' mid [fi] 'he entered,' high [fi] 'intestines' and extra-high [fi] 'they entered.' Within a word, the vowels /ε ɔ/ are raised to [e o] when followed by /i/ or /u/ within a word, and /i u/ do not co-occur with /ɪ ʊ/. Andersen (1986) proposes that the language therefore distinguishes [+ATR] vowels, [i e o u], from [-ATR] vowels, [ɪ ε ɔ ʊ].

Table 97.7 High tone in U where the vowel is high in Hu and/or Lamet (a) *vs.* low tone when the vowel is non-high in the related languages (b).

	<i>U</i>	<i>Hu</i>	<i>Lamet</i>	
a.	nchí	nsíu?	sí?	'louse'
	sí	(pa)sí?	(pl)sí?	'rope'
	nthú		ntu?	'hole'
	thú		tu?	'vegetable'
b.	sì	θé?	khé?	'tree'
	ŋkhù	ŋkhó?		'rice'
	khù	sŋkhó?		'yesterday'

In the second syllable of disyllabic verb stems, high and extra-high tone are in complementary distribution: high tone occurs when the vowel is [–ATR], [áví] 'play' *vs.* extra-high tone when it is [+ATR] [át sí] 'walk.' In nouns, high tone only occurs on [–ATR] vowels, and the extra-high tone can occur on both [–ATR] and [+ATR] vowels, e.g. high [àrí] 'blood' but *[àrí] and [òtsé] 'dog' *vs.* [òdú] 'thigh.' Andersen proposes that the high tone split in Western Lugbara and became high when the vowel bearing it was [–ATR] and extra-high when that vowel was [+ATR].

Higher F₀ has been associated with [+ATR] in other languages (Denning 1989), so ATR differences may affect vowels' intrinsic F₀ much like vowel height does, probably because [+ATR] vowels are often also somewhat higher than [–ATR] vowels.

6.3 Why is tonogenesis from vowel height so rare?

Tone splits from vowel height or ATR contrasts are decidedly rare. Why should a vowel's own intrinsic F₀ be so unable to split its tone, while F₀ perturbations brought about by neighboring consonants' laryngeal articulations can so readily do so? The most plausible answer to this question is that intrinsic F₀ differences between vowels differing in height depend on the vowels being prominent (Reinholt Peterson 1978; Ladd & Silverman 1984; Steele 1986; Kingston 2007) or bearing a high(er) rather than low(er) tone (Hombert 1977; Zee 1980; Connell 2002), while the effects of consonants' laryngeal articulations on the F₀ of adjacent vowels do not appear to depend on the vowels' prominence or tones. If the intrinsic F₀ differences between vowels were less consistent across prosodic contexts than the F₀ differences between consonants, learners would be less likely to reinterpret them as differences in tone.⁸

⁸ The bias favoring the learning of modular constraints proposed by Moreton *et al.* (2008) and Moreton (2008a, b) does not help here, because the constraints referring to tone and vowel height are no more a-modular than those referring to tone and consonants' laryngeal articulations.

7 From stress and intonation to tone: Tonogenesis in Germanic

Before concluding this chapter, I sketch the probable paths through which tone evolved in three North Germanic languages, Swedish, Norwegian and Danish (Gårding 1977; Riad 1998; Lahiri *et al.* 1999; Riad 2000, 2003), and in Central and Low Franconian (Hermans 1999; Gussenhoven 2000b; Boersma 2006; Kehrein 2007). Unlike all the other examples discussed in this chapter, the sources of tone in these languages are not the laryngeal articulations of segments, although the tones' distribution is partly regulated by or correlated with various segmental properties. The tones in these languages instead come from the F0 correlate of stress in the Scandinavian languages and from intonation in Central and Low Franconian.

7.1 North Germanic word accents

In the conservative variety of Swedish spoken in and around Stockholm, i.e. Central Standard Swedish, words contrast in whether they bear Accent 1 or Accent 2. Other dialects of Swedish, as well as Norwegian dialects, differ in whether the accents still contrast and the timing of the F0 events that realize the accents relative to the segment strings of the words bearing them (Bruce & Gårding 1978; Bruce 1999; Gussenhoven & Bruce 1999). Despite these differences between dialects and languages, their various synchronic patterns all descend from the same reinterpretation of the F0 correlates of stress as word accents in late Proto-Nordic, between 800 and 1200 CE (Riad 1998, 2003).

On the surface, both word accents can be analyzed as a sequence of a H and L tone (Gussenhoven & Bruce 1999, among many others; see also CHAPTER 45: THE REPRESENTATION OF TONE; CHAPTER 32: THE REPRESENTATION OF INTONATION). In words bearing Accent 1, the L tone is aligned with the stressed syllable, while in words bearing Accent 2, it is the H tone that is aligned with that syllable. Thus the two word accents apparently do not contrast in the tones of which they are composed but the alignment of those tones with respect to that word's primary stressed syllable (Bruce 1977). Phonetically, F0 is low from the beginning of the stressed vowel in words bearing Accent 1, while it starts high and falls to a low value across that syllable in words bearing Accent 2. For words bearing Accent 1, the H only appears if there is a preceding unstressed syllable. When they are the last word in a focused constituent, both Accent 1 and Accent 2 words bear a focal H tone that appears immediately after the word accent tones, and initial and final L% boundary tones appear at the beginning and end of each intonational phrase. All these tones are necessarily realized roughly a syllable later in phrases containing Accent 2 words than those containing Accent 1 words.

Riad's (1998, 2003) phonological analysis differs from this superficial account. Rather than a contrast in the tune-to-text alignment of a HL contour that determines when the other tones of the intonational contour are realized, Accent 2 words contrast privatively in having a lexical H* aligned with their stressed syllable which is absent in Accent 1 words. Focus is still marked by an H tone, which follows the lexical H*, if any. The L that invariably precedes this H is not lexical but instead either part of focus marking, a default L, or one inserted to separate the lexical and focal Hs in Accent 2 words and satisfy the OCP. The melody of an Accent 1 word is therefore [LH]_{Focus}-L%, and that of an Accent 2 word H*-[LH]_{Focus}-L%.

The diachronic development of this phonological contrast began with a number of reducing sound changes in Proto-Nordic, particularly, syncope of vowels in light (CV) syllables (sixth–ninth centuries CE), e.g. heavy–light–heavy /'doomi,jan/ > heavy–heavy */'døø,man/ 'to judge' and heavy–light /'gastiz/ > /'gæstr/ 'guest.' Stress was quantity-sensitive at this stage, and any heavy syllable would have been stressed. Syncope of medial vowels created stress clashes whenever the syllables that became adjacent as a result were both heavy. Stresses also clashed in many other words where heavy syllables abutted even prior to syncope, e.g. */'wur.,ðoo/ 'words (NOM/ACC PL).' Riad proposes that stress clash was resolved by destressing the second syllable through shortening and other changes that left the affected syllable light: */'døø,man/ > /'døø.ma/ and */'wur.,ðoo/ > /'wor.ðu/.

Riad hypothesizes that high F0 was one of the phonetic correlates of stress at this time, and that this F0 peak survived destressing. Words that had undergone destressing would then have had two F0 peaks, one on the remaining primary stressed syllable and the other on the newly destressed syllable. After destressing, an F0 peak would no longer be a correlate of stress because only the first of these peaks would still be associated with a stressed syllable. Once destressing eliminated the prosodic equivalence of these two peaks, the first, the one still associated with the primary stressed syllable, was re-analyzed as a lexical H* tone. This is the path of development to present-day Accent 2 words. Words in which the primary stressed syllable was final would not have any stress clash to resolve, would not have undergone destressing and would not ever have borne two prosodically non-equivalent F0 peaks. No re-analysis of the F0 peak on a final stressed syllable as a lexical H* would therefore take place, so what would become Accent 1 words would not acquire a specification for a lexical H*. The F0 peak on this syllable, as well as the one on the destressed syllable in Accent 2 words-to-be, would then be reinterpreted as intonational in origin, i.e. as the present-day focal H. Subsequent sound changes added syllables to words that were once monosyllabic and produced words with non-final stress and Accent 1 and thus possible contrasts with Accent 2, notably the appearance of svarabhakti vowels before syllabic sonorants, e.g. /akr/ > /aker/ 'field,' /fogl/ > /fogel/ 'bird,' and /sookn/ > /sokken/ 'parish,' and enclisis of the definite article, e.g. **/and hinn/ 'duck the,' */and-in/ > /anden/, cf. /anden/ 'the ghost,' with Accent 2.

Lack of space prevents me from taking up the debates as to whether the present-day contrast between word accents is privative or equipollent, whether Accent 2 is synchronically marked (Riad 1998, 2003) or Accent 1 (Lahiri *et al.* 2005) if the contrast is privative, and whether the accents are lexically or morphologically determined in the present-day languages (see for discussion Riad 1998, 2003; Morén 2006).

7.2 Danish *stød*

Danish *stød* is phonetically a glottal stop or creaky voice that causes F0 to drop sharply at the end of the sonorant interval in a syllable bearing it. It is represented here with an apostrophe following the end of this interval. A syllable can bear *stød* if it is stressed and bimoraic (heavy), and its second mora is a vowel or a sonorant followed by another consonant. If the second mora is a sonorant consonant and word-final, then *stød* cannot occur. These conditions are referred to collectively as the '*stød* basis.' Syllables bearing *stød* are typically either the

sole syllable in monosyllabic words or final stressed syllables in longer words. Following Itô and Mester (1997), Riad (2000) analyses *stød* as the allophone of a general HL word contour that occurs when these conditions are met, i.e. when both tones are compressed into a single word-final stressed syllable. When the stressed syllable is non-final, the two tones can be distributed across two syllables and no *stød* occurs.

Given the constraints on its distribution, it should not be surprising that Danish *stød* corresponds to the similarly restricted Accent 1 in Swedish and Norwegian. The correspondence is not perfect, however, because the distribution of *stød* is constrained further by the *stød* basis, while Accent 1's distribution is only constrained by the original position of stress in the word. If *stød* is simply the allophone of a general HL contour that is realized under the segmental and prosodic conditions specified by the *stød* basis, then, as Riad (2000) emphasizes, these conditions only determine how that contour can be realized phonetically and do not restrict whether the underlying HL can occur, unlike the conditions on the distribution of Accent 1 in Swedish and Norwegian.

Riad (2000) proposes that *stød* developed from word accents in a North Germanic dialect quite like the Central Swedish dialect of Western Mälardalen, centered around the city of Eskilstuna, southwest of Stockholm (cf. Liberman 1982). The tones in this dialect are shifted earlier compared to Central Stockholm Swedish, such that the L% boundary tone is aligned with the stressed syllable, which crowds the tones of the focal contour earlier, too, displacing the focal L from the stressed syllable and aligning the focal H with it. A consequence of this crowding of the focal H and L% boundary tones onto the stressed syllable is that in the appropriate pragmatic conditions, the L% boundary tone is realized as a steep drop in F0 that may end in creaky voice.

The Eskilstuna "curl" phonetically resembles Danish *stød*. However, *stød* occurs in a narrower range of contexts than curl (the *stød* basis), it is categorical in the contexts where it occurs rather than pragmatically conditioned (CHAPTER 89: GRADIENCE AND CATEGORICALITY IN PHONOLOGICAL THEORY), and word accents no longer contrast in Danish, unlike in Eskilstuna and Western Mälardalen generally. The alignment of the L% boundary tone with the stressed syllable in the Eskilstuna-like ancestor of Danish motivated the segmental restrictions on the occurrence of *stød* that constitute its basis: the L tone needed sonorant material on which to realize itself. The shift of the focal H tone to the stressed syllable in this Eskilstuna-like ancestor would have aligned H tones with stressed syllables generally, which would lead to their re-analysis as stress correlates and the loss of any phonological distinction between the lexical H* of Accent 2 and the focal H. In words with Accent 1, nothing changes as a result of this re-analysis, but in words with Accent 2, the re-analysis of the focal H would have led speakers to hypothesize secondary stresses on the syllables bearing the focal H tone that were actually unstressed. At that point, none of the tones are lexical any longer. These sound changes effectively reverse the sequence of prosodic changes that originally created the word accents from the F0 peaks aligned with stressed syllables in late Proto-Nordic.

This analysis appears to predict, incorrectly, that *stød* should correspond to Accent 2 in addition to Accent 1. Riad (2000) points to two properties that would have blocked such correspondences. First, the restrictions imposed by the *stød* basis would block many words with Accent 2 from developing *stød*. Second, large numbers of vowel-final Danish words that correspond to Swedish or Norwegian

words with Accent 2 end in schwa rather than a full vowel, and schwa cannot bear *stød*. These characteristics jointly limit the number of possible Accent 2 words that could have met the conditions to develop *stød*.

7.3 Scandinavian summary

In Riad's (1998, 2003) account, word accents developed in the ancestor of Swedish and Norwegian once clash-resolving destressing of the second of two stressed syllables prosodically differentiated the H tone that remained aligned with the primary stressed syllable from that which had been aligned with the destressed syllable. The H that remained aligned was re-analyzed as a lexical H* tone, producing Accent 2. Final primary stressed syllables would not have destressed, the H tone aligned them would not have been re-analyzed as a lexical tone, and as a result Accent 1 words are not specified for tone lexically. Danish *stød* developed from word accents as a result of a shift of the L% boundary tone and the focal H tone to the stressed syllable, which led to a re-analysis of H tones as correlates of stress and the reintroduction of covert secondary stresses that reversed the sequence of sound changes that originally produced the word accents.

7.4 Tonogenesis in Central and Low Franconian

In Central and Low Franconian dialects, heavy, stressed syllables bear one of two tone patterns, referred to variously as "*Stosston*" or "*stoottoon*" vs. "*Schleifton*" or "*sleeptoon*," "*Schärfung*" vs. "*Trägheitakzent*," "*acute*" vs. "*circumflex*" and "*Accent 1*" vs. "*Accent 2*" (Gussenhoven 2000b; Boersma 2006; Kehrein 2007).⁹ Their distribution depends on the height of the vowel in the stressed syllable of a word and the voicing of the following consonant, but neither dependency is a byproduct of the effects that vowel height or voicing may have on F0. This sketch of their historical development is a synopsis of Boersma's (2006) account, broken into three stages: Old Low Franconian to Early Middle Limburgian (900–1100 CE), Early to Late Middle Limburgian (1300–1400 CE) and Late to Present-day Middle Limburgian. The first two stages are illustrated in Table 97.8:

Table 97.8 First two stages in development of Low and Central Franconiantonogenesis. At each stage, the first row shows the underlying quantitative structure and the second row the alignment of the declarative HL melody. The interrogative LH melody would be aligned in the same fashion.

stages	Accent 1		Accent 2				
	'sleep'	'bed'	'grape'	'walk'	'hold'	'brook'	'chest'
1	sl _μ a _μ pən	bε _μ d _μ də	dru _μ wvə	l _μ wpən	fi _μ ldən	bε _μ kə	ke _μ stə
	sláápən	bédðə	drúwvə	lówpən	fiáldən	békə	késtə
2 OSL	sl _μ a _μ pən	bε _μ d _μ də	dru _μ u _μ və	l _μ u _μ pən	fi _μ ldən	bε _μ ε _μ kə	ke _μ stə
	sláápən	bédðə	drúúvə	lúpən	fiáldən	béékə	késtə

⁹ Only the so-called "rule A" dialects are discussed. Rule B dialects reverse the assignment of accents in many, although not all, forms but the diachronic path to reversal remains obscure.

In the first stage, a quantity contrast developed between bimoraic long non-high vowels (“sleep”) and monomoraic long high vowels (“grape”), diphthongs (“walk”), and short vowel–sonorant sequences (“hold”) (see also CHAPTER 20: THE REPRESENTATION OF VOWEL LENGTH; CHAPTER 57: QUANTITY-SENSITIVITY). Open and closed stressed syllables containing short vowels were also monomoraic (“brook” and “chest,” respectively), except when the following consonant was a geminate, whose first half also projected a mora (“bed”). Both tones of the declarative HL or interrogative LH focal accents could map onto the stressed syllable when its nucleus was a long non-high vowel or a short vowel followed by a geminate consonant, but only the first tone could map onto the single mora in all other stressed syllables because tones were mapped left-to-right, at most one tone to a mora, and at most one mora to a tone.

Quantity differed between high and non-high long-vowel vowels because high vowels are inherently shorter than non-high ones, prior lowering of short high vowels to a higher mid quality eliminated the quantity contrast in high vowels in Early Middle Limburgian and the long high vowels consisted of a vocalic segment followed by a homorganic glide. They thus resembled diphthongs and short vowel–sonorant sequences structurally in consisting of a vocalic segment followed by a consonantal one. At this stage, the realization of the focal pitch accents remained entirely predictable from the quantity differences between the two kinds of stressed syllables.

Open syllable lengthening (“brook”) eliminated this predictability and transferred the original quantity contrast to a pitch accent contrast in the second stage. Original long non-high vowels bore Accent 1, while the newly lengthened non-high vowels bore Accent 2. The long high vowels, diphthongs, and short vowel–sonorant sequences were necessarily reinterpreted as bimoraic after open syllable lengthening, but they, too, retained Accent 2. This accentual contrast preserved the original mapping and phonetic timing of the focal pitch accents relative to syllables of the first stage, at the expense of violating the constraint mapping just a single mora to each tone. Henceforth, F₀ changed during the stressed syllable itself in Accent 1 words, while in Accent 2 words it changed between the stressed and following unstressed syllable, a difference reminiscent of the superficial timing difference between Accent 1 and Accent 2 words in Swedish and Norwegian.

In the third stage, short vowels in closed syllables that previously alternated with lengthened vowels in open syllables in nominal, verbal, and adjectival paradigms lengthened, e.g. /dak/ > /daak/ ‘roof (FEM SG),’ /dax/ > /daax/ ‘day (MASC SG)’ and /lam/ > /laam/ ‘lame (SG),’ by analogy with their plurals /daakə/, /daayə/ and /laamə/ (see also Gussenhoven 2000b). The singulars would have borne Accent 2, either because they all had short vowels previously or on analogy with their plurals, which as products of open syllable lengthening bore Accent 2 themselves.

Final schwa apocope introduced Accent 1 on words with long high vowels, diphthongs, and lengthened vowels followed by voiced consonants through a shift of the L that had been aligned with the schwa to the first syllable, e.g. /drúúvə/ > /drúúv/ > /drúúv/. Three properties made this tone’s preservation and shift possible: the consonant preceding the schwa belonged to the same mora as the schwa; it therefore bore the tone mapped onto that mora; and that tone could be heard during a voiced consonant. That is, the pronunciation before apocope was

[drúúvə̃]. This shift produced new alternations between /lé̃v/ 'live (1sg)/ (IMP sg)' and /dáà/ 'days' with Accent 1, on the one hand, and /lé̃və̃n/ 'to live' and /dááx/ 'day' with Accent 2, on the other. In the Central Franconian dialects described as undergoing Rule A but not those undergoing Rule A2, the extension of Accent 1 generalized to words in which the schwa did not drop, e.g. in /lé̃və̃n/ 'to live.' Accent 1 was also retained in words with geminates when the geminate was voiced, /bèddə̃/ 'bed' > /bédd/ and /zòhə̃n/ 'sun' > /zòh/ (cf. /nákkə̃/ 'neck' > /nákk/). Later degemination produced /bêd and /zôn/, with Accent 1, *vs.* /nák/, with Accent 2. Accent 2 replaced Accent 1 when the geminate was voiceless, because the second tone of the pitch accent could not be heard during a voiceless consonant.

The development of the accentual contrast in Central and Low Franconian certainly depended on both vowel height and consonant voicing, each at a different stage in its history, but not in any way that reflected the direct influences these segmental contrasts may have on F0. Instead, it was the inherently shorter duration of high compared to non-high vowels, the absence of a quantity contrast in the high vowels, and the structural parallel between long high vowels, falling sonority diphthongs, and short vowel-sonorant sequences that determined the initial difference in the mapping of the two tones of the focal pitch accents. And it was the audibility of F0 values during voiced intervals, including those of voiced obstruents, that determined the later appearance of Accent 1 where Accent 2 might otherwise have been expected. The inception of the accentual contrast at stage 2, however, did not depend on either property, but instead on conserving the previously predictable mapping of tones to syllables after open syllable lengthening had largely eliminated the quantity contrast that previously determined that mapping.

Gussenhoven (2000b) and Kehrein (2007) present a number of additional empirical arguments for not treating the distribution of the accents as instances of tonogenesis from the intrinsic F0 differences between vowels differing in height or on vowels preceding rather than following obstruents differing voicing. First, vowel qualities changed subsequently in directions opposite those expected from the tones they bear. Second, voiced consonants only induced Accent 1 in place of Accent 2 on high vowels in words of more than one syllable, across the board in Rule A and Rule A2 dialects following final schwa apocope, and when schwas were retained in Rule A dialects, while original monosyllables with high vowels consistently exhibit Accent 2. The presence of a following vowel should have been of no consequence if Accent 1 developed from the effect of the voicing contrast on the preceding vowel's F0. This difference is expected, however, if the voiced consonant instead preserved and made audible the tone on the second syllable. Perhaps, the most compelling argument, however, is that Accent 1 and Accent 2 are only realized with a HL *vs.* sustained H melody on the stressed syllable in declaratives. In interrogatives, they are instead realized with LH *vs.* sustained L melodies. If both H and L tones can be regulated by both non-high and high vowels and by both voiced and voiceless obstruents within the same language, then the effects of vowel height and obstruent voicing differences on F0 cannot have determined the accents' distributions.

This last argument raises the question, should this accentual contrast's development be treated as an instance of tonogenesis at all? In the present-day languages, the tones themselves arise from the intonation, and there is no reason

to think that they have not done so throughout the period when the accentual contrast developed. The contrast may therefore have always been in how intonational tones were aligned with the utterance's segmental material. Kehrein (2007) argues for just such a synchronic analysis in which there are no lexical tones, and a word's (original) segmental properties determine whether it projects a moraic trochee and Accent 1 alignment or syllabic trochee and Accent 2 alignment. He also shows that phonetic evidence for a lexical tone can be hard to find in the F0 contours of present-day Central and Low Franconian words (Gussenhoven 2000a, b; cf. Gussenhoven & Peters 2004).

7.5 Differences between Central and Low Franconian and Scandinavian

Boersma's analysis sharpens the synchronic and diachronic differences between the Central and Low Franconian accents and the Scandinavian accents. Even though tones are realized earlier in Accent 1 than Accent 2 words, in both the tones remain properties of the intonation in Central and Low Franconian, while they now arise from the lexicon and/or morphology in the Scandinavian languages. Word accents developed in the Scandinavian languages as a result of clash-resolving destressing and the resulting reinterpretation of the F0 peaks that had previously been predictable correlates of stress. In Central and Low Franconian, inherent differences in duration between high and non-high vowels and differences in the audibility of F0 between voiced and voiceless targets instead determined how focal pitch accents were aligned with segments. The result in the Scandinavian languages was the development of a contrast between the presence and absence of a lexical tone, that is, true tonogenesis, but in Central and Low Franconian, the contrast was instead between prosodic structures that forced intonational tones to align differently.

8 Summary and conclusions

This chapter has reviewed the ways that languages have acquired contrastive tone, particularly tonogenesis and tone splitting in East and Southeast Asian language families, including Sino-Tibetan, Hmong, Tai, Kam-Sui, the few tonal Mon-Khmer and Chamic languages, Athabaskan, Yabem, and Korean. The laryngeal articulations of consonants raised or lowered F0 in neighboring vowels, those effects on F0 were exaggerated, and contrast transferred from the consonants to tone once the consonants were otherwise no longer pronounced differently. Just two languages, U and Lugbara, have apparently split their tones under the influence of intrinsic F0 differences between vowels contrasting for height and ATR, respectively.

The chapter closed by discussing how the word accents developed in Swedish and Norwegian from clash-resolving destressing and the resulting re-analysis of F0 peaks as lexical and focal tones rather than as correlates of stress, how *stød* subsequently developed from these word accents in Danish when F0 peaks realigned with stressed syllables and were once again analyzable as stress correlates, and how contrasting patterns of tune-text alignment developed from original quantity contrasts and subsequent changes in quantity in Central and

Low Franconian. The Franconian case can be described as a transfer of contrast from segments to tone, but one where segmental properties affected the timing and audibility of intonational F0 targets rather than F0 values. In phonologizing a formerly predictable correlate of stress, the Scandinavian word accents also transfer a contrast: Accent 2 emerged in words in which secondary stresses were lost to resolve stress clash *vs.* Accent 1 on words in which no stress clash occurred because the final syllable bore primary stress. Subsequent sound changes affecting Accent 1 words introduced following unstressed syllables, and words with non-final primary stress now contrast for word accent.

In Athabaskan and East and Southeast Asian languages, consonants with particular laryngeal articulations were the source of higher tones in one language and lower tones in another. This variability was attributed to the presence of contrasts for laryngeal articulations in sonorants as well as obstruents. No phonetic constraints on laryngeal articulations in sonorants prevent them from being pronounced so as to either raise or lower F0. Individual languages, groups of languages, or whole families opt to pronounce the laryngeal articulations in sonorants one way or the other, and the obstruents with the same laryngeal articulations follow suit. Athabaskan differs from the East and Southeast Asian language in preserving the laryngeal contrasts in sonorants and transferring them from obstruents, while it is the other way around for the East and Southeast Asian languages. As a result, particular groups of languages and individual languages in the Athabaskan family have repeatedly changed their pronunciation of the sonorants, while in East and Southeast Asia language groups are far more uniform, with the exception of the Voiced Low *vs.* Voiced High difference. These facts suggest that consonants should be specified for tone, using [stiff] and [slack], in addition to [voice], [spread glottis] and/or [constricted glottis].

This chapter does not account for tonogenesis in the many tonal Central American, African, and New Guinean languages (except Yabem). Tones have been reconstructed for the proto-languages from which the present-day Central American and African languages descend, so it has not been possible to work out how these languages became tonal. Catalogues are beginning to emerge of the types of tone languages found in New Guinea, particularly in the Trans-New Guinea stock (Donohue 1997, 2005; Ross 2005), but there the data vary too much to generalize about their historical development.

ACKNOWLEDGMENT

I have been helped enormously in writing this chapter by Paul Boersma, Marc Brunelle, James Kirby, Wolfgang Kehrein, Tomas Riad, the editors Keren Rice and Marc van Oostendorp, two anonymous reviewers and especially David Solnit. If its virtues are largely theirs, its errors remain mine.

REFERENCES

- Alderete, John. 2001. *Morphologically governed accent in Optimality Theory*. New York & London: Routledge.
- Andersen, Torben. 1986. Tone splitting and vowel quality: Evidence from Lugbara. *Studies in African Linguistics* 17. 55–68.

- Avery, Peter & William J. Idsardi. 2001. Laryngeal dimensions, completion and enhancement. In T. A. Hall (ed.) *Distinctive feature theory*, 41–70. Berlin & New York: Mouton de Gruyter.
- Ballard, W. L. 1988. *The history and development of tonal systems and tone alternations in South China*. Tokyo: Institute for the Study of Languages and Cultures of Asia and Africa.
- Baxter, William H. 1982. *A handbook of Old Chinese phonology*. Berlin & New York: Mouton de Gruyter.
- Bell-Berti, Fredericka & Hajime Hirose. 1975. Palatal activity in voicing distinctions: A simultaneous fiberoptic and electromyographic study. *Journal of Phonetics* 3. 69–74.
- Benedict, Paul K. 1972. *Sino-Tibetan: A conspectus*. Cambridge: University Printing House.
- Boersma, Paul. 2006. The history of the Franconian tone contrast. Unpublished ms., University of Amsterdam.
- Bradshaw, Joel. 1979. Obstruent harmony and tonogenesis in Jabêm. *Lingua* 49. 189–205.
- Brown, J. Marvin. 1975. The great tone split: Did it work in two different ways? In Jimmy G. Harris & James R. Chamberlain (eds.) *Studies in Tai linguistics in honor of William J. Gedney*, 33–48. Bangkok: Office of State Universities.
- Bruce, Gösta. 1977. *Swedish word accents in sentence perspective*. Lund: Gleerup.
- Bruce, Gösta. 1999. Word tone in Scandinavian languages. In Harry van der Hulst (ed.) *Word prosodic systems of the languages of Europe*. Berlin & New York: Mouton de Gruyter. 606–633.
- Bruce, Gösta & Eva Gårding. 1978. A prosodic typology for Swedish dialects. In Eva Gårding, Gösta Bruce & Robert Bannert (eds.) *Nordic prosody*, 219–228. Lund: Gleerup.
- Brunelle, Marc. 2005. Register in Eastern Cham: Phonological, phonetic, and sociolinguistic approaches. Ph.D. dissertation, Cornell University.
- Cassimjee, Farida. 1998. *IsiXhosa tonology: An optimal domains theory analysis*. Munich: Lincom Europa.
- Cassimjee, Farida & Charles W. Kisseberth. 1998. Depressor consonants in Mijikenda and Nguni. *Proceedings of the Annual Meeting, Berkeley Linguistics Society* 18. 26–40.
- Collier, René. 1975. Physiological correlates of intonation patterns. *Journal of the Acoustical Society of America* 58. 249–255.
- Connell, Bruce. 2002. Tone languages and the universality of intrinsic F0: Evidence from Africa. *Journal of Phonetics* 30. 101–129.
- Denning, Keith. 1989. The diachronic development of phonological voice quality, with special reference to Dinka and other Nilotic languages. Ph.D. dissertation, Stanford University.
- Diffloth, Gérard. 1989. Proto-Austroasiatic creaky voice. *Mon-Khmer Studies* 15. 139–154.
- Donnelly, Simon. 2009. Tone and depression in Phuthi. *Language Sciences* 31. 161–178.
- Donohue, Mark. 1997. Tone systems in New Guinea. *Linguistic Typology* 1. 347–386.
- Donohue, Mark. 2005. Tone and the Trans New Guinea languages. In Shigeki Kaji (ed.) *Cross-linguistic studies of tonal phenomena: Historical development, tone-syntax interface, and descriptive studies*. Tokyo: ILCAA. 33–54.
- Downing, Laura J. 2009. On pitch lowering not linked to voicing: Nguni and Shona group depressors (with an appendix by Thilo C. Schadeberg). *Language Sciences* 31. 179–198.
- Downing, Laura J. & Bryan Gick. 2005. Voiceless tone depressors in Nambya and Botswana Kalang'a. *Proceedings of the Annual Meeting, Berkeley Linguistics Society* 27. 65–80.
- Edmondson, Jerald A. & John H. Esling. 2006. The valves of the throat and their functioning in tone, vocal register and stress: Laryngographic case studies. *Phonology* 23. 157–191.
- Erickson, Donna, Kiyoshi Honda, Hiroyuki Hirai, Mary E. Beckman & Niimi Seiji. 1994. Global pitch range and the production of low tones in English intonation. *Proceedings of the 3rd International Conference on Spoken Language Processing*, 651–654. Yokohama: Acoustical Society of Japan.
- Ewan, William G. 1976. Laryngeal behavior in speech. Ph.D. dissertation, University of California, Berkeley.

- Gårding, Eva. 1977. *The Scandinavian word accents*. Lund: Gleerup.
- Gregerson, Kenneth J. 1976. Tongue-root and register in Mon-Khmer. In Philip Jenner, Laurence Thompson & Stanley Starosta (eds.) *Austroasiatic studies*. Honolulu: University Press of Hawaii. 323–369.
- Gussenhoven, Carlos. 2000a. The boundary tones are coming: On the non-peripheral realization of boundary tones. In Michael B. Broe & Janet B. Pierrehumbert (eds.) *Papers in laboratory phonology V: Acquisition and the lexicon*, 132–151. Cambridge: Cambridge University Press.
- Gussenhoven, Carlos. 2000b. On the origin and development of the Central Franconian tone contrast. In Aditi Lahiri (ed.) *Analogy, leveling, markedness: Principles of change in phonology and morphology*. Berlin & New York: Mouton de Gruyter. 215–260.
- Gussenhoven, Carlos & Gösta Bruce. 1999. Word prosody and intonation. In Harry van der Hulst (ed.) *Word prosodic systems of the languages of Europe*. Berlin & New York: Mouton de Gruyter. 233–271.
- Gussenhoven, Carlos & Jörg Peters. 2004. A tonal analysis of Cologne Schärfung. *Phonology* 21. 251–285.
- Halle, Morris & Kenneth N. Stevens. 1971. A note on laryngeal features. *MIT Research Laboratory of Electronics Quarterly Progress Report* 101. 198–213.
- Haudricourt, André-George. 1954a. Comment reconstruire le chinois archaïque. *Word* 10. 351–364.
- Haudricourt, André-George. 1954b. De l'origine des tons en vietnamien. *Journal Asiatique* 242. 69–82.
- Haudricourt, André-George. 1972. Two-way and three-way splitting of tonal systems in some Far Eastern languages. In Jimmy G. Harris & Richard B. Noss (eds.) *Tai phonetics and phonology*, 58–86. Bangkok: Central Institute of English Language.
- Henderson, Eugenie J. A. 1967. Grammar and tone in South-East Asian languages. *Wissenschaftliche Zeitschrift der Karl-Marx-Universität-Leipzig (Gesellschafts- und Sprachwissenschaftliche Reihe)* 1–2. 171–178.
- Hermans, Ben. 1999. A description of tonal accent in a Limburgian dialect. In Harry van der Hulst (ed.) *Word prosodic systems of the languages of Europe*. Berlin & New York: Mouton de Gruyter. 633–658.
- Hirose, Hajime, C.-Y. Lee & Tatsujiro Ushijima. 1974. Laryngeal control in Korean stop production. *Journal of Phonetics* 2. 145–152.
- Hirose, Hajime, Hea Suk Park, Hirohide Yoshioka, Masayuki Sawashima & Hiroyuki Umeda. 1981. An electromyographic study of laryngeal adjustments for the Korean stops. *Annual Bulletin, Research Institute of Logopedics and Phoniatrics, University of Tokyo* 15. 31–43.
- Hombert, Jean-Marie. 1977. Consonant types, vowel height, and tone in Yoruba. *Studies in African Linguistics* 8. 173–190.
- Hombert, Jean-Marie. 1978. Consonant types, vowel quality, and tone. In Victoria A. Fromkin (ed.) *Tone: A linguistic survey*. New York: Academic Press. 77–111.
- Hombert, Jean-Marie, John J. Ohala & William G. Ewan. 1979. Phonetic explanations for the development of tones. *Language* 55. 37–58.
- Honda, Kiyoshi, Hiroyuki Hirai, Shinobu Masaki & Yasuhiro Shimada. 1999. Role of vertical larynx movement and cervical lordosis in F0 control. *Language and Speech* 42. 401–411.
- Huffman, Franklin. 1976. The register problem in fifteen Mon-Khmer languages. In Philip Jenner, Laurence Thompson & Stanley Starosta (eds.) *Austroasiatic studies*. Honolulu: University Press of Hawaii. 575–589.
- Hyman, Larry M. 2008. Enlarging the scope of phonologization. *University of California Berkeley Phonology Lab Annual Report*. 382–409.
- Itô, Junko & Armin Mester. 1997. Stø?det i dansk. Handout, Scandinavian Summer School in Generative Phonology, HvalfjarDarströnd.

- Jessen, Michael & Justus Roux. 2002. Voice quality differences associated with stops and clicks in Xhosa. *Journal of Phonetics* 30. 1–52.
- Jun, Sun-Ah. 1996. Influence of microprosody on macroprosody: A case of phrase-initial strengthening. *University of California Los Angeles Working Papers in Phonetics* 92. 97–116.
- Kagaya, Ryohei. 1974. A fiberoptic and acoustic study of the Korean stops, affricates, and fricatives. *Journal of Phonetics* 2. 161–180.
- Kang, Kyoung-Ho & Susan G. Guion. 2008. Clear speech production of Korean stops: Changing phonetic targets and enhancement strategies. *Journal of the Acoustical Society of America* 124. 3909–3917.
- Kehrein, Wolfgang. 2007. There's no tone in Cologne: Against tone segment interactions in Franconian. Unpublished ms., University of Amsterdam.
- Kingston, John. 1985. The phonetics and phonology of the timing of oral and glottal events. Ph.D. dissertation, University of California, Berkeley.
- Kingston, John. 1990. Articulatory binding. In John Kingston & Mary E. Beckman (eds.) *Papers in laboratory phonology I: Between the grammar and physics of speech*, 406–434.
- Kingston, John. 1991. Integrating articulations in the perception of vowel height. *Phonetica* 48. 149–179.
- Kingston, John. 1992. The phonetics and phonology of perceptually motivated articulatory coordination. *Language and Speech* 35. 99–113.
- Kingston, John. 2005. The phonetics of Athabaskan tonogenesis. In Sharon Hargus & Keren Rice (eds.) *Athabaskan prosody*. Amsterdam & Philadelphia: John Benjamins. 137–184.
- Kingston, John. 2007. Segmental influences on F0: Automatic or controlled? In Carlos Gussenhoven & Tomas Riad (eds.) *Tones and tunes, vol. 2: Experimental studies in word and sentence prosody*, 171–210. Berlin & New York: Mouton de Gruyter.
- Kingston, John & Randy L. Diehl. 1994. Phonetic knowledge. *Language* 70. 419–454.
- Kingston, John & Randy L. Diehl. 1995. Intermediate properties in the perception of distinctive feature values. In Bruce Connell & Amalia Arvaniti (eds.) *Papers in laboratory phonology IV: Phonology and phonetic evidence*, 7–27. Cambridge: Cambridge University Press.
- Kingston, John & David Solnit. 1989. The inadequacy of underspecification. *Papers from the Annual Meeting of the North East Linguistic Society* 19. 264–278.
- Kingston, John, Randy L. Diehl, Cecilia J. Kirk & Wendy A. Castleman. 2008. On the internal perceptual structure of distinctive features: The [voice] contrast. *Journal of Phonetics* 36. 28–54.
- Krauss, Michael E. 2005. Athabaskan tone. In Sharon Hargus & Keren Rice (eds.) *Athabaskan prosody*. Amsterdam & Philadelphia: John Benjamins. 51–136.
- Ladd, D. Robert & Kim E. A. Silverman. 1984. Vowel intrinsic pitch in connected speech. *Phonetica* 41. 31–40.
- Lahiri, Aditi, Tomas Riad & Haike Jacobs. 1999. Diachronic prosody. In Harry van der Hulst (ed.) *Word prosodic systems of the languages of Europe*. Berlin & New York: Mouton de Gruyter. 335–421.
- Lahiri, Aditi, Allison Wetterlin & Elisabet Jönsson-Steiner. 2005. Lexical specification of tone in North Germanic. *Nordic Journal of Linguistics* 28. 61–96.
- Leer, Jeff. 1979. *Proto-Athabaskan verb stem variation. I: Phonology*. Fairbanks: University of Alaska, Alaska Native Language Center.
- Leer, Jeff. 1999. Tonogenesis in Athabaskan. In Shigeki Kaji (ed.) *Cross-linguistic studies of tonal phenomena: Tonogenesis, typology, and related topics*. Tokyo: ILCAA. 37–66.
- Leer, Jeff. 2001. Shift of tonal markedness in Northern Tlingit and Southern Athabaskan. In Shigeki Kaji (ed.) *Cross-linguistic studies of tonal phenomena: Tonogenesis, Japanese accentology, and other topics*, 61–89. Tokyo: ILCAA.
- Lieberman, Anatoly. 1982. *Germanic accentology: The Scandinavian languages*. Minneapolis: University of Minnesota Press.

- Lindau, Mona. 1979. The feature expanded. *Journal of Phonetics* 7. 163–176.
- Löfqvist, Anders & Hirohide Yoshioka. 1980. Laryngeal activity in Swedish obstruent clusters. *Journal of the Acoustical Society of America* 68. 792–801.
- Löfqvist, Anders, Thomas Baer, Nancy McGarr & Robin Seider Story. 1989. The cricothyroid muscle in voicing control. *Journal of the Acoustical Society of America* 85. 1314–1321.
- Maddieson, Ian. 1978. Universals of tone. In Joseph H. Greenberg, Charles A. Ferguson & Edith A. Moravcsik (eds.) *Universals of human language*, vol. 2: *Phonology*, 335–365. Stanford: Stanford University Press.
- Maddieson, Ian. 1984. The effects on F0 of a voicing distinction in sonorants and their implications for a theory of tonogenesis. *Journal of Phonetics* 12. 9–15.
- Maddieson, Ian. 2003. The sounds of Bantu languages. In Derek Nurse & Gérard Phillipson (eds.) *The Bantu languages*, 15–41. London: Routledge.
- Maddieson, Ian & Keng-Fong Pang. 1993. Tone in Utsat. *Oceanic Linguistics Special Publications* 24. 75–89.
- Matisoff, James A. 1972. *The Loloish tonal split revisited*. Berkeley: University of California.
- Matisoff, James A. 1973. Tonogenesis in Southeast Asia. In Larry M. Hyman (ed.) *Consonant types and tone*. Los Angeles: University of Southern California. 71–95.
- Mazaudon, Martine. 1977. Tibeto-Burman tonogenetics. *Linguistics of the Tibeto-Burman Area* 3. 1–123.
- Mazaudon, Martine. 1978. Consonantal mutation and tonal split in the Tamang sub-family of Tibeto-Burman. *Kailash* 6. 157–179.
- Mazaudon, Martine. Forthcoming. Paths to tone in the Tamang branch of Tibeto-Burman (Nepal). In Gunther de Vogelaer & Guido Seiler (ed.) *Dialects as a testing ground for theories of language change*. Amsterdam & Philadelphia: John Benjamins.
- Mazaudon, Martine & Alexis Michaud. 2008. Tonal contrasts and initial consonants: A case study of Tamang, a “missing link” in tonogenesis. *Phonetica* 65. 231–256.
- Mei, Tsu-lin. 1970. Tones and prosody in Middle Chinese and the origin of the Rising tone. *Harvard Journal of Asian Studies* 30. 86–100.
- Morén, Bruce. 2006. Here/now versus there/then: Synchrony and diachrony in Scandinavian pitch accent. Paper presented at the 28th Generative Linguistics in the Old World Conference, Geneva.
- Moreton, Elliott. 2004. Non-computable functions in Optimality Theory. In John J. McCarthy (ed.) *Optimality Theory in phonology*, 141–164. Oxford: Blackwell.
- Moreton, Elliott. 2008a. Learning bias as a factor in phonological typology. *Proceedings of the West Coast Conference on Formal Linguistics* 26. 393–401.
- Moreton, Elliott. 2008b. Modeling modularity bias in phonological pattern learning. *Proceedings of the West Coast Conference on Formal Linguistics* 27. 1–16.
- Moreton, Elliott, Gary Feng & Jennifer L. Smith. 2008. Syllabification, sonority, and perception: New evidence from a language game. *Papers from the Annual Regional Meeting, Chicago Linguistic Society* 41. 341–355.
- Ohala, John J. 1973. The physiology of tone. In Larry M. Hyman (ed.) *Consonant types and tone*. Los Angeles: University of Southern California. 1–14.
- Ohala, John J. & Brian Eukel. 1987. Explaining the intrinsic pitch of vowels. In R. Channon L. Shockey (ed.) *In honour of Ilse Lehiste*, 207–215. Dordrecht: Foris.
- Ohala, John J. & Carol J. Riordan. 1979. Passive vocal tract enlargement during voiced stops. In Jared J. Wolf & Dennis H. Klatt (eds.) *Speech communication papers*, 89–92. New York: Acoustical Society of America.
- Phu, Van Han, Jerold A. Edmondson & Kenneth J. Gregerson. 1992. East Cham as a tone language. *Mon-Khmer Studies* 20. 31–43.
- Pulleyblank, Edwin G. 1962. The consonantal system of Old Chinese. *Asia Major, Series 2*, 9. 58–144, 206–265.
- Peterson, Niels R. 1978. Intrinsic fundamental frequency of Danish vowels. *Journal of Phonetics* 6. 177–189.

- Riad, Tomas. 1998. The origin of Scandinavian tone accents. *Diachronica* 15. 63–98.
- Riad, Tomas. 2000. The origin of the Danish *stød*. In Aditi Lahiri (ed.) *Analogy, leveling, markedness: Principles of change in phonology and morphology*. Berlin & New York: Mouton de Gruyter. 261–300.
- Riad, Tomas. 2003. Diachrony of the Scandinavian accent typology. In Paula Fikkert & Haike Jacobs (eds.) *Development in prosodic systems*, 91–144. Berlin & New York: Mouton de Gruyter.
- Ross, Malcolm D. 1993. Tonogenesis in the North Huon Gulf Chain. *Oceanic Linguistics Special Publications* 24. 133–153.
- Ross, Malcolm D. 2005. Towards a reconstruction of the history of tone in the Trans New Guinea family. In Shigeki Kaji (ed.) *Cross-linguistic studies of tonal phenomena: Historical development, tone–syntax interface, and descriptive studies*. Tokyo: ILCAA. 3–31.
- Rycroft, David K. 1980. *The depression feature in Nguni languages and its interaction with tone*, vol. 8. Grahamstown: Department of African Languages, Rhodes University.
- Rycroft, David K. 1983. Tone patterns in Zimbabwean Ndebele. *Bulletin of the School of Oriental and African Studies, University of London* 46. 77–135.
- Sagart, Laurent. 1999. The origin of Chinese tones. In Shigeki Kaji (ed.) *Cross-linguistic studies of tonal phenomena: Tonogenesis, typology, and related topics*. Tokyo: ILCAA. 91–103.
- Schachter, Paul. 1976. An unnatural class of consonants in Siswati. *Studies in African Linguistics*. Suppl. 6. 211–220.
- Schuh, Russell. 1978. Tone rules. In Victoria A. Fromkin (ed.) *Tone: A linguistic survey*. New York: Academic Press. 221–256.
- Silva, David J. 2006. Acoustic evidence for the emergence of tonal contrast in contemporary Korean. *Phonology* 23. 287–308.
- Solnit, David & John Kingston. 1988. Voiced high splits: Putting the blame on sonorants. Paper presented at the 63rd Annual Meeting of the Linguistic Society of America, New Orleans.
- Steele, Shirley A. 1986. Interaction of vowel F0 and prosody. *Phonetica* 43. 92–105.
- Stevens, Kenneth N. & Sheila E. Blumstein. 1981. The search for invariant acoustic correlates of phonetic features. In Peter D. Eimas & Joanne L. Miller (eds.) *Perspectives on the study of speech*, 1–38. Mahwah, NJ: Lawrence Erlbaum.
- Strazny, Philipp. 2003. Depression in Zulu: Tonal effects of segmental features. In Jeroen van de Weijer, Vincent J. van Heuven & Harry van der Hulst (eds.) *The phonological spectrum: Segmental structure*, vol. 1, 223–239. Amsterdam & Philadelphia: John Benjamins.
- Suwilai, Premsrirat. 2003. Khmu dialects: A case of register complex and tonogenesis. In Shigeki Kaji (ed.) *Cross-linguistic studies of tonal phenomena: historical development, phonetics of tone, and descriptive studies*. Tokyo: ILCAA. 13–28.
- Svantesson, Jan-Olof. 1989. Tonogenetic mechanisms in northern Mon-Khmer. *Phonetica* 46. 60–79.
- Thongkum, Theraphan L. 1987. Phonation types in Mon-Khmer languages. *University of California Los Angeles Working Papers in Phonetics* 76. 29–48.
- Thurgood, Graham. 1999. *From ancient Cham to modern dialects: Two thousand years of language contact and change*. Honolulu: University of Hawai'i Press.
- Thurgood, Graham. 2002. Vietnamese and tonogenesis. *Diachronica* 19. 333–363.
- Traill, Anthony. 1990. Depression without depressors. *South African Journal of African Languages* 10. 166–172.
- Traill, Anthony, James S. M. Khumalo & Paul Fridjhon. 1987. Depressing facts about Zulu. *African Studies* 46. 255–274.
- Wang, Li. 1958. *Hanyu shi gao*. [A sketch of the history of the Han (Chinese) language.] Beijing: Kezue Chubanshe.
- Westbury, John R. 1983. Enlargement of the supraglottal cavity and its relation to stop consonant voicing. *Journal of the Acoustical Society of America* 73. 1322–1336.



- Whalen, Douglas & Andrea G. Levitt. 1995. The universality of intrinsic F0 of vowels. *Journal of Phonetics* 23. 349–366.
- Whalen, Douglas, Bryan Gick, Masanobu Kumada & Kiyoshi Honda. 1999. Cricothyroid activity in high and low vowels: Exploring the automaticity of intrinsic F0. *Journal of Phonetics* 27. 125–142.
- Yoshioka, Hirohide, Anders Löfqvist & Hajime Hirose. 1981. Laryngeal adjustments in the production of consonant clusters and geminates in American English. *Journal of the Acoustical Society of America* 70. 1615–1623.
- Zee, Eric. 1980. Tone and vowel quality. *Journal of Phonetics* 8. 247–258.

