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EXPLORATION AND CLASSIFICATION OF VOCAL FRY, PERIOD DOUBLING, AND MODAL VOICE USING ACOUSTIC AND EGG MEASURES

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I. OVERVIEW

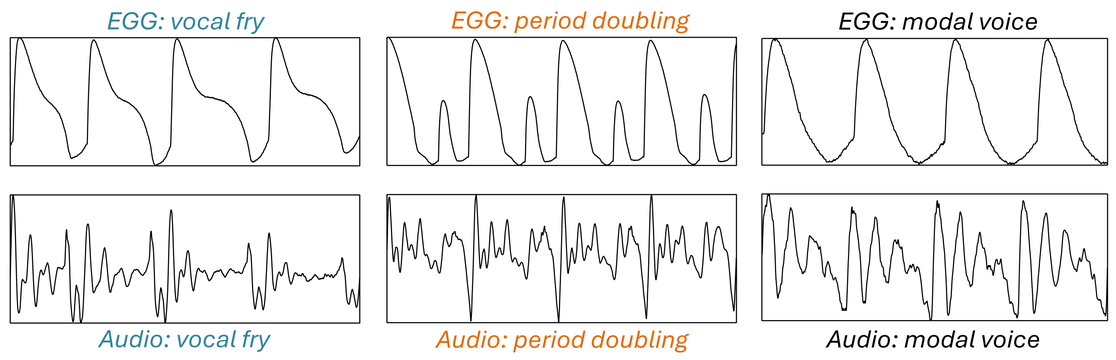
Creaky voice differs from modal voice in acoustic & phonatory properties, but how subtypes of creaky voice differ is less clear.

Existing classification of creak subtypes are mainly based on acoustic waveforms (Hedelin & Huber 1990, Redi & Shattuck-Hufnagel 2001)

***Q:* How do subtypes of creaky voice differ in their acoustic and phonatory properties?**

Common acoustic attributes of creaky voice	Low f0	Low spectral tilt	Irregular f0	Others
prototypical	x	x	x	
vocal fry	x	x		damped pulses
period doubling	alternation	x		subharmonics
aperiodic		x	x	

After Keating et al. 2015, Huang 2022



***Goal*: evaluate the importance of source and filter characteristics in distinguishing between vocal fry, period doubling (PD), and modal voice**

- Most important **acoustic** measures: **f0, H1-H2, H1, SoE, H2, H4, and HNR (0-500Hz)**
- Most important **phonatory** measures: **duration of the glottal opening phase** and **contact quotient** of the glottal pulse

II. METHODS

- Simultaneous recordings of audio and electroglottography (EGG) of continuous read speech in Mandarin (Huang 2024)
- 20 university students (10F); 480 sentences/recording
- Fixed carrier sentence with varying trisyllabic words + picture fillers
- wo3 tɕau1 nji3 STIMULUS tsən3 mɤ5 ʂwo1
- "I teach you how to say the STIMULUS."
- Tokens of vocal fry, PD, and modal voice were located using EGG

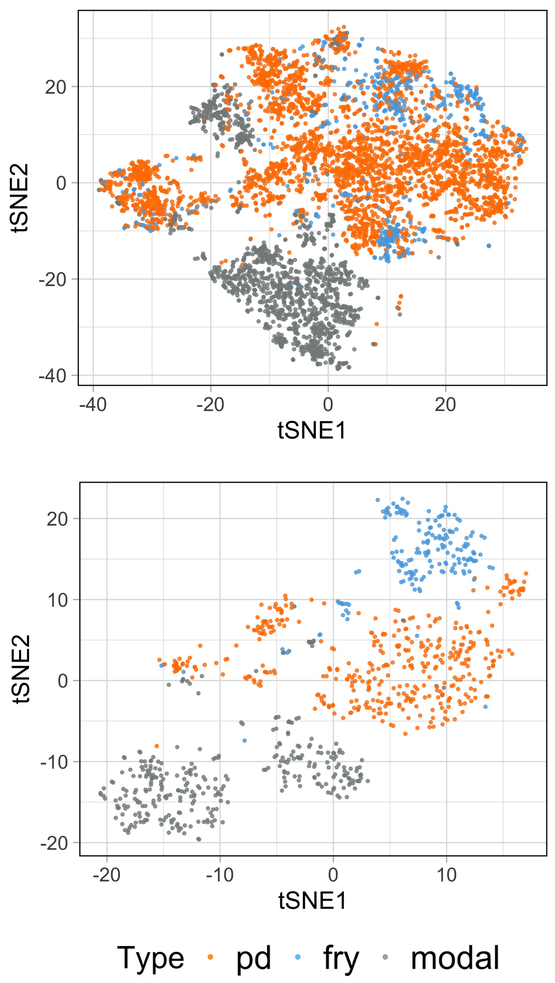
32 acoustic & 11 EGG normalized measures (VoiceSauce, EGGWorks):

- Harmonics & spectral tilts: e.g., H1*, H2*, H4*, H2K*, A1*, A2*, A3*, H1*–H2*, H2*–H4*, H1*–A1*, H1*–A2*, H1*–A3*, H4*–H2K*
- HNRs, CPP, SHR (subharmonic-to-harmonic ratio)
- Formants & bandwidths; Energy measures
- Contact quotient (CQ), Cycle peak/minimum velocity/time, Speed Quotient (SQ); Contacting and opening duration

t-SNE clustering & ML models:

- Multinomial logistic regression with *l1* regularization (Lasso)
- Random forest model
- Cross-validation: 2/3 training & 1/3 test sets

III. T-SNE CLUSTERING



Acoustics dataset

	Vocal fry	Period doubling	Modal
Women	482	2354	1175
Men	156	943	428
Total	638	3297	1603

5538 rows x 33 cols (gender coded as 0/1)

Acoustics + EGG dataset

	Vocal fry	Period doubling	Modal
Women	154	324	187
Men	25	91	137
Total	179	415	324

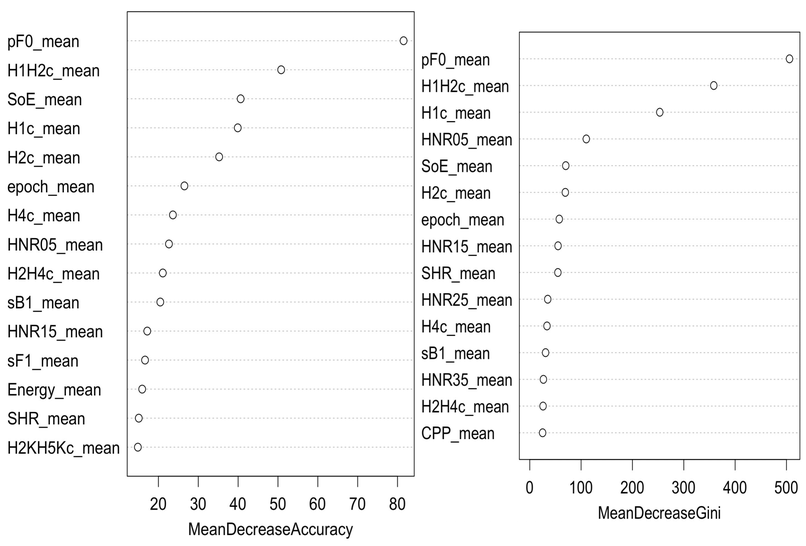
918 rows x 44 cols (gender coded as 0/1)

IV. CLASSIFICATION RESULTS

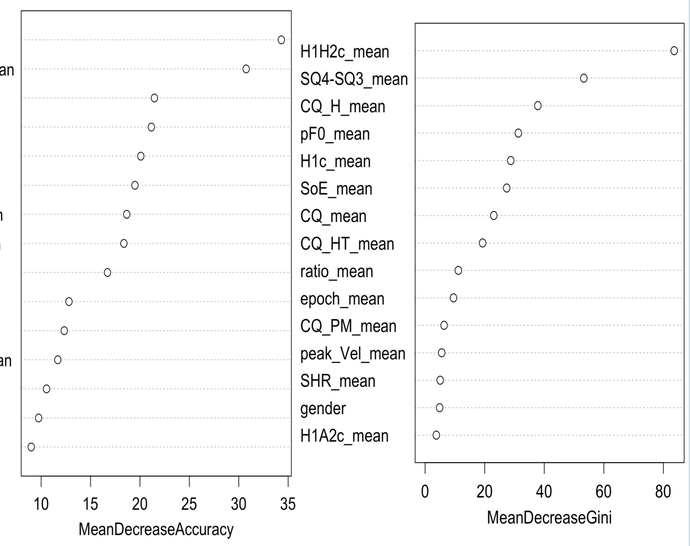
Accuracy, precision, recall scores in two datasets

Acoustic	Lasso regression	Random forest
Accuracy	0.9112	0.9312
Macro avg. precision	0.8749	0.9098
Macro avg. recall	0.8137	0.8529
Acoustic + EGG	**Lasso regression**	**Random forest**
Accuracy	0.9837	0.9967
Macro avg. precision	0.9840	0.9975
Macro avg. recall	0.9784	0.9970

Top 15 important acoustic measures



Top 15 important acoustic + EGG measures



V. DISCUSSION & CONCLUSIONS

- Phonatory measures such as EGG contribute to the separation of subtypes of creaky voice
- Voicing types have stronger ties to the source dynamics associated with our vocal folds than the filter
- Mapping between perception and acoustics is direct, but what about phonatory characteristics? How are they accessible to listeners?

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