# Hypothesis

- Listeners are better at distinguishing pitch values during modal phonation (plain voicing) than during breathy phonation

# Motivation for hypothesis

- Pitch is primarily determined by glottal pulse period and harmonic structure
- Glottal pulse rate in breathy vowels is irregular in Jalapa Mazatec (an Otomanguean language of Oaxaca, Mexico; Kirk, Ladefoged

**and Ladefoged 1993); harmonics of Jalapa Mazatec breathy vowels involve significant bandwidth increases and noise (Silverman, Blankenship, Kirk, and Ladefoged 1995, Silverman, *to appear*)**

- **Pitch differences may be less reliably discriminible during breathy phonation than during modal phonation**

# Stimuli

- **Natural speech stimuli from Jalapa Mazatec:**

**(spectrograms)**

| m͡m̤æ̤͡æ˥ | ⁿda̤͡a˥ | ᵑgi-ǂᵑga̤͡a˥ |
|---|---|---|
| **(he wants)** | **(hard)** | **(he fastened)** |

- **Both breathy portion and modal portion extracted from each word**
- **Pitch of modal portions lowered to equal pitch of breathy portions (with SoundEdit16.2 "bender" feature)**
- **Amplitude of six spectra normalized for peak amplitude, onsets and offsets ramped to avoid click artifacts**

- **Frequency of each portion increased in increments of one-eighth tones of major scale (approximately 3 Hz.), up to one whole tone, producing six continua with eight steps each.**
- **All 56 forms converted to 200 msec in length**
- **All possible within-continuum pairs (up to one-half tone differences) produced, for a total of 366 stimulus pairs**
- **1000 trials/listener (501 “different” pairs; 499 “same” pairs), presented in blocks of 50 pairs. Inter-stimulus interval = 300 msec; inter-trial interval = 3 sec.**

- **Subjects judged for each pair whether the two stimuli were the same or different pitch.**

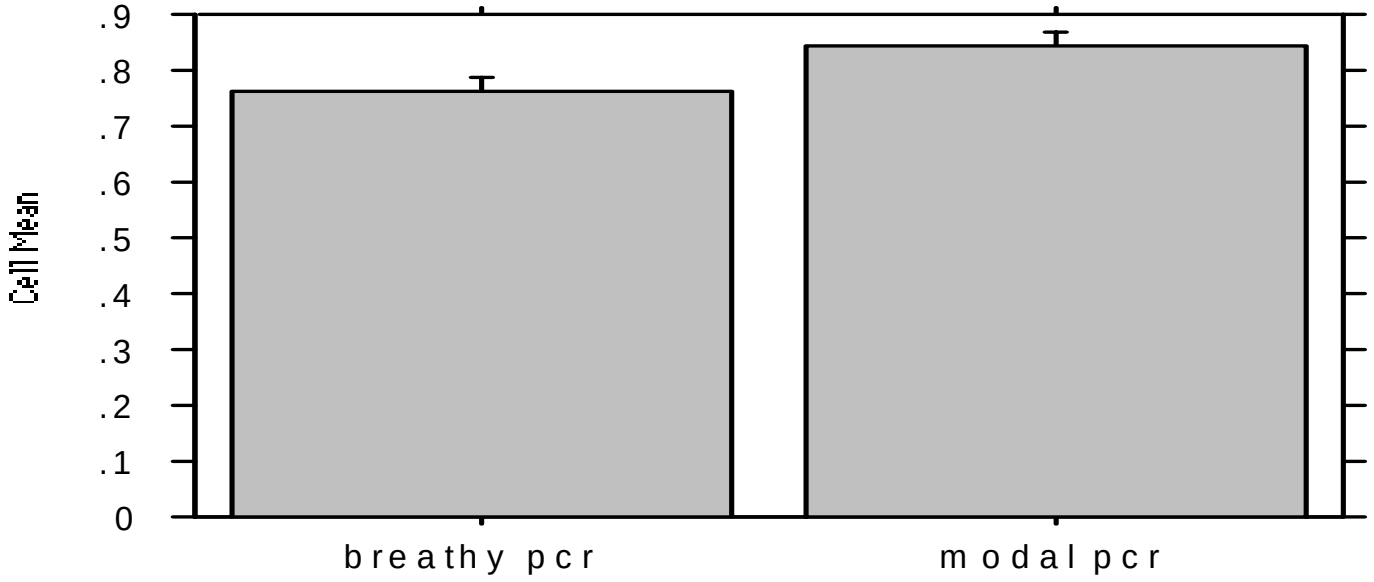
# Preliminary Results

# overall

**Paired t-test**
**Hypothesized Difference = 0**

| | Mean Diff. | DF | t-Value | P-Value |
|---|---|---|---|---|
| breathy pcr, modal pcr | -.077 | 11 | -5.586 | .0002 |

**Cell Bar Chart**
**Error Bars: ± 1 Standard Error(s)**

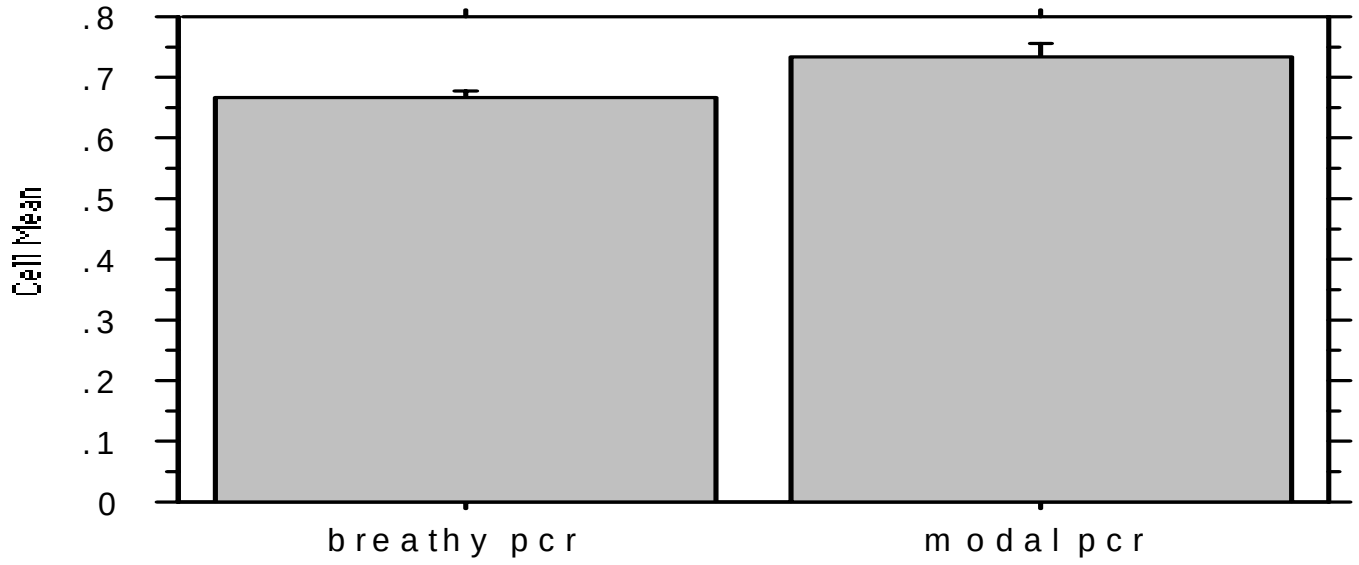


# Step 1(≅3Hz.)

**Paired t-test**
**Hypothesized Difference = 0**
**Row exclusion: tdata**

| | Mean Diff. | DF | t-Value | P-Value |
|---|---|---|---|---|
| breathy pcr, modal pcr | -.065 | 3 | -2.030 | .1353 |

**Cell Bar Chart**
**Error Bars: ± 1 Standard Error(s)**
**Row exclusion: tdata**

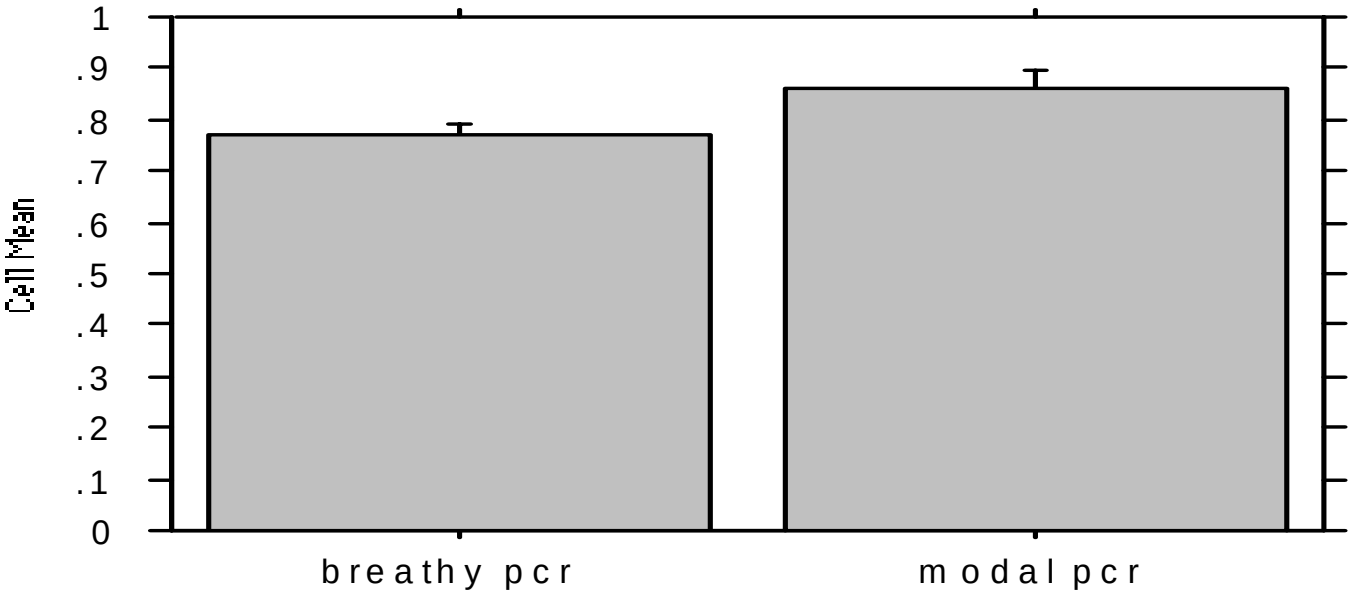


# Step 2 (≅6Hz.)

**Paired t-test**
**Hypothesized Difference = 0**
**Row exclusion: tdata**

| | Mean Diff. | DF | t-Value | P-Value |
|---|---|---|---|---|
| breathy pcr, modal pcr | -.088 | 3 | -3.217 | .0487 |

**Cell Bar Chart**
**Error Bars: ± 1 Standard Error(s)**
**Row exclusion: tdata**

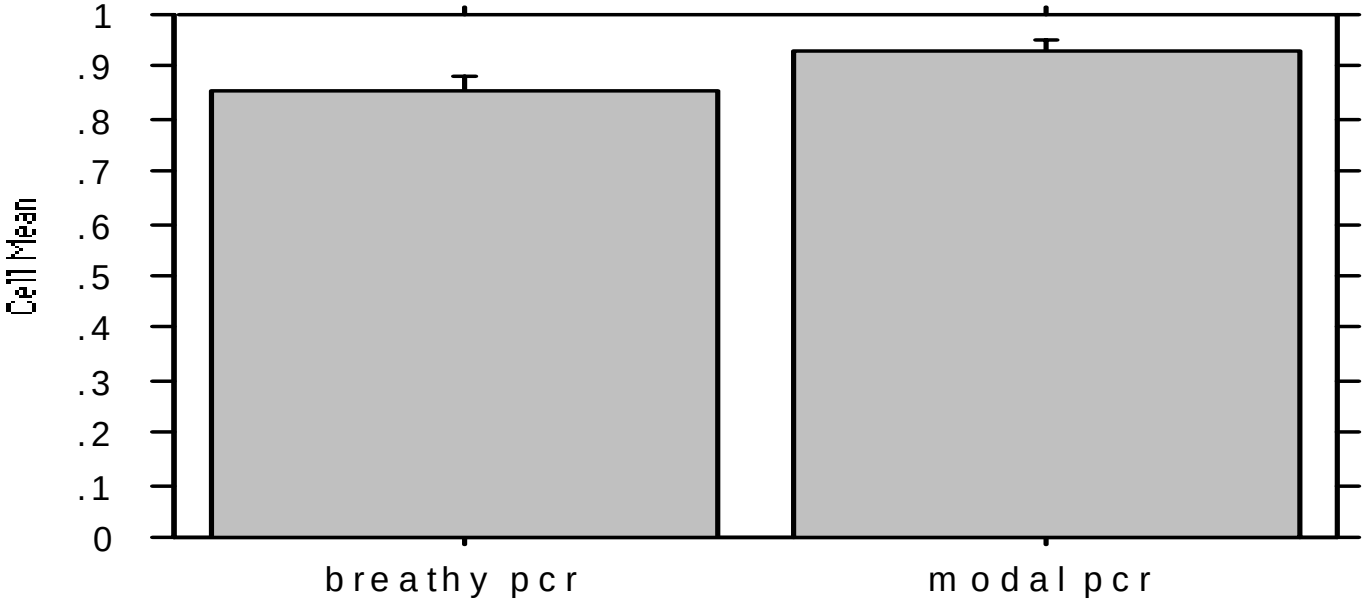


# Step 3 (≅9Hz.)

**Paired t-test**
**Hypothesized Difference = 0**
**Row exclusion: tdata**

| | Mean Diff. | DF | t-Value | P-Value |
|---|---|---|---|---|
| breathy pcr, modal pcr | -.077 | 3 | -5.191 | .0139 |

**Cell Bar Chart**
**Error Bars: ± 1 Standard Error(s)**
**Row exclusion: tdata**



# Discussion

- **Most Otomanguean languages, including Jalapa Mazatec, possess vowels which are "laryngeally complex"; vowels in which contrastive phonation *and* contrastive pitch (tone) cross-classify (Silverman 1993, 1995, *to appear*)**
- **Laryngeally complex vowels are realized in a part-modal part-nonmodal fashion**
- **Such patterns are present in Mazatec, as well in related Chinantec and Trique:**

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| **Mazatec** | hV́ | | | ʔV́ | | |
| **Chinantec** | hV́ | V́h | | ʔV́ | V́ʔ | |
| **Trique** | hV́ | V́h | V́hV́ | ʔV́ | V́ʔ | V́ʔV́ |

# Conclusion

- **Since pitch may be less reliably discriminble during breathy phonation (and creaky phonation; Rosenberg 1965), tone and non-modal phonation may be *sequenced* such that the laryngeally complex vowel is realized in a part modal/part non-modal fashion**

- **In this way, both tone and phonation contrasts may be saliently cued to the listener**

## A note on the SoundEdit16.2 “bender” feature

**The SE16.2 “bender” slows down or speeds up the playback of a sound. The playback sample rate is manipulated and the sound is resampled to the original (and constant) sample rate. The spectra are equally shifted in frequency and thus the ratios of the component frequencies are preserved. Given the spectral shift involved, some slope distortion may be added to the modifed signal: a shift up in formants for sped-up playback, and a shift down for slowed-down playback. But given the very minor signal adjustments employed in this study (roughly 3 Hz. per step),**

**spectral shifts are exceedingly minor, increasing, of course, as more steps are made.**

**(FFTs here)**

# References


**Kirk, P.L., J. Ladefoged, and P. Ladefoged (1993) "Quantifying Acoustic Properties of Modal, Breathy, and Creaky Vowels in Jalapa Mazatec," in A. Mattina and T. Montler, eds., *American Indian Linguistics and Ethnography in Honor of Lawrence C. Thompson*. Occassional Papers in Linguistics 10, University of Michigan, 435-450.**

**Rosenberg, A.E. (1965) "Pitch Discrimination of Jittered Pulse Trains," Journal of the Acoustical Society of America 39.5:920-928.**

**Silverman, D. (to appear). Phasing and Recoverability. Outstanding Disserations in Linguistics series. New York : Garland.**

**Silverman, D., B. Blankenship, P. Kirk, and P. Ladefoged (1995) "Phonetic Structures in Jalapa Mazatec," Anthropological Linguistics 37.1:70-88.**

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