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Phonation in Nine* Languages

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* In fact, only 7 reported here

Introduction

Across languages with phonation contrasts, the phonation categories are distinguished by a variety of measures (e.g. Gordon & Ladefoged 2001), but these are inter-related and far outnumber the contrasting categories.

Our questions:

•What is a **low-dimension space** (acoustic, physiological) for voice quality?

•How are the phonation categories of different languages **located** in this space?

Language Samples

We compare contrastive and other phonations of 10 languages from 4 groups

Here we report results from 7 languages with both audio and EGG recordings – about 13,000 tokens

•**Bo** (Tibeto-Burman)
Tonal; **tense vs. lax** (largely independent of pitch)
12 speakers in Yunnan, China (isolated words)

• **California English** (Indo-European)
Non-tonal; intonational creak
22 speakers in Los Angeles USA (isolated words)
NO EGG AVAILABLE; **not reported here**

•**Gujarati** (Indo-European)
Non-tonal; **modal vs. breathy**
10 speakers in Los Angeles (sentence-initial words)

• **Luchun Hani** (Tibeto-Burman)
Tonal; **tense vs. lax** (largely independent of pitch)
10 speakers in Yunnan, China (isolated words)

•**White Hmong** (Hmong-Mien)
Tonal; **modal vs. breathy** on one pitch; **creaky** low tone
32 speakers in St. Paul USA (isolated words)

•**Beijing Mandarin** (Sino-Tibetan)
Tonal; Tone 3 has **allophonic creak**
20 speakers in Beijing, China (disyllables)

• **Jalapa Mazatec** (Oto-Manguean)
Tonal; **modal vs. breathy vs. creaky** (crossed w/ tones)
16 speakers in Mexico (isolated wds in online archive)
NO EGG AVAILABLE; **Not reported here**

• **Black Miao** (Hmong-Mien)
Tonal; **modal vs. breathy** at one pitch, **creaky** low tone **pressed** high tone)
15 speakers in Guizhou, China (isolated words)
Not reported here

•**Southern Yi** (Tibeto-Burman)
Tonal; **tense vs. lax** (largely independent of pitch)
12 speakers in Yunnan, China (isolated words)

•**Santiago Matatlán and San Juan Guelavia Valley Zapotec** (Oto-Manguean)
(Two varieties grouped together here)
Tonal; **creaky** large-falling tone and **breathy** small-falling tone
6 speakers in Los Angeles, USA (isolated words)

Acoustic Measures

Acoustic measures over time were made semi-automatically from the audio by **VoiceSauce** (Shue et al. 2011), a free UCLA program.

Spectral measures analyzed:

•**F0** by the STRAIGHT algorithm (Kawahara et al. 1999) for finding harmonics

•Corrected (*: Hanson 1995, Iseli et al. 2007) **harmonic amplitudes and differences:**
- **•H1*, H2*, H4*, A1*, A2*, A3***
- **•H1*-H2*, H2*-H4***
- **•H1*-A1*, H1*-A2*, H1*-A3***

•Noise measures (NOT REPORTED HERE)
- **•Cepstral Peak Prominence**
- **•Harmonic-Noise ratios**
- **•Subharmonic-harmonic ratio**

EGG Measures

Electroglottographic signals were recorded with the audio for 8/10 languages. Automated EGG measures were made by **EggWorks**, a free UCLA program.

EGG measures analyzed:

•**CQ_H: Contact Quotient**, here using the "hybrid" method with 3/7 threshold

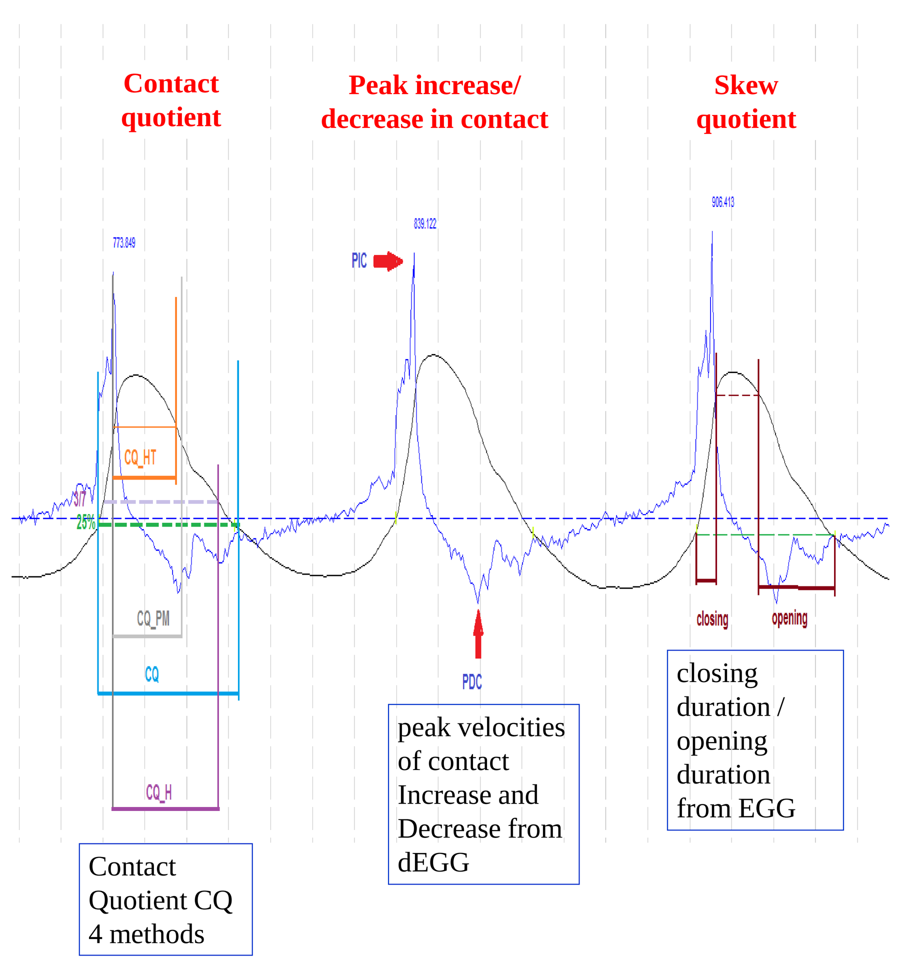
•**PIC: Peak Increase in Contact** (the peak positive value in the EGG derivative, like DECPA (Michaud 2004))

•**PDC: Peak Decrease in Contact** (the peak negative value in the EGG derivative)

•**OP_DUR: Opening duration** (not included)

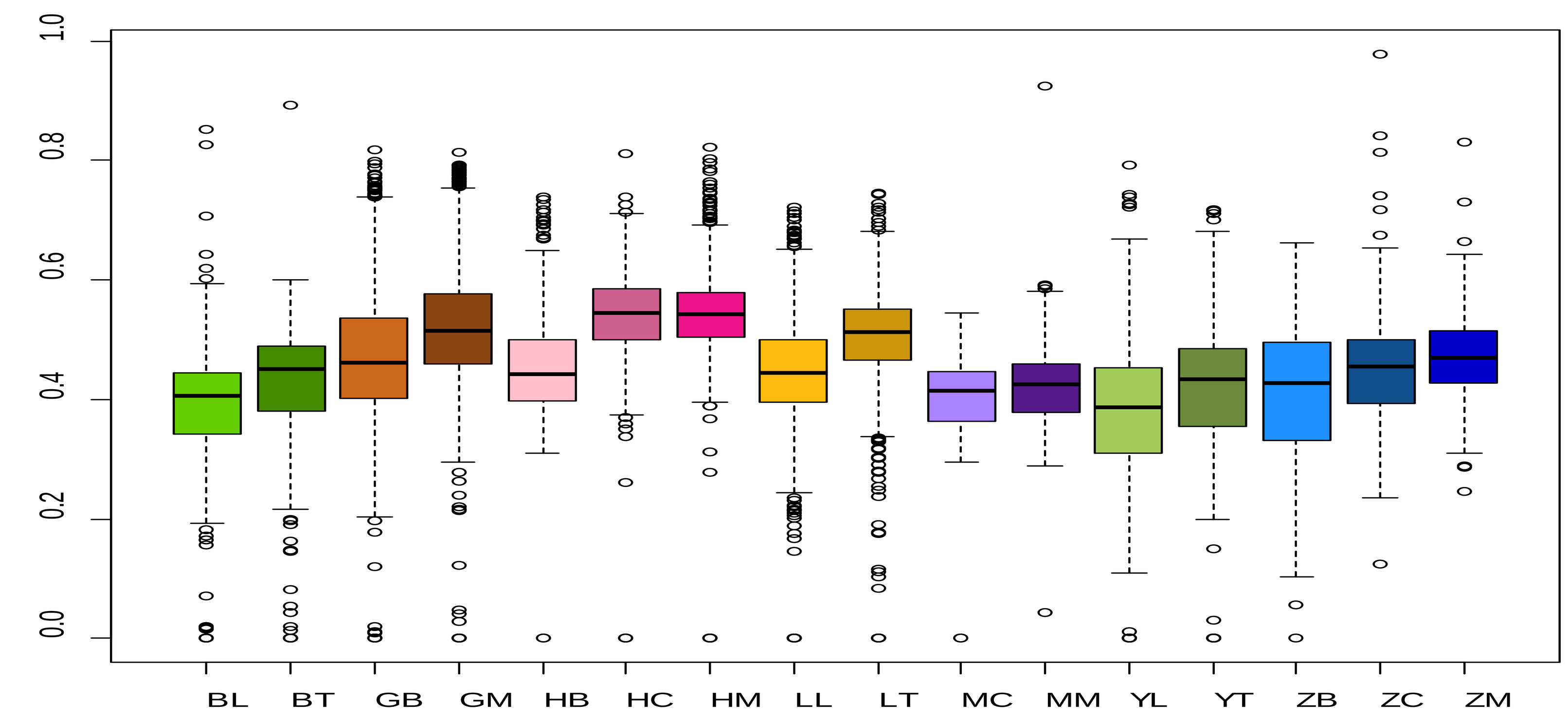
•**CL_DUR: Closing duration**

•**SQ: Skew quotient** (ratio of CL_DUR/OP_DUR)



Categories across languages

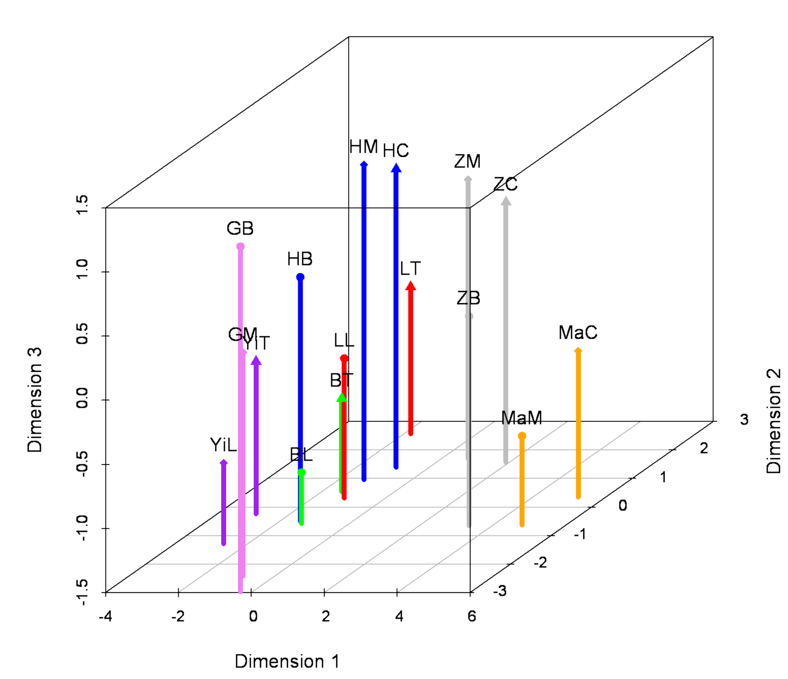
Boxplot of CQ_H of 16 phonation categories in 7 languages with EGG data.
- Categories mostly **cluster within a limited middle range** of values
- Within languages, **cross-category differences are often small**, although always statistically significant
- The **"same" category can be very different** across languages
- Languages with **more categories** do not necessarily have **less variable** categories

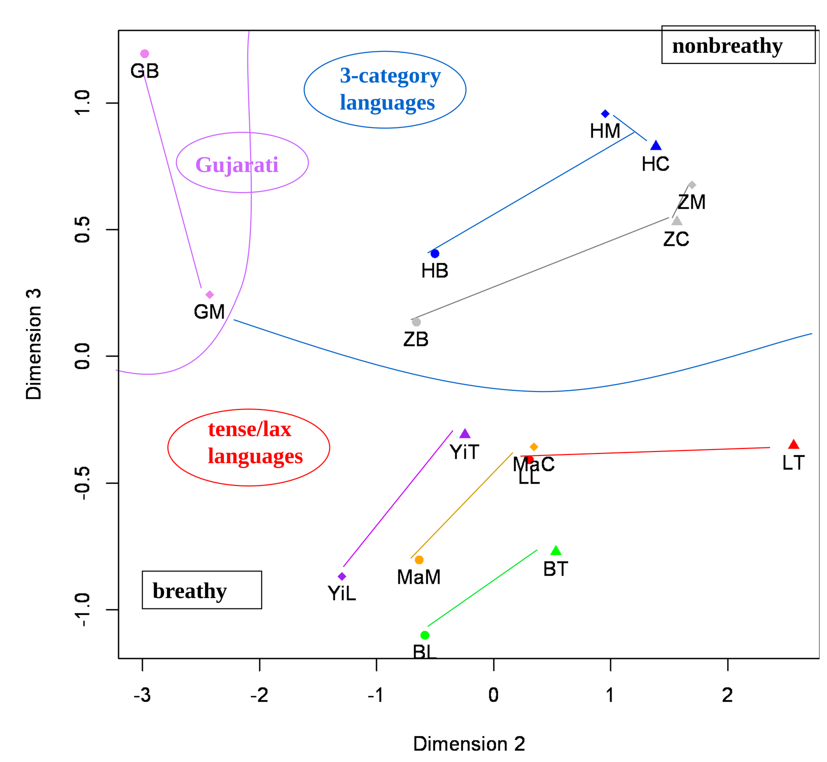


Low-dimensional phonetic spaces

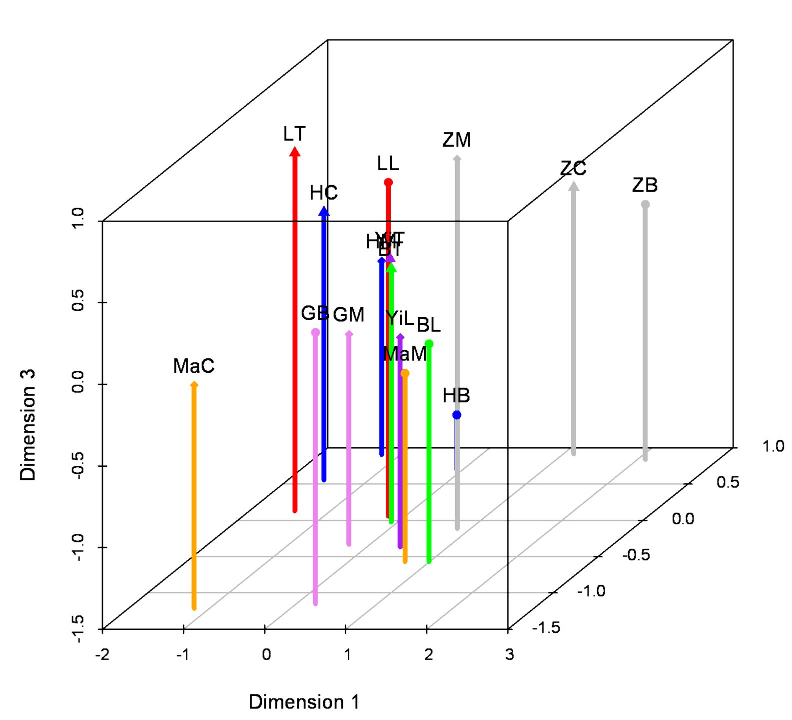
Multi-Dimensional Scaling of spectral and EGG measures
- All 16 language-specific phonation categories in these 7 languages
- **Male speakers only**
- Data for each measure are normalized from 0 to 1 for all languages together
- **3-D solutions and 2-D planes of 3-D solutions are plotted**

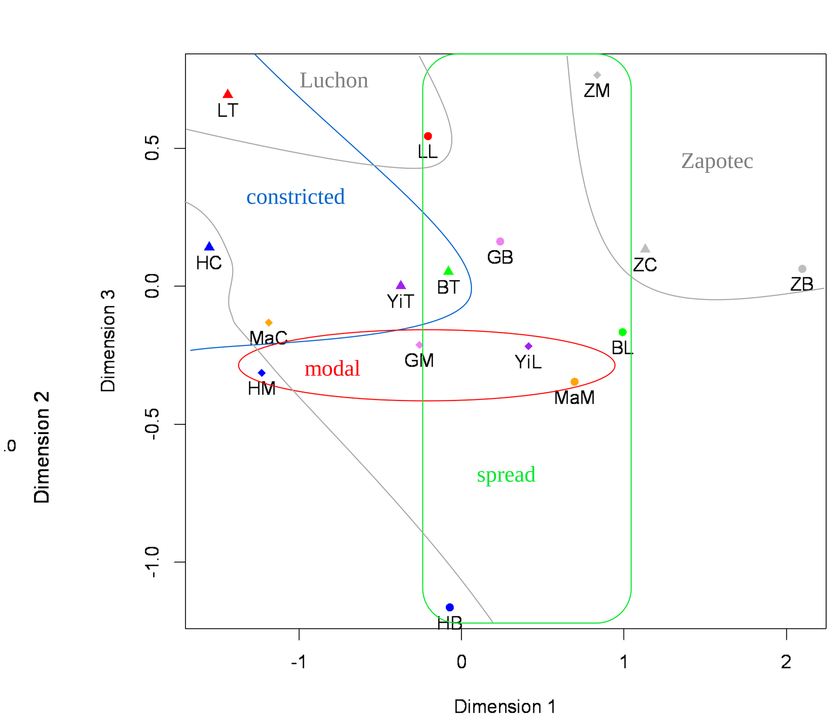
Spectral measures
- **Dimension1** distinguishes some languages (relates to H4*, A1*, A2*, A3*)
- **Dimensions 2+3** (right) together distinguish breathy vs. non-breathy along one diagonal, and group languages together by contrast types: Gujarati vs. 3-category languages vs. tense/lax languages (where Mandarin patterns)
- Differences on **Dimension2** relate most to H1*-H2*; differences on **Dimension3** to H1*-H2*, H1*-A1*/A2*/A3*





EGG measures
- **Dimension 1** distinguishes some languages, and most **breathy/lax** vs. **creaky/tense** (relates most to SQ, PIC, PDC)
- **Dimension 3** distinguishes **modal** from others (relates to CQ, as does dim2)
- **Dimensions 1+3** together (right) distinguish **languages**, and **creaky/tense**





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Conclusions

Low-dimensional phonetic spaces for phonation can be derived from acoustic and physiological measures of phonation. These spaces distinguish **languages** (speakers, recordings) as much as they do phonation **categories**.

•In the **spectral** space, **languages** seem to group together by **type of contrast**.

•In the **EGG** space, **phonation categories** in most of the languages seem to group together by **type of category**, with breathy the most variable category.