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A Prosodic Theory of Laryngeal Timing

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We discuss three major patterns in the languages of the world for how obstruents and sonorants are pre- and post-laryngealized. Based on these patterns we propose that laryngeal timing is driven in great part by sonority sequencing, with laryngeals falling between obstruents and sonorants on the sonority scale.

1. Introduction[i]

We present here a cross-linguistic survey of how obstruents and sonorants are pre- and postaspirated, and pre- and postglottalized. Our main finding is that there are three major patterns for laryngealized sounds across languages and that these patterns seem to result from sonority sequencing. The central complex pattern is that obstruents are post-aspirated (t^{h}a) and ejective (t'a) in the onset but pre-aspirated (a^{h}t) and pre-glottalized (a^{ʔ}t) in the coda, while sonorants are the reverse, namely pre-aspirated (^{h}na) and pre-glottalized (^{ʔ}na) in the onset but post-aspirated (an^{h}) and post-glottalized (an^{ʔ}) in the coda. We call this *the prosodic pattern* because it follows directly from sonority sequencing if laryngeals are more sonorous than obstruents and less sonorous than sonorants (1). Rising sonority in the onset then yields post-aspiration (t^{h}a) and ejection (t'a) for obstruents but pre-aspiration (^{h}na) and pre-glottalization (^{ʔ}na) for sonorants. Falling sonority in the coda yields pre-aspiration (a^{h}t) and pre-glottalization (a^{ʔ}t) for obstruents but post-aspiration (an^{h}) and post-glottalization (an^{ʔ}) for sonorants (2).

(1) The sonority hierarchy

stop < fricative < laryngeal < nasal < liquid < glide

The prosodic pattern is found in a large number of languages including Mongolian (t^{h}a^{h}t), Gitksan (t'a^{ʔ}t), Mlabri (^{h}nan^{h}), and Shuswap (^{ʔ}nan^{ʔ}) and can be schematized as follows:

(2) The *prosodic pattern* for aspirated and glottalized sounds

	Aspiration	Glottalization
Obstruents	t^{h}a^{h}t	t'a^{ʔ}t
Sonorants	^{h}nan^{h}	^{ʔ}nan^{ʔ}

Again, the pattern makes sense if laryngeals fall between obstruents and sonorants on the sonority scale: sonority rises in the onset (t^{h}a, t'a, ^{h}na, ^{ʔ}na) and falls in the coda (a^{h}t, a^{ʔ}t, an^{h}, an^{ʔ}).

The second pattern generalizes the way onsets are realized in the prosodic pattern: obstruents are post-aspirated (tʰa) and ejective (t'a) and sonorants are pre-aspirated (ʰna) and pre-glottalized (ʔna), *in onsets as well as in codas*. We call this *the onset pattern*. For languages that do not follow the prosodic pattern in (2), this is the commonest pattern to follow, suggesting that the ways laryngeals are realized in onsets represent the unmarked option for consonants generally. The onset pattern is found in Eastern Armenian (tʰatʰ), Yokuts (t'at'), and Tsimshian (ʔnaʔn) and may be represented schematically as follows:

(3) *The onset pattern* for aspirated and glottalized sounds

	Aspiration	Glottalization
Obstruents	tʰatʰ	t'at'
Sonorants	ʰnaʰn	ʔnaʔn

Again, onsets are pre- and post-glottalized as they are in the prosodic pattern; codas are realized in the same way as onsets.

The third pattern generalizes the way codas are realized in the prosodic pattern: obstruents are pre-aspirated (ʰta) and pre-glottalized (ʔta) while sonorants are post-aspirated (nʰa) and post-glottalized (nʔa), in onsets as well as codas. We call this *the coda pattern*. For languages that do not follow the prosodic pattern, this is the less common option, suggesting that ways laryngeals are realized in codas are the marked option. In fact, Thompson Salish (nʔanʔ) and Northern Pame (nʔanʔ, nʰanʰ) are the only clear cases of a coda pattern we have found so far. A schematic representation of the pattern is given below:

(4) The *coda pattern* for aspirated and glottalized sounds

	Aspiration	Glottalization
Obstruents	ʰtaʰt	ʔtaʔt
Sonorants	nʰanʰ	nʔanʔ

Again, the coda pattern is significantly less common than the onset pattern, suggesting that codas represent a more marked option for laryngeal timing in consonants.

A fourth pattern is logically possible but completely unattested in our survey. It has the opposite pattern of the prosodic pattern in (2), with obstruents pre-aspirated (ʰta) and pre-glottalized in the onset (ʔt) and post-aspirated (atʰ) and ejective (at') in the coda, and sonorants post-aspirated (nʰa) and post-glottalized (nʔa) in the onset and pre-aspirated (ʰna) and pre-glottalized (aʔn) in the coda :

(5) The *aprosodic pattern* for aspirated and glottalized sounds (unattested)

	Aspiration	Glottalization
Obstruents	ʰtatʰ	ʔtat'
Sonorants	nʰaʰn	nʔaʔn

We call this *the aprosodic pattern* since it treats timing relations in exactly the opposite way as the prosodic pattern does and seems to be unnatested in the languages of the world. We hypothesize that it is unattested because it is *contra naturam.*

In general our study supports Howe & Pulleyblank's claim that 'the distribution of glottalization appears to be governed by syllable structure' (2001: 45) and expands the

implications of this in two ways. First, we expand the claim to cover aspiration as well as glottalization, yielding a generalized account of laryngeal timing. Second, we drive the explanation deeper into syllable structure by linking it directly to sonority sequencing.

In the rest of this paper we discuss timing patterns across languages as they fit into our typology: languages that fit the prosodic pattern (§2), the onset pattern (§3), and the coda pattern (§4) and the complete lack of languages that fit the antipattern (§5). We discuss the special status of intervocalic consonants in §6, and address the question of how voiced laryngealization fits into the picture in §7. We end with a short conclusion (§8).

2. The prosodic pattern

There is no standard place in the sonority hierarchy for aspiration and ejection/glottalization. This is probably due to how onsets with aspiration and ejection/glottalization are treated traditionally. If aspiration and glottalization stand alone in an onset or coda, there is no need for sonority sequencing and they are treated as segments of their own, as [h] and [ʔ]. If aspiration or glottalization occur in the onset or coda with a supralaryngeal articulation they are generally treated subsegmentally as aspiration [t□], ejection [t'], or glottalization [ˀn] of the supralaryngeal consonant rather than as a cluster of consonants [th tʔ ʔn]; in this case it is the whole consonant that must be ordered within the onset or coda and sonority sequencing again does not become an issue.

For those languages that alternate pre- and post- specifications, however, clearly more needs to be said. If we treat aspirated and glottalized onsets and codas as simple segments [t^h t' ˀn], we need to specify when the aspiration and glottalization follows the supralaryngeal articulation and when it precedes. If we treat aspirated and glottalized onsets as complex [th tʔ ʔn], we need to specify the order of the two consonants within the onset.

Kehrein & Golston (2004) have shown that no language contrasts simplex laryngeal onsets and codas [t^h t' ˀn] with complex laryngeal onsets and codas [th tʔ ʔn]. We therefore treat the two cases identically and assume that timing relations between laryngeal and supralaryngeal articulations within an onset or coda are the same whether a researcher treats the sounds as segmentally simple or complex. In what follows we use superscript notation to stand for both cases: [t^h] stands both for an aspirated stop and for a stop+h cluster, precisely because there is no phonological difference between the two and because we want to cast our predictions as widely as possible.

In this section we'll look at what we've called *the prosodic pattern* of pre- and post-laryngealization, which manifests itself in four subpatterns, repeated here for convenience:

(6) *The prosodic pattern* for glottalized and aspirated sounds

Obstruents are:	post-aspirated and ejective in the onset (t^ha t'a),
	pre-aspirated and pre-glottalized in the coda (a^ht aˀt).
Sonorants are:	pre-aspirated and pre-glottalized in the onset (^{h}na ˀna),
	post-aspirated and post-glottalized in the coda (an^h $an^ˀ$).

This complex pattern follows from sonority sequencing (Sievers 1881; Jespersen 1904), which requires that sonority rise in the onset (t^ha t'a ^{h}na ˀna) and fall in the coda (a^ht aˀt an^h $an^ˀ$), *if* we assume that laryngeals are more sonorous than obstruents and less sonorous than

sonorants. Phonetic evidence for this claim comes from the amplitude of laryngeals, which seems to fall between those of most obstruents and sonorants (Parker 2002). We say 'most obstruents' because it is true of stops (which have no amplitude) but not true of fricatives ; aspirated and glottalized fricatives are quite rare, however, making predictions difficult to test. We'll see below that the aspirated and glottalized fricatives that do occur generally fit the predictions set forth here. Sonority is ultimately a phonological category rather than a phonetic one, however, so we will turn directly to the phonological evidence for the sonority of laryngeals, to their ordering within onsets and codas in languages exhibiting the sonority pattern of laryngeal timing.

2.1 Aspirated obstruents

Standard Mongolian (also known as Halh or Khalkha Mongolian), spoken in and around the capital city of Ulaanbaatar, contrasts plain and aspirated voiceless stops and affricates in dental and alveo-palatal stops (tʰ t tʲʰ tʲ) and affricates (tsʰ ts tʃʰ tʃ):

(7) Consonant phonemes of Halh Mongolian (following Karlsson 2005)

	Lab	Dent	Alv-Pal	Pal	Vel	Uvu
stop	p pʲ	t tʰ	tʲ tʲʰ	gʲ	g	ɢ
affr		ts tsʰ	tʃ tʃʰ			
fric		s	ʃ	xʲ	x	
nas	m mʲ	n	nʲ		ŋ	
appr	w wʲ	ɮ r	ɮʲ rʲ	j		

Aspiration in Halh has been well-studied and phonetic studies show that 'postaspiration is consistent and salient in word-initial position' (Karlsson & Svantesson 2002: 10).

(8) Prosodic pattern in Halh Mongolian (following Karlsson & Svantesson 2002)

Onset		Coda	
[tʰaɮ]	'steppe'	[aʰt]	'camel gelding'
[tsʰam]	'mask dance'	[aʰts]	'fork'
[tʃʰuɮu]	'stone'	[aʰtʃ]	'grandson'

In word-final position, the situation is the reverse and we find clear and consistent pre-aspiration in the coda (Halh has preaspiration intervocalically, but we put off discussion of this till section §6). We note here that Mongolian allows complex codas only if they fall in sonority (Karlsson 2005: 50), so our claim that preaspiration results from sonority sequencing is not ad hoc in this regard.

The Halh pattern for pre- and post-aspiration occurs in a number of other languages as well. Many of these come from three language families in northern Europe, Germanic, Celtic, and Lappic. Germanic languages include Northern Faroese and Icelandic, both discussed below; dialects of Norwegian including Jæren and Gudbrandsdalen (Helgason 2002); and various dialects of Swedish including those of the Åboland archipelago in Finland (Helgason 2002), Åland (Helgason 2001), Ankarsrum, Asby, and Burseryd (Tronnier 2002), Arjeplog (Wallström 1943; Stölten 2002; Wretling et al. 2002), Gräsö (Helgason 1999, 2002), Härjedalen (Reitan 1930), Kökar (Karsten 1892), the central standard spoken in and around

Stockholm (Rositzke 1940), Vemdalen and northern dialects generally (Wretling et al. 2002). See Hansson (2001) and Helgason (2002) for comprehensive discussion of the synchronic and diachronic situation. Some Celtic languages have it too, including Irish (Ní Chasaide & Ó Dochartaigh 1984) and Scottish Gaelic (see below). It is also found in Western Yugur (Roos 2000), Tohono O'odham (Alvarez & Hale 1970) and Tarascan (Foster 1969), though the latter has codas only word-medially.

A number of English dialects follow the prosodic pattern in one way or another. Middlesborough (Jones & Llamas 2003, 2006) has postaspiration in onsets and preaspiration in codas, as does Newcastle (Docherty and Foulkes 1999) and Tyneside (Watt & Allen 2003), where younger women show the pattern the most. Some dialects of American English have postaspiration of stops in the onset and pre*glottalization* of stops in the coda (Avery & Idsardi 2001), varying the laryngeal gesture but not the patterning of pre- and post-:

(9) Prosodic pattern in American English (Avery & Idsardi 2001)

Onset	Complex Onset	Coda
[pʰe] 'pay'	[pʰr̥e] 'pray'	[hiˀp] 'heap'
[tʰi] 'tea'	[tʰr̥e] 'tray'	[hiˀt] 'heat'
[kʰi] 'key'	[kʰr̥e] 'cray'	[hʊˀk] 'hook'

Standard Scottish English (Gordeeva & Scobbie 2007) likewise has postaspiration of stops in onsets and preglottalization of stops in codas, but a different pattern with fricatives, which exhibit preaspiration in codas but neither pre- nor postaspiration in onsets.

In some languages of this type we can see the aspiration showing up in consonant clusters as well. Northern Faroese (Thráinsson et al. 2004), for instance, has postaspiration of onset stops [tʰa] that shows up as voicelessness on a following sonorant [pl̥a]; and it has preaspiration of coda stops [aʰt] that shows up as voicelessness on a preceding sonorant [an̥t]. Icelandic is well known for the same phenomenon and Scottish Gaelic (Ladefoged et al. 1998) seems to be the same.

Some languages exhibit one of these patterns with minor twists whose exact analysis we do not have space to go into here. Thus in Särna Swedish (Reitan 1930), we find preaspiration only on medial geminates with some variation in that position. Icelandic (Thráinsson 1978; Friðjónsson 1984), Ingush (Nichols 1994), and Standard Faroese (Thráinsson et al. 2004) have pre-aspiration only on geminates and some clusters.

Finally, some languages show only a subset of the prosodic pattern. These are languages with a Halh-like pattern in which aspiration is only realized post-vocalically. Toreva Hopi (Whorf 1944) and Northern Sami (Bye 2001) have the Halh pattern but lack any word-initial aspiration. Eastern Ojibwa (Bloomfield 1956) and Southern Paiute (Miller et al. 2005) have the same pattern as Toreva Hopi and Northern Sami, but only with geminates; they provide a nice minimal pair of sorts in that Eastern Ojibwa has intervocalic preaspiration after stressed syllables while Southern Paiute has it before stressed syllables.

Aspiration, pre- and post-, has a lot of phonetic variation across languages (Silverman 2003), and this is true of [h] as well. The variation is due in great part to the fact that spreading the glottis open doesn't affect the supralaryngeal configuration of the vocal tract. Aspiration thus picks up whatever else is going on in the mouth (especially the position of the tongue and lips) and changes accordingly, to [ç] near [i], to [x] near [a], to [ɸ] near [u], and

so on. To keep matters clear, we have focused here on cases where pre-aspiration is in complementary distribution with post-aspiration and thus is profitably viewed as an effect of laryngeal timing. For languages which have the prosodic pattern with obstruents it seems that the timing of laryngeal gestures is driven by sonority sequencing: post-aspiration in onsets and pre-aspiration in codas.

2.2. Glottalized obstruents

The prosodic pattern is also found with glottalized obstruents, where onset post-glottalization is realized as ejection in voiceless stops and pre-glottalization is realized as some sort of creak on the preceding vowel or sonorant or as a short glottal stop.

Zinacantan Tzotzil (Haviland 1981) contrasts plain and glottalized voiceless stops and affricates at four places of articulation:

(10) Consonant phonemes of Zinacantan Tzotzil (following Haviland 1981)[1]

	Lab	Dent	Alv-Pal	Vel	Glott
stop	p p' b	t t'		k k'	ʔ
affr		ʦ ʦ'	ʧ ʧ'		
fric	v	s	ʃ		h
nas	m	n			
appr		l (r)	j		

The glottalized voiceless stops show up as ejectives in onsets and as preglottalized stops in codas. Intervocalic stops are realized as preglottalized ejectives, something we turn to in section 6:

(11) Prosodic pattern in Zinacantán Tzotzil (following Haviland 1981)

Onset	Coda
[k'in] 'fiesta'	[x'e.leːʔk] 'thief'
[bal.ʧ'uh] 'to slip'	[muːʔk.ta] 'large'

Again, the pattern makes sense if glottalization is more sonorant than voiceless obstruents and less sonorant than sonorants and yields a rising sonority profile in the onset and a falling profile in the coda.

Other languages with this pattern of glottalization include Takelma (Sapir 1912), Kalapuya (Lewis 2003), and Chitimacha (Swadesh 1934, 1946), with the minor difference that Chitimacha has glottalized stops in a coda only following a long vowel or diphhtong. Coast Tsimshian (Sm'algyax, Dunn 1995) has ejection in the onset and preglottalization in the coda as well, and an interesting intervocalic pattern that will be discussed in §6. Glottalized stops in Gitksan are 'slack ejectives' (Ingram & Rigsby 1987): 'acoustically, the glottalization of these final obstruents is manifested in a way very similar to that of the initial lenis glottalized obstruents, i.e., as creaky voice quality at the margin of the vowel' (Rigsby & Ingram 1990)

[1] Haviland uses [b] for a voiced glottalized stop.

but follow the same prosodic pattern as Tzotzil, with postglottalization in the onset [t͡ʼa] and preglottalization in the coda [aˀ͡t], though word-final stops are realized as simultaneously preglottalized and postaspirated [aˀtʰ], due to a separate process that aspirates word-final voiceless stops.

Glottalization with voiceless stops seems pretty much dependent on syllable structure. In most cases we get ejection everywhere; the few cases where preglottalization shows up it is bound to codas (e.g. taˀt.na *vs.* tan.tʼa) with some complications in intervocalic position. This holds true of 'spontaneous glottalization' of voiceless stops in Sui as well (Edmondson et al. 2004).

2.3. Aspirated sonorants

Aspirated sonorants occur in a small number of languages and they (amost) always occur in the same pattern, with preaspiration in onsets and postaspiration in codas. Minor Mlabri is one such language (Rischel 1995), with an almost full set of contrastively aspirated sonorants (transcribed here as ʰm, ʰw, ʰl, etc., where Rischel writes *hm, hw,* hl, etc.):

(12) Consonant phonemes of Minor Mlabri (following Rischel 1995)

	Lab	Dent	Pal	Vel	Glott
stop	p pʰ	t tʰ	ʧ ʧʰ	k kʰ	ʔ
	b ʔb	d ʔd	ɟ	g	
nasal	m ʰm	n ʰn	ɲ ʰɲ	ŋ ʰŋ	
appr	w ʰw ʔw	l ʰl r ʰr	j ʔj ʰj		h

The aspirated nasals occur only syllable-initially, where they are preaspirated and won't worry us further. Both liquids and the palatal glide can occur aspirated syllable-finally. The aspiration in a sound like [ʰl] tears away from the supralaryngeal articulation, leading to preaspiration in the onset [ʰl] and postaspiration in the coda [lʰ], in the familiar prosodic pattern:

(13) Prosodic pattern in Mlabri (following Rischel 1995)

Onset	Coda
[ʰwɤɤŋ] 'puddle'	[gajʰ] 'nine'
[ʰlah] 'love (vb)'	[mʌʌlʰ] 'name'
[ʰmaaj] 'wife'	[bɯrʰ.ralʰ] 'heavy'
[ʰnʌm] 'year'	[ʧʰɯrʰ.kalʰ] 'quills of a porcupine'
[dəm.ʰnat] 'cold weather'	

Again, if [h] is less sonorous than [l], sonority should have it early in the onset [ʰla] and late in the coda [alʰ].

Languages with this pattern occur, but so few languages have aspirated sonorants in coda position, that it is hard to show the full pattern outside of Mlabri. Klamath (Barker 1964) comes closest to the pre/post pattern of Mlabri, but sonorants are preaspirated and voiceless throughout in onset position, and postaspirated only in word-final position, while voiceless but unaspirated in word-medial codas: [ʰn̥an̥.tanʰ].

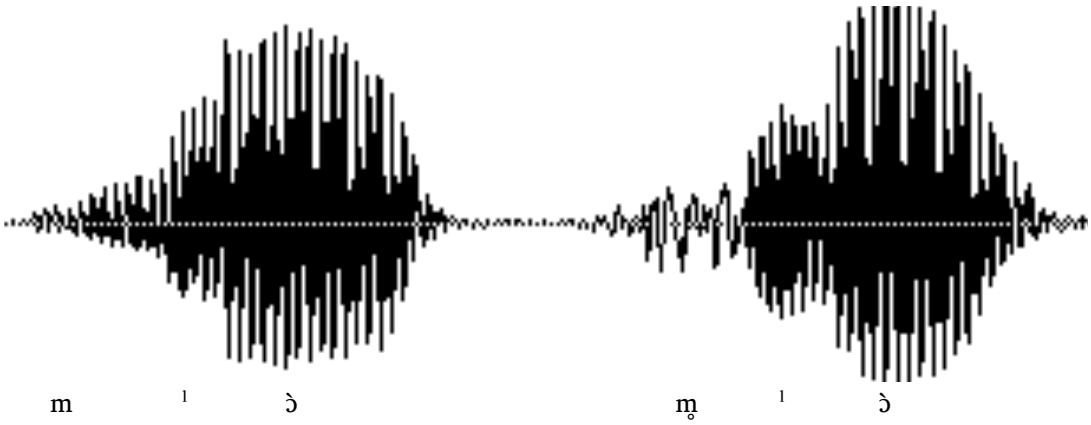
Kashaya (Buckley 1992, 1994) has aspirated sonorants in coda position, where they show up postaspirated as expected. But aspirated sonorants do not occur in onsets, so the pattern is defective in this language [nan^{h}]. Conversely, Jalapa Mazatec (Kirk, Ladefoged & Ladefoged 1993), Burmese (Dantsuji 1984, Ladefoged & Maddieson 1996), Sui (Edmondson et al. 2004), Sedang (Smith 1968), Waimoa (Bowden 2003) and White Hmong (Fulop & Golston 2008) have preaspirated nasals, but they only occur in onsets [^{h}na] and thus only show part of the general pattern. White Hmong contrasts a full complement of voiceless nasals and liquids with their modal counterparts:

(14) Consonant phonemes of White Hmong (Fulop & Golston 2008)

	Lab	Dent	Ret	Pal	Vel	Uv	Glott
stop	p p^{h}	t t^{h} d d^{h}	ʈ ʈ^{h}	c c^{h}	k k^{h}	q q^{h}	
lat rel	p^{l} p^{lh}						
prenas	^{m}b ^{m}b^{h}	^{n}d ^{n}d^{h}	^{n}ɖ ^{n}ɖ^{h}	^{ɲ}ɟ ^{ɲ}ɟ^{h}	^{ŋ}g ^{ŋ}g^{h}	^{N}G ^{N}G^{h}	
strid		ts ts^{h}	ʧ ʧ^{h}				
prenas/lat	^{m}b^{l} ^{m}b^{lh}						
prenas/strid		^{n}ts ^{n}ts^{h}	^{n}ʧ ^{n}ʧ^{h}				
fric	f v	s	ʃ ʃ^{h}	ç ʝ			
nasal	m ^{h}m	n ^{h}n		ɲ ^{h}ɲ			
lat rel	m^{l} ^{h}m^{l}						
appr		l ^{h}l					h

This large number of aspirated sonorants includes one complex articulation, the aspirated laterally released nasal [^{h}m^{l}]. Here as elsewhere in White Hmong, the voicelessness is realized early, as the following shows for laterally released nasals:

(15) White Hmong [m^{l}ɔ̀] and [m̥^{l}ɔ̀]



The rough portion in the wave form during [m̥] shows where the modal voicing is replaced with aspiration; note that the lateral release in [m̥^{l}ɔ̀] is unaffected by the initial aspiration.

2.4. Glottalized sonorants

Turning now to glottalized sonorants, we see the prosodic pattern again, with pre-glottalization in the onset and post-glottalization in the coda. Kwak'wala has a large set of glottalized stops and sonorants (Boas 1900, 1947):

(16) Consonant phonemes of Kwak'wala (following www.firstvoices.com/en/Kwakwala)

	Lab	Alv	Pal-Vel	Lab-Vel	Uv	Lab-Uv	Glott
stop	p pʼ b	t tʼ d	kʲ kʼʲ gʲ	kʷ kʼʷ gʷ	q qʼ ɢ	qʷ qʼʷ ɢʷ	ʔ
aff		ts tsʼ dz					
lat aff		tɬ tɬʼ dl					
fric		s ɬ	xʲ	xʷ	χ	χʷ	h
nasal	m mˀ	n nˀ					
appr	w wˀ	l lˀ	j jˀ				

Lincoln & Rath (1980) show that glottalized sonorants are preglottalized in the onset of a syllable and postglottalized in the coda:

(17) Prosodic pattern in Kwak'wala (following Howe & Pulleyblank 2001)

Onset		Coda	
[ʔlaχʷ.ʔid]	'to stick tongue out'	[nəlˀ.dzi]	'south, upriver'
[ʔnə.qʷa]	'to swallow'	[bənˀ.ʁə.má.ɬa]	'to start to creep sitting'
[ʔlu.qʷa]	'halibut fish'	[ɬəlˀ]	'dead'
[ʔjə.xʷa]	'to dance'	[cəjˀ.qa]	'to dip among'
[χi.ˀma.la]	'to creep sitting'		

Other languages with this pattern include Achumawi (Nevin 1998), Caddo (Chafe 1976), Cua (Maier 1969), Kalapuya (Lewis 2003), and Oowek'yala (Lincoln & Rath 1980; Howe 2000). Chitimacha (Swadesh 1934), Shuswap (Kuipers 1974), and Yowlumne (Plauché et al. 1998) follow the same pattern, but do not show it fully as they lack glottalized sonorants in word-initial position ; preglottalization can only be found in word-medial onsets in these languages. Yapese (Maddieson & Larson 2002) and St'át'imcets (Lillooet ; Bird et al. 2008) have preglottalization in the onset, postglottalization in the coda and glottalization throughout the sonorant intervocalically [ʔnan̰anʔ] so the status of the medial cases is a trade-off of sorts, something we return to in §6. Klamath has preglottalized creaky sonorants in onsets [□n□a], and creaky sonorants in codas [an̰], slightly underreplicating the pattern but not contradicting it. Kashaya has no glottalized sonorants in onset position at all, but does have the expected postglottalized sonorants in coda position [nanˀ.nanˀ] (Buckley 1992, 1994). Glottalized sonorants are restricted to word-final codas in Coatlán-Loxicha Zapotec; again these sounds are postglottalized [nan.nanˀ] (Plauché et al 1998).

3. The onset pattern

We turn our attention now to languages that overgeneralize the onset pattern, with [tʰ] and [tʼ] postglottalized regardless of syllable position, and [ʰn] and [ʔn] preglottalized regardless

of syllable position. Across the languages of the world, onsets generally license more consonant types than codas do, making them the unmarked place for a consonant to be realized. It should not come as a surprise, therefore, that the onset pattern generalizes what has independently been claimed to be the default case. Sapir made this observation a number of times, showing that stops and affricates tend to have glottalization realized at their release or offset, while nasals, liquids, and glides have glottalization realized at their onset.[2]

3.1. Aspirated obstruents

A number of languages have postaspirated obstruents in all positions of the word. Yokuts (Newman 1944) is one of these:

(18) Consonant phonemes of Chukchansi Yokuts

	Lab	Alv	AlvPal	Vel	Glott
stop	p p^h p’	t t^h t’	ʧ $ʧ^h$ ʧ’	k k^h k’	ʔ
fric		s	ʃ	x	h
nasal	m m’	n n’			
appr	w w’	l l’	j j’		

Aspirated stops are postaspirated regardless of position in the syllable, generalizing the pattern found for onsets:

(19) Onset pattern in Chukchansi Yokuts

Onset		Coda	
[p^heːliw]	‘on the road’	[noːnip^h]	‘nine’
[t^haː]	‘that’	[k’ut’]	‘tail’
[k^haʔjuʔ]	‘coyote’	[wixwik^h]	‘worm’

The Chukchansi pattern is found in other Yokuts dialects (Wikchamni, Gamble 1978; Yowlumne, Plauché et al. 1998) as well as in Eastern Armenian (Ladefoged & Maddieson 1996), in Kabardian (Colarusso 1989, 1992), Georgian (Aronson 1997) and other ‘Caucasian’ languages, in Standard Bangla (Das 2009) and other Indic languages.[3] The pattern also occurs in German and other languages with a minor twist: even plain voiceless stops are postaspirated finally (see Vaux & Samuels 2005, for more examples).

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[2] Kingston (1985, 1990) argues that the situation for stops and affricates has a functional explanation, that late glottalization of these sounds makes the glottal part easier to perceive by lining up the hard-to-perceive glottal with the easy to perceive burst that accompanies plosive release. Silverman (1997) argues essentially that the same applies to glottalized sonorants, but in reverse: low-energy glottals are kept away from the important high-energy boundary between a sonorant and the following vowel, because decreasing the amount of energy in that boundary would dampen the transition cues that are so important for identifying the place and manner of the sonorant.

[3] The Kabardian and Georgian contrasts are /t, t^h, t’/ and not /t, d, t’/ as is often assumed traditionally. For Kabardian, see Kuipers (1960); for Georgian see Robins & Waterson (1952) and Chitoran, Goldstein & Byrd (2001).

3.2. Glottalized obstruents

Like many languages, Yokuts realizes glottalized stops as ejectives regardless of their syllabic position, mirroring the onset pattern it shows with aspiration:

(20) Onset pattern in Chukchansi Yokuts

Onset		Coda	
[p'onoʃ]	'hand'	[soːnop']	'snot'
[t'axiʃ]	'calf (of leg)'	[pʰalaːt'at']	'woodpecker'
[k'owiʔ]	'thigh'	[tuk']	'ear'

This onset pattern occurs in, among others, Kwak'wala (Howe & Pulleyblank 2001), Tlingit (Maddieson et al. 2001), Inezeño Chumash (Applegate 2008), Kashaya (Buckley 1992, 1994), Saanich (Montler 1986), Squamish (Kuipers 1967), Yucatec Maya (Frazier 2009), Georgian (Aronson 1997), and Kabardian (Colarusso 1989, 1992).

3.3. Aspirated sonorants

We have not as yet found a language that has preaspirated sonorants in all syllabic positions (ʰnaʰn). We regard this as an accidental gap, due to the fact that aspirated sonorants are generally very rare in coda position. The few cases we know of are realized with post-aspiration, in conformity with sonority (see 2.3.).

(21) An unattested Onset pattern?

Onset		Coda	
[ʰnɪp]	'nip'	[pæʰn]	'pan'
[ʰlɪp]	'lip'	[pæʰl]	'pal'

3.4. Glottalized sonorants

Languages such as Sm'algyax (Tsimshian; Dunn 1995) generalize the onset pattern to all positions in the word.

(22) Onset pattern in Sm'algyax

Onset		Coda	
[ʔməˑʔnétʃ]	'excrement'	[q'áʔw.χeʔ]	'yellow bell (flower)'
[ʔwíˑʔwá]	'wild'	[χáʔm]	'dry'
[səˑʔmú]	'mare'	[ʃéʔj]	'this, that'

Montana Salish (Flemming et al. 2008) is another language with the Sm'algyax pattern. Inezeño Chumash (Applegate 2008) comes close to that pattern except that it has no word-initial glottalized sonorants.[4] A large number of languages have preglottalized sonorants, but have them only in onset position [ʔnaˑʔnan], including Gbeya (Samarin 1966), Hausa (Kraft &

[4] Glottalized sonorants seem to lose their glottalization in word-medial codas as well, so the pattern is [nanˑʔnaʔn]: http://www.chumashlanguage.com/lesson-07/less-07-3-fr.html.

Kraft 1973), Nambiquara (Price 1976), Nuu-chah-nulth (Nootka; Howe & Pulleyblank 2001, Bird et al. 2008), Sui (Li 1948, Edmondson et al. 2004), Tampuan (Crowley 2000), and !Xóõ (Traill 1985). It's hard to say whether these have the Sm'algyax or the Kwak'wala pattern, obviously, since there is no glottalization of coda sonorants, the only thing that distinguishes the two patterns.

4. The coda pattern

Given that codas are generally marked, we do not expect many languages to generalize the coda pattern to all positions in the word, with [^{h}t] and [^{ʔ}t] preglottalized regardless of syllable position, and [n^{h}] and [n^{ʔ}] postglottalized regardless of syllable position. We know of just two rather clear cases of languages overgeneralizing the coda pattern, and both apply it only to sonorants.

Nłeʔkepmxcin (Thompson Salish; Bird et al. 2008) has a set of glottalized sonorants, realized with post-glottalization in onsets, in codas, and even in nuclei.[5]

(23) Consonant phonemes of Nłeʔkepmxcin (Thompson & Thompson 1992)

CONSONANTS	labial	alveolar	alveo-palatal	velar	uvular	pharyngeal	glottal
Stops	p	t		k k^{w}	q q^{w}		ʔ
Ejectives	ṗ	t’		k̓ k̓^{w}	q̓ q̓^{w}		
Lateral Eject.		ƛ̓					
Nasal	m	n					
Glottalized	ṁ	ṅ					
Affricates		c̣ [ts]	c [tʃ]				
Ejective		c̓ [ts’]					
Fricatives		s̟ [s]	s [ʃ]	x x^{w}	x̣ x̣^{w}		h
Lateral		ɬ					
Approximant	(w)	z	y [j]	w		ʕ ʕ^{w}	
Lateral		l					
Glottalized	(ẇ)	ż	ẏ	ẇ		ʕ’ ʕ’^{w}	
Glott. Lateral		l’					

(24) Coda pattern in Nłeʔkepmxcin

Onset		Coda	
[jʔɛ́]	‘good’	[k’ət.nímʔ]	‘fishing with a rod’
[k’^{w}ɛ́t.nʔij]	‘mouse’	[ʃχájʔ.wi]	‘husband’
[hú.mʔɛɬ]	‘good bye’	[nɛ́.x^{w}əmʔ]	‘it's true’
[wʔɛ.wʔí.kn̩]	‘seeing things’		
Syllabic			
[n̩ʔ.tɛ́ʃ]	‘give (food)’		

[5] Bird et al. (2008) report post-glottalization in 81% of all their tokens. Pre-glottalization does occur to some extent in pre-stress intervocalic position (3%).

Northern Pame has a three-way laryngeal contrast with sonorants (plain, glottalized, aspirated). As in Nɬe?kepmxcin, glottalized sonorants are postglottalized in onsets, codas, and nuclei.

(25) Consonant phonemes of Northern Pame (Berthiaume 2012)

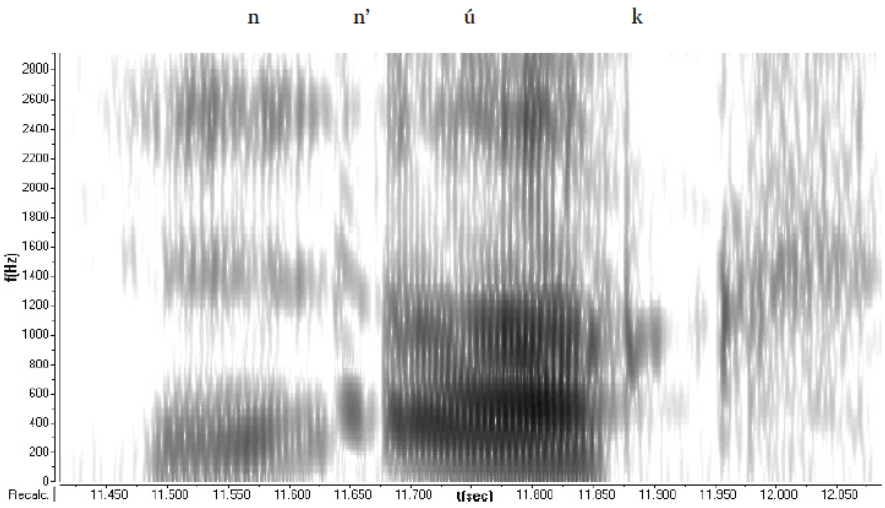
	Lab	Alv	AlvPal	Vel	Glott
stop	p p^h b	t t^h t' d		k k^h k' g	ʔ
affr		ts ts^h ts'	ʧ $ʧ^h$ ʧ'		
fric		s	ʃ		h
nasal	m m^h m'	n n^h n'	ɲ $ɲ^h$ ɲ'		
lateral		l l^h l'	ʎ $ʎ^h$ ʎ'		
rhotic		ɾ	$ɾ^j$		
appr	w		j		

(26) Coda pattern in Northern Pame

Onset		Coda	
[n̥.n^{ʔ}úk]	'my lice'	[tə.ʔă.hɑwn^ʔ]	'I ask'
[l^{ʔ}aé]	'person, man'	[ts'ú.ʔul^ʔ]	'bites'
[l^{ʔ}ɑʧ]	'they kick'	[ʧ^{h}úl^ʔ]	'mirrors'
Syllabic			
[n̥^{ʔ}.p^{j}úʔ]	'his butter'		

(27) shows a spectrogram with a postglottalized nasal in onset position.

(27) Postglottalized sonorant in Northern Pame [n̥.n^{ʔ}úk] 'my lice' (Berthiaume 2012: 27)



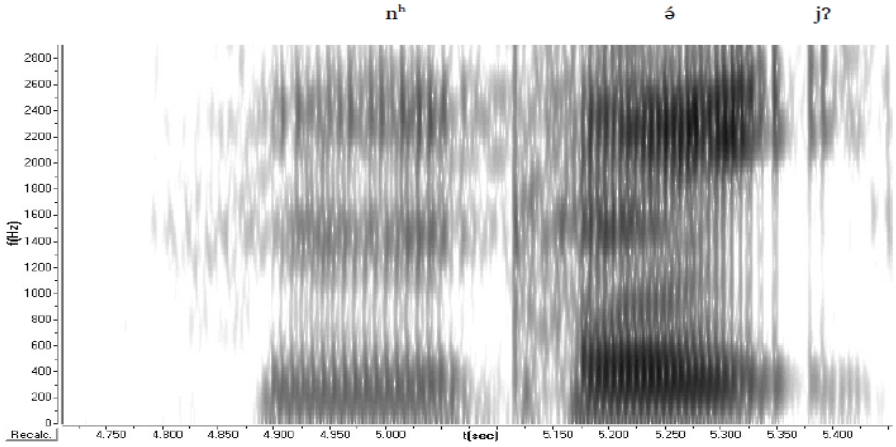
Aspirated sonorants are postaspirated in onsets (and nuclei), too, but they seem to be banned from coda position.[6]

[6] Postaspirated sonorants in onset position are also reported for Khonoma Angami (Blankenship et al. 1993). These sounds are voiced for half of their duration, then voiceless (1/4) followed by

(28) Defective coda pattern in Northern Pame

Onset		Coda
[mʰʲə́n]	‘soup’	-
[nʰə́jˀ]	‘he enters’	
Syllabic		
[n̩ʰ.pú.hu]	‘my chair’	

(29) Postaspirated sonorant in Northern Pame [nʰə́jˀ] ‘he enters’ (Berthiaume 2012: 27)



Notice that the phoneme chart in (25) lacks aspirated and glottalized glides – though only because Berthiaume prefers to treat combinations of glides and laryngeals as clusters /wh, wʔ, jh, jʔ/ rather than as single segments. Interestingly, laryngealized glides do *not* follow the coda pattern, but the common *prosodic pattern*, i.e. they are pre-glottalized [ˀw, ˀj, ʰw, ʰj] in onsets and – where permitted – post-laryngealized in codas [wˀ, jˀ].

(30) Prosodic pattern for laryngealized glides in Northern Pame

Onset		Coda	
[ˀwúts’]	‘he writes’	[sə́wˀ]	‘he teaches’
[ˀjŭ́ś]	‘my houses’	[ʃəʔjŭjˀ]	‘polio’
[ʰwə̌tʃ]	‘he hunts’	-	
[ʰjə́ʔ]	‘you sg.’	-	

We do not know of a language with prelaryngealized obstruents in all positions, but two languages show half of the pattern. Huautla Mazatec (Pike & Pike 1947 ; Golston & Kehrein 1998) and Osage (Quintero 2004) have preaspirated stops in *onset* position, but disallow *codas* altogether. The pattern is thus defective: [ʰta.ʰta]. The interesting conundrum for us then is the lack of [ʰt] codas to spread to the rest of the word.

(31) Distinctive preaspiration in Huautla *onsets*

Plain		Preasp	
[ti^{34}]	‘boy’	[ʰti^{4}]	‘fish’
[ka^{43}]	‘he falls’	[ʰka^{34}]	‘stubble’
		[ha^{4}.ʰtʂo^{3}]	‘in the opening of’

---

postaspiration (1/4), i.e. something like [nnn̥ʰa]. As in Northern Pame, there are no aspirated sonorants in coda position.

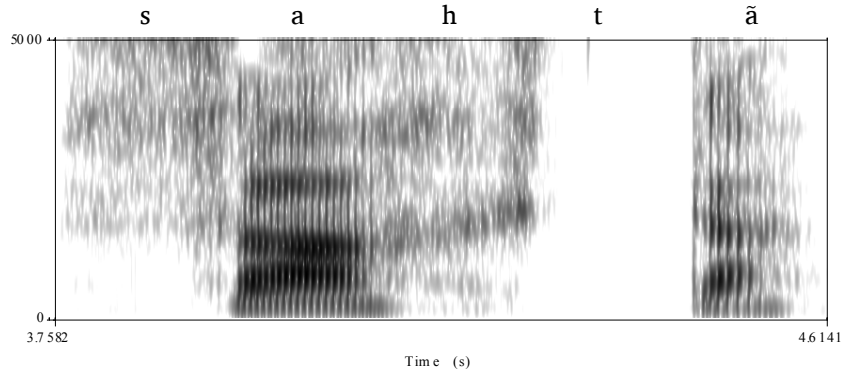
Golston & Kehrein (1998) argue that exceptional preaspiration in Huautla helps to keep [spread] onsets apart from [spread] nuclei. The latter are realized with early breathiness[7], resulting in near minimal pairs like [tạa^4] 'light in weight' ([spread] nucleus) vs. [^{h}ti^4] 'fish' ([spread] onset).

(32) Distinctive preaspiration in Osage *onsets*

Plain		Preasp	
ke	'scattered, dispersed'	^{h}kée	'turtle'
káa	'here!'	^{h}kawa	'horse'
ką́ąze	'Kaw, Kanza'	^{h}ką́ące	'apple, fruit'
kǫ́ða	'he/she wants'	^{h}kǫ́bra	'I want'
tą	'when, if'	^{h}tá	'deer'
sá.ta	'stiff'	sá.^{h}tą	'five'
ą.kóo.ta	'we borrow'	ąkó.^{h}ta	'ours'

Like Huautla, Osage is said to have preaspirated stops[8] and no codas. Unlike in Huautla, however, preaspirates in Osage alternate with geminates (or 'fortis stops') [^{h}t] ~ [tː], and thus things like ^{h}t in (32) are mere morphophonemic labels (Q writes *ht*), not phonetic transcriptions.[9] Listening to the words in (32) as spoken in isolation reveals clear preaspiration in word-medial position (33), though no trace of preaspiration word-initially (34).[10] Notably, we could not perceive a difference between initial [k] in [kǫ́ða] 'he/she wants' and alleged [^{h}k] in [^{h}kǫ́bra] 'I want', both sounding like [k] to us. If true, the t/^{h}t contrast is neutralized word-initially (or possibly utterance-initially) in contemporary Osage, as it is in Hidatsa.

(33) Medial preaspiration in Osage [sá.^{h}tą] 'five'



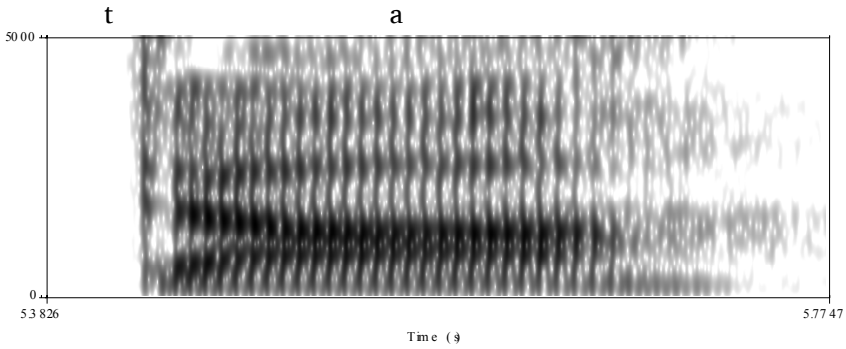
[7] Presumably, as argued by Golston & Kehrein 1998, to leave the final portion of the vowel for tonal information.

[8] A series of preaspirated stops has been reconstructed for Proto-Siouan, where they might have been restricted to pre-stress position (Rankin 2003: 195). Preaspirates occur as plain stops [t] (Winebago), postaspirates [t^h] (Dakota), or geminates (or 'fortis stops') [tː] (Omaha) in most contemporary Siouan languages (see Rankin 2003, for discussion). And in those languages that still have them, they deaspirate to plain stops [t] word-initially (Hidatsa; Jones 1979).

[9] Quintero (2004: 29) states that '[a] complete study of the exact conditions for this variation or alternation has not been undertaken.'

[10] Sound files can be found at: http://www.osagetribe.com/language/info_sub_page.aspx?subpage_id=14.

(34) No initial preaspiration in Osage [^{h}tá] ‘deer’



5. The aprosodic pattern

The final logically possible pattern is what we have termed the aprosodic pattern, because in this pattern onsets and codas both violate sonority sequencing: obstruents are preaspirated and preglottalized in onsets [^{h}ta, ^{ʔ}ta], but postaspirated and postglottalized in codas [at^{h}, at’], while sonorants are postlaryngealized in onsets [n^{h}a, n^{ʔ}a] and prelaryngealized in codas [a^{h}n, a^{ʔ}n].

(35) The *aprosodic pattern* for aspirated and glottalized sounds (unattested)

	Aspiration	Glottalization
Obstruents	^{h}tat^{h}	^{ʔ}tat’
Sonorants	n^{h}a^{h}n	n^{ʔ}a^{ʔ}n

The aprosodic pattern is, to the best of our knowlege, unattested in the languages of the world. This strongly suggests that sonority is indeed an important factor for laryngeal timing, resulting in the PROSODIC PATTERN, if no other (high ranked) constraint intervenes. Whatever does outrank sonority affects onsets and codas alike, resulting in either the ONSET PATTERN or the CODA PATTERN. Notice that even though our labels (and descriptions) might imply that we assume laryngeal timing in one subsyllabic constituent (onset, coda) to take precedence over the other, we will leave the question open at this point as to what the respective constraints actually are. Phonetically-based approaches, such as optimization of perceptual salience (Silverman 1997), would be able to generate the onset pattern to some extent; as for the (rare) coda pattern, however, such models do not seem to add much.

6. Intervocalic consonants

Languages following the prosodic pattern show an interesting three-way split in how they realize laryngealized consonants in intervocalic positions. In some languages, they behave like ‘true’ onsets, i.e. obstruents are post-laryngealized [at^{h}a, at’a] and sonorants are pre-laryngealized [a^{h}na, a^{ʔ}na]; in others, they look more like codas, with obstruents being pre-laryngealized [a^{h}ta, a^{ʔ}ta] and sonorants post-laryngealized [an^{h}a, an^{ʔ}a]; and in yet others, we find what looks like a combination of both, with laryngealization showing up on *both sides* of obstruents [a^{h}t^{h}a, a^{ʔ}t’a], but in the *middle* of sonorants [an̥n̥na, an^{ʔ}na].

(36) Intervocalic timing and the prosodic pattern

	Aspiration	Glottalization	
Obstruents	tʰatʰaʰt	t’at’aʔt	like onset
	tʰaʰtaʰt	t’aʔtaʔt	like coda?
	tʰaʰtʰaʰt	t’aʔt’aʔt	like both?
Sonorants	ʰnaʰnanʰ	ʔnaʔnanʔ	like onset
	ʰnanʰanʰ	ʔnanʔanʔ	like coda?
	ʰnan̥nanʰ	ʔnanʔnanʔ	like both?

We believe that sonority plays a crucial role in these cases, too, sometimes interacting with others prosodic factors (syllable structure, foot structure, moraic licensing) in complex ways. Our main point here is that such intervocalic consonants are ambiguous in the sense that the laryngeal and supralaryngeal components of a sound can in principle occur in either syllable: [aʰt.a], [atʰ.a], [aʰ.ta], [at.ʰa], [a.ʰta], [a.tʰa], [aʰ.tʰa]. Some of these are rather unlikely for reasons other than sonority: [aʰt.a] and [atʰ.a], for instance, go against well-known preferences in languages to have onsets (ONS) and not to have codas (NOCODA). Others do violate sonority, such as [a.ʰta], with a sonority fall in the onset. Notice that [at.ʰa], while obeying syllable-internal sonority, is nevertheless inferior to [aʰ.ta] from the perspective of SYLLABLE CONTACT (Murray & Vennemann 1983, Gouskova 2004), another well-established sonority-driven principle. Importantly, all attested patterns in (36) are in line with sonority, *if* syllabified as [a.tʰa], [aʰ.ta] and [aʰ.tʰa]. Admittedly however, we lack information on syllable boundaries (or evidence from syllable weight, for instance) for many of the languages in our data base. For this reason, we’ll describe the attested patterns below (adding information on prosodic structure where possible), rather than speculate on their proper analysis.

6.1. Intervocalic cases as onsets or codas

We start by contrasting intervocalic cases that look like onsets with those that look like codas. Aspirated stops in Halh Mongolian are postaspirated in onsets and prespirated in codas (2.1.). As shown in (37), they are prespirated in intervocalic position, too.

(37) Intervocalic consonants like codas in Halh Mongolian

Onset		VCV		Coda	
[tʰaɮ]	‘steppe’	[aʰta]	‘camel gelding-Refl.’	[aʰt]	‘camel gelding’
[tsʰam]	‘mask dance’	[aʰtsa]	‘fork-Refl.’	[aʰts]	‘fork’
[ʧʰuɮu]	‘stone’	[aʰʧa]	‘grandson-Refl.’	[aʰʧ]	‘grandson’
		[ḁltan]	‘gold-Refl.’	[ḁlt]	‘gold’

We have no evidence to decide whether preaspiration in words like [aʰta] should be regarded as belonging to the first syllable [aʰ.ta] or to the second syllable [a.ʰta]. But we do have evidence that aspiration and oral closure *can* split up between syllables in Halh: looking at the final row in (37), we find that preaspiration in sonorant+obstruent clusters is realized as voicelessness on the sonorant both finally [ḁlt] and medially [ḁlta], the latter strongly suggesting a syllabification like [ḁl.ta].

Chahar Mongolian seems to have the same distribution of pre- and post-aspiration initially and finally, but the facts are less well established than they are for Halh. As for intervocalic position, Svantesson et al. (2005: 17) cite work by Köke & Coyijongjab (1999), showing

'rather heavy postaspiration on word-medial [tʰ], and no visible preaspiration'. They make the preliminary conclusion that 'Chahar and other Mongolian dialects spoken in China have preaspiration only word-finally, and postaspiration in other positions' including intervocalically.

A situation similar to Halh and Chahar Mogolian can be found in Southern (= Standard) and Northern dialects of Icelandic. Standard Icelandic contrasts plain and post-aspirated stops in (root-initial) onsets (38), and plain and pre-aspirated stops in codas, provided this coda is *moraic*. That is, an aspiration contrast is found with word-final geminates and consonant clusters, but not with single consonants (39). As in Halh, preaspiration is realized as voicelessness on a sonorant in sonorant+stop clusters.

(38) Icelandic initial onsets: plain-*post* contrast (Hansson 2003: 51)

plain		postasp	
[tiːna]	'mattress'	[tʰiːna]	'to pick'
[krau]	'grey'	[kʰr̥au]	'pub'

(39) Icelandic final codas: plain-*pre* contrast only with moraic codas (geminate or cluster)

plain		preasp	
[viːt]	'wit'	*	
[kapː]	'hoax'	[kʰaʰp(ː)]	'zeal'
[krʏnt]	'land, ground'	[krʏn̥t]	'burned down'

Word-medially, too, the aspiration contrast depends on a moriac coda, and thus plain geminates and heterosyllabic clusters contrast with their preaspirated counterparts, but only plain sounds are possible after open syllables. Notice that Icelandic vowels are predictably long (in open syllables) or short (in closed syllables), thereby telling us which clusters start a medial syllable (stop+r, j) and which do not (all others).

(40) Icelandic medials: plain-pre contrast only with moraic codas (geminates and clusters)

plain		preasp	
[raː.tar]	'knows the way-3Sg.' / 'radar'	*	
[sɪː.kri]	'sugar-dat.'	*	
[nɛː.pja]	'chilliness'	*	
[kʰɔp.par]	'joung seal-Pl.'	[kʰɔʰp.par]	'small pot-pl.'
[van.ta]	'treat with care'	[van̥.ta]	'lack'
[kɛk.na]	'follow'	[vaʰk.na]	'wake up'

Northern dialects of Icelandic differ from the standard variant in two interesting ways: first, word-medial onsets are realized with postaspiration, i.e. [raː.tʰar] 'knows the way-3Sg.', [sɪː.kʰr̥i], [nɛː.pʰj̥a]. While originally predicatable, plain onsets have been introduced through recent borrowings, and thus postaspiration in [raː.tʰar] now contrasts with plain [t] in [raː.tar] 'radar' (Hansson 2003). Second, sonorant+stop clusters are realized with postaspiration in Northern Icelandic, i.e. [van.tʰa] 'lack', again showing word-medial aspiration in the onset.[11]

[11] The actual situation is somewhat more complex because early aspiration does occur with (i) r+stop clusters, e.g. [pjœ̥r.kar] 'birches', (ii) geminates [kʰɔʰp.par] and (iii) stop+sonorant clusters [vaʰk.na], as in the Standard language.

Glottalized stops in Chitimacha resemble the aspirated stops of Northern Icelandic: they are post-glottalized (ejective) in initial and medial onsets (including intervocalic position), but pre-glottalized in codas.

(41) Intervocalic consonants like onsets in Chitimacha (Swadesh 1934: 359)

onset		coda	
[ʦ'oːt]	'chicken'	[teiˀk]	'sitting'
[p'ak.p'ak.niʃ]	'flat'	[noːˀt.ʃiːˀk]	'drifting'
[ʃa.k'i.ti]	'he hung it up'	[waːˀp.ten]	'knife'
[ni.t'ik]	'presumably'	[k'e.ʔeːˀp]	'bed'

Coast Tsimshian (Sm'algyax, Dunn 1995) and Gitksan (Rigsby & Ingram 1990), too, have ejectives in onsets and preglottalized stops in codas [t'aˀt] (2.2.). Intervocalic consonants, however, are ejective only when stress follows, but pre-glottalized when stress precedes : [aˈt'a], but [ˈaˀta]. This is prosodic in a different way, presumably having to do with glottal attraction to stress (or feet). We suggest syllabifications like [a.ˈt'a], with sonority rising in the onset, and [ˈaˀ.ta] with sonority falling across syllable boundaries, but do not have independent evidence for our claim.

(42) stress-dependent pre-post stops in Coast Tsimshian

pre-stress		post-stress	
[kaːʦ'íːba]	'tie ones hair'	[t'óːˀʦip]	'fortress'
[nak'éːda]	'muskrat'	[liːwáːˀpah]	'cabin (of a boat)'
[hat'áːpa]	'(stone) pestle'	[wáˀtuk]	'ling cod'

American English (Avery & Idsardi 2001) is like Coast Tsimshian, though with a minor twist, in that the laryngeal series of stops is realized with post*aspiration* [tʰ] in the onset but with pre*glottalization* [ˀt] in the coda: [tʰiˀk] 'teak'. Medial preglottalization in words like [ˈtʰiˀkiˀt] 'ticket' suggests that intervocalic cases behave like codas, but postaspiration in, e.g., [piˈkʰʌm] 'become' makes clear that stress (or foot-structure) is involved here, too: stops are preglottalized when stress precedes (i.e. foot-medially) and postaspirated when stress follows (foot-initially).

Glottal attraction to stress with glottalized sonorants occurs in, e.g., Sənčáθen (Saanich; Montler 1986; Caldecott 1999) and the Cowichan dialect of Halkomelem (Leslie 1979), two Central Salish languages (see Bird et al. 2008 for discussion). Glottalized sonorants in Saanich are postglottalized (i.e. coda-like) in codas and in pre-stress position, but preglottalized (i.e. onset-like) in poststress position.[12]

(43) stress-dependent pre-post sonorants in Saanich (Caldecott 1999)

coda	[kʷáˀnənˀ]	'dolphin'
pre-stress	[skʷəjˀáʧən]	'grizzly bear'
post-stress	[ʔíˀnət]	'say what'

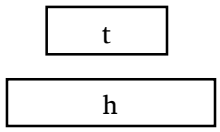
Compare this to glottalized sonorants in Kwak'wala (2.4.), with postglottalization in codas ([ɬəlˀ], [nəlˀ.dzi]) and preglottalization in onsets ([ˀnə.qʷa]), including intervocalic position ([χi.ˀma.la]).

[12] Glottalizated sonorants do not occur word-initially in Saanich.

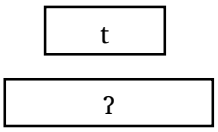
6.2. Laryngeal overlap and laryngeal containment

The final type of laryngeal timing we find in intervocalic position has a falling-rising sonority profile: obstruents are pre- *and* postaspirated [ʰtʰ] or pre- *and* postglottalized [ʔtʼ], while sonorants are realized with laryngealization towards the center of the oral articulation: [nn̥n], [nʔn]. We assume that laryngeal overlap occurs when the aspiration or glottalization has a longer duration than the oral articulation it accompanies; aligning the *centre* of each gesture yields laryngeal overlap (44). Conversely, laryngeal containment occurs when the aspiration or glottalization has a shorter duration than the oral articulation it accompanies; again aligning the *centre* of each gesture yields laryngeal containment (45).

(44) Laryngeal overlap with obstruents

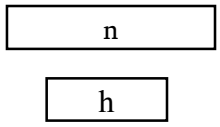
[ʰtʰ] = 

[aʰtʰa]

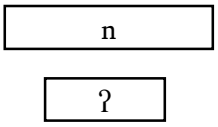
[ʔtʼ] = 

[aʔtʼa]

(45) Laryngeal containment with sonorants

[nn̥n] = 

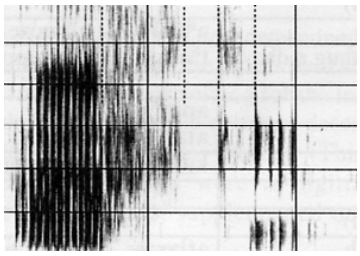
[ann̥na]

[nʔn] = 

[anʔna]

A number of languages evince this peculiar pattern in which aspiration or glottalization spills over to either side of the supralaryngeal closure in a single token [aʰtʰa, aʔtʼa]. This was first noticed, as far as we know, for Scottish Gaelic:

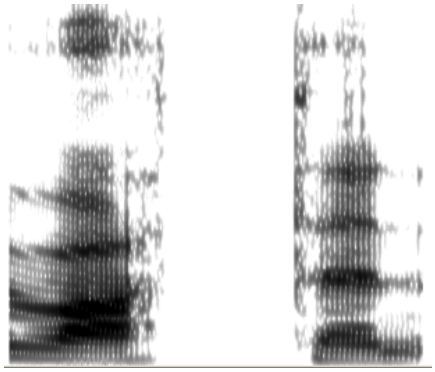
(46) Laryngeal overlap in Scottish Gaelic (Ladefoged et al. 1998)



a ʰ k ʰ ə ‘at them’

The same phenomenon is reported for Swedish:

(47) Laryngeal overlap in Åland Swedish (Helgason 2001)



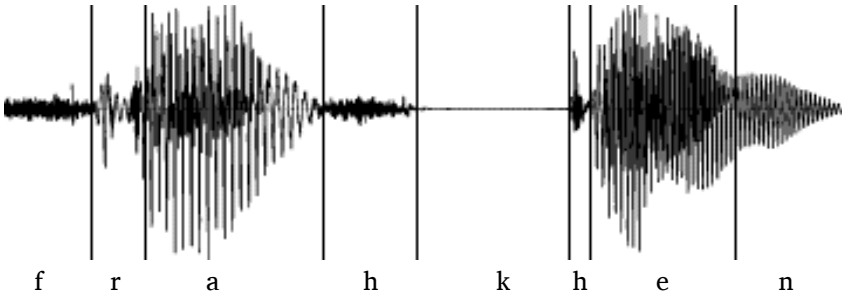
‘water’

As Helgason points out:

> ...a stop can be both preaspirated and postaspirated simultaneously. This applies in particular to the phonologically long stops. Here, both preaspiration and postaspiration are relatively short when compared with other instances of preaspiration and postaspiration in the data, and it is as if the ‘burden‘ of expressing the fortis category is shared equally between the two. (Helgason 2001: 4)

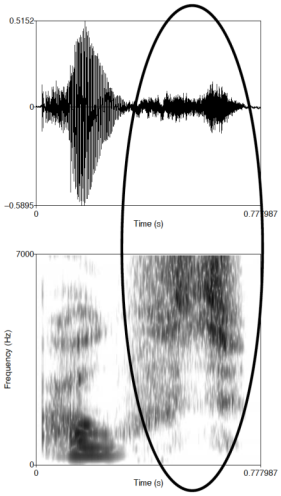
Some northern Norwegian dialects have the same type of thing, as the following waveform clearly shows:

(48) Laryngeal overlap in northern Norwegian (NTNU 2008)



Some dialects of English share this phenomenon, too, showing that it is in part an areal feature of northwestern Europe. Liverpool English involves an especially noteworthy case: coronal stops can spirantize to [s] with laryngeal overlap on both sides and can even do so pre-pausally, so that ‘out’ shows up as [aʊʰsʰ] ‘out’:

(49) Laryngeal overlap in Liverpool English (Watson 2007)



a ʊ ʰ s ʰ ‘out’

Another clear case of this comes from Northern Paiute, which has an intervocalic contrast of lenis, fortis, and voiced fortis stops. The fortis stops are both pre- and post-aspirated, e.g., [ta^{h}k^{h}a] ‘arrowhead’ (Kataoka 2007).

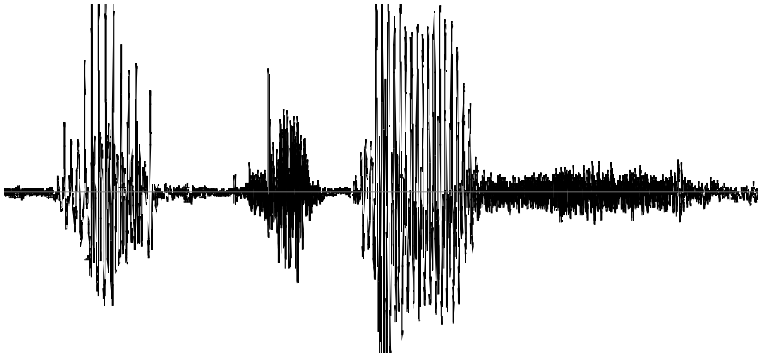
Laryngeal overlap with glottalized stops is found in Zinacantec Tzotzil.

(50) Laryngeal overlap in Zinacantec Tzotzil (Haviland et al. 2006)

Strongly glottalized in word-initial or post-consonant position:
[k’in] ‘party’
[balʧ’ux] ‘to slip’
Preglottalized and lightly articulated in word-final or pre-consonant position:
[x’ele:ʔk] ‘thief’
[mu:ʔkta] ‘big’
Strongly preglottalized in intervocalic position:
[buʔʧ’u] ‘who’
[naʔk’al] ‘hidden’

The intervocalic cases (‘who’ and ‘hidden’) show the laryngeal overlap, with simultaneous pre-glottalization and ejection:

(51) Laryngeal overlap in Zinacantec Tzotzil (Haviland et al. 2006)



a ʔ t s ’ i s ‘you sewed it’

LARYNGEAL CONTAINMENT with glottalized sonorants occurs in St'át'imcets ('Lillooet'; Bird & Caldecott 2004; Bird et al. 2008). The language follows the familiar prosodic pattern, i.e. sonorants are preglottalized in onsets and postglottalized in codas. In intervocalic position, Bird & Caldecott find that 'cues to glottalization occurred in the middle of the resonant with modal voicing occurring both before and after glottalization' (Bird & Caldecott 2004: 330).

(52) Laryngeal containment in St'át'imcets ('Lillooet')

Onset	[ˀmə́mˀ.ʃməʃ]	'little cow'
Coda	[təxʷ.tʃámˀ]	'to raise the price of something'
Intervocalic	[xiʷmm̰mín]	'to put sth. out of sight'

A similar pattern is found in Yapese (Maddieson & Larson 2002), with sonorants being preglottalized in initial position, postglottalized finally, and (usually) glottalized throughout in word-medial position [ˀna̰nanˀ].

7. Voicing

Voicing changes things in interesting ways: while glottalized *voiceless* stops are *post*-glottalized in onsets [t'a], their *voiced* counterparts are consistently *pre*-glottalized in initial and medial position [ˀdaˀda].[13] And while voiceless aspiration with sonorants is typically realized early in onsets [ʰna] (or [n̥na]), breathy voicing is uniformly realized late with sonorants in all positions [nʱanʱanʱ].

A number of languages have preglottalization with *voiced* stops. These languages are especially common in southeast Asia, where they have been studied for some time (Li 1943). A very detailed articulatory study of Sui by Edmondson and his colleagues (2004) shows that the preglottalized voiced stops 'are preceded by a moderate glottal stop, and the voiced consonant following this initial glottal stop is in modal voice' (Edmondson et al. 2004: 57). Other languages with preglottalized voiced stops like this include Cua (Maier 1969), Jarai (Blust 1980), Katu (Wallace 1969), Mlabri (Rischel 1995), Temoyan Otomi (Andrews 1949), Tenango Otomi (Blight & Pike 1976), Sedang (Smith 1968), Stieng (Haupers 1969), and Tampuan (Crowley 2000).

There are two ways of looking at the opposite timings of glottalization with voiceless and voiced stops. One is to assume that languages like Sui or Stieng evince the (missing) CODA PATTERN with glottalized obstruents [ˀda.ˀda], i.e. onsets are realized with a sonority profile typically found in codas. To us, this view is problematic, not only because the languages listed above do not have glottalized codas, but because it doesn't explain why these cases should all and only occur with voiced stops, i.e. why (and how) does obstruent voicing follow from a specific timing pattern?

The second way, which we pursue here, regards preglottalization as the *consequence* of voicing. We assume that the glottalization precedes the voicing [ˀd] because the glottal stop is *less sonorous* than the voiced stop: [ˀd] rises in sonority, as preferred in onset position. This accounts for voiced stops being preglottalized rather than ejective: they are more sonorous than glottal stops and thus follow them in the onset (53).

[13] None of the languages we studied allows them in coda position.

(53) The revised sonority hierarchy (Part 1)

t < s < h, ʔ < d < n < l < j

Regarding voiced obstruents as sonorant-like isn't a new idea, of course (Rice & Avery 1990 among many others). From the perspective of the languages above at least, (53) makes perfect sense, because all other onsets in these languages show a regular rising sonority profile. We exemplify this with laryngealized onsets from Sedang and Sui.[14]

(54) pre- and postlaryngealization in Sedang (Silverman 1997) and Sui (Li 1948)

Voiced stops and sonorants are pre-glottalized in onsets			
Sedang		Sui	
[ˀbok]	'honorific address'	[ˀba]	'wide'
[ˀmot]	'to hunt with a dog'	[ˀma]	'soft'
Sonorants are pre-aspirated in onsets			
[ʰno]	'village name'	[ʰma]	'dog'
Voiceless stops are postaspirated in onsets			
[kʰi]	'thief'	[pʰa]	'blue'

Aspirated sonorants are typically pre-aspirated in onsets, and – in the few cases we found – post-aspirated in codas [ʰnaʰnanʰ]. But breathy-voiced sonorants do not work like this at all. As we saw with glottalized obstruents, adding voicing in to the mix reverses the basic pattern: just as voiced glottalized sounds are uniformly pre-glottalized in the onset [ˀda], breathy-voiced sonorants are uniformly post-breathy in the onset [nʱa]. Besides, for those languages that allow them in coda position, they are uniformly post-breathy, too: [nʱanʱanʱ].

Breathy voiced sonorants are most common on the Indian subcontinent. Marathi (Esposito et al. 2006), for instance, has postbreathy nasals and liquids in all positions, except word-finally. Konkani (Miranda 2003) has postbreathy nasals, liquids, and glides, though the aspiration is 'rare' non-initially (p. 738) and the phonetic details of all this are not reported. Torwali and Indus Kohistani (Bashir 2003a) have postbreathy nasals and liquids, too, but their distribution is not reported. Postbreathy nasals and liquids occur in Bhojpuri (Shukla 1981, Verma 2003a), Magahi (Verma 2003b), Bengali and Hindi (Esposito et al. 2006), though not in word-initial position. The Tibeto-Burman languages Newar (Ladefoged & Maddieson 1996) and Sumi (Harris 2009) have postbreathy nasals and liquids, but only in onsets. Outside the Indian subcontinent, postbreathy liquids and nasals are attested in onsets of Tsonga (Bantu; Traill & Jackson 1988) and Wu (Chinese; Cao 1990; Cao & Maddieson 1992).

Just as with pre-glottalized stops [ˀda], we assume that the timing reversal follows from voicing (rather than voicing following from timing). The breathy voicing is more sonorous than a sonorous consonant because it is realized simultaneously with the modal voicing of the following vowel: it stands to reason that a section of breathy *vowel* is more sonorous than a section of modal *nasal* or *liquid* (55) (see Miller 2012, for a similar view).

(55) The revised sonority hierarchy (final version)

t < s < h, ʔ < d < n < l < j < ɦ

[14] Recall from 2.2., that voiceless stops are proglottalized in Sui codas [ˀt]. The other languages mentioned above do not have laryngealized consonants in coda position.

Notice that all these languages have aspirated voiceless stops, and all (save Sumi) have breathy voiced stops, too. These sounds are post-aspirated and post-breathy in onsets and – where allowed – also in codas, i.e. they are representatives of the onset pattern. We give some examples from Marathi in (56).

(56) post-aspiration and post-breathiness in Marathi (Dhongde & Wali 2009)

initial		final	
[tʰap]	'a lie'	[satʰ]	'company'
[dʱap]	'painting'	[sadʱ]	'gain'
[nʱaːɲ]	'bath'	-	

8. Summary and Conclusion

We have argued that the timing of laryngeal and supralaryngeal articulations in onsets and codas is, to a large extent, governed by sonority sequencing. All else being equal, obstruents are post-aspirated and ejective [tʰa, t'a] in the onset but pre-aspirated and pre-glottalized [aʰt, aʔt] in the coda, while sonorants are the reverse, namely pre-aspirated and pre-glottalized [ʰna, ʔna] in the onset but post-aspirated and post-glottalized [anʰ, anʔ] in the coda (PROSODIC PATTERN). A number of languages generalize the way onsets are realized (ONSET PATTERN), and a few generalize the way codas are realized (CODA PATTERN), but no language seems to reverse sonority in both onsets and codas (*APROSODIC PATTERN).

Languages following the PROSODIC PATTERN show different laryngeal timings in intervocalic position. Basically, laryngeal timing can be ONSET-LIKE, with obstruents post-laryngealized [atʰa, at'a] and sonorants pre-laryngealized [aʰna, aʔna]; or CODA-LIKE, with obstruents pre-laryngealized [aʰta, aʔta] and sonorants post-laryngealized [anʰa, anʔa]; or like both, with obstruents pre- *and* post-laryngealized [aʰtʰa, aʔt'a] and sonorants internally laryngealized [ann̥na, anʔna]. Our preliminary evaluation of these cases is that sonority plays a crucial role here, too, both syllable internally and externally (syllable contact law), though interacting with other prosodic factors (syllable and foot structure) in ways we don't fully understand yet. Finally, we suggested that apparent timing reversals with glottalized voiced stops [ʔd] and breathy voiced sonorants [nʱ] are in fact perfectly regular, if voiced stops [d] and [ʱ] are given the right rank on the sonority hierarchy.

We end by giving a full typology of attested and unattested patterns of laryngeal timing, arranged according to the different combinations of consonants (obstruents, sonorants) and laryngeals (aspirated, glottalized). Patterns marked by '***' are systematically absent in our opinion, those marked by '???' might be accidental gaps (due to the incompleteness of our data base), and '≈' indicates that a language does not show a pattern fully.

(57) Typology of attested and unattested patterns of laryngeal timing

1. Aspirated Obstruents

	language	pattern
tʰaʰtaʰt	Halh	Prosodic pattern; VCV like coda
tʰatʰaʰt	Chahar	Prosodic pattern; VCV like onset
tʰatʰatʰ	Yokuts	Onset pattern
ʰtaʰtaʰt	≈ Huautla	Coda pattern

tʰaʰtatʰ	***	VCV unlike onset or coda
ʰtatʰaʰt	***	VCV unlike onset or coda
ʰtaʰtatʰ	***	Aprosodic pattern
ʰtatʰatʰ	***	Aprosodic pattern

2. Glottalized Obstruents

	language	pattern
t'aʔtaʔt	Gitksan	Prosodic pattern; VCV like coda
t'at'aʔt	Chitimacha	Prosodic pattern; VCV like onset
t'at'at'	Yokuts	Onset pattern
ʔtaʔtaʔt	Sui	Coda pattern
t'aʔtat'	***	VCV unlike onset or coda
ʔtat'aʔt	***	VCV unlike onset or coda
ʔtaʔ.tat'	***	Aprosodic pattern
ʔta.t'at'	***	Aprosodic pattern

3. Aspirated Sonorants

	language	pattern
ʰnanʰanʰ	???	Prosodic pattern; VCV like coda
ʰnaʰnanʰ	Mlabri	Prosodic pattern; VCV like onset
ʰnaʰnaʰn	???	Onset pattern
nʰanʰanʰ	≈ Northern Pame	Coda pattern
nʰaʰnanʰ	***	VCV unlike onset or coda
ʰnanʰaʰn	***	VCV unlike onset or coda
nʰanʰaʰn	***	Aprosodic pattern
nʰaʰnaʰn	***	Aprosodic pattern

4. Glottalized Sonorants

	language	pattern
ʔnanʔanʔ	Saanich	Prosodic pattern; VCV like coda
ʔnaʔnanʔ	Shuswap	Prosodic pattern; VCV like onset
ʔnaʔnaʔn	Tsmimshian	Onset pattern
nʔanʔanʔ	Thompson Salish	Coda pattern
nʔaʔnanʔ	***	VCV unlike onset or coda
ʔnanʔaʔn	***	VCV unlike onset or coda
nʔanʔaʔn	***	Aprosodic pattern
nʔaʔnaʔn	***	Aprosodic pattern

References

Alvarez, Albert and Kenneth Hale. 1970. Toward a manual of Papago grammar: some phonological terms. *International Journal of American Linguistics* 36. 83–97.

Andrews, Henrietta. 1949. Phonemes and Morphophonemes of Temoayan Otomi. *International Journal of American Linguistics* 15. 213-222.

Applegate, Richard. 2008. Inezeño Chumash Language Tutorial. <http://www.chumashlanguage.com>.

Aronson, Howard I. 1997. Georgian phonology. Alan S. Kaye (ed.) *Phonologies of Asia and Africa (including the Caucasus)* Volume 2. Winona Lake, Ind.: Eisenbrauns. 929-939.

Avery, Peter and W. Idsardi. 2001. Laryngeal dimensions, completion and enhancement. Tracy Alan Hall (ed.) *Distinctive Feature Theory*. Berlin and New York: de Gruyter. 41-70.

Barker, M.A.R. 1964. *Klamath Grammar*. Berkeley and Los Angeles: University of California Press.

Bashir, Elena. 2003. Dardic. George Cardona and Dhanash Jain (eds.). *The Indo-Aryan Languages*. London: Routledge. 818-894.

Berthiaume, Scott Charles. 2012. *A Phonological Grammar of Northern Pame*. SIL e-Books 37.

Bird, Sonya and Marion Caldecott. 2004. Glottal timing in St'át'imcets glottalised resonants: Linguistic or biomechanical? *Proceedings of the Tenth Australian International Conference on Speech Science and Technology*. 328-333.

Bird, Sonya, Marion Caldecott, Fiona Campbell, Bryan Gick, and Patricia A. Shaw. 2008. Oral-laryngeal timing in glottalised resonants. *Journal of Phonetics* 36. 492-507.

Blankenship, Barbara, Peter Ladefoged, Peri Bhaskararao, and Nichumeno Chase. 1993. Phonetic Structures of Khonoma Angami. *Linguistics of the Tibeto-Burman Area* 16. 69-88.

Blight, Richard C. and Eunice V. Pike. 1976. The phonology of Tenango Otomi. *International Journal of American Linguistics* 42. 51-57.

Bloomfield, Leonard. 1956. *Eastern Ojibwa*. Ann Arbor: University of Michigan Press.

Blust, Robert. 1980. More on the origins of glottalic consonants. *Lingua* 52. 125-156.

Boas, Franz. 1900. Sketch of the Kwakiutl language. *American Anthropologist* 2.4. 708-721.

Boas, Franz. 1947. Kwakiutl Grammar. With a Glossary of the Sufixes. *Transactions of the American Philosophical Society New Series* 37.3. 203-377.

Bowden, John. 2003. Consonant contrasts in Waimaha. http://chl.anu.edu.au/linguistics/projects/Waimaha/eng/contrasts.html

Buckley, Eugene. 1992. Kashaya laryngeal increments, contour segments, and the moraic tier. *Linguistic Inquiry* 23. 487-496.

–. 1994. *Theoretical aspects of Kashaya phonology and morphology*. Stanford: CSLI.

Bye, Patrik. 2001. *Virtual phonology: rule-sandwiching and multiple opacity in North Saami*. Doctoral dissertation, University of Tromsø.

Caldecott, Marion. 1999. *A comparison of glottalised resonants in Senchothen and St'át'imcets*. M.A. thesis. University of British Columbia.

Cao, Jianfen. 1990. On Phonation Types of Initial Nasals and Some Related Considerations in Chinese Wu Dialects. *Proceedings of ICSLP '90*. Kobe: Japan.

Cao, Jianfen, and Ian Maddieson. 1992. An exploration of phonation types in Wu dialects of Chinese. *Journal of Phonetics* 20. 77-92.

Chafe, Wallace L. 1976. *The Caddoan, Iroquoian, and Souian languages. Trends in Linguistics: State-of-the-Art Reports* no. 3. The Hague: Mouton.

Chitoran, Ioana, Louis Goldstein, and Dani Byrd. 2001. Gestural overlap and recoverability: articulatory evidence from Georgian. Warner and Gussenhoven (eds.): *Papers in Laboratory Phonology* 7. 419-448.

Colarusso, John. 1989. East Circassian (Kabardian dialect). B. George Hewitt (ed.) *The Indigenous Languages of the Caucasus* Volume 2, *The North West Caucasian Languages.* New York: Caravan. 261-355.

–. 1992. *A Grammar of the Kabardian Language.* Calgary: University of Calgary Press.

Crowley, James Dale. 2000. Tampuan phonology. *Mon-Khmer Studies* 30. 1-21.

Dantsuji, Masatake. 1984. A study on voiceless nasals in Burmese. *Studia Phonologica* l8. 1-14.

Das, Anuopam. 2009. The distribution of aspirated stops and /h/ in Bangla: An optimality theoretic account. *The Linguistics Journal* 4.2. 51-76.

Dhongde, Ramesh Vaman and Kashi Wali. 2009. *Marathi*. [London Oriental and African Language Library 13.] Amsterdam and Philadephia: John Benjamins.

Docherty, Gerard J. & Paul Foulkes. 1999. Derby and Newcastle: instrumental phonetics and variationist studies. Paul Foulkes & Gerard J. Docherty (eds). *Urban voices*. London: Arnold. 47-71.

Dunn, John A. 1995. *Sm'algyax: A Reference Dictionary and Grammar for the Coast Tsimshian Language*. Washington, D.C.: University of Washington Press and Sealaska Heritage Foundation.

Edmondson, Jerold A., John H. Esling, Jimmy Harris, and James Wei. 2004. A phonetic study of the Sui consonants and tones. *Mon-Khmer Studies* 34. 47-66.

Esposito, Christina M., Sameer ud Dowla Khan and Alex Hurst. 2006. Breathy Nasals and /Nh/ Clusters in Bengali, Hindi, and Marathi. *UCLA Working Papers in Phonetics* 104. 82-106.

Flemming, Edward, Peter Ladefoged and Sarah Thomason. 2008. Phonetic structures of Montana Salish. *Journal of Phonetics* 36. 465–491.

Foster, Mary LeCron. 1969. *The Tarascan Language. University of California Publications in Linguistics* 56. Berkeley and Los Angeles: University of California Press.

Frazier, Melissa. 2009. The Production and Perception of Pitch and Glottalization in Yucatec Maya. PhD dissertation, Chapel Hill.

Friðjónsson, Jón. 1984. *Phonetics of modern Icelandic*. Reykjavík.

Fulop, Sean, and Chris Golston. 2008. Breathy and whispery voicing in White Hmong. Paper presented at the 155th Annual Meeting of the Linguistic Society of America.

Gamble, Geoffrey. 1978. *Wikchamni Grammar*. Berkeley: University of California Press.

Golston, Chris and Wolfgang Kehrein. 1998. Mazatec onsets and nuclei. *International Journal of American Linguistics* 64. 311-337.

Gordeeva, Olga B. and James M. Scobbie. 2007. Non-normative preaspirated voiceless fricatives in Scottish English: phonetic and phonological characteristics. *QMU Speech Science Research Centre Working Papers*. WP-12.

Gouskova, Maria. 2004. Relational hierarchies in Optimality Theory: the case of syllable contact. *Phonology* 21. 201-250.

Hansson, Gunnar Oláfur. 2001. Remains of a submerged continent. Preaspiration in the languages of Northwest Europe. L. Brinton (ed.). *Historical Linguistics* 1999. Amsterdam: John Benjamins. 157-173.

Hansson, Gunnar Oláfur. 2003. Laryngeal licensing and laryngeal neutralization in Faroese and Icelandic. *Nordic Jornal of Linguistics* 26.1. 45-79.

Harris, Thomas. 2009. *An Acoustic and Articulatory Study of Sonorant Phonation in Sumi.* Honors Thesis. University of Melbourne.

Haupers, Ralph. 1969. Stieng phonemes. *Mon-Khmer Studies* 3. 131-137.

Haviland, John Beard. 1981. *Sk'op Sotz'leb: El Tzotzil de San Lorenzo Zinacantan.* Universidad Nacional Autónoma de México.

Haviland, John Beard, Stuart Robinson & Esteban Gutierrez. 2006. *Sk'op Sotz'leb: The Tzotzil of Zinacantán.* <http://www.zapata.org/Tzotzil/Chapters/chapt1.html>.

Helgason, Pétur. 1999. Preaspiration and sonorant devoicing in the Gräsö dialect: preliminary findings. *Fonetik 99: Proceeding from the Twelfth Swedish Phonetics Conference*. Gothemburg University, June 2-5, 1999. 77–80.

Helgason, Pétur. 2001. Convergence in historical phonetics: Stop contrasts in Åland and Iceland. *Proceedings of Fonetik 2001: Working Papers* 49. Dept. of Linguistics, Lund University. 54–57.

–. 2002. *Preaspiration in the Nordic languages: synchronic and diachronic aspects*. Doctoral Thesis, Stockholm University.

Howe, Darin. 2000. *Oowek'yala segmental phonology and morphology.* PhD dissertation, UBC.

Howe, Darin and Douglas Pulleyblank. 2001. Patterns and timing of glottalisation. *Phonology* 18. 45-80.

Ingram, John, and Bruce Rigsby. 1987. Glottalic stops in Gitksan: an acoustic analysis. *Proceedings of the Eleventh International Congress of Phonetic Sciences* August 1987. Talinn, Estonia. 134-137.

Jespersen, Otto. 1904. *Phonetische Grundfragen.* Leipzig and Berlin: Teubner.

Jones, A. Wesley. 1979. Morphological Constellations in Hidatsa: Locative, Demonstrative, Relative. *IJAL* 45.3. 232-235.

Jones, Mark J. and Carmen Llamas. 2003. Fricated pre-aspirated /t/ in Middlesbrough English: an acoustic study. *Proceedings of the 15th ICPhS.* Barcelona. 655-658.

–. 2006. Voice source variation in vowel-consonant sequences in Middlesbrough English. *Handout, BAAP 2006, QMUC.* Edinburgh.

Karlsson, Anastasia Mukhanova. 2005. *Rhythm and intonation in Halh Mongolian*. Travaux de l'Institute de Linguistique de Lund 46.

Karlsson, Anastasia Mukhanova and Jan-Olof Svantesson. 2002. Preaspiration in Halh Mongolian. Ms, Lund University.

Karsten, Anton. 1892. Kökarsmålets ljud- och formlära. *Svenska landsmål* och svenskt folkliv 12(3).

Kataoka, Reiko. 2007. Phonetics of Mono Lake Northern Paiute medial stops. SSILA annual meeting. http://linguistics.berkeley.edu/~paiute/kataoka_2007.pdf.

Kehrein, Wolfgang and Chris Golston. 2004. A prosodic theory of laryngeal contrasts. *Phonology* 21. 325-357.

Kingston, John. 1985. *The phonetics and phonology of the timing of oral glottal events.* PhD dissertation, University of California, Berkeley.

Kingston, John. 1990. Articulatory binding. John Kingston and Mary E. Beckman (eds.). *Papers in laboratory phonology I: between the grammar and physics of speech.* Cambridge, Cambridge University Press. 406-434.

Kirk, Paul L., Jenny Ladefoged and Peter Ladefoged. 1993. Quantifying acoustic properties of modal, breathy, and creaky vowels in Jalapa Mazatec. Anthony Mattina and Timothey Montler (eds.). *American Indian linguistics and ethnography in honor of Laurence C. Thompson* (= UM Occasional Papers in Linguistics 10). 435-450.

Köke and Coyijongjab. (1999). *Monggol kelen-ii abiyan-u dagun-u uqagan-ujadalulta.* [Acoustic analysis of Mongolian speech sounds]. Kokeqota: OMYS-yin keblel-iin qoriy-a.

Kraft, C.H. and M.G. Kraft. 1973. *Introductory Hausa*. Berkeley: University of California Press.

Kuipers, Aert H. 1960. *Phoneme and Morpheme in Kabardian.* The Hague: Mouton.

–. 1967. *The Squamish Language.* The Hague: Mouton.

–. 1974. *The Shuswap Language: Grammar, Texts, Dictionary.* Janua Linguarum, Series Practica 225. The Hague: Mouton.

Ladefoged, Peter, Jenny Ladefoged, Alice Turk, Kevin Hind, and St. John Skilton. 1998. Phonetic structures of Scottish Gaelic. *Journal of the IPA* 28. 1-41.

Ladefoged, Peter and Ian Maddieson. 1996. *The Sounds of the World's Languages.* Oxford: Blackwell.

Leslie, A. R. 1979. *A grammar of the Cowichan Dialect of Halkomelem Salish.* Ph.D. dissertation, University of Victoria.

Lewis, J. William. 2003. Central Kalapuya Phonology: The Segmental Inventory of John Hudson's Santiam. Master Thesis. University of Victoria.

Li Fang Kuei. 1943. The hypothesis of a series of pre-glottalized consonants in Primitive Tai. *Bulletin of the Institute of History and Philology, Academia Sinica* 2.2.

–. 1948. The Distribution of Initials and Tones in the Sui Language. *Language* 24. 160-167.

Lincoln, Neville J. and John C. Rath. 1980. *North Wakashan comparative root list.* Ottawa, National Museum of Canada.

Maddieson, Ian, and Julie Larson. 2002. Variability in the production of glottalised sonorants: data from Yapese. *ICSLP* 2002. 1097-1100.

Maddieson, Ian, Caroline L. Smith and Nicola Bessell. 2001. Aspects of the phonetics of Tlingit. *Anthropological Linguistics* 43. 135–176.

Maier, Jacqueline G. 1969. Cua phonemes. *Mon-Khmer Studies* 3. 9-19.

Miller, Brett. 2012. Sonority and the Larynx. Steve Parker (ed.). *The Sonority Controversy*. Berlin and New York: de Gruyter. 257-288.

Miller, Wick R., Dirk Elzinga, and John E. McLaujghlin. 2005. Preaspiration and gemination in Central Numic. *International Journal of American Linguistics* 71. 413-444.

Miranda, Rocky V. 2003. Konkani. George Cardona and Dhanash Jain (eds.). *The Indo-Aryan Languages*. London: Routledge. 729-765.

Montler, Timothy. 1986. An outline of the phonology and morphology of Saanich, North Straits Salish. *Occasional Papers in Linguistics*. University of Montana Linguistics Laboratory, Missoula.

Murray, Robert W., and Theo Vennemann. 1983. Sound Change and Syllable Structure in Germanic Phonology. *Language* 59.3. 514-528.

Newman, Stanley. 1944. *Yokuts language of California*. New York: Viking Fund.

Nevin, Bruce E. 1998. *Aspects of Pit River Phonology*. Dissertation. University of Pennsylvania.

Ní Chasaide, Ailbhe. and Cathair Ó Dochartaigh. 1984. Some durational aspects of preaspiration. J.A. Higgs and R. Thelwall (eds.). *Topics in Linguistic Phonetics: in Honor of E.T. Uldall.* Occasional Papers in Linguistics and Language Learning no. 9. Department of Linguistics: The New University of Ulster. 141-157.

Nichols, Johanna. 1994. Ingush. Rieks Smeets (ed.). *The Indigenous Languages of the Caucasus, vol. 4. North East Caucasian Languages, Part 2*. New York: Caravan. 79-146.

Norges teknisk-naturwitenskapelige universitet (NTNU). 2008. www.ling.hf.ntnu.no

Parker, Steve. 2002. *Quantifying the sonority hierarchy*. Ph.D. thesis. University of Massachusetts Amherst.

Pike, Kenneth L. and Evelyn V. Pike. 1947. Immediate constituents of Mazatec syllables. *International Journal of American Linguistics* 13. 78-91.

Plauché, Madelaine C., Rosemarie Beam de Azcona, Rungpat Roengpitya and William F. Weigel. 1998. Glottalized sonorants: A phonetic universal? *BLS* 24. 381-390

Price, P. David. 1976. Southern Nambikwara phonology. *International Journal of American Linguistic* 42. 338-348.

Quintero, Carolyn. 2004. *Osage Grammar*. University of Nebraska Press.

Rankin, Robert L. 2003. The Comparative Method. Brian D. Joseph and Richard Janda (eds.). *The Handbook of Historical Linguistics*. Malden, MA: Blackwell. 183-212.

Reitan, Jørgen. 1930. *Vemdalsmålet, med oplysninger om andre Herjedalske mål*. Oslo: Det Norske Videnskaps-Akademi.

Rice, Keren and Peter Avery. 1990. On the interaction between sonority and voicing. *NELS* 20. 428-442.

Rigsby, Bruce and John Ingram. 1990. Obstruent voicing and glottalic obstruents in Gitksan. *International Journal of American Linguistics* 56. 251-263.

Rischel, Jørgen. 1995. *Minor Mlabri: a hunter-gatherer language of Northern Indochina*. Copenhagen: Museum Tusculanum Press.

Robins, R.H. and N. Waterson. 1952. Notes on the phonetics of the Georgian word. *Bulletin of the School of Oriental and African Studies* 14. 55-72.

Roos, Martina Erica. 2000. *The Western Yugur (Yellow Yugur) Language: Grammar, Texts, Vocabulary*. Diss. University of Leiden.

Rositzke, Harry A. 1940. Epenthetic consonants in Swedish. *Journal of English and Germanic Philology* 39. 473–485.

Samarin, William J. 1966. *The Gbeya Language*. Berkeley & Los Angeles: The University of California Press.

Sapir, Edward. 1912. The Takelma Language of Southwestern Oregon. Franz Boas (ed.). *Handbook of American Languages* Part 2. Smithsonian Institution, Washington D.C. 1-296.

Shukla, Shaligram. 1981. *Bhojpuri Grammar*. Washington, D.C.: Georgetown University Press.

Sievers, Edward. 1881. *Grundzüge der Phonetik*. Leipzig: Breitkopf und Härtl.

–. 1997. *Phasing and Recoverability*. New York: Garland Press.

–. 2003. On the rarity of pre-aspirated stops. *Journal of Linguistics* 39. 575–598.

Smith, Kenneth D. 1968. Laryngealization and delaryngealization in Sedang phonemics. *Linguistics* 38. 52-69

Stölten, Katrin. 2002. Dialektalitet som ålders- och könsmarkör i arjeplogsdialekten: ett auditivt test och mätningar på preaspiration och VOT. C-uppsats, Stockholm University.

Svantesson, Jan-Olof, Anna Tsendina, Anastasia Karlsson, and Vivan Franzén. 2005. *The phonology of Mongolian*. Oxford: Oxford University Press.

Swadesh, Morris. 1934. The phonetics of Chitimacha. *Language* 10.4. 345-362.

Swadesh, Morris. 1946. Chitimacha. Harry Hoijer (ed.). *Linguistic Structures of Native America.* Viking Fund Publications in Anthropology 6. New York: Viking Fund. 312-336.

Thompson, Laurence C. and Terry M. Thompson. 1992. *The Thompson language*. Missoula, Mt.: University of Montana Occasional Papers in Linguistics 8.

Traill, Anthony and Michael Jackson. 1988. Speaker variation and phonation type in Tsonga nasals. *Journal of Phonetics* 16. 385-400.

Traill, Anthony. 1985. *Phonetic and Phonological Studies of !Xóõ Bushman.* Hamburg: Buske.

Thraínsson, Höskuldur. 1978. On the phonology of Icelandic preaspiration. *Nordic Journal of Linguistics* 1. 3-54.

Thráinsson, Höskuldur, Hjalmar P. Petersen, Jógvan í Lon Jacobsen, and Zakaris Svabo Hansen. 2004. *Faroese: An Overview and Reference Grammar*. Føroya Fróðskaparfelag.

Tronnier, Mechtild. 2002. Preaspiration in southern Swedish dialects. *Proceedings of Fonetik 2002. Speech, Music and Hearing Quarterly Progress and Status Report* 44. 33-36.

Vaux, Bert and Bridget Samuels. 2005. Laryngeal markedness and aspiration. *Phonology* 22. 395-436.

Verma, Manindra K. 2003. Bhojpuri. George Cardona and Dhanash Jain (eds.), *The Indo-Aryan Languages*. London: Routledge. 515-537.

Verma, Sheela. 2003. Magahi. George Cardona and Dhanash Jain (eds.). *The Indo-Aryan Languages*. London: Routledge. 498-514.

Wallace, Judith M. 1969. Katu phonemes. *Mon-Khmer Studies* 3. 64-73.

Wallström, Sigvard. 1943. *Studier i övre Norrlands språkgeografi med utgångspunkt från Arjeplogmålet*. Uppsala: Almqvist & Wiksells.

Watson, Kevin. 2007. Liverpool English. *Journal of the IPA* 37. 351-360.

Watt, Dominic and William Allen. 2003. Tyneside English. *Journal of the IPA* 33. 267-271.

Whorf, Benjamin L. 1944. The Hopi language, Toreva dialect. *Viking Fund Publications in Anthropology* 6. New York: Viking Fund. 158-183.

Wretling, Pär, Eva Strangert & Feliz Schaeffler. 2002. Quantity and preaspiration in Northern Swedish dialects. *Proceedings of speech prosody 2002, Aix-en-Provence, France 11-13 April 2002*. <www.ling.gu.se/~anders/SWEDIA/papers/wretling_sp 2002.pdf> [accessed 4th January 2009].

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