The roles of phonation and F0 in Zhuang

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Acoustic correlates of tone

- Fundamental Frequency (F0) (cf. Yip 2002)
  - peak delay
    - Mandarin Chinese (Xu 1998, 1999), Chichewa (Kim 1998, Myers 1999) and Yoruba (Akinlabi and Liberman 1995)
  - downstep and declination

- Phonation and tone (cf. Silverman 1997)
  - laryngeally complex languages
    - Oto-Manguean (e.g. Jalapa Mazatec, Garellek & Keating 2011; Triqui DiCanio 2008; Quiaviní Zapotec, Chávez-Péon 2010), Nilotic (e.g. Dinka, Andersen 1993), Burmese (Watkins 1997, 2000, Lee 2007, 2008, Gruber 2011), Green Mong (Andruski & Ratliff, 2000, Andruski 2006), Chong (DiCanio 2009), Vietnamese (Honda 2006), Black Miao (Mazaudon & Michaud 2008, Kuang 2013, Mazaudon 2014)

- Other acoustic correlates
  - duration

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Creakiness Detection Algorithm

Creakiness Traces for Unchecked Tones – Speaker DZ00
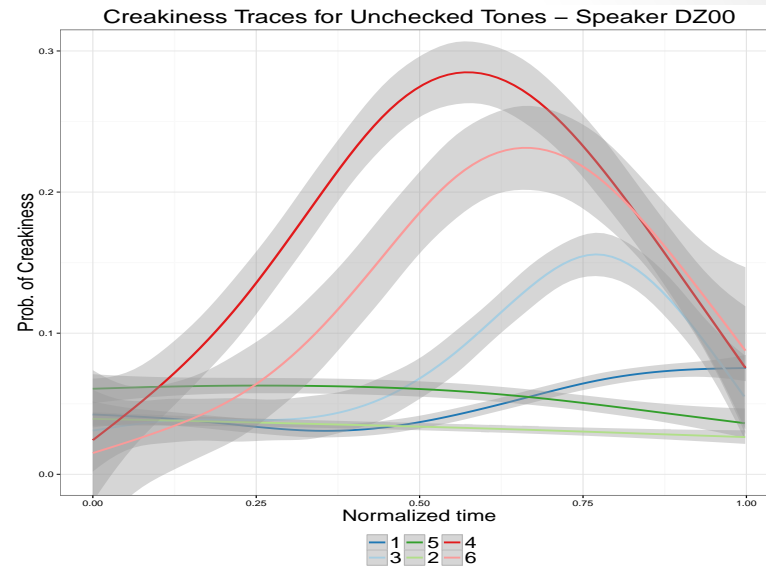
- a composite method used to measure creakiness
  - creakiness is estimated every 10 ms using the method in Degottex et al. (2014).
  - the algorithm effectively determines the odds of a frame being creaky based on a combination of acoustic features
    - the difference between the first two harmonics (H2-H1)
    - F0 contour
    - residual peak prominence
    - a group of features used by Ishi et al (2008)
      - including inter-pulse similarity, intra-frame periodicity
    - To minimize false positives, three measures are included
      - normalized signal energy, number of zero-crossings, variance in the very short-term power contour

- The results are given by an Artificial Neural Network (ANN) trained with creakiness manually labeled.

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SSANOVA

- Fit smoothing spline ANOVA models in Gaussian regression (Gu 2014)
  - **F0** and **creakiness** are explained by the factors *Tone* (6 unchecked Du'an tones) and *normT* (the normalized duration of each token), and their interaction
  - We used a Restricted Maximum Likelihood (REML) method with the default smoothing parameters given by the R library.

F0 Traces for Unchecked Tones – Speaker DZ00

- A similar methodology was used in analyses of the lingual and labial articulation of whistled fricatives (Lee-Kim et al. 2014)
- F0 contours and larynx height for Mandarin tones (Moisik et al. 2013)
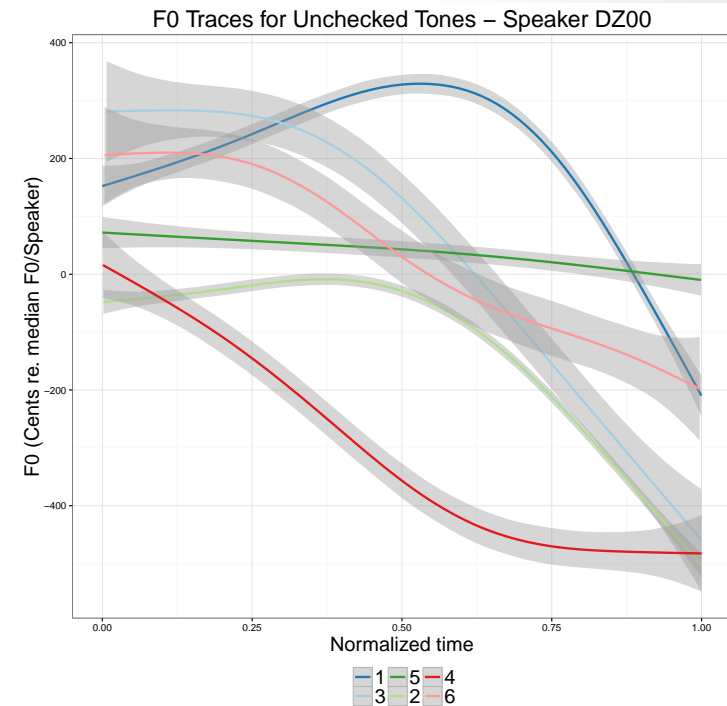
Zhuang

- Zhuang has the largest number of speakers of the 55 official minority languages in China
    - Zhuang is in the Tai-Kadai family (Thai, Laos, Vietnam, Myanmar & China)
    - The variety spoken in Wuming is considered the standard variety (Wei & Qin, 1980).
    - There is a vast degree of dialectal difference within Zhuang.
    - Many Zhuang dialects are not mutually intelligible.

- Du'an Zhuang is not mutually intelligible with Wuming Zhuang, mainly due to tonal differences.
    - We ultimately aim to describe these differences via phonetic measurement, although we focus on Du'an Zhuang in this talk.

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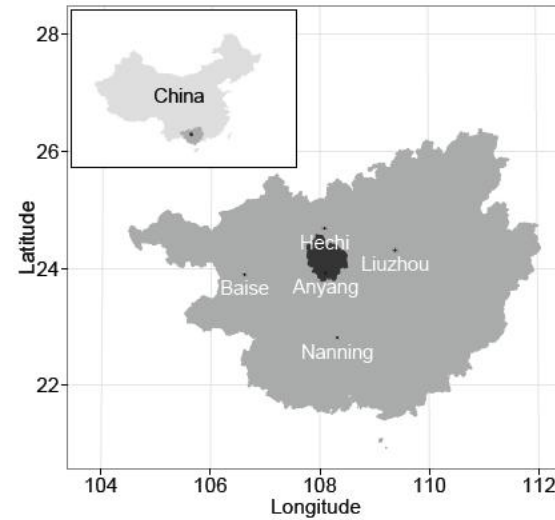
Overview

- **Part I:** A production study on a single Du'an Zhuang speaker done in the USA in 2007-08 suggested a tone system with contrastive creaky phonation.
  - We use this speaker's data to demonstrate how Degottex et al.'s (2013), Kane et al.'s (2013), and Drugman's (2014) method can identify creakiness from the acoustic signal.
- **Part II:** A production study in December 2015 in Nanning, China with 3 Du'an Zhuang speakers suggested that contrastive phonation is not a general phenomenon in Du'an Zhuang.
  - We summarize the tone system for Du'an Zhuang, as one where F0 and not creakiness contrasts define the tonal system.

Part I - Data Collection

- Consultant
  - One male native speaker of Du'an Zhuang in his mid 20's was recorded in a sound-proof booth in 2007-2008 when he was a graduate student in the USA.
  - He lived in Du'an until age 10, then moved to Liuzhou, where he spoke a Guangxi variety of Mandarin.
  - He was exposed to Yao language while living in Du'an as a child.
  - At the time of the elicitation, the consultant communicated with his immediate family members and relatives in Zhuang over the phone. In the US, however, he spoke Mandarin Chinese with his wife, who is a Miao descendant but only speaks Mandarin.

- Procedure
  - Zhuang words were elicited from a list of Chinese characters. These words were pronounced in isolation to exclude possible tone sandhi effects.
  - The tones for these words in Wuming Zhuang are known, facilitating comparison between the two dialects.
  - Onset type and coda type is balanced over the tokens.

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# Part I Results –F0 in Tones 1 to 6

Mean Pitch Tracks (Frequency in Hz on Vertical Axis; Time in ms on Horizontal Axis)

F0 Traces for Unchecked Tones – Speaker DZ00
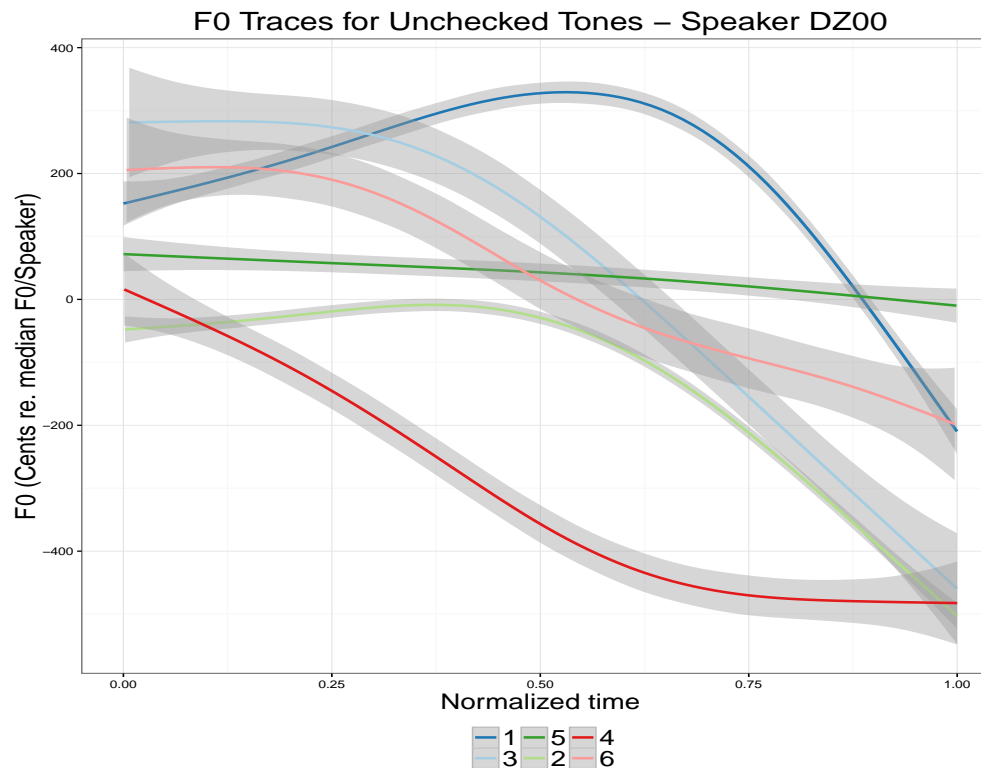
- Vowel length as transcribed in Wuming Zhuang, did not correspond to any differences in vowel length, nor of F0, in Du'an Zhuang. Thus, pitch tracks are plotted without regard to underlying vowel length.

Tones 1 to 6 appear on unchecked syllables (open syllables or syllables with a nasal coda)

Part I Discussion – Tone 2 and tone 4


F0 Traces for Tones 2 & 4 – Speaker DZ00
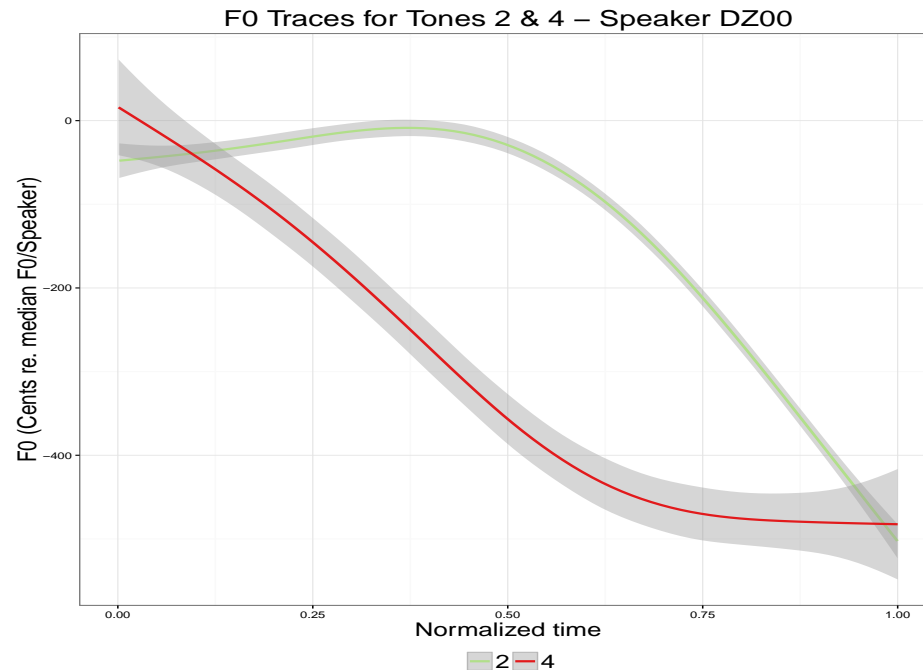
- Falling tones in Du'an Zhuang
  - Both fall from 0 to –500 cents.
  - Timing Difference: Tone 2 falls towards the end and tone 4 falls early.
- Phonation
  - Tone 4 is noticeably creakier than tone 2.
  - Rose and Seidl (1990) reported that creaky phonation correlates with an earlier fall in F0 in Thai-Phake.

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Examples – Tone 2 & Tone 4

- Creakiness can be observed as irregularly spaced glottal pulses

Modal tone 2 "ears" (left)   vs.   Creaky tone 4 "meeting" (right)
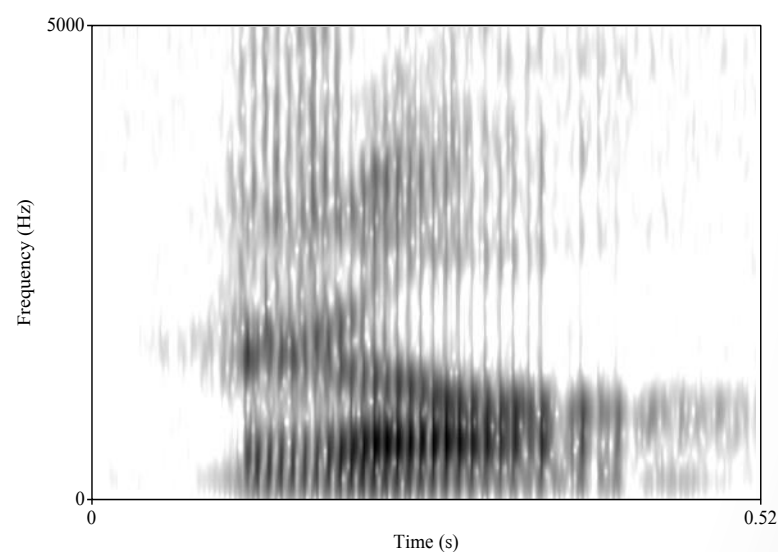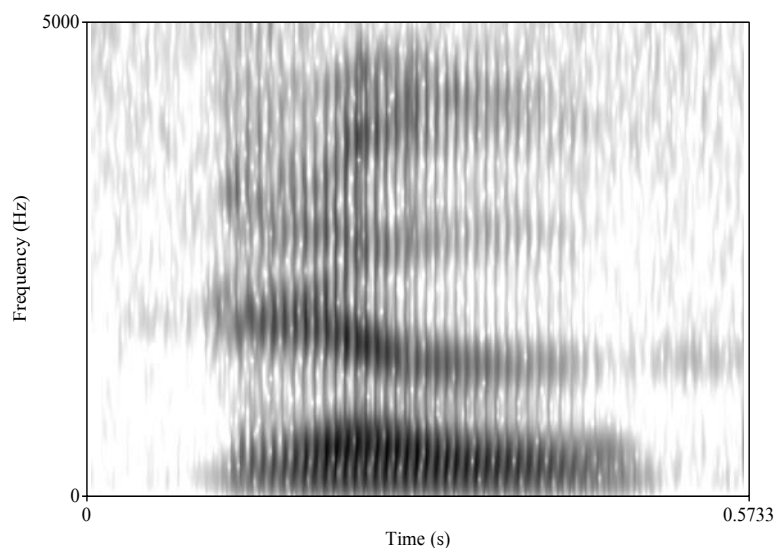
F0 and Creakiness

- Overlaid temporal contours of F0 (dashed line) and Creakiness (solid line)
  - tone 2 (top panel)
    - no change in creakiness and F0 drops toward the end of the syllable
  - tone 4 (middle panel)
    - as creakiness increases, F0 falls (purple arrow)
  - tone 6 (bottom panel)
    - as creakiness increases, F0 falls (green arrow, though at a later point compared to tone 4)

tone 2

tone 4

tone 6

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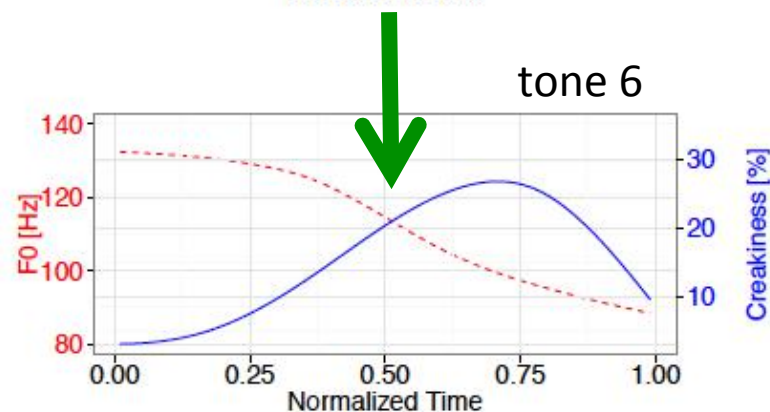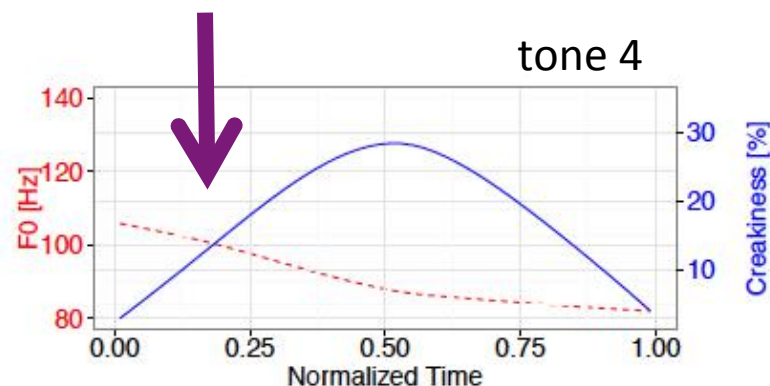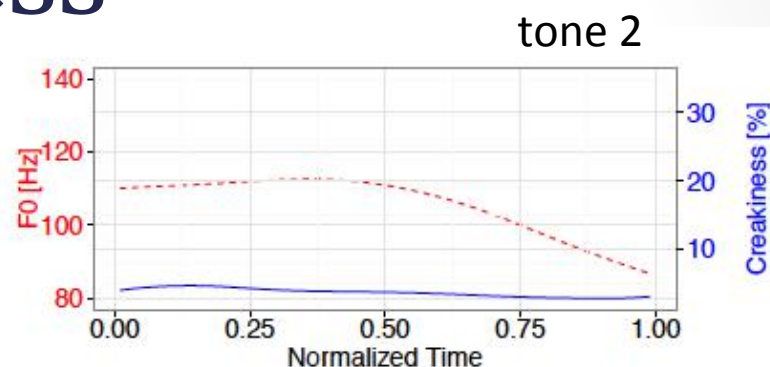
Tone 2 – Tone 4 Contrast

- For speaker DZ00, the difference between tone 2 (31 modal) and tone 4 (31 creaky) lies in the phonation and the timing of the falling of F0.

  - Tone 2 has modal phonation and has a late phonetic fall.

  - Tone 4 has creaky phonation and has an early phonetic fall.

    - Tone 2 corresponds to [31] in Wuming Zhuang and tone 4 corresponds to [42] in Wuming Zhuang.
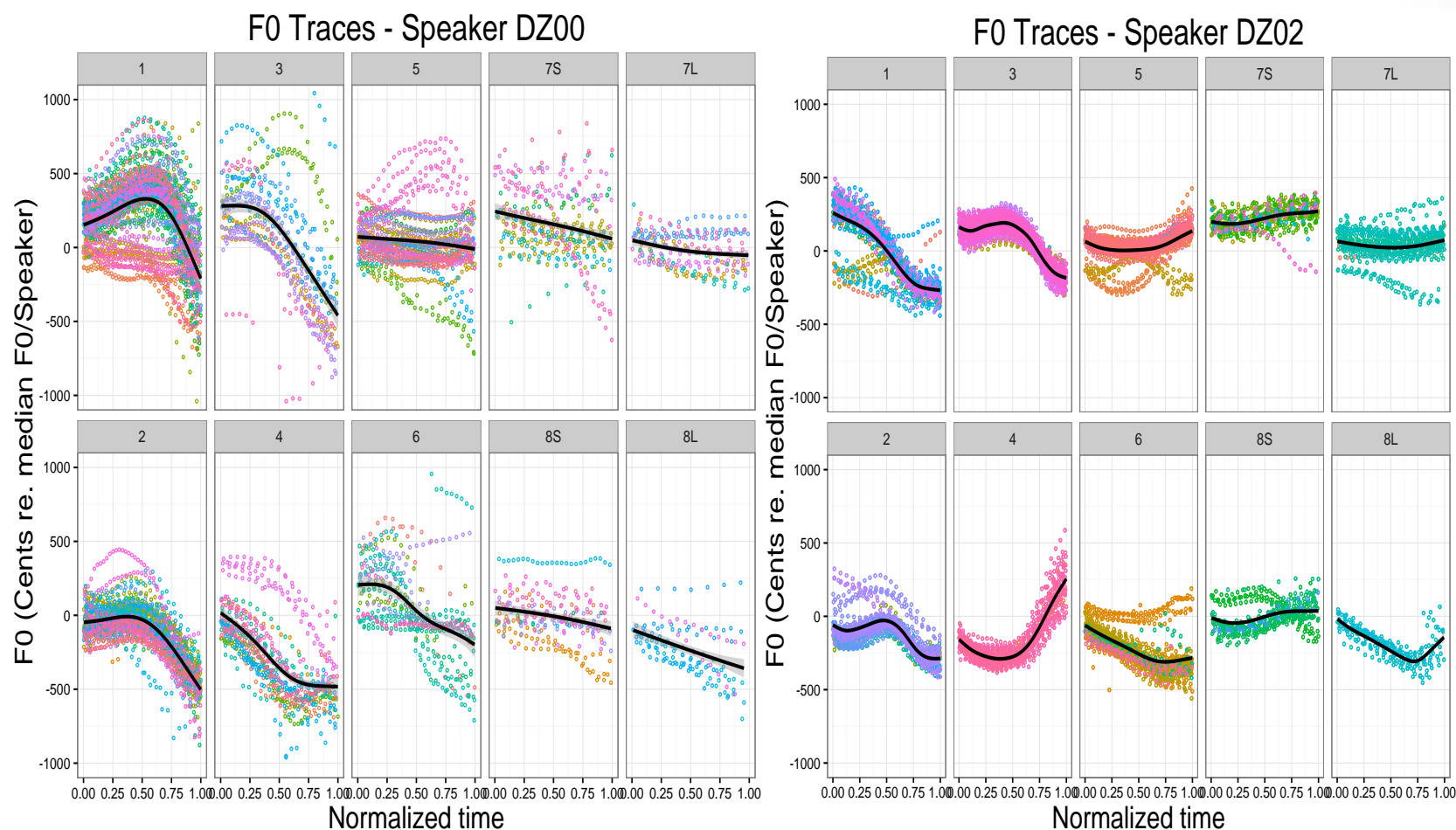
Part II – Data Collection

- Consultants
  - Two male speakers and one female native speaker of Du'an Zhuang in their early 20's were recorded in a sound-attenuated booth at Guangxi University, Nanning, China in Dec. 2015.
  - The speakers were bilingual Du'an Zhuang/Mandarin speakers and spoke regularly with their family in Du'an Zhuang. They grew up in Du'an.

- Procedure
  - 197 Zhuang words were selected from Wei & Qin (1980) and Zhang et al. (1999).
  - The selection was done so that approximately equal numbers of tokens of each tone would be used (not strictly possible).
  - The tones for these words in Wuming Zhuang are known, facilitating comparison between the two dialects.
  - 5 repetitions of each word were included, with all tokens randomized uniquely for each speaker (987 tokens per speaker).

Part II - Results – F0

F0 Traces for Unchecked Tones – Du'an Zhuang
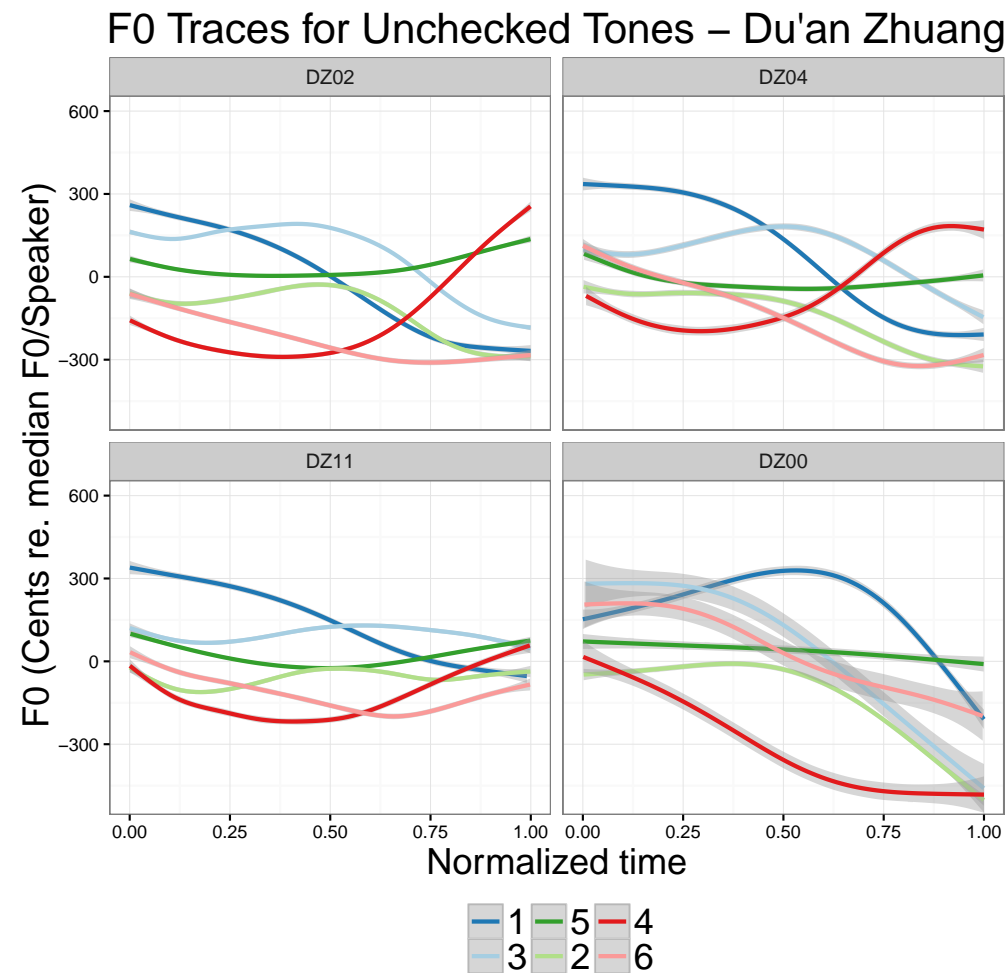
$r^2 = 0.494$
(0.633 without DZ00)

Consistency Within Speakers – F0

F0 Traces - Speaker DZ00

F0 Traces - Speaker DZ02

Acoustic Analysis - Creakiness

Creakiness Traces for Unchecked Tones – Du'an Zhuang
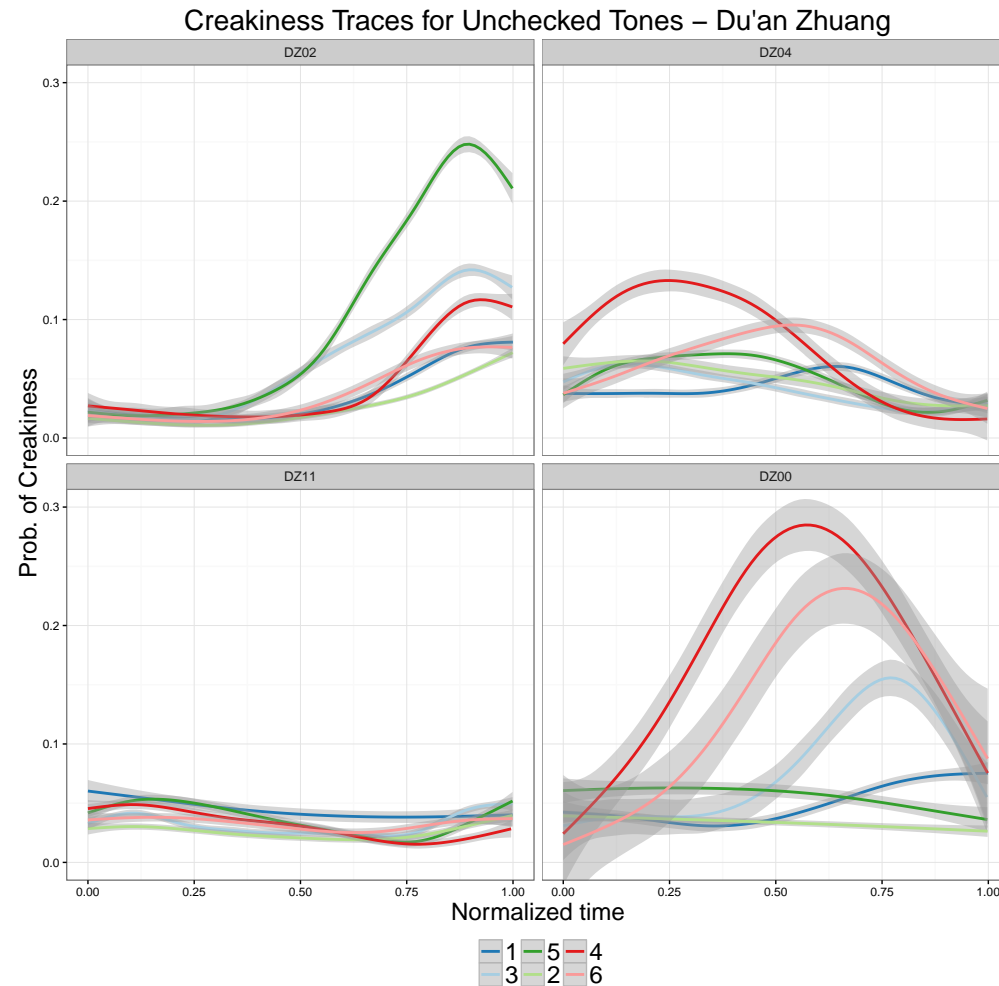
$r^2 = 0.057$
(0.258 without DZ00)

Creakiness & F0 in Du'an Zhuang

- The creakiness detection algorithm, coupled with the F0 contour, shows that F0 and not creakiness is consistent within tones and across speakers.
  - This implies that F0 and not creakiness is contrastive in the tonal system of Du'an Zhuang.
- For one speaker (DZ00), there is evidence of contrastive creaky phonation.
  - The timing of when the creakiness increases affects the F0 profile
    - as creakiness increases, F0 drops
  - F0 is dependent on the creakiness profile
  - His tone system may be influenced by Yao, and possible even to the extent that it may be unstable.

Conclusion

- Acoustic methods are used to further understand the interplay between phonation and F0, two known acoustic properties that are related to tone.
  - Creakiness detection algorithm
  - SSANOVA

- F0, and not creakiness is contrastive in the Du'an Zhuang tone system.
- In one speaker's tonal system:
  - The timing of the fall of F0 coincided with the rise of creakiness in Du'an Zhuang, which disambiguated the puzzle of early fall vs. late fall.
  - This speaker may have been influenced by Yao; had a less stable production of tones.

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