Using H1 instead of H1–H2 as an acoustic correlate of glottal constriction

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INTRODUCTION

- H1–H2 is one of the most frequently used acoustic measures in studies of voice quality or phonation type.
- Fischer-Jørgensen (1967) and Bickley (1982) proposed H1–H2 as **a way to measure H1** (amplitude of the first harmonic) while controlling for overall sound pressure level (SPL).
- Relative to other frequencies (including H2), the amplitude of H1 is lower when the vocal folds are more constricted; higher when there is less constriction.
  - But choice of H2 as normalizing amplitude is arbitrary; other studies rely on other landmarks (like A1, the amplitude of F1); cf. Fischer-Jørgensen (1967).
  - The relationship between H1–H2 and glottal Open Quotient (OQ) has been shown in numerous studies (Kreiman et al. 2012, Samlan et al. 2013).
- But there are several issues with measuring H1–H2 (see below), which can influence acoustic analyses of voice quality.

SOME ISSUES WITH H1–H2

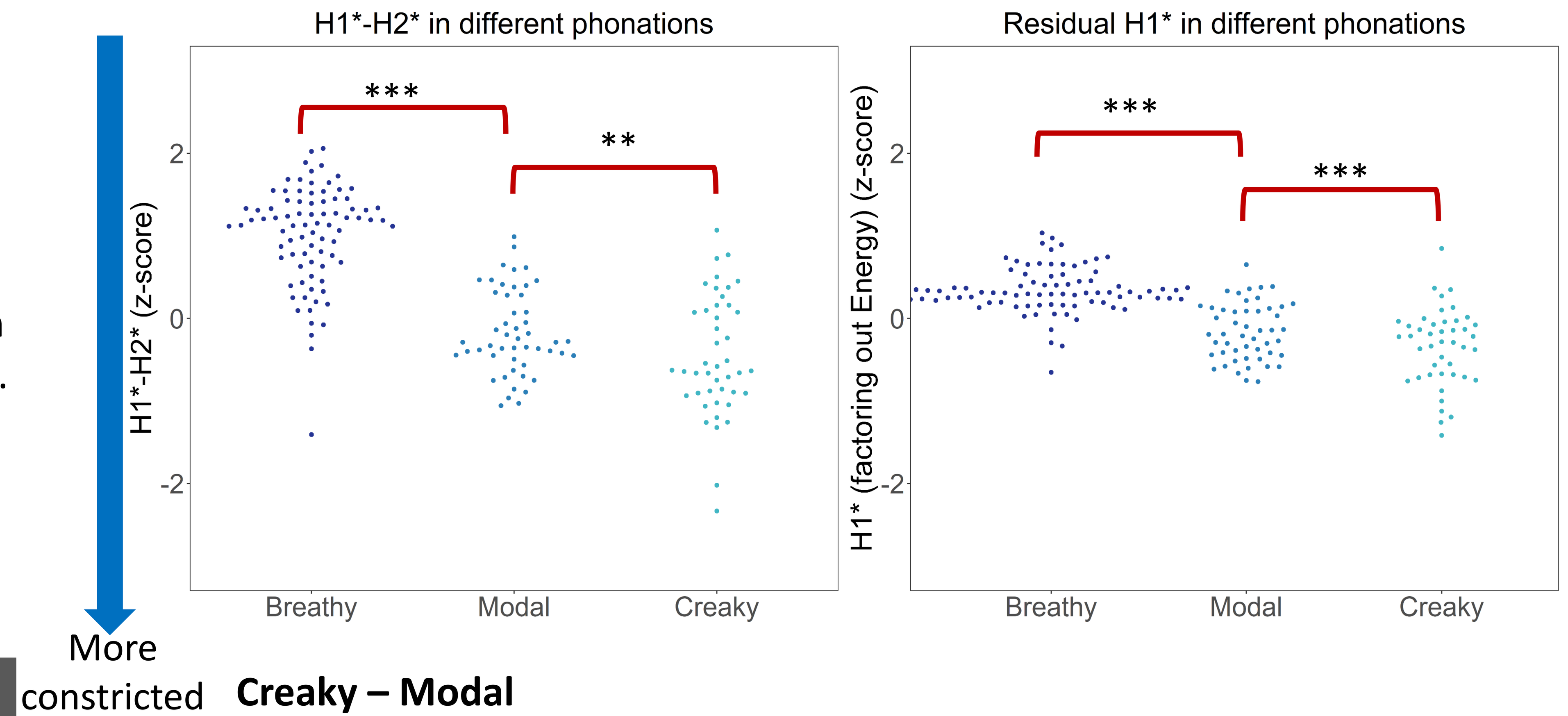
- H1–H2 might be a better index of vocal fold thickness than glottal area or OQ (Zhang 2016).
- When OQ is high, glottal skew can affect H2 but not H1 (Gobl & Ní Chasaide 2019).
- First nasal pole variably affects H1 or H2, depending on the f0 (Simpson 2012).
- H1–H2 requires correct estimation of two harmonics, which can be challenging when the f0 is irregular (as in creaky voice).
- H1–H2 can lead to more error propagation than H1.

CURRENT PROPOSAL: USING H1

- Here we compare H1 to H1–H2, and control for differences in SPL using root mean-squared (RMS) energy when analyzing H1.
  - We do this using H1* and H1*–H2*, which are corrected for formant frequencies and bandwidths.
- **How to control for the RMS of H1:**
  - Using H1* as a dependent variable: **H1*** ~ main factor(s) + **Energy**
  - Using H1* as an independent variable
    - **Step one** Get the coefficient of energy b1: **H1*** ~ b_0 + $\mathbf{b_1}$***energy**
    - **Step two** Calculate Residual H1*: **Residual H1* = H1* - $\mathbf{b_1}$ * energy**
    - **Residual H1*** represents the value of H1* after correcting for formant and bandwidths and **factoring out the effect of energy.**

PHONATION TYPES IN !XÓÕ (TAA)

Breathy-Modal-Creaky contrasts on /a/ vowels (Garellek, to appear; 10 speakers)
Data from UCLA Phonetics Lab Archive



Creaky – Modal

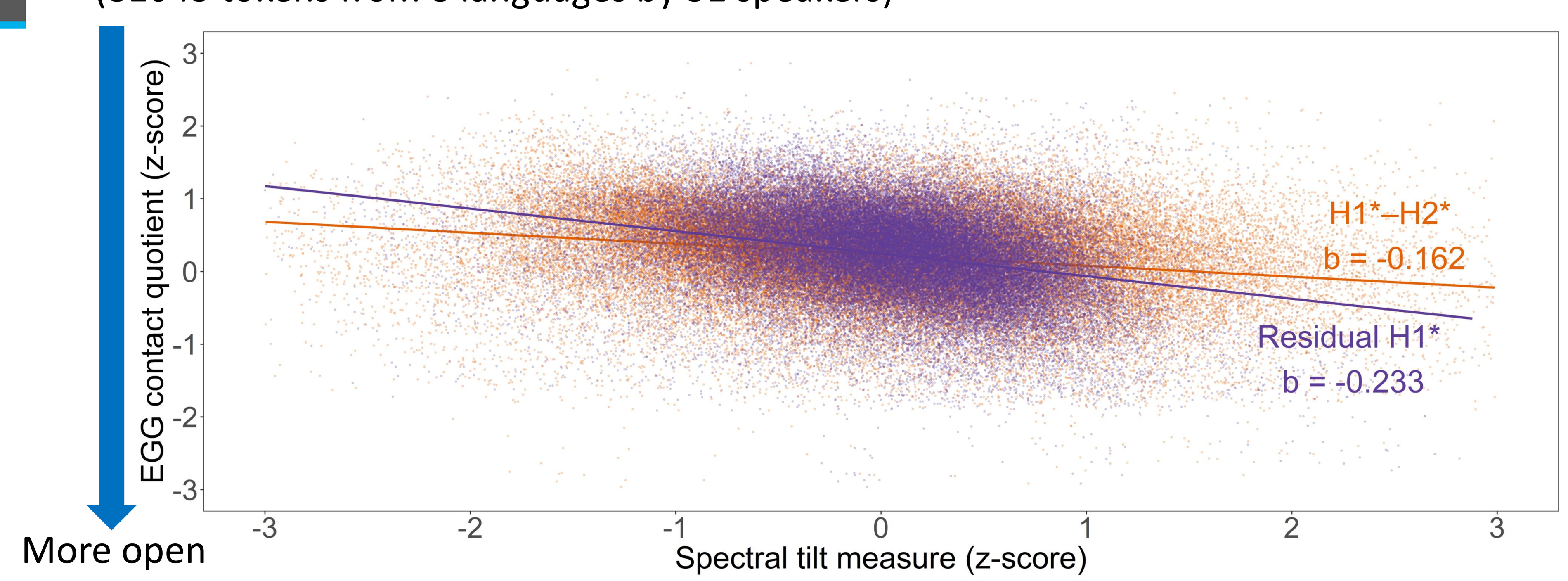
Model	β	Std. Error	t value
H1*–H2* ~ Phonation	-0.334	0.110	-3.045 **
H1* ~ Phonation + Energy	-0.391	0.058	-6.786 ***

Breathy – Modal

Model	β	Std. Error	t value
H1*–H2* ~ Phonation	1.193	0.105	11.339 ***
H1* ~ Phonation + Energy	0.512	0.053	9.596 ***

RELATIONSHIP TO GLOTTAL OPEN QUOTIENT

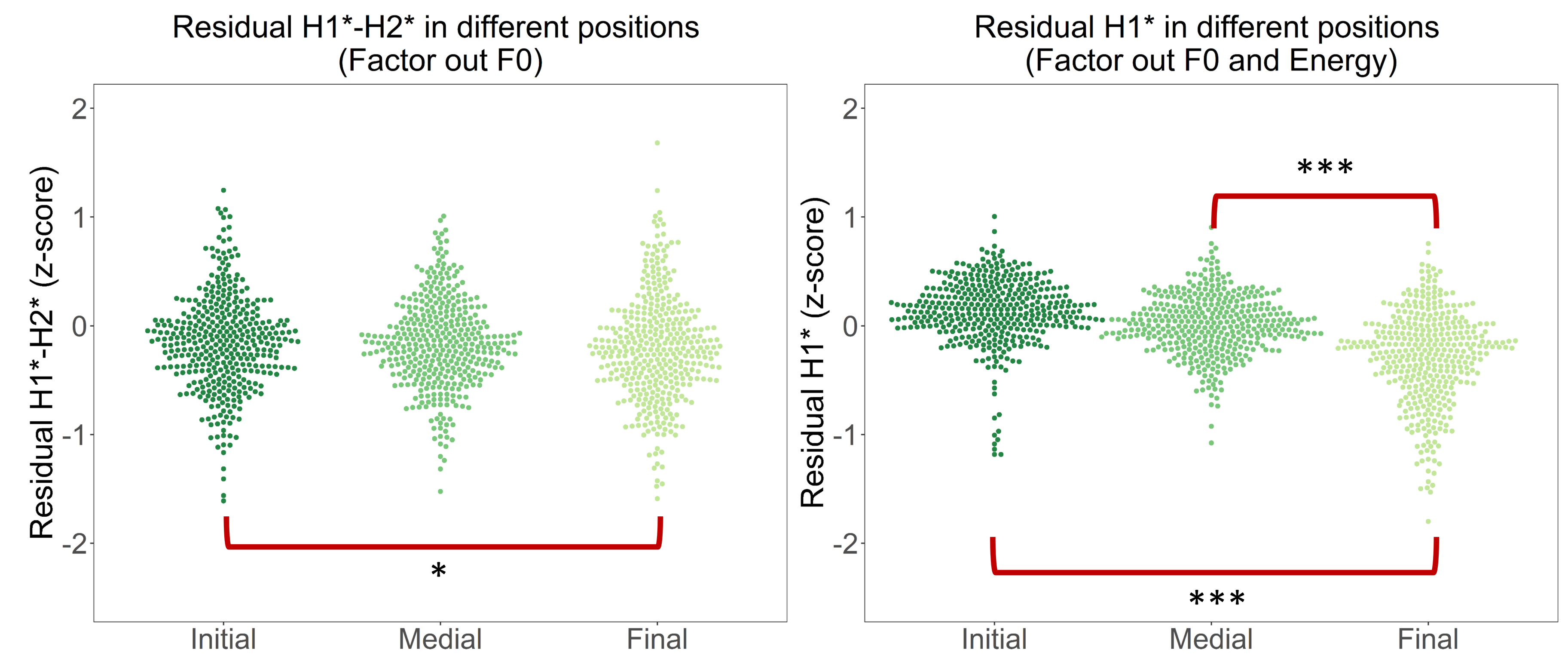
H1*–H2* and H1* both correlate with OQ (measured using EGG contact quotient)
Data from "Production and Perception of Linguistic Voice Quality" project at UCLA
(81043 tokens from 8 languages by 31 speakers)



Model	β	Std. Error	t value
Contact Quotient ~ **H1*–H2***	-0.162	0.003	-53.40 ***
Contact Quotient ~ **Residual H1***	-0.233	0.005	-51.57 ***

PHRASING IN MANDARIN

In Mandarin declaratives, tendency for voice quality to become creakier over the course of the phrase, as indicated by voice quality measures such as HNR and results from creak voice detector (Chai, 2019; 32 speakers)



Initial – Final

Model	β	Std. Error	t value
H1*–H2* ~ Position + F0	0.119	0.057	2.067 *
H1* ~ Position + Energy + F0	0.489	0.059	8.287 ***

Medial – Final

Model	β	Std. Error	t value
H1*–H2* ~ Position + F0	0.076	0.049	1.557
H1* ~ Position + Energy + F0	0.331	0.038	8.668 ***

CONCLUSIONS

- H1* distinguishes **phonations types** in !Xóõ better than H1*–H2*.
- H1* shows **voice quality changes in different phrasal positions** in Mandarin better than H1*–H2*.
- H1* has a **similar correlation with OQ** as H1*–H2*.
- H1* has **less variance** than H1*–H2*.
- **Especially for creaky voice**, researchers should also consider looking at H1*, factoring out the effect of sound pressure level.

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