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 (Gobi & Ni Chaisaide 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* ~ b1 + b2* + energy
    - Step two Calculate Residual H1*: Residual H1* = H1* - b1* + energy
  - Residual H1* represents the value of H1* after correcting for formant and bandwidths and factoring out the effect of energy.

PHONATION TYPES IN IXÓÓ (TAA)

Breath-Modal-Creaky contrasts on /a/ vowels (Garellek, to appear; 10 speakers)

Data from UCLA Phonetics Lab Archive

<table>
<thead>
<tr>
<th>H1*–H2* in different phonations</th>
<th>Residual H1* in different phonations</th>
</tr>
</thead>
<tbody>
<tr>
<td>Breath</td>
<td>Modal</td>
</tr>
</tbody>
</table>

Model: $\beta$ Std. Error $t$ value

<table>
<thead>
<tr>
<th>Model</th>
<th>$\beta$</th>
<th>Std. Error</th>
<th>$t$ value</th>
</tr>
</thead>
<tbody>
<tr>
<td>H1*–H2* ~ Phonation</td>
<td>-0.344</td>
<td>0.110</td>
<td>-3.045 **</td>
</tr>
<tr>
<td>H1* ~ Phonation + Energy</td>
<td>-0.391</td>
<td>0.058</td>
<td>-6.786 ***</td>
</tr>
</tbody>
</table>

RELATIONSHIP TO GLOTTAL 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 (B1043 tokens from 8 languages by 31 speakers)

<table>
<thead>
<tr>
<th>H1*–H2* and H1* correlate with OQ (measured using EGG contact quotient)</th>
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<tbody>
<tr>
<td>Model</td>
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<tr>
<td>-------</td>
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<tr>
<td>Initial</td>
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<tr>
<td>Final</td>
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CONCLUSIONS

- H1* distinguishes phonations types in IXóó 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.

REFERENCES

Simpson, A. P. (2012). The first and second harmonics should not be used to measure breathiness in male and female voices. JASA, 132, 477–490.