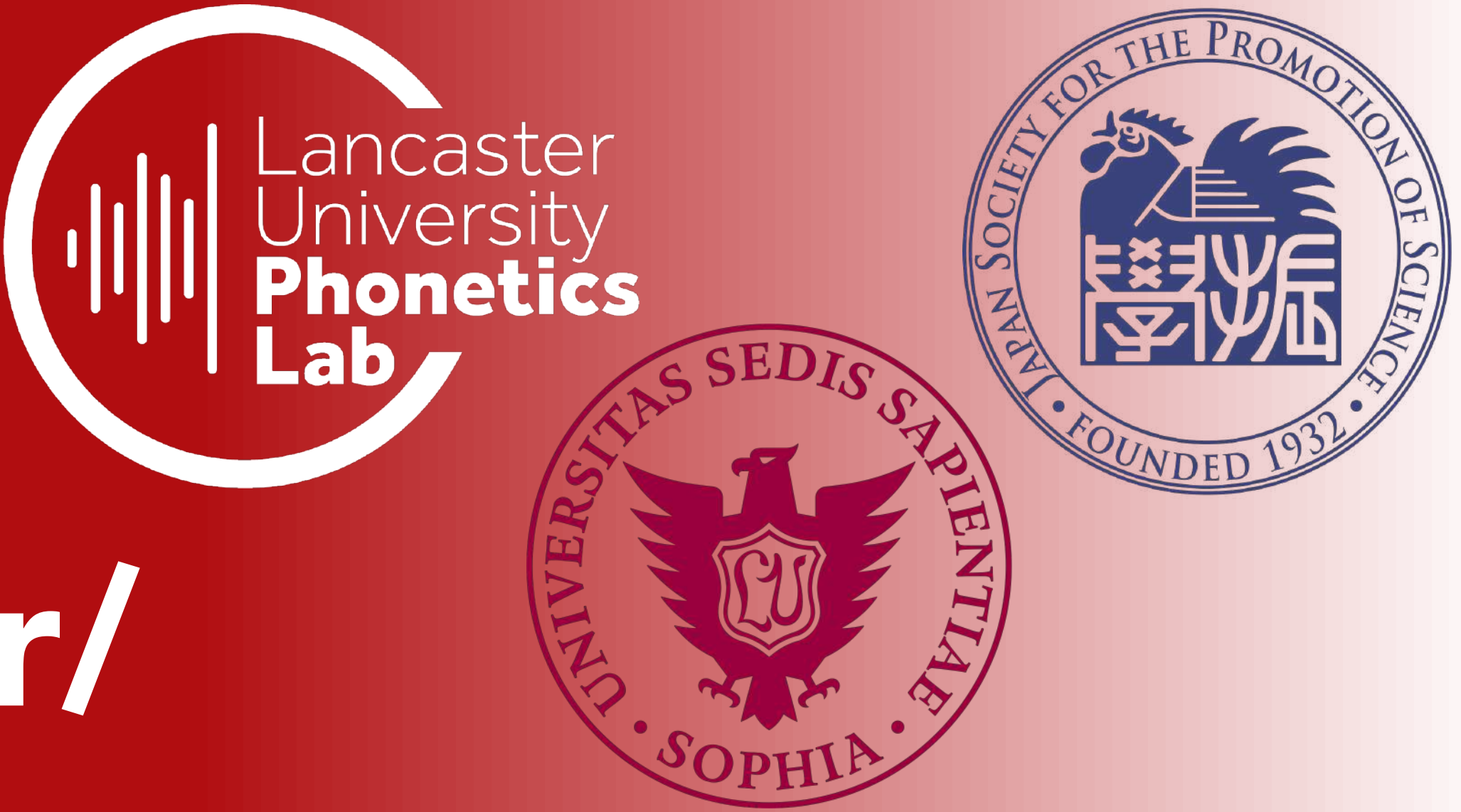


Spatio-temporal properties of Japanese coronal consonants: An ultrasound study of /d/ and /r/



Maho Morimoto Sophia University / JSPS
maho.morimoto.jp@gmail.com

Takayuki Nagamine Lancaster University
t.nagamine@lancaster.ac.uk

Background:

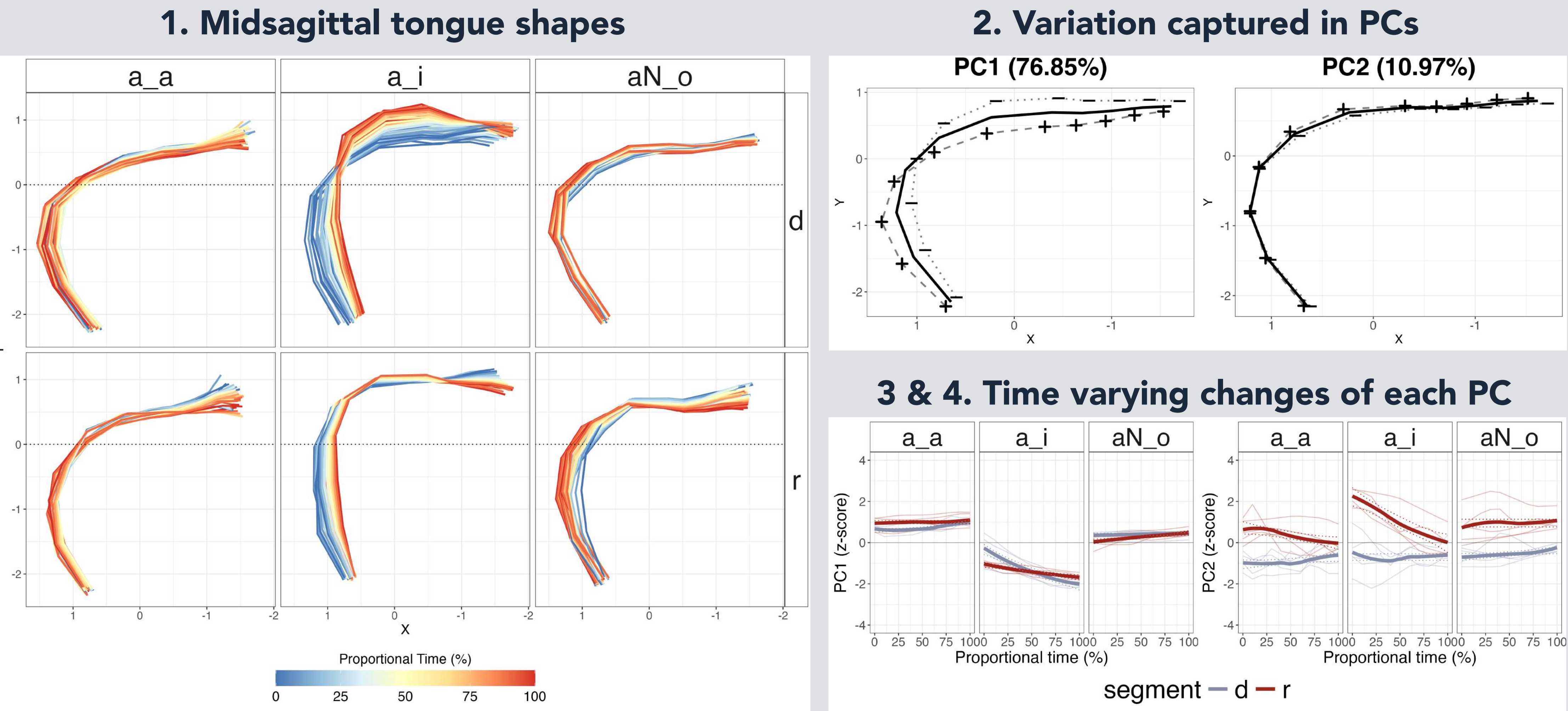
Japanese /r/ = weak /d/?

- Japanese /r/ is canonically produced as **alveolar taps or flaps** [r]^[1]
- There is also a wide range of allophonic variations including **[d]-like realizations** phrase-initially & **after nasals**^[2]
- Electropalatography (EPG) studies suggest differences between /r/ and /d/: /r/ shows a **varying degree of tongue tip contact** across vowel contexts^[3, 4]
- This study aims to complement the above findings by **providing ultrasound data** to investigate **articulatory differences between /r/ and /d/ in Japanese**

Methods

- Simultaneous ultrasound & audio recording from one male speaker (21 years old)
- Using the MicrUS system, recorded with Articulate Assistant Advanced (AAA)^[5]
- Tokens of /r/ and /d/ elicited in three vowel contexts: **a_a**, **a_i**, and **aN_o**
- Phonemic boundaries were determined acoustically using Montreal Forced Aligner
- Tongue splines were estimated using DeepLabCut on AAA

Results



- Qualitative differences in midsagittal tongue shape, especially in the a_i context
- The principal component analysis (PCA) identifies **tongue dorsum retraction** (PC1) and variation around the tongue body (PC2) as major lingual dimensions
- Time-varying changes in **PC1** suggest that:
 - /r/ exhibits a **retracted tongue dorsum** compared to /d/ in **a_i** context
 - /r/ and /d/ are largely comparable in a_a & aN_o contexts
- Time-varying changes in **PC2** suggest that:
 - the tongue body is more raised for /r/ than for /d/
 - the difference between /r/ and /d/ is consistent throughout the consonantal interval

Discussion: Japanese /r/ is not weak /d/.

- Key articulatory differences between /d/ and /r/ in **tongue retraction and stabilization** (captured by PC1)
 - Overall retracted tongue dorsum for /r/ in a_a context^[6]
 - Different dorsal movements in a_i context with indication of dorsal stabilization for /r/^[7]
- Similar articulation in aN_o context in which /r/ and /d/ are predicted to be similar
- Slight raising of the tongue body for /r/ (captured by PC2) could result from different manner requirements for /r/ and /d/, with the tongue body slightly compressed for /r/

Next step

- More speakers, more tokens in more vowel contexts!
- Comparison with acoustics: especially in terms of **duration**
- Accounting for dynamic jaw displacement: the current a_i results might result from a **joint effect of tongue movement & jaw closing** transitioning from /a/ to /i/^[8]

Acknowledgements

We thank Professor Takayuki Arai and the Speech Communication Lab at Sophia University. This study was supported by JSPS KAKENHI Grant Number JP20K21979 awarded to M.M.

References

[1] Akamatsu, T. (1997). "Japanese phonetics: Theory and practice (Vol. 3)". Lincom Europa. [2] Arai, T. (2013). "On why Japanese /r/ sounds are difficult for children to acquire". In: Interspeech 2013. Lyon, France: International Speech Communication Association, pp. 2445–2449. [3] Kawahara, S., Matsui, M., & Shaw, J. (2017). "Some aspects of Japanese consonant articulation: A preliminary EPG study". In: ICU Working Papers in Linguistics II, pp. 1–12. [4] Kochetov, A. (2017). "Linguopalatal contact contrasts in the production of Japanese consonants: Electropalatographic data from five speakers". In: Acoustical Science and Technology 39.2, pp. 84–91. [5] Articulate Instruments (2023). Articulate Assistant Advanced version 221.0.0. Articulate Instruments. Edinburgh. [6] Morimoto, M. (2020). "Geminated Liquids in Japanese: A Production Study". PhD Thesis, University of California Santa Cruz. [7] Proctor, M. (2011). "Towards a gestural characterization of liquids: Evidence from Spanish and Russian". In: Laboratory Phonology, 2.2, pp. 451–485. [8] Scobbie, J. M., Wrench, A. A., & van der Linden, M. (2008). "Head-Probe stabilisation in ultrasound tongue imaging using a headset to permit natural head movement." In: Proceedings of the 8th International Seminar on Speech Production, Strasbourg, France: INRIA, pp. 373–376.