



# Creaky voice in Yoruba

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# Introduction

- The low tone in Yoruba carries creaky voice
- Series of two experiments confirms and expands previous results
- Show that this holds in different kinds of words/syllable positions; CV and CVCV
- Places Yoruba in growing body of evidence that boundary between “tone” and “register” languages is a fuzzy one

# Plan

- Give background
- Go through experiment one – CV
- Go through experiment two – CVCV
- Discussion

# Creaky voice

- Mode of phonation with glottal folds drawn closely together
- Irregular pitch periods and lower intensity in waveforms (Ladefoged 1971; Laver 1980)
- Lower F0, irregular F0, low spectral tilt (Laver 1980; Klatt & Klatt 1990)
- Known to the layman as “vocal fry” (though (Keating et al. 2015) shows that this is slightly different)

# Creaky voice and tone

- In tone languages with non-modal phonation, often associated to a particular tone category
  - Pitch perceptually primary, consistent differences in phonation (Mandarin (Davidson 1991), Cantonese (Yu & Lam 2014), Cham (Brunelle 2012))
  - Phonation perceptually primary, consistent differences in pitch (Burmese (Bradley 1982), Hmong (Huffman 1987))
- “Fuzzy boundary” between tone and register languages (Abramson & Luangthongkum 2009)

# Creaky voice and tone

- Not just a property of E/SE Asian languages<sup>1</sup>:
- Full phonation/tone contrast in Jalapa Mazatec (Mexico; Silverman et al. 1995; Ladefoged & Maddieson 1996):  
já “tree” já̰ “he wears” já̃ “he carries”
- Breathy low tone in Kalam Kohistani (Pakistan; Baart 1996)
- Is Yoruba in this range of languages as well?

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<sup>1</sup>See Gordon & Ladefoged (2001) for a typological survey of non-modal phonation

# Yoruba

- Yoruba: Niger-Congo language; 28 million speakers concentrated in Nigeria, Benin, Togo
- Three tone-levels (H, M, L)
- Mid tone considered “default”, doesn’t participate in tonal processes (Akinlabi 1985; Pulleyblank 1986)
- Low tone shows a falling contour in isolation or word finally, mid and high more stable (Connell & Ladd 1990)

# Creaky voice and Yoruba

- Very limited reference to creaky voice in Yoruba
- Welmers (1974), p.109: “Low tone is ... very commonly associated with a creaky voice quality”
- Yu (2010) cites Welmers (1974)
- Hayward et al. (2004) – only acoustic study addressing non-modal phonation in Yoruba, find a distinctive creaky quality for low tones in CV words
- Given limited knowledge of this phenomenon, worth repeating



# CV words

- 63 CV target words, all combinations of the seven vowels (/i e ε a ə o u/), three tones (high, mid, low) with three initial consonants (/t n l/) x5 repetitions = 315 data points
- Frame sentence: Sọ \_\_\_ lẹ kan sí i  
/sə \_\_\_ lɛ kã sí i/  
*Say \_\_\_ once more*
- Presented with PsychoPy (Peirce 2007)

# CV words

- One speaker – 31M, lived in Nigeria until age of 26, here for school. Raised in bilingual Yoruba-English environment. Indicated that he spoke Yoruba “all the time” as a child and still uses it frequently. Reported no difficulties in speaking. Yoruba-speaking colleague was present and attested to the quality of the participant’s speech and also engaged him in conversation in Yoruba before the task began.

# CV words

- Took place in sound-attenuated booth at Phonology Laboratory at Rutgers Center for Cognitive Science using a Logitech H390 USB microphone headset attached to the researcher's laptop running Audacity audio recording software version 2.3.0 recording in mono at a project rate of 44100Hz.
- Segmentation done in Praat (Boersma 2001)
- Statistical analysis done in R (R Core Team 2017)

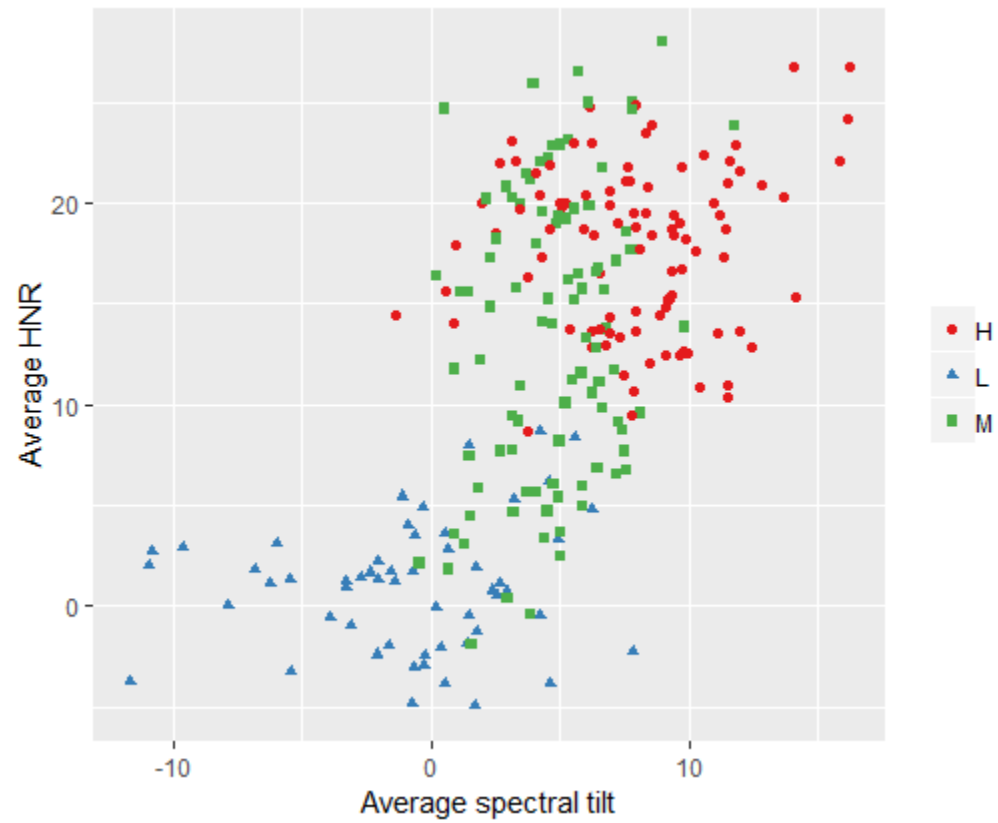
# CV words: expectations

- Hypothesize that low tones have acoustic properties characteristic of creak, mid and high do not
- Quantify creak via:
  - Harmonic-to-Noise Ratio (HNR): measure in dB of F0 irregularity, lower is creakier
  - spectral tilt: degree to which intensity increases as frequency decreases, H1-H2, lower is creakier
- Keating et al. (2015) finds these to be most consistent indicators of creak

# CV words: findings

	F0	HNR	spec tilt	duration
H	149.39	17.84	7.91	0.26
	<i>6.44</i>	<i>4.15</i>	<i>3.43</i>	<i>0.04</i>
M	126.97	13.56	4.84	0.27
	<i>6.37</i>	<i>7.22</i>	<i>2.30</i>	<i>0.05</i>
L	98.48	0.71	-0.19	0.17
	<i>5.08</i>	<i>3.06</i>	<i>4.73</i>	<i>0.04</i>

# CV words: findings



# CV words: findings

- Linear mixed effects models as implemented in `lme4()` (Bates et al. 2015)
- HNR and spectral tilt as dependent variables, tone (and others) as independent variables, *block* and *word* in random effects structure

# CV words: HNR

- HNR as dependent variable, tone and vowel as independent variables
- Significant difference between both low and mid tones ( $\beta = 11.75, p < 0.001$ ) and low and high tones ( $\beta = 15.76, p < 0.001$ ) with model  $R^2 = 0.87$ .
- Conclusion: low HNR reliably marks low tones as creaky in Yoruba CV words



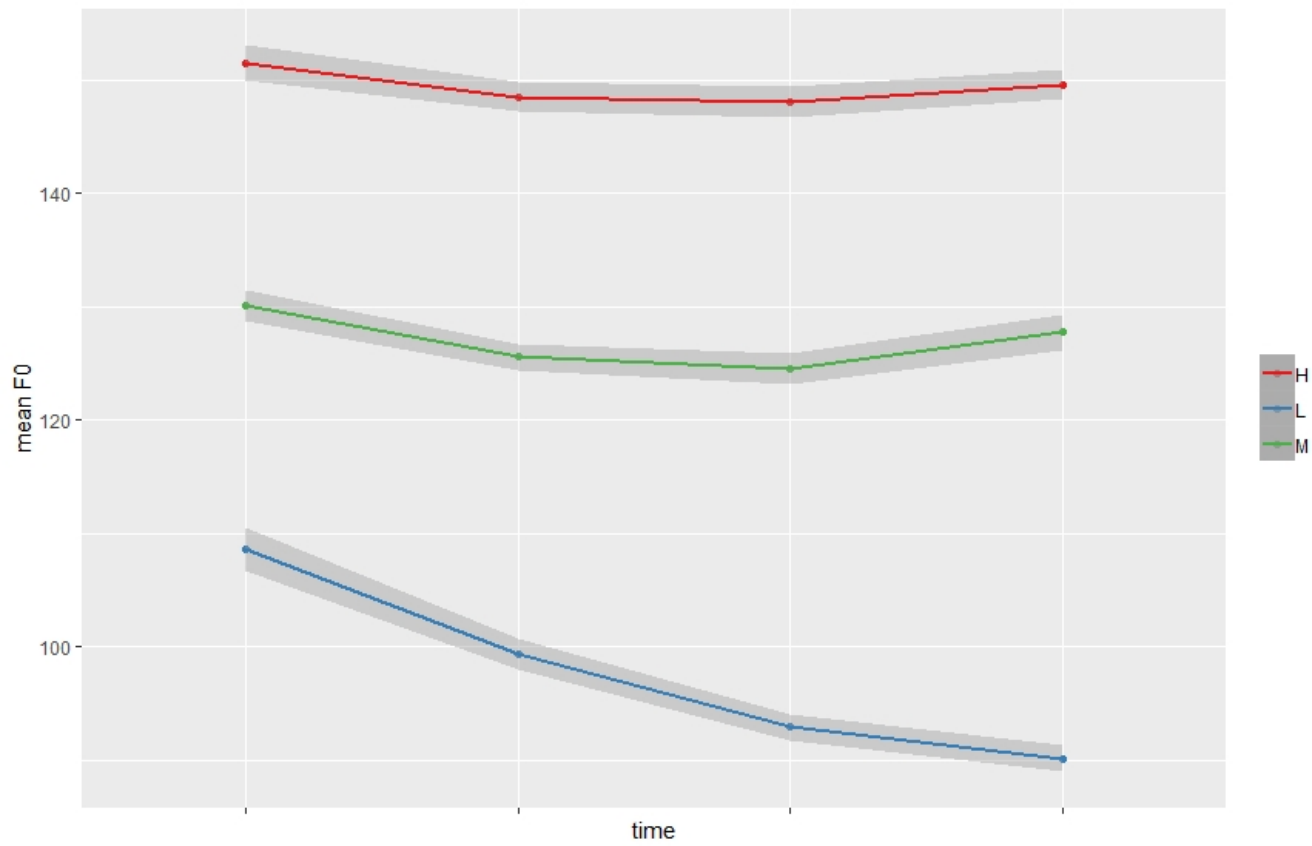
# CV words: spectral tilt

- Spectral tilt as a dependent variable, tone, vowel, and onset as independent variables
- Significant difference between both low and mid tones ( $\beta = 5.22, p < 0.001$ ) and low and high tones ( $\beta = 8.30, p < 0.001$ ) with model  $R^2 = 0.55$ .
- Conclusion: low spectral tilt reliably marks low tones as creaky in Yoruba CV words

# CV words: remarks

- Results suggest a creaky quality for low tone absent from mid or high tone
- Low HNR, low spectral tilt
- Consistent with Hayward et al. (2004)
- Question: Is this a true effect or an artifact of some other factor? Frame sentence? Falling L contour?

# CV words: remarks



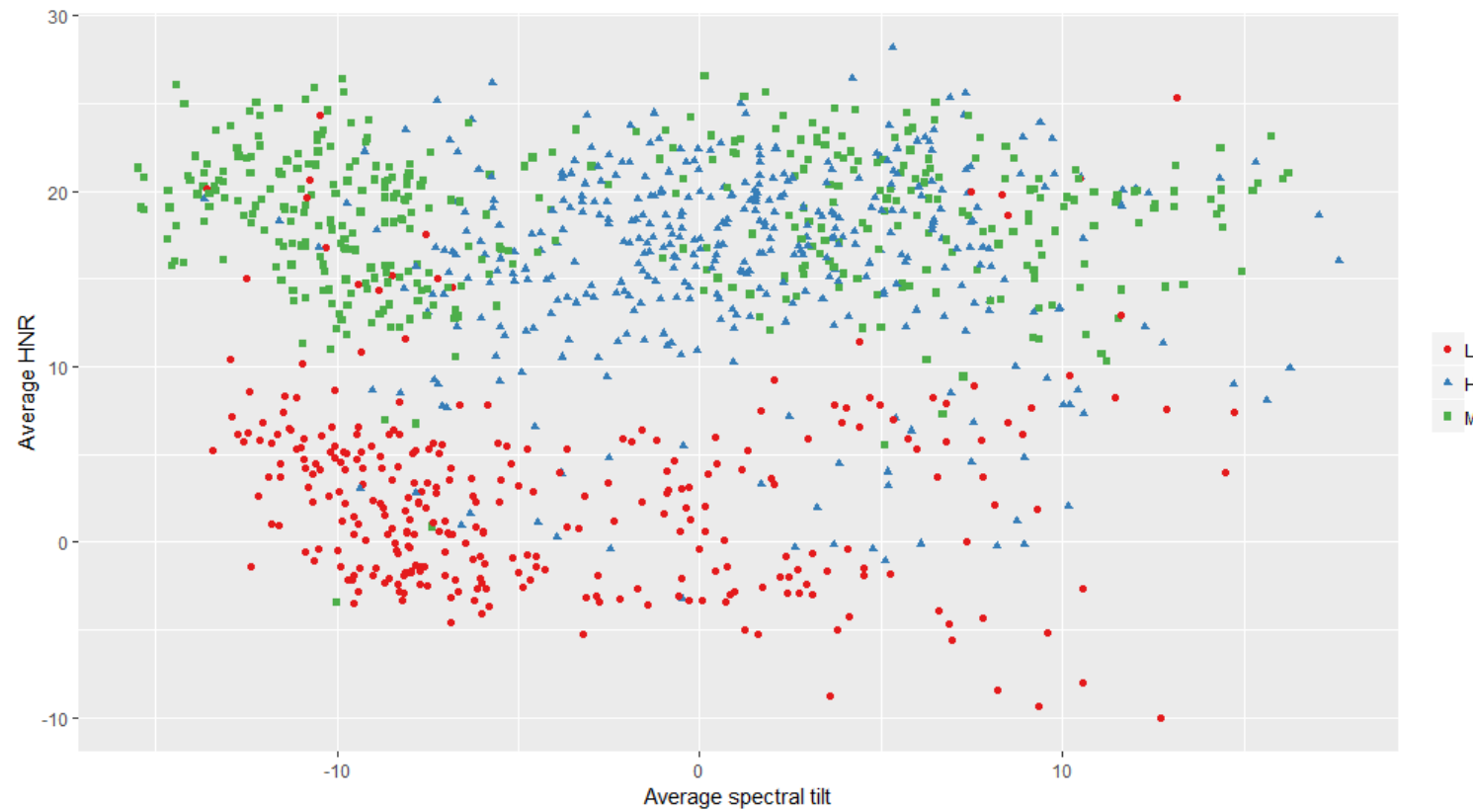
# CVCV words

- 81 CVCV target words, vowels (/i u a/), three tones (high, mid, low) with /n/ x5 repetitions = 324 data points
- Same frame sentence
- Two speakers (second speaker has similar profile), same location
- Marantz PMD660 recording device recording in mono with a Shure SM10A head-worn microphone

# CVCV words: findings

F0		HNR		SpecTilt		
	Syll1	Syll2	Syll1	Syll2	Syll1	Syll2
H	170.66	163.84	18.03	13.95	-0.42	3.05
	<i>18.38</i>	<i>21.70</i>	<i>3.87</i>	<i>6.39</i>	<i>7.17</i>	<i>5.89</i>
M	149.59	144.56	19.29	17.55	-3.52	-0.77
	<i>16.21</i>	<i>16.40</i>	<i>3.87</i>	<i>3.86</i>	<i>7.59</i>	<i>9.69</i>
L	111.98	118.49	2.76	1.42	-3.90	-2.65
	<i>10.01</i>	<i>19.13</i>	<i>6.31</i>	<i>3.75</i>	<i>7.17</i>	<i>6.97</i>

# CVCV words: findings



# CVCV words: HNR

- HNR as dependent variable, tone and vowel as independent variables
- Significant difference between low and mid tones and low and high tones in both the first (mid  $\beta = 16.50, p < 0.001$  high  $\beta = 15.24, p < 0.001, R^2 = .78$ ) and second syllables (mid  $\beta = 16.06, p < 0.001$  high  $\beta = 12.34, p < 0.001, R^2 = .75$  )
- Conclusion: low HNR reliably marks low tones as creaky in Yoruba words

# CVCV words: spectral tilt

- spectral tilt as dependent variable, tone as independent variables
- Significant difference between low and high tones in first syllable ( $\beta = 3.26, p < 0.001$ ) but not low and mid tones ( $\beta = 0.14, p = 0.7$ )
- Same in second syllable, high: ( $\beta = 4.60, p < 0.001$ ), mid: ( $\beta = 0.96, p = 0.07$ )



# CVCV words: remarks

- Spectral tilt less reliable as a measure of creak in low tones
- Possibilities:
  - nVnV words, nasal cavity damps higher frequencies, could affect values
  - Speaker variation
  - Syllable position

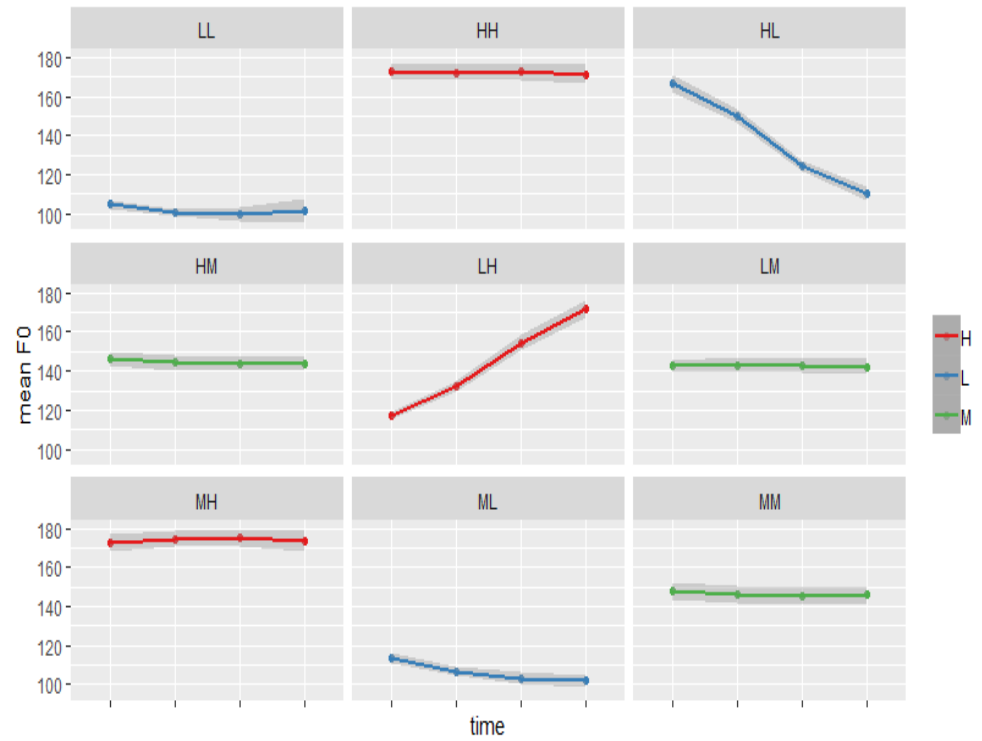
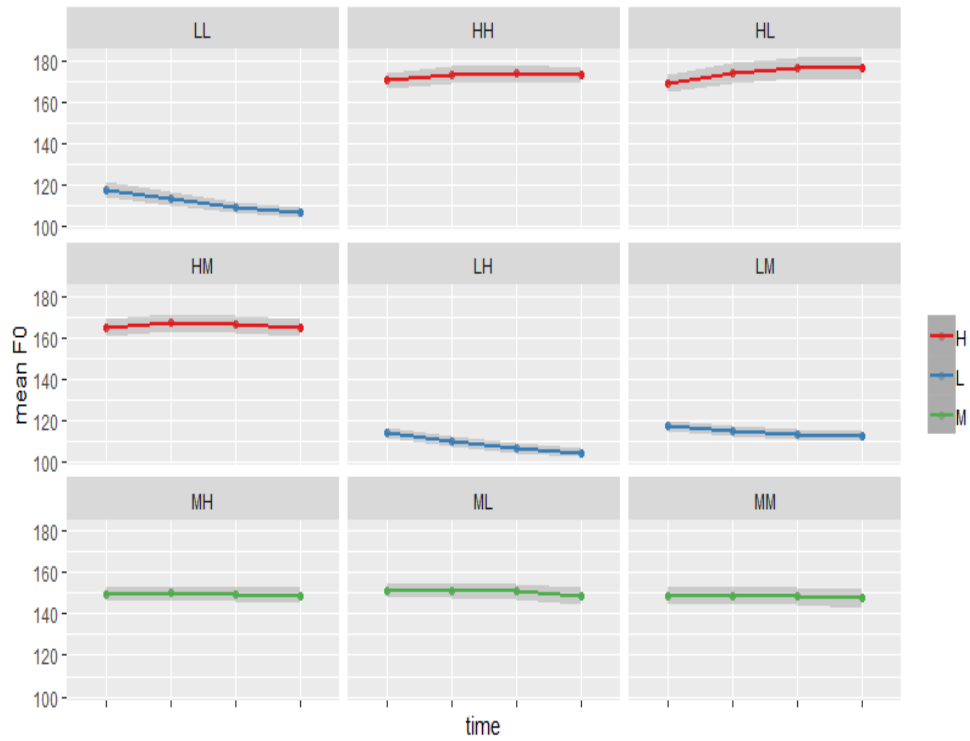
# CVCV words: remarks

- HNR most robust acoustic reflex of creak in Yoruba
- Not a factor of position – both syllables show similar HNR values
- Holds across speakers
- Remaining questions to pursue?

# CVCV words: tone sequence

- Tone sequence: creakiness in LL vs. LM, LH and vs. ML, HL
- LL vs. LM vs. LH, no significant difference between LL and LH ( $\beta = -0.27, p = 0.7$ ), statistically significant difference between LL and LM ( $\beta = 3.73, p < 0.001$ )
- LL vs. ML vs. HL, no significant difference between LL and ML ( $\beta = 0.13, p = 0.8$ ), statistically significant difference between LL and HL ( $\beta = 5.02, p < 0.001$ )

# CVCV words: remarks



# Discussion

- Yoruba low tone has creaky character best quantified with HNR
- Creakiness in first vs. second syllable – significant difference?
- Other reliable acoustic measures?
- Perception?
- More speakers?

# Thanks!

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