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

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Background:
Japanese /r/ = weak /d/?

- Japanese /r/ is canonically produced as **alveolar taps or flaps [ɾ]** [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

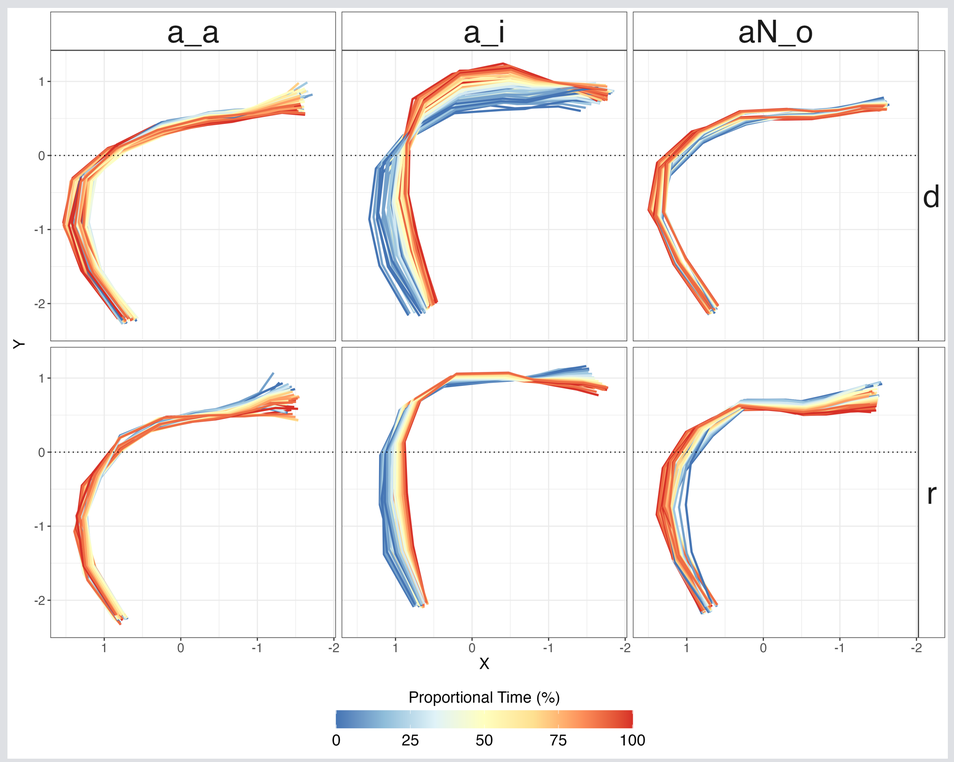
- Simultaneous ultrasound & audio recording from one male speaker (21 years old)
- Using the MicrUS system, recorded with Articulate Assistant Advanced (AAA) [5]
- Tokens of /r/ and /d/ elicited in three vowel contexts: **a_a**, **a_i**, and **aN_o**
- Phonemic boundaries were determined acoustically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

Word list

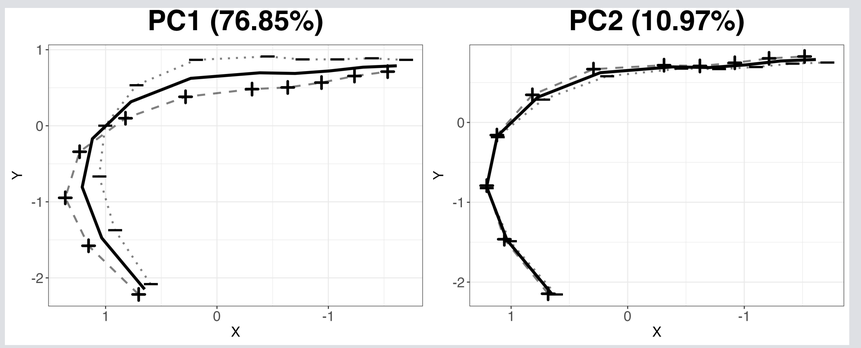
Word		Gloss
仇	/ada/	avenge
粗	/ara/	coarseness
バディー	/badi:/	body/buddy
バリー	/bari:/	Barry
感動	/kaNdou/	sensation
甘露	/kaNro/	honeydew

Results

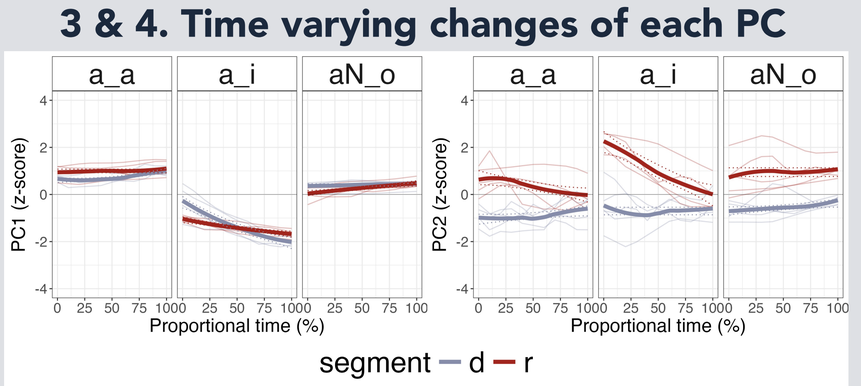
1. Midsagittal tongue shapes



2. Variation captured in PCs



3 & 4. Time varying changes of each PC



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

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References

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