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Articulatory and acoustic properties of period-doubled voice in Mandarin

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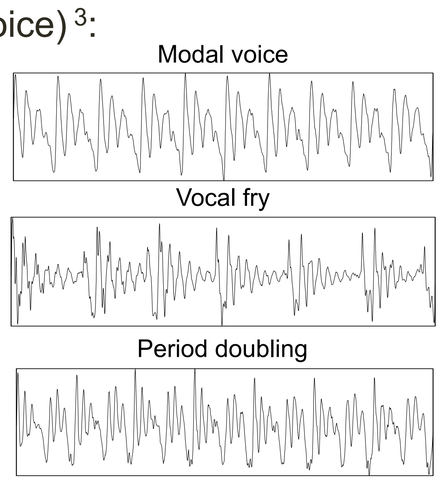
INTRODUCTION

- Period-doubled voice (PD) contains two **simultaneous periodicities**, heard as an indeterminate pitch with a low & rough quality [1, 2, 3, 4].
- A subtype of creaky voice (multiply pulsed voice) [3]:
  - noise, glottal constriction, subharmonics
- Also called “pitch doubling” (two pitches)
- Long & short periods; high & low amplitudes
- The uses of PD (or creak) in Mandarin:
  - with noise, PD hinders tone perception [5]
  - less attractive, sarcastic speech [6]
  - marks utterance finality [7]



Acoustic waveforms of the vowel [ai] from a Mandarin speaker.

☛ There lacks a systematic analysis of the **defining characteristics** of PD in natural speech

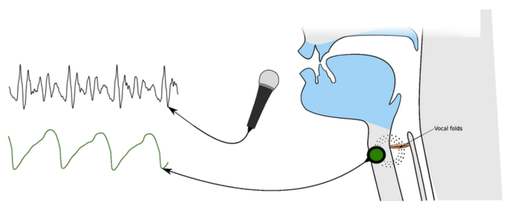
☛ Research question: **What are the articulatory and acoustic properties of period-doubled voice?**

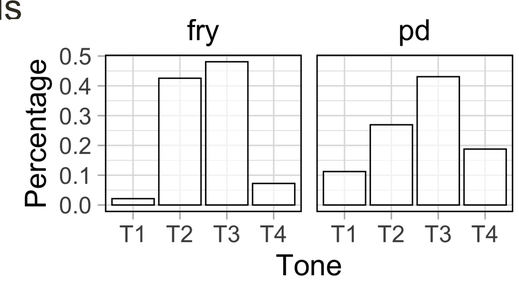
METHODS

- Read speech from audio & electroglottography (EGG) corpus for contextual tonal variation [8]
- Stimuli are embedded in a carrier sentence:

  我教你wo3 tɕau1 ni3 STIMULUS 怎么说 tsən3 mɤ5 ʂʷo1

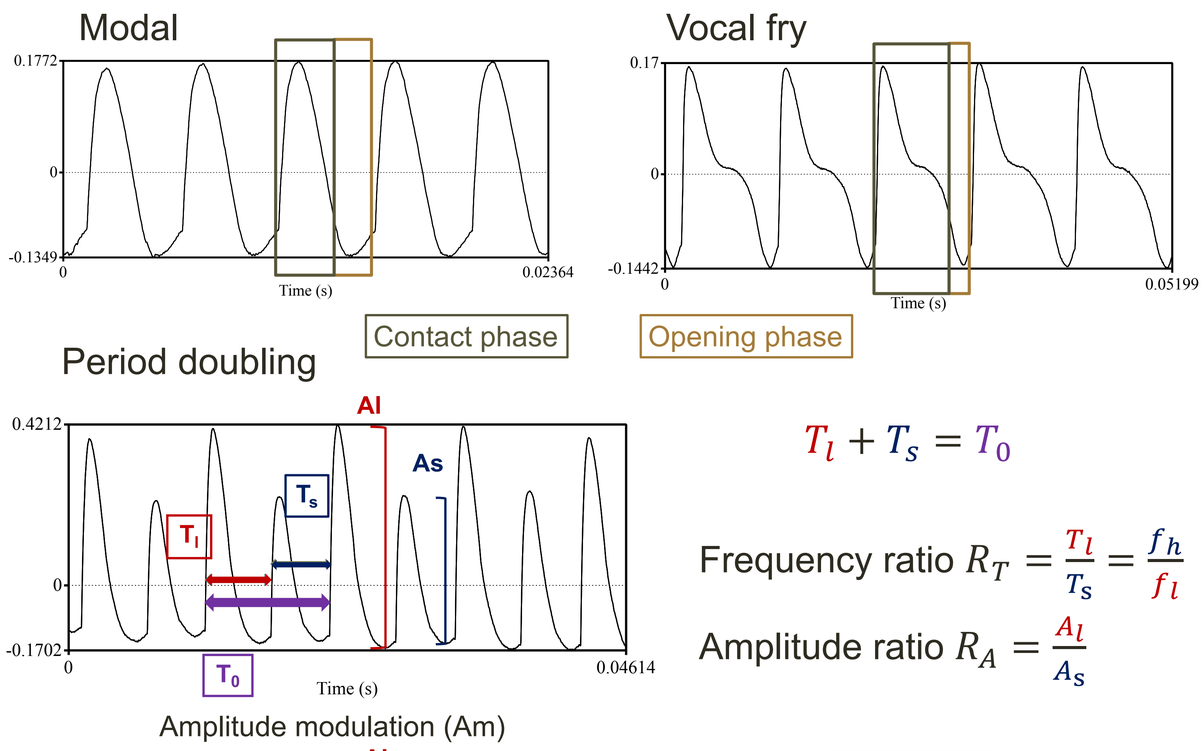
  “I teach you how to say the STIMULUS.”
- 20 native Mandarin speakers (10F); 384 sentences/recording
- Stimuli = trisyllabic Mandarin compounds





- Used EGG to locate tokens of PD, vocal fry, and modal voice
- EGG & acoustic measures (Praat scripts, VoiceSauce and EGGWorks)
  - Waveform characteristics: Frequency ratio and Amplitude ratio between two alternating glottal pulses
  - Glottal constriction measures: Contact quotient (CQ), Peak increase in contact (PIC), Speed Quotient (SQ)
  - Spectral tilt measures: H1*–H2*
  - Periodicity measures: Harmonics-to-noise ratio (HNR)

EGG WAVEFORM LANDMARKS



$$T_l + T_s = T_0$$

Frequency ratio $R_T = \frac{T_l}{T_s} = \frac{f_h}{f_l}$

Amplitude ratio $R_A = \frac{A_l}{A_s}$

	Overall mean	Am	Fm	Women	Men
R_T	1.52 (0.23)	1.44 (0.13)	1.90 (0.34)	1.55 (0.24)	1.48 (0.15)
R_A	2.03 (0.71)	2.07 (0.78)	1.63 (0.35)	1.75 (0.81)	1.71 (0.55)

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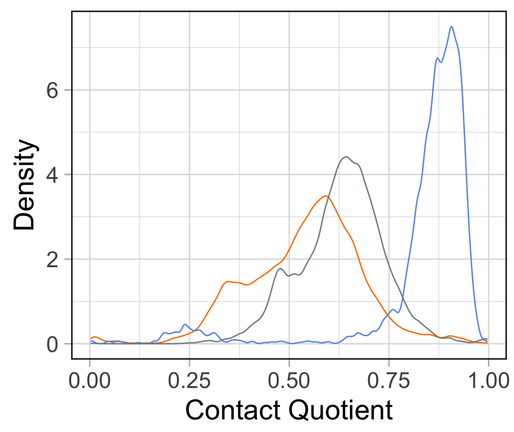
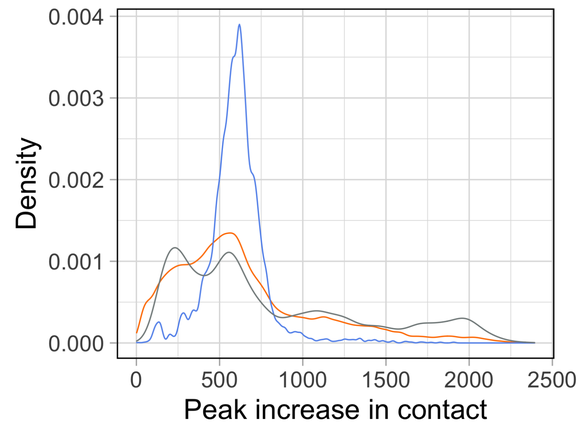
ARTICULATION RESULTS

PD ~= modal voice < vocal fry

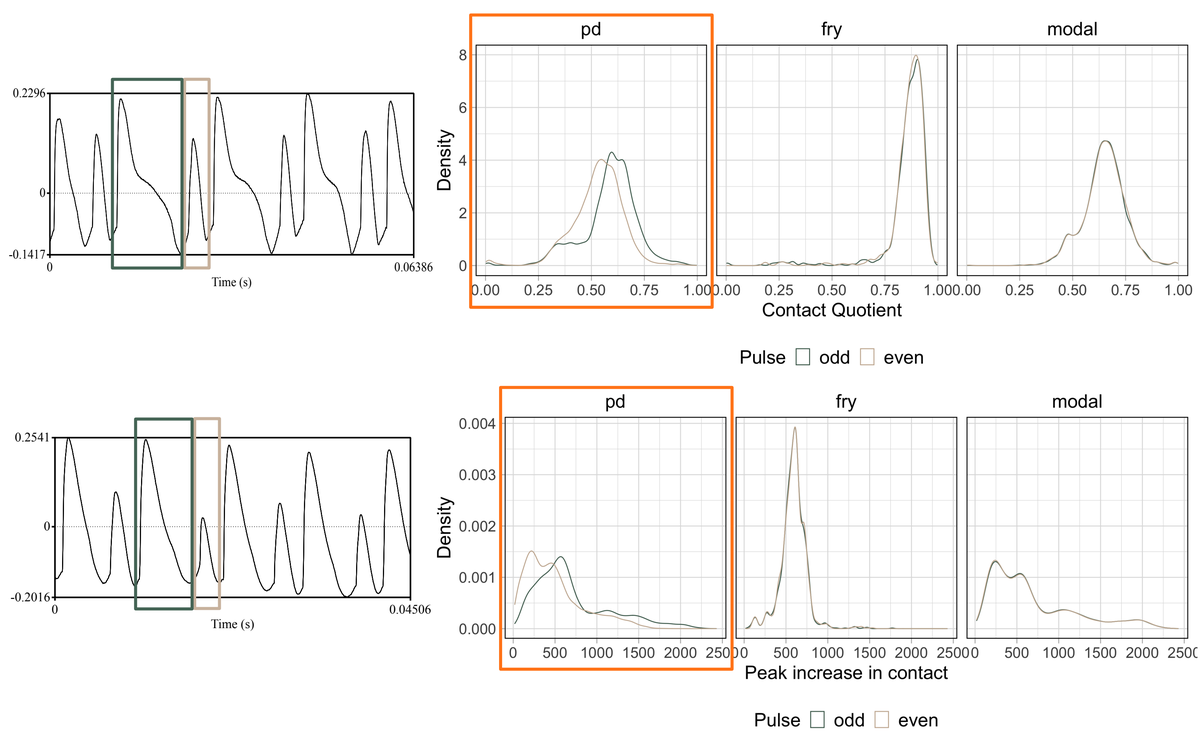


- CQ = the proportion of the cycle during which the vocal folds are in contact
- Higher = more constricted



- PIC = Maximum speed of contacting slope
- Higher = more abruptly closing

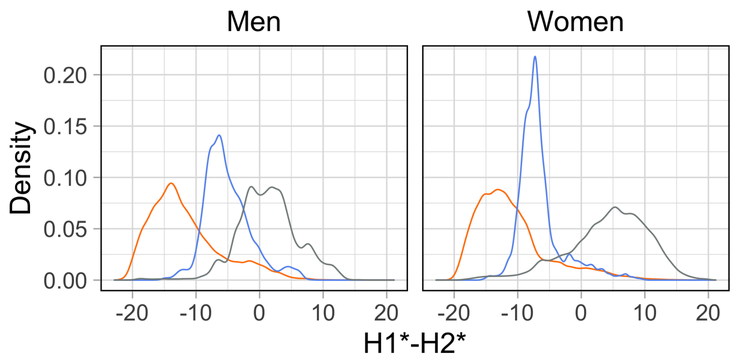
PD pulses alternate between CQ/PIC values



ACOUSTICS RESULTS

- H1*–H2*: correlated with glottal adduction
- Lower = more constricted
- Higher = breathier
- HNR: measure of noise around f0
- Lower = noisier
- Higher = more regular voicing

PD < vocal fry < modal voice



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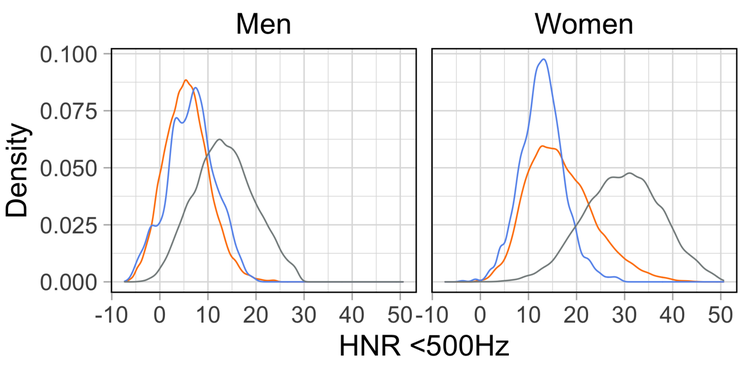

DISCUSSION & CONCLUSION

✓ Articulation: Period doubling is produced with alternating amplitudes and/or frequencies and degrees of glottal constriction with different **voice qualities** and **pitches**

✓ Acoustics: Period doubling is distinct from vocal fry and modal voice

✓ Period doubling may have a different linguistic distribution from other kinds of creaky voice (e.g., vocal fry) and affect lexical tone perception differentially (future study)

References

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