# **Phonation Contrasts Across Languages** P. Keating<sup>1</sup>, C. Esposito<sup>2</sup>, M. Garellek<sup>1</sup>, S. Khan<sup>1,3</sup>, J. Kuang<sup>1</sup> <sup>1</sup>UCLA; <sup>2</sup>Macalester College; <sup>3</sup>Brown University

#### Introduction

Across languages with phonation contrasts, the phonation categories are distinguished by a variety of measures (e.g. Gordon & Ladefoged 2001, Esposito 2010), but not by every measure in each language. **Our questions**:

•What **measures** distinguish phonation categories within and across languages?

•What are the **dimensions** of the acoustic voice quality **space**?

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

#### **Methods**

We compare the contrastive phonations of four unrelated languages on several acoustic measures, and for three languages on measures from electroglottographic (EGG) recordings:

#### **Acoustic Measures**

Acoustic measures over time were made semi-automatically from the audio by VoiceSauce (Shue et al. 2009), a free UCLA program:

•F0 by the STRAIGHT algorithm (Kawahara et al. 1998) for finding harmonics

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

•Cepstral Peak Prominence (CPP) •Energy

#### **EGG Measures**

EGG signals were recorded with the audio via a Glottal Enterprises EG2. Automated EGG measures were made by **EggWorks**, a free UCLA program:

•CQ\_H: Contact Quotient, here using the "hybrid" method with 25% threshold

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

<b>Language</b> (variety) (family)	Phonations	Tones	Source of recordings	# of speakers	EGG # of speakers
<b>Gujarati</b> (Indo-European)	Modal, breathy	No	Fieldwork in Los Angeles	10 (7F, 3M)	Yes (7F, 3M)
Hmong (White) (Hmong-Mien)	Modal, breathy, creaky	Yes	Fieldwork in St. Paul	32 (9F, 23M)	Yes (5F, 6M)
Mazatec (Jalapa) (Otomanguean)	Modal, breathy, creaky	Yes	UCLA online phonetic archive	16 (6F, 10M)	-None-
<b>Yi</b> (Southern) (Tibeto-Burman)	Lax, tense	Yes	Fieldwork in SW China	12 (6F, 6M)	Yes (6F, 6M)

### Individual-language Results

Success of various acoustic and EGG measures. A check mark indicates that the measure significantly distinguished some/all phonations in a given language:

Measure	Gujarati	Hmong	Mazatec	Yi
H1*-H2*	$\checkmark$	$\checkmark$	$\checkmark$	$\checkmark$
H2*-H4*				
H1*-A1*	$\checkmark$		$\checkmark$	$\checkmark$
H1*-A2*	$\checkmark$		$\checkmark$	$\checkmark$
H1*-A3*	$\checkmark$		$\checkmark$	$\checkmark$
CPP		$\checkmark$	$\checkmark$	$\checkmark$
Energy			$\checkmark$	
CQ_H	$\checkmark$	$\checkmark$	N/A	$\checkmark$
PIC		$\checkmark$	N/A	$\checkmark$

H1\*-H2\* is higher for breathier phonations, and can also vary with tone (here, tones grouped into High-Mid-Low):



**CQ\_H.** Breathy phonations are made with longer glottal openings (lower CQ\_H). All 3 languages use CQ\_H and, acoustically, H1\*-H2\*:



• **Timecourse** effects: Where in the vowel are the phonation contrasts strongest? • Gender effects: No significant interactions.

•Multi-Dimensional Scaling of the acoustic measures in all 10 (2+3+3+2) language-specific phonation categories in all languages (using Manhattan distances), for midtone non-high vowels, is plotted for the **3-D** solution.

•The cross-language differences are much greater than the withinlanguage contrasts. Contrasts differ on Dimension 3, which most reflects H2\*-H4\* and H1\*-H2:



**PIC**. Contrary to expectation, breathy phonations show *faster contact* (higher PIC). PIC is used in the 2 languages with creak; acoustically, these languages also use CPP:



**Hmong**: beginning (for breathy), end (for creaky) Mazatec: beginning Yi: throughout

## LabPhon 12

# **July 10, 2010**

#### **Cross-language Results**

•Linear Mixed Effects models were run for each acoustic measure on all 10 language-specific phonation categories to determine how many are distinct, and on which measures:

•Modals and breathy/lax differ across all languages on a variety of measures

•Creaky/tense differ across all languages only in H1\*-A1\*, CPP, and Energy

#### **References & Acknowledgments**

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