How do listeners identify creak?

The effects of pitch range, prosodic position and creak locality in Mandarin

Aini Li[1], Wei Lai[2], Jianjing Kuang[1]
1: University of Pennsylvania
2: Vanderbilt University

Speech prosody 2022, May 25

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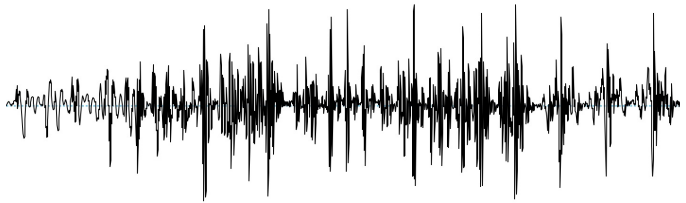
Creak

- **Creak**: a phonation type in which the arytenoid cartilage in the larynx are drawn together such that the vocal folds are more constricted.



- Characteristics of creak:

Slow vocal fold vibration	**Irregular vocal fold vibration**	**Glottal constriction**	Damped pulses	Sub-harmonics

- Contrastive vs. non-contrastive

Allophonic Creak

- Non-contrastive creak is linguistically associated with:
  - **Prosodic position**
    - sentence-final positions (Redi and Shattuck-Hufnagel 2001; Garellek 2015, Kuang 2018)
    - unstressed syllables: e.g., Neutral tone in Mandarin (Kuang 2018)
  - **Pitch range**
    - low pitch range (Hollien and Michel 1968; Blomgren et al 1998; Kuang 2017):
    - low tonal categories (Belotel-Grenié & Grenié 1994, 1997, 2004; Yu & Lam 2014; Kuang 2017, Huang 2020) : Tone 3 (& Tone 4) in Mandarin

Allophonic Creak

- Non-contrastive creak bears social connotations:
  - **Emotions**: creak ~ boredom, sadness (Laver 1980; Gobl & Chasaide 2003)
  - **Social status**: creak ~ higher social status (Esling 1978; Pittam 1987)
  - **Persona construction**: creak ~ certain personas such as “hardcore Chicano gangster” (Mendoza-Denton 2011; Esposito 2016, 2017)
  - **Gender**: creak ~ women in US (Yuasa 2010; Wolk et al 2012; Henton 1989; Davidson 2019)

Research question

How do factors such as **prosodic position**, **pitch range (or gender?)**, and **tone** influence listeners' identification of creak?

Research question

- Perception of creak
    - **Prosodic position**: final < nonfinal (Davidson 2019, Garellek 2015)
    - **Pitch range**: extremely low pitch = creak (Davidson 2020)
    - **Creak locality**: wholly creaky utterances > partially creaky fragments (Davidson, 2019)
    - **Gender**: rates of identifying creak in male and female speakers are similar (Davidson 2019)
- What about languages where tone also interacts with creaky voice?

This study: Mandarin creak identification

Mandarin creak identification

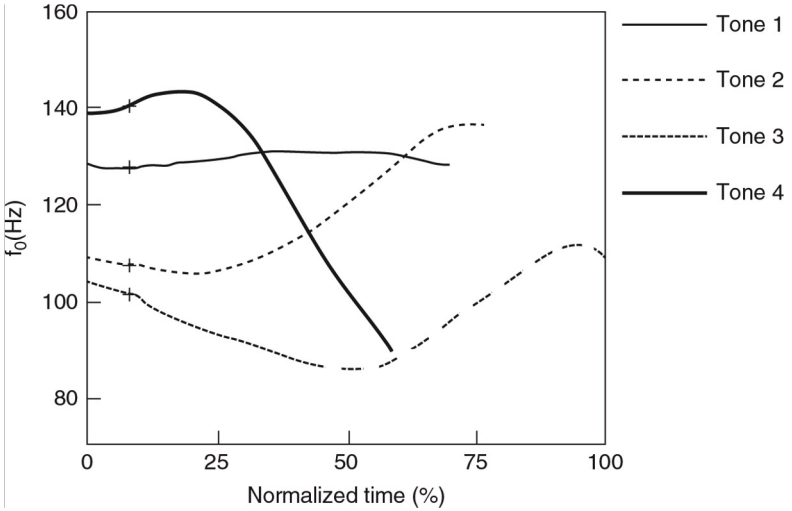
Mandarin creak identification

Experimental design

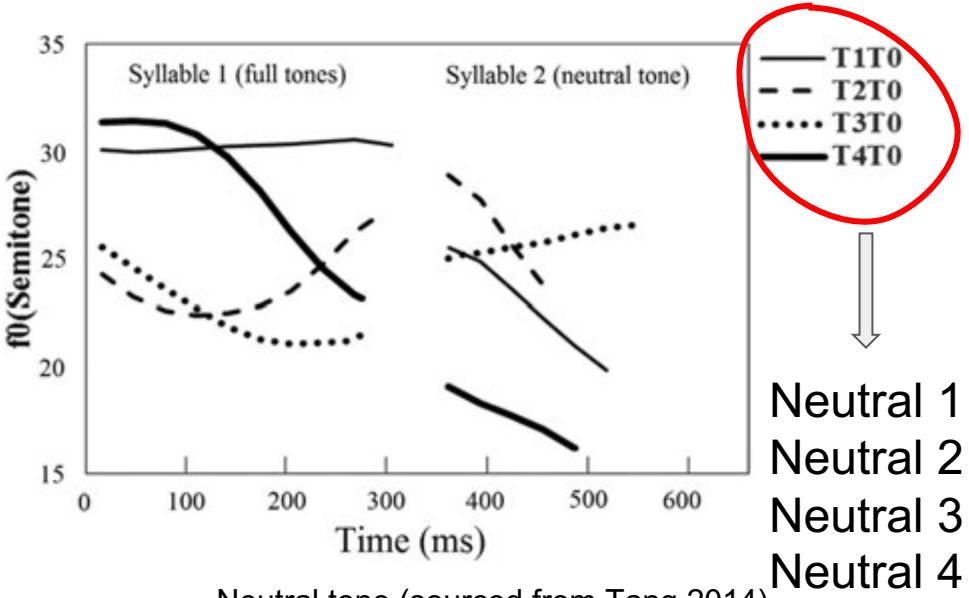
- A 8 (Tone) X 2 (Pitch range) X 2 (Prosodic position) X 3 (Creak locality) within-subject design
    - **Pitch range**: high vs. low
    - **Prosodic position**: sentence final vs. non-final
    - **Creak Locality**: global vs. local vs. modal
    - **Tone**: lexical tones (T1, 2, 3, 4) and neutral tone (T0)

Mandarin creak identification

Mandarin tones



Lexical tones (sourced from Xu 1997)



Neutral tone (sourced from Tang 2014)

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Experimental design

Table 1: A schema of the experimental design

Sentence	Tone	Prosodic position	Creak locality
MMMMMMMCCCCC	T1	Final	Global creak
MMMMMMMMMMMC	T2	Final	Local creak
MMMMMMMMMMMM	T3	Final	Modal
MMMMMMMMMMMM	T4	Final	Modal
CCCCCMMMMMMM	N1	Nonfinal	Global creak
MCMMMMMMMMMM	N2	Nonfinal	Local creak
MMMMMMMMMMMM	N3	Nonfinal	Modal
MMMMMMMMMMMM	N4	Nonfinal	Modal

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Stimuli creation

- 64 declarative sentences
- 12-syllable long with the same syntactic structure (NP1 - VP - NP2), varying in content and lexical items
- NP1 and NP2 are disyllabic **person names** and only the tone of the second syllable was different (X **Y1** vs. X **Y2**)
- Names were all sonorants

(1) 李艾在公园散步碰到了李哀[1]。
Li Ai4 zai gongyuan sanbu pengdao le **Li Ai1**.
Li Ai4 at park walk met ASP Li Ai1
'Li Ai4 met Li Ai1 while taking a walk in the park'.
1: highlighted are creak-containing target syllables

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Recording & manipulation

- 64 sentences naturally produced by a female native speaker (mean pitch: **225Hz**)
- Sentences were produced in equalized speech rates (40 bpm) to control for speech rate
- Digitized at a sampling rate of 44,100 Hz and 32 bit sample width
- Each sound file lasted around 2.5 seconds in duration

- Manipulated into low-pitched targets by adjusting vowel formant frequencies and pitch range (mean pitch:**110Hz;** vowel formant ratio: **0.75**)
- Normalized to an average intensity of 65 dB

- In the end: 128 audio files - unnatural ones (4) = 124 critical stimuli

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Participants

- 40 native monolingual speakers (8 M, 33 F, aged 19-36) of Mandarin recruited from the mainland of China

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Procedure

- An online survey conducted using Qualtrics

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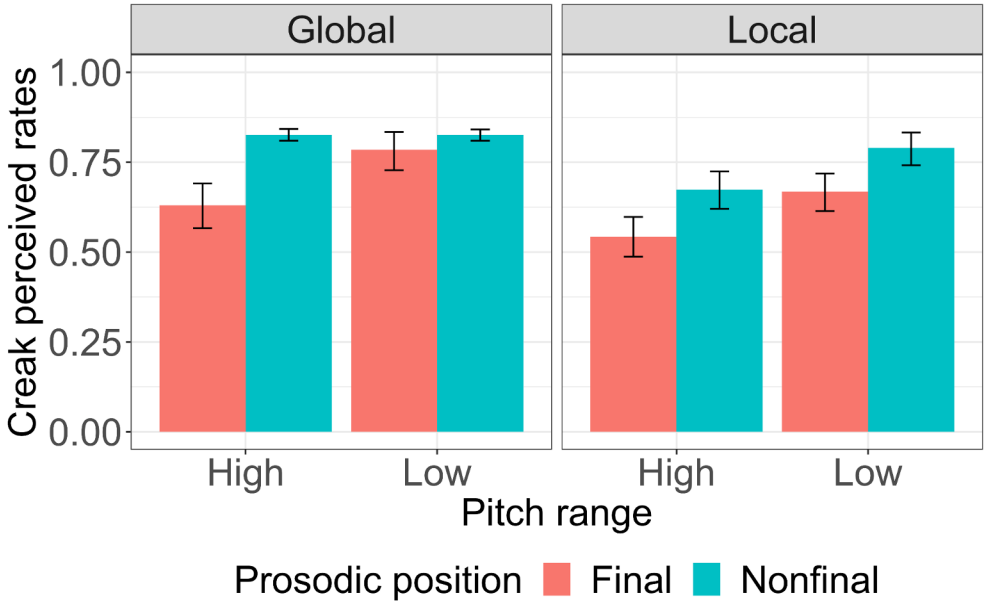
Results: creaky syllables

- Perceived creak~ creak locality * prosodic position * pitch range



Global creak ↑ ***

High pitch range ↓ ***

Sentence final ↓ ***

High pitch range x Final ↓ *

Global creak x Final ↓ ***

High pitch range x Global x Final ↓ **

Mandarin creak identification

Interim summary

- Creaky syllables are easier to be identified when their surrounding syllables are also creaky
- Creaky syllables are harder to be identified in utterance-final positions
- Creaky voice is identified more often in the low-pitched voice

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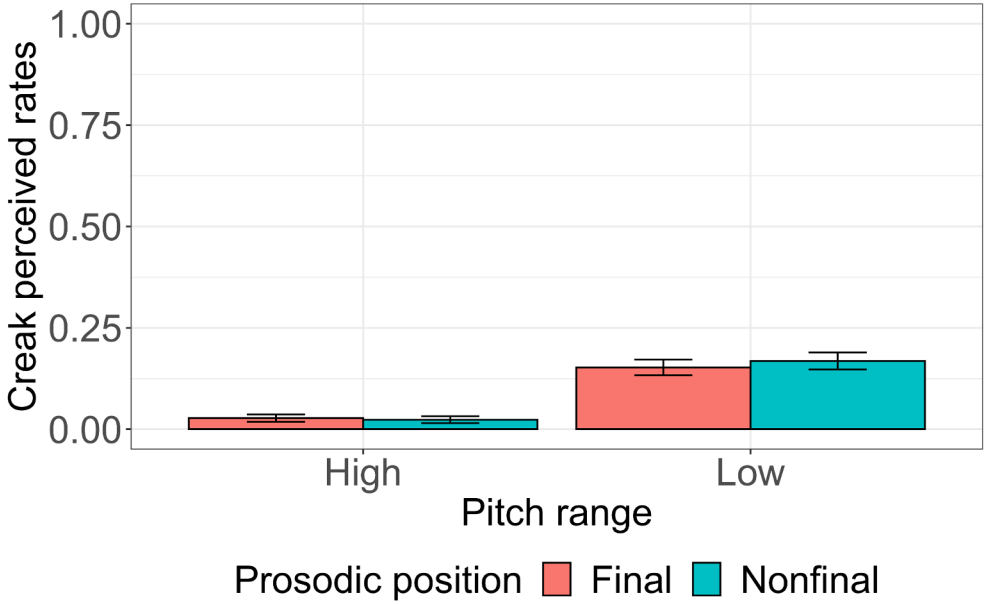
Results: modal syllables

- Perceived creak ~ prosodic position * pitch range



High pitch range ↓

Sentence final —

High pitch range & Final —

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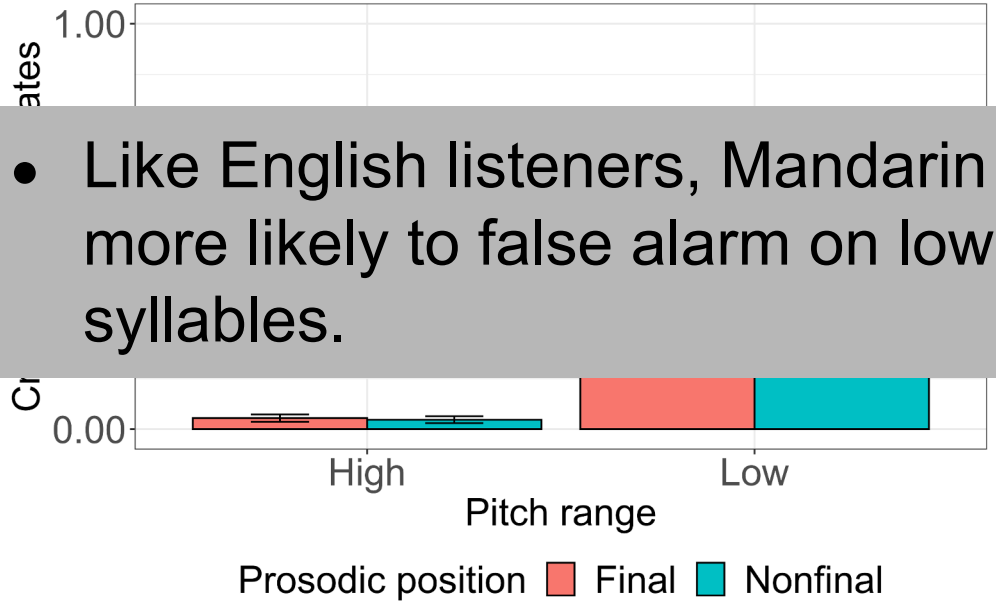
Results: modal syllables

- Perceived creak ~ prosodic position * pitch range



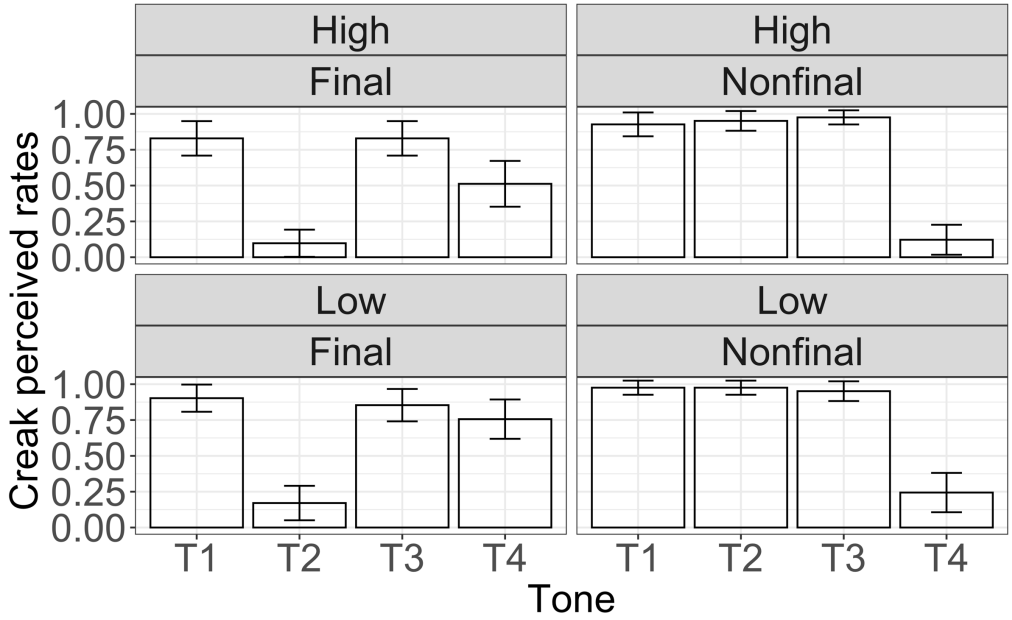
- Like English listeners, Mandarin listeners are more likely to false alarm on low-pitched modal syllables.

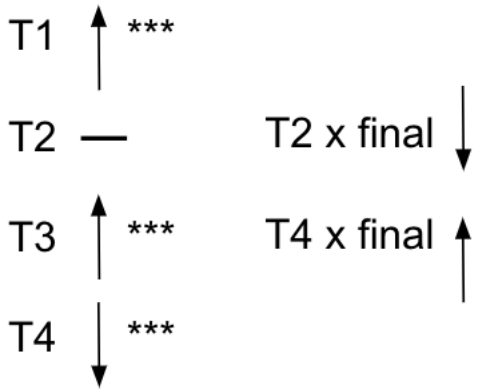
Final —

Mandarin creak identification

Results: local creaky syllables: lexical tones

- Perceived creak ~ tone + prosodic position + pitch range + tone * prosodic position + pitch range * prosodic position





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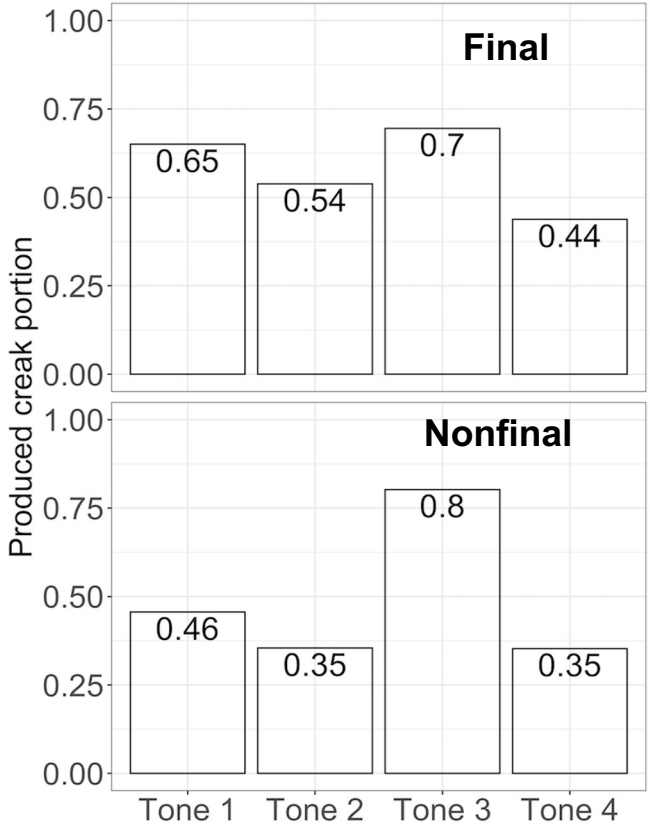
Results: local creaky syllables

- Produced creak portion

Tone 1 and Tone 3 > Tone 2 and Tone 4



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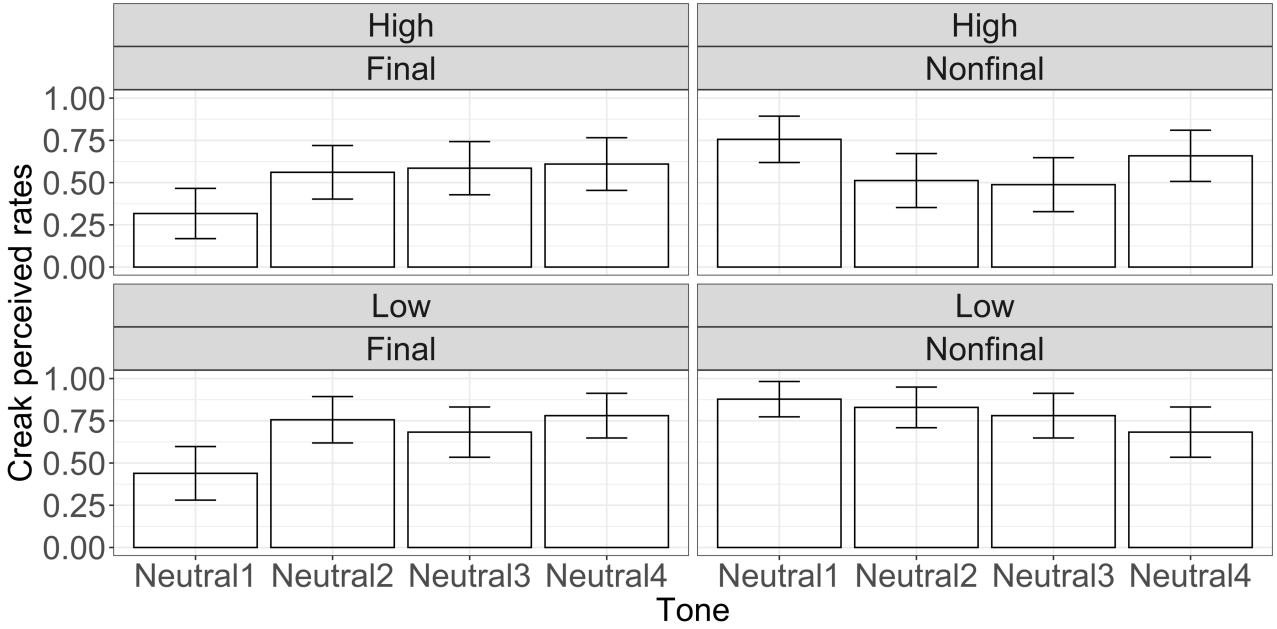
Results: local creaky syllables: neutral tone

- Perceived creak ~ tone + prosodic position + pitch range + tone * prosodic position + prosodic position * pitch range



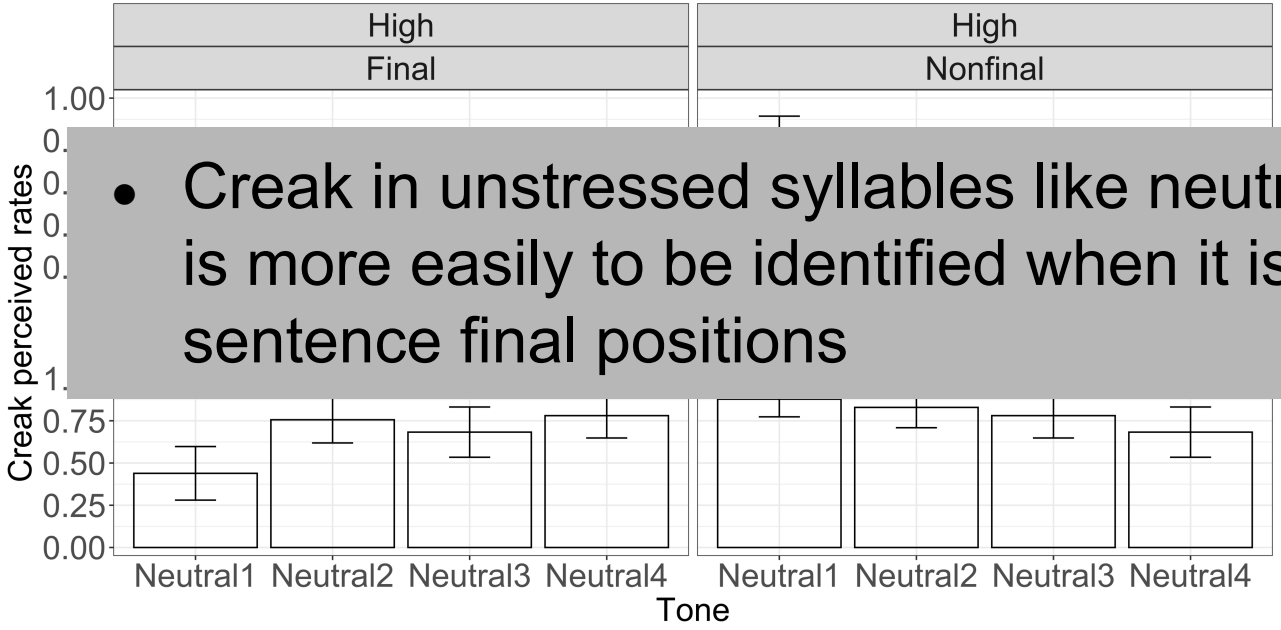
Neutral 2: —
Neutral 3: —
Neutral 4: —

Neutral 2 x final
Neutral 3 x final
Neutral 4 x final

Mandarin creak identification

Results: local creaky syllables: neutral tone

- Perceived creak ~ tone + prosodic position + pitch range + tone * prosodic position + prosodic position * pitch range



- Creak in unstressed syllables like neutral tone is more easily to be identified when it is in sentence final positions

Neutral 2: —

— x final

— x final

Neutral 4 x final

Mandarin creak identification

Discussion & conclusion

- Creak is easier to be identified when the surrounding syllables of target syllables are also creaky
- Low **pitch range** facilitates creak identification for creaky syllables and false alarms for modal syllables
- Creaky syllables in sentence **final positions** are hard to be identified

Mandarin creak identification

Discussion & conclusion

- Creak identification is influenced by tone: 1) by how much creak was produced for each tonal category; 2) by contour shape which is further modulated by prosodic position — non-final: rising > falling; final: falling > rising
- Creak in unstressed syllables like neutral tone is more easily to be identified when it is in sentence final positions

Mandarin creak identification

Discussion & conclusion

- Similar to English, creak identification in Mandarin is more influenced by its phonetic contexts (than its social connotations)

Thank you for your attention!

Acknowledgement: special thanks also goes to Marc Garellek, Nicole Holliday and members of the Penn Phonetics Lab for their suggestions and comments.