On residual H1* as a measure of voice quality

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Introduction: Voice quality (VQ) has many uses across the world's languages. Some languages use it for paralinguistic purposes [1,2], whereas others use VQ distinctions for phonological contrasts (see [3] for an overview). It has long been established that these VQ distinctions have correlates in the acoustic signal, with the most influential being the difference in amplitude between H1 and H2 [4].

[5] have recently shown that H1-H2 and the other spectral-tilt measures are less robust than was previously thought. Instead, they propose using the Residual H1 measure, which factors out the root mean squared energy from H1. They show that this new measure better captures the VQ distinctions in !Xóõ and Mandarin than H1-H2.

This paper tests the validity of this new measure in distinguishing the four-way VQ contrast in Santiago Laxopa Zapotec. We show that this measure better captures the contrasts than the traditional spectral-tilt measures.

Santiago Laxopa Zapotec (SLZ): SLZ is an endangered indigenous language from the municipality of Santiago Laxopa, Ixtlán, Oaxaca, Mexico, and spoken by approximately 1000 speakers. This variety is unique for being a Northern Core Zapotec that has developed breathy voice (B; 1b) in addition to the two types of laryngealization that characterize the rest of the Zapotecan languages, namely checked (C; 1c) and rearticulated (R; 1d) (see [6] for a detailed typology of VQ in Zapotecan languages). This contrast can be seen in the near minimal quadruple in (1a-d).

(1) a. *ya* [ʝa˦] 'temazcal' b. *yah* [ʝa̤˧] 'iron' c. *cha'* [tʃaa̰˧] 'pot' d. *ya'a* [ʝaa̰a˧] 'market'

SLZ additionally has three tones and two contours independent of the VQ contrast. This results in an almost complete overlap between which tones can appear with which VQs. Additionally, it is well known that tone does interact with VQ [3].

Methodology: We collected word list elicitations from 10 native SLZ speakers (five female) in Santiago Laxopa, Oaxaca. This word list contained 76 words across the four VQ contrasts. Each word was said in isolation and a carrier sentence three times. The vowels from the carrier sentences were segmented following [7], and processed using VoiceSauce [8]. Three measures were assessed in this study: corrected H1*-H2*, Residual H1* as discussed in [5], as well as corrected H1*-A3, following previous work on this variety [9]. The resulting measurements were then assigned to their position in the vowel (1st, middle, 3rd). Three linear mixed effects regression models were fitted, one each for H1*-H2*, H1*-A3, and resid. H1*, with the interaction between VQ and Position and Tone as fixed effects and Vowel and the interaction between Speaker, repetition, and word as random intercepts.

Results: The following three plots show the three VQ measures across each of the three positions of the vowel. Fig. 1 shows H1*-H2* and that each of the non-modal VQs have lower values than M and they overlap in each of the three vowel positions. Fig. 2 shows that the only contrasts reliably captured by H1*-A3 are B, C, and M; R and M are nearly identical throughout the vowel. Fig. 3 shows that resid. H1* reliably separates B, C, and R from M, and also captures the positional distinction between R and C.

The linear mixed-effects models support the visualizations. The H1*-H2* model fails to find the crucial interactions between position and phonation type for C (β=-0.1402, SE=0.041, $p<0.001$), and R (β=-0.136, SE=0.05, $p = 0.006$), in contrast, the H1*-A3 and the resid. H1* models find all of these interactions. A likelihood ratio test was conducted and the AICs were compared following [10] to confirm the model strengths. The model with the highest log-likelihood ratio and smallest AIC was judged to be the most successful: H1*-H2* (LogLik=-21716, AIC=43469.29), H1*-A3 (LogLik=-19048, AIC=38134.12), and resid. H1* (LogLik=-16113, AIC=32264.81).

Conclusions: The results of this limited study on Santiago Laxopa Zapotec suggest that residual H1* is indeed a more reliable measure of the strength of the first harmonic for assessing phonation type in languages with complex phonation systems.

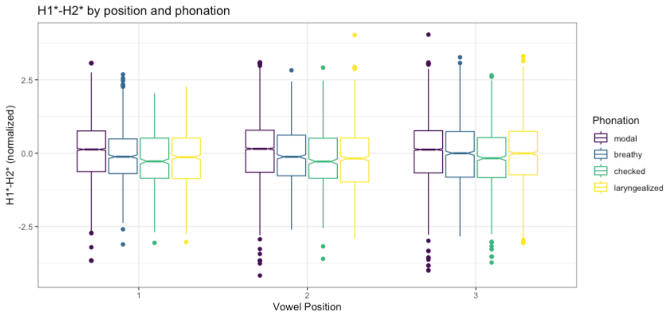

Fig. 1. The H1*-H2* scores for each VQ across all speakers for each of the three vowel positions.

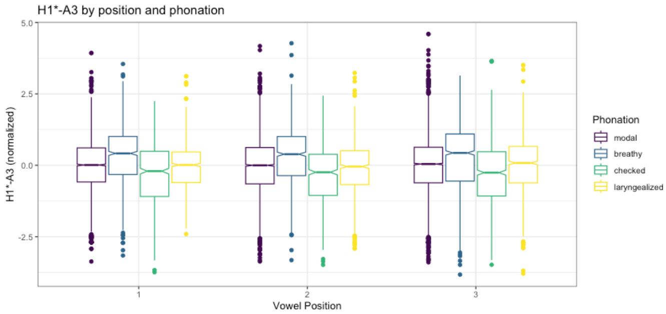

Fig. 2. The H1*-A3 scores for each VQ across all speakers for each of the three vowel positions.

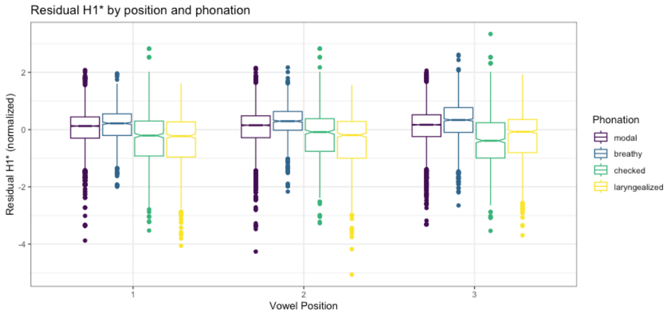

Fig. 3. The Residual H1* scores for each VQ across all speakers for each of the three vowel positions.

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