Phonation type

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What is phonation type?

Phonation type refers to the source signal produced by varying the relative constriction between the vocal folds while expelling air through the glottis.

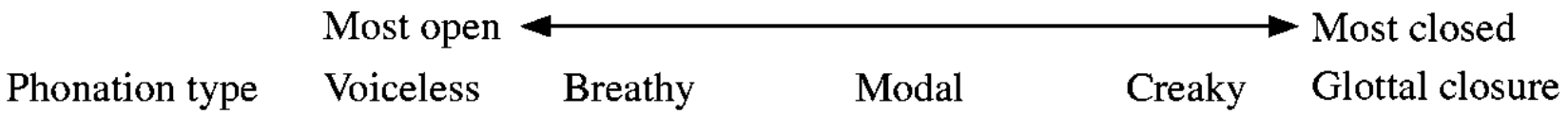
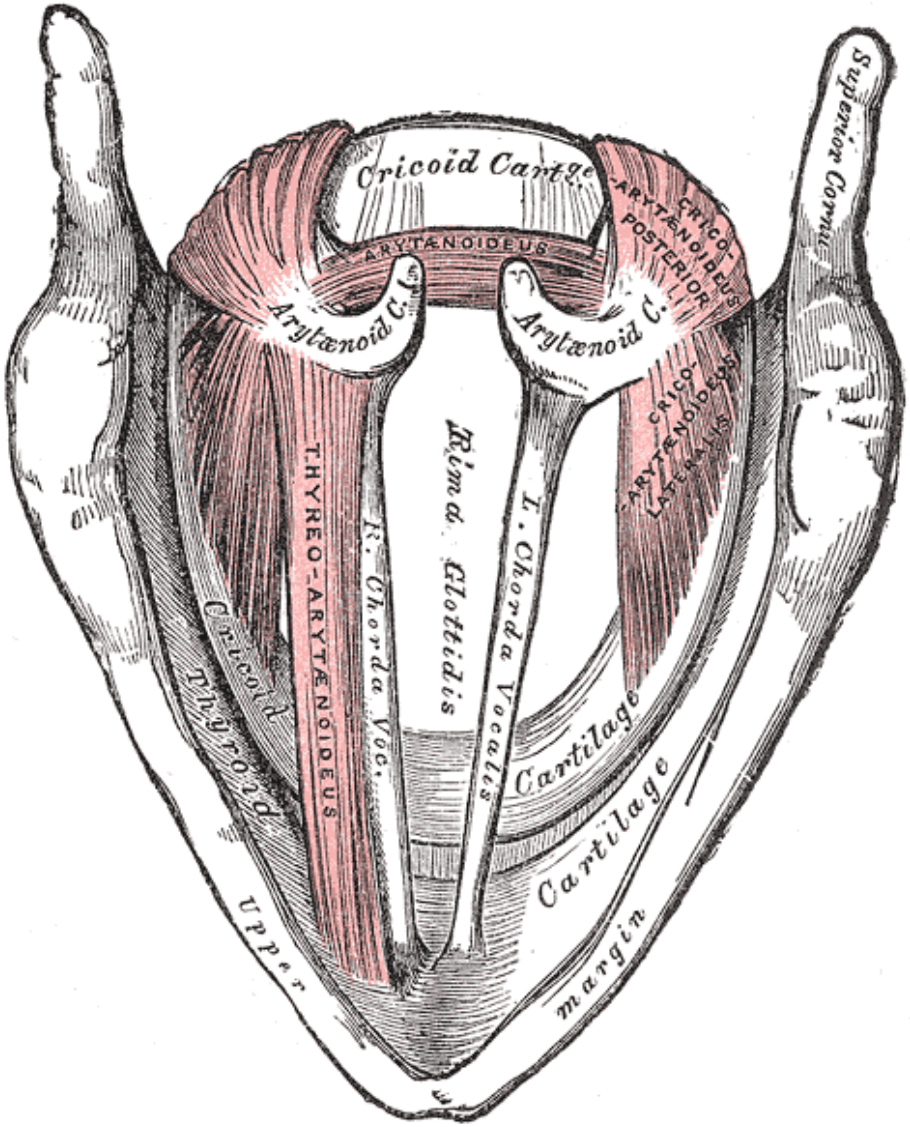


Figure 1. Continuum of phonation types (after Ladefoged, 1971).

By varying glottal aperture different voice qualities are produced (Gordon and Ladefoged, 2001).

Constriction occurs asymmetrically with the vocal folds, more at the anterior end near the thyroid notch than at the posterior end where the arytenoid cartilages lie.


Cricoid Cartge.
ARYTÆNOIDEUS
ARYTÆNOIDEUS POSTERIOR
CRICO-
Arytænoid C.
Arytænoid C.
Superior Cornu
THYREO-ARYTÆNOIDEUS
R. Chorda Voc.
Rima Glottidis
L. Chorda Vocalis
ARYTÆNOIDEUS LATERALIS
CRICO-
Cricoid
Thyroid
Cartilage
Cartilage
Upper
margin

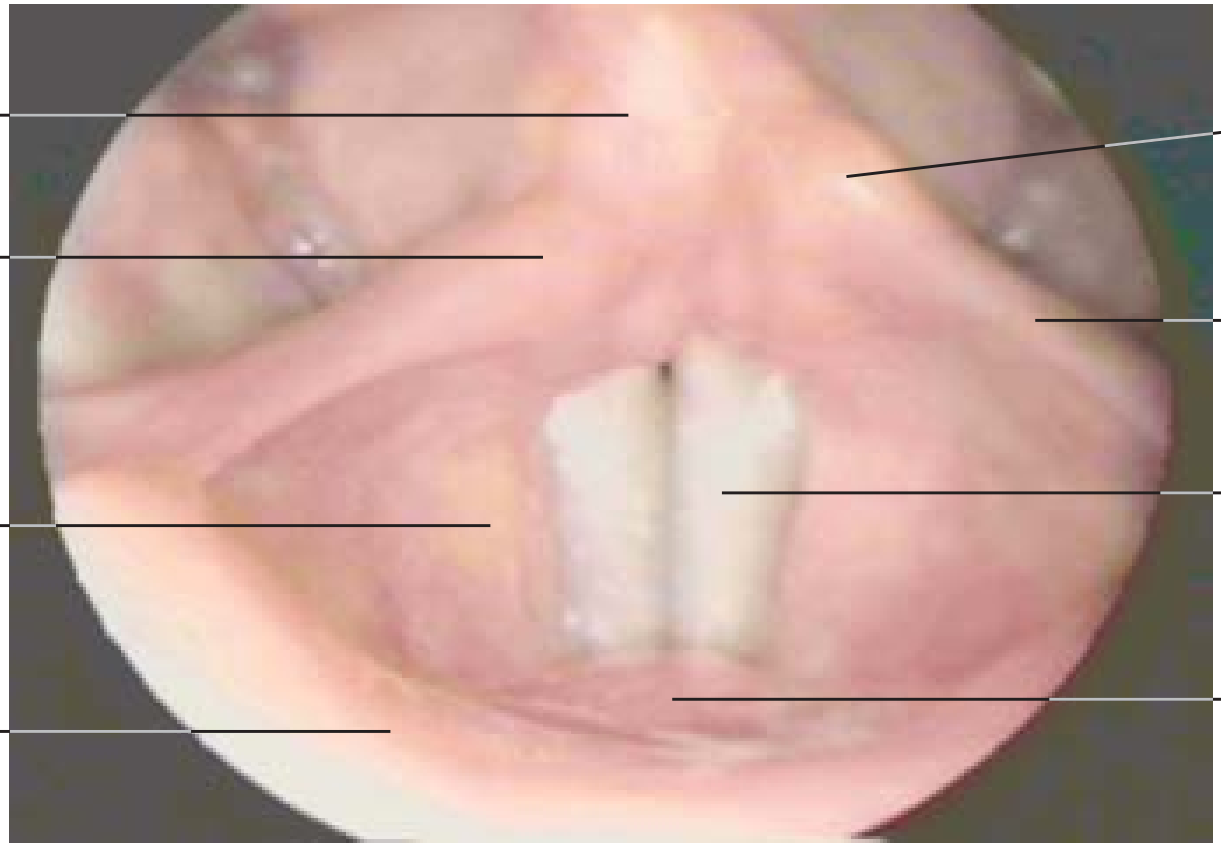
Constriction

In addition to changing glottal aperture, changes in tension also occur at the vocal folds. Generally speaking, phonation types with a narrower aperture involve greater medial compression of the vocal folds.

However, the longitudinal tension of the vocal folds may also vary with phonation types. We also control longitudinal tension for producing changes in F_0.

Important to remember that we are referring to changes in the temporary resting state of the vocal folds here; they still open/close with voicing. Examples on disk from Jalapa Mazatec, Gujarati, Mpi, Bruu.

Modal voicing (Edmondson and Esling, 2006)



Breathy voicing (Edmondson and Esling, 2006)

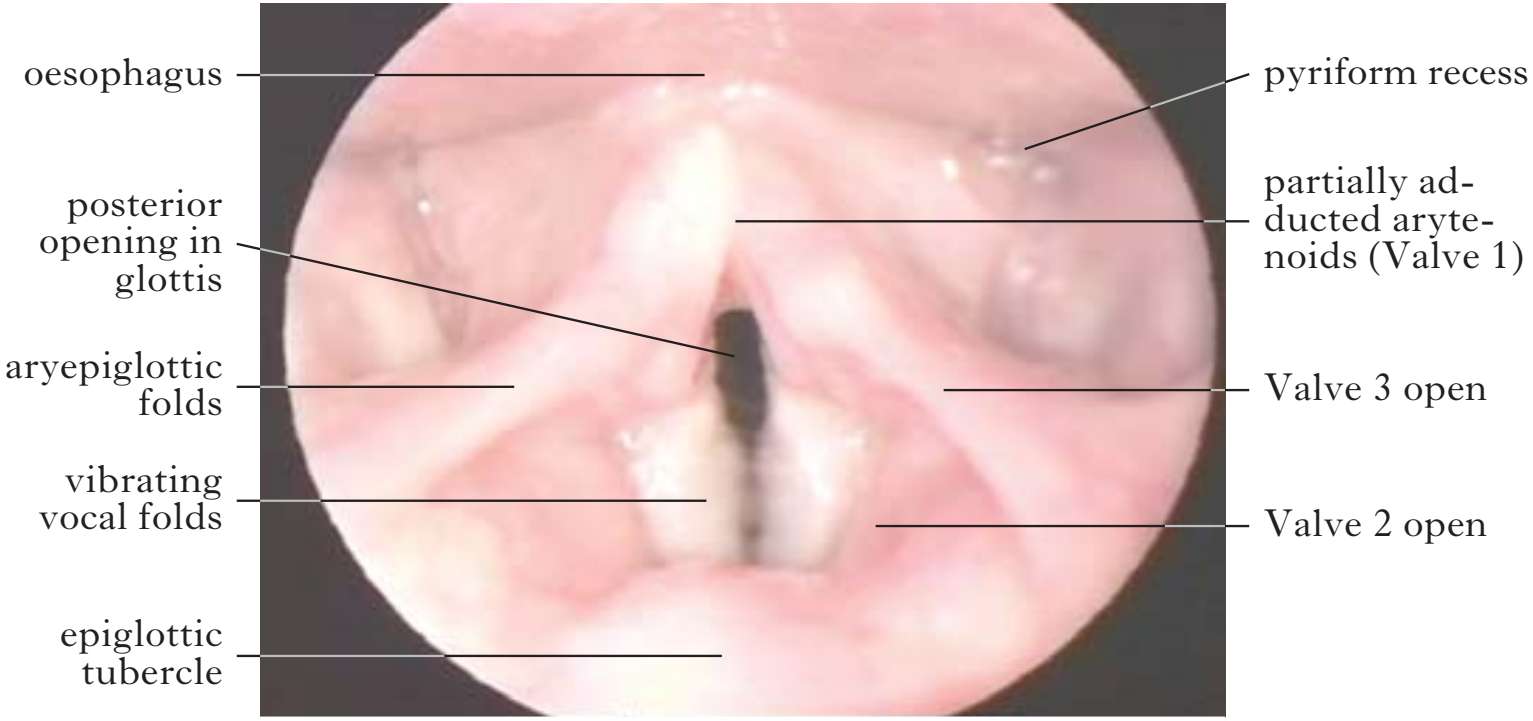
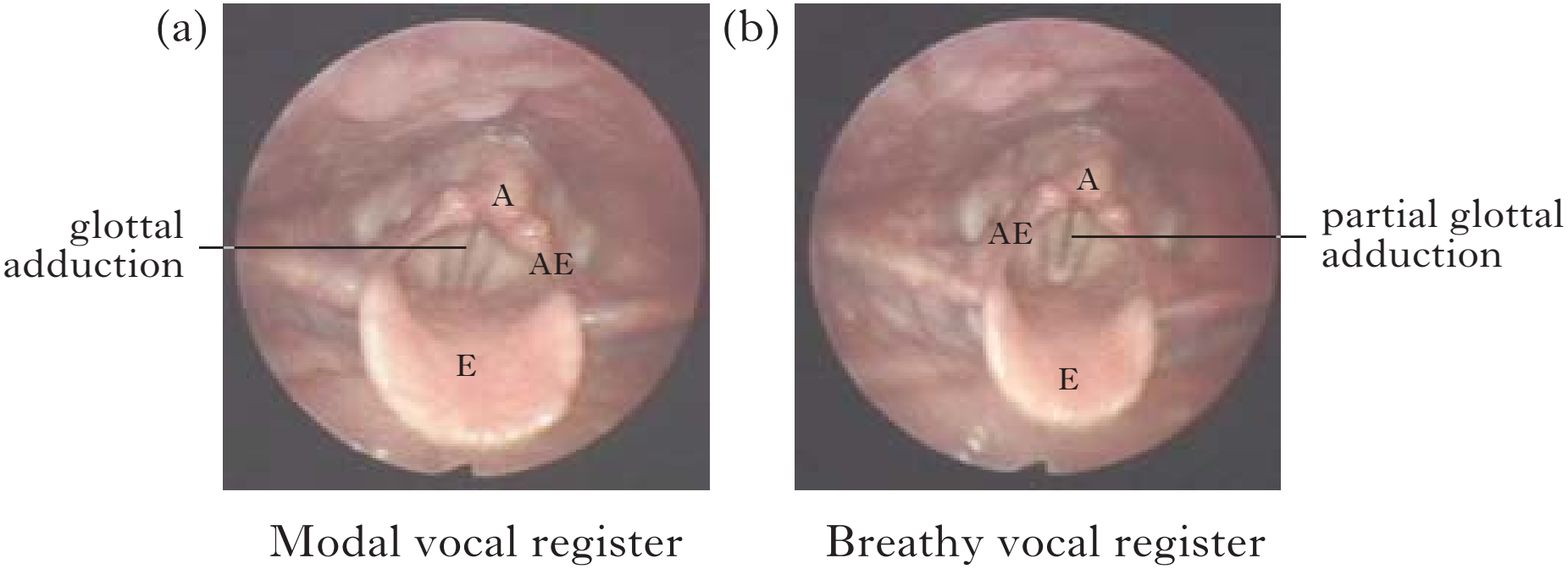


Figure 8

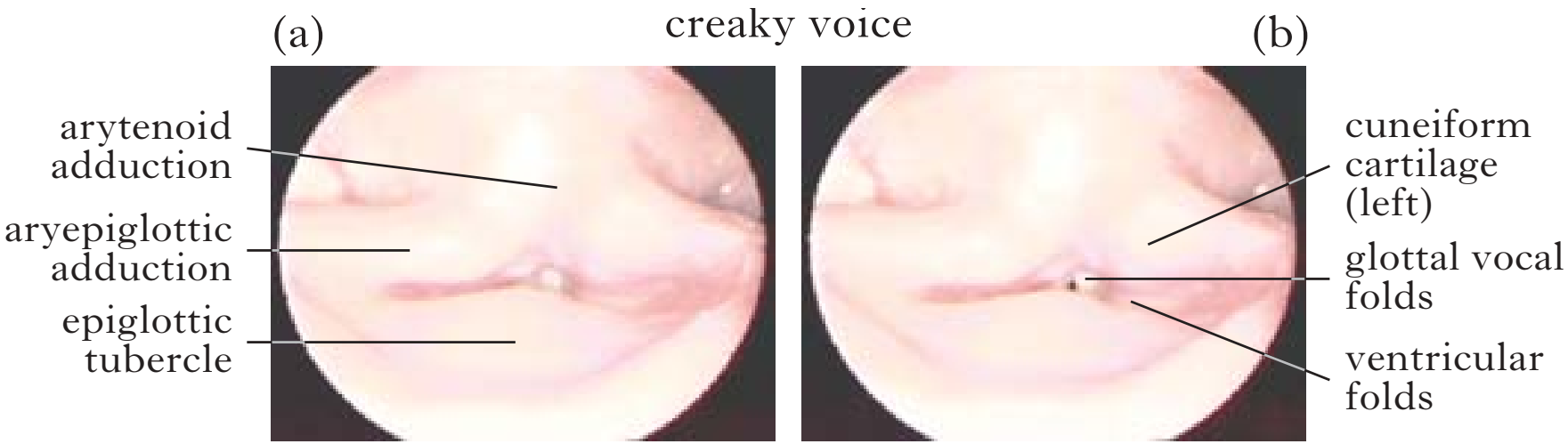
Canonical Breathy Voice showing a partial closure of Valve 1, leaving a large aperture between the arytenoid cartilages. The glottal vocal folds can oscillate anteriorly along the ligamental glottis, while remaining open posteriorly.

Breathy vs. Modal voicing in Bor Dinka



Modal vowel on [rīŋ] '*run*' (left) vs. Breathy vowel on [r̤ìŋ] '*meat*' (right); (Edmondson and Esling, 2006)

Creaky voicing (Edmondson and Esling, 2006)



Note the narrowing of the entire cavity here and the greater aryepiglottic constriction. Only the posterior portion of the vocal folds permits airflow and vocal fold vibration due to this greater overall constriction.

Articulation and acoustic consequences

- The vocal folds are open for longer during breathy phonation, so glottal frication is produced along with voicing. This has the effect of reducing the amplitude of the signal as less subglottal pressure is powering voicing.

- Greater constriction of the vocal folds with creaky or tense phonation causes changes in how fast the vocal folds close. They close much more quickly and stay closed for longer than they do with modal or breathy phonation.

Electroglottography (EGG)

EGG is an articulatory method which allows us to examine vocal fold vibration, including the closing/opening phase of the vocal folds.

When the vocal folds are adducted, there is greater electrical conductance between the electrodes. When the vocal folds are abducted, there is less electrical conductance between the electrodes.

Opening/Closing phase

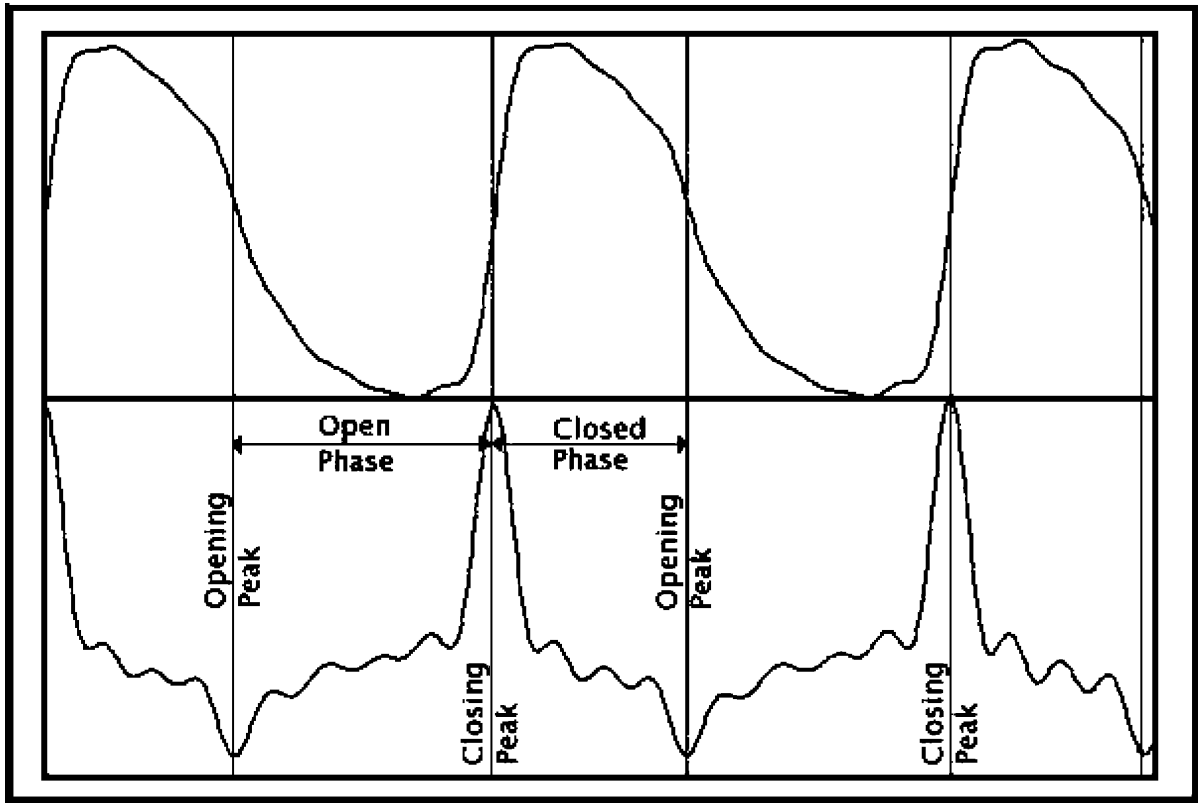


Figure 1 Example of Filtered EGG (top) and DEGG (bottom) signal.

(DiCanio, 2009)

Acoustic effects - breathy phonation

As a consequence of noise in breathy phonation, there is much more aperiodic energy across the spectrum and the formant structure is less clear.

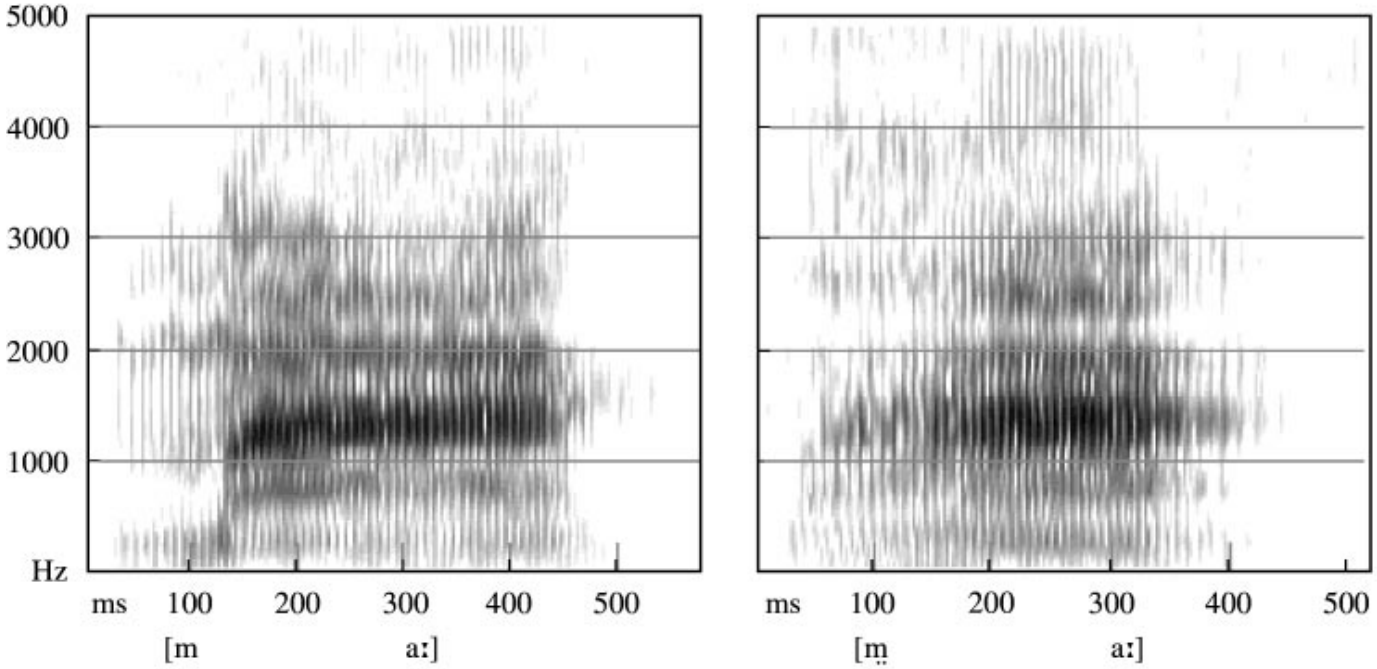
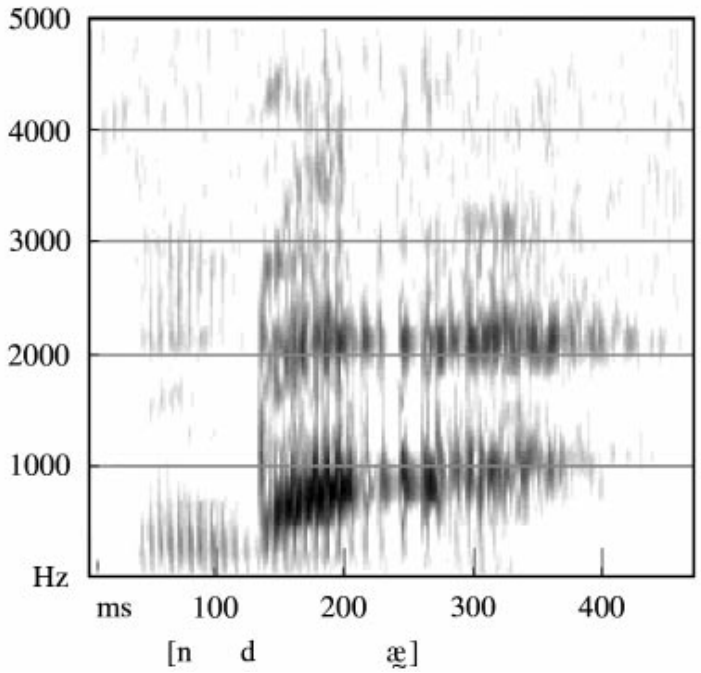


Figure 2. Spectrograms and waveform excerpts of modal and breathy voiced nasals in the Newar words /maː/ "garland" and /m̤aː/ "be unwilling" (male speaker).

(Gordon and Ladefoged, 2001)

Acoustic effects - creaky phonation

Creaky phonation is characterized with irregular glottal periods (jitter) but with clear formant structure. As a consequence of this irregularity, F_0 is not (usually) calculated so accurately.



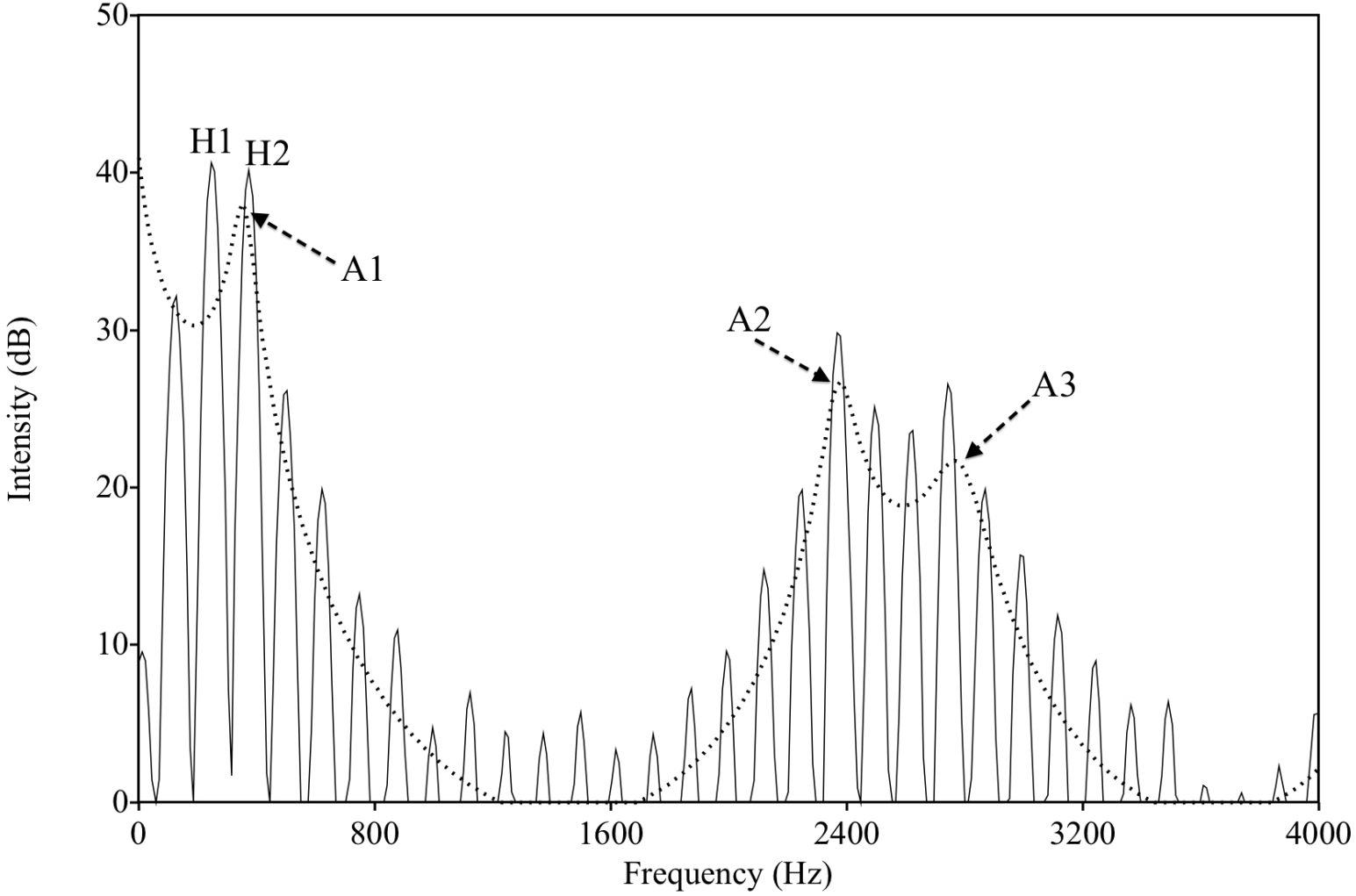
Jalapa Mazatec [ndæ̃] '*buttocks*' (Gordon and Ladefoged, 2001)

Spectral tilt

The vocal folds come together more quickly in the production of creaky or tense phonation. As a result of this, vocal fold closure produces a higher amplitude transient. This excites a greater number of harmonics and resonances across the spectrum, resulting in a flatter overall **spectral tilt** than one finds for modal voice (Kirk et al., 1993).

By contrast, the closing phase of the vocal folds is slower for breathy phonation. The resulting weaker transients fail to excite higher resonances in the vocal tract and the spectrum is steeper.

Involves the estimation of amplitude difference between different harmonics/formants in the spectrum.



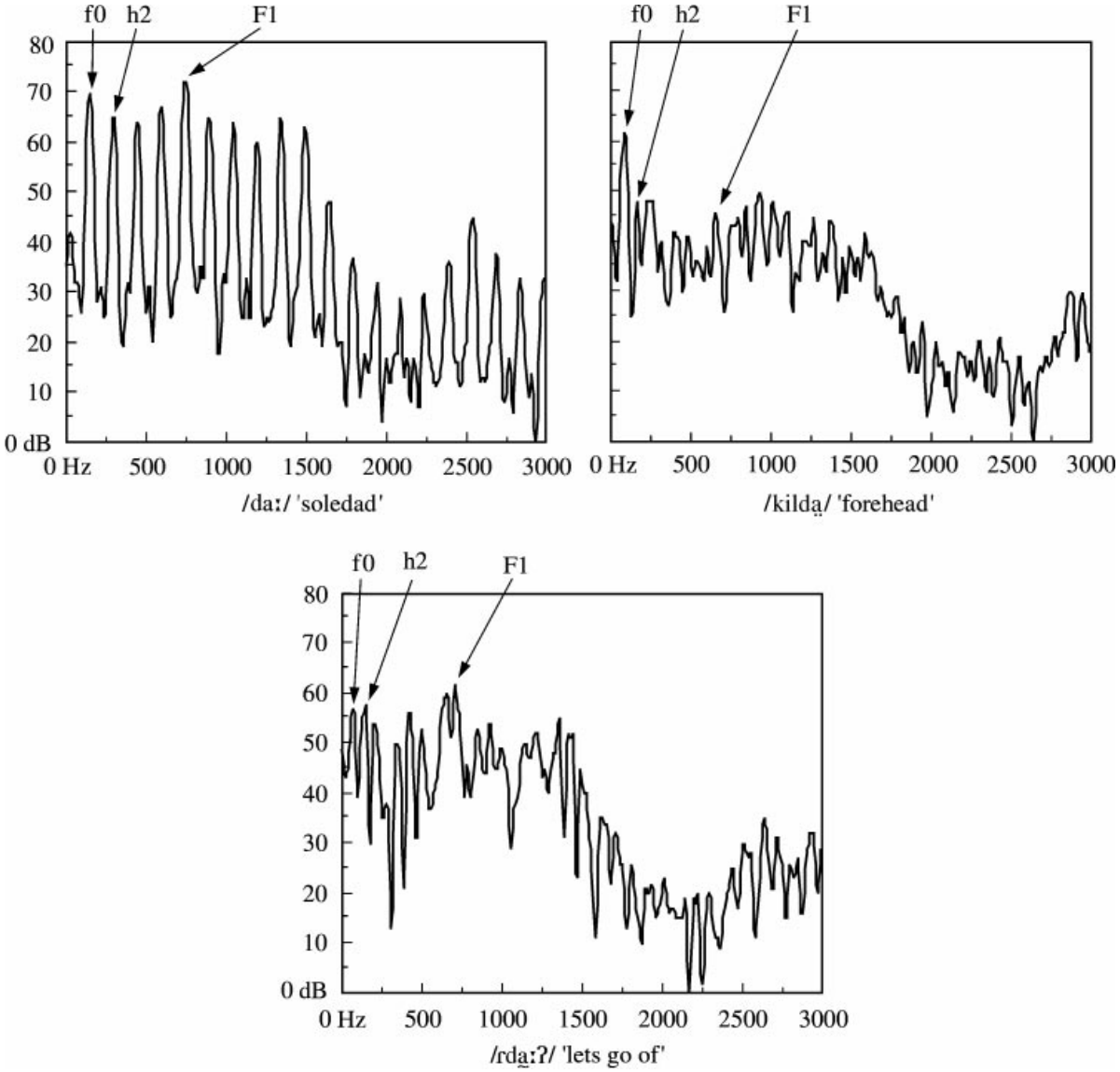


Figure 7. FFT spectra of modal, breathy, and creaky /a/ in the San Lucas Quiaviní Zapotec words /daː/ "Soledad", /kilda̤/ "forehead", and /ɾdaːʔ/ "lets go of" (male speaker).

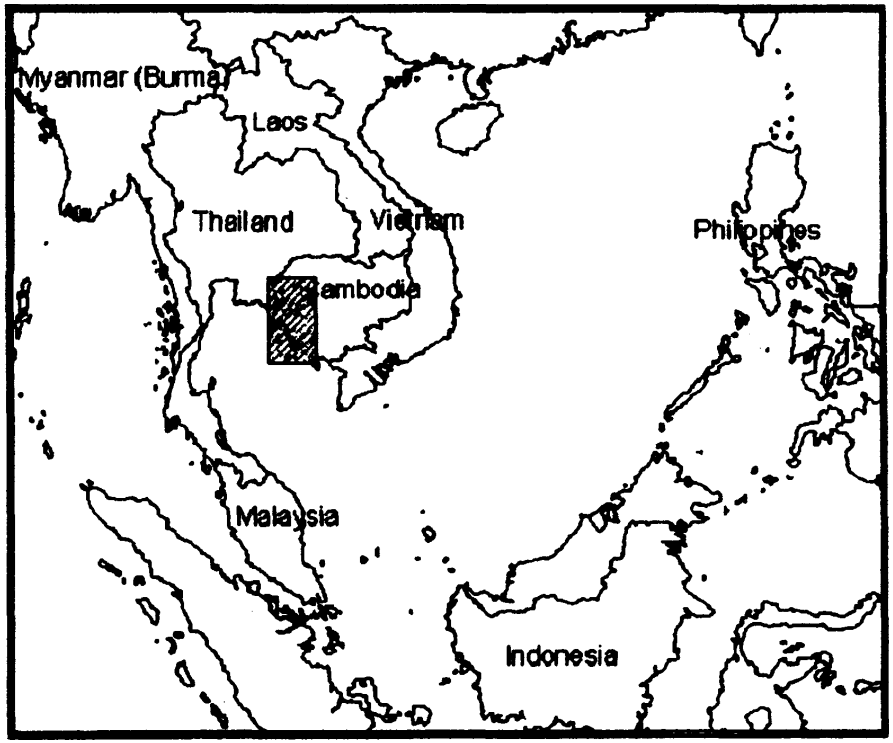
Chong phonation: a case study

While some languages distinguish between **breathy**, **modal**, and **creaky** voice qualities, there is this language Chong (spoken in Thailand) that distinguishes all three and another – **breathy-creaky** phonation type (as it was called then).

But how can you produce breathy *and* creaky phonation type at the same time?

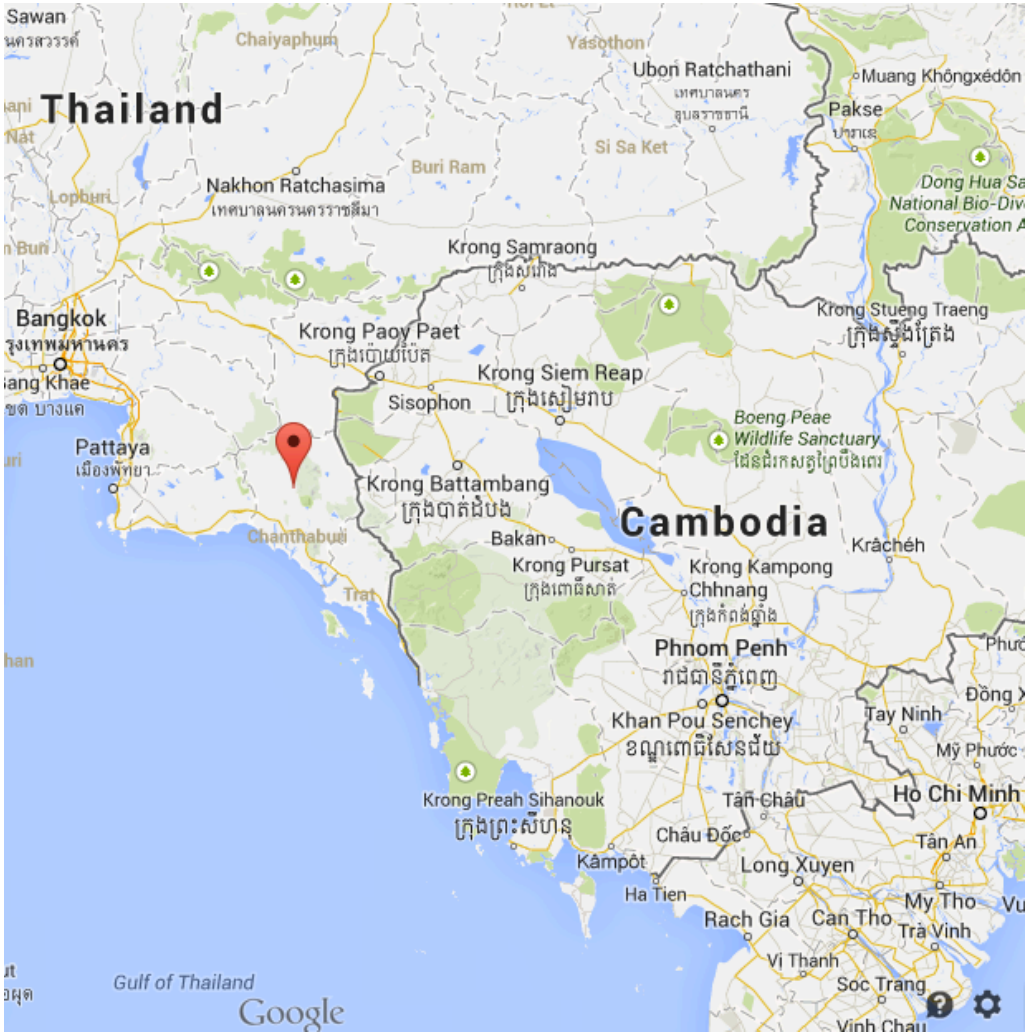
Chong dialects

Chong is an austro-asiatic language spoken in Thailand and Cambodia. It is endangered and in some communities, the only speakers are those over the age of 40.



(Choosri, 2002)

Takhian Thong Chong



Chong phonation

Chong contains a four-way contrast in what is called "voice register." Words are distinguished mainly by phonation type and secondarily by pitch and other cues.

Modal	Breathy	"Creaky"	"Breathy-Creaky"
tɔɔŋ	ra̤a̤j	tɔ̰ɔ̰ŋ	pa̤a̰j
'*six*'	'*ten*'	'*fear*'	'*two*'
kəlɔɔŋ	lɔ̤ɔ̤ŋ	lɔ̰ɔ̰n	cɕɔ̤ɔ̰ŋ
'*stride*'	'*husband*'	'*navel*'	'*Chong*'
ceew	cṳṳn	pḛḛw	ro̤o̰j
'*to go*'	'*to send*'	'*dinner*'	'*melon*'

The investigation

- Visit to Thailand and organization with researchers who work in the area.
- Compilation of wordlist from work on a related dialect (Ungsitipoonporn, 2001).
- Fieldwork on-site with EGG and acoustic recordings.
- Measures: Closing quotient and opening quotient from EGG, spectral tilt (H1-H2, H1-A3), F_0, duration.
- Research question: what acoustic dimensions do speakers use? how is the breathy-creaky register produced?

Measuring OQ

Open quotient is the proportion of the glottal cycle which is open. How do you measure this from the EGG signal?

It is difficult to estimate exactly when closure occurs from the raw signal, but there is a way to estimate when the curve showing glottal closure changes more abruptly - the derivative of the signal.

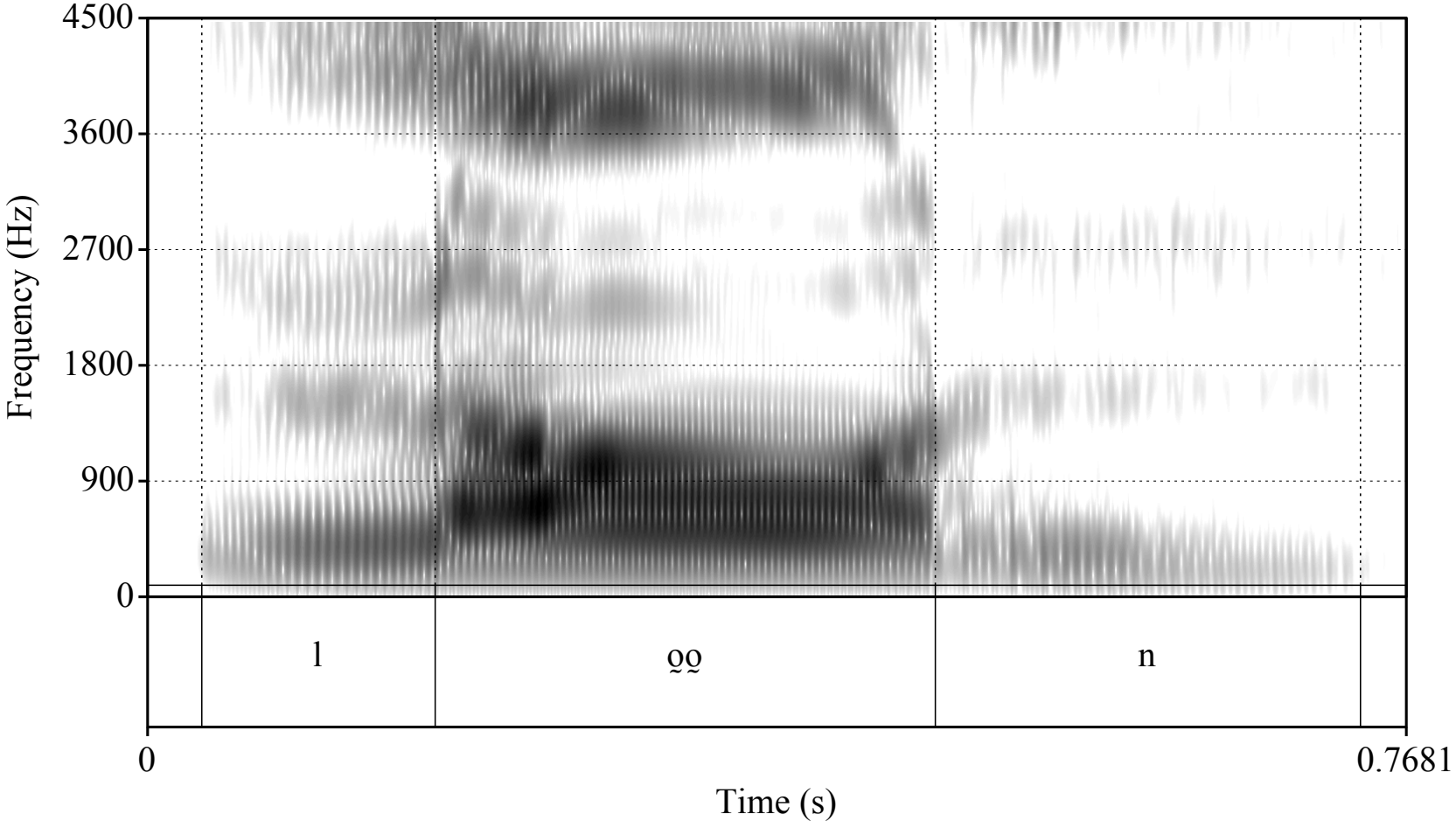
(Demonstration in Praat)

Creaky vs. Tense

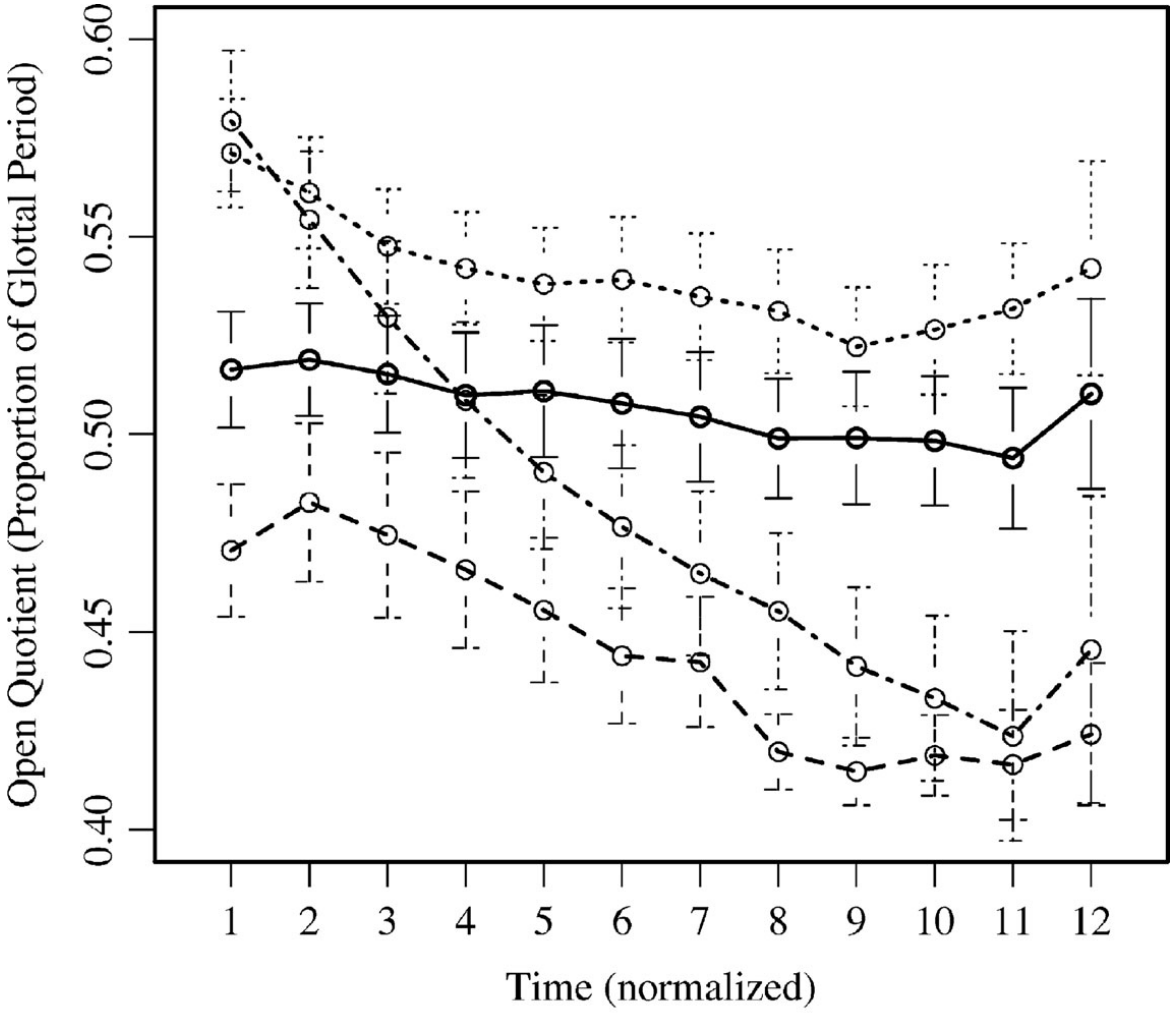
The "creaky" register is better described as *tense*. Both phonation types are characterized with increased adductive tension (Ní Chasaide and Gobl, 1997). While tense phonation is characterized with mostly periodic vocal fold vibration, creaky phonation contains substantial frequency modulation (jitter) and amplitude modulation (shimmer) (Childers and Lee, 1991; Blomgren et al., 1998; Pennington, 2005).

The difference between *creaky* and *tense* phonation is that the latter involves greater longitudinal tension of the vocal folds (stiffness) so that voicing can be maintained.

It's not creaky in Chong, but tense

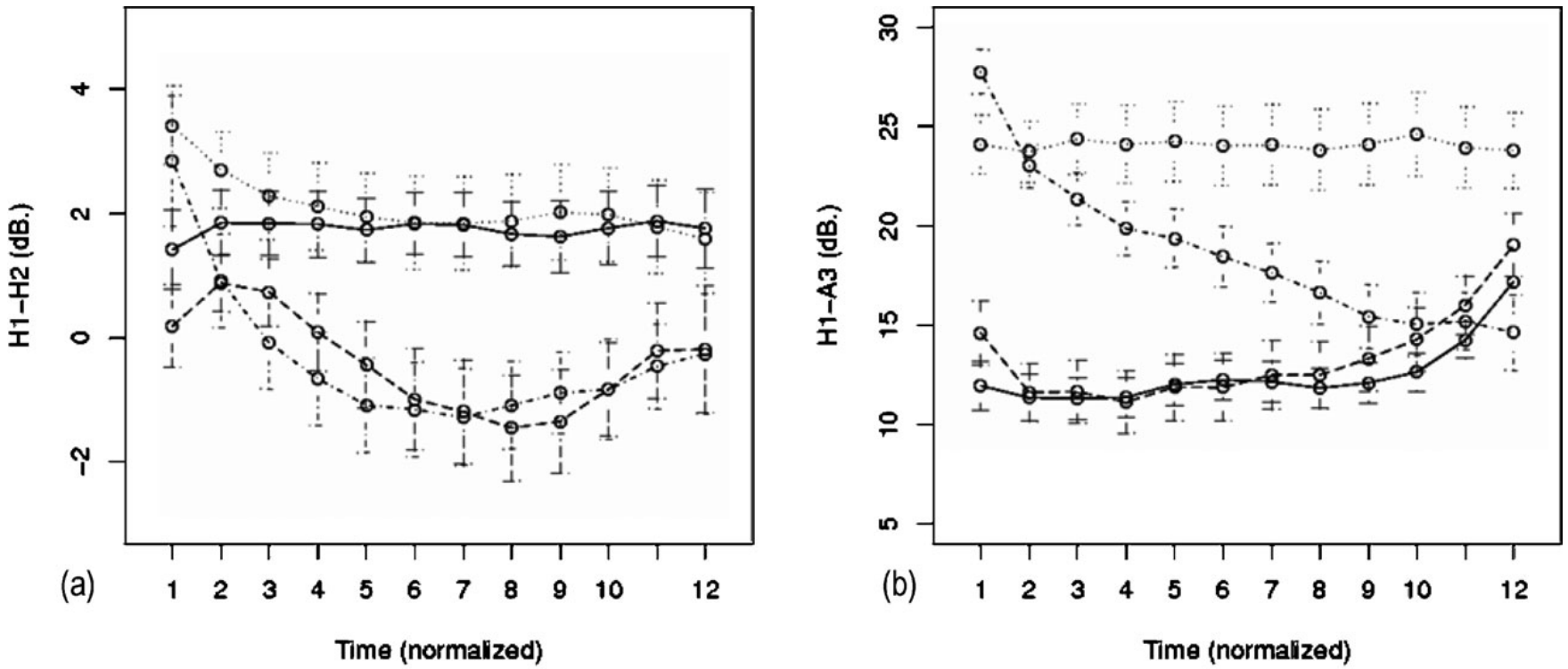


EGG results



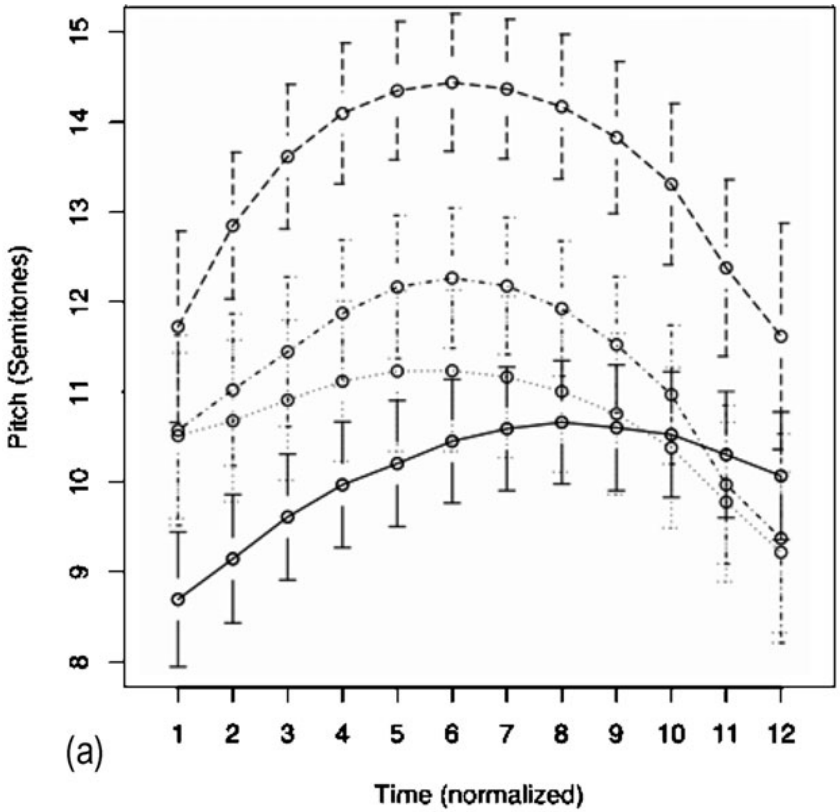
Key: Modal = solid, Breathy = dots, Tense = dashes, Breathy-Tense = dash-dot

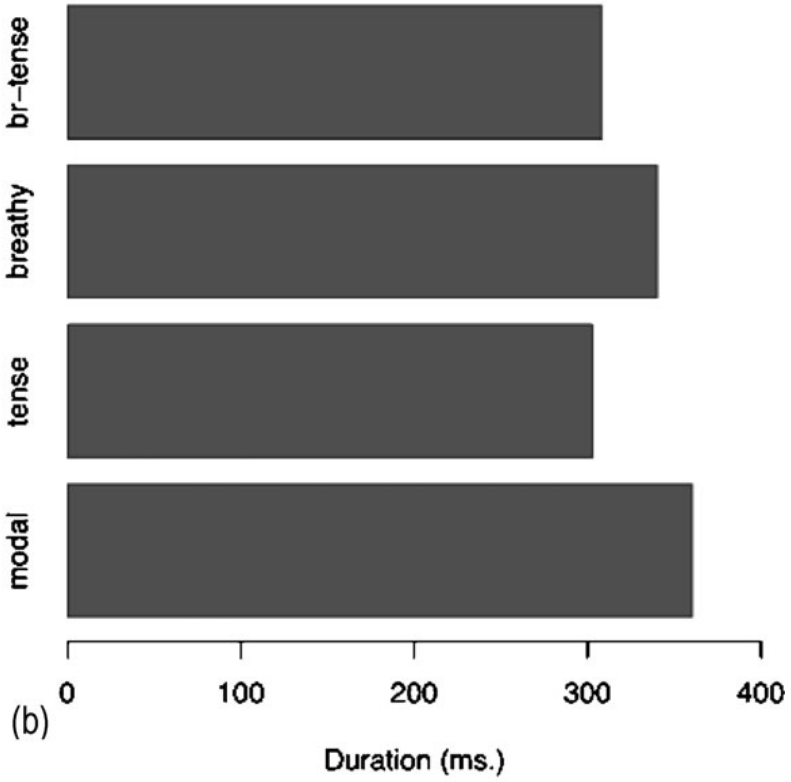
Spectral tilt results



Solid = modal; Dots = breathy; Dashes = tense; Dash-dot = breathy-tense

Pitch/Duration results





Key: Modal = solid, Breathy = dots, Tense = dashes, Breathy-Tense = dash-dot

Summary

- To distinguish words, Chong speakers use a number of different acoustic cues, including phonation type, F_0, and, to a small extent, duration.
- Research on phonation type involves investigating multiple acoustic/indirect measures to get a clear sense of what is happening.
- When laryngoscopic data is not available, one must infer what is happening from our knowledge of the articulatory-acoustic mapping and from whatever tools are at our disposal.

Key concepts

- Phonation type and its articulatory settings
- Electroglottography
- Acoustic correlates of phonation types
- Spectral tilt
- Acoustic cues to Chong registers

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