A Note on Pharyngeal Features♣

Bert Vaux, Harvard University

Originally published as Vaux, Bert. 1999. A Note on Pharyngeal Features. Harvard Working Papers in Linguistics 7, Susumu Kuno and Bert Vaux, eds., 39-63. Cambridge, MA: Harvard University Linguistics Department. References slightly updated in December 2022.

1. Introduction 2
2. Uvulars 4
  2.1. The feature specification of uvulars 7
    2.1.1. Uvulars as [+back] 8
    2.1.2. Uvulars as [-high] 10
    2.1.3. Uvulars as [-atr] 13
  2.2. Uvular asymmetry 18
3. The Position of [atr] in Feature Geometry 22
  3.1. [atr] as an independent articulator 22
  3.2. [atr] and the Laryngeal Node 23
  3.3. [atr] and the Pharyngeal Node 25
    3.3.1. Pharyngeals and Pharyngealized and Emphatic Consonants 29
    3.3.2. Pharyngealized vowels 34
  3.4. The Lower Vocal Tract Node 34
4. Conclusions 35
References 36

♣ Thanks to Andrea Calabrese, Morris Halle, and Stuart Davis for comments on an earlier version of this paper presented at the 1993 LSA annual meeting in Los Angeles, which was circulated in manuscript form with the title “ATR-Voice Interactions and the Geometry of the Lower Vocal Tract”. Research documented herein was supported by a grant from the National Science Foundation.

1. Introduction

The inventory and organization of lower-vocal-tract (i.e. pharyngeal and laryngeal) features have received a great deal of attention in recent work on phonological theory (cf. Steriade 1987, Clements 1989, Halle 1989, Hayward and Hayward 1989, Trigo 1991, Goad 1992, van der Hulst and Mous 1992, Bessell 1993, Parkinson 1993, McCarthy 1994), yet many of the central issues raised by these researchers remain unresolved. The goal of this paper is to approach the larger problem of features produced in the lower vocal tract through a detailed examination of the phonological behavior of features produced in the pharynx.

The central claims I make are that (i) [atr] is not an ersatz feature employed to encode height distinctions, as has been claimed by Clements 1989, but rather plays an important role in both consonants and vowels; (ii) the distribution of uvulars, both in terms of alternations with velars and the general lack of the voiced uvular stop *G*, is motivated by the nature of the feature [atr]; (iii) all properties of guttural (i.e. lower-vocal-tract) segments observed by the researchers mentioned above can be captured by the feature geometry proposed in (1); and (iv) the tongue root features [atr] and [rtr] are analogous to tongue height features in producing a three-way contrast in possible segments.

Most of the topics discussed in this paper revolve around the radical features [atr] and [rtr] and segments that involve these features. Thus, I consider it appropriate at this point to present briefly the assumptions I make concerning these elements. I assume that the lower vocal tract (= LVT in (1)) contains two articulators, the tongue root and the larynx, represented in (1) by the Radical and Laryngeal nodes respectively. The structure of the Laryngeal node is based on work by Halle 1989. I suggest that the Radical node dominates two features, [atr] and [rtr]. The feature [rtr] differs from [atr] in involving the pharyngeal constrictors and perhaps the posterior wall of the pharynx (cf. McCarthy 1994) in addition to the tongue root. The possible values for these features have the following interpretation:

[+atr]	=	advancement of the tongue root;
[-atr]	=	retraction of the tongue root;
[+rtr]	=	constriction of the pharynx, involving retraction of the tongue root and activation of the pharyngeal constrictor muscles;
[-rtr]	=	the neutral position of the tongue root.

The features [atr] and [rtr] freely combine, subject to the constraint that [+atr, +rtr] is physically impossible, like [+high, +low].

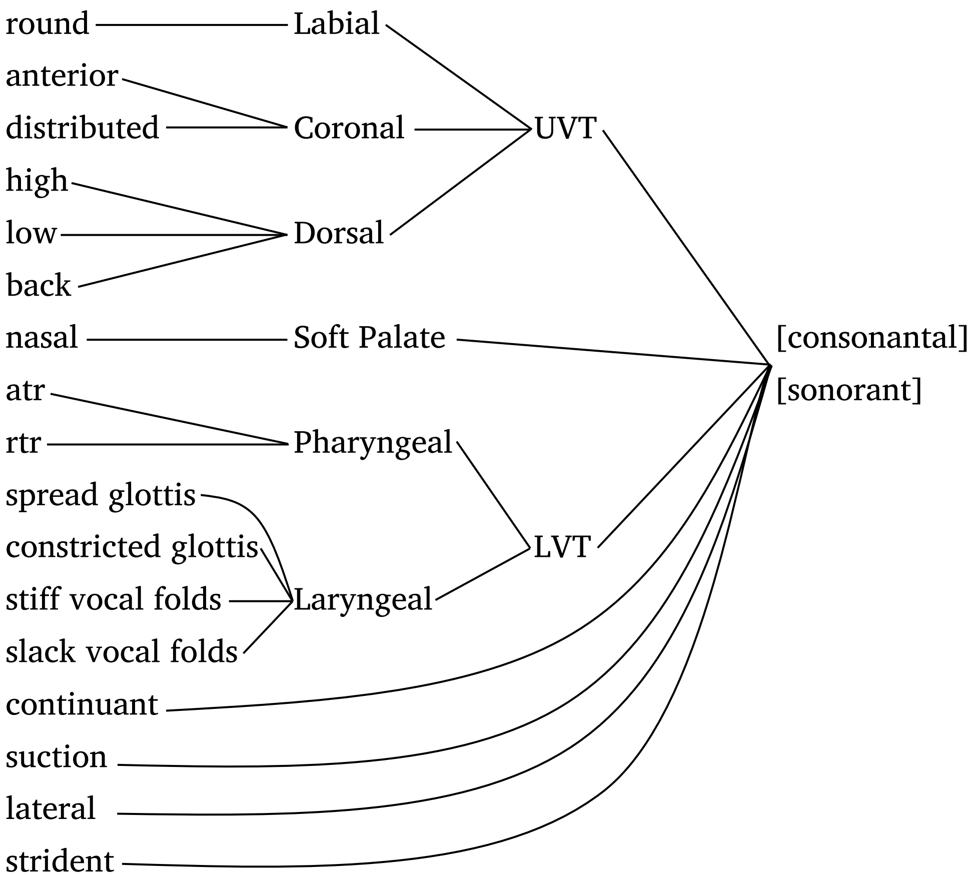
I argue that the various combinations of [atr] and [rtr] values produce the following segment types:

[+atr, -rtr]	=	voiced stops (as a secondary articulation)
[-atr, -rtr]	=	epiglottals (as a primary articulation)
		uvulars (as a secondary articulation)
[-atr, +rtr]	=	pharyngeals

I know of no [+atr, -rtr] segments with the tongue root as their primary articulator. Voiced stops have as their primary articulator whatever has been assumed in the past; thus, for example, both *t* and *d* have Coronal as their primary articulator, but *d* also has a Radical secondary articulation containing the features [+atr, -rtr]. Uvulars have a Dorsal primary articulation which may be either [-back, +high] in the case of palatalized uvulars, or [+back, -high] in the case of regular uvulars. My motivations for making these assumptions are justified in the rest of this paper.

I support a representational structure which incorporates the findings of McCarthy 1994 within the general proposal of Halle 1989 and Halle, Vaux, and Wolfe 2000, as in (1) (UVT = Upper Vocal Tract, LVT = Lower Vocal Tract):

(1)



I adopt Halle 1989's Glottal node (equivalent to my Laryngeal node) and McCarthy 1994's Pharyngeal node. My UVT node is isofunctional with the standard Place node; I have eschewed the term 'place' because the Laryngeal and Radical articulators are technically places of articulation as well.

2. Uvulars

In this section I examine the relevance of uvular segments for understanding the phonological structure of the Lower Vocal Tract. I first argue in section 2.1 that true uvular consonants are characterized by a [-atr] secondary articulation. In section 2.2 I then show how this [-atr] specification, when combined with the insight that voiced obstruents can have a [+atr] specification, allows us to account for the striking cross-linguistic rarity of voiced uvular stops relative to their voiceless counterparts.

The idea that voiced obstruents can be [+atr] is based on the observation that many languages show interactions between consonant voicing and vocalic [atr] values; for example, vowels may become [+atr] adjacent to voiced obstruents, or conversely (and less commonly) consonants may become voiced adjacent to [+atr] vowels. These interactions are extensively documented in Trigo 1987, 1991 and Vaux 1996 for Akan, several Armenian dialects, Babine, Buchan Scots English, Madurese, Mon Khmer languages, and the Southwest Turkic languages. Trigo 1987 and Vaux 1996 propose on the basis of these data that voiced obstruents can possess a [+atr] specification.

The effect of the [+atr] specification of voiced obstruents on adjacent vowels can be seen in the Armenian dialect of Malatia, as described by Danieljan 1967. According to Danieljan (1967:22), the proto-Armenian plain voiced stops have merged with the voiceless aspirated stops (2a-b), and the original plain voiceless stops have become voiced (2c).

(2)	**Proto-Armenian**	**Malatia**	**gloss**
a.	burd	p‘urt‘	wool
	garun	k‘arun	spring
	dadar	t‘at‘ar	rest
b.	p‘esay	p‘esa	bridegroom
	k‘aṙasun	k‘aṙsun	forty
	t‘t‘u	t‘ut‘u	sour
c.	pakas	bagas	less
	tasn	dasə	ten

However, Danieljan notes that vowels that follow original voiceless aspirated stops are more “open” than vowels following original voiced stops. He exemplifies this difference with the forms in (3), stating that the <a> in (3a) is more open than the <a> in (3b).

(3)

	Proto-Armenian	Malatia	gloss
a.	t‘as	t‘as	cup
b.	das	t‘as	lesson

I interpret the difference in openness observed by Danieljan as the manifestation of an [atr] contrast: the more open vowels that occur after original voiceless aspirates are [-atr], and the more closed vowels that follow original voiced stops are [+atr]. This interpretation is illustrated in (4).

(4)

	Proto-Armenian	Malatia (IPA value)	gloss
a. [-atr]	t‘as	t^{h}ɑs	cup
	p‘ot‘	p^{h}ɔt^{h}	plait
	p‘uk‘	p^{h}ʊk^{h}	breath
b. [+atr]	das	t^{h}ɐs	lesson
	boyt‘	p^{h}ot^{h}	thumb
	buk‘	p^{h}uk^{h}	snowstorm

If we assume following Trigo 1987 and Vaux 1996 that voiced obstruents are [+atr], the facts in (4) are easily accounted for by postulating that before the Malatia dialect underwent the consonant shift illustrated in (2), it was subject to the rule in (5), which states that a consonant spreads its [atr] specification to a following vowel.

(5) C V

[+atr]

Original voiceless consonants did not trigger rule (5), since they have no [atr] specification. Original voiced stops, being [+atr], spread this feature to immediately following vowels, as shown in (6) for the ‘lesson’ word in (4b).

(6) d a s

[+atr]

If we further assume that vowels not affected by rule (5) surface as [-atr], we obtain a straightforward account for the Malatia facts. Crucially, it is difficult to account for the Malatia data without assuming that voiced stops are [+atr].

The theory that voiced stops have a [+atr] specification has interesting implications for the behavior of uvular consonants. A number of phonologists now assume that uvulars are characterized by a primary dorsal articulation and a secondary [-atr] articulation (cf. Elorrieta 1992). If this is true, we should expect voiced uvular stops to be rare, because the tongue root cannot be simultaneously advanced (because it is a voiced stop) and retracted (because it is a uvular). This distribution is strikingly confirmed in the world's languages. Furthermore, many languages with [atr] harmony show synchronic alternations between k and q and between g and the voiced uvular fricative ʁ, which I show below to be easily accounted for if we assume that voiced stops are [+atr] and uvulars are [-atr].

In the remainder of this section I consider the arguments presented in the literature for a [-atr] element in uvulars, and survey the evidence of uvular asymmetry and velar-uvular alternations. I conclude that the facts surveyed provide independent support for the claims that voiced stops are [+atr] and that uvulars are [-atr].

2.1. The feature specification of uvulars

The first generative treatment of uvulars, by Chomsky and Halle (1968), proposed that uvulars are [-high, +back] (ibid., p. 305). Chomsky and Halle provided no empirical support for this position, but may have had in mind the Turkic languages, most of which show alternations between velar and uvular consonants conditioned by the [back] or [high] specifications of neighboring vowels. We exemplify and examine these alternations in sections 2.1.1 and 2.1.2, and then show in 2.1.3 that true uvulars crucially possess a [-atr] specification.

2.1.1. Uvulars as [+back]

All Turkic languages display alternations between two series of Dorsal consonants. In Standard Turkish the two series are [+back] and [-back] velars, but in non-standard dialects of Turkish and in most other Turkic languages the two series are uvulars and velars. The most common state of affairs in Turkic languages is for these two series to alternate systematically according to the backness of adjacent vowels: Dorsal consonants surface as velars when adjacent to [-back] vowels, and as uvulars when adjacent to [+back] vowels.[1] In Uyghur, for example, the underlying voiced Dorsal stop /G/ surfaces as the velar stop [g][2] next to [-back] vowels (7a-c), and as the uvular fricative [ʁ][3] next to [+back] vowels (8a-c).[4]

(7) Uyghur velar-uvular alternations (data from Hahn 1991)

a.	dative /-GA/	hädä ‘elder sister’	→	hädi-gä
		küç ‘power’	→	küç-kä
b.	past /-GAn/	käl- ‘come’	→	käl-gän
		kir-mä- ‘enter-neg’	→	kir-mi-gän
c.	imperative 3sg /-GIn/	käl- ‘come’	→	käl-gin
		išli- ‘work’	→	išli-gin

---

[1] Most if not all Turkic languages also have a limited number of non-alternating velar and uvular consonants, normally in words borrowed from Arabic and Persian.

[2] Or [k] following a voiceless consonant, as in küç-kä.

[3] Or [q] following a voiceless consonant, as in waqit-qa.

[4] The vowel /i/ is neutral in Uyghur, and can cooccur with both velar and uvular consonants; cf. hädi-gä vs. bali-ʁa. Its allophonic variations are more complex; see Hahn 1991 for details.

(8) Uvulars with [+back] vowels

a.	dative /-GA/	bala ‘child’	→	bali-ʁa
		waqit ‘time’	→	waqit-qa
b.	past /-GAn/	bar- ‘go’	→	bar-ʁan
		oqu- ‘read’	→	oqu-ʁan
c.	imperative 3sg /-GIn/	bar- ‘go’	→	bar-ʁin
		oqu- ‘read’	→	oqu-ʁin

Along similar lines, the underlying voiceless Dorsal stop /K/ surfaces as the velar stop [k] next to [-back] vowels (9a), and as the uvular stop [q] next to [+back] vowels (9b).

(9) Alternations in the Uyghur 1st plural present-future conditional /-K/

a.	oqu- ‘read’	→	oqu-saq
b.	käl- ‘come’	→	käl-säk

Let us assume that Dorsal consonants that show surface velar/uvular alternations are underlyingly unspecified for the feature [back], and receive their [back] specification from an adjacent vowel via the spreading rule in (10).

(10) X X

[back]

This being the case, the alternations in (7-9) are straightforwardly explained by assuming that velars are [-back] and uvulars are [+back]. In (11a), spreading of the harmonic [-back] feature to the /G/ produces a [-back] Dorsal segment, which by hypothesis represents a velar. Similarly spreading of the harmonic [+back] feature to the /G/ in (11b) produces a [+back] Dorsal segment, which by hypothesis represents a uvular. (In the following diagram, capital letters represent segments underspecified for the harmonic feature.)

(11) a. K A l G A n

[-back]

b. *b A r G A n*

[-back]

This sort of alternation between velar and uvulars conditioned by the [back] specification of adjacent vowels is consistent with Chomsky and Halle's assertion that uvulars differ from velars in that the former are [+back] and the latter are [-back].

The binary opposition between velars and uvulars in terms of the feature [back] can also straightforwardly account for a pattern we find in dialects of several K'ichean languages wherein velar stops are palatalized when followed by a uvular in the same root (Campbell 1998:74). If we assume that palatalized velars are {Dorsal, [-back]}, uvulars are {Dorsal, [+back]}, and plain velars are simply Dorsal with no [back] specification, we can interpret the K'ichean pattern as a dissimilation process that informally takes the form Ø → [-back] / _ {Dorsal} ... {Dorsal, [+back]}.

2.1.2. Uvulars as [-high]

There are also numerous phenomena which corroborate the second prong of Chomsky and Halle's proposal, namely that uvulars are [-high]. Uvulars commonly lower adjacent high vowels, e.g. in Greenlandic (Elorrieta 1992:144). (Compare also Aleut, where "uvular consonants have a significant effect on the formants of following high vowels" (Taff et al. 2001:231).)

Conversely, spreading of [-high] from vowels changes Dorsal consonants to uvulars in some languages. The Turkic language Yakut, for example, has the vowel system in (12); note that the vowels fall into two sets, [+high] and [-high], as in Turkish.

(12) Yakut vowel system (using turcological orthography)

a.	short vowels	[+high]	i	ü	ı	u
		[-high]	e	ö	a	o
b.	long vowels	[+high]	i:	ü:	ı:	u:
		[-high]	e:	ö:	a:	o:
c.	diphthongs		uo	üö	ıa	ie

Yakut also possesses two Dorsal consonants—one voiced, one voiceless—that alternate between velars and uvulars according to context. Abstracting away from effects of neighboring consonants, these alternants have the distribution in (13) (Wetzels 1986:174):[5]

(13)	**underlying form**	**surfaces as**	**after**
a.	/K/	[q]	a o e ö ıa uo ie üö
		[k]	elsewhere
b.	/G/	[ʁ]	a o e ö ıa uo ie üö
		[g]	elsewhere

The alternations for /G/ can be seen in the surface forms of the second-person plural suffix /-GIt/, illustrated in (14) (data from D'jaçkovskij 1987).

[5] Wetzels states that q is actually an affricate, and ʁ is a voiced uvular stop. I have assigned these allophones the symbols q and ʁ based on their pronunciation by my informant, Margarita Borisova, a native speaker of Yakut from Njurba.

(14)	a.	[g]	tɪ:-gɪt	your (pl) boat
			kel-li-git	you pl. came
	b.	[ʁ]	sa:-ʁɪt	your (pl) gun
			d'ie-ʁit	your (pl) house
			kinige-ʁit	your (pl) book
			oʁo-ʁut	your (pl) child
			öŋö-ʁüt	your (pl) service

It is clear from (13) that the uvular allophones [q] and [ʁ] occur after [-high] vowels, and the velar allophones occur elsewhere. This distribution is easily accounted for by assuming that velars are [+high] and uvulars are [-high], and that Yakut possesses a rule that spreads the [high] specification of a vowel to a following consonant, as in (15).

(15) V C

[high]

Application of rule (15) to a [-high] vowel preceding a Dorsal consonant will produce a [-high] Dorsal, which by our above hypothesis represents a uvular.

A similar but slightly more complicated interaction between [-high] vowels and uvulars occurs in the Tungusic language Sibe, where the velar segments k and x become the uvulars q and χ respectively when preceded anywhere in the word by a [-high] vowel (Li 1996:201-202). In (16a), for example, the suffixal dorsal consonant in the word for 'long' becomes uvular by virtue of the fact that it is preceded by the [-high] vowel ö; contrast this with the forms in (16c), where the same suffix surfaces with a k, because it is not preceded by a [-high] vowel.

(16) k, x → q, χ when preceded anywhere in the word by a [-high] vowel

a.	ɢölmi(n)-qɨn	long
	ʤalu-qun	full

	adʒi(g)-qɨn	small
b.	bɔdu-χu	to consider
	lavdu-χu	to become more
	ömi-χɨ	to drink
c.	ɨldɨ(n)-kɨn	bright
	ulu-kun	soft
	tɨ-xɨ	to sit
	türü-xu	to rent

(17) the Sibe vowel system (Li 1996)

[+high]	i	ü	ɨ	u
[-high]	ɛ	ö	a	ɔ

Just as in Yakut, this phenomenon can be analyzed as spreading of [-high] from a vowel to a Dorsal consonant. (For an explanation of why this process can ignore intervening [+high] vowels, see Vaux 1999.)

In sum, the Greenlandic, Yakut, and Sibe facts considered in this subsection provide convincing support for Chomsky and Halle's proposition that uvulars contain a [-high] component. Note that without this assumption, it would be extremely difficult if not impossible to provide a unified account for the facts just discussed.

2.1.3. Uvulars as [-atr]

Recent work by Cole 1987, Elorrieta 1992, Vaux 1994, and others has suggested that uvulars include a [-atr] component, as in (18). (N.B. Elorrieta, following Trigo 1991, assumes that there is a second type of uvular which has no [-atr] element; I believe that this type, which we find in Standard Turkish, is simply a back velar, and should not be called a uvular. I consider back velars later in this paper):

(18)

X
UVT — LVT
| |
Dorsal — Radical
| |
[±back] [±high] — [-atr]

The primary piece of evidence adduced by Cole 1987 and Elorrieta 1992 in support of uvulars having a [-atr] element comes from Coeur d'Alene, where [atr] harmony is blocked by uvular consonants.[6]

The assumption that uvulars have a [-atr] specification also enables us to account for the alternations between velars and uvulars produced by [atr] harmony in the Tungusic and Mongolic languages (and perhaps Coeur d'Alene—see Elorrieta 1992:148). In both of these language families, roots are associated with floating [+atr] or [-atr] features (q.v. Vaux 1997), which then spread to all eligible segments in the root and suffixes. Underlying Dorsal consonants surface as velars in [+atr] words, but as uvulars in [-atr] words, as schematized in (19) for the Tungusic language Even (Ard 1980:28, Comrie 1981:70).

(19)	/K, G/→	k, g	/_{i e u o ie}
		q, ʁ	/_{ɪ ɑ ʊ ɔ ɪɑ}[7]

[6]Doak 1992 suggests that uvulars do not block [atr] harmony in Coeur d'Alene, but her argument crucially depends on the assumption of radical underspecification. For convincing arguments against radical underspecification see Mohanan 1991, Calabrese 1995, and Steriade 1995.

[7] Aralova et al. 2011 transcribe these vowels as <ị a ụ ọ ịa>; I have rendered these into what I believe their IPA values to be on the basis of the formant plots presented there (ibid., p. 242).

Similar alternations are found in the Bikin dialect of the Tungusic language Nanay, as can be seen in (20): the suffix /-KsA/ 'skin' surfaces with a velar [k] in [+atr] words, but with a uvular [q] in [-atr] words (20a); the agent suffix /-md'UgA/ surfaces with a velar [g] in [+atr] words, but with a uvular [ʁ] in [-atr] words (20b) (Sem 1976:36-7).

(20) Bikin Nanay

a. -KsA	giu	'wild deer'	→	giu-ksə	'wild deer skin'
	mafa	'bear'	→	mafa-qsa	'bear skin'
b. -md'UgA	ulfi-	'sew'	→	ulfimd'ugə	'seamstress'
	dala-	'lead'	→	dalamd'ʊʁa	'leader'

Mongolic languages, which like the Tungusic languages generally possess [atr] harmony systems, also show velar-uvular alternations conditioned by the [atr] specification of the word. In Khalkha Mongolian, for example, the voiced Dorsal consonant /G/ surfaces as velar [g] in words showing [+atr] harmony, and as uvular [G] or [ʁ] in words with [-atr] harmony (Rialland and Djamouri 1984).

Traditional accounts for the velar-uvular alternations in Tungusic and Mongolic languages assume that the feature that spreads to these consonants from adjacent vowels is [back], and [+back] dorsal consonants become uvular as a result of a phonetic implementation rule (cf. Colarusso 1974, Comrie 1981, Ramsey 1987, etc.). This account encounters at least two problems: (i) the harmonic feature is actually [atr] (see Rialland and Djamouri 1984 and Svantesson 1985 for Mongolian, Ard 1980 and Li 1996 for Tungusic, and also Vaux 1997); (ii) it is not clear why [+back] dorsals should become uvulars—note that in the Tungusic languages both front and back [-atr] vowels change velars into uvulars, and [+back, +atr] vowels do not. If we assume that uvulars are Dorsals with a [-atr] secondary articulation, however, the Tungusic and Mongolic facts fall in line: when [-atr] spreads to a Dorsal consonant a [dorsal, -atr] segment is produced, which is a uvular. I consider this phenomenon further in the next section.

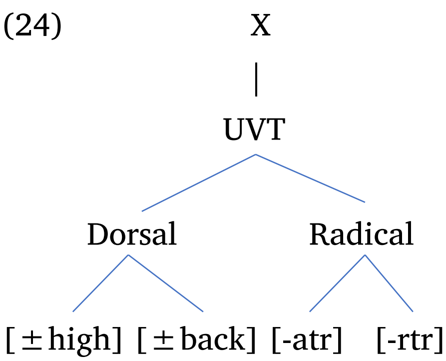
One might suggest that the Tungusic and Mongolic facts indicate that uvulars are not crucially [+back], since they are produced from underlying Dorsals regardless of the [back] values of neighboring vowels. This is not necessarily true, because we could postulate that dorsals with a secondary [-atr] articulation automatically become [+back, -high] as well. There is evidence that uvulars can be [-back], however; according to Colarusso 1975, several Northwest Caucasian languages have [-back] uvulars opposed to a set of [+back] uvulars. This is notably the case in Abkhaz, which I have been able to confirm in work with a native informant (see discussion below and Andersson et al. (2021)), and holds for Nanay as well, according to Colarusso (1974:54).

Trigo 1991:124-5 presents further historical evidence for uvulars containing a Pharyngeal component: in the Kedah dialect of Malay, a process of oral depletion changes the voiced uvular fricative ʁ into the voiced pharyngeal fricative ʕ; and in Nootka, uvulars become pharyngeals after a historical process of oral depletion has applied. Colarusso 1985:367 mentions similar developments of pharyngeals from historical uvulars in Nitinat, Columbian, Abkhaz, Abaza, and Northwest Semitic. Both Trigo and McCarthy 1994 assume that the secondary articulation of uvulars is Pharyngeal, not [-atr], so that the above processes simply result from delinking of the Dorsal element. Remember that for the reasons outlined above we must assume that uvulars are actually [-atr]; we can still maintain Trigo and McCarthy's analysis, however, if we assume that pharyngeals are actually [-atr, +rtr], as has been proposed by McCarthy 1994:53. I consider this issue further in section 3.3.

We have seen in this section that there is ample evidence for uvulars containing a [-atr] specification. Importantly, though, the existence of palatalized uvulars in Abkhaz and other Northwest Caucasian languages suggests that uvulars need not be [+back], as is currently assumed. Moreover, given the constraint that [+consonantal] segments cannot be [-high, -back] (Halle 1995), these palatalized uvulars must be [+high]. In other words, a palatalized glottalized[8] uvular /$q^{'j}$/ differs from a [-back] /$k^{'j}$/ (both of which exist in Abkhaz) solely with respect to the feature [atr]: /$k^{'j}$/ is [+high, -back] and unspecified[9] for [atr], whereas /$q^{'j}$/ is [+high, -back, -atr]. (For more detailed discussion of the phonological contrasts between Dorsal consonants in Abkhaz, see Vaux 1997.) The same analysis should be made for the Northwest Caucasian language Ubykh (Colarusso 1988:438).

In light of these facts, I propose that uvulars are represented as follows:

(24)



In this representation uvulars still have a primary dorsal articulation, but the values for the features [high] and [back] vary, as discussed above: palatalized uvulars are [+high, -back, -atr, -rtr], and regular uvulars are [-high, +back, -atr, -rtr]. I assume that uvulars are [-rtr] based on the fact that they do not show the apparent spreading of [+low] characteristic of [+rtr] segments. I assume that the production of uvulars from the pharyngealization (i.e. spreading of [-atr, +rtr]) of dorsals in Semitic languages results from the activity of a marking

---

[8]By historical chance, Abkhaz has glottalized but not plain uvular stops (though it does possess a plain k^j).

[9] My usage of "unspecified" corresponds to Steriade's (1995) concept of permanent underspecification; in other words, the velar /$k^{'j}$/ does not receive a specification for [atr] at any stage in the derivation.

statement *[-atr, +rtr]/_[+cons], which delinks the feature [+rtr] in [-atr] consonants.

2.2. Uvular asymmetry

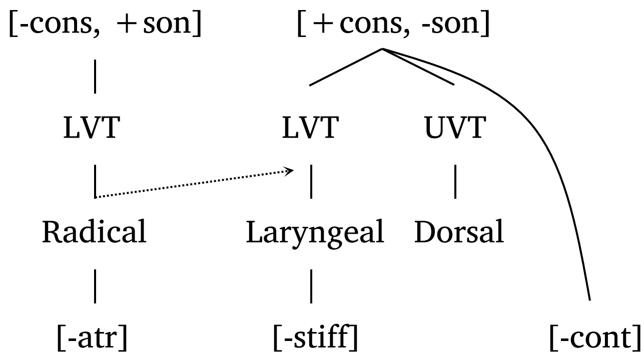
In the preceding sections I presented evidence that voiced stops have a [+atr] specification and that uvulars are dorsals with a [-atr] specification. If these hypotheses are correct, we should expect that voiced uvular stops should be highly complex and rare, because it is not physically possible to simultaneously advance the tongue root to produce voicing and retract the tongue root to produce a uvular articulation. This prediction is born out in the languages of the world, notably in the Northwest Caucasian, Daghestanian, Semitic, and Turkic families, which generally have rich systems of uvular and pharyngeal consonants, but not uvular G. The most striking illustration comes from the Turkic languages, which have extensive synchronic alternations between k ~ q and g ~ ʁ, as we have already seen in (7-9), (13-14).

I propose that in these cases spreading of [-atr] to an underlying g produces the configuration [-stiff, -atr], which violates an active marking statement *[-stiff, -atr]/_[-cont] (cf. Calabrese 1995). In other words, the retraction of the tongue root spread from the preceding vowel prevents the creation of a sufficient pressure differential to produce the voicing targeted by [-stiff]. In order to produce voicing while preserving the [-atr] feature, the illicit segment is then repaired by delinking [-cont], thereby becoming the uvular fricative ʁ[10], which does not require [+atr] in order to be voiced. This process would be represented as follows (intermediate nodes omitted):

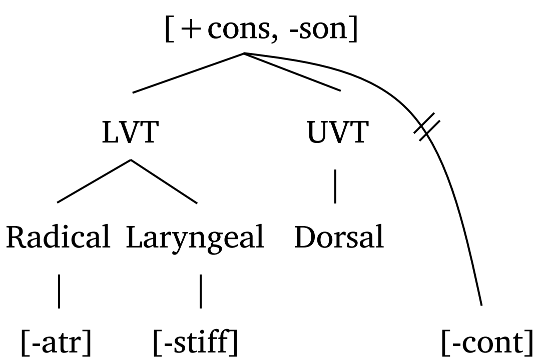
[10]I assume following Calabrese 1988 that delinking of a binary feature entails insertion of its inverse, so that delinking of [-cont] produces a [+cont] segment. Note in this case that delinking does not apply to either of the features in the marking statement ([-stiff] or [-atr]), but rather to the feature specified in the environment ([-cont]).

(25)

a. stage 1: [-atr] spreads from a preceding vowel to a voiced dorsal stop



b. stage 2: [-stiff vocal folds] delinks from the resulting voiced uvular stop, yielding a voiced uvular fricative



It appears that the [-atr] feature of the uvular articulation is more important than the [+atr] feature required for voicing (i.e. [-atr] ɢ becomes ʁ and not g), and similarly the voice feature is more important, so we do not get g ~ q; this makes sense, considering that [+atr] is merely a side-product of stop voicing, and not a feature independently required for voiced stops.

It is important to note that some languages do have ɢ, however. One might suggest that these must all be languages with uvulars of the [dorsal, +back] type (i.e. without a [-atr] element). We should expect, then, that uvulars in these languages will not block [atr] harmony, will not develop into pharyngeals, and will not show any of the other characteristics associated with the [-atr] element of uvulars discussed in section 2.1. I would like to claim, however, that *all* uvulars have a [-atr] element, and that the dorsal, [+back] segments are simply back velars such as we find in modern Turkish. Voiced stops of this type seem to be just as acceptable as *g*'s without a [back] specification; consequently, if these were actually uvulars we would not expect to find the widespread absence of uvular ɢ among the world's languages. My theory predicts that the languages possessing ɢ are able to manipulate other mechanism(s) typically involved in the facilitation of voicing, such as the lowering of the larynx mentioned (Trigo 1991, Cohn 1993), in order to produce voicing in uvular voiced stops. This alternative strategy is highly marked and complex, presumably because of the difficulty involved in manipulating these structures independently of the pharynx. The status of non-[atr] uvulars and alternative voicing strategies are empirical questions which I will not consider in this paper.

Interestingly, many of the languages with ɢ have no voiceless counterpart q (Maddieson 1984 lists Persian, Klamath, Somali, Kunimaipa, Kwakw'ala, and Lak; Kibrik and Kodzasov 1990 also include the Daghestanian language Andi). It is possible that these languages actually have a conventional unaspirated voiceless uvular q, and the investigators of these languages mistook the absence of aspiration for voicing, as is common for speakers of English. This may well be the case in Lak, for example, which according to a different analysis (Murkelinskij 1967) possesses an unaspirated q, but no ɢ. In the case of Persian, however, we have reasonably reliable evidence from phoneticians (Majidi and Ternes 1991) that Persian velar "ɣ" is pronounced [ɢ] initially, after nasals, and when geminated. Further study of the articulatory mechanisms involved in this case would be useful.

There are also languages with both ɢ and q: Awiya (cited in Maddieson 1984), Haida, Tsimshian, and Kwakiutl (Boaz 1911), Chilcotin (Cook 1986), and the Daghestanian languages Tabasaran (Djubek dialect), Rutul, Tsaxur, Kryz, Budux, and Xinalug (Kibrik and Kodzasov 1990). Unfortunately these languages (mainly American Indian languages of the Pacific Northwest and Daghestanian languages of the Caucasus) have not been properly studied to date, and we cannot be sure what the actual phonetic status of ɢ is in each case. Note that Swanton 1911:211 says Haida ɢ is pronounced 'feebly', which may mean that it is actually a lenis stop or a fricative, and Boaz 1911:293 observes that Tsimshian ɢ is pronounced as ʁ except in slow speech, and Kwakiutl ɢ is 'so strong that it is very easily mistaken for a surd' (1911:429); in each of these cases there appears to be trouble producing the ɢ, and spirantization or devoicing is employed to make it more pronounceable. If any of these languages actually possesses both [ɢ] and [q], however, we cannot appeal to the aspiration argument just mentioned, but must assume their voiced uvular stops are of the [dorsal, +back] type, or that some mechanism other than tongue root advancement is being employed to expand the supraglottal cavity.

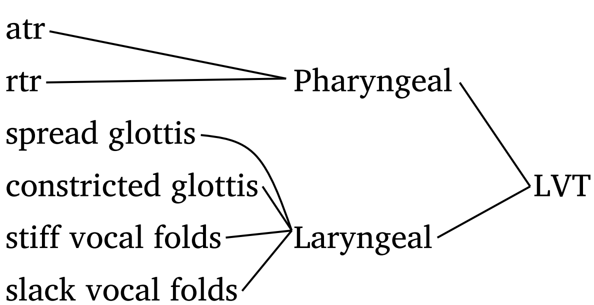
Mark Hale (personal communication) has suggested that the ɢ gap does not involve [atr] clash, as I am proposing, but is rather an extreme case of the so-called "p/g gap", whereby according to traditional linguists languages tend to have b more often than p, and k more often than g. Under this interpretation, the lack of uvular ɢ is merely an extension of the k-g distribution. I do not find the two analyses to be incompatible. Though Maddieson 1984:36 has shown that the p/g gap is not statistically significant among the world's languages, I believe that Hale's basic insight is correct, namely that constraints on the articulatory apparatus underlie the absence of p, g, and ɢ cross-linguistically. In the case of g and ɢ, the relevant constraint is the difficulty involved in producing a sufficiently large cavity between the dorsal constriction and the vocal folds to allow voicing; in this much I agree with Hale. The analysis I am proposing here goes beyond this general statement, however, in attributing the significantly greater rarity of voiced uvular stops to the fact that tongue root retraction required by uvulars makes it even more difficult to produce a sufficiently large supralaryngeal cavity.

In this section I have examined the feature specifications of uvulars, concentrating on the proposal that uvulars have a [-atr] specification (Cole 1987, Trigo 1991, Elorrieta 1992), and I have shown that the combination of this idea with the theory that voiced stops have a [+atr] specification correctly predicts the peculiar distribution of voiced uvulars in the world's languages. In the next section I consider what these facts might suggest about the structure of the Laryngeal and Pharyngeal nodes.

3. The Position of [atr] in Feature Geometry

The feature [atr] has received three basic interpretations in the literature: Cole 1987 and Halle 1987 classify [atr] as an oral Place node, together with Labial, Coronal, and Dorsal; Halle 1989 places it under the Laryngeal node; and McCarthy 1994 (implicitly) places it under the Pharyngeal node. In this section I argue that [atr] belongs under the Radical node and support the configuration in (26):

(26)

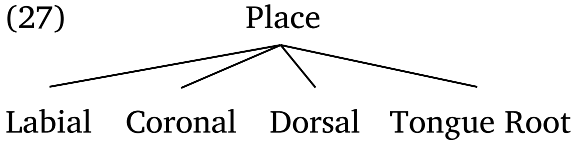


This structure is essentially a combination of McCarthy and Halle's proposals; though formally almost identical to Halle 1989's system, it also allows us to account for the generalizations about guttural segments described in McCarthy 1994, and the patterning of pharyngeal versus laryngeal segments discussed in Elorrieta 1992.

3.1. [atr] as an independent articulator

Early works on feature geometry (Halle 1987, Cole 1987) assumed that the Tongue Root was an independent articulator dominated by the Place node, as in (27):

(27)

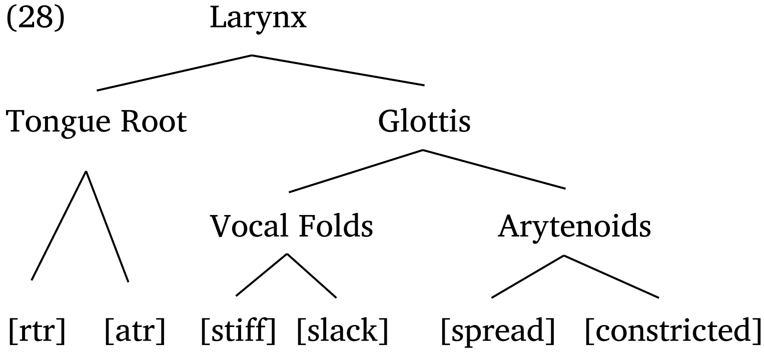


I will not consider this proposal in detail here, because it is not directly relevant to my theory, but merely point out some basic problems it encounters. First of all, it does not capture the common patterning of uvular, pharyngeal, and laryngeal segments established by McCarthy 1994. Second, it cannot account for the fairly common development of pharyngeals from uvulars, which I consider in more detail in section 3.3. Finally, the structure in (27) implies that there will exist segments defined solely by a [+atr] or [-atr] articulation, which is incorrect if we accept McCarthy's proposal that uvulars are [+back, -atr] and pharyngeals are [+rtr, -atr]. Clearly advancement of the tongue root will not produce any type of constriction; it appears that retraction of the tongue root also cannot produce consonantal constriction. Consequently, [atr] must be subordinate to some other primary articulator (though not in the strict geometric sense).

3.2. [atr] and the Laryngeal Node

The extensive interactions between voicing and [atr] described Trigo 1987 and Vaux 1996 might lead us to look favorably upon Halle's (1989) proposal that (for independent reasons) places both [atr] and [stiff vocal folds] under the laryngeal node, as in (28):

(28)



In this subsection I argue that Halle's model enables us to capture the generalizations considered in this paper, but first requires some modifications of potentially confusing node labels.

Though in some respects, such as grouping [atr] and [rtr] under a common node, the structure in (28) is similar to the one proposed in McCarthy 1994, it makes certain strong predictions about interactions between Tongue Root features and voicing which do not seem to be correct. It is true, as Halle has pointed out, that pharyngeal articulations are often associated with laryngeal gestures, such as the common production of creaky voice in pharyngeal ʕ and ħ, but these types of interaction do not necessarily imply affiliation under a common node. The main problem is that we do not want to implicate [atr] and [rtr] in processes of voicing assimilation and final devoicing, which are generally taken to involve spreading and delinking of the laryngeal node respectively. For example, given that final devoicing in Sanskrit and other languages with distinctive aspiration delinks both voice and aspiration features, we may suppose (following McCarthy 1988) that the process traditionally labeled "final devoicing" is actually deletion of the Laryngeal node. If we take Halle's proposal at face value, we should expect that final uvulars become velars in languages with final devoicing; this is incorrect, as we can see in Turkic languages such as Tatar (Poppe 1968:18):

(29)	/ayaG/ 'foot' →	nom. sg.	ayaq
		poss. sg.	ayaʁ-ı 'his foot'

In the example in (29), the underlying voiced Dorsal /G/ becomes uvular when it receives the harmonic [+back] specification from the preceding vowel. The output of this rule then undergoes devoicing, as it is located in word-final position. If final devoicing delinked the [-atr] specification of the word-final uvular, we might expect the nominative singular form to surface as *[ayak], with a velar consonant. The fact that a voiceless uvular stop is what actually surfaces suggests that the [-atr] specification of the uvular is not deleted by the final devoicing rule.

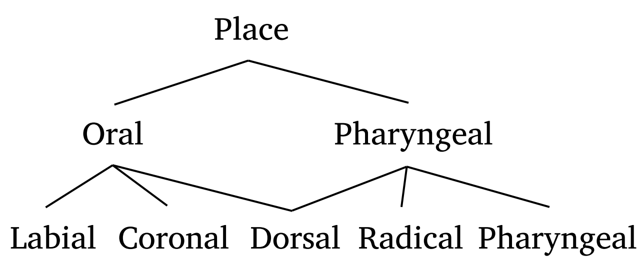
By similar reasoning, we should expect that pharyngeal consonants would be deleted (or perhaps become h) by final devoicing, because they would lose their pharyngeal features if these were dominated by the Laryngeal node. McCarthy 1994:35-6 has shown that pharyngeals are in fact unaffected by such processes, suggesting again that pharyngeal features are not dominated by the Laryngeal node.

The issues just mentioned do not actually pose more than a terminological problem for Halle's system, however: what is termed laryngeal assimilation and delinking in other theories would simply be operations on Halle's Glottis node. If we say that final devoicing is actually delinking of his Glottis node, tongue root and pharyngeal features remain unaffected, as desired. My revised geometry (26) is essentially identical to Halle's, but resolves the terminological confusion produced by his term 'glottis'. In my system final devoicing is still delinking of the Laryngeal node, but the content and structure of the Laryngeal node is identical to that of Halle's Glottis node. In the next section I consider how this structure differs empirically from McCarthy's proposal.

3.3. [atr] and the Pharyngeal Node

McCarthy 1994 provides convincing evidence for the existence of a Pharyngeal node, dominated by the Place node and dominating Radical, Pharyngeal, and Dorsal articulators (30).

(30)



The affiliation of the Dorsal articulator to both the Oral and Pharyngeal nodes is problematic. Halle 1989 has demonstrated that the data which led McCarthy to postulate this structure can be accounted for by a model in which the Dorsal articulator is dominated only by the Place node (= McCarthy's Oral node). McCarthy also implies that [atr] belongs under the Radical articulator, though this is never explicitly stated. Given the evidence presented earlier for uvulars having a [-atr] element, it is a simple matter to augment his representation of uvulars as {Dorsal, Radical} with an [atr] node placed under the Radical articulator. Since this addition does not interfere with his analysis in any way, and allows us to account for the [-atr] element of uvulars and pharyngeals, I henceforth assume that McCarthy's Radical articulator dominates [atr]. Similarly, I assume that the Radical articulator dominates [rtr], for reasons to be discussed in section 3.3.1. My modifications of McCarthy's tree are summarized in (31):

(31) Radical

[atr] [rtr]

McCarthy (1991:53) proposes the representations of uvulars, pharyngeals, and laryngeals given in (32a, f, h) (N.B. I have replaced his [radical] with [-atr]):

(32)	(a)	[+back, -atr]	uvulars
	(b)	[-atr]	Ø
	(c)	[+atr]	Ø
	(d)	[+atr, +rtr]	Ø
	(e)	[+atr, -rtr]	Ø
	(f)	[-atr, +rtr]	pharyngeals
	(g)	[-atr, -rtr]	Ø
	(h)	[+rtr]	laryngeals (maybe)
	(i)	[-rtr]	Ø

I have added the other possible permutations of McCarthy's pharyngeal features for the sake of completeness[11]. As Elorrieta 1992:145 has pointed out, the structure in (31) allows us to account for the patterning of uvulars and pharyngeals against laryngeals in Coeur d'Alene: uvulars and pharyngeals share the feature [-atr], whereas laryngeals are only [+rtr]. McCarthy seems to treat [rtr] as a privative feature, so that [-rtr] is the same as being unspecified for [rtr]; this assumption rules out (32e, g, i). [atr], on the other hand, is equipollent and can therefore be positive, in the case of voiced consonants and tense vowels, *or* negative, in the case of uvulars, pharyngeals, and lax vowels. [+atr] and [-rtr] cannot form constrictions for the same reason that [-high] cannot, as discussed earlier, so consonants cannot be of the types (32c, e, i). We might expect type (32b) to exist, but apparently it does not, so we must assume that retraction of the tongue root does not by itself form sufficient constriction to produce consonantal articulation. Presumably the reason that [+rtr] is sufficient constriction for a consonant but [-atr] is not is that [+rtr] involves constriction of both walls of the pharynx, as well as the epiglottis, whereas [-atr] only involves the front wall of the pharynx; in this sense, [+rtr] involves twice as much constriction as [-atr]. I argue below, however, that laryngeals do not in fact possess Radical features, and that neither [atr] nor [rtr] is sufficient to produce a consonantal articulation.

McCarthy suggests (with some reservations) that laryngeal segments (h and ʔ) are [+rtr]. If this were the case, though, we should expect laryngeals to have the same effects that are associated with other segments containing a [+rtr] specification. McCarthy himself observes that pharyngeals make adjacent high vowels [+low] in Semitic languages; this must come from the [+rtr] feature,

[11]I have included single feature possibilities such as [-atr] (25b) because McCarthy assumes underspecification, and such combinations therefore are theoretically possible. In Articulator Theory, the model of phonology that I assume here (Halle, Vaux, and Wolfe 2000), activation of one radical feature entails activation of the other, so only four combinations are possible, one of which ([+atr, +rtr]) is ruled out by a marking prohibition. These possibilities are discussed below.

because as we have seen, [-atr] only makes high vowels into mid vowels[12]. Consequently, if laryngeals are [+rtr], they should also make high vowels [+low], but they in fact have no effect on adjacent vowels, as McCarthy observes.[13]

Similarly, we should expect that laryngealized [+atr] vowels would not exist, because of the incompatibility of tongue root retraction and pharyngeal constriction mentioned above; the fact that all vowels can be laryngealized in languages such as Sedang, an Austro-Asiatic language with a standard seven vowel system (Smith 1968), again indicates that laryngeals cannot be [+rtr]. We should also expect if laryngeals are defined by a [+rtr] feature that h and ʔ would not be affected by rules deleting the Laryngeal node; this does not appear to be the case in Sanskrit, which as mentioned above delinks laryngeal features in word-final position, and does not allow final h. Similarly, the Siouan language Dakota allows only plain voiceless stops, voiceless fricatives, and the coronal sonorants l, n, and y in word-final position, and disallows aspirated, ejective, and voiced consonants, voiced fricatives, m, w, h, and ʔ (Shaw 1989:5-6). Dakota thus appears to have a constraint which disallows laryngeal features (voicing, aspiration, ejection) in word-final codas; the fact that h and ʔ are disallowed in this environment strongly suggests that they are defined in terms of laryngeal features, and not pharyngeal features. Finally, if laryngeals were [+rtr] we would

---

[12]This fact is of course only significant in languages possessing mid vowels. In Articulator Theory (Halle, Vaux, and Wolfe 2000) we assume a set of equivalencies between consonantal and vocalic features in order to capture common C-V interactions. Among these equivalencies are:

consonantal	:	*vocalic*
[+rtr]	:	[+low]
coronal, [-ant]	:	[-back]
Labial	:	[+round]

[13] It is true, though, that the laryngeal h patterns with the pharyngeal ħ in lowering ʌ to a in the Ethiopic language Tigrinya.

not be able to describe the Northeast Caucasian epiglottals, which contrast with pharyngeals and laryngeals in Agul and Avar[14]. I propose that the epiglottals are actually [-rtr, -atr], and (following Halle and Stevens 1971) h and ʔ are actually [+spread] and [+constricted] respectively. My revised geometry still captures the generalizations about Semitic gutturals observed by McCarthy 1994: gutturals are the class of segments defined by the Lower Vocal Tract node.

The final possibility predicted by McCarthy's system is (30d), which in my theory should describe pharyngealized and emphatic voiced stops; I consider these segments briefly now.

3.3.1. Pharyngeals and Pharyngealized and Emphatic Consonants

I assume that pharyngeals are [-atr, +rtr], and that pharyngealization and emphasis are phonologically identical, both being characterized by a [+rtr] specification. In addition to the evidence for this classification adduced by McCarthy 1994, Hoberman 1988, Czaykowska-Higgins 1987, Halle 1989, and others, I would add the empirical observation that there do not appear to be any languages which employ both pharyngealization and emphasis.

As I mentioned above, pharyngealized and emphatic voiced consonants are perfectly plausible given the structure in (28)—[atr] and [rtr] are distinct features, and therefore should be able to act separately. Phonetically speaking, however, we might expect emphatic/pharyngealized voiced stops to be rare, because the pharyngeal constriction produced by [+rtr] could interfere with the expansion of the pharyngeal cavity carried out by the tongue root in order to produce voicing in stops. Pharyngealized and emphatic voiced stops do in fact appear to be quite rare: the Northwest Caucasian languages, for example, have rich inventories of

---

[14]My information on Agul and Avar comes from the UCLA phonetic database, which illustrates contrasts in these two languages between pharyngeals, epiglottals, and laryngeals. According to Kibrik and Kodzasov 1990:320-46, epiglottals are quite common in the Daghestanian languages, though earlier grammars as a rule do not mention these segments.

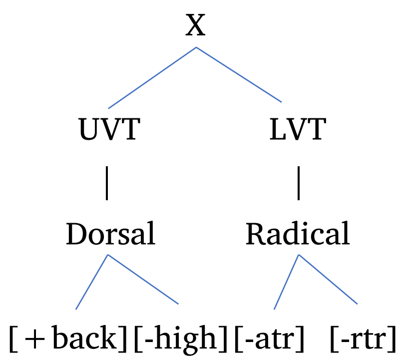
pharyngealized consonants, but these are normally not formed from voiced stops (Colarusso 1988:421-54). Arabic is unique among the Semitic languages in having an emphatic $d^ʕ$, which seems to have developed from a lateral fricative (McCarthy 1994:3). Note, however, that none of the Semitic languages possess an emphatic equivalent of g, though many have an emphatic equivalent of k, namely q. Maddieson 1984 lists a 'pharyngealized voiced dental/alveolar stop' $d^ʕ$ in the Berber language Shilha, and a 'pharyngealized voiced dental plosive' $d^ʕ$ in the Berber language Tuareg; other than these cases, which may be borrowed from Arabic, I have found no emphatic or pharyngealized voiced stops in the languages of the world.

I attribute the limited presence of pharyngealized/emphatic voiced stops to variation in the techniques used to produce [+rtr]: in addition to activating the pharyngeal constrictors, it sometimes involves pulling the epiglottis back toward the back wall of the pharynx (Ladefoged 1982:149), but sometimes involves both epiglottal retraction *and* tongue root retraction (McCarthy 1994:5). The independence of the epiglottis from the rest of the pharynx is shown by the presence of both epiglottal and pharyngeal fricatives in Caucasian languages such as Avar and Agul; the epiglottis and pharyngeal walls normally seem to work in tandem, however. In the cases where [+rtr] is produced solely by retraction of the epiglottis, voiced emphatics should be possible, because movement of the epiglottis does not alter the volume of the supraglottal cavity. The rarity of pharyngealized / emphatic voiced stops seems to indicate that production of [+rtr] normally involves tongue root retraction as well, just as it normally but not always involves laryngeal activity (Ladefoged 1982:149).

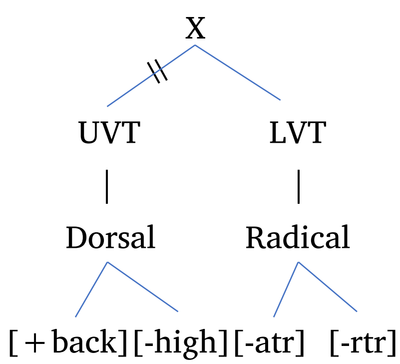
I believe that this type of articulatory implication within the pharynx can also account for the development of pharyngeals from uvulars in Nootka, Nitinat, Columbian, Abkhaz, Abaza, and Northwest Semitic. McCarthy 1994 suggests that these developments result from a process which deletes Oral Place features, but does not explain how we get the [+rtr] element of the pharyngeals. Since according to my analysis uvulars are [-atr, -rtr], delinking of the uvular's primary Dorsal articulator should produce pure [-atr, -rtr] segments; as we have already seen, though, this feature configuration is not sufficient to produce [+consonantal] constriction. I propose that this fact is reflected in a UG marking statement of the form *[-atr, -rtr]/_[-cons], which is active in all languages except those possessing epiglottals. The debuccalization process mentioned above produces violations of this marking statement, which are repaired by delinking [-rtr]. The stages of development from uvulars to pharyngeals would then be represented as follows:

(33)

a. stage 1: uvular consonant



b. stage 2: debuccalization



c. stage 3: segment has no [+cons] constriction; becomes [-cons]

X
|
[-cons]
[-son]
|
LVT
|
Radical
/ \
[-atr] [-rtr]

d. stage 4: *[-atr, -rtr]/_[-cons] marking statement violated

e. stage 5: violation repaired by delinking [-rtr] ([+rtr] is then supplied automatically)

X
|
[-cons]
[-son]
|
LVT
|
Radical
/ \
[-atr] [-rtr]

f. stage 6: final form: pharyngeal glide

X
|
[-cons]
[-son]
|
LVT
|
Radical
/ \\
[-atr] [+rtr]

Another interesting manifestation of pharyngeal coarticulation is the production of uvular q from emphatic k in the Semitic languages. This phenomenon has led some researchers to postulate that emphasis is actually [-atr], not [+rtr], which is supported to some extent by the fact that uvulars and emphatics sometimes pattern together in phonological rules (McCarthy 1994:57-8). Within Articulator Theory, however, emphasis must involve either both radical features or neither, given the requirement of full specification. I assume that emphasis involves a secondary articulation containing the radical features [-atr, +rtr]. It is then a simple matter to say that the cases where emphatics cause vowels to become [+low] involve spreading of [+rtr], whereas cases where they pattern with uvulars involve [-atr].

An interesting case study for the analysis presented here is Ubykh, which according to Colarusso 1988:438 possesses a plain q, a palatalized q^j, and a pharyngealized $q^{\text{ʕ}}$. My proposal distinguishes these three uvulars in the following manner: q = [dorsal, -atr, -rtr]; q^j = [dorsal, +high, -back, -atr, -rtr]; $q^{\text{ʕ}}$ = [dorsal, -rtr, +rtr].

3.3.2. Pharyngealized vowels

Given the relationship between tongue root and pharyngeal activity that we have established in this paper, we should expect that pharyngealized [+atr] vowels should not exist, as expressed by the prohibition *[+atr, +rtr]. This prediction appears to be born out in the languages I have examined. The standard five vowel system {i ɛ a ɔ u} of the Afro-Asiatic language Hamer, for example, surfaces as {ɪˤ ɛˤ ɑˤ ɔˤ ʊˤ} when pharyngealized (Lydall 1976), indicating that [+atr] vowels become [-atr] under these conditions. Given the common lowering effect of [+rtr] on vowels, one might wonder why the Hamer vowels do not all become [+low]. I suggest that Universal Grammar provides a marking statement *[+rtr, -low] which is deactivated in Hamer but active in languages where [+rtr] vowels become [+low].

Apparent cases of pharyngealized [+atr] vowels in systems of five vowels or fewer should not necessarily bother us, because of the tendency to transcribe vowels as <i e a o u>, regardless of their actual [atr] values. What is really needed is a seven vowel system (i.e. {i e ɛ a ɔ o u}) with pharyngealized counterparts, where we can be sure that there are actually [atr] oppositions; such systems apparently do not exist.

3.4. The Lower Vocal Tract Node

In the preceding sections I provided evidence for a revised version of Halle and McCarthy's proposed feature geometries, represented in (1). This new theory differs from McCarthy's in grouping pharyngeal and laryngeal features under a common node, explicitly placing [atr] under the Radical articulator, and describing laryngeals with laryngeal rather than pharyngeal features. It allows us to capture the fact that gutturals (uvulars, pharyngeals, and laryngeals, the class defined by our Lower Vocal Tract node) pattern together in Semitic, and describe the patterning of uvulars and pharyngeals against laryngeals in terms of a common node (our Radical node) instead of a common feature ([-atr]). Thus, in our theory the groupings {uvular, pharyngeal} and {uvular, pharyngeal, laryngeal} are exactly parallel, being defined by affiliation to a common node, whereas

McCarthy's theory must appeal to two different types of determinant. Note that our theory predicts uvulars and pharyngeals will pattern together with epiglottals against laryngeals: I have not yet pursued this possibility.

I have also shown that we should revise McCarthy's analysis of the segments produced by combining the pharyngeal features [atr] and [rtr], given in (32). In my revised system, these features produce the following alternatives:

(34)

a.	[+atr, +rtr]	(impossible)
b.	[+atr, -rtr]	voiced stops (2° articulation)
c.	[-atr, +rtr]	pharyngeals, pharyngealized consonants (2° articulation)
d.	[-atr, -rtr]	epiglottals, uvulars (2° articulation)

In this system, laryngeals have only laryngeal features: /h/ is [+spread, -constricted, +stiff, -slack], and /ʔ/ is [+constricted, -spread, +stiff, -slack] (cf. Halle and Stevens 1971:209).

My proposal is thus essentially a combination of Halle and McCarthy's structures, though in many respects it is more similar to Halle's.

4. Conclusions

The combination of the theory of consonantal [atr] (Trigo 1987, Vaux 1996) with McCarthy's (1994) theory of pharyngeal structure makes several strong predictions concerning the interaction of voicing with uvulars, pharyngeals, and pharyngealized consonants. I have examined a number of these predictions, and shown that many of them appear to be correct, particularly involving asymmetries among uvular and pharyngealized consonants and velar-uvular alternations. I have also argued that the interactions between consonant voicing and vocalic tenseness do not necessarily support Halle 1989's claim that [atr] belongs to the Laryngeal node, and proposed that [atr] actually belongs under a modified version of McCarthy 1994's Pharyngeal node.

Perhaps the most significant implication of the phenomena considered in this paper is the idea that [atr] and [rtr] are not ‘ersatz’ features, as has been claimed by Clements 1991, who attempts to eliminate them from the universal inventory of features. Clements’ model fails to capture the special behavior of [atr], which as we have seen in this paper plays a significant role in phonological interactions between consonants and vowels. These interactions make perfect sense when viewed as products of tongue root manipulations, but become completely arbitrary in terms of Clements’ family of [open] features, which have no phonetic connection to voicing, emphasis, uvularity, or any of the other features discussed in this paper. (For further arguments against Clements’ theory of aperture features, see Zetterstrand 1998.) I conclude that the features [atr] and [rtr] are a vital and integral part of the feature geometry provided by UG.

References

Andersson, Samuel, Bert Vaux, and Zihni Pysipa. 2021. Cwyzhy Abkhaz. Journal of the International Phonetic Association.

Aralova, Natalia, Sven Grawundera, and Bodo Winter. 2011. The acoustic correlates of tongue root vowel harmony in Even (Tungusic). ICPhS XVII Regular Session Hong Kong, 240-243.

Ard, Josh. 1981. A sketch of vowel harmony in the Tungus languages. In Bernard Comrie (ed.), Studies in the languages of the USSR. Edmonton: Linguistic Research.

Bessell, Nicola. 1993. Preliminary notes on some Pacific Northwest Coast Pharyngeals. Papers for the 28th International Conference on Salish and Neighbouring Languages.

Bessell, Nicola. 1996. Local and non-local consonant-vowel interaction in Interior Salish. Phonology 15.1:1-40.

Bessell, Nicola and Ewa Czaykowska-Higgins. 1991. The phonetics and phonology of postvelar sounds in Moses-Columbia Salish (Nxa'amxcin). Toronto Working Papers in Linguistics.

Campbell, Lyle. 1998. Historical linguistics: an introduction. Edinburgh: Edinburgh University Press.

Colarusso, John. 1974. Forms and Treatment of Vowel Harmony. Manuscript, Harvard University.

Comrie, Bernard. 1981. The languages of the Soviet Union. Cambridge: Cambridge University Press.

Cook, Eung do. 1989. Pharyngealization: Evidence from Athapaskan. Theoretical perspectives on native american languages.

Danieljan, T‘evan. 1967. Malat‘iayi Barbaṛě [The Dialect of Malatia]. Erevan: Haykakan SSH GA Hratarakch‘ut‘yun.

D’jaçkovskij, Nikolaj. 1987. Pogovorim po-jakutski. Yakutsk: Jakutskoe Knizhnoe Izdatel’stvo.

Hahn, Reinhard. 1991. Spoken Uyghur. Seattle: University of Washington Press.

Halle, Morris. 1989. The intrinsic structure of speech sounds. Manuscript, MIT.

Halle, Morris, Bert Vaux, and Andrew Wolfe (2000) “On Feature Spreading and the Representation of Place of Articulation,” Linguistic Inquiry 31.2.

Hansson, Gunnar. 2000. Chilcotin vowel flattening and sibilant harmony: diachronic clues to a synchronic puzzle. [abstract for ALC; I have]

Hayward, K. and R. Hayward (1989) “Guttural: Arguments for a New Distinctive Feature,” *Transactions of the Philological Society* 87.2:179-93.

Hiller, Markus. 1998. Pharyngeality, laryngeality, and their relationship in phonology. Magisterarbeit, Universität Tübingen. [I have]

Hong, Sunghoon (1995) “On the Representation of Uvulars,” *Hansung Journal* 19:37-67.

Howe, Darin. 2000. Oowekyala segmental phonology. Phd thesis, University of British Columbia.

Li, Bing (1996) *Tungusic vowel harmony: description and analysis*. Den Haag: Holland Academic Graphics.

McCarthy, John (1994) “The Phonetics and Phonology of Semitic Pharyngeals,” *Papers in Laboratory Phonology III: Phonological Structure and Phonetic Form*, P. Keating, ed. London: Cambridge University Press.

Mohanan, K. P. (1991) "On the bases of radical underspecification," *Natural Language & Linguistic Theory* 9.285-325.

Parkinson, Frederick (1993) "The Problem of Guttural Transparency," *ESCOL '93*, A. Kathol and M. Bernstein, eds. 259-67.

Ramsey, S. Robert (1987) *The Languages of China*. Princeton: Princeton University Press.

Rialland, Annie and Redouane Djamouri (1984) "Harmonie vocalique, consonantique et structures de dépendance dans le mot en mongol khalkha," *Bulletin de la Société de Linguistique de Paris* 89:333-383.

Sakarna, Ahmad. 1999. Phonological aspects of √abady Arabic, a Bedouin Jordanian dialect. Doctoral dissertation, University of Wisconsin-Madison.

Steriade, Donca (1987) "Locality Conditions and Feature Geometry," *NELS* 17.595-618. Amherst: University of Massachusetts.

Svantesson, Jan-Olof. 1985. Vowel harmony shift in Mongolian. Lingua 67:283-327.

Taff, Alice, Lorna Rozelle, Taehong Cho, Peter Ladefoged, Moses Dirks, and Jacob Wegelin. 2001. Phonetic structures of Aleut. Journal of Phonetics 29:231-271.

van der Hulst, Harry and Maarten Mous. 1992. Transparent Consonants. Linguistics in the Netherlands 101-112.

Vaux, Bert (1994) *Armenian Phonology*. Doctoral dissertation, Harvard University.

Vaux, Bert (1996) "The Status of ATR in Feature Geometry," *Linguistic Inquiry* 27.1.

Vaux, Bert. 1997a. ATR Harmony in the Altaic Languages," *Proceedings of the 8th Biennial Non-Slavic Languages Conference*, Chicago, May 1993. Chicago: Chicago Linguistic Society.

Vaux, Bert (1999) "On Locality," manuscript, Harvard University.

Vaux, Bert. 1997b. The Phonetics and Phonology of Secondary Articulations in Abkhaz. *Proceedings of the 10th Non-Slavic Languages Conference,* Chicago, May 1997.

Wetzels, W. Leo (1986) "Sonority, major class features, syllable structure, manner features: How much of the same? The case of Yakut." Linguistics in the

Netherlands 1989, edited by Hans Bennis and Ans van Kemenade, Berlin, Boston: De Gruyter Mouton, 1989, pp. 173-184.

Zawaydeh, Bushra. 1999. The Phonetics and Phonology of Gutturals in Arabic. Doctoral dissertation, Indiana University.

Zetterstrand, Sylvia (1998) *The Phonological Representation of Vowel Height.* Doctoral dissertation, Harvard University.