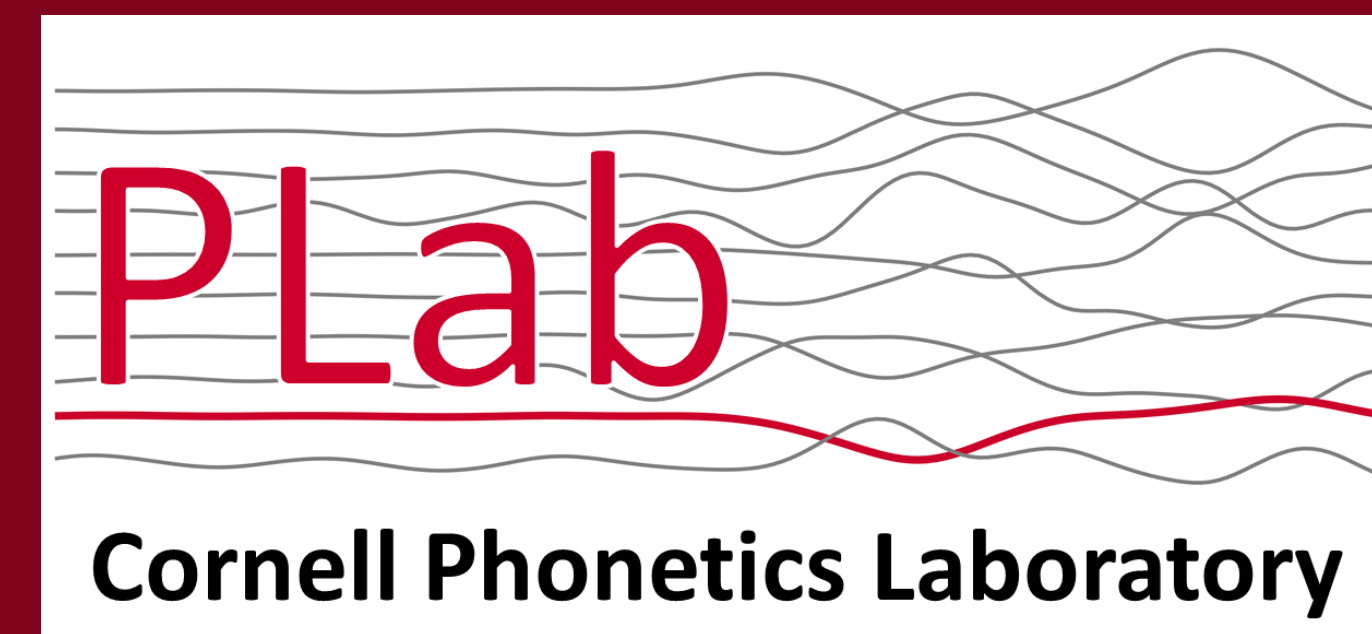


# Laryngeal elevation in native and non-native lexical tone production

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## 1 Motivation

Acoustic studies show native and non-native speakers differ in tone precision, but **articulation differences** remain understudied. Both laryngeal elevation (extrinsic) and cricothyroid contraction (intrinsic) contribute to f0 modulation.

**Laryngeal ultrasound** offers a novel window into extrinsic laryngeal control during tone production [1,2,3].

**Hypothesis:** Learning to produce tones involves reweighting articulatory strategies, shifting from extrinsic toward intrinsic f0 control.

**Prediction:** Elevation-f0 correlations are weaker in native than non-native speakers during tone production.

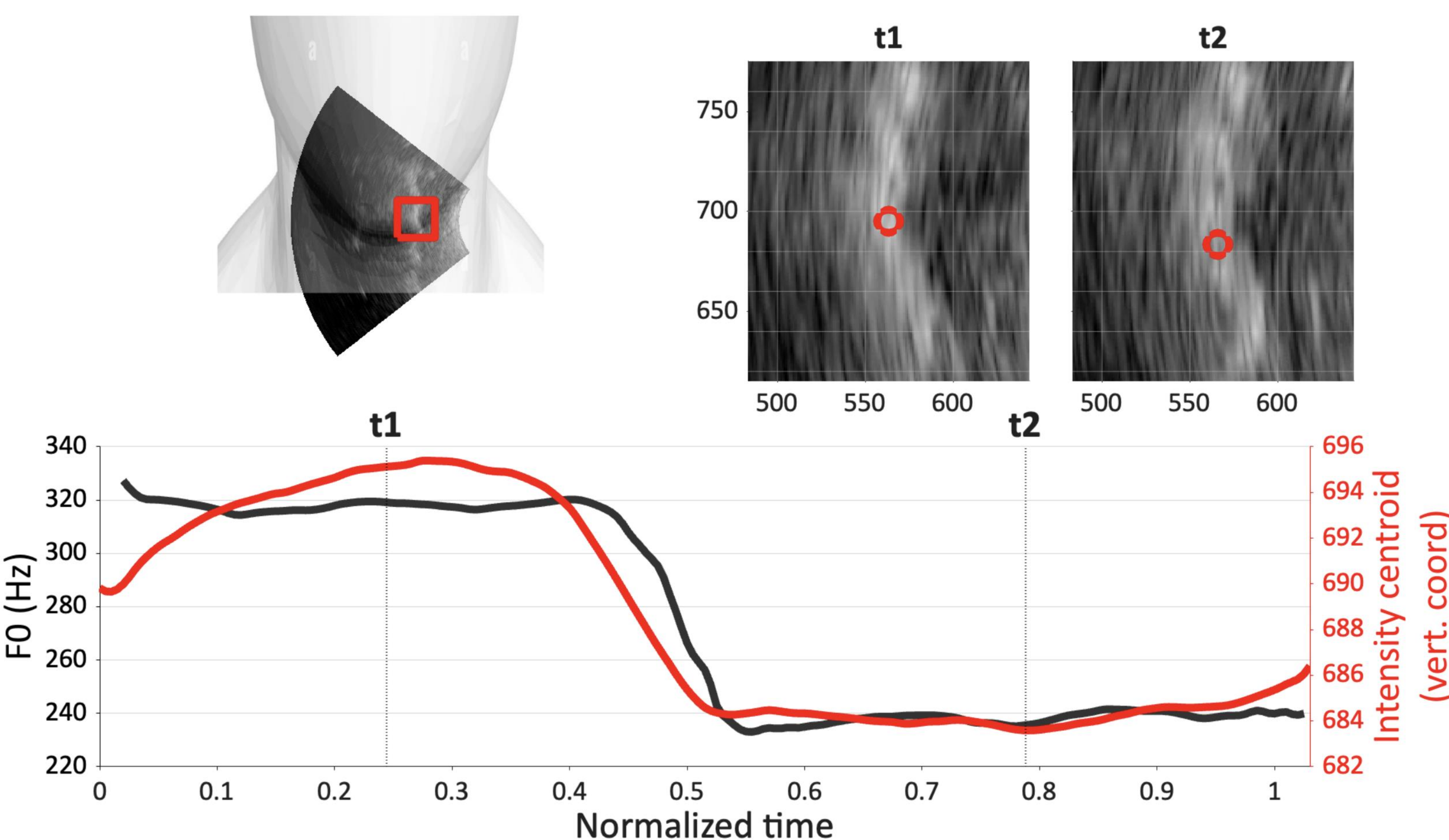
## 2 Coronal-orientation laryngeal ultrasound

**Four participants:** 2 native Mandarin speakers, 2 phonetically trained non-native speakers.

**Tasks:** high-to-low (HL) and low-to-high (LH) pitch sweeps + four Mandarin tones on *ma*.

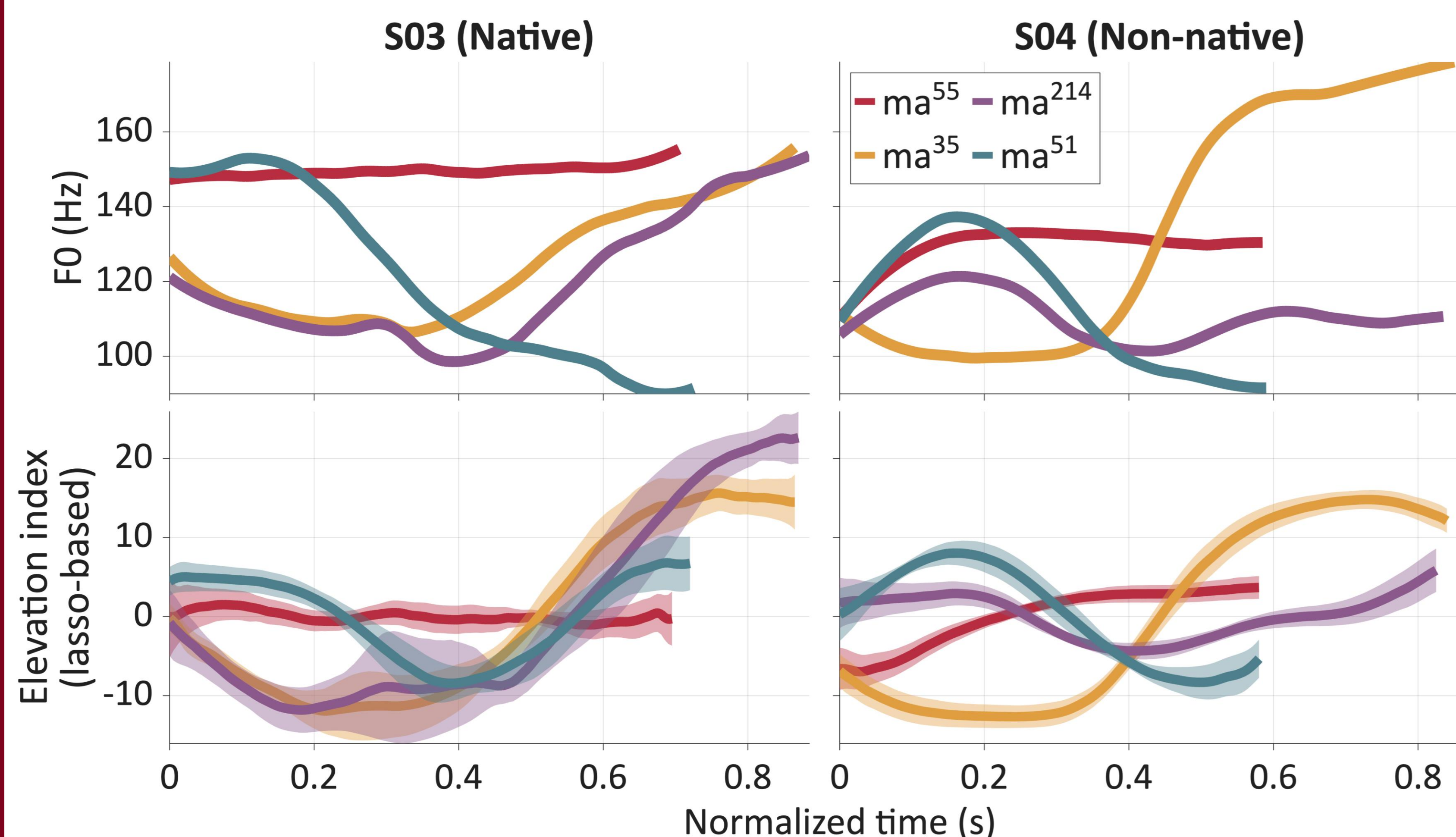
**Two measures of laryngeal elevation**

- *Centroid*: tracks vertical center of pixel intensity
- *Lasso-weighted sum*: weighted sum of pixel intensity sampled on a semipolar image grid, with weights from averages of lasso regressions predicting f0.

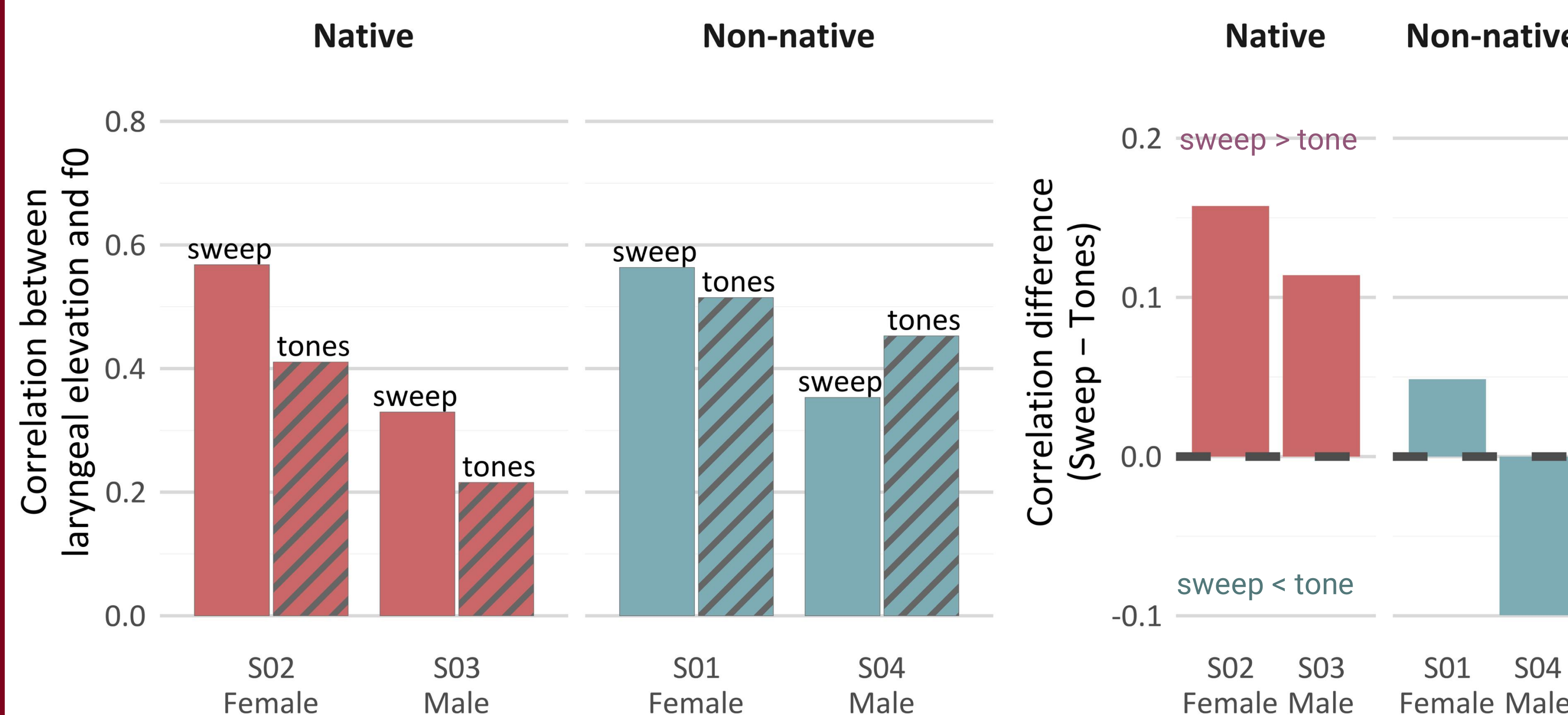


## 3 Results: native and non-native speakers differ in how laryngeal elevation relates to f0 across tasks.

**1. Laryngeal elevation positively correlates with f0** across participants and tasks (replicates prior work [1, 4])



**2. Native speakers show stronger elevation-f0 correlations in sweeps than tones; non-native speakers show weaker or reversed correlations.**



## 4 Discussion

**Assumption:** Pitch sweeps reflect maximal utilization of laryngeal elevation, providing a baseline reference for extrinsic laryngeal control.

**In sweeps:** Strong positive correlation between laryngeal elevation and f0 → extrinsic control is active and available in both groups.

**In tones:** Such correlation drops substantially for native but not non-native speakers for tones.

**Interpretation:** Native speakers have learned to exploit intrinsic (cricothyroid) control of f0 as well, and may prefer it in normal speech, consistent with least-effort and/or motor equivalence principles.

## 5 Take-aways

- ① **Coronal-orientation laryngeal ultrasound** can track laryngeal elevation, which correlates with f0.
- ② **Native and non-native speakers differ** in elevation-f0 coupling across tasks.
- ③ **Speech learning may involve a reweighting of articulatory strategies.**

## 6 References

- [1] Moisk, S. R., Lin, H., & Esling, J. H. (2014). A study of laryngeal gestures in Mandarin citation tones using simultaneous laryngoscopy and laryngeal ultrasound (SLLUS).
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- [3] Schweizer, D., Brunelle, M., Ahn, S., & Audet, A. (2025). A laryngeal and lingual ultrasound study of the Canadian French voicing contrast.
- [4] Honda, K., Hirai, H., Masaki, S., & Shimada, Y. (1999). Role of Vertical Larynx Movement and Cervical Lordosis in F0 Control.

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