**Introduction**

Multidimensional cues: Chinese Wu dialects use redundant cues to distinguish between upper and lower tonal registers (Cao & Maddieson, 1992; Zhang & Yan, 2015; Jiang & Kuang, 2016)

- Pitch (onset FO): Upper ~ high, Lower ~ low
- Phonation: Upper ~ modal, Lower ~ breathy
- Contour: steepness/lateness is realized slightly differently

Dialectal difference: Shanghai speakers are argued to be in the process of losing breathiness (e.g. Gao & Halle, 2013), lower register is less breathy.

Individual variability: Group-level results do not present how individuals use cues differently, and whether there is structured variability (e.g. Kong & Edwards, 2016)

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**Results: Group-level**

**Experiment 1**

- Static linear mixed-effect model
  - Main effects: Breath + Pitch + Contour
  - Random effects: by-participant random intercept and slopes (including two-way interactions)
  - Cue weights are main effect coefficient estimates

**Experiment 1:**

- All three cues significant for JS and SH
- Primary cue: pitch for SH, contour for SH
- JS has higher weight for breathiness

**Experiment 2**

- Statically significant correlation: contour ~ pitch + breath

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**Results: Individual Variability**

Weights are coefficients from simple logistic regression models fitted for each individual; spearman’s rho

**Experiment 1**

- JS: Positive correlation: pitch – breath
  - Negative correlation: contour – pitch + breath
- SH: no significant correlation

**Experiment 2**

- JS: Positive correlation: pitch – breath
- No significant correlation with contour
- SH: no significant correlation

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**Discussion: Individuals**

**Individual differences**

JS: positive correlation between physiologically related cues (pitch and breathiness), negative correlation between contour and pitch + breathness

**Conclusion**

- The role of secondary cues: increase cue weight when other cues are ambiguous; shift cue weight for different tones (Jiashan);
- Structured individual variability: the more a Jiashan listener uses pitch, the more they use breathiness (positive correlation), and the less they use contour (negative correlation)
- Indication: listeners first integrate physiologically related cues, and then choose between independent, redundant cues in multidimensional contrasts.
- Dialectal difference: Shanghai listeners have smaller weights for breathiness, not sensitive to the degree of breathiness, not much individual variability

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**Reference**