Towards the use of ultrasonography to study aging effects in vowel production

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Introduction

- The aging process affects speech production
- Most studies focus on acoustic cues of aging speech
  - Production studies were not conclusive
  - Formant frequencies variation of European Portuguese (EP) vowels with age might be related to specific articulatory adjustments [1,3]
- **Lack of articulatory data about:**
  - Aging effects on speech
  - EP oral vowels
- Ultrasounds (US) tongue imaging can be used to investigate the physiological differences between elderly and young adult speech
- The processing, visualization and analysis of the US data is a challenge

Objective

- Development of an automatic method to detect and characterize tongue measures in US tongue imaging:
  - To study the age effects on the EP vowels
  - To allow analysis of a large set of subjects

Method

Speech corpus

- 9 EP oral vowels ([i], [e], [ɛ], [a], [o], [ɔ], [u], [ɐ], [ɨ]) in isolated context and in a disyllabic sequence C**V**.Cv (in stop and fricative consonant context)
- In a carrier sentence: "Em C**V**.Cv temos **V**."
- Each participant repeated each sentence 3 times

Data Acquisition

- US tongue imaging synchronized with audio:
  - Software Articulate Assist Advanced
  - US machine Mindray DP6900 (frame rate of 90Hz)
  - Endocavitary probe (65EC10EA) with 90º field of view under the participants' chin using a stabilization helmet
  - Audio: Philips SBC ME400 microphone and external sound system (UA-25 EX USB)
  - /tatatata/ sequence to assess synchronization

- Acoustic data was automatically segmented with WebMAUS

Image Processing

- US images at the temporal midpoint of the vowels
- Points of-interest were extracted used an **unsupervised method** (Fig.1):
  - Radial sweep approach: for each radial (steps of 5º of angular distance [4]) collects all the pixel intensities
  - Coordinates of the highest intensity point is automatically extracted for each radial

Parameters Extraction

- The highest y: highest point of the tongue body (TH)
- The x-coordinate: front back position of the tongue in the highest y coordinate (TA)

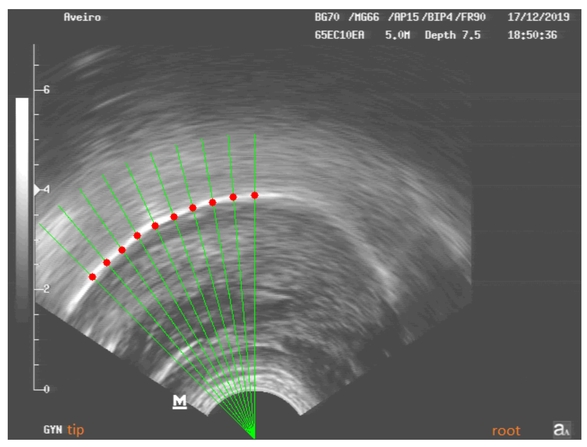

Fig.1 10 radial sweeps and the extracted points on the tongue for vowel [a]

First results

- A Young female speaker
- Central EP vowels [a], [ɐ] and [ɨ]
  - selected based on age-related changes in the acoustical vowel space (i.e., reduction of the F1 space <-> tongue elevation alterations)
- 9 repetitions of each isolated vowel per speaker

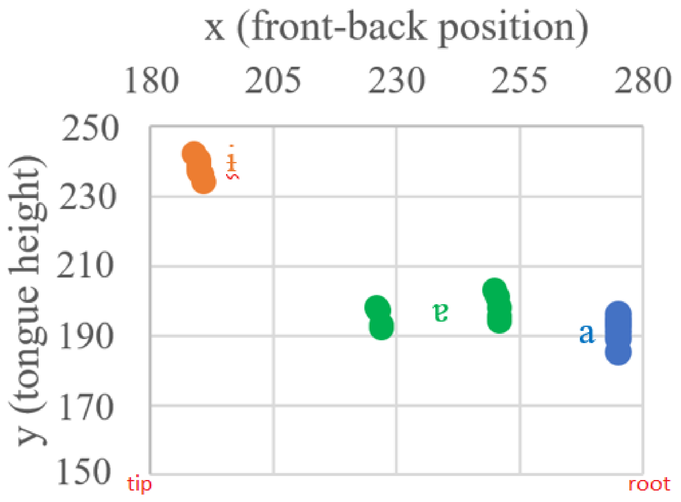

Fig.2 Dispersion of highest point coordinates in central EP vowels

- [ɐ] and [a]: similar TH; different TA
- [ɐ]: large dispersion in TA
- [ɨ]: higher TH; higher TA

Conclusions

- Contribute to **increase the feasibility** of the articulatory vowel study in lifespan
- Starting point for a larger ongoing project concerning the analysis of the relationship between tongue measures collected by US and formant frequencies across the lifespan

References:

[1] L. Albuquerque, C. Oliveira, A. Teixeira, P. Sa-Couto, and D. Figueiredo, "Age-related changes in European Portuguese vowel acoustics," in INTERSPEECH, 2019, pp. 3965–3969.

[2] L. Albuquerque, C. Oliveira, A. Teixeira, P. Sa-Couto, J. Freitas, and M. S. Dias, "Impact of age in the production of European Portuguese vowels," in INTERSPEECH, 2014, pp. 940–944.

[3] L. Albuquerque, C. Oliveira, A. Teixeira, P. Sa-Couto, and D. Figueiredo, "A Comprehensive Analysis of Age and Gender Effects in European Portuguese Oral Vowels," J. Voice, 2020 (in press).

[4] L. Ménard, C. Toupin, S. R. Baum, S. Drouin, J. Aubin, and M. Tiede, "Acoustic and articulatory analysis of French vowels produced by congenitally blind adults and sighted adults," J. Acoust. Soc. Am., vol. 134, no. 4, pp. 2975–2987, 2013.

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