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*A prosodic theory of laryngeal contrasts**

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Current models of laryngeal licensing allow as many laryngeal contrasts within a syllable as there are segments, at least in principle. We show here that natural languages are much more economical in their use of laryngeal contrasts than segmental models would lead us to expect. Specifically, we show that voicing, aspiration and glottalisation occur at most once per onset, nucleus or coda in a given language, and that the order in which they are produced within onset, nucleus and coda is never contrastive. To account for these restrictions, we propose that laryngeal features are properties not of segments, but of the onsets, nuclei and codas that dominate them.

Phonetic transcription allows us to put in square brackets many things that languages do not actually make use of, such as aspirated glottal stops [ʔʰ] or creaky-voice *h* [h̰]. It also allows us to posit unattested contrasts like pre- *vs*. postglottalised nasals [ˀm] *vs*. [mˀ] or breathy-creaky *vs*. creaky-breathy phonation [a̤ḛ] *vs*. [a̰e̤] and to entertain what seem to be purely orthographic distinctions like [pha] *vs*. [pʰa]. We show here that natural language does not use such refined distinctions, and that a restrictive theory of laryngeal features treats them as properties of syllable margins and nuclei, not as properties of individual consonants and vowels.

Following Ladefoged & Maddieson (1996: 2), our study focuses on the elements 'that are known to distinguish lexical items within a language', i.e. on laryngeal contrasts involving voicing, aspiration and glottalisation that account for minimal pairs.[1] The facts that we present here suggest

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[1] Following much work in the area, we assume that tone is licensed prosodically as well as autosegmental theory has shown (Odden 1995, Yip 1995 and references therein). But tones can be licensed by individual moras, so that rising and falling

that natural languages allow for at most a single unordered set of laryngeal features per margin or nucleus, *whatever* the number of segments in that domain. For this reason, we propose that:

(1) An onset, nucleus or coda has a single unordered set of laryngeal features.

The idea that laryngeal features may characterise prosodic levels above the segment is not new of course (Harris 1944, Firth 1948, 1957, Goldsmith 1990, Bagemihl 1991). What is novel is our claim that laryngeal features only characterise prosodic levels above the segment; segments never license these laryngeal features on their own. A number of predictions follow from this claim that do not follow from segmental or subsegmental accounts of laryngeal licensing. Specifically, we expect to find:

(2) a. *No conflicting laryngeal contrasts within a margin or nucleus*
  i. *not margins in any language*
   ^{h}p’   hˀ   hpʔ hʔ   p^{h}t’ p’t^{h}
  ii. *not nuclei in any language*
   a̰͡a̤   a̤͡a̰   haʔ ʔah   a̰i̤   a̤ḭ
 b. *No pre/post contrasts within a margin or nucleus*
  i. *no contrasts in margins in any language*
   ^{h}p ~ p^{h} hp ~ ph   p^{h}t ~ pt^{h}
   ˀp ~ p’   ʔp ~ pʔ   p’t ~ pt’
  ii. *no contrasts in nuclei in any language*
   a̤͡a ~ a͡a̤   ha ~ ah   a̤i ~ ai̤
   a̰͡a ~ a͡a̰   ʔa ~ aʔ   a̰a ~ aa̰
 c. *No segment/cluster contrasts within a margin or nucleus*
  i. *no contrasts in margins in any language*
   p^{h} ~ ph   pt^{h} ~ pth
   p’ ~ pʔ   pt’ ~ ptʔ
  ii. *no contrasts in nuclei in any language*
   a̤ ~ ah   a̤i ~ ahi
   a̰ ~ aʔ   a̰i ~ aʔi

We give a few examples of laryngealised onsets below to illustrate how our prosodic treatment of laryngeal features models the restrictions in (2); identical representations hold for laryngeal features in nuclei and codas, where each nucleus and coda dominates a single laryngeal node that is phonologically unordered with respect to any speech sounds (root nodes)

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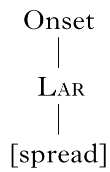
tones contrast within a nucleus. As we will see, this is *not* found with creaky and breathy voice, even on long vowels and diphthongs, suggesting that moras and rhymes license tone and register (Lin 1999), while onsets, nuclei and codas license voicing, aspiration and glottalisation.

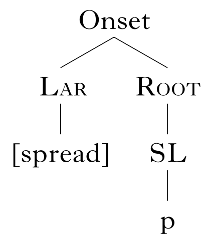
in that nucleus or coda. We abbreviate featural representations here, to focus on our claim that each onset (or nucleus or coda) has a single set of laryngeal features:

(3) *Laryngeal features licensed prosodically*

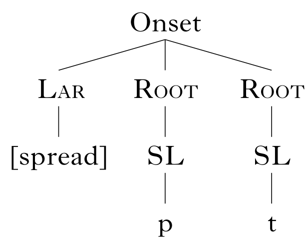
a. [h]



b. [p^h ^hp ph hp]



c. [p^ht^h p^ht pt^h ^hpt pth pht phth]



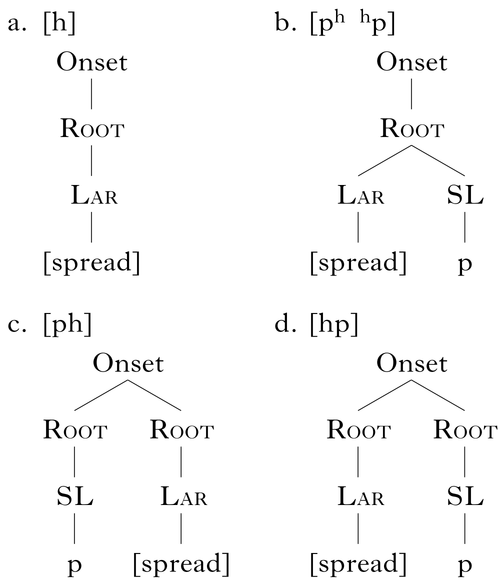
The tree in (3a) shows what is traditionally treated as the laryngeal segment [h], a simple onset with the laryngeal feature [spread] and no supralaryngeal specifications, like the first sound in *hat*. If a simple onset has a single laryngeal node, we rule out glottalised *h* [$h^ʔ$] and aspirated glottal stop [$ʔ^h$], using feature co-occurrence restrictions against [spread] and [constricted] familiar from previous work (e.g. Lombardi 1991, 1995b).

The tree in (3b) shows [spread] linked to an onset with a labial stop [p]; we intend no temporal ordering between the laryngeal node and the root node that is its sister. According to our proposal in (1), this phonological representation covers both aspirated stops [p^h ^hp] and clusters made up of a stop + *h* [ph hp], since aspiration ([^{h}]) and *h* ([h]) are indistinguishable under our account, as both consist of a [spread] specification directly linked to the onset. This models (2b) and (c) above: no language contrasts pre- and postaspirated sounds (^hp *vs.* p^h; hp *vs.* ph), which are phonologically indistinguishable, however distinct they may be phonetically. No language contrasts laryngealised segments and laryngeal clusters (^hp *vs.* hp; p^h *vs.* ph), because there is no distinct way of representing them phonologically either.

(3c) shows [spread] with a complex onset [pt]: it differs from (3a) and (3b) by successive addition of supralaryngeal articulations, but does not differ with respect to laryngeals. Given at most one set of laryngeal features per onset, nucleus and coda, there is no way to multiply laryngeal features in complex constituents by increasing the number of segments. Thus (3c) represents not only [p^ht^h pt^h], but also [phth], [pth] and a number of other non-contrasting sounds. This models (2) for complex constituents: no language allows for contrastive ordering or conflicting laryngeal features in complex onsets, nuclei or codas. This rules out the tautosyllabic laryngeal clusters [hʔ] and [ʔh], and does so without further stipulation.

We may contrast this prosodic approach to a more traditional approach in which each *segment* bears its own set of laryngeal features (e.g. Clements 1985, McCarthy 1988, Keyser & Stevens 1994):

(4) *Laryngeal features licensed segmentally*

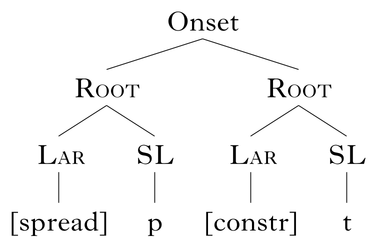


Segmental and prosodic licensing make identical predictions for pure laryngeal sounds like [h] (4a) and for laryngealised sounds like [p^h ^hp] (4b). Existing segmental models rule out glottalised *h* and aspirated glottal stop with feature co-occurrence restrictions, and rule out pre- *vs*. postaspiration contrasts by assuming that the laryngeal features within a segment may not be contrastively ordered. But segmental models make markedly different predictions for laryngeal clusters (4c, d). Segmental licensing of laryngeal features is compatible with a three-way phonological contrast among (4b–d), such that [p^hat phat hpat] might constitute a minimal triple in some language. The prosodic approach we propose here is not compatible with such a contrast.

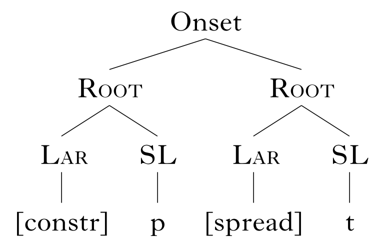
Segmental licensing makes markedly different predictions for complex constituents of the type in (3c) as well: if every sound can host its own laryngeal specification, segmental licensing allows tautosyllabic clusters like $[\text{p}^{\text{h}}\text{t'a}]$ or $[\text{p't}^{\text{h}}\text{a}]$, where adjacent consonants in an onset have conflicting laryngeal features:

(5) *Unattested complex onsets*

a. $[\text{p}^{\text{h}}\text{t'}]$



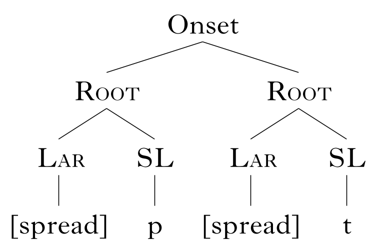
b. $[\text{p't}^{\text{h}}]$



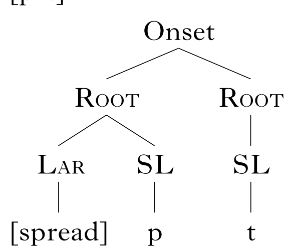
Such onsents do not seem to occur in the languages of the world. Segmental licensing also allows three-way contrasts like the following, where $[\text{p}^{\text{h}}\text{t}^{\text{h}}\text{a}]$, $[\text{p}^{\text{h}}\text{ta}]$ and $[\text{pt}^{\text{h}}\text{a}]$ constitute a minimal triple:

(6) *Unattested contrasts in complex onsets*

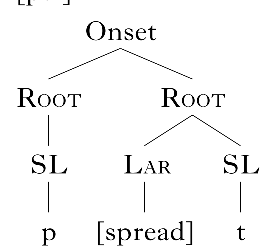
a. $[\text{p}^{\text{h}}\text{t}^{\text{h}}]$



b. $[\text{p}^{\text{h}}\text{t}]$



c. $[\text{pt}^{\text{h}}]$



Again, our prosodic approach is not compatible with such contrasts.

We note here at the outset that our results are not meant to argue for a particular set of laryngeal features. We use [voice, spread, constricted] instead of e.g. [glottal tension, glottal width, glottal height] (Avery & Idsardi 2001), but we expect that our claims will hold either way. In this paper, we will focus on what licenses features rather than the set of features so licensed.[2]

In what follows we motivate the general claim that the laryngeal contrasts found in languages do not increase with the segmental complexity of the margin or nucleus: simple and complex margins and nuclei show essentially the same range of laryngeal options (§1). We then substantiate the three more specific claims in §§2–4, consider those languages that look problematic for our proposals (§5) and end with theoretical implications of our results (§6).

1 Complex margins and nuclei are laryngeally simple

Simple margins can have up to six distinct types of contrastive laryngeal setting: plain, voiced, aspirated, breathy, ejective and implosive (Halle & Stevens 1971, Ladefoged 1973, Lombardi 1991, Iverson & Salmons 1995). These can be analysed with three privative features, [spread], [constricted] and [voice], and a co-occurrence restriction against the antagonistic combination [spread, constricted]. The full range of six contrasts is found only with stops:[3]

	∅	spread	constr	voice	spread voice	constr voice
Beja	t	tʰ	ʔ͡t	d	d̤	d̰
Owerri Igbo	t	tʰ	t’	d	d̤	ɗ
Zhu|’hõasi	k	kʰ	k’	g	ᶢkʰ	ᶢk’
!Xóõ	ts	tsʰ	ts’	dz	ᵈtsʰ	ᵈts’

Table I
Languages with six laryngeal series of stops.

Sonorant consonants and vowels lack distinctive [voice] (Cho 1991, Lombardi 1991), so the maximal number of laryngeal contrasts in

[2] An anonymous reviewer points out that some of our findings may not be compatible with treating both tone and voicing in terms of [stiff] and [slack] (Halle & Stevens 1971), as this makes it hard to see why we find contrastive tonal contours within nuclei (áì *vs.* àí) but no contrastive breathy or creaky contours (a̤ḭ *vs.* a̰i̤). We leave this to future research.

[3] In the tables that follow, languages are included which show a contrast at at least one place of articulation. For simplicity, we show the contrasts using coronals ([a] for vowels), but this should not be taken to imply that only coronals show these contrasts. Labials and velars are given when coronals fail to show the maximal number of contrasts, as in Zhu|’hõasi below.

sonorant consonants (4) and vowels (5) is reduced to three: modal (∅), [spread] and [constricted]:

	∅	spread	constr	*voice	*spread voice	*constr voice
Klamath, Zhu|'hõasi	m	m̤	m̰	*	*	*
Mazatec, Sedang	n	n̥n	n̰n	*	*	*
Sui	n	n̥	ˀn	*	*	*

Table II
Languages with three laryngeal series of sonorants.

	∅	spread	constr	*voice	*spread voice	*constr voice
Green Mong, White Hmong	a	a̤	a̰	*	*	*
Jalapa Mazatec	a	a̤a	a̰a	*	*	*
Trique	a	aḁa	aˀa	*	*	*

Table III
Languages with three laryngeal series of vowels.

Fricatives co-occur with all three laryngeal features, but we find no language that contrasts aspirated or glottalised fricatives with their voiced aspirated and voiced glottalised counterparts respectively. Fricatives disallow the complex laryngeal configurations [spread, voice] (Vaux 1998) and [constricted, voice], yielding a maximum of four laryngeal series. As shown below, all four series are needed to describe the attested patterns; but we have not been able to find a single language with a four-way laryngeal contrast.[4] The Bzhedugh and Shapsugh dialects of Adyghe (Chirikba 1996, Michael Job, personal communication) come closest to such a situation: all four laryngeal configurations are attested in these dialects, but no more than three are used at a given place of articulation. We leave the lack of a pure four-way laryngeal contrast for fricatives as an accidental gap that more research will hopefully fill.

[4] According to the structuralist analysis in Spotts (1953), Mazahua (Otomí) has four alveolar 'phonemes': /s z sʰs'/. But when we look at what sounds actually *contrast* we find that Mazahua has no underlying /z/ (Bartholomew 1975, Rensch 1976).

	∅	spread	constr	voice	*spread voice	*constr voice
Burmese	s	sʰ		z	*	*
Amharic, Hausa, Dakota	s		s’	z	*	*
Abzakh Adyghe	ɕ		ɕ’	ʑ	*	*
Chumash, Mazahua	s	sʰ	s’		*	*
Bzhedugh and Shapsugh Adyghe	ɕ ʂ	 ʂʰ	ɕ’	ʑ ʐ	*	*

Table IV
Languages with three laryngeal series with fricatives.

The laryngeals [spread] and [constricted] appear alone in margins in many languages as [h] and [ʔ], e.g. Hawaiian [haʔa] ‘dance’, [ʔaʔa] ‘dare’, [aʔa] ‘vein’ (Pukui & Elbert 1971). But [voice] never appears alone in a margin, and needs some sort of carrier to be perceived.

Voiced [ɦ] is a free or contextual variant of [h] in some languages (cf. English *a*[ɦ]*ead*), but it occurs as the sole or primary realisation of a single [spread] series in others, like Hadza (Sands *et al*. 1993), Wichita (Rood 1975), Gujarati (Cardona 1965: 29), Hindi, Kashmiri, Punjabi, Kharia, !Xũ (Maddieson 1984), Northern Sotho (Louwrens *et al*. 1995), Shona (Carter & Kahari 1979), Gẽ) (Ladefoged 1964), Dutch (Booij 1995) and Czech (Dankovičová 1997). [h] and [ɦ] reportedly contrast in Zulu (Traill *et al*. 1987), SiSwati (Bradshaw 1999), Musey (Shryock 1995) and Wu (Cao & Maddieson 1992).

Voiced glottal stop is extremely rare but something like it occurs here and there:

> In the great majority of languages we have heard, glottal stops are apt to fall short of complete closure, especially in intervocalic positions. In place of a true stop, a very compressed form of creaky voice or some less extreme form of stiff phonation may be superimposed on the vocalic stream. (Ladefoged & Maddieson 1996: 75)

Gimi (Lloyd *et al*. 1981) is the only language reported to contrast creaky voice in this way (Peter Ladefoged and Ian Maddieson, personal communication); we represent the ‘voiced glottal stop’ as [ʔ̬]:

	∅	spread	constr	*voice	spread voice	constr voice
Hupa, Tlingit, Klamath, Sedang, Chong, Popoloca, Hawaiian, Yuchi, Wikchamni	∅	h	ʔ	*		
Hadza, Wichita, Gujarati, !Xũ, Shona, Gɛ̃, Dutch, Czech	∅	ɦ	ʔ	*		
Zulu, SiSwati, Musey, Wu	∅	h		*	ɦ	
Gimi	∅		ʔ	*		ʔ̰

Table V
Contrastive series of 'laryngeal segments'.

There is of course a wide range of phonetic variation among these sounds, primarily in terms of vertical larynx movement, extent of glottal opening and timing of laryngeal and supralaryngeal gestures; but none of this is *contrastive*. Contrast is best modelled by [voice], [spread] and [constricted], which are both necessary and sufficient to generate all attested laryngeal contrasts and exclude all non-existing contrasts within simple onsets, nuclei and codas.

When we turn to complex margins and nuclei, we find that they allow *the same* (sometimes fewer) laryngeal contrasts as do simple margins and nuclei: the addition of extra consonants and vowels within a margin or nucleus does not open up additional laryngeal possibilities. Consonant clusters in a margin have the same range of laryngeal contrasts as single consonants, and diphthongs in a nucleus have the same range of laryngeal contrasts as monophthongs.[5] This is an unexpected finding from a segmental perspective, and it strongly suggests that there is a single set of laryngeal features per margin or nucleus, whether that margin or nucleus is simple or complex.

We start with examples from obstruent clusters in onsets and codas. In the following we show laryngeal series with simple margins in the first line of each row and those with complex margins in the second line. As might be expected, most of the data comes from onsets rather than codas, due to the universal distaste for complex margins in general and complex codas in particular.

[5] We use the term 'diphthong' here in a broad sense that includes any type of supralaryngeally complex nucleus without implying a monosegmental status (contrary to vowel sequences for instance). Crucially, whether or not phonologists choose to analyse nuclei like [ai au] as monosegmental or bisegmental has no influence on the number of laryngeal contrasts, because there is at most one set of laryngeal features.

	∅	spread	constr	voice	spread voice	constr voice
Polish, Lithuanian	t s kt pʂt^ʂ			d z gd bzd		
East Armenian, Ancient Greek	t kt	t^h k^{h}t^h		d gd		
Kabardian	p pχ	p^h p^{h}χ^h	p’ p’q’			
Adyghe	p pk	p^h pk^h	p’ pk’			
Klamath	p pq	p^h pq^h	p’ pq’			
!Xóõ	t	t^h χ tχ	t’ t’q^χ’	d	^{d}t^h ^{d}tχ	^{d}t’ ^{d}t’q^χ’

Table VI
Laryngeal contrasts in obstruent + obstruent margins.

(In !Xóõ, [χ] and clusters with [χ] behave as [spread] with respect to laryngeal co-occurrence restrictions between onsets and nuclei: *C^{h}V̤ and *(C)χV̤ (Traill 1985: 92ff). This is why we have put them in the spread column rather than the plain column to its left.) None of the languages has more laryngeal series for complex onsets than for simple onsets. Polish (Lombardi 1991, 1995a, Rochoń 2000) and Lithuanian (Ambrazas 1997), like other Balto-Slavic languages, contrast plain and voiced onsets, whether simplex or complex. Eastern Armenian and Ancient Greek contrast plain, voiced and aspirated stops, as well as plain, voiced and aspirated stop + stop onsets (Allen 1987). Kabardian (Colarusso 1989, 1992), Adyghe (Paris 1989)[6] and Klamath (Barker 1964) have plain, aspirated and glottalised simple and complex obstruent onsets, and !Xóõ (Traill 1985) has the full set of six laryngeal contrasts for simple stop onsets, and only a subset of those for clusters.

None of these languages, nor any other we have found, has any of the mixed clusters we would expect if laryngeals were properties of individual segments. None combines aspirated and glottalised stops in a complex onset or coda: *[p^{h}ɕ’ p’ɕ^h p’q^h t^{h}q^χ’], and none contrasts combinations of plain and laryngeally specified obstruents with their mirror image, i.e. */phɕ/ *vs.* /pɕ^h/, */p’ɕ/ *vs.* /pɕ’/, */gt/ *vs.* /kd/.

Comparing !Xóõ with Ancient Greek and Eastern Armenian, it is clear that the combinations [spread, voice] and [constricted, voice] are only possible in complex constituents if they occur in simple constituents

[6] Notice that ‘Caucasian languages’ are traditionally described as having plain, voiced and glottalised stops (and plain and voiced fricatives). Although it is not crucial to the argument here (though see § 5 on Georgian), we assume [p p^h p’] rather than [b p p’] for phonetic and phonological reasons (cf. Rice 1994 for a similar reanalysis of Athapaskan languages).

(!Xóõ), not as the result of combining consonants. Thus Greek and Armenian each use [spread] and [voice], but they disallow their combination in both simple onsets (*[d̤]) and complex onsets (*[dkʰ tʰg d̤g dgʱ]). This is the pattern in all languages we know of; it makes little sense if every consonant has its own laryngeal possibilities, but follows immediately if every margin does.

Phonetically, plain and voiced onsets are uniformly realised as plain [p s tk pq] or voiced [b z dg bzd] throughout in these languages for any number of segments, while [spread] and [constricted] show up either once per cluster [pqʰ pq’] (Adyghe, Klamath) or once per consonant [pʰqʰ p’q’] (Eastern Armenian, Ancient Greek,[7] Kabardian, !Xóõ). But no language contrasts the two possibilities, such that [pqʰa] and [pʰqʰa] could signal different things.

Notice that the [spread, voice] and [constricted, voice] clusters of !Xóõ have one instance of prevoicing followed by a single phase of laryngeal abduction or larynx raising (with or without release of the first consonant; Traill 1985: 154). Thus, laryngeal features in simple and complex onsets are phonetically identical even in !Xóõ: both simplex [ᵈtʰ] and complex [ᵈtχʰ] have voicing-then-aspiration, and both simplex [ᵈt’] and complex [ᵈt’qᵡ’] have voicing-then-glottalisation.

Laryngeal contrasts in complex margins with a stop and a sonorant behave similarly:

	∅	spread	constr	voice	spread voice	constr voice
Icelandic	p l pl	pʰ l̥ pl̥				
Nuxalk	qʷ l qʷl		qʷ’ l̰ qʷ’l̰			
Klamath	q l w ql qw	qʰ l̥ w̥ ql̥ qw̥	q’ l̰ w̰ q’l̰ q’w̰			
Bhojpuri (codas)	t n nt	tʰ nʰ ntʰ		d nd	dʱ ndʱ	

Table VII

Laryngeal contrasts in stop + sonorant margins.

All of these languages have parallel laryngeal series for simple and complex margins. Word-initial onsets in Icelandic (Friðjónsson 1984) are either plain [p l pl] or aspirated [pʰ l̥ pl̥], but we do not find a four-way laryngeal contrast in complex onsets, */pl pʰl pl̥ pʰl̥/, as might be expected if a different set of laryngeals were licensed by each segment. Even though

[7] The phonetics of [spread] clusters in Ancient Greek is a matter of speculation; we follow Allen (1987), who argues on orthographic grounds that both stops were separately released (and thus aspirated). In any case, the language clearly did not contrast [tʰkʰ] with [tkʰ] or [tʰk].

Icelandic has distinctively [spread] sonorants, it has the same binary laryngeal contrast in complex onsets as languages without such sounds, like English and German (Iverson & Salmons 1995, Jessen & Ringen 2002) or Faroese (Lockwood 1977, Petersen *et al*. 1998).

Nuxalk (‘Bella Coola’) has plain and glottalised stops and sonorants, as well as complex stop + sonorant onsets (Bagemihl 1991). The latter are either plain [q^{w}l] or glottalised [q$^{w’}$l̰], but never mixed [q$^{w’}$l] or [q^{w}l̰] (Nater 1984). Here again, complex onsets are specified as a whole for laryngeal features, not individually for each consonant.

Klamath has a three-way contrast for simple stops [q q^h q’] and sonorants [l l̥ l̰] and exactly the same three-way contrast for complex onsets with stop + sonorant clusters [ql ql̥ q’l̰].[8] We do not find single laryngeal features distinctively linked to individual consonants, */q^{h}l/ *vs.* /ql̥/ *vs.* /q^{h}l̥/, nor do we find onsets that contain both [spread] and [constricted], */q^{h}l̰ q’l̥/. Klamath has /h/ and /ʔ/ as well, but they do not occur in clusters. We do not find */t^{h}ʔ t’h hʔ ʔh/, all of which should be possible if laryngeals are segmental.

Bhojpuri (Shukla 1981) has four laryngeal series with stops, /t t^h d d^h/, and two with sonorants, /n n^h/. Once again, complex codas show the same laryngeal contrasts as simple stops, i.e. /nt nt^h nd nd^ɦ/. There are no [n^{h}t n^{h}t^h n^{h}d n^{h}d^ɦ] codas to contrast with them. Notice that complex codas in Bhojpuri are laryngeally identical to stop + liquid onsets in a language like Gujarati (Cardona 1965, Mistry 1997), [kr k^{h}r gr g^{ɦ}r], even though Gujarati has no [spread] sonorants. The richer segmental inventory of Bhojpuri does not lead to a richer onset inventory.

The phonetic timing of laryngeal features in stop + sonorant clusters is usually straightforward. Voicing is realised during stop closure, so that the distinctive voicing is not masked by the redundant voicing on sonorants. Aspiration and glottalisation are phased after stop closure for all the languages above, yielding voiceless and creaky voiced (or partially voiceless and creaky voiced) sonorants in complex onsets, [pl̥] and [p’l̰].

Languages with laryngeally specified sonorants and sonorant clusters in onsets or codas are exceedingly rare, but Klamath has them. Since sonorants do not support distinctive [voice], they allow for only three laryngeal series in Klamath, as do sonorant clusters:

	∅	spread	constr	*voice	*spread voice	*constr voice
Klamath	w l wl	w̥ l̥ wl̥	w̰ l̰ wl̰	*	*	*

Table VIII

Laryngeal contrasts in sonorant + sonorant margins.

[8] Barker (1964) and Blevins (1993) transcribe these clusters as /q’l/ and /q^{h}l/ respectively, but Barker (1964: 24) states that glottalised stops in stop + sonorant clusters have ‘a strong glottal release upon the following segment’, i.e. [q’l̰].

The transcriptions above suggest that the laryngeal gesture covers only the second sonorant in Klamath. But this timing issue is purely phonetic, not contrastive: Klamath has tautosyllabic [wl̥], but not *[w̥l̥] or *[w̥l].

What holds for complex margins is found with complex nuclei as well. In every language we have examined, complex nuclei have the same laryngeal contrasts as simplex nuclei. The number of vowels in a nucleus does not increase the number of available laryngeal contrasts:

	∅	spread	constr	*voice	*spread voice	*constr voice
Sedang	a iə iɔ		a̰ ḭə̰ ḭɔ̰	*	*	*
Gujarati	a ai au	a̤ a̤i̤ a̤ṳ		*	*	*
Green Mong, White Hmong	a ai ia	a̤ a̤i̤ i̤a̤	a̰ a̰ḭ ḭa̰	*	*	*

Table IX
Laryngeal contrasts in complex nuclei.

Sedang (Smith 1968) contrasts plain and [constricted] vowels, Gujarati (Cardona 1965, Mistry 1997) contrasts plain and [spread] vowels; Green Mong (Andruski & Ratliff 2000) and White Hmong have the full set of three laryngeal contrasts with vowels. In these languages, monophthongs and diphthongs allow the same laryngeal contrasts. A nucleus is either modal, breathy or creaky, but *never* contrastively modal-then-breathy, modal-then-creaky, breathy-then-creaky or the like, regardless of the number of vowels involved.

Thus a complex margin or nucleus allows the same laryngeal contrasts as a simple margin or nucleus. Phonetically, too, laryngeal features are realised in quite parallel ways in simple and complex constituents: [voice] usually extends throughout obstruents and obstruent clusters; [spread] and [constricted] are usually realised after stop closure but throughout vowels. We turn now to a more detailed look at the more specific claims in (2) and at some languages that are *prima facie* problematic.

2 No conflicting laryngeal contrasts within a margin or nucleus

Despite an extensive search, we have been unable to find a single language in which aspiration and glottalisation occur within the same onset, nucleus or coda. This is expected for simple margins and nuclei, because standard theory posits only a single set of laryngeal features per consonant or vowel. This rules out *[ˀtʰ ˀn͡n̥] and the like as simple margins and *[a̰͡a̤ e̤͡ḛ] and so on as monophthongs. More interesting is the lack of complex margins like *[p’t^{h} ʔtn̥], etc., and the lack of diphthongs like *[a̰i̥ e̤ṵ]. To rule these out we need to restrict the laryngeal possibilities of complex margins and nuclei to those of simple margins and nuclei, as proposed here.

In the rest of this section we address a number *of prima facie* counter-examples, none of which stands up to close scrutiny.

Western Popoloca is reported to have breathy-then-creaky complex onsets like [hʔ thʔ hnʔ] (Williams & Pike 1968). Complex onsets like these are compatible with segmental theories of laryngeal licensing, but not with ours, which prohibits aspiration and glottalisation in the same margin. But Steriade (1994) shows that postconsonantal [ʔ] in Western Popoloca is phonetically and phonologically a feature of the following nucleus, so that Williams & Pike’s [hʔe] ‘he’, [thʔéè] ‘his brains’ or [hnʔáa] ‘your (SG) hill’ are really [hḛ t^{h}ḛ́è n̥á̰a], with a breathy onset and a creaky nucleus. Steriade’s analysis explains the presence of [hʔ] and absence of *[ʔh] in Western Popoloca by limiting aspiration to the onset. It also removes at one stroke *all* the onsets in that language that seem to contain both aspiration and glottalisation.

According to Diffloth (1989), the Mon-Khmer language Chong has plain (Register 1), breathy (R2) and creaky (R3) vowels, plus one series of breathy-then-creaky vowels (R4). Our proposal rules out breathy-then-creaky nuclei entirely; segmental analysis rules out breathy-then-creaky *monophthongs*, but allows breathy-then-creaky *diphthongs*. But another analysis is available, which does not require both [spread] and [constricted] in the nucleus. Huffman (1985) and Silverman (1995) treat the glottalisation of R3 and R4 as a property of the coda. According to Silverman (1995: 44):

> Chong possesses both breathy and creaky vowels. But while breathy vowels enjoy a relatively free distribution with respect to other elements of the root syllable, creaky vowels may be present ONLY when a supralaryngeally-articulated coda consonant is present as well. Moreover, while creakiness overlaps with post-vocalic consonants, it is purely vocalic in the context of a postvocalic stop; vowel laryngealization here may be viewed, in effect, as the realization of a glottalized stop.

Their analysis is superior to Diffloth’s because it explains why Chong lacks syllables that are creaky-then-breathy: nuclei may be plain or breathy, but not creaky; codas may be plain or creaky, but not breathy. The missing creaky-then-breathy register would require a creaky nucleus and a breathy coda, neither of which is possible. If Huffman and Silverman are right, Chong never has conflicting laryngeal features with a nucleus, bringing it in line with prosodic licensing of laryngeal features. Chong does of course allow conflicting laryngeal features within a *rhyme* (across nucleus and coda), but this does not conflict with any proposals we know of in the literature. Diffloth (1989: 145) cites two related languages, Samrê and Son, with the same contrasts in related words; it appears that these languages can be treated with creaky codas as well.

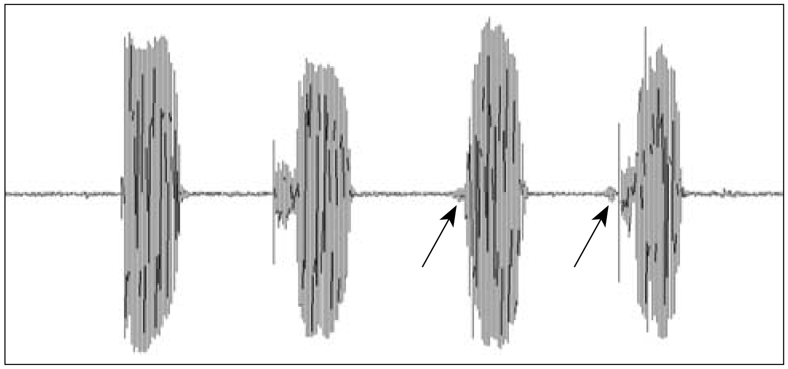


Figure 1
Voicing in White Hmong.

Our last problematic case involves a preglottalised postaspirated stop [ˀtʰ], reported by Heimbach (1979) for White Hmong. This sound, written *dh* in Hmong orthography, would require creaky-then-breathy in the same consonant. It violates standard accounts of laryngeal licensing, which prohibit conflicting laryngeals within a segment, and it violates our proposal, which prohibits conflicting laryngeals within any onset, simple or complex. But, as the waveform comparison of orthographic *to, tho, do, dho* in Fig. 1 shows, the closure in the 'preglottalised' sounds is simply *voicing*. (Our speaker is a 35-year old native speaker of White Hmong now living in central California.) We have indicated the 40 ms or so of voicing in the final two cases with arrows. Heimbach provides no grounds for claiming that these sounds are anything but voiced, so we treat them here as [d] and [dʰ], involving [spread] and [voice], as suggested by the orthography. What is interesting about White Hmong is thus how the laryngeal features are linearised, with [voice] realised during closure and [spread] realised upon release; but the combination of laryngeal features is not problematic.

To summarise, none of the cases before us actually seems to involve conflicting laryngeals within a margin or nucleus. Standard theory is adequate for ruling out breathy-then-creaky monophthongs in Chong as well as creaky-then-breathy stops in Hmong; but it does not rule out breathy-then-creaky diphthongs in Chong or the creaky-then-breathy clusters [ʔh thʔ hnʔ] in Western Popoloca. To rule out all of these one needs to exclude conflicting laryngeals within *any* margin or nucleus, whether simple or complex.

One might think that something physiological excludes extreme changes in glottal width over a short period of time, making *[ʰpˀ m̰m̥ a̰ḁ], etc. too hard to say. But the asymmetry between consonantal clusters within and across syllables shows that this is not the case: heterosyllabic clusters have exactly those combinations of aspirated and glottalised consonants that tautosyllabic clusters lack. As we have seen, we find no cases of tautosyllabic CʰC’V or C’CʰV, but we do find cases *of heterosyllabic* VCʰ.C’V and VC’.CʰV in a number of languages, including Klamath (Barker 1964, Blevins 1993), Western Popoloca (Williams & Pike 1968), Yowlumne (Newman 1944), Kashaya (Buckley 1994) and Wikchamni (Gamble 1978).

	$\text{Coda}_{[spr]}+\text{Onset}_{[constr]}$	$\text{Coda}_{[constr]}+\text{Onset}_{[spr]}$
Klamath	n̥.t’ l̥.t’ m̥.t’	
Western Popoloca		ʔ.tʰ ʔ.w̥
Yowlumne		m̰.tʰ
Kashaya	l̥.q’	l̰.qʰ
Wikchamni	tʰ.p’ h.k’ tʰ.ʔ h.ʔ	tʃ’.pʰ ʔ.tʰ t’.h ʔ.h

Table X

Conflicting laryngeal features *across* subsyllabic constituents.

Such clusters occur morpheme-internally (Kashaya [háj̥.t’a] ‘redbud’; Klamath [ʔam̥.k’a] ‘maybe’), under affixation (Kashaya [can̰-pʰi] ‘if he sees’; Klamath [kuw̥-j̰as] ‘venereal disease’, from [kuw̥] ‘swell up’), and even through stem-internal vowel deletion (Wikchamni [put̪ʰ.k’-in] ‘will sour’, from [pot̪ʰok’] ‘sour’).

This can only be stated in terms of syllabic constituents, requiring a prosodic analysis of laryngeals. Similarly, while we never find breathy-then-creaky within a margin or nucleus, we do find it across margins and nuclei, as in Western Popoloca [tʰa̰] (onset + nucleus), Hmong [kʰo̰] (onset + nucleus) and Chong [a̤n̰ (nucleus + coda). Purely gestural (Browman & Goldstein 1986) and cue-based (Steriade 1997) models of laryngeal licensing are unable to capture this difference between tautosyllabic and heterosyllabic clusters, as far as we can see.

3 No pre/post contrasts within a margin or nucleus

Some languages use more than one phasing option in complex constituents, e.g. have preaspirated and postaspirated clusters, or preglottalised and postglottalised clusters. As with simple constituents, however, these timing differences are not contrastive, but always a matter of phonetic variation, depending on syllable position or the type of consonant involved.[9] A well-known instance of this is the difference in aspiration in

[9] Notice that pre- and postaspirated [ʰt tʰ] and pre- and postglottalised [ˀt t’] simple constituents (or single segments) are predicted to be non-contrastive by the standard theory, though not by all models: articulatory phonology (Browman & Goldstein 1989), aperture theory (Steriade 1994) and the licensing by cue approach (Steriade 1997) all rely to some extent on the claim that such temporal ordering

complex onsets like [pl̥] and [sp], where late phasing is the norm for stop + sonorant onsets and early phasing is the norm for fricative + stop onsets (Browman & Goldstein 1989, Iverson & Salmons 1995, 1999). All reported cases of pre- and postlaryngeal contrasts we have found reduce to this sort of thing. We turn now to consider these in detail.

Faroese and Icelandic have both pre- and postaspirated clusters, but the two do not contrast. Instead, [spread] is realised late in complex onsets [pl̥], but early in complex codas [l̥p]. The latter is entirely parallel to the preaspiration of geminates (Lombardi 1995b, Kehrein 2002, 2004). Thus, [spread] codas in Faroese and Icelandic are preaspirated if strong (moraic), and postaspirated if weak (non-moraic).

Strong codas in Faroese and Icelandic are realised with preaspiration *independent* of the source of aspiration. Suffixation of/-tʰ/, for instance, creates preaspirated clusters, e.g. Faroese *deil-t* [l̥t] 'divided', *eym-t* [m̥t] 'miserable-NEUT', *byg-t* [ʰkt] 'built', *søk-t* [ʰkt] 'sunk', *fylg-t* [l̥kt] 'followed', *fylk-t* [l̥kt] 'gathered'.[10] The result is always a preaspirated strong coda, no matter if the stem itself ends in a plain (*byg*, *fylg*) or [spread] (*søk*, *fylk*) coda. This is predicted under prosodic licensing, where there is a single [spread] per coda, and where its timing is never contrastive. Segmental analyses (Lombardi 1995b, Petersen *et al*. 1998) require some derivational machinery to detach the aspiration from [t] and move it to the left; 'sonorants devoice before aspirated stops, which stops are always deaspirated; there is no devoicing before unaspirated stops. This can be analyzed as a movement of the aspiration feature from the stop to the preceding sonorant' (Lombardi 1995b: 52 on Icelandic).

Words like *byg-t* [ʰkt] show that Faroese would need a similar mechanism for stop clusters; and *fylg-t* [l̥kt] would require aspiration to move even further to the left. Segmental analyses like this require neutralisation of suffixal aspiration for stems which already end in aspirate to explain why, e.g. *søk-t* is realised as [sœʰkt] rather than [sœʰktʰ] or [sœʰkʰt], and why *fylk-t* is realised as [fɪl̥kt] rather than [fɪl̥kʰt] or [fɪl̥ktʰ] or the like.Under a prosodic approach like ours, onsets and codas in these languages are either plain or aspirated, the latter realised as postaspiration in onsets and 'weak' codas, and as preaspiration in 'strong' codas.

Klamath contrasts plain, aspirated and ejective stops and sonorants, with an interesting timing difference in word-initial onsets. Aspiration and ejection are phased with the release of stops in stop + sonorant onsets [kʰm kʼm] (the latter being rather [kʼm̰]; see note 8) and are realised finally in all other clusters [kpʰ kpʼ wl̥ wl̰ spʰ spʼ]. The full set of word-initial

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contrasts are attested in some languages. Golston & Kehrein (1998) discuss these languages, including well-known cases like Huautla Mazatec (Pike & Pike 1947) and Kashaya (Buckley 1994), and argue that none of them actually has laryngeal timing contrasts within simple constituents.

10 Faroese [ʰkt] and [l̥kt] correspond to Icelandic [xt] and [l̥xt] respectively. Notice that 'voiceless' fricatives pattern as [spread] sounds in Icelandic and Faroese, as is evident from 'sonorant devoicing' in words like *hei*[m̥s] 'world-GEN' (Kehrein 2004).

complex onsets in Klamath is listed below (data from Blevins 1993: 254f):[11]

stop + sonorant	∅	pl pj pw tl tj tm tn tw tᶴl km ql qn qw
	[spread]	pʰl pʰn tʰl tʰj tʰm tʰw tᶴʰl tᶴʰj tᶴʰw kʰl kʰj kʰm kʰn kʰw qʰl qʰj qʰm qʰn qʰw
	[constr]	p'n t'l t'w tᶴ'l tᶴ'm tᶴ'n tᶴ'w k'l k'm k'n k'w q'l q'j q'm q'w
stop + stop	∅	pq tp tk tq tᶴk kp kt qp qt
	[spread]	ptʰ ptᶴʰ pkʰ pqʰ tpʰ tkʰ tqʰ kpʰ ktʰ ktᶴʰ qtʰ qtᶴʰ
	[constr]	pt' ptᶴ' pk' pq' tk' tq' kp' kt' ktᶴ' qp' qt' qtᶴ'
other + sonorant	∅	sl sj sn sm sw lm lw mn wn wl
	[spread]	wl̥ wj̥
	[constr]	sl' sn' sm' sw' lm' wl' wj'
s + stop	∅	sp st stᶴ sk sq
	[spread]	spʰ stʰ stᶴʰ skʰ sqʰ
	[constr]	sp' st' stᶴ' sk' sq'
other + *s*	∅	ps ts ks ms ws

Table XI
Word-initial clusters in Klamath.

This merely shows that different types of consonants prefer different phasings for laryngeal gestures (Silverman 1995): aspiration and glottalisation are phased with stop release in stop + sonorant onsets, and finally in other onsets. (Klamath shows preaspiration and preglottalisation in word-final codas [m'tᶴ n's l's lʰt], but this is just more prosodic conditioning of the type we have already seen.)

Languages do of course differ in the way they phonetically order laryngeal features in complex constituents. Laryngeal gestures may be phased early, late or throughout complex constituents, but if multiple phasing options occur in a single language, they are always condition by syllable position (e.g. onset *vs.* coda) or by consonantal make-up (e.g. fricative + stop, stop + sonorant). No language we know of makes *contrastive* use of these differences within an onset or coda.

Complex nuclei behave in exactly the same way. As with syllable margins, some languages use more than one timing of laryngeal gestures

[11] Blevins (1993) additionally lists sonorant + stop clusters as onsets because 'word-initial clusters arguably constitute syllable onsets'. However, Barker explicitly states that sonorants preceding obstruents are syllabic (they even carry pitch), i.e. clusters like /mp mpʰ l̩t'/ are [m̩.p m̩.pʰ l̩.t'].

within a single nucleus, but never to form phonological contrasts. We give two examples below.

	spread	constr
Green Mong, White Hmong	a̤i̤	a̰ḭ aiˀ
Zhu|'hõasi	a̤i̤ a̤i	

Table XII

Different phasings of laryngeal features in complex nuclei.

Breathy voice is realised throughout a nucleus in (H)mong, but creaky voice nuclei may be realised with creak throughout [a̰ a̰ḭ] or just towards the end [aˀ aiˀ]. But the variable realisation of creaky voice is not contrastive.

Ju|'hoansi (= Zhu|'hõasi; Miller-Ockhuizen 2001) has entirely breathy vowels and diphthongs [a̤ a̤i̤] as well as initially breathy vowels and diphthongs [a̤͡a a̤i]. Miller-Ockhuizen claims that the timing of [spread] is distinctive in Zhu|'hõasi, but her own description (2001: 151) strongly suggests that they are actually in complementary distribution: the former occur exclusively with super low (SL) and low (L) tones, and the latter are restricted to SL-L and L-H tones. Crucially, as shown in the final column below, all four tones do occur with plain vowels in Zhu|'hõasi, and thus the durational difference in breathy voice is best understood as phonetic variation conditioned by different tonal patterns (i.e. register *vs.* contour tones).

tone	V̤	V̤V	V
SL	gȍ̤ȍ̤ 'flower'	*	ʃȅȅ 'to return'
L	ǂò̤à̤ 'to copy'	*	!xòò 'to be unsuccessful'
SL-L	*	g|ȍ̤ò 'to be dwarf-like'	ǂȅè 'spur'
L-H	*	ò̤ó (no example)	bòó 'medicine'

Table XIII

Apparent contrasts of full and partial breathiness in Zhu|'õasi (Miller-Ockhuizen 2001).

In sum, none of these languages distinctively orders laryngeal features in nuclei, simple or complex. The final case we will consider here, Tsou, is somewhat involved, but we will see that the apparent cases of laryngeal ordering are all tied up with different types of stricture and can be reduced to those differences in stricture, much like the cases we have just seen.

The Formosan Austronesian language Tsou (Tung 1964, Tsuchida 1976) has CC obstruent clusters that seem to allow for laryngeal specifications on a segmental basis.[12] Since reduplication treats these clusters as an entity, Wright (1996) claims that they constitute complex onsets both word-initially and medially, and thus Tsou syllables are maximally [CCVː]. Phonetically, C_1 is separately released in clusters, presumably to recover its acoustic cues (Wright 1996). The complete set of obstruent clusters is given below; clusters in parentheses only occur word-medially.[13]

C_1/C_2	Labial	Coronal	Dorsal
Labial	*	pt pts pɗ ps ɓs ft fts fs fz vts vz (pz ɓz)	pk fk (vk)
Coronal	tp tɓ tf tv tsp tsf tsv sp sɓ sf sv zv (tsɓ)	tsz	tk tsk sk
Dorsal	kv (kp)	kɗ ks (kts)	*

Table XIV
Complex onsets in Tfuya Tsou (Wright 1996: 35).

Clusters of homorganic obstruents are disallowed in Tsou, but almost every other combination (and order) of consonants is attested. Specifically, 'voiced fricatives' [v z] and implosives [ɓ ɗ] combine with other obstruents in either order, e.g. [sv zv vts tɓ ɓs sɓ ɓz], in apparent violation of our claim that laryngeal specifications are never contrastively ordered within a margin or nucleus.

The clusters with [v z] are problematic only if these sounds are truly voiced fricatives, and not semivowels or some other kind of sonorant. But as Ohala & Ohala (1993: 227–228) point out, 'many so-called non-sibilant "voiced fricatives" such as [v, ð, ɓ, ɣ] do not have appreciable frication and are, rather, frictionless continuants'. This seems to be the case for Tsou as well. The sounds in question are historically semivowels (*w j) (Li 1972), and there is evidence that they still are semivowels synchronically. First, they show little if any frication in published spectrograms (Wright & Ladefoged 1994, Wright 1996). Second, different dialects realise them as vocalic or consonantal: [(i)z] in Tfuya and Duhtu Tsou corresponds to stressed [i] in Tapangʉ Tsou, e.g. *omza* 'upper side' in Tfuja *vs.* *omia* in Tapangʉ (Wright 1996: 30). Most importantly, they alternate with vowels, so that [ɪ] and [o u] are realised as [z] and [v] respectively when followed by a vowel-initial suffix (Li 1972, Szakos 1994). Clearly, if [v] and [z] are sonorants in Tsou, clusters like

12 We do not discuss apparent onsets composed of laryngeal segments [th ht tʔ ʔt hʔ ʔh] in this paper. See Kehrein (2002) for a reanalysis along the lines stated above for Western Popoloca.

13 Wright lists word-medial /ɓk/, but he neither mentions it in his discussion of stop+stop clusters (1996: 50–52), nor gives an example in his word list. Szakos (1994: 28) notes that medial /ɓk/ and /ɓts/ (the latter not included in Wright's list) are 'neutralised' to [pk] and [pts] respectively, and we have thus omitted them from (21).

[vt^{s} vk tv t^{s}v sv kv pz fz t^{s}z] pose no problem for laryngeal ordering, because they are laryngeally unspecified onsets composed of obstruent and sonorant. Notice that comparable clusters are attested with nasals: [mt^{s} mk tm t^{s}m sm km pn fn t^{s}n].

The second set of apparently problematic clusters, [ɓs ɓz sɓ], poses no problem, because Tsou (like most languages) prohibits implosive fricatives and sonorants. Since implosion can only be realised on the stop in clusters like [ps pz sp], the features that encode it, [voice, constricted], need not be contrastively ordered: they just show up where they can.[14]

Stop clusters are more interesting: Tsou has plain and implosive labials and dentals, [p t ɓ ɗ], and since different places of articulation are generally free to co-occur in either order, a segmental analysis would lead us to expect eight different types of complex onsets: [pt tp pɗ tɓ ɓt ɗp ɓɗ ɗɓ]. Remarkably, however, only half of these occur in the language: stops in clusters are either both voiceless [pt tp] or voiceless stops precede implosives [pɗ tɓ],[15] but we do not find implosive + stop, *[ɓt ɗp], or fully implosive clusters, *[ɓɗ ɗɓ]. The gaps are surprising if every segment has its own set of laryngeal features, but not if every *onset* does. Implosion is phased late in complex onsets, [pɗ tɓ], never early, *[ɓt ɗp], or throughout clusters, *[ɓɗ ɗɓ]. Notice that 'late implosion' in clusters parallels the increase in voicing amplitude found in single implosives in Tsou (Wright 1996: 39). Crucially, the phasing of implosion is not distinctive within stop + stop clusters of Tsou, allowing for a prosodic account of laryngeal features in this language.[16]

We end this section with some examples of laryngeal contrasts in *heterosyllabic* clusters. They make very clear that the lack of laryngeal timing contrasts is a property of single onsets and codas, not of clusters in general.

	$\text{C}{\small\text{ODA}}_{\text{lar}}+\text{O}{\small\text{NSET}}_{\emptyset}$	$\text{C}{\small\text{ODA}}_{\emptyset}+\text{O}{\small\text{NSET}}_{\text{lar}}$
Klamath	m̥.t m̰.t	m.t^{h} m.t'
Kashaya	l̥.q l̰.q	l.q^{h} l.q'
Yowlumne	l̰.p k'.l	l.p' s.k'
Wikchamni	t^{h}.p h.t k'.p ʔ.t	t.p^{h} t.h t.k' t.ʔ

Table XV

Temporal ordering contrasts of laryngeal features across subsyllabic constituents.

[14] For the same reason, implosion is realised on the stop in nasal + stop cluster, e.g. [nɓ mɗ ŋɗ]. Implosives don't generally occur in clusters (Greenberg 1978), and we have not been able to find a language where nasally released implosives like [ɓn ɗm ɗŋ] are contrastive sounds. According to Goyvaerts (1988), Lendu has implosive + lateral clusters in onsets for voiceless stops and for voiced implosives, including [pi bl ʢl ɓl], where we find again that the implosion is realised on the stop.

[15] The only cluster with a dorsal consonant, [kɗ], fits into the picture here as well.

[16] An anonymous reviewer points out that the missing clusters might also be ascribed to implosives bearing the distinctive feature [−obstruent] (Clements & Osu 2002,

Notice that heterosyllabic sonorant + stop clusters in Klamath do contrast ([m̥.t m̰.t] *vs.* [m.t^{h} m.tʼ]), but the same clusters in word-final codas do not ([l̥t m̥t^{ʃ}], *[lt^{h} mt^{ʃʼ}]). The reason for this is simple on a prosodic analysis: sequences of coda + onset can have two sets of laryngeal features, while a single onset or coda has but one. We note again that this should pose problems for any model of laryngeal licensing that eschews prosodic licensing: the contrasts above are all neutralised when the clusters involved are tautosyllabic.

4 No segment/cluster contrasts within a margin or nucleus

Laryngeals have always played two closely related roles in phonology, serving both as segments [h ʔ] and as secondary properties of other segments in the form of aspiration and glottalisation in consonants and breathy or creaky voice in vowels. But, with a few exceptions, the difference between a Ch cluster and a C^{h} aspirate has never been claimed to be contrastive.

Aspirated or glottalised consonants are often analysed as separate series, [p^{h} pʼ], or as clusters, [ph pʔ], on the basis of economy or parsimony. If a language has [p h p^{h}], the latter is often analysed as a cluster [ph] rather than an aspirate [p^{h}], thereby simplifying the system of phonemes (e.g. Hockett 1955). Conversely, if a language seems to have aspirates, it is usually assumed that Ch clusters are banned. But such considerations are not without costs. A cluster analysis [ph] usually complicates the syllable structure to simplify the phoneme inventory, just as an aspirate analysis [p^{h}] complicates the phoneme inventory to simplify the syllable structure. Feature economy (Clements 2001, 2003) predicts that any language with both [p] and [h] would prefer an aspirate [p^{h}] (which drives up the numbers of segments per feature, increasing economy) to a cluster [ph] (which drives down the number of segments per feature, decreasing economy). Considerations of syllable complexity point in the same direction, since [p^{h}] is a simple onset, while [ph] is complex.

But the crucial test for Ch clusters and C^{h} aspirates, or Cʔ cluster and Cʼ ejectives, is *contrast*. Theories that assume both Ch and C^{h} (or Cʔ and Cʼ) tacitly assume the two will contrast in some language. We have found no language with such a contrast and therefore doubt that the issue of clusters *vs.* aspirates can be substantiated empirically. We can think of only two ways to perceive a difference between [^{h}] and [h], or between [ʼ] and [ʔ]. The first is in terms of phonetic length. It is well known of course that

Clements 2003), since the stop + implosive clusters (e.g. [pɗ] but not *[ɗp]) would be ruled out by sonority sequencing. But Tsou onsets do not always follow sonority sequencing, as the clusters [mt ms ŋt ŋf] show, and we even find an implosive-initial cluster [ɓs] next to [sɓ], suggesting that sonority is not the relevant factor here. Implosives may well be sonorants, but Tsou doesn't seem to provide evidence for this position.

languages differ with respect to the duration of glottalisation or aspiration. Aspirated and ejective alveolar stops in Apache, for instance, have a VOT of 58 and 46 ms respectively, and in Navajo 130 and 108 msec (Cho & Ladefoged 1999: 219ff). We might represent the Apache cases as [t^h tʼ] and the Navjao cases as [th tʔ]. But although languages vary to a large degree in the phonetic length of aspiration and glottalisation, no language makes contrastive use of it, i.e. no language contrasts /C^h/ and /Ch/ or /Cʼ/ and /Cʔ/ under this interpretation.

The second way to distinguish /C^h Cʔ/ and /Ch Cʔ/ involves phonetically aspirated and glottalised sounds *vs.* sequences of independent consonants and laryngeals. A few languages seem to contrast singletons and clusters in this way, e.g. the Salish languages Secwepemctsín ('Shuswap'; Kuipers 1974) and St'at'imcets ('Lillooet'; van Eijk 1997). But a lot hinges in these languages upon the syllable structure one assigns such words. As we will see below, there is a great deal of evidence that such contrasts involve tautosyllabic *vs.* heterosyllabic clusters. If single-segment C^h and Cʼ are tautosyllabic, while multi-segment Ch and Cʔ are heterosyllabic, the difference between laryngealised segment and laryngeal segment reduces again to prosody. Such cases are in line with our proposals as long as the contrast is *across* margins and not *within* them, as seems to be the case.

In sum, no language seems to have both Ch clusters and aspirated C^h segments or both Cʔ clusters and glottalised C^ʔ segments within an onset, nucleus or coda. And if no language has both, no language contrasts the two *a fortiori*. Linguists may imagine a difference, deciding to treat glottalisation as subsegmental [p^ʔ] in one language and as segmental [pʔ] in another. But if they contrast in no language, the distinction is probably specious.

The generalisation holds true for supralaryngeally empty and complex constituents as well: no language contrasts [^{h}a] *vs.* [ha] or [^{ʔ}a] *vs.* [ʔa]; and no language contrasts [pl^h] and [plh], or [plʼ] and [plʔ] either. But this means that having supralaryngeal articulation(s) or not is actually irrelevant to the argument: no matter what the supralaryngeal material is, laryngeal features and laryngeal segments never contrast in any language. Such distinctions seem to be purely orthographic differences allowed by phonetic transcription, but not by the grammar of natural languages.

Notice finally that [h] and [ʔ] do not violate (2a) and (b) any more than they violate (2c). No languages combines [spread] and [constricted] within margins or nuclei by using laryngeal segments *[phʔ pʼh hʔ ʔh], and no language contrastively orders laryngeal and supralaryngeal specifications in this way, e.g. *[th] *vs.* [ht].[17] Klamath, as we have seen, has a ternary laryngeal contrast for stops [t t^h tʼ] and sonorants [n n̥ n̰], but no onsets like *[pʼt^h p^{h}tʼ] nor contrasts between [p^{h}t] and [pt^h], for example. In addition, the language has both [h] and [ʔ], but these do not combine with anything

[17] Huautla Mazatec (Pike & Pike 1947, Steriade 1994) and Tsou (Wright 1996) are potential countexamples to this claim, but see Golston & Kehrein (1998) and Kehrein (2002), respectively, for reanalyses.

else in an onset or coda: there is no contrast between [t^{h}] and [th], or between [t’] and [tʔ], and there are no clusters like *[t^{h}ʔ t’h hʔ ʔh].

5 Problem languages

Before closing our discussion of existing and non-existing laryngeal contrasts in margins and nuclei we would like to comment on a small set of languages which seem to violate our proposals systematically. Here we discuss Mon-Khmer, Berber, Salish and Georgian, and show that upon closer inspection none of them provides a clear counterexample to our claims in (1) and (2), though some come very close.

Many Mon-Khmer, Berber and Salish languages possess extremely unusual consonant clusters as, for instance, initials in Khasi [bt, dk^{h}] (Schmidt 1904, Rabel 1961, Henderson 1976a, b), Semai [gpgh, t^{s}tt^{s}ʔ, kdkrld] (Diffloth 1976a, b), Kammu [t$^{\text{s̥d}}$kb] (Svantesson 1983), Moses-Columbia Salish [xt$^{\text{ɬ}}$, t$^{\text{ɬ’}}$x^{w}, k’t^{s}] (Czaykowska-Higgins & Willett 1997), Lillooet [q’ʔ] (van Eijk 1997) or obstruent-only words such as Tashlhiyt Berber [tftktstː] (Dell & Elmedlaoui 1985, 1988, 2002), Bella Coola [q’psttχ, t$^{\text{s’}}$ktsk^{w}t$^{\text{s’}}$] (Newman 1947, Nater 1984) and Oowekyala Wakashan [t’xt’k$^{\text{w’}}$s, t^{h}p^{h}x^{w}p^{h}st, k^{h}t$^{\text{s̥d}}$] (Lincoln & Rath 1980, Howe 2000).

While much early work on these languages assumed fairly unrestricted types of consonant clusters, more recent research in these languages has shown that what appear at first to be tautosyllabic clusters are actually *heterosyllabic*. The literature is too extensive to cover in a paper of this size, so we will just refer the reader to some of the more important contributions. For Mon Khmer languages, see Lamontagne (1993), Shaw (1993). For various dialects of Berber, see Applegate (1958), Bell (1978), Dell & Elmedlaoui (1985, 1988, 2002). For various Salishan languages, see Hoard (1978), Broselow & McCarthy (1983), Bagemihl (1991), Galloway (1993), Flemming *et al*. (1994), Czaykowska-Higgins & Willett (1997), Bates & Carlson (1992, 1998). For Northern Wakashan, see Howe (2000). Much of this literature will be familiar to linguists already, so we will try and just summarise it here.

There is a great deal of evidence that the long clusters in these languages are actually heterosyllabic and that the syllables involved are quite simple: CV, CVVC, CRVC and the like. Thus Temiar /kdkrdlḁ̃d/ ‘curly hair’ is syllabified for phonological and morphological reasons as [kɛd.kʌrɛd.lḁ̃d], with fairly simple syllables and no tautosyllabic clusters (Shaw 1993). Berber /tzdmt/ ‘gather wood (2SG)’ looks very complex laryngeally, but morphological and poetic evidence shows that it is [tz̩.dm̩t], with simple margins and simple nuclei throughout (Dell & Elmedlaoui 1985, 1988, 2002). While [tz] would make a difficult piece of data for our proposals, [tz̩] is does not, as it only shows that onsets and nuclei need not share laryngeal specifications. Newman’s (1947) and Bagemihl’s (1991) account of Bella Coola [t$^{\text{s’}}$ktsk^{w}t$^{\text{s’}}$] ‘he arrived’ as containing *no* syllables are of course fraught with consequences, but they disappear with more recent analyses which strongly indicate that Salish languages, like Berber, have syllabic obstruents yielding syllabifications like those already proposed by Hoard (1978): [t̩ˢʼ.k̩.ts̩.k̩ʷ.t̩ˢʼ] (see Kehrein 2002 for a summary). As the syllabic analyses for these languages simplify, the tautosyllabic laryngeal clusters disappear, taking with them the major source of counterexamples to our proposals.

Georgian is well known for its extremely complex clusters, e.g. /gvprtˢkvnis/ 'he is peeling us' (Catford 1977, Aronson 1997), some of which are problematic with respect to our claims about laryngeals. Since sonorants often intervene between obstruents in violation of standard sonority principles, the overall pattern is reminiscent of Berber and the Salish languages discussed above; and in fact, Georgian clusters have been analysed as containing headless syllables (Nepveu 1994), empty nuclei (Toft 1999) and syllabic sonorants (Butskhrikidze 2002; see Butskhrikidze 2002 for a summary). Most researchers, however, treat word-initial clusters as single onsets, and this seems to be consistent with native speakers' intuitions and poetic metre (Michael Job, personal communication), so we will attempt an analysis of Georgian that takes these complex onsets by their laryngeal horns.

Obstruent clusters are traditionally divided into recessive clusters, where front places of articulation precede back (ptk), and accessive clusters, where back places precede front (ktp).[18] Recessive clusters are either plain, aspirated or glottalised throughout, in line with our proposals here, and need not concern us further. Accessive clusters show similar patterns, but the aspiration and glottalisation peter out before the end of the cluster in some combinations [tʰp qʼt]. Chitoran (1999) and Chitoran *et al*. (2002) show that these laryngeal gestures fall short, due to the longer inherent duration of the accessive clusters in which they occur. None of this is contrastive, and it is possible to maintain that 'in Georgian a consonant cluster licenses at most a single laryngeal gesture' (Chitoran *et al*. 2002: 443), bringing the contrastive possibilities of modern Georgian clusters in line with the claims of the present paper.[19]

6 Implications

Languages do not allow both aspiration and glottalisation within a margin (pʰʼ pʰtʼ) or nucleus (ḁ͡a̰ ḁḭ); they do not order laryngeal and supralaryngeal

[18] Following Chitoran (1998, 1999) and Chitoran *et al*. (2002), we assume that Georgian contrasts plain, aspirated and ejective stops (cf. Vogt 1958: 49), rather than plain, voiced and ejective stops. Voiceless stops are aspirated in all positions (Robins & Waterson 1952: 62–64), and the 'weakly voiced' obstruents (Aronson 1991, 1997) are voiceless in most contexts; intervocalic voicing does occur, but for all three laryngeal series (Robins & Waterson 1952: 66).

[19] See Aronson (1997), Butskhrikidze & van der Weijer (2000) and Kehrein (2002) for laryngeal issues with morphologically complex words; see Kehrein (2002) for some problematic diachronic data from Vogt (1958). These issues are not insuperable for our proposals, but fall beyond the scope of the present paper.

features distinctively within a margin (p^h *vs.* ^hp, p^ht *vs.* pt^h) or nucleus (ḁ͡a *vs.* a͡ḁ, ḁi *vs.* ai̥); and they do not distinguish between laryngeal clusters (ph pʔ) and laryngealised sounds (p^h pʼ). Moreover, the laryngeal contrasts available in *complex* margins and nuclei are the same in a given language as those available in *simple* margins and nuclei.

Importantly, these findings cannot be reduced to purely physiological factors or to a constraint banning laryngeals on adjacent segments, because laryngeal contrasts *across* margins and nuclei are not restricted in parallel ways: while onsets like [p^htʼ] seem to be universally disallowed, the same types of clusters are well formed in a number of languages when heterosyllabic: [p^h.tʼ]. Nor can we ascribe the lack of pre- *vs.* post-contrasts ($p^h \sim {}^hp$) to phonetic abilities, because both possibilities are attested, even within a single language.

This strongly suggests that onsets, nuclei and codas are phonologically limited to at most one set of laryngeal features, and that these laryngeal features are unordered with respect to the supralaryngeal material within the same domain. We have opted for a representational solution here, in which laryngeal features are licensed directly by subsyllabic constituents. Prosodic licensing accounts for the generalisations in (2) in a single stroke, and allows for laryngeal contrasts across syllables that are not found within syllables, as the data seem to require.

This is not the way of standard theory, however, which posits one set of laryngeal features per segment. We have tried to show that standard accounts seriously overgenerate the kinds of contrasts one actually finds in natural languages. An anonymous reviewer suggests that an OCP restriction (Leben 1973) against multiple laryngeal nodes within margins and nuclei might do the trick, but this is not the case. Such a restriction would predict (2a), banning [^{h}pʼ], [hʔ] and [p^htʼ], for example, but would leave (2b, c) unaccounted for. Banning adjacent laryngeal nodes within a margin or onset fails to address why no contrast is found for pairs like [hp ~ ph], [$p^ht \sim pt^h$], [a̰i ~ aḭ] and so on (2b), where the hypothetical contrast arises from associating a single laryngeal node to different segments in a margin or nucleus, not from having more than one laryngeal node in a margin or nucleus. Nor can it explain why we don't find contrasts like [p^h ~ ph] or [pt^h ~ pth], etc., where the hypothetical contrast comes from whether the laryngeal node belongs to a supralaryngeally articulated segment [pt^h] or forms a segment on its own [pth].

Gestural accounts of licensing (Browman & Goldstein 1986, 1989, 1992) fail in the same way, insofar as they do without prosodic licensing. Nothing in these models prohibits a contrast between tautosyllabic pre- and postaspiration ($p^h \sim {}^hp$) or between tautosyllabic pre- and post-glottalisation ($p^ʔ \sim {}^ʔp$). And a purely gestural account fails to differentiate tautosyllabic restrictions on laryngeal clusters from heterosyllabic restrictions, which are looser in many languages, as we have seen. This difference between tauto- and heterosyllabic laryngeal possibilities is equally problematic for cue-based accounts of laryngeal contrast which reject prosodic licensing of phonological contrasts (e.g. Steriade 1997);

such approaches cannot distinguish illicit tautosyllabic [p^{h}tʼ] from permissible heterosyllabic [p^{h}.tʼ] in languages like Klamath, Western Popoloca, Yowlumne, Kashaya and Wikchamni. Cue-based and gestural models seem to fail by *overestimating* the laryngeal possibilities of tautosyllabic clusters, which are a proper subset of the laryngeal possibilities of heterosyllabic clusters.

Anderson (1978), Traill (1985), Iverson & Salmons (1995), Pulleyblank (1997) and others have proposed that *clusters* in many languages license a single set of laryngeal features. Again, though, these proposals fail to distinguish tauto- from heterosyllabic clusters, no matter if the restriction is formulated in representational terms (as autosegmental spreading) or as a constraint (AgreeLar).

Lombardi (1991, 1995a, b, 1999) defends a prosodic model that limits laryngeals to positions that are followed by a tautosyllabic sonorant. This 'laryngeal constraint' is violable, and as such not intended to derive any of the universal restrictions we have discussed here. But it also fails on a number of more specific observations: for instance, Klamath has plain, aspirated and glottalised obstruents and sonorants; laryngeal contrasts are obviously licensed before a tautosyllabic sonorant ([kʼma, k^{h}ma]), and we thus incorrectly expect the sonorant itself to possess contrastive laryngeal specifications, e.g. *[kʼm̥a, k^{h}m̰a]. We would also expect to find languages that allow laryngealised nuclei before syllable-final sonorants, [a̰n], though not in open syllables, *[a̰], or syllables closed by an obstruent, *[a̰t]. We are not aware of such a language.

We hasten to add that our proposal is not incompatible with other areas of laryngeal phonology, such as neutralisation and assimilation. On the contrary, prosodic licensing of laryngeals gives a straightforward explanation for the observation that neutralisation affects margins (most notably codas) as a whole, rather than segment by segment, and that assimilation unites two constituents (coda + onset) rather than just adjacent sounds. Thus, some languages license laryngeal features in coda position (e.g. Serbo-Croatian *mla*[d] 'young', *gro*[zd] 'bunch of grapes'), and many others don't (e.g. Russian *sa*[t] 'garden-nom sg', *vi*[sk] 'squeal-nom sg'). But we do not find languages that neutralise laryngeal features on a segmental basis (**i*[zp], **i*[sb]). Likewise, codas and following onsets share laryngeal features in many languages, no matter the number of segments, e.g. Polish *wie* [ʒd^{ʒ}b]*a* 'prophecy'. Assuming that laryngeal constraints operate at the levels of onset, nucleus and coda (e.g. NoLarCoda, AgreeLarMargin), but *not* individual segments, these facts fall out naturally. It also explains why laryngeal contrasts within onsets, nuclei and codas differ fundamentally from those across these constituents: for the former, the restriction to one set of laryngeal contrasts is universally respected and thus, we suspect, a fundamental matter of phonological representation. Codas and following onsets quite often share laryngeal features, but they do not do so necessarily. They are thus best treated in the grammar (either by spreading or as a constraint operating on subsyllabic constituents).

Whatever model of grammar one adopts, we hope to have shown that none of them can give a complete story to laryngeal licensing without the generalisations in (2) and some mechanism to capture them along the lines of (1).

REFERENCES

Allen, W. Sidney (1987). *Vox Graeca : a guide to the pronunciation of Classical Greek*. 3rd edn. Cambridge: Cambridge University Press.

Ambrazas, Vytautas (ed.) (1997). *Lithuanian grammar*. Vilnius: Baltos Lankos.

Anderson, Stephen R. (1978). Syllables, segments and the Northwest Caucasian languages. In Bell & Hooper (1978). 47–58.

Andruski, Jean E. & Martha Ratliff (2000). Phonation types in production of phonological tone: the case of Green Mong. *Journal of the International Phonetic Association* **30**. 31–36.

Applegate, Joseph R. (1958). *An outline of the structure of Shilḥa*. New York: American Council of Learned Societies.

Aronson, Howard I. (1991). Modern Georgian. In Alice C. Harris (ed.). *The indigenous languages of the Caucasus*. Vol. 1: *The Kartvelian languages*. Delmar, NY: Caravan, 219–312.

Aronson, Howard I. (1997). Georgian phonology. In Kaye (1997: vol. 2). 929–939.

Avery, Peter & William J. Idsardi (2001). Laryngeal dimensions, completion and enhancement. In Hall (2001). 41–70.

Bagemihl, Bruce (1991). Syllable structure in Bella Coola. *LI* **22**. 589–646.

Barker, M. A. R. (1964). *Klamath grammar*. Berkeley & Los Angeles: University of California Press.

Bartholomew, Doris (1975). Some morphophonemic rules in Mazahua. *IJAL* **41**. 293–305.

Bates, Dawn & Barry F. Carlson (1992). Simple syllables in Spokane Salish. *LI* **23**. 653–659.

Bates, Dawn & Barry F. Carlson (1998). Spokane (Npoqínišcn) syllable structure and reduplication. In Ewa Czaykowska-Higgins & M. Dale Kinkade (eds.) *Salish languages and linguistics : theoretical and descriptive perspectives*. Berlin & New York: Mouton de Gruyter. 99–123.

Bell, Alan (1978). Syllabic consonants. In Greenberg *et al*. (1978). 153–201.

Bell, Alan & Joan Bybee Hooper (eds.) (1978) *Syllables and segments*. Amsterdam: North-Holland.

Blevins, Juliette (1993). Klamath laryngeal phonology. *IJAL* **59**. 237–279.

Booij, Geert (1995). *The phonology of Dutch*. Oxford: Clarendon Press.

Bradshaw, Mary M. (1999). *A crosslinguistic study of consonant–tone interaction*, PhD dissertation, Ohio State University.

Broselow, Ellen & John McCarthy (1983). A theory of internal reduplication. *The Linguistic Review* **3**. 25–88.

Browman, Catherine P. & Louis Goldstein (1986). Towards an articulatory phonology. *Phonology Yearbook* **3**. 219–252.

Browman, Catherine P. & Louis Goldstein (1989). Articulatory gestures as phonological units. *Phonology* **6**. 201–251.

Browman, Catherine P. & Louis Goldstein (1992). Articulatory phonology: an overview. *Phonetica* **49**. 155–180.

Buckley, Eugene (1994). *Theoretical aspects of Kashaya phonology and morphology*, PhD dissertation, University of California, Berkeley.

Butskhrikidze, Marika (2002). *The consonant phonotactics of Georgian*. PhD dissertation, University of Leiden.

Butskhrikidze, Marika & Jeroen van de Weijer (2000). On v-metathesis in Modern Georgian. Paper presented at the SFB colloquium, Wuppertal.

Cao, Jianfen & Ian Maddieson (1992). A exploration of phonation types in Wu Dialects of Chinese. *JPh* **20**. 77–92.

Cardona, George (1965). *A Gujarati reference grammar*. Philadelphia: University of Pennsylvania Press.

Carter, Hazel & G. P. Kahari (1979). *Kuverenga Chishóna: an introductory Shona reader with grammatical sketch*. Part 2: *A short grammar of Shona, annotations to passages and bibliography*. London: School of Oriental and African Studies.

Catford, J. C. (1977), Mountain of tongues: the languages of the Caucasus. *Annual Review of Anthropology* **6**. 283–314.

Chirikba, Viacheslav A. (1996). *Common West Caucasian: the reconstruction of its phonological system and parts of its lexicon and morphology*. 2 vols. PhD dissertation, University of Leiden.

Chitoran, loana (1998). Georgian harmonic clusters: phonetic cues to phonological representation. *Phonology* **15**. 121–141.

Chitoran, Ioana (1999). Accounting for sonority violations: the case of Georgian consonant sequencing. In John Ohala, Yoko Hasegawa, Manjari Ohala, Daniel Granville & Ashlee Bailey (eds.) *Proceedings of the 14th International Congress of Phonetic Sciences*. Berkeley: Department of Linguistics, University of California, Berkeley. 101–104.

Chitoran, loana, Louis Goldstein & Dani Byrd (2002). Gestural overlap and recoverability: articulatory evidence from Georgian. In Gussenhoven & Warner (2002). 419–447.

Cho, Taehong & Peter Ladefoged (1999). Variation and universals in VOT: evidence from 18 languages. *JPh* **27**. 207–229.

Cho, Young-Mee Yu (1991). Voiceless sonorants are aspirates. Paper presented at the 65th Annual Meeting of the Linguistic Society of America, Chicago.

Clements, G. N. (1985). The geometry of phonological features. *Phonology Yearbook* **2**. 225–252.

Clements, G. N. (2001). Representational economy in constraint-based phonology. In Hall (2001). 71–146.

Clements, G. N. (2003). Feature economy in sound systems. *Phonology* **20**. 287–335.

Clements, G. N. & Sylvester Osu (2002). Explosives, implosives and nonexplosives: the linguistic function of air pressure differences in stops. In Gussenhoven & Warner (2002). 299–350.

Colarusso, John (1989). East Circassian (Kabardian dialect). In Hewitt (1989). 261–355.

Colarusso, John (1992). *A grammar of the Kabardian language*. Calgary: University of Calgary Press.

Czaykowska-Higgins, Ewa & Marie Louise Willett (1997). Simple syllables in Nxaʔamxcín. *IJAL* **63**. 385–411.

Dankovičová, Jana (1997). Czech. *Journal of the International Phonetic Association* **27**. 77–80.

Dell, François & Mohamed Elmedlaoui (1985). Syllabic consonants and syllabification in Imdlawn Tashlhiyt Berber. *Journal of African Languages and Linguistics*. **7**. 105–130.

Dell, François & Mohamed Elmedlaoui (1988). Syllabic consonants in Berber. *Linguistics* **34**. 357–395.

Dell, François & Mohamed Elmedlaoui (2002). *Syllables in Tashlhiyt Berber and in Moroccan Arabic*. Dordrecht: Kluwer.

Diffloth, Gérard (1976a). Minor-syllable vocalism in Senoic languages. In Jenner *et al*. (1976). 229–247.

Diffloth, Gérard (1976b). Expressives in Semai. In Jenner *et al*. 249–264.

Diffloth, Gérard (1989). Proto-Austroasiatic creaky voice. *Mon-Khmer Studies* **15**. 139–154.
Eijk, Jan van (1997). *The Lillooet language : phonology, morphology, syntax*. Vancouver: UBC Press.
Firth, J. R. (1948). Sounds and prosodies. *Transactions of the Philological Society*. 127–152.
Firth, J. R. (1957). *Papers in linguistics*. London: Oxford University Press.
Flemming, Edward, Peter Ladefoged & Sarah Thomason (1994). The phonetic structures of Montana Salish. *UCLA Working Papers in Phonetics* **87**. 1–33.
Friðjónsson, Jón (1984). *Phonetics of Modern Icelandic*. Reykjavík.
Galloway, Brent D. (1993). *A Grammar of Upriver Halkomelem*. Berkeley: University of California Press.
Gamble, Geoffrey (1978). *Wikchamni grammar*. Berkeley: University of California Press.
Goldsmith, John A. (1990). *Autosegmental and metrical phonology*. Oxford & Cambridge, Mass.: Blackwell.
Goldsmith, John A. (ed.) (1995). *The handbook of phonological theory*. Cambridge, Mass. & Oxford: Blackwell.
Golston, Chris & Wolfgang Kehrein (1998). Mazatec onsets and nuclei. *IJAL* **64**. 311–337.
Goyvaerts, Didier L. (1988). Glottalized consonants: a new dimension. *Belgian Journal of Linguistics* **3**. 97–102.
Greenberg, Joseph H. (1978). Some generalizations concerning initial and final consonant clusters. In Greenberg *et al*. (1978). 243–279.
Greenberg, Joseph H., Charles A. Ferguson & Edith A. Moravcsik (eds.) (1978). *Universals of human language*. Vol. 2: *Phonology*. Stanford: Stanford University Press.
Gussenhoven, Carlos & Natasha Warner (eds.) (2002). *Laboratory phonology 7*. Berlin & New York: Mouton de Gruyter.
Hall, T. Alan (ed.) (2001). *Distinctive feature theory*. Berlin & New York: Mouton de Gruyter.
Halle, Morris & Kenneth N. Stevens (1971). A note on laryngeal features. *MIT Quarterly Progress Report* **101**. 198–212.
Harris, Zellig S. (1944). Simultaneous components in phonology. *Lg* **20**. 181–205.
Heimbach, Ernest E. (1979). *White Hmong–English Dictionary*. Revised edn. Ithaca: Cornell University.
Henderson, Eugénie J. A. (1976a). Vestiges of morphology in modern Standard Khasi. In Jenner *et al*. (1976). 477–522.
Henderson, Eugénie J. A. (1976b). Khasi initial clusters. In Jenner *et al*. (1976). 523–538.
Hewitt, B. George (ed.) (1989). *The indigenous languages of the Caucasus*. Vol. 2: *The North West Caucasian languages*. Delmar, NY: Caravan.
Hoard, James E. (1978). Syllabication in Northwest Indian languages, with remarks on the nature of syllabic stops and affricates. In Bell & Hooper (1978). 59–72.
Hockett, C. F. (1955). *A manual of phonology*. Baltimore: Waverly Press.
Howe, Darin (2000). *Oowekyala segmental phonology*. PhD dissertation, UBC.
Huffman, Franklin E. (1985). The phonology of Chong: a Mon-Khmer language of Thailand. In Suriya Ratanakul, David Thomas & Suwilai Premsrirat (eds.) *Southeast Asian linguistic studies presented to André-G. Haudricourt*. Bangkok: Mahidol University. 355–388.
Iverson, Gregory K. & Joseph C. Salmons (1995). Aspiration and laryngeal representation in Germanic. *Phonology* **12**. 369–396.
Iverson, Gregory K. & Joseph C. Salmons (1999). Glottal spreading bias in Germanic. *Linguistische Berichte* **178**. 135–151.

Jenner, Philip N., Laurence C. Thompson & Stanley Starosta (eds.) (1976). *Austroasiatic studies*. Part 1. Honolulu: University Press of Hawaii.

Jessen, Michael & Catherine Ringen (2002). Laryngeal features in German. *Phonology* **19**. 189–218.

Kaye, A. S. (ed.) (1997). *Phonologies of Asia and Africa* (*including the Caucasus*). 2 vols. Winona Lake, Ind.: Eisenbrauns.

Kehrein, Wolfgang (2002). *Phonological representation and phonetic phasing: affricates and laryngeals*. Tübingen: Niemeyer.

Kehrein, Wolfgang (2004). The laryngeal phonology of Icelandic and Faroese. Ms, Philipps University Marburg.

Keyser, Samuel Jay & Kenneth N. Stevens (1994). Feature geometry and the vocal tract. *Phonology* **11**. 207–236.

Kuipers, Aert H. (1974). *The Shuswap language: grammar, texts, dictionary*. The Hague & Paris: Mouton.

Ladefoged, Peter (1964). *A phonetic study of West African languages*. Cambridge: Cambridge University Press.

Ladefoged, Peter (1973). The features of the larynx. *JPh* **1**. 73–83.

Ladefoged, Peter & Ian Maddieson (1996). *The sounds of the world's languages*. Cambridge, Mass. & Oxford: Blackwell.

Lamontagne, Greg (1993). *Syllabification and consonant cooccurrence conditions*. PhD dissertation, University of Massachusetts, Amherst.

Leben, William (1973). *Suprasegmental phonology*. PhD dissertation, MIT.

Li, Paul Jen-Kuei (1972). On comparative Tsou. *Bulletin of the Institute of History and Philology, Academia Sinica* **44**. 311–338.

Lin, Yi-Jiun Kirsten (1999). Tone is a feature of rhymes. In Baozhang He & Wenze Hu (eds.) *Proceedings of the 11th North American Conference on Chinese Linguistics*. Cambridge, Mass.: East Asian Language Programs, Harvard University.

Lincoln, Neville J. & John C. Rath (1980). *North Wakashan comparative root list*. Ottawa: National Museums of Canada.

Lloyd, J. A., Sam McBride, Nancy McBride & Kabazo (1981). Contrasting glottal stops in Gimi. *Folia Phoniatrica* **33**. 133–136.

Lockwood, W. B. (1977). *An introduction to Modern Faroese*. 3rd edn. Tórshavn: Føroya Skúlabókagrunnur.

Lombardi, Linda (1991). *Laryngeal features and laryngeal neutralization*. PhD dissertation, University of Massachusetts, Amherst. Published 1994, New York: Garland.

Lombardi, Linda (1995a). Laryngeal neutralization and syllable wellformedness. *NLLT* **13**. 39–74.

Lombardi, Linda (1995b). Laryngeal features and privativity. *The Linguistic Review* **12**. 35–59.

Lombardi, Linda (1999). Positional faithfulness and voicing assimilation in Optimality Theory. *NLLT* **17**. 267–302.

Louwrens, Louis J., Ingeborg M. Kosh & Albert E. Kotzé (1995). *Northern Sotho*. Munich: Lincom Europa.

McCarthy, John J. (1988). Feature geometry and dependency: a review. *Phonetica* **45**. 84–108.

Maddieson, Ian (1984). *Patterns of sounds*. Cambridge: Cambridge University Press.

Miller-Ockhuizen, Amanda L. (2001). *Grounding Ju|'hoansi root phonotactics: the phonetics of the guttural OCP and other acoustic modulations*. PhD dissertation, Ohio State University.

Mistry, P. J. (1997). Gujarati phonology. In Kaye (1997: vol. 2). 653–673.

Nater, H. F. (1984). *The Bella Coola language*. Ottawa: National Museums of Canada.

Nepveu, Denis (1994). *Georgian and Bella Coola: headless syllables and syllabic obstruents*. MA thesis, UCSC.

Newman, Stanley (1944). *Yokuts language of California*. New York: Viking Fund.
Newman, Stanley (1947). Bella Coola I: phonology. *IJAL* **13**. 213–222.
Odden, David (1995). Tone: African languages. In Goldsmith (1995). 444–475.
Ohala, John J. & Manjari Ohala (1993). The phonetics of nasal phonology: theorems and data. In Marie K. Huffman & Rena A. Krakow (eds.) *Nasals, nasalization, and the velum*. San Diego: Academic Press. 225–249.
Paris, Catherine (1989). West Circassian (Adyghe: Abzakh dialect). In Hewitt (1989). 155–260.
Petersen, Hjalmar P., Jógvan í Lon Jakobsen, Zakaris S. Hansen & Höskuldur Thráinsson (1998). *Faroese : an overview for students and researchers*. Ms, Tórshavn & Reykjavík.
Pike, Kenneth L. & Eunice Victoria Pike (1947). Immediate constituents of Mazatec syllables. *IJAL* **13**. 78–91.
Pukui, Mary Kawena & Samuel H. Elbert (1971). *Hawaiian dictionary*. Honolulu: University of Hawaii Press.
Pulleyblank, Douglas (1997). Optimality Theory and features. In Diana Archangeli & D. Terry Langendoen (eds.) *Optimality Theory : an overview*. Cambridge, Mass. & Oxford: Blackwell. 59–101.
Rabel, Lili (1961). *Khasi, a language of Assam*. Baton Rouge: Louisiana State University Press.
Rensch, Calvin R. (1976). *Comparative Otomanguean phonology*, Bloomington: Indiana University.
Rice, Keren (1994). Laryngeal features in Athapaskan languages. *Phonology* **11**. 107–147.
Robins, R. H. & Natalie Waterson (1952). Notes on the phonetics of the Georgian word. *Bulletin of the School of Oriental and African Studies* **14**. 55–72.
Rochoiń, Marzena (2000). *Optimality in complexity : the case of Polish consonant clusters*. Berlin: Akademie Verlag.
Rood, David S. (1975). The implications of Wichita phonology. *Lg* **51**. 315–357.
Sands, Bonny, Ian Maddieson & Peter Ladefoged (1993). Phonetic structures of Hadza. *UCLA Working Papers in Phonetics* **84**. 67–87.
Schmidt, P. W. (1904). Grundzüge einer Lautlehre der Khasi-Sprache. *Transactions of the Royal Bavarian Academy of Sciences* **22**. 657–810.
Shaw, Patricia A. (1993). The prosodic constituency of minor syllables. *WCCFL* **12**. 117–132.
Shryock, Aaron M. (1995). Investigating laryngeal contrasts: an acoustic study of the consonants of Musey. *UCLA Working Papers in Phonetics* **89**.
Shukla, Shaligram (1981). *Bhojpuri grammar*. Washington, D.C.: Georgetown University Press.
Silverman, Daniel (1995). *Phasing and recoverability*. PhD dissertation, UCLA.
Smith, Kenneth D. (1968). Laryngealization and de-laryngealization in Sedang phonemics. *Linguistics* **38**. 52–69.
Spotts, Hazel (1953). Vowel harmony and consonant sequences in Mazahua (Otomí). *IJAL* **19**. 253–258.
Steriade, Donca (1994). Complex onsets as single segments: the Mazateco pattern. In Jennifer Cole & Charles Kisseberth (eds.) *Perspectives in phonology*. Stanford: CSLI. 203–291.
Steriade, Donca (1997). Phonetics in phonology: the case of laryngeal neutralization. Ms, UCLA.
Svantesson, Jan-Olof (1983). *Kammu phonology and morphology*. Lund: CWK Gleerup.
Szakos, József (1994). *Die Sprache der Cou : Untersuchungen zur Synchronie einer austronesischen Sprache auf Taiwan*. PhD dissertation, University of Bonn.

Toft, Zoe (1999). Grunts and gutturals in Georgian: an investigation into initial consonant clusters. *SOAS Working Papers in Linguistics* **9**. 275–297.

Traill, Anthony (1985). *Phonetic and phonological studies of !Xóõ Bushman*. Hamburg: Buske.

Traill, Anthony, J. S. M. Khumalo & Peter Fridjhon (1987). Depressing facts about Zulu. *African Studies* **46**. 255–274.

Tsuchida, S. (1976). *Reconstruction of Proto-Tsouic phonology*. Tokyo: Institute for the Study of Languages and Cultures of Asia and Africa.

Tung, T'ung-ho (1964). *A descriptive study of the Tsou Language, Formosa*. Taipei: Institute of History and Philology.

Vaux, Bert (1998). The laryngeal specifications of fricatives. *LI* **29**. 497–511.

Vogt, Hans (1958). Structure phonémique du Géorgien. *Norsk Tidskrift for Sprogvidenskap* **18**. 5–90.

Williams, Ann F. & Eunice V. Pike (1968). The phonology of Western Popoloca. *Lingua* **20**. 368–380.

Wright, Richard (1996). *Consonant clusters and cue preservation in Tsou*. PhD dissertation, UCLA.

Wright, Richard & Peter Ladefoged (1994). A phonetic study of Tsou. *UCLA Working Papers in Phonetics* **87**. 67–92.

Yip, Moira (1995). Tone in East Asian languages. In Goldsmith (1995). 476–494.