The 12th International Seminar on Speech Production (ISSP2020), New Haven, CT, 14-18 December, 2020

Malayalam three-way rhotic contrast: Articulatory modelling based on MRI data

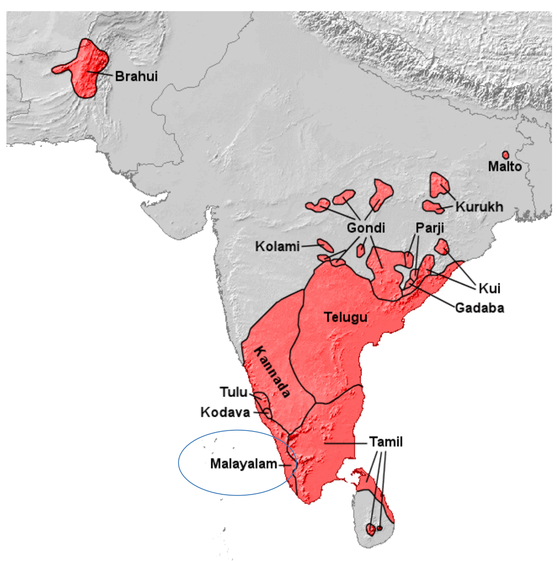
Alexei Kochetov[1,2], Christophe Savariaux[2], Laurent Lamalle[3], Camille Noûs[4], Pierre Badin[2]

[1] University of Toronto, [2] Univ. Grenoble Alpes, CNRS, Grenoble INP, [3] Inserm US 17, CNRS, Univ. Grenoble Alpes & CHU de Grenoble, [4] Cogitamus laboratory

Introduction

Malayalam (Dravidian)

- Has an unusual 3-way contrast in rhotics (*r*-sounds)
  - alveolar tap /ɾ/, alveolar trill /r/, retroflex approximant /ɻ/ [1, 2]



/ɾ/	kaɾi	കരി	*soot*
	paːɾa	പാറ	*crow bar*
/r/	kari	കറി	*curry*
	paːra	പാറ	*rock*
/ɻ/	kaɻi	കഴി	*eat*
	paːɻam	പഴം	*fruit*

- Previous work: Scobbie *et al.* (2013) [3], ultrasound, 1 speaker
  - The finding of secondary articulations:
    - weak palatalization for /ɾ/ (root fronting, body raising)
    - pharyngealization for /r/ (root backing, body lowering)
    - weak palatalization and no retroflexion for /ɻ/: "a bunched tip down rhotic".

Method

Participants

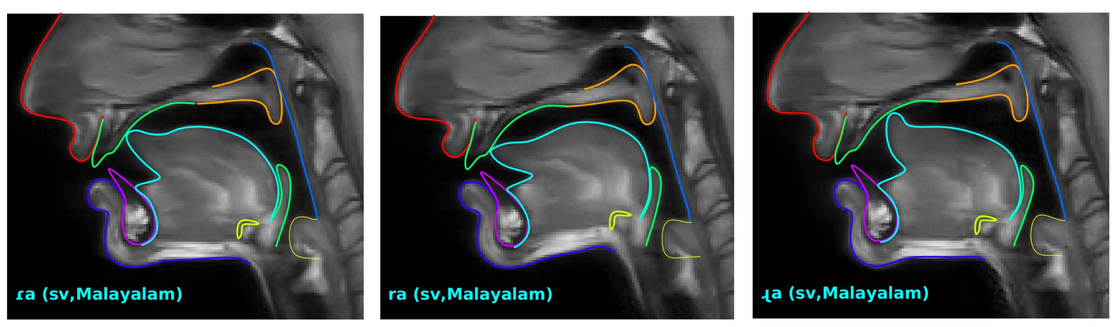
- 2 speakers (1 f) of Malayalam from Trivandrum, Kerala; in their 20s.

Materials and procedure

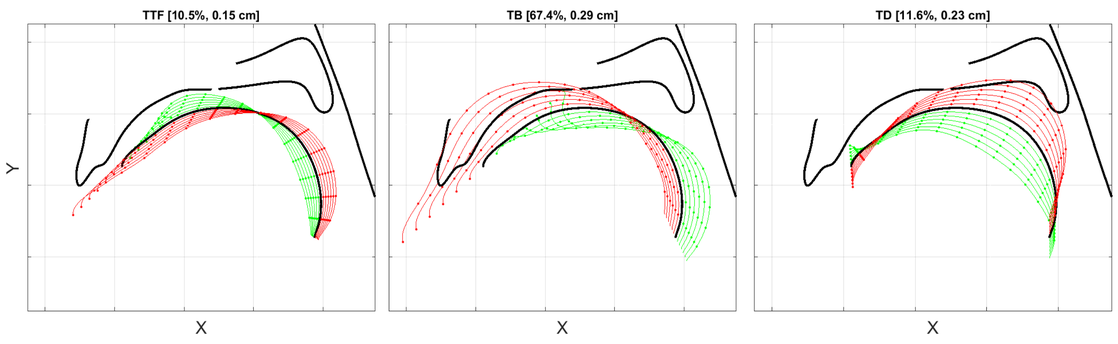
- Sustained /ɾ r ɻ/ in symmetric V_V with /i e a o u/, as part of a corpus of 24 consonant phonemes
- A *Philips Achieva 3.0T dStream* scanner; a 20 channel head-neck coil; the *Turbo Spin Echo* mode.
- Static midsagittal single-slice images, 6.9 s/image, 4 mm thickness.

Analysis

- Semi-automatic segmentation [4]; manual tracings and automatic prediction of articulator contours; head tilt correction
- Linear articulatory modelling: guided PCAs [5]
- Average contours and radar plots of parameter differences:
  - tongue tip fronting, tongue body, tongue dorsum, etc.



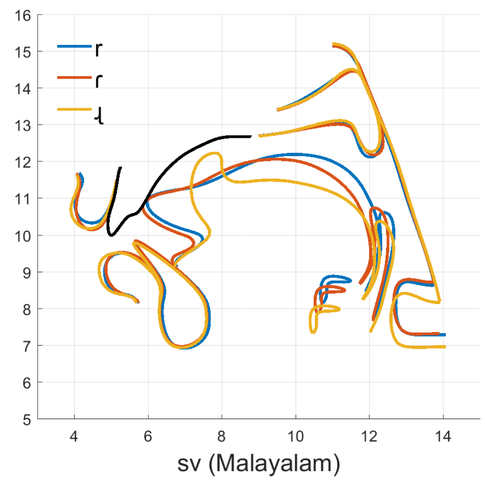
Tracings for /ɾ r ɻ/ in the [a_a] context (speaker SV)

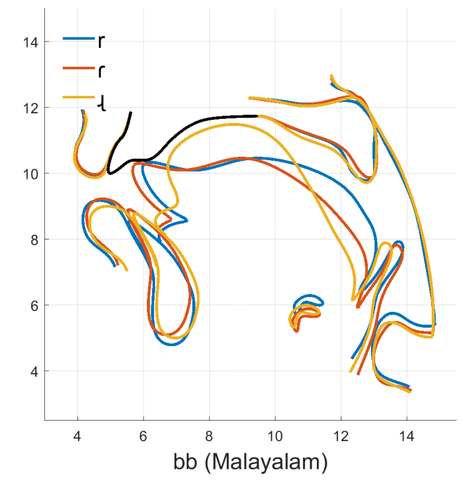


Nomograms for tongue tip fronting (TTF), tongue body (TB), and tongue dorsum (TD; speaker SV)

Results

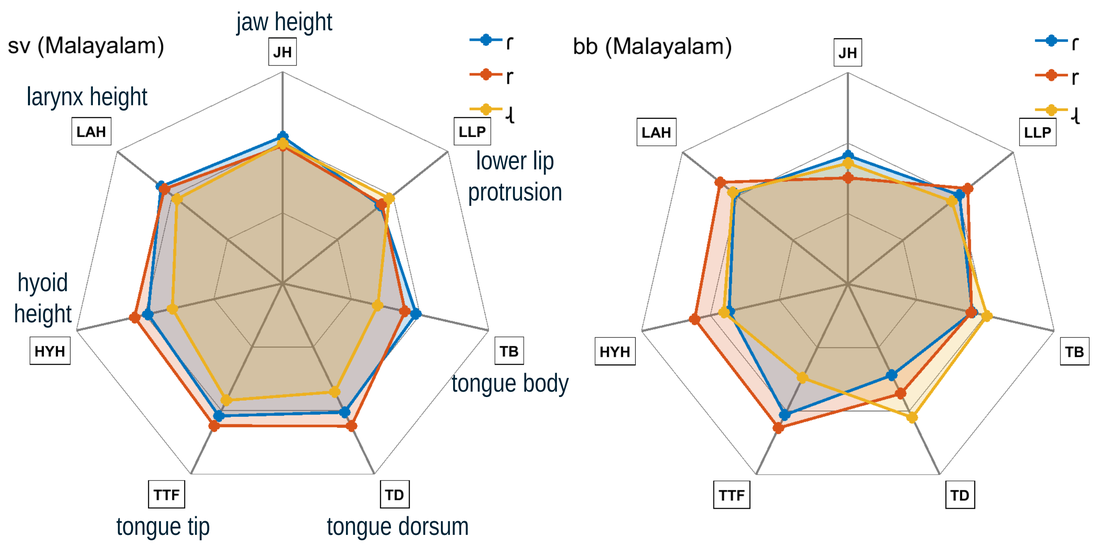
Overlaid average contours





- Both speakers: the trill and the tap are alveolar, with /r/ showing uvularization/pharyngealization (raised & retracted dorsum).
- Inter-speaker differences in /ɻ/:
  - a tip-up retroflex with a lowered body for SV;
  - a strongly bunched body, fronted/lowered dorsum for BB (cf. [3]).

Radar plots: Articulatory parameters



- Key differences:
  - tap vs. trill: tongue tip fronting, dorsum, & hyoid height (/r/ > /ɾ/)
  - tap/trill vs. approximant: tip fronting & hyoid height (/ɾ, r/ > /ɻ/), body & dorsum (/ɾ, r/ > /ɻ/), for SV, (/ɻ/ > /ɾ, r/) for BB.

Discussion

- Malayalam rhotics produced by our speakers are complex:
  - combinations of primary and secondary constrictions, but not fully consistent with [3]
  - involving both lingual and non-lingual articulators
- Unexpected between-speaker variability in /ɻ/, yet relatively similar acoustics (high F2, low F3 & F4; cf. [2])
  - reminiscent of the North American English /ɹ/ variation [6].

Selected references

[1] Kumari, S. B. (1972). *Malayalam phonetic reader.* Central Institute of Indian Langs.
[2] Punnoose, R., Khattab, G., & al-Tamimi, J. (2013). The contested fifth liquid in Malayalam: a window into the lateral-rhotic relationship in Dravidian languages. *Phonetica*, *70*, 274–297.
[3] Scobbie, J., Punnoose, R., & Khattab, G. (2013). Articulating five liquids: A single speaker ultrasound study of Malayalam. In *Rhotics: New data and perspectives*. (pp. 99–124). BU Press.
[4] Labrunie, M., Badin, P., Voit, D., et al. (2018). Automatic segmentation of speech articulators from real-time midsagittal MRI based on supervised learning. *Speech Communication*, *99*, 27–46.
[5] Badin, P., Bailly, G., Revéret, L., et al. (2002). Three-dimensional linear articulatory modeling of tongue, lips and face, based on MRI and video images. *J. of Phonetics, 30*, 533–553.
[6] Delattre, P. & Freeman, D. C. (1968). A dialect study of American r's by x-ray motion picture. *Linguistics, an International Review, 44*, 29–68.

Acknowledgements

Supported by *Social Sciences and Humanities Research Council of Canada* and the *Agence Nationale de la Recherche* of France.