THE 'WHOLE LARYNX' APPROACH TO LARYNGEAL FEATURES

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ABSTRACT

This research posits a set of phonetic laryngeal features to account for the role of the epilarynx in laryngeal articulation. The focus is to move beyond a 'glottal' view of the larynx and beyond the lingual paradigm of pharyngeal articulation to a more 'global' view that integrates observations about how the epilaryngeal structure constitutes the locus of constriction in pharyngeal consonants, influences vocal fold dynamics, and can produce harsh voice sources. A key component of this new feature scheme is [±constricted epilaryngeal tube] or [±cet]. Our model provides a new interpretation of glottal stop and of pharyngeals and accounts for the distinctive use of epilaryngeal sound sources.

Keywords: laryngeal features, distinctive features, epilaryngeal tube, pharynx, articulatory phonetics

1. INTRODUCTION

In many contemporary models of articulatory phonetics and phonology, there is a strong conceptual disjunction between the larynx and the rest of the vocal tract.

On one hand, there are models that constitute a *glottal paradigm*, where the focus is on actions that control the configuration of the glottis and the glottis constitutes the laryngeal configuration, or state, and ultimate source mechanism. Central to this type of model is the abduction-adduction continuum [13, 19] for the control of phonation type and longitudinal tension for control of pitch.

On the other hand, there are models (e.g. [14, 19, 28]) of pharyngeal articulation, which generally ascribe agency to the tongue root, and which must retract to produce constriction in the pharynx. These models can be categorized as belonging to a *lingual paradigm* of pharyngeal articulation. Although interactions between sounds involving such constrictions have been repeatedly noted to correlate with various glottal states (e.g. [5, 13, 31]), the emphasis is usually on effects of vowel quality rather than of voice quality.

The overwhelming majority of research on pharyngeal articulation draws on x-ray data for empirical support (e.g. [16]) and, more recently, lingual ultrasound (e.g. [12]). In either case, these techniques do not provide an optimal view of the epilaryngeal tube – *the structure that physically links the larynx with the tongue*. Importantly, while x-ray imaging can be used to view the epilaryngeal tube, this region is often absent from x-ray traces [7]. Lingual ultrasound cannot be used to image the epilaryngeal tube at all. We suspect that these factors have contributed to the lack of focus on the epilaryngeal tube and its important lingual-laryngeal linking function.

In this paper, we seek to reconcile the conceptual divide between the larynx and the rest of the vocal tract by proposing that articulatory models of phonetics and phonology – and the interface between them – should integrate the epilaryngeal tube as the articulatory mechanism responsible for the production of pharyngeals and for providing a physiological link between larynx and tongue that is manifest in phonetic and phonological phenomena. Our perspective will be from the larynx because of its role as both source and articulator; hence, we are redefining the *laryngeal features*. The empirical basis for the features we propose is well established [7, 8, 9], and we draw heavily upon the Laryngeal Articulator Model [10] as a conceptual foundation.

2. LARYNGEAL FEATURES

Our work proceeds in the spirit of research that expresses the contrastive potential of articulatory gestures as a finite set of discrete features [14, 15, 16, 18, 19, 21]. It is our impression that an update to this type of feature model is long overdue in light of contemporary research that underscores the role of the aryepiglottic sphincter and the epilaryngeal tube in providing an articulatory link between glottal, lingual, and pharyngeal adjustments used contrastively or as concomitants of speech sounds. Since our model emphasizes the importance of the epilaryngeal tube as a link between laryngeal and lingual articulatory events, the system of features we present pertains to both laryngeal and pharyngeal articulation, in contrast to previous models that have segregated these categories (e.g. [15, 19]).

2.1. The Laryngeal Articulator Model

The basis for our model is the Laryngeal Articulator Model (LAM) [10]. The LAM establishes that pharyngeals are primarily aryepiglotto-epiglottal strictures and that there are canonical relationships among the three components of laryngeal constriction (larynx raising, lingual retraction, and intrinsic laryngeal muscle constriction) that characterize various articulations. These are summarized in Table 1. It is important to note, particularly concerning larynx height, that these relationships represent non-antagonistic settings of the components and thus act as natural complements: it does not mean that they are required for the articulation to occur.

Table 1: Canonical component relationships.

epilaryngeal tube	unconstricted	constricted
larynx height	lowered	raised
tongue position	advanced	retracted
phonation	breathy, slack or modal	creaky, tense or harsh
voice quality	lowered lx. voice, faucalized	raised lx. voice, pharyngealized
vowel quality	peripheralized	centralized

2.2. Rethinking 'tongue root'

Despite the ubiquity of the term *tongue root* in the literature, we choose to avoid its use in our model, since it does not provide a precise conception of pharyngeal articulation: it is merely a convenient anatomical landmark [16]. A better choice would be to refer to the epiglottis [19], which constitutes the contact surface in the region of the tongue root; but this does not help clarify the lingual-laryngeal relationship either. The most useful notion is *tongue retraction*, which is adopted in the LAM, as this most directly relates to muscular control of the tongue, entails displacement of the epiglottis, and is an important concomitant of laryngeal constriction.

2.3. The revised laryngeal feature set

The new set of features is characterized by the adoption of a feature that represents epilaryngeal constriction. Previous research has suggested [±constricted] as a suitable label for the feature [7, 8, 10], but this is avoided here because of its potential confusion with similarly named features such as [±constricted glottis] and [±constricted pharynx] and its vagueness with regard to what is constricting. Hess [16] uses [laryngopharynx] to represent constriction in the lower pharynx, but we judge this as still too vague to denote the very specific aryepiglotto-epiglottal constriction that is at the very heart of our model. In light of this, we suggest [±constricted epilarynx tube (cet)], which is both precise and introduces acoustic connotations (via the concept of *tube*).

Figure 1: Schematic for the relationship of the laryngeal features. cet = constricted epilaryngeal tube; epl = epilaryngeal; gl = glottal; rtd = retracted (tongue). Larynx height (lx. h.): N = neutral larynx; L = lowered larynx; R = raised larynx. Dashed lines indicate dual association of a feature with multiple articulators.

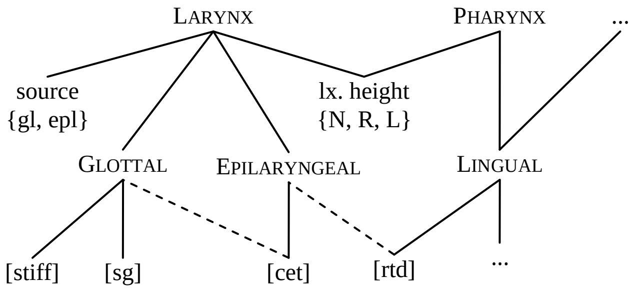

Table 2: Illustration of the proposed laryngeal features. Sources: gl = glottal; epl = epilaryngeal; nil = no phonation. Larynx height (LH): N = neutral larynx; L = lowered larynx; R = raised larynx. Features: [cet] = [constricted epilaryngeal tube]; [sg] = [spread glottis]; [stf] = [stiff vocal folds].

C	V	place	source	LH	[stf]	[sg]	[cet]
h R̥	V̥	GLOTTAL	nil	N	−	+	−
ħ	W	EPILARYNGEAL	nil	R	−	+	+
ɦ	V̤	GLOTTAL	gl	L	−	+	−
	V̩	EPILARYNGEAL	gl	R	−	+	+
	V	GLOTTAL	gl	N	−	−	−
ʔ	Vˀ	GLOTTAL	nil	N	+	−	+
R'	V̠	GLOTTAL	gl	N	−	−	+
ʕ tˤ	Vˤ	EPILARYNGEAL	gl	R	−	−	+
ʜ	Vᴴ	EPILARYNGEAL	epl	R	−	+	+
ʢ	Vʢ	EPILARYNGEAL	gl, epl	R	−	−	+
ʡ		EPILARYNGEAL	nil	R	+	−	+
	V́	GLOTTAL	gl	R	+	−	−
	V̀	GLOTTAL	gl	L	−	−	−
	V́L̥	GLOTTAL	gl	L	+	+	−
	V́!	GLOTTAL	gl	R	+	−	+

Critically, this feature very clearly must be distinguished from simple *pharyngeal constriction*, implied by former feature names such as [±constricted/expanded pharynx] (see [18, 21]), which, through tongue retraction, occurs fully independently of epilaryngeal constriction. It is possible to employ a feature for pharyngeal constriction, but a feature for tongue retraction would also be suitable. We use [±retracted (rtd)] following [10]. Neither of these features, however, would be sufficient to characterize pharyngeals, which are represented primarily by [+cet].

Figure 1 depicts the conceptual organization of the features in relation to the articulators (glottal, epilaryngeal, lingual) and articulatory regions (larynx, pharynx). The coverage of these features is shown in Table 2. From Halle & Stevens' model [15], we retain [±spread glottis (sg)] and [±stiff]. The former is used to represent glottal aperture, and the latter serves to represent pitch and internal vocal fold tension for some articulations (as in glottal stop). Larynx height is not a distinctive feature, but it is included in the model as an important component of laryngeal-pharyngeal state. Phonation is also treated as a parameter, and four states can occur: no phonation, glottal-level phonation, epilaryngeal-level phonation, and a mix of glottal and epilaryngeal phonation. Finally, [±cet] has two interpretations depending on place of articulation: linked with GLOTTAL, [+cet] indicates ventricular incursion (constriction of the lower margin of the epilaryngeal tube); when dominated by EPILARYNGEAL, [+cet] denotes aryepiglotto-epiglottal constriction.

3. CONSEQUENCES OF THE NEW FEATURES

3.1. Glottal stop and creaky voice

Our model represents glottal stop as more than activity merely at the glottal level [13]. Rather, we assert that the ventricular folds play a critical role in the production of glottal stop and creaky voice through *ventricular incursion* [2, 7, 11, 15, 17, 20, 22, 23], and hence we abandon the traditional practice of using [+constricted glottis].

We suggest that there are three primary biomechanical effects that ventricular incursion has on vocal fold dynamics via mechanical coupling: (i) additional mass will introduce new degrees of freedom to the overall oscillating system and result in new modes of vibration, (ii) the additional mass itself will decrease the frequency of oscillation, and (iii) the presence of ventricular fold mass will interfere with or change the mucosal wave of the vocal folds that is essential for self-sustained oscillation in non-coupled, modal phonation [29]. All of these effects will ultimately lead to more irregular oscillations, at a lower frequency, and ultimately, with enough ventricular damping, to complete cessation of vocal fold movement.

The ventricular folds also provide a link between glottal and pharyngeal categories because of their role in laryngeal constriction, which progresses from glottal to ventricular to aryepiglotto-epiglottal closure. Ventricular incursion then is the intermediary phase between simple glottal adduction and the hermetic sealing of the larynx that characterizes an aryepiglotto-epiglottal (pharyngeal) stop. These facts are reflected in the phonologies of various languages: where glottal stop alternates in free variation with pharyngeal stop, as in Tigre [24]; and where the so-called uvular resonants (viz. glottalized pharyngeal approximants) in Interior Salish are found to be produced as full aryepiglotto-epiglottal stops [1]. It also may account for contrasts between creaky phonation and full glottal stop that are attested in Gimi [19], in some Northeast Caucasian languages [2], and as part of the phonatory register system in Quiavin íZapotec [3].

3.2. Pharyngeal consonants

Our model shifts away from the traditional lingual oriented/[−ATR] conception of pharyngeal articulation where 'the root of the tongue assumes the shape of a bulge and is drawn back towards the vertical back wall of the pharynx to form a stricture' [6]. This conception implies that pharyngeals will trigger retraction effects on neighbouring sounds; but in our model, we contend that pharyngeals and pharyngealized vowels do not guarantee any particular vowel quality. While retraction is a possibility, pharyngeals can also trigger vowel fronting [4], or fail to retract vowels where uvulars do (e.g. Arabic [ħæ:l] 'condition', [χɑ:l] 'maternal uncle' [24]).

3.3. Epilaryngeal trilling and voice sources

The new laryngeal features directly account for the occurrence of extra-glottal sound sources produced by the epilaryngeal tube [26]. This is relevant for strident register in !Xóõ [30], which has remained recalcitrant to the standard, glottal paradigm of laryngeal features [13]. Similar registers are documented for Ju|hoansi [25] and Jianchuan Bai [7]. Epilaryngeal trilling also occurs as a phonetic enhancement on pharyngeal segments, such as in Iraqi Arabic [8] (possibly used to distinguish these sounds from glottal consonants). Impressionistic labelling of such sounds in the literature provides some support that epilaryngeal trilling may be more common than supposed. Rose [27] describes low/yang tones in the Zhenhai dialect of Wu Chinese as 'growled'. Colarusso [4] reports a 'remarkably raucous' category of pharyngeal which he calls the 'adytals', involving constriction at the aryepiglotto-epiglottal place, encountered in Northeast and Northwest Caucasian languages (cf. [19]).

4. CONCLUSION

We present a revised set of laryngeal features based upon empirical evidence that constriction of the epilaryngeal tube constitutes an integral part of laryngeal and pharyngeal articulation, generates a contrastive or enhancing sound source, and contributes to changes in acoustic resonance. Our model uses epilaryngeal features as a means to link glottal and lingual gestures, which were segregated in prior models. The critical feature is [+cet], which denotes ventricular incursion for glottal stop (replacing [+constricted glottis]) and denotes aryepiglotto-epiglottal constriction for pharyngeal consonants. The model also posits an epilaryngeal source that phonologies can employ distinctively and which can account for the occurrence of strident/harsh/growled registers.

5. ACKNOWLEDGEMENTS

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6. REFERENCES

[1] Carlson, B.F., Esling, J.H. 2003. Phonetics and physiology of the historical shift of uvulars to pharyngeals in Nuuchahnulth (Nootka). *Journal of the International Phonetic Association* 33(2), 183-193.

[2] Catford, J.C. 1977. Mountain of tongues: The languages of the Caucasus. *Annual Review of Anthropology* 6, 283-314.

[3] Chávez-Peón, M.E. 2010. *The Interaction of Metrical Structure, Tone, and Phonation Types in Quiaviní Zapotec*. Doctoral dissertation, University of British Columbia.

[4] Colarusso, J.J. 1985. Pharyngeals and pharyngealization in Salishan and Wakashan. *International Journal of American Linguistics* 51(4), 366-368.

[5] Czaykowska-Higgins, E. 1987. *Characterizing Tongue Root Behavior*. Manuscript, MIT, Cambridge, MA.

[6] Delattre, P. 1971. Pharyngeal features in the consonants of Arabic, German, Spanish, French and American English. *Phonetica* 23, 129-155.

[7] Edmondson, J.A., Esling, J.H. 2006. The valves of the throat and their functioning in tone, vocal register, and stress: Laryngoscopic case studies. *Phonology* 23, 157-191.

[8] Edmondson, J.A., Padayodi, C.M., Hassan, Z.M., Esling, J.H. 2007. The laryngeal articulator: Source and resonator. *Proc. 16th ICPhS* Saarbrücken, 2065-2068.

[9] Esling, J.H. 1999. The IPA categories 'pharyngeal' and 'epiglottal': Laryngoscopic observations of pharyngeal articulations and larynx height. *Language & Speech* 42, 349-372.

[10] Esling, J.H. 2005. There are no back vowels: The laryngeal articulator model. *Canadian Journal of Linguistics* 50, 13-44.

[11] Gerratt, B.R., Kreiman, J. 2001. Toward a taxonomy of nonmodal phonation. *J. Phon.* 29, 365-381.

[12] Gick, B., Pulleyblank, D., Campbell, F., Mutaka, N. 2006. Low vowels and transparency in Kinande vowel harmony. *Phonology* 23, 1-20.

[13] Gordon, M., Ladefoged, P. 2001. Phonation types: A cross-linguistic overview. *J. Phon.* 29, 383-406.

[14] Halle, M. 1995. Feature geometry and feature spreading. *Linguistic Inquiry* 26, 1-46.

[15] Halle, M., Stevens, K. 1971. A note on laryngeal features. *MIT Quarterly Progress Report* 101, 198-212.

[16] Hess, S. 1998. *Pharyngeal Articulations*. Ph.D. dissertation, UCLA.

[17] Hollien, H., Allen, E.L. 1972. Laminagraphic investigation of pulse register (vocal fry) phonation (A). *JASA* 52(1A), 124.

[18] Keyser, S.J., Stevens, K.N. 1994. Feature geometry and the vocal tract. *Phonology* 11, 207-236.

[19] Ladefoged, P., Maddieson, I. 1996. *The Sounds of the World's Languages*. Cambridge, MA: Blackwell.

[20] Laver, J. 1980. *The Phonetic Description of Voice Quality*. Cambridge: Cambridge University Press.

[21] Lindau, M. 1978. Vowel features. *Language* 54, 541-563.

[22] Lindblom, B. 2009. Laryngeal mechanisms in speech: The contributions of Jan Gauffin. *Logopedics Phoniatrics Vocology* 34(4), 149-156.

[23] Lindqvist-Gauffin, J. 1972. A descriptive model of laryngeal articulation in speech. *Quarterly Progress and Status Report, Speech Transmission Laboratory, Royal Institute of Technology* 13(2-3), 1-9.

[24] McCarthy, J. 1994. The phonetics and phonology of Semitic pharyngeals. In Keating, P. (ed.), *Papers in Laboratory Phonology III*. Cambridge: Cambridge University Press, 191-233.

[25] Miller, A. 2007. Guttural vowels and guttural co-articulation in Ju|hoansi. *J. of Phon.* 35, 56-84.

[26] Moisik, S.R., Esling, J.H., Crevier-Buchman, L. 2010. A high-speed laryngoscopic investigation of aryepiglottic trilling. *JASA* 127(3), 1548-1558.

[27] Rose, P.J. 1989. Phonetics and phonology of yang tone phonation types in Zhenhai. *Cahiers de Linguistique Asie Orientale* 18, 229-245.

[28] Rose, S. 1996. Variable laryngeals and vowel lowering. *Phonology* 13, 73-117.

[29] Story, B.H., Titze, I.R. 1995. Voice simulation with a body-cover model of the vocal folds. *JASA* 97(2), 1249-1260.

[30] Traill, A. 1986. The laryngeal sphincter as a phonatory mechanism in !Xóõ (Bushman). In Singer, R., Lundy, J.K. (eds.), *Variation, Culture and Evolution in African Populations: Papers in Honour of Dr. Hertha de Villiers*. Johannesburg: Witwatersrand University Press, 123-131.

[31] Trigo, L. 1991. On pharynx-larynx interactions. *Phonology* 8, 113-136.