Perceptual cues of laryngeal contrasts in Trique

Christian T. DiCanio
dicanio@gmail.com

Laboratoire Dynamique du Langage
Université Lumière Lyon 2
http://linguistics.berkeley.edu/∼dicanio

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Focus

- What are the cues used in the perception of glottal consonants?
- To what degree are coarticulatory cues used in the perception of glottal consonants?

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Roadmap

1. Background - Phonation Type
2. Background - Itunyoso Trique
3. Laryngeal Category Labelling Experiment: Method & Stimuli Design
4. Laryngeal Category Labelling Experiment: Results
5. Discussion

Glottal Consonants & Non-Modal Phonation

- Substantial research on the production mechanisms and the acoustics of non-modal phonation (Kirk et al., 1984; Ladefoged et al., 1988; Gordon and Ladefoged, 2001; Blankenship, 2002; Wayland and Jongman, 2003; Pennington, 2005; Esposito, 2006; Keating and Esposito, 2006; Kreiman et al., 2007; DiCanio, 2009, 2008, among others).

- Until recently, little work on the perceptual status of different acoustic properties.

Perceptual Cues for Phonation Type

- **Spectral Slope**
  - H1-H2 (OQ measure) (Esposito, 2010; Kreiman et al., 2010)
  - Global spectral shape (H1-A3, A1-A3, etc.) (Esposito, 2006; Kreiman et al., 2010)
- **Noise-related**
  - Cepstral Peak Prominence (Kreiman et al., 2010)
- **Prosodic / Suprasegmental**
  - Intensity Contour (Hillenbrand and Houde, 1996; Gerfen and Baker, 2005)
  - Pitch (Hillenbrand and Houde, 1996; Gerfen and Baker, 2005)
  - Duration (Lyon, 2008)

Perceptual cues, cont.

Perceptual findings with respect to voice quality come from:

- Linear discriminant analyses on the discrimination performance of listeners evaluating natural stimuli (Esposito, 2010).
- Discrimination tasks where prosodic cues were manipulated using resynthesized natural speech (Hillenbrand and Houde, 1996; Gerfen and Baker, 2005).
- Discrimination tasks where spectral cues were manipulated using synthetic speech (Kreiman et al., 2010).

...But how important are these cues relative to each other?

Perceptual Cue Weight

- Listeners pay attention to certain cues more than others in speech perception (Broersma, 2005; Cho and McQueen, 2006; Escudero, 2005; Gottfried and Beddor, 1998; Harnsberger, 2001; McGuire, 2007).

- What cues are more important for listeners in their perception of glottal consonants?

Itunyoso Trique

- Itunyoso Trique is an Oto-Manguean language spoken in San Martín Itunyoso, Oaxaca, Mexico by approximately 1,606 people (DiCanio, 2010). One of three major Trique dialects (DiCanio, 2008).
- Original fieldwork by author since 2004.
- All syllables are open, with the exception of final syllables which may be closed by one of two laryngeal codas: / ʔ/ or /h/.
- Nine contrastive tones in final syllables but fewer tones contrast in non-final syllables (only level tones).

Laryngeal Contrasts

- Itunyoso Trique has a 3-way rime-type contrast: /V:/, /Vh/, /V?/.
- Coda /h/ is usually realized as vocalic breathiness spread across the latter half of the rime. Coda /?/ is realized with an abrupt glottal closure.
- Duration of modal vowel before laryngeal coda is shorter than duration of vowel without coda (DiCanio, 2008).

nne^3 '*plough*' nne?^{3} '*fiber rope*' nneh^3 '*toothless*'

A number of acoustic correlates distinguish these rime types in production (DiCanio, 2008).

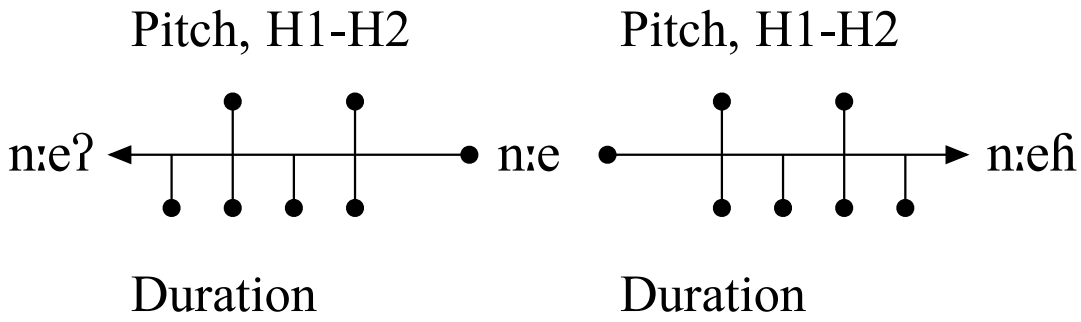
- Duration: /V:/ (160 ms) > /Vh/ (100 ms) > /V?/ (80 ms).
- Spectral tilt: H1-H2 and H1-A3 differences on preceding vowel. Higher H1-H2 and H1-A3 values occur across the duration of the breathy rime. Lower H1-A3 (but not H1-H2) values on vowel immediately preceding /?/.
- Pitch: significant effect of coda /h/ on pitch, causing slight lowering across the vowel. Very small and local effect of coda /?/ on preceding pitch target.

...but how important are these cues in perception?

Method - Multidimensional Scaling & Resynthesis

- AX identification task with 14 native speakers of Itunyoso Trique.
- Manipulated duration, H1-H2, and pitch on modal vowel word (nne^3 '*plough*') to match values on laryngealized rimes (nneh^3 '*toothless*' and nne?^{3} '*fiber rope*') with help of Praat and Matlab scripts.
- 3 sets of two dimensions: duration X pitch, duration X H1-H2, H1-H2 X Pitch.
- 2 laryngeal conditions were tested: /V:/ vs. /Vh/, /V:/ vs. /V?/.
- Total of 6 blocks (3 x 2).

- Manipulated duration using 6 steps, other cues using 4 steps. For the H1-H2 X Pitch condition, manipulated H1-H2 using 6 steps. Total of 24 stimuli, each repeated twice (48 trials).



- Targets spliced into original carrier sentence:
  <target> ka^{3}tah^{3} ri^{3}ə̃^{32}reʔ^{1}', **<target>** I told you!'.

- Listeners pressed right or left button on keyboard corresponding to visual target on screen.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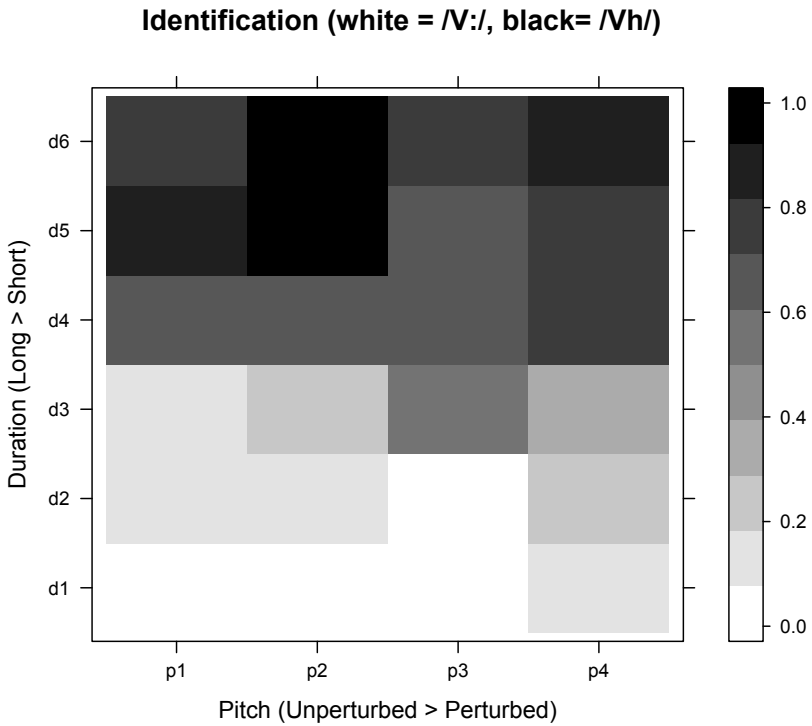
Results

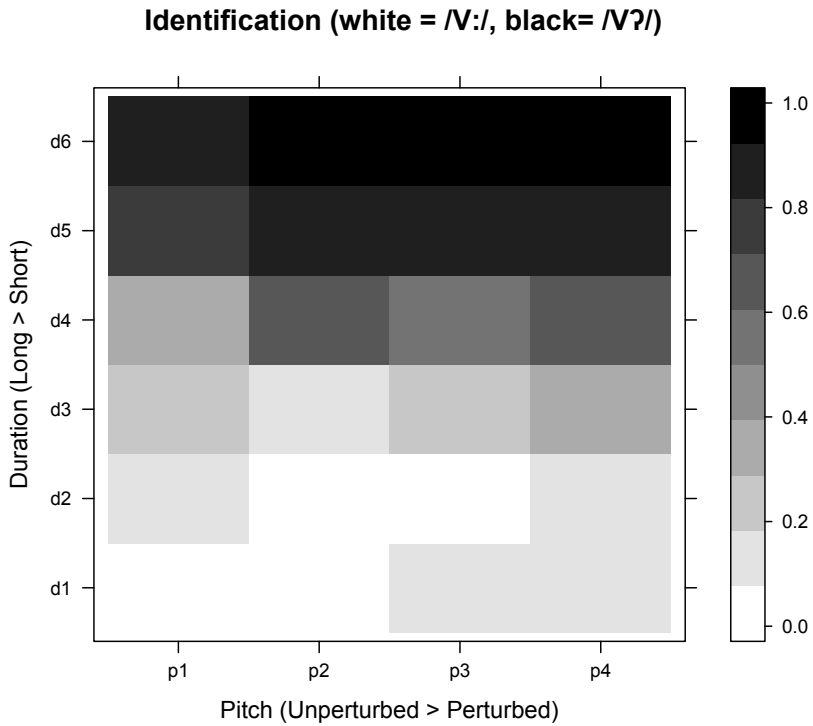
- Identification results analyzed with a linear mixed effects model with manipulated dimensions as fixed effects and subject as a random effect.

- Reaction Time results analyzed in a two-way repeated measures ANOVA with subject as an error term.

Results I: Duration and Pitch Manipulation

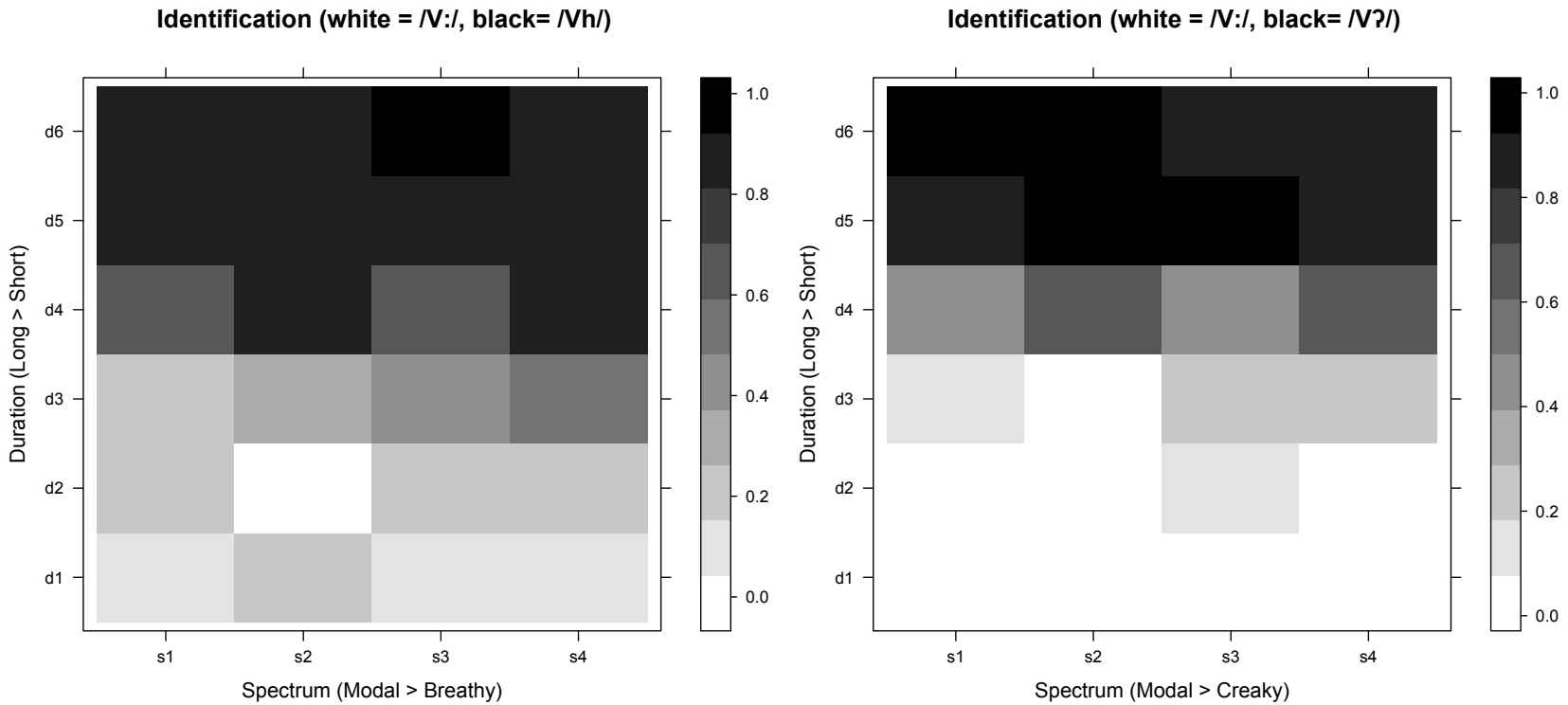
- For the /V:/ - /Vh/ condition, duration, but not pitch, is a significant cue.
- For the /V:/ - /V?/ condition, duration is significant and pitch is near significant.





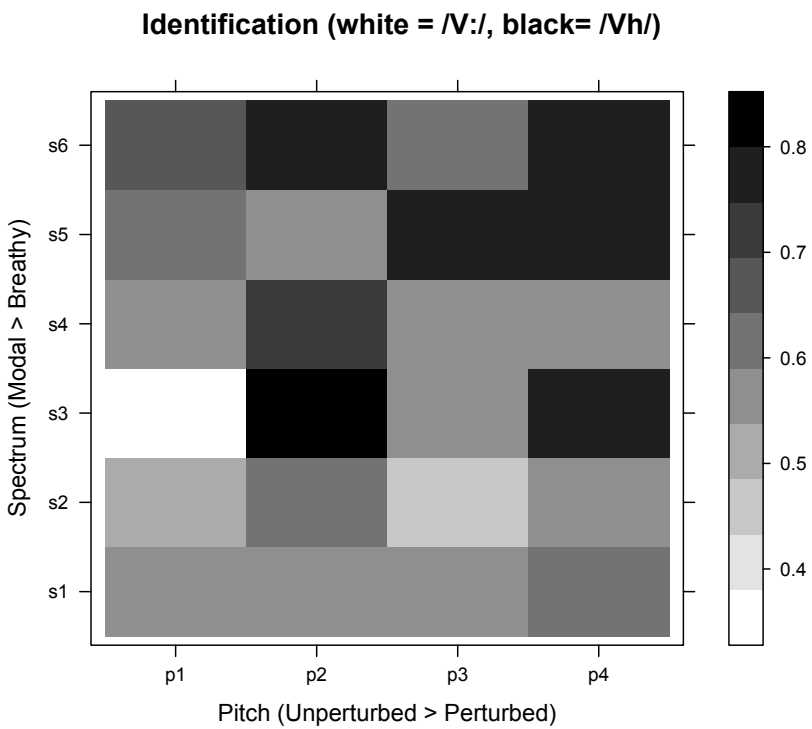
Results 2: Duration and H1-H2 Manipulation

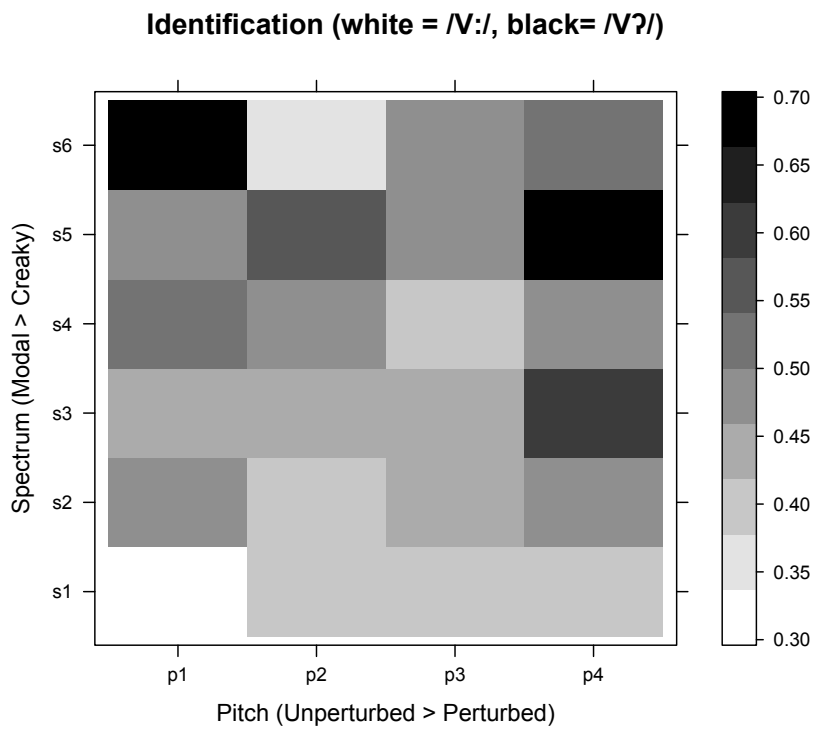
- For the /V:/ - /Vh/ condition, duration, but not H1-H2, is a significant cue. There was a significant interaction between duration and H1-H2.
- For the /V:/ - /Vʔ/ condition, duration is significant but not H1-H2.



Results 3: Pitch and H1-H2 Manipulation

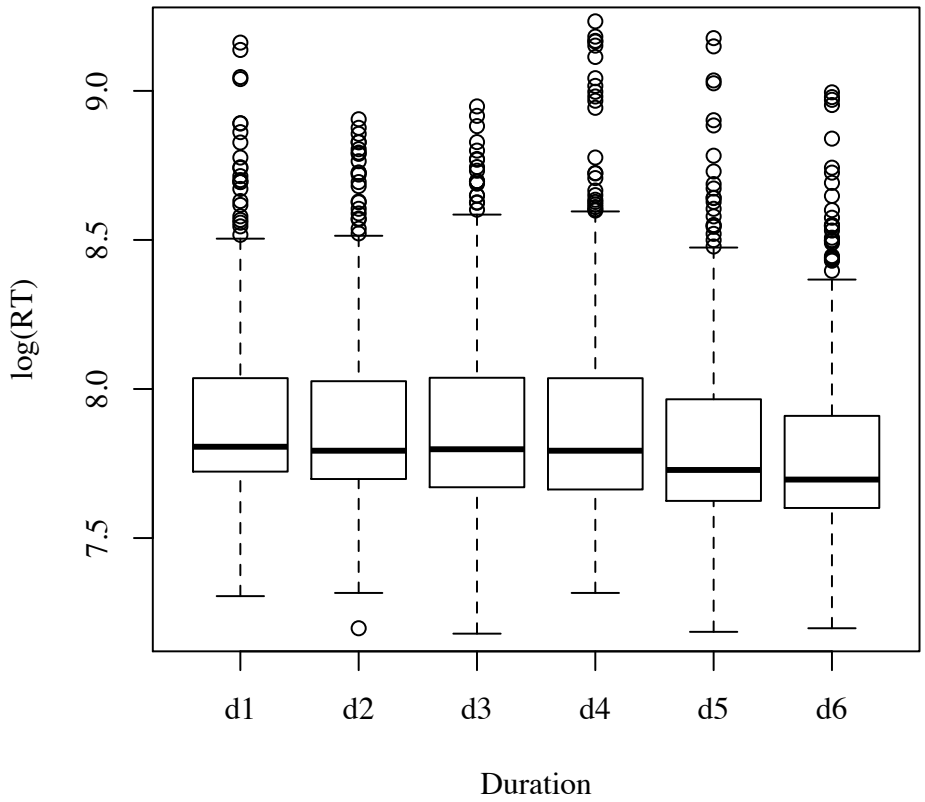
- For the /V:/ - /Vh/ condition, pitch, but not H1-H2, is a significant cue.
- For the /V:/ - /V?/ condition, no cues significantly identify contrast.





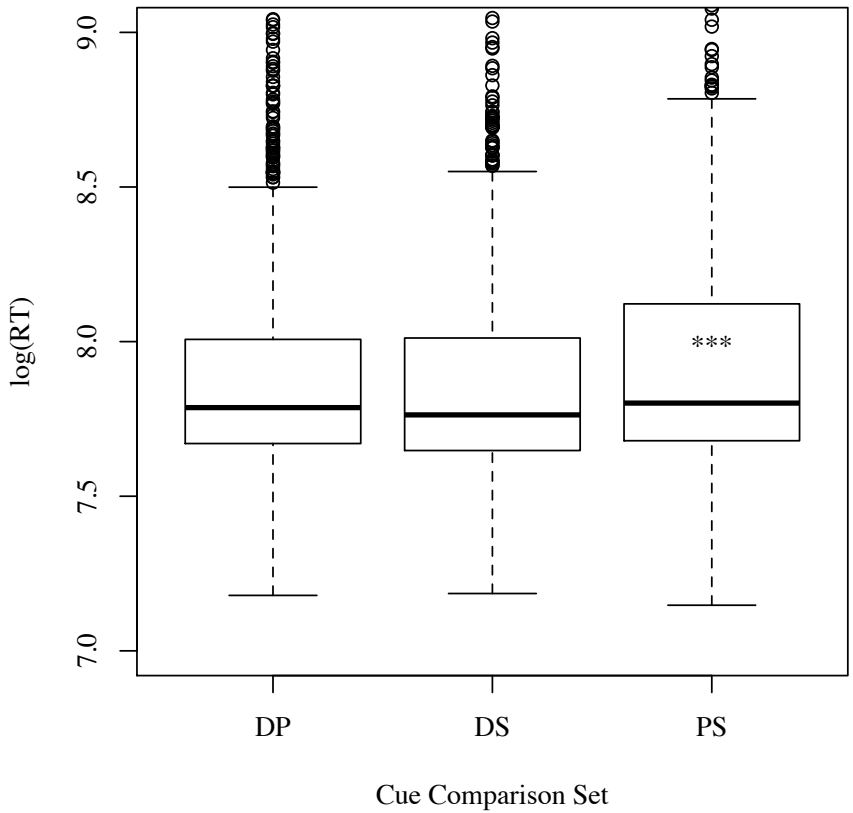
Results: Reaction Time

Significant effect of duration cue on log(RT). As the vowel duration got shorter, subjects responded more quickly identifying the stimulus as laryngealized (/Vh/ or /V?/).



Results: Reaction Time

- Significant effect of cue comparison set (**S**pectrum (H1-H2) x **P**itch, **D**uration x **P**itch, **D**uration x **S**pectrum (H1-H2)) on log(RT). When duration was neutralized, subjects took longer to identify stimuli.



Summary

- In all cases where duration is not neutralized, it is used as a strong cue for /Vh/ and /V?/ rimes. Shorter duration stimuli are identified faster than longer duration stimuli.
- When H1-H2 is neutralized, laryngeally-induced pitch raising caused a small shift in identification of /V:/ > /V?/.
- When pitch is neutralized and duration is ambiguous, H1-H2 acts as a cue to distinguish /V:/ and /Vh/ rimes.
- When duration is neutralized, only pitch acts as a cue to distinguishing /V:/ and /Vh/ rimes.

Discussion

What are the cues used to distinguish the glottal consonant contrast in Itunyoso Trique?

- /Vh/ vs. /V:/ Duration > Pitch > H1-H2
- /V?/ vs. /V:/ Duration > Pitch

Laryngeally-induced pitch perturbations are used as perceptual cues, but H1-H2 is not.

The Perception of Coarticulation

- Final syllables in Trique are bimoraic, consisting of either a long vowel /V:/ or a vowel followed by a glottal coda (/h/, /ʔ/).
- While duration is prosodic cue related to the presence or absence of a coda consonant, changes in voice quality and accompanying pitch perturbations are unambiguously the result of vowel-glottal coarticulation.
- Supports the hypothesis that coarticulatory cues in speech production are useful for the perceptual identification of phonological contrasts (Beddor and Krakow, 1999; Holt and Lotto, 2006; Nowak, 2006; Beddor, 2009).

Laryngeal cues

- As per DiCanio (2008), greater coarticulatory overlap in /Vh/ rime causes more salient changes in pitch and spectral tilt on the vowel. Such effects are not compensated for, but are directly related to the perception of laryngeal contrasts. Listeners use coarticulatory effects in perceptual identification.

- Laryngeally-induced pitch perturbations are perceptually-relevant, as hypothesized by Hombert et al. (1979) in relation to tonogenesis. Such perturbations are relevant even for listeners of a complex tone language.

Thank you.

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$$\text{ku}^{2}\text{ru}^{3}\text{a}^{1}\text{re?}^{1}$$

Beddor, P. S. (2009). A Coarticulatory Path to Sound Change. *Language*, 85(4):785–821.

Beddor, P. S. and Krakow, R. A. (1999). Perception of coarticulatory nasalization by speakers of English and Thai: Evidence for partial compensation. *Journal of the Acoustical Society of America*, 106(5):2868–2887.

Blankenship, B. (2002). The timing of nonmodal phonation in vowels. *Journal of Phonetics*, 30:163–191.

Broersma, M. (2005). Perception of familiar contrasts in unfamiliar positions. *Journal of the Acoustical Society of America*, 117(6):3890–3901.

Cho, T. and McQueen, J. M. (2006). Phonological versus phonetic cues in native and non-native listening: Korean and Dutch listeners' perception of Dutch and English Consonants. *Journal of the Acoustical Society of America*, 119(5):3085–3096.

DiCanio, C. T. (2008). *The Phonetics and Phonology of San Martín Itunyoso Trique*. PhD thesis, University of California, Berkeley.

DiCanio, C. T. (2009). The Phonetics of Register in Takhian Thong Chong. *Journal of the International Phonetic Association*, 39(2):162–188.

DiCanio, C. T. (2010). Illustrations of the IPA: San Martín Itunyoso Trique. *Journal of the International Phonetic Association*, 40(2):227–238.

Escudero, P. (2005). *Linguistic Perception and Second Language Acquisition: Explaining the attainment of optimal phonological categorization*. PhD thesis, Utrecht University.

Esposito, C. (2006). *The Effects of Linguistic Experience on the Perception of Phonation*. PhD thesis, UCLA.

Esposito, C. (2010). The effects of linguistic experience on the perception of phonation. *Journal of Phonetics*, 38:306–316.

Gerfen, C. and Baker, K. (2005). The production and perception of laryngealized vowels in Coatzospan Mixtec. *Journal of Phonetics*, 33:311–334.

Gordon, M. and Ladefoged, P. (2001). Phonation Types: A cross-linguistic overview. *Journal of Phonetics*, 29:383–406.

Gottfried, T. L. and Beddor, P. S. (1998). Perception of temporal and spectral information in French vowels. *Language and Speech*, 31:57–75.

Harnsberger, J. D. (2001). The perception of Malayalam nasal consonants by Marathi, Punjabi, Tamil, Oriya, Bengali, and American English listeners: A multidimensional scaling analysis. *Journal of Phonetics*, 29:303–327.

Hillenbrand, J. M. and Houde, R. A. (1996). Role of F_0 and Amplitude in the Perception of Intervocalic Glottal Stops. *Journal of Speech and Hearing Research*, 39:1182–1190.

Holt, L. L. and Lotto, A. J. (2006). Cue weighting in auditory categorization: Implications for first and second language acquisition. *Journal of the Acoustical Society of America*, 119(5):3059–3071.

Hombert, J. M., Ohala, J. J., and Ewan, W. (1979). Phonetic explanations for the development of tones. *Language*, 55(1):37–58.

Keating, P. A. and Esposito, C. (2006). Linguistic voice quality. *UCLA Working Papers in Phonetics*, 105:85–91.

Kirk, P. L., Ladefoged, P., and Ladefoged, J. (1984). Using a spectrograph for measures of phonation types in a natural language. *UCLA Working Papers in Phonetics*, 59:102–113.

Kreiman, J., Gerratt, B., and Antoñanzas Barroso, N. (2007). Measures of the glottal source spectrum. *Journal of Speech, Language, and Hearing Research*, 50:595–610.

Kreiman, J., Gerratt, B. R., and ud Dowla Khan, S. (2010). Effects of native language on perception of voice quality. *Journal of Phonetics*, 38(4):588–593.

Ladefoged, P., Maddieson, I., and Jackson, M. (1988). Investigating phonation types in different languages. In Fujimura, O., editor, *Vocal Physiology: voice production, mechanisms and functions*, pages 297–317. Raven Press, Ltd., New York.

Lyon, J. (2008). A Perception Study of Glottalization in Gitksan Resonants. *manuscript*, University of British Columbia.

McGuire, G. L. (2007). *Phonetic Category Learning*. PhD thesis, The Ohio State University.

Nowak, P. M. (2006). The role of vowel transitions and frication noise in the perception of Polish sibilants. *Journal of Phonetics*, 34:139–152.

Pennington, M. (2005). *The Phonetics and Phonology of Glottal Manner Features*. PhD thesis, Indiana University.

Wayland, R. and Jongman, A. (2003). Acoustic correlates of breathy and clear vowels: the case of Khmer. *Journal of Phonetics*, 31:181–201.