

# Breathiness contrasts in consonants and vowels

## A comparative study of Gujarati and White Hmong

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### Background

Many lgs. exhibit a **modal vs. breathy voice contrast**, restricted to either:

- Consonants, e.g. Indic lgs. (O83), or
- Vowels, e.g. Zapotec lgs. (E10a)

**Very few languages maintain this contrast on consonants *and* vowels.**

- Khoisan lgs. (T85), Hmong, Gujarati

**Phonetic studies of the breathy V vs. breathy C<sup>fi</sup> contrast are few.**

### Research questions

**Is breathiness the “same” regardless of association to V or C<sup>fi</sup>?**

Claimed to be phonetically **similar** by some (L&M96, D89), and **distinct** (“whispery vs. breathy”) by others (L81, E&H05, F&G08).

Since oral stop C breathiness is realized in the release into a following V...

**...is [CV] distinguished from [C<sup>fi</sup>V]?**

**Two hypotheses are explored:**

#### 1. Localization of breathiness

Vs following breathy-aspirated Cs will only be breathy adjacent to the C release, while breathy Vs will be breathy throughout.

#### 2. Magnitude of breathiness

Post-(br.-)aspirated Vs will show a different magnitude of breathiness than breathy Vs.

**We examine data from Gujarati and White Hmong**, two **unrelated** languages, among the **very few** to contrast breathiness on Cs and Vs

### About the languages



#### Gujarati (ગુજરાતી)

•**4-way voi & asp contrast**, e.g. /t<sup>h</sup> d d<sup>fi</sup>/

•**4 breathy Vs**: /ɛ̃ ɔ̃ ɐ̃ ʌ̃/ (some spkrs have more)

•**[CV] distinguished from [C<sup>fi</sup>V]** by:

- Spectral measures: H1-H2, H2-H4, H1-A1, H1-A2, H1-A3 (F-J67, B82, K&a10, K11)
- Noise measures: CPP, HNR (K11)
- EGG measures: CQ (K&a10, K11)

•**No study of Gujarati [C<sup>fi</sup>V].**

#### White Hmong (Hmoob Dawb)

•**4-way voi & asp contrast** in alvs: /t<sup>h</sup> d d<sup>fi</sup>/

•7 tones, including **falling breathy tone (42)**

•**[CV] distinguished from [C<sup>fi</sup>V]** by:

- Spectral: H1-H2 (H87, A&R00, E10b, K&a10)
- EGG measures: CQ, DECPA (E10b, K&a10)

•F&G08 compared **[CV]**, **[C<sup>fi</sup>V]**, **[C<sup>fi</sup>V]** in 2 spkrs.

- H1-H2, H1-H3, and harmonicity distinguished all three at C release.

### Methods

#### Speakers

- 10 Gujarati speakers**: 3 M, 7 F
- 12 White Hmong speakers**: 6 M, 6 F

#### Wordlists

- 3 (near)-minimal sets**: see chart →
- Gujarati: In semi-naturalistic speech
- WhHmong: In fixed carrier sentences

#### Properties measured

- Acoustic**
  - Measured by VoiceSauce (S&a09)
  - H1\*-H2\*** (\*=corrected)
  - H1\*-A3\***
  - CPP**: cepstral peak prominence
- Electroglottographic (EGG)**
  - Measured by EggWorks (T09)
  - CQ**: closing quotient (hybrid)
  - DECPA**: Der-EGG closure peak amp.

Gujarati			White Hmong		
Breathy V	Breathy-asp. C	Modal	Breathy V	Breathy-asp. C	Modal
b̤ar	b <sup>h</sup> ar	bar	d̤a 42	d <sup>h</sup> a 22	da 52
‘outside’	‘burden’	‘twelve’	‘lie; fool’	‘separate’	‘yellow’
b̤anū	b <sup>h</sup> an	ban	d̤i 42	d <sup>h</sup> i 22 d <sup>h</sup> u 22	
‘excuse’	‘consciousness’	‘arrow’	‘probe; dig with a stick’	‘the bubbling sound of boiling food’	
d̤əḷū	d <sup>h</sup> əḷū	d̤olo	d̤ə 42 d̤i 42	d <sup>h</sup> ə 22	d̤o 22
‘polluted’	‘to spill’	‘eyeball’	‘average’	‘fits together’	‘onion’

#### Analysis

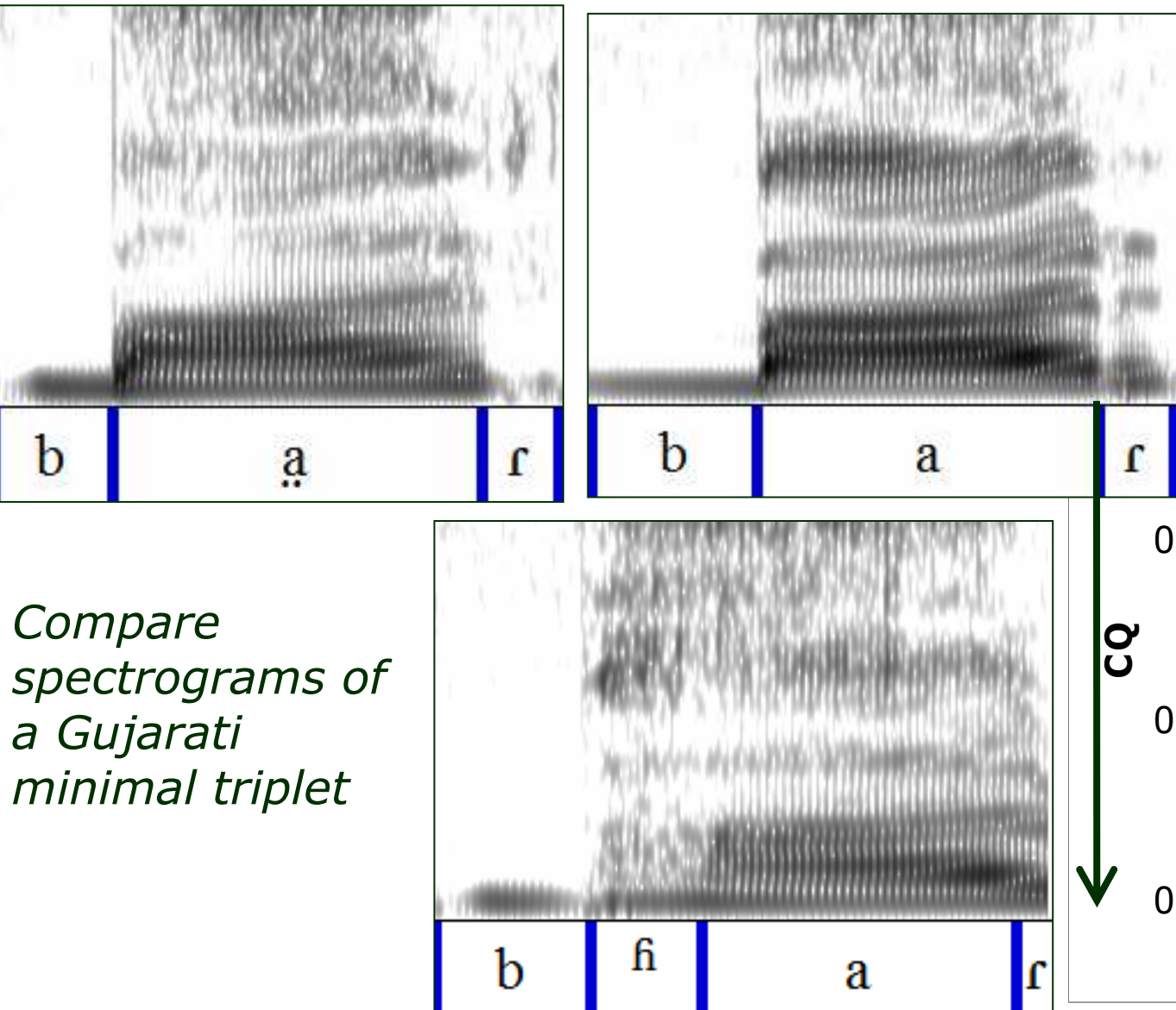
- Values averaged in every 1/9 of the V duration: “timepoints” (T)
- Only T1-T5 (beginning & middle of the vowel) were examined
- ANOVAs & post-hoc comp. looked for signif. (p≤.001) diff. b/w categories



### Results: Gujarati

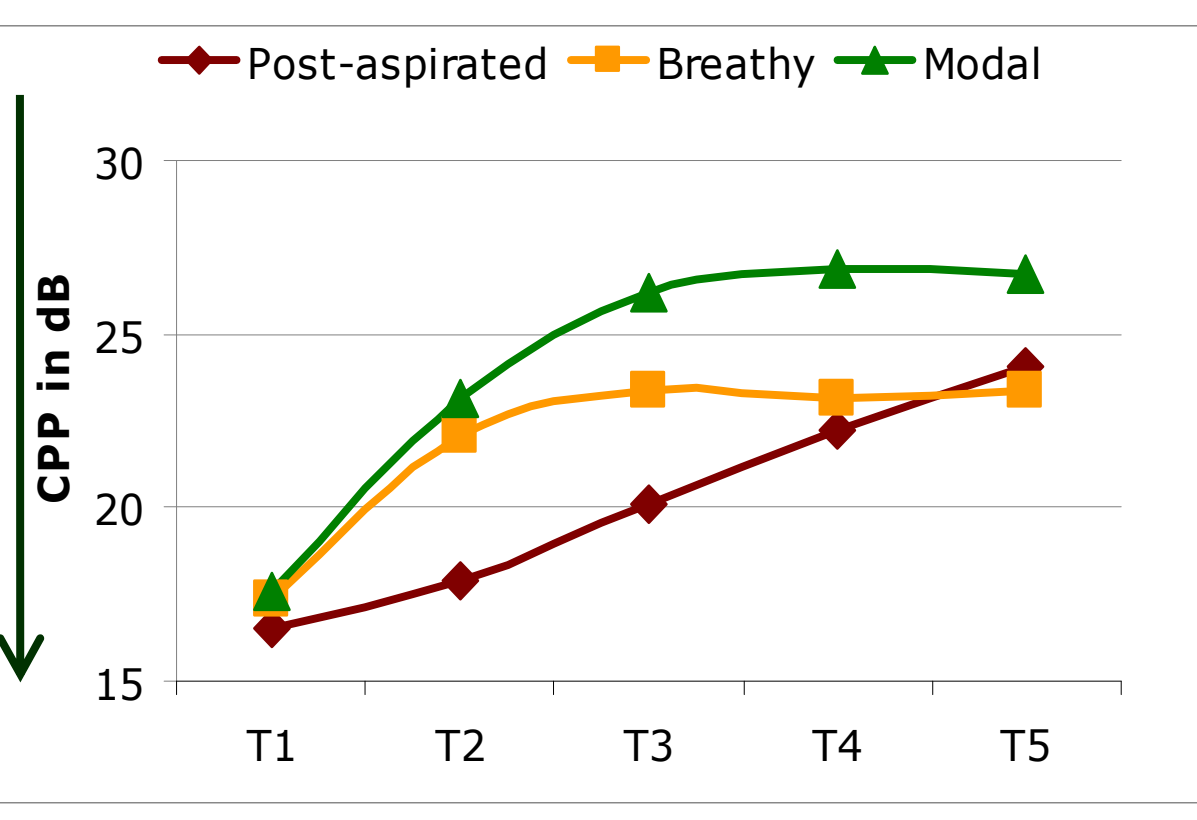
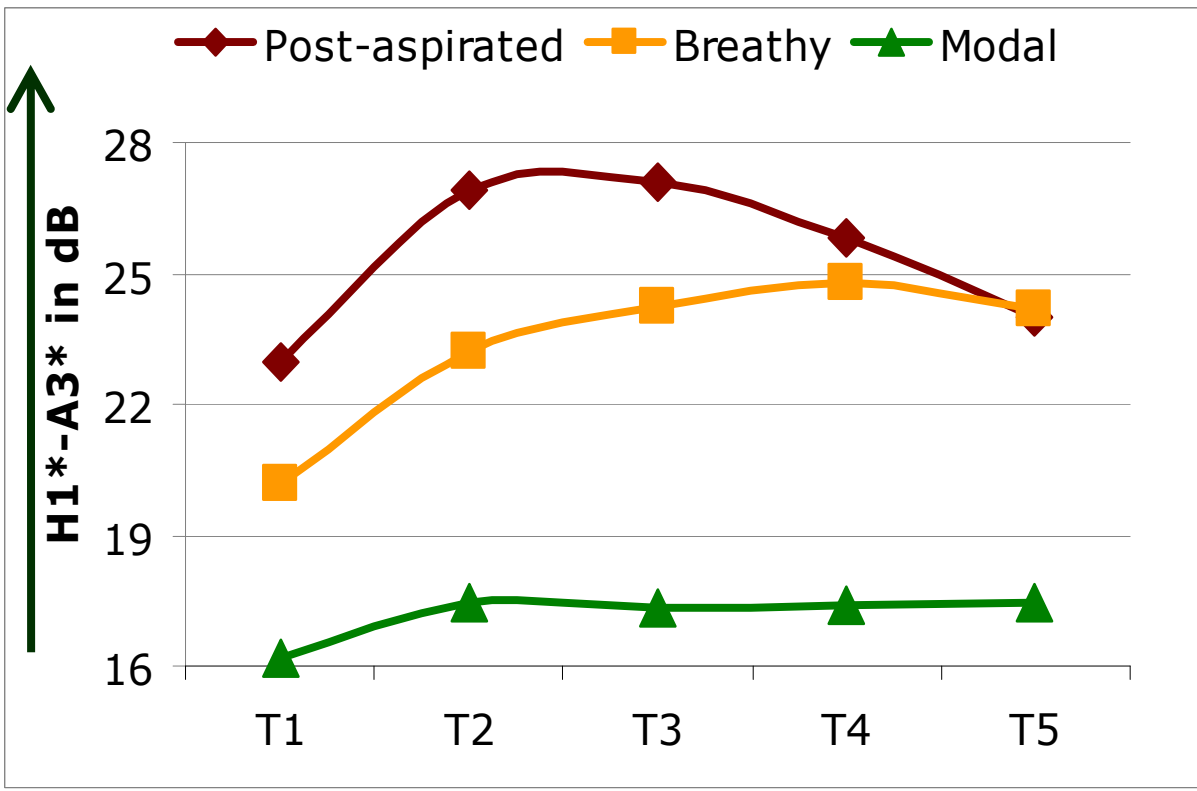
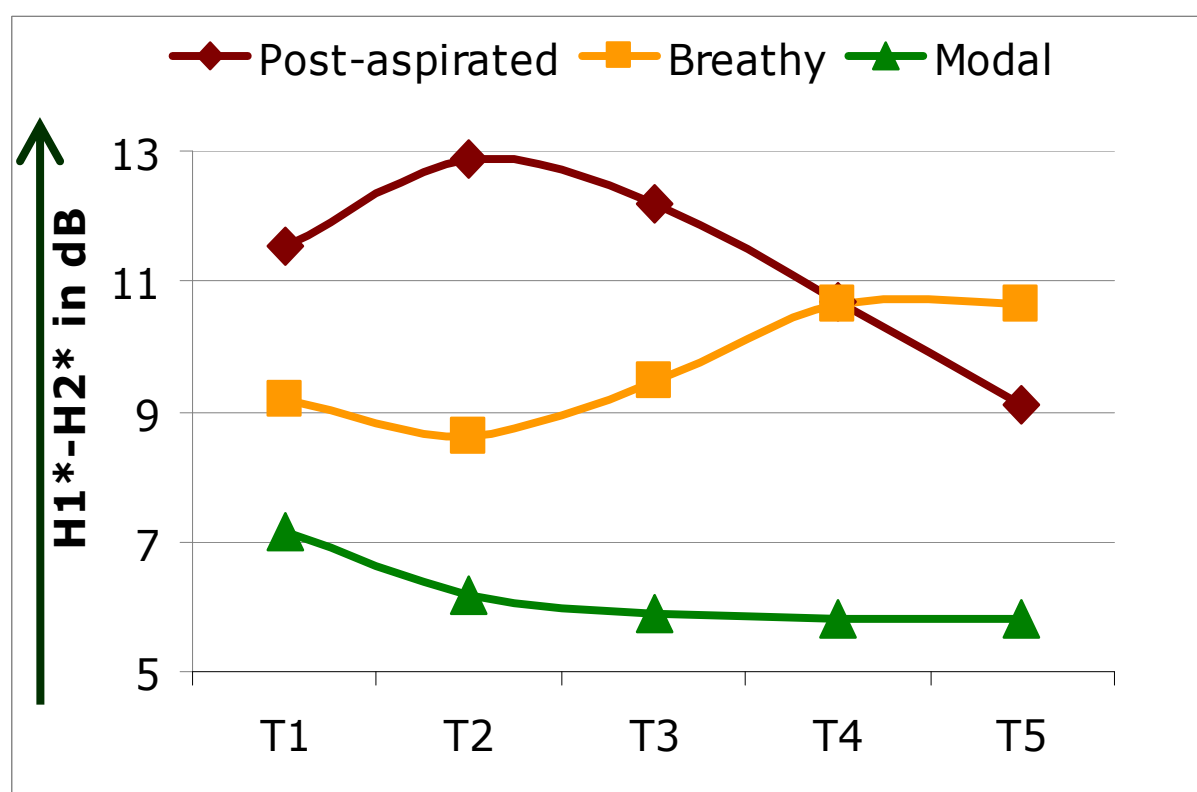
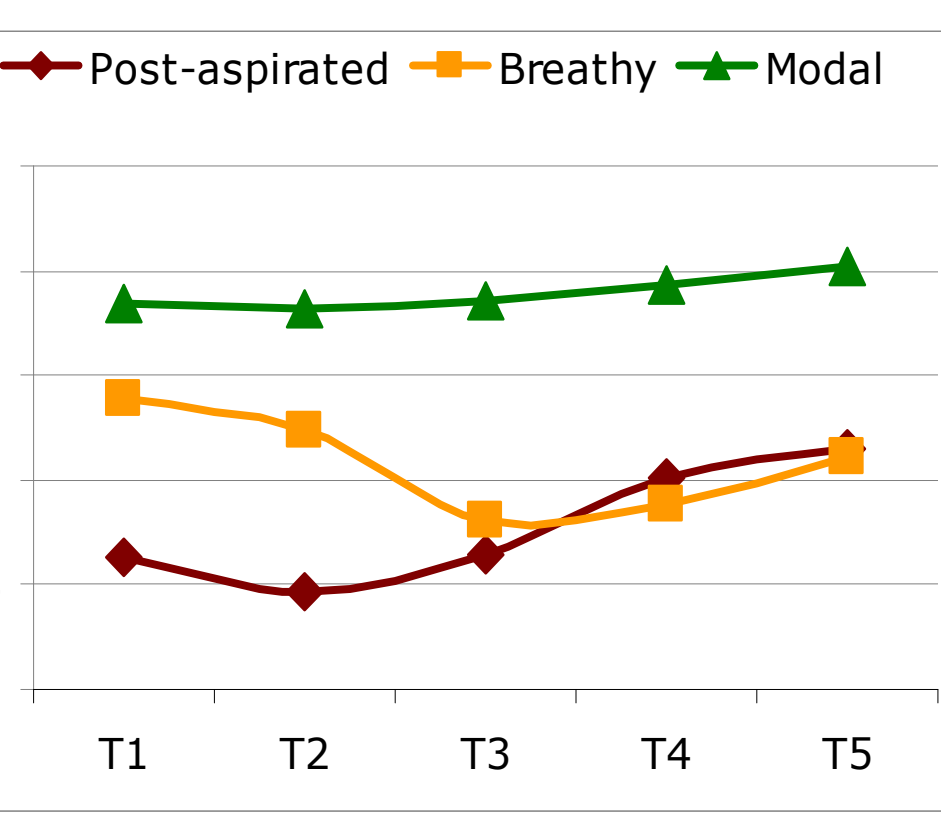
Measures that distinguish Gujarati post-aspirated Vs from					
	T1	T2	T3	T4	T5
<b>Breathy Vs</b>	<i>H1*-H2*</i>	<b>CPP</b> <b>H1*-H2*</b> <b>H1*-A3*</b> <i>CQ</i>	<b>CPP</b> <b>H1*-H2*</b> <b>H1*-A3*</b>		
<b>Modal Vs</b>	<i>CPP</i> <b>H1*-H2*</b> <b>H1*-A3*</b> <b>CQ</b> <i>DECPA</i>	<b>CPP</b> <b>H1*-H2*</b> <b>H1*-A3*</b> <b>CQ</b>	<b>CPP</b> <b>H1*-H2*</b> <b>H1*-A3*</b> <b>CQ</b>	<b>CPP</b> <b>H1*-H2*</b> <b>H1*-A3*</b> <b>CQ</b>	<b>CPP</b> <b>H1*-H2*</b> <b>H1*-A3*</b> <b>CQ</b>

Boldfaced measures distinguished phonation types with p≤0.001. Italicized measures distinguished phonation types with 0.001<p<0.01



Compare spectrograms of a Gujarati minimal triplet

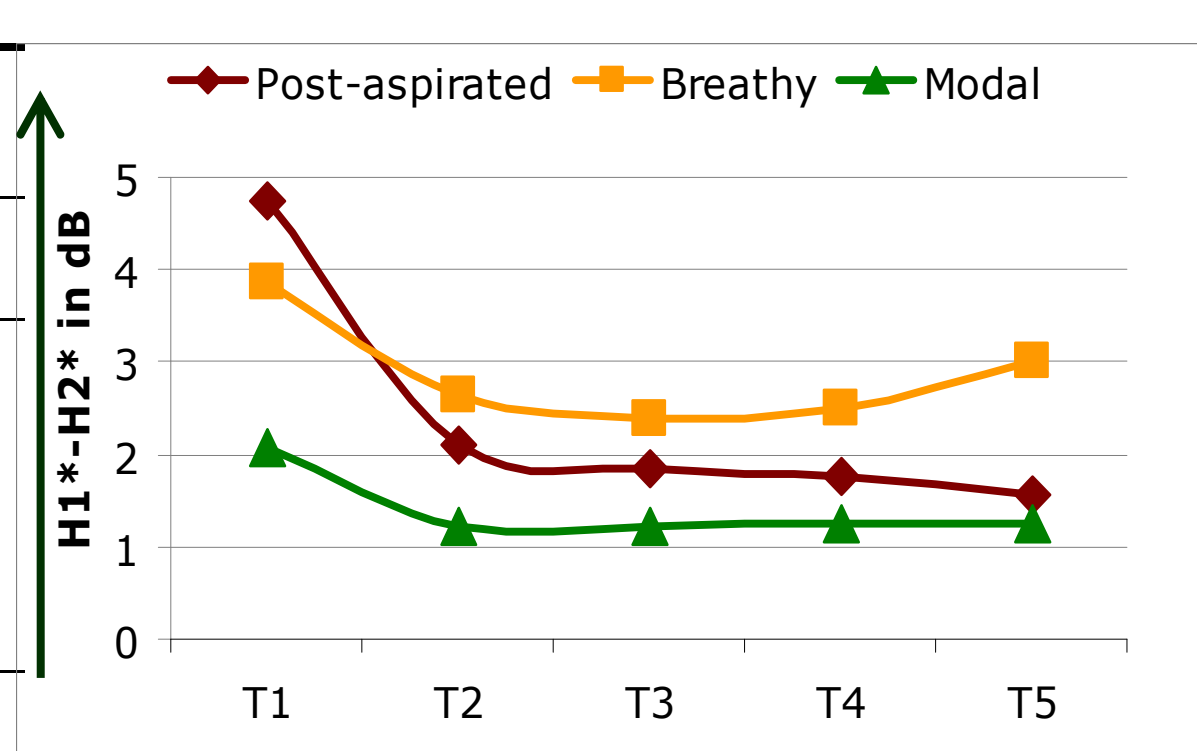
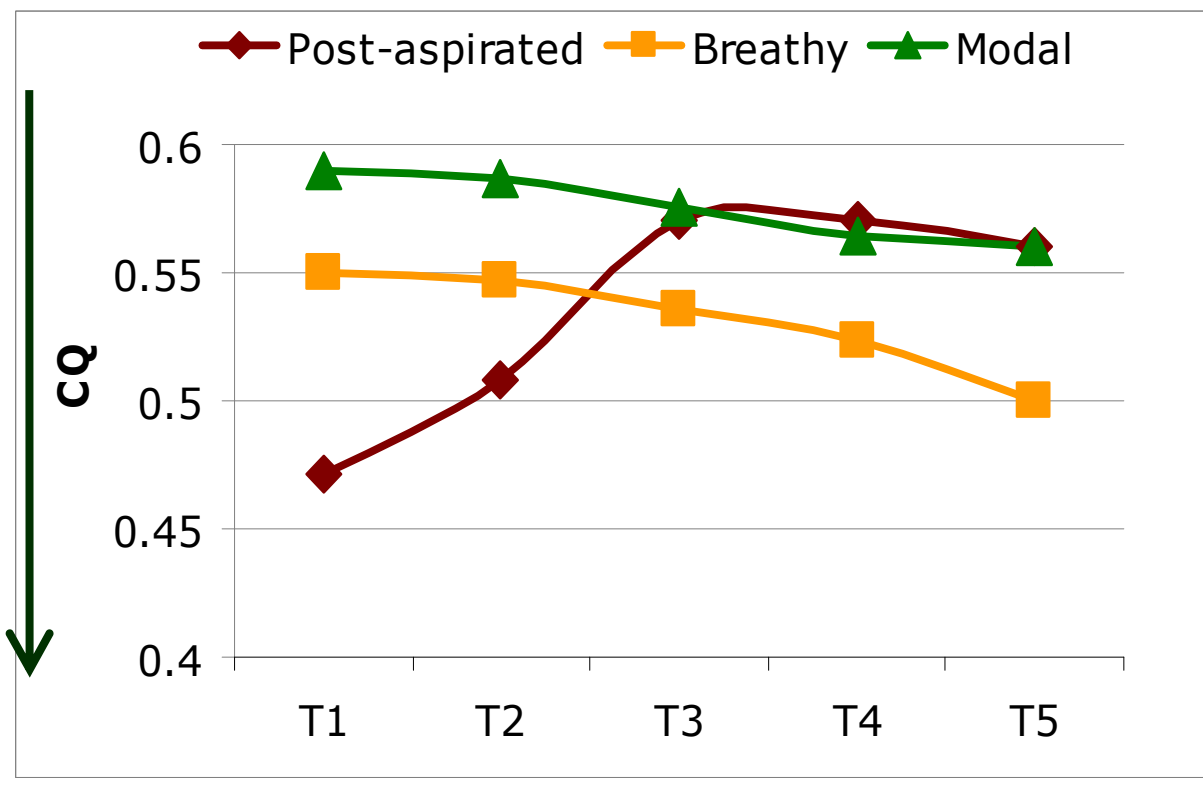
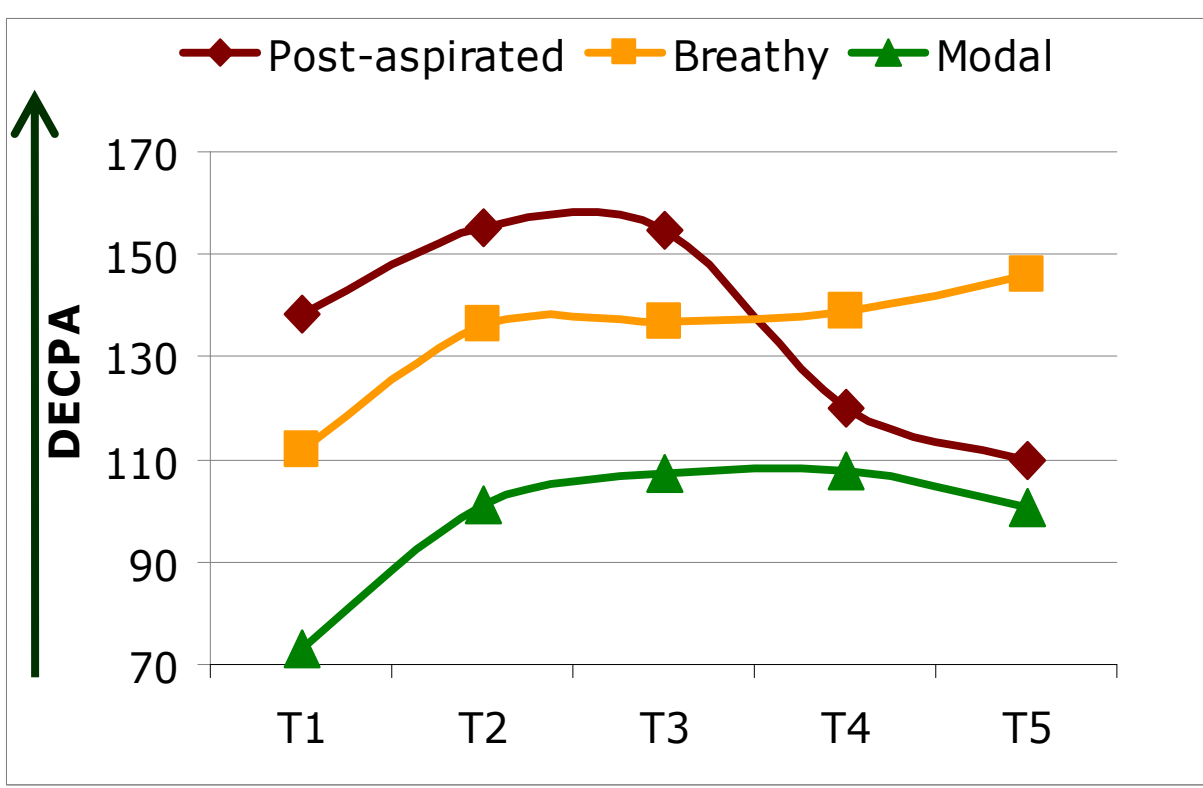
Graphs of average CQ, CPP, H1\*-A3\*, and H1\*-H2\* values for post-aspirated Vs, breathy Vs, and modal Vs in Gujarati across five timepoints. The arrow points in the direction of increased breathiness.



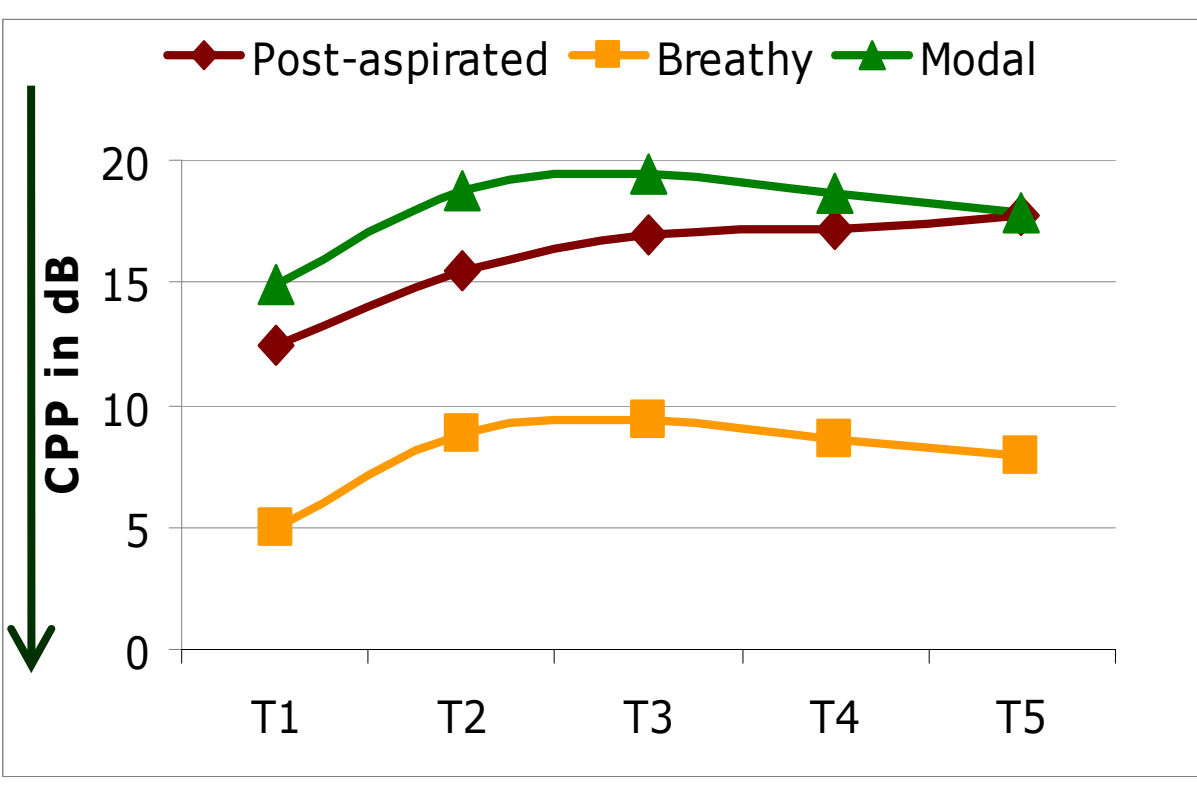
### Results: White Hmong

Measures that distinguish White Hmong post-aspirated Vs from					
	T1	T2	T3	T4	T5
<b>Breathy Vs</b>	<b>CPP</b> <b>H1*-H2*</b> <b>CQ</b> <b>DECPA</b>	<b>CPP</b> <b>CQ</b> <b>DECPA</b>	<b>CPP</b> <b>CQ</b> <b>DECPA</b>	<b>CPP</b> <b>CQ</b> <b>DECPA</b>	<b>CPP</b> <b>H1*-H2*</b> <b>CQ</b> <b>DECPA</b>
<b>Modal Vs</b>	<b>H1*-H2*</b> <b>CQ</b> <b>DECPA</b>	<b>H1*-H2*</b> <b>CQ</b> <b>DECPA</b>	<b>DECPA</b>		

All measures distinguish phonation types with p ≤ 0.001.



Graphs of the average CQ, DECPA, CPP, and H1\*-H2\* values for post-aspirated Vs, breathy Vs, and modal Vs in White Hmong across five timepoints. The arrows point in the direction of increased breathiness.



### Cross-language comparison

Qualities shared by both languages

**Are C and V breathiness the “same”?**

- Yes, in that both consonantal and vocalic breathiness are characterized by:
  - **More open glottis** (high H1\*-H2\*, low CQ)
  - **Less periodicity** (low CPP)

•However, we find **two important differences**:

#### 1. Localization of breathiness

•Brief, early realization of breathiness reflects association to C, not V.

#### 2. Magnitude of breathiness

•Greater magnitude of breathiness reflects association to C, not V.

- Amplification may be hard to sustain.
- Amplification may counteract short duration.

#### Language-specific qualities

**Post-asp.: more modal or breathy?**

•Post-asp. Vs are indistinguishable on more measures and timepoints from:

- **Breathy Vs in Gujarati**
- **Modal Vs in White Hmong**

#### Measuring vocal fold speed

•Both DECPA (EGG) and H1\*-A3\* (acoustic) are proposed as measures of **vocal fold speed**

- However, of these two...
  - **Only DECPA** distinguishes WH [C<sup>fi</sup>V] & [CV]
  - **Only H1\*-A3\*** does so in Gujarati

### Conclusions

**Gujarati and White Hmong are among the few lgs. with both breathy Cs and breathy Vs**

- Even closely-related lgs. do not have both

Acoustic & EGG measures show that in both lgs., **[C<sup>fi</sup>V] & [CV] are very similar**, except...

•**[C<sup>fi</sup>V] involves:**

- **Greater magnitude of breathiness**
- **Localized at the V's onset**, while

•**[CV] involves:**

- **Subtler realization of breathiness**
- **Spread across the 1st half of V**

•Future perception studies can determine if these differences are reliably used by speakers

### Acknowledgments and references

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