

Contrastive breathiness across consonants and vowels

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A comparative study of Gujarati and White Hmong

Christina M. Esposito (Macalester College) & Sameer ud Dowla Khan (Brown University)

esposito@macalester.edu, sameeruddowlakhan@gmail.com, Poster 5aSC17



Background

Many languages exhibit a **modal vs. breathy phonation contrast**, restricted to either:
• Consonants, e.g. Indic lgs. (O83, D89, Y84)
• Vowels, e.g. Zapotec lgs. (E10a, M&L99, J&K77).

Very few languages contrast modal and breathy voicing on consonants and vowels.
• Khoisan lgs. (T85), Hmong, and Gujarati

While the phonetics of the breathy vs. modal contrast in Vs has been studied, **acoustic and articulatory studies of the breathy V vs. breathy C contrast are few.**

Research questions

Is breathiness the "same" regardless of its segmental association (C or V)?

Breathy Cs & breathy Vs claimed to be phonetically **similar** by some (L&M96, D89), and **distinct** by others (L81, E&H05, F&G08).

Since oral stop C breathiness is realized in the release into a following V, **are breathy Vs distinguished from Vs following breathy Cs?**

Two hypotheses will be explored

1. Timing of breathiness

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

2. Degree of breathiness

Post-aspirated Vs will show a different degree 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

• Indo-European; west-central India
• **4-way voi & asp contrast**, e.g. /tʰ d dʰ/
• **4 breathy Vs**: /ɛ ʌ ə ɔ/ (some spkrs have >4)

• **Breathy Vs distinguished from modal Vs** by:
• H1-H2 (F-J67, B82, K&a10, K10)
• H1-A1, H1-A2, H1-A3 (F-J67, K&a10, K10)
• Closing quotient, CQ (K&a10, K10)

• **No acoustic/EGG study of breathy-asp Cs.**

White Hmong

• Hmong-Mien; Laos and NE Thailand
• **4-way voi & asp contrast** in alvs: /tʰ d dʰ/
• 7 tones, including **falling breathy tone (42)**
• Restriction: **breathy Cs cannot be followed by breathy Vs** (V with breathy tone 42)

• **Breathy Vs distinguished from modal Vs** by:
• H1-H2 (H87, A&R00, E10b, K&a10)
• CQ (E10b, K&a10)
• Deriv-EGG closure peak amplitude or DECPA (E10b), AKA peak increase in contact (K&a10)

• F&G08 compared breathy Vs, modal Vs, and Vs following breathy-asp Cs in 2 speakers of WH.
• At C release, H1-H2, H1-H3, and harmonicity distinguished all three.

• During closure phase, only H1-H2 distinguished modal Vs from breathy Vs.
• Suggests that breathy Vs are distinct from Vs following breathy Cs.

Methods

Speakers

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

Wordlists

• (Near)-minimal sets of:
• **Breathy Vs**: phonemically breathy V (Cʰ)
• **Post-aspirated Vs**: phonemically modal V following breathy-voiced aspirated C (CʰV)
• **Modal Vs**: modal V following modal C (CV)

Gujarati			White Hmong		
Breathy V	Breathy-asp. C	Modal	Breathy V	Breathy-asp. C	Modal
bar	bʰar	bar	dɔ 42	dʰa 22	da 52
'outside'	'burden'	'twelve'	'lie, fool'	'separate'	'yellow'
bɔnɔ	bʰan	baŋ	ɔj 42	dʰɔ 22 dʰa 22	
'excuse'	'consciousness'	'arrow'	'yoke; dig with a stick'	'the bubbling sound of boiling food'	
dɔlɔ	dʰɔlɔ	dɔlɔ	dɔ 42 dɔ 42	dʰs 22	da 22
'polluted'	'to spill'	'evening'	'average'	'fits together'	'union'

Recording

• Audio & EGG signals recorded simultaneously in:
• Semi-naturalistic speech for Gujarati
• Fixed carrier sentences for White Hmong

Measurements

Acoustic

• Measured by VoiceSauce (S&a09)
• **H1*-H2*** (*=corrected for effects of f₀ms)
• **H1*-A3***
• **CPP**: cepstral peak prominence
• **Electroglottographic (EGG)**
• Measured by EggWorks (T09)
• **CQ**: closing quotient (hybrid, 25% threshold)
• **DECPA**: Deriv-EGG closure peak amplitude
• Values averaged in every 1/9 of the target V duration: "timepoints" (T).
• Only T1-T5 (beg. & middle of V) were examined.

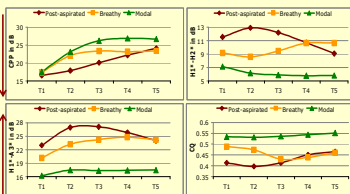
Statistics

• ANOVAs and post-hoc pair-wise comparisons were used to determine if there was a significant (p<.001) difference between phonation types.

Results: Gujarati

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

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



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

Summary of statistically-significant results

CPP

• At T2, post-aspirated Vs have lower CPP than breathy and modal Vs, which are not distinguished.
• At T3, all three phonation types are distinguished; modal > breathy > post-aspirated.
• At T4, modal Vs have higher CPP than breathy and post-aspirated Vs, which are not distinguished.

Results: Gujarati (cont.)

H1*-H2*

• At T2&T3, all three phonation types are distinguished; post-aspirated > breathy > modal.
• At T4, modal Vs have lower H1*-H2* than breathy and post-aspirated Vs, which are not distinguished.

H1*-A3*

• Post-aspirated Vs higher than breathy Vs in T2-T3.
• Both are higher than modal Vs in T3-T5.

CQ

• Post-aspirated Vs start out with lower CQ than both breathy and modal Vs through T2.
• By T3, post-aspirated and breathy Vs are not distinguished; both have lower CQ than modal Vs.

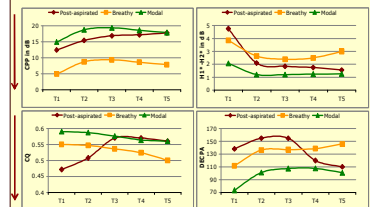
DECPA

• Post-aspirated Vs higher than modal Vs at T1.

Results: White Hmong

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

All measures distinguish phonation types with p<0.001.



Graphs of the average CPP, H1*-H2*, CQ, and DECPA 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.

Summary of statistically-significant results

CPP

• Post-aspirated and modal Vs not distinguishable.
• Both have higher CPP than breathy Vs throughout.

H1*-H2*

• Post-aspirated Vs start out with higher H1*-H2* than breathy Vs at T1.
• Post-aspirated V H1*-H2* then lowers; not distinguishable from breathy Vs across T2-T4.
• Post-aspirated V H1*-H2* further lowers by T3; not distinguishable from modal Vs.
• Post-aspirated Vs decrease in H1*-H2* while breathy Vs increase until they are significantly different at T5.

H1*-A3*

• Does not distinguish WH phonations (cf. F&G08).

CQ

• Post-aspirated Vs start out with lower CQ than breathy Vs through T2.
• Post-aspirated Vs then sharply increase in CQ; from T3 onwards, they are higher than breathy Vs and no longer distinguishable from modal Vs.

DECPA

• Post-aspirated Vs have higher DECPA than breathy and modal Vs through T3.
• Post-aspirated Vs then lower in DECPA; lower than breathy Vs and no longer distinguishable from modal Vs from T4 onwards.

Cross-language comparison

Qualities shared by both languages

1. Timing of breathiness

• **Brief, early realization of breathiness reflects association to C, not V.**
• Post-aspirated Vs generally begin very breathy, but become more modal at the V midpoint.

2. Degree of breathiness

• **Greater degree of breathiness reflects association to C, not V.**
• Post-aspirated Vs begin even breathier than breathy Vs in various measures.

Language-specific qualities

• **Post-aspirated: more modal or more breathy?**

• **Post-aspirated Vs are indistinguishable** on more measures and timepoints from:

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

Dynamic breathy Vs

• While post-aspirated Vs are dynamic in both lgs., **breathy Vs are dynamic only in Gujarati.**
• **Breathy Vs in Gujarati start out more modal**, but become breathier by T5.
• **Breathy Vs in White Hmong are more uniformly breathy.**

Speed of vocal fold closure

• Both DECPA and H1*-A3* are described in the literature as measures of vocal fold closure speed.
• **Gujarati H1*-A3* but not DECPA** distinguishes breathy & post-aspirated from modal.
• **White Hmong DECPA but not H1*-A3*** distinguishes breathy & post-aspirated from modal.

Further questions: Perception

If presented with breathiness in a CV sequence, **can listeners rely on either timing or degree alone** to determine the association of breathiness?

...or **do tone or duration help cue association?**

- White Hmong breathy Vs have a falling tone
- Gujarati breathy Vs often produced as disyllable
- Neither is true of post-aspirated Vs

...or **do post-aspirated Vs exhibit phonetic properties independent of breathy Vs?**

Acknowledgments and references

This study is part of a collaborative NSF-supported project entitled "Production and perception of Linguistic Voice Quality" (Keating, et al., beg. 2007), exploring aspects of phonation in various languages.

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