THE LARYNGEAL ARTICULATOR: SOURCE AND RESONATOR

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ABSTRACT

The laryngeal articulator, consisting of the glottal mechanism, the supraglottic tube, the pharyngeal/ epiglottal mechanism, and including three levels of folds: the vocal folds, the ventricular folds, and the aryepiglottic folds, is shown to be responsible for the generation of multiple source vibrations and for the complex modification of the pharyngeal resonating chamber that accounts for a wide range of contrastive auditory qualities. Laryngoscopic evidence drawn from Tibeto-Burman, Semitic, Cushitic, Kwa, and Gur languages demonstrates the distinctive use of the laryngeal articulator in pharyngeal trilling combined with glottal voicing, voiceless pharyngeal trilling, and epilaryngeal tube shaping to create opposing vocal register series. One such series is the [ATR/–ATR] contrast.

Keywords: laryngeal articulator, aryepiglottic folds, pharynx, –ATR, laryngoscopy.

1. INTRODUCTION

There is a relationship between a wide range of sounds produced with the laryngeal articulator that has neither been sufficiently explored nor adequately correlated. Many phonetic realizations of the pharyngeal consonants of the languages of the world, for example in Arabic [12], have been attested, as have secondary pharyngeal features. Other varied contrastive features, including the ubiquitous [tense] feature and the phonological feature [Advanced Tongue Root] have been invoked to explain suspected adjustments within the pharyngeal space [16, 17, 21]. It is the aim of this paper to present data to show (a) that various complex adjustments within a relatively simple mechanism – the laryngeal constrictor – are responsible for the production of multiple manners of pharyngeal consonants, secondary sound source vibrations, and changes in pharyngeal cavity resonance, and (b) how some languages use these articulatory parameters to generate phonological distinctions such as [tense/lax] or [+ATR/-ATR].

[ATR] has been regarded as one of the most significant innovations in the analysis of African languages in the last forty years. It was proposed by Stewart [20] to account for the vowel harmonies in Akan. Despite its success in vocalic phonology analysis, there has been controversy from the start about its phonetic basis. Suspected correlates have ranged from tongue-root height position [20], to pharyngeal expansion and larynx height [17], to overall differences in pharyngeal volume [21].

Various spectral measures have also been employed to isolate [ATR], but since the pharynx produces both pharyngeal articulations and 'harmony features', the approach of this paper is to identify the articulatory similarities between previously unattested pharyngeal gestures and the articulatory correlates of harmony series, in 'ATR' languages as well as other types of phonologies. Pharyngeal gestures to be examined include stop, less-attested trills, and unattested tap.

2. METHODS

2.1. Language backgrounds and selection

To determine what the mechanism of pharyngeal trilling is, and where it occurs in the speech sounds of a language with pharyngeals in its phonology, as well as to identify the mechanism of pharyngeal shaping that generates contrasting laryngeal features such as [+ATR/–ATR] vowels, we devised a study using one speaker each of: Bai, Iraqi Arabic, Somali, Yi, Akan, and Kabiye.

Laryngeal/pharyngeal production in each language was studied by means of transnasal laryngoscopy. Bai was chosen because of its vocal register contrast that involves a complex of glottal and supraglottic phonatory modification [10]; Iraqi Arabic because of its extreme and phonetically challenging pharyngeal reflexes [2, 12, 14]; Somali because it has pharyngeals as well as a vocalic harmony system that interacts with shaping in the pharynx [19]; Yi because of its register series that do not induce phonatory contrasts [10]; Akan

because much is known about its phonetics, and because it occupies the historical position of being the model language for ATR harmony [4]. Kabiye, a Gurunsi language of Togo, Ghana, and Benin, compares closely with Akan and has extremely regular vowels and virtually exceptionless adherence to the rules of ATR harmony [5, 7, 15].

2.2. Experimental procedures and approach

Experimental phonetic equipment consists of a Kay Elemetrics Rhino-laryngeal-stroboscope (RLS 9100) with a constant halogen cold light source to photograph the actions of the larynx. An Olympus ENF-P3 fibreoptic nasendoscope is attached to the camera (Panasonic GP-US522) and light source with a 28mm lens for optimal wide-angle framing of larynx mechanisms during extreme pharyngeal articulations and of laryngeal postures during the varying pitch conditions in which tonal paradigms occur. Recordings were made directly on a Sony DCRTRV17 Mini-DV Digital Camcorder. Video images were postprocessed with Adobe Premiere 6.5 software. Canonical phonetic profiles [11, 8, 9] served as the basis of comparison of the production of phonemic contrasts by native-speaker subjects: 5 males, 1 female (Kabiye).

3. EXPERIMENTAL OBSERVATIONS

3.1. Pharyngeal (aryepiglottic) trilling

3.1.1. Bai (Tibeto-Burman)

Bai has a 15-way syllable distinction, with pitch, phonation type, laryngeal-constrictor tension, and nasal quality interacting to generate contrasting registers [10]. At lower tones, in the tense series, phonatory register becomes progressively more harsh. Low 21 tone is so harsh that it demonstrates diplophonic aryepiglottic trilling – a secondary sound source. Apart from the specialized genre of Tibetan chanting, Bai 21 tone affords some of the earliest visual evidence of pharyngeal trilling being used to produce a speech sound. The example /tɕḭ^{21}/ ‘bracelet’ is shown in video file 1.

3.1.2. *Iraqi Arabic (Semitic)*

Video recordings of Iraqi Arabic capture numerous reflexes of the two pharyngeal consonants, /ħ ʕ/. The first is glottally voiceless, pharyngeal [ħ] and demonstrates extreme laryngeal constriction of the aryepiglottic folds at the top border of the epilaryngeal tube. The aryepiglottic folds sometimes trill – quite strongly in the case of a medial geminate /-ħħ-/, in which case the transcription would be [ʜː]. This is shown in video file 2: /saħħar/ ‘made magic’. This is one of the most convincing pieces of evidence to date to record voiceless pharyngeal trilling as a speech sound. The second pharyngeal is usually termed voiced and may be realized as an approximant [ʕ], sometimes with very slight aryepiglottic trilling. It may even be termed a pharyngeal tap, as shown in video file 3: /saʕiid/ ‘happy’. The aryepiglottic-fold approximation forwards to the tubercle of the epiglottis and the rapid burst suggest that it could be a tap. No speech sound has ever been identified as such before (apart from paralinguistic effects), although it probably occurs among the voluminous data in Heselwood’s treatise [12]. When /-ʕʕ-/ is a medial geminate, the sound is a full epiglottal stop [ʡː] with complete closure of the airway, as shown in video file 4: /faʕʕal/ ‘made active’ and corroborated in the acoustic spectrum. As far as we know, this is the first visual evidence to confirm that the epiglottal stop is a common phonetic occurrence in Iraqi Arabic, supporting earlier work by Butcher and Ahmad [2]. In Iraqi Arabic, therefore, laryngeal articulator constriction can be seen to generate two levels of stop closure, [ʔ ʡ], and two levels of sound source generation, glottal vibration and aryepiglottic fold vibration.

3.2. Modification of pharyngeal resonance

3.2.1. Somali (Cushitic)

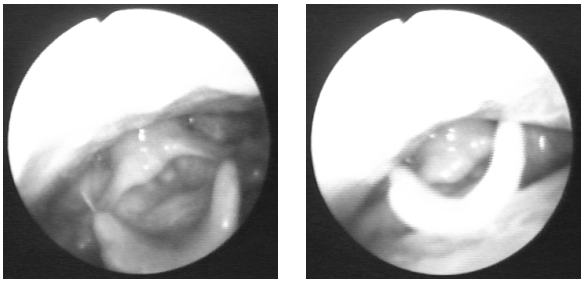
Somali has pharyngeals like Arabic, but, like Akan and Kabiye, it has also been termed an ATR-harmony language [19], making it phonetically intermediate between languages with primarily segmental realizations of laryngeal constriction and languages with ‘quality’ distinctions. Somali has both harsh (moderately trilled) phonatory reflexes, like Bai and Iraqi Arabic, and constricted supraglottic reflexes, like Akan and Kabiye.

The laryngoscopic evidence from Somali shows an effect of harsh trilling that extends up through the supraglottic tube: [rɪ̰ʜ] ‘to push’ (video file 5). It appears that the combination of tight, harsh phonation at the glottis propagates through the supraglottic tube, inducing vibrations of the narrowed structures above it, including the tip of the epiglottis. Our aim is not to describe this propagation, which would require an aerodynamic

study, but rather to demonstrate that the two key levels of the laryngeal constrictor mechanism, glottal and pharyngeal, can operate in synergy. This is, nevertheless, an unusual effect in our experience of observing behaviour in the pharynx. The supraglottic constriction phenomenon in Somali is also correlated with tight phonation (and opposed to breathier/ lowered-larynx phonation), which is not the case in the West African 'ATR' languages, where supraglottic 'quality' rather than phonatory 'state' predominates. It still must be shown, however, that the mechanism that narrows the pharynx in Somali is the same mechanism that accounts for 'ATR/-ATR'.

3.2.2. Yi (Tibeto-Burman)

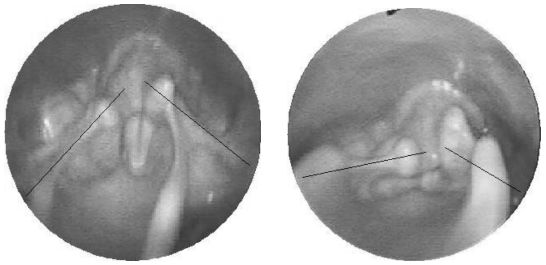
Figure 1: Laryngoscopic images of the Yi [-constr/+constr] contrast: /pv^{33}/ 'river deer' (left); /pv̱^{33}/ 'to go back' (right).



Although areally similar, Yi differs from Bai in having a supraglottic constriction contrast with minimal phonatory effects [3]. This variety of Yi has 5 pairs of lax/tense vowels [10]. Vowel quality differs considerably across most pairs, notably /ɯ ɑ̱/, whereas West African [+ATR/–ATR] systems usually have vowel pairs that are similar in height [13]. Yi also has fricativized vowels. The visual comparison of supraglottic tube shape in Fig. 1 demonstrates a constellation of adjustments that may not be comparable in other phonologies. The [+constr] member of the pair (right) always has (a) extreme narrowing through the supraglottic tube, occasionally producing minor vibratory effects (not nearly as extreme as in Somali), (b) tongue retraction over the larynx, and (c) elevation of the larynx itself; all of which produce a significantly reduced resonating space. This combined effect may not be the same with [-ATR]. Any one of these laryngeal constrictor concomitants will have an influence on the resonance that results, in conjunction of course with the posture of the oral vocal tract. What is significant in all of these languages is that vowel quality is systematically altered by the posture of the laryngeal articulator.

3.2.3. Akan (Kwa)

Figure 2: Akan /i i̱/ vowels in /midi/ 'I eat' (left) and /mɪ̱dɪ̱/ 'I am called' (right). Lines represent the aryepiglottic-fold angle moving forwards to the base of the epiglottis in frame 2: [ɪ̟].



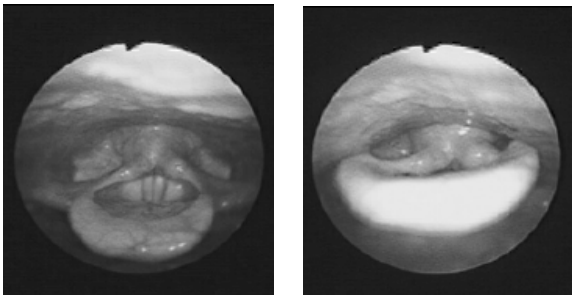
Akan (Asante/Fante/Twi) is a key example of the ATR contrast and of the resulting vowel harmony within a phonological word [1, 20, 6, 18, 4]. Some forms have 9 vowels; others 10, as in the variety studied here. In Fig. 2, [+ATR] /i/ [i] is [-constr] (left); [-ATR] /i̱/ [ɪ] is [+constr] (right). Images are not comparable vowel-by-vowel across languages because of differences in vowel targets, but the mechanism of constriction is the same; [-constr] forms in Akan mirror the same three features of the [-constr] (lax) form in Yi: an open epilaryngeal space, a less retracted tongue, and neutral larynx height. The [+constr] forms in Akan share the features of the [+constr] (tense) form in Yi: a flatter forward-bending laryngeal sphincter angle, a more retracted tongue, and raised laryngeal structures. The contrasts filmed for Akan show a consistent difference in the posture of the laryngeal constrictor for [i ɪ̱, e ɛ̱, u ʊ̱, o ɔ̱] and also [a ɑ̱].

3.2.4. Kabiye (Gur)

More regular harmony constraints are observed in Kabiye [5, 15]. Its vowel harmony system operates within a 9-vowel system of extreme regularity with no exceptions within the phonological word. Laryngoscopic observations reveal a series of contrasting images for Set 1 [-constr] and Set 2 [+constr] vowels [i e u o] and [ɪ̱ ɛ̱ ʊ̱ ɔ̱ a̱]. Vocal register does not play a major role in either Akan or Kabiye for most speakers, though some speakers of Akan may employ a phonatory contrast. Fig. 3 illustrates the mid-vowel position of the laryngeal articulator for /tú/ 'elephant' [-constr] vs. /tʊ́/ 'bee' [+constr]. The mid-vowel (and low-tone) contrast is seen in video file 6 /lɔ̀/ 'cut at (imper)' [-constr] vs. video file 7 /lɔ̰̀/ 'thatch (imper)' [+constr]. As in the Yi and Akan contrastive series, Kabiye constricted vowels are systematically narrowed forwards and upwards across the aryepiglottic

sphincter, tongue-retracted, and larynx-raised. In all of these cases, the [-constr] token corresponds to what has been called [+ATR], and the [+constr] token corresponds to what has been called [-ATR].

Figure 3: Kabiye /tú/ 'elephant' [-constr] (left) vs. /tu̱/ 'bee' [+constr] (right): aryepiglottic folds move up and forwards.



The impact of the visual evidence is to show that tongue retraction is only one component of the laryngeal constriction process and that some languages (Bai, Somali) can use constriction to affect phonation without retracting the tongue for particular segments. Other languages (Yi, Akan, Kabiye) can use constriction to achieve significant pharyngeal resonator reduction without changing phonation to any great extent.

4. THEORETICAL IMPLICATIONS

The articulatory data gathered in laryngoscopic observations suggest that the harmony phenomena of Somali, Yi, Akan, Kabiye and potentially many other similar systems are better explained from an *a priori* laryngeal-stricture account than from an *a posteriori* acoustic resonance account. The similarity between the manners of articulation of pharyngeal consonants and the shape adjustments of the pharynx for various retracted-quality series are evidence that the active articulator in this stricture is the paired aryepiglottic fold movement towards the passive articulator, the epiglottis. This approach provides an explanation for the presence or absence of vocal register quality with vowel quality differences. The variety of adjustments within the laryngeal articulator explains how within one speech community – Akan, for example – there can be speakers with more phonatory effect or less phonatory effect accompanying their vowel harmony. Some languages – such as Bai – are clear cases of combined vocal-register/ vowel-quality differences. Based on these observations, there is good reason to consider that harmony may reside in the settings of a single articulator to account for constricted vowels instead of a system that requires separate targets for each of the [-ATR] vowel types. It is therefore proposed that [+constr] is the feature that captures the articulatory generalization of the laryngeal constrictor, from pharyngeal consonants to quality harmony, by creating an independent designation for the action of the lower part of the vocal tract.

5. REFERENCES

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