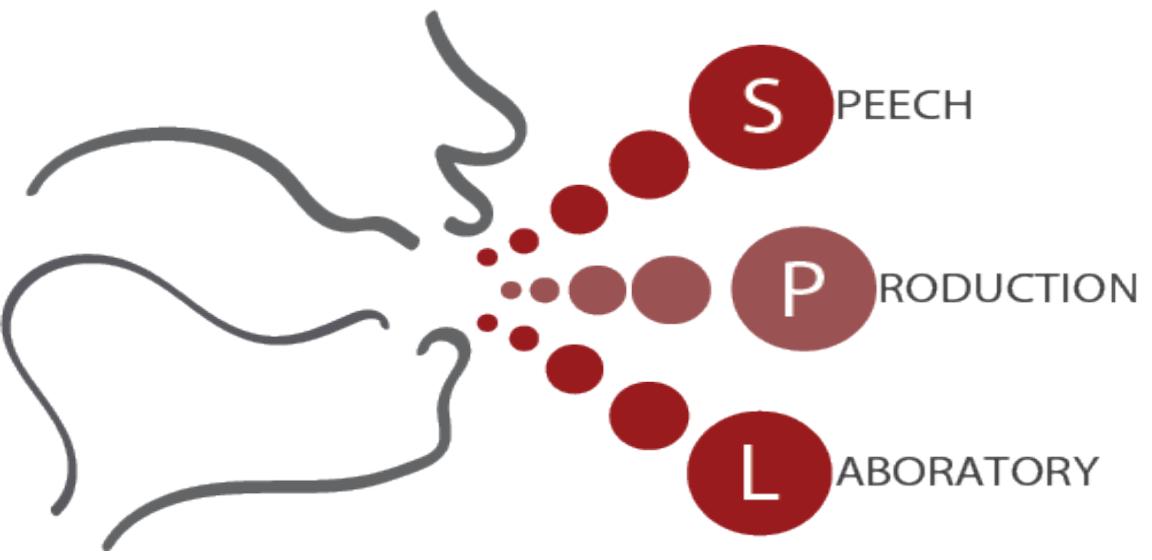


The position of the tongue root in the articulation of posterior sibilants in Polish

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Introduction

- Polish has two series of contrasting posterior sibilants: (1) “soft” prepalatals articulated with a strong raising of the tongue body towards the palate, transcribed as [ç z t̪ d̪ z̪], and (2) the non-palatalized “hard” series, the latter escaping a straightforward categorization. Additionally, “hard” posteriors are allophonically secondarily palatalized when preceding [i].
- The non-palatalized posterior sibilants of Polish are transcribed by different authors as either palatoalveolars [ʃ ʒ tʃ dʒ], as retroflex [ʂ ʐ tʂ dʐ] or using Slavic transcription symbols implying lack of palatalization [š ž tʂ dʐ]. Ladefoged and Disner (2012:169) use /ʂ, ʐ tʂ dʐ/ making a strong case that neither IPA symbols for palatoalveolars nor retroflexes should be used.

“soft” posteriors	“hard” posteriors
neutral context	before [i]
ç z t̪ d̪ z̪	ʂ ʐ tʂ dʐ

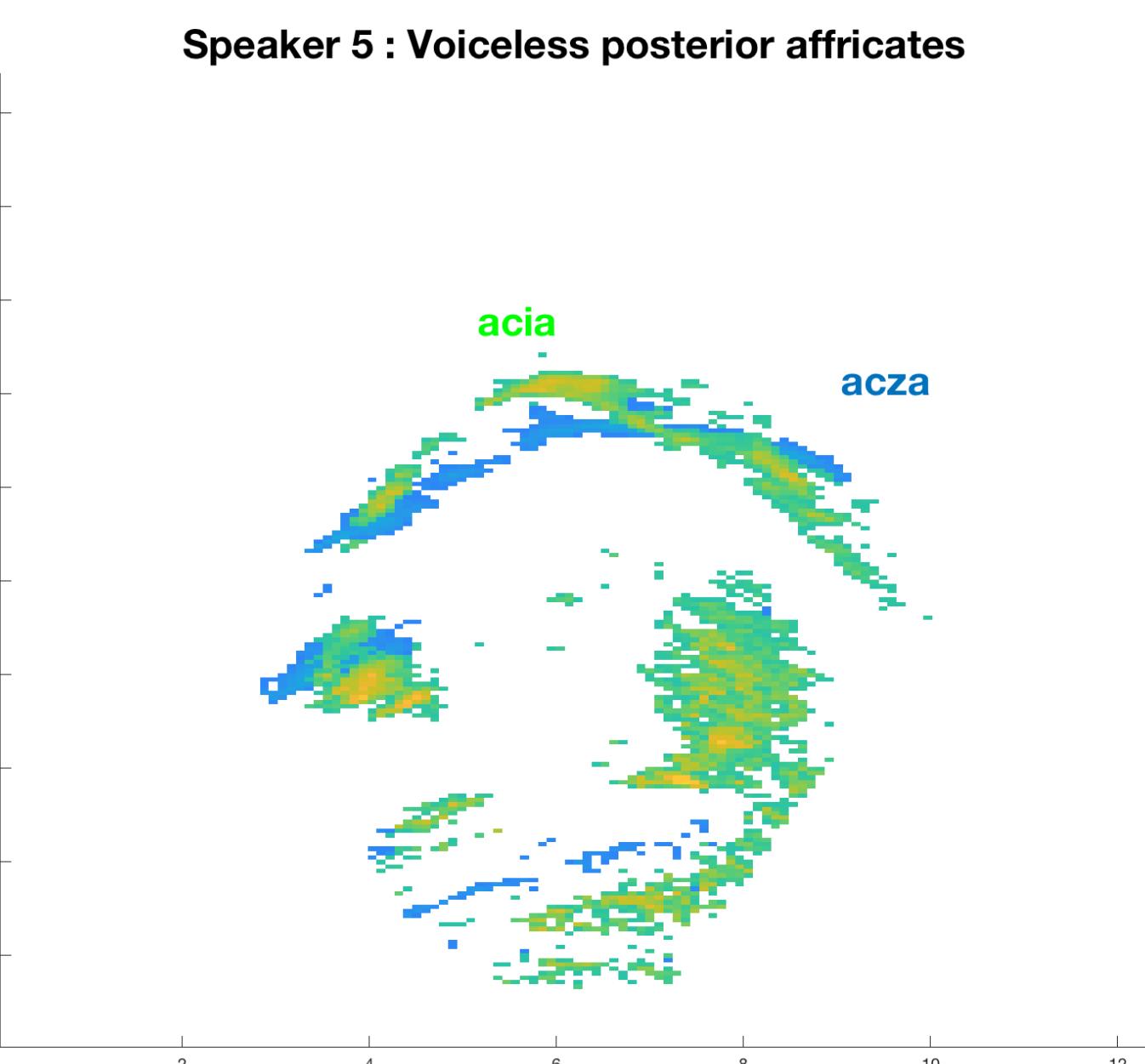
- X-ray data for Polish speech production exists (Koneczna & Zawadowski 1951, Wierzchowska 1967, 1980), however there are no images of contextual variants of “hard” posteriors in a palatalizing context of a high front vowel [i].
- Apart from providing previously unavailable images of contextual variants of “hard” posterior sounds, the current 3D ultrasound study provides more detail that cannot be clearly seen in X-ray images for all posterior sounds. For example, we demonstrate the differences in the raising of the tongue in the coronal and horizontal views, including a groove along the center of the back of tongue/tongue root in the prepalatals. Ultrasound images provide some hints about the muscular mechanisms in the articulation of the sounds.

Method

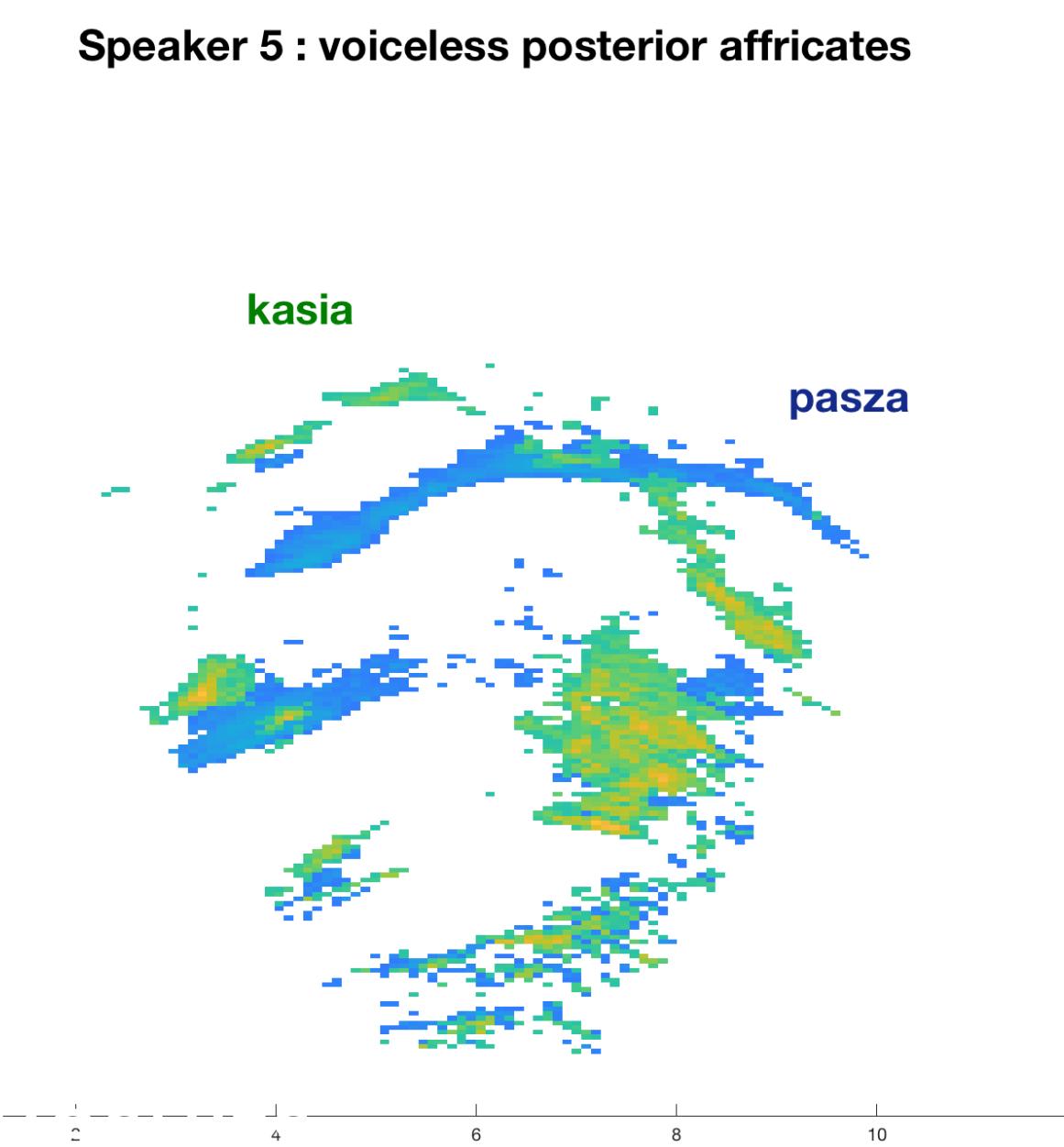
- 5 Polish native speakers (3 women, 2 men) participated in the recordings, some of them in multiple sessions. Participants read word lists.
- Palate impressions were made using dental alginate & digitized with a NextEngine3D laser scanner; data were saved in binary STL format.
- Ultrasound images were recorded with a Philips EpiQ7G system using an xMatrix6-1 digital 3D/4D transducer secured under the chin using an Articulate Instruments ultrasound stabilization headset.
- Fully uncompressed DICOM ultrasound files were transferred to a Windows 7 computer.
- Ultrasound/palate files were analyzed w/ a custom MATLAB toolbox, called “WASL”.
- Palates were manually registered with the tongue data.
- Audio was recorded with a SHURE KSM32 microphone placed approximately 1 meter in front of the participant, at 48kHz sampling rate.

Results

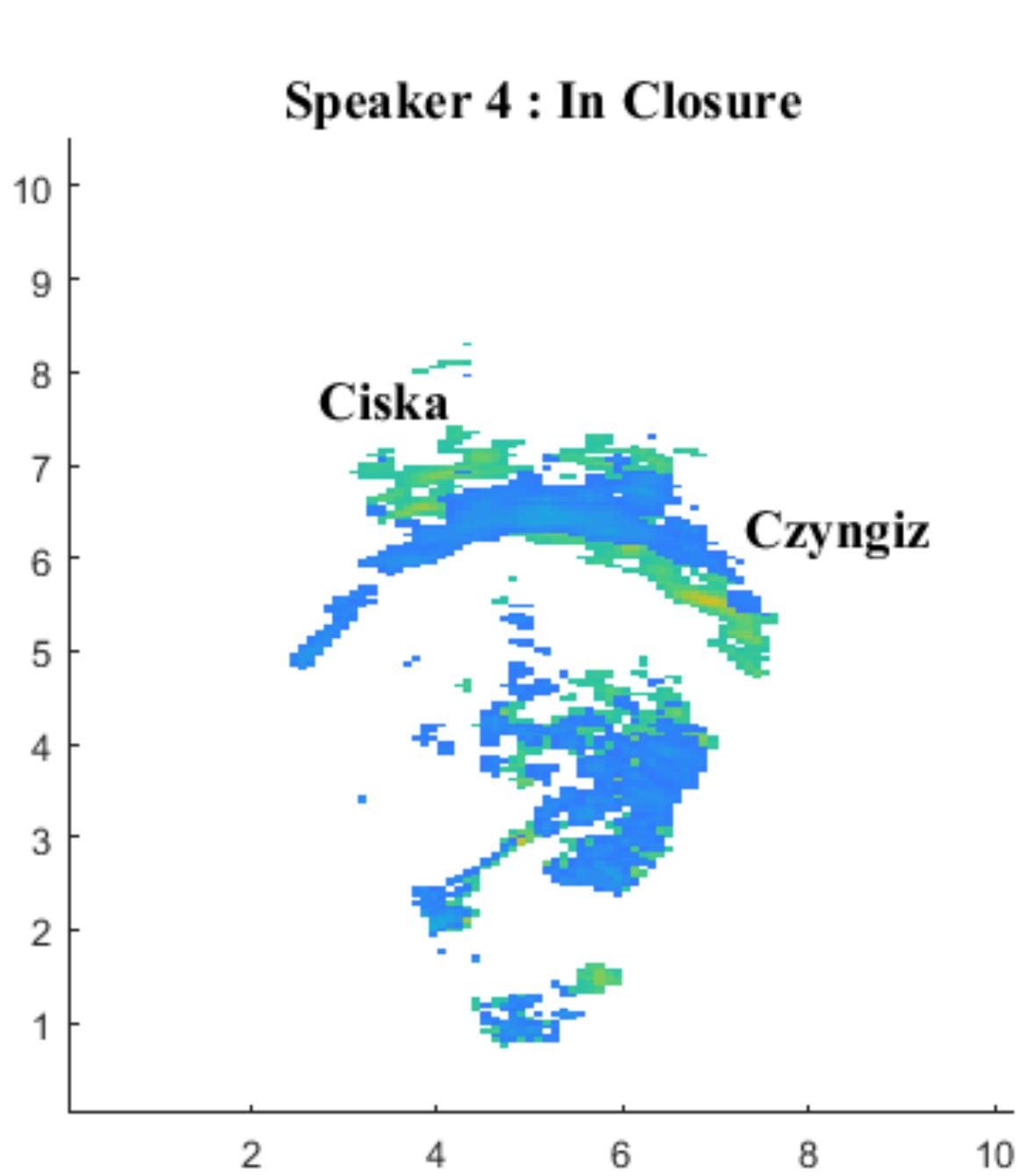
Posterior affricates – [a] context



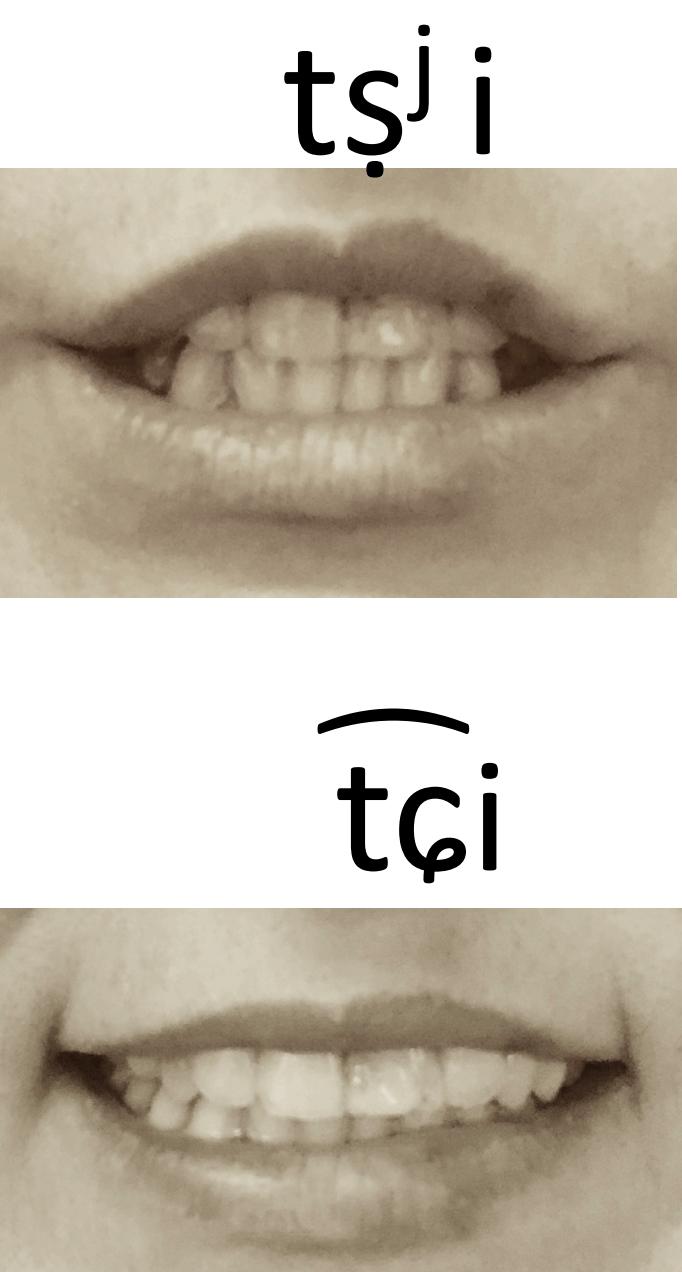
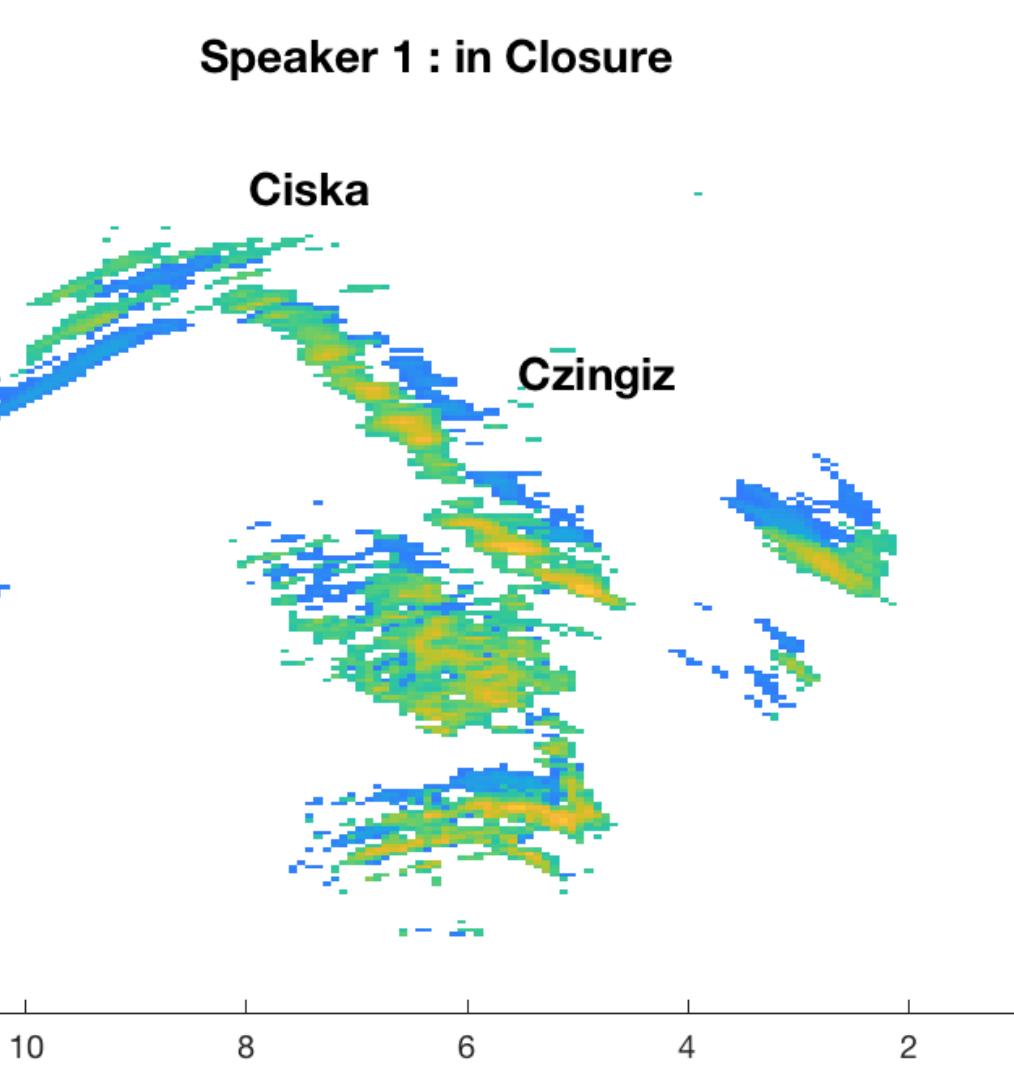
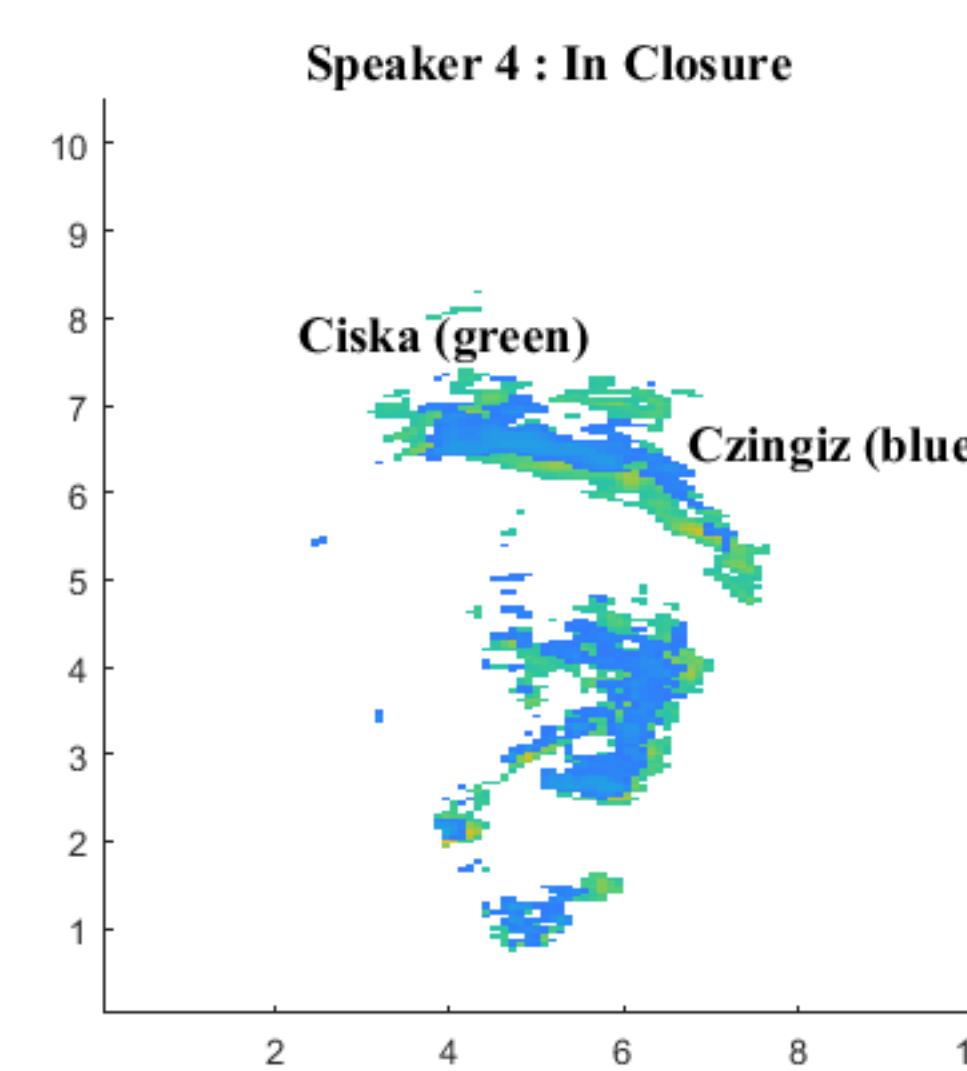
Posterior fricatives – [a] context



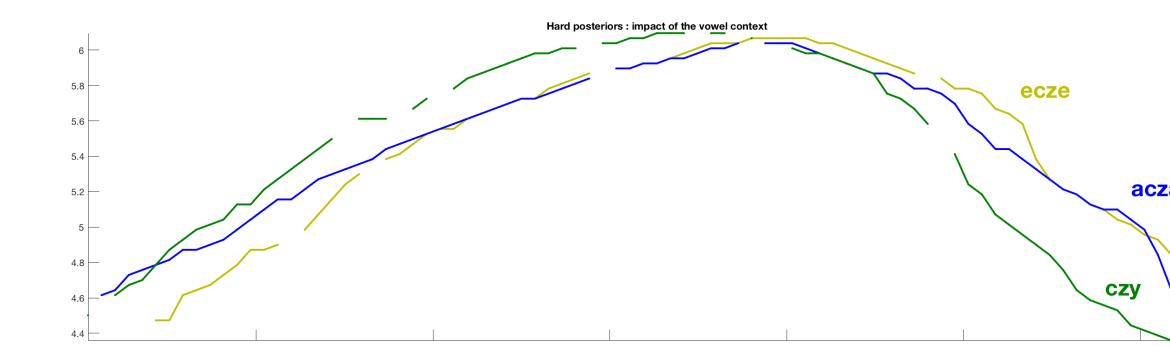
Posterior affricates – front V context



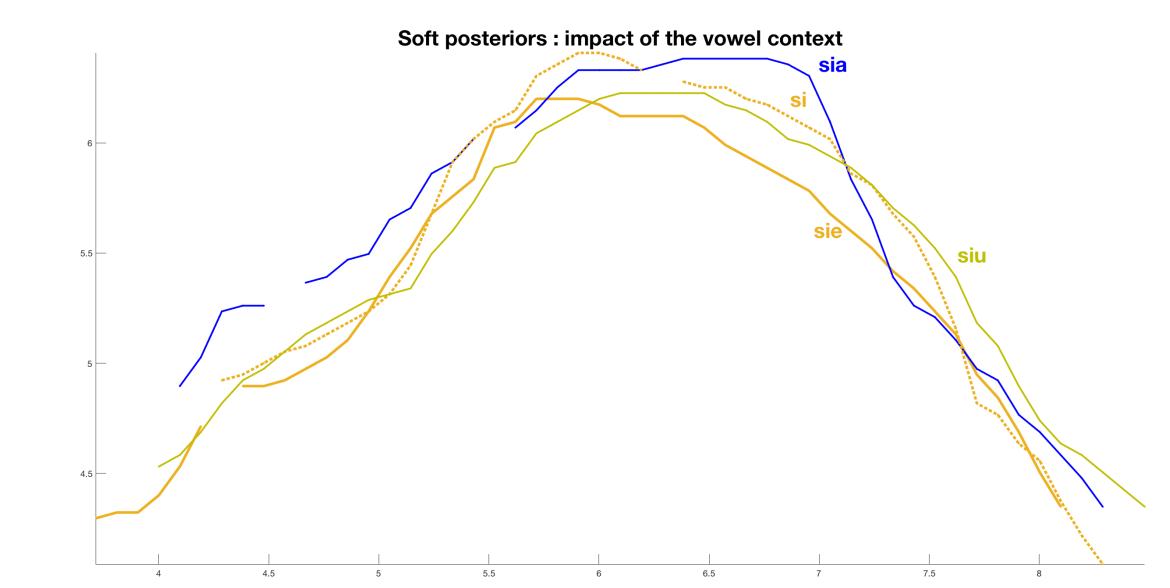
Palatalized ‘hard’ posteriors versus soft posteriors



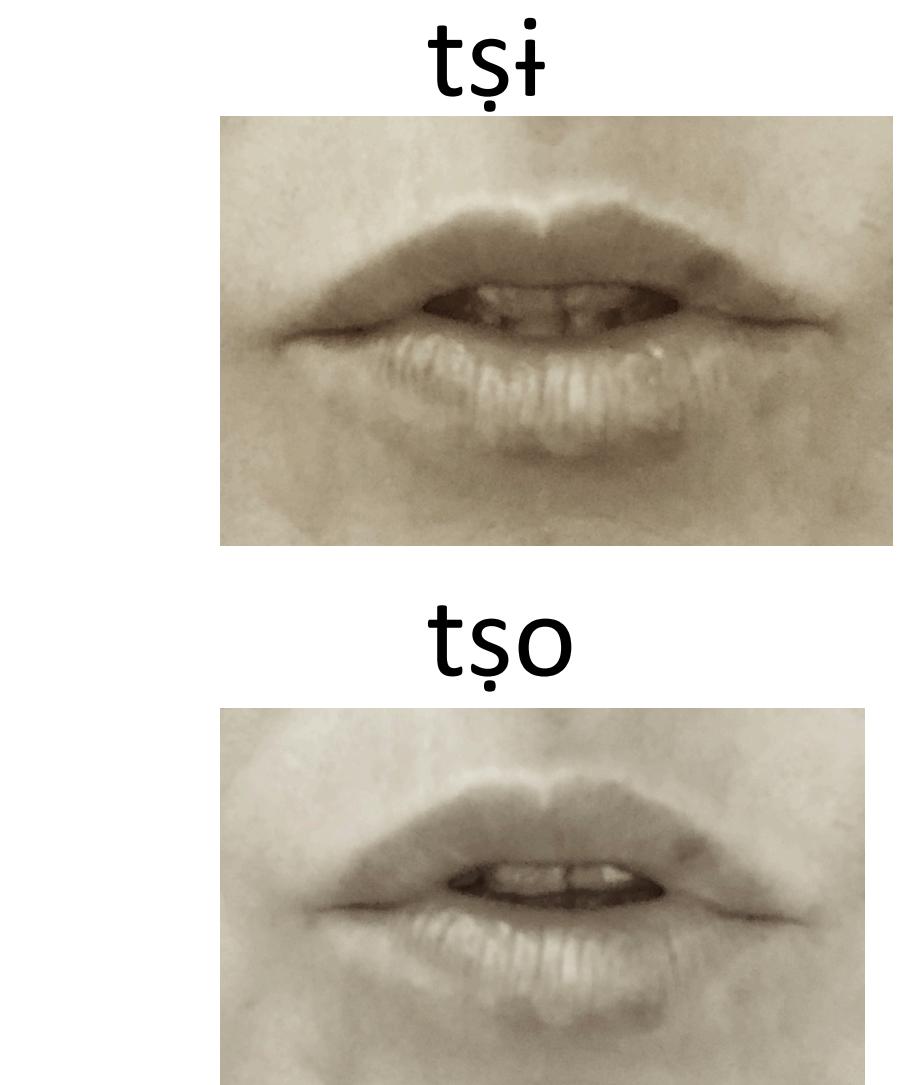
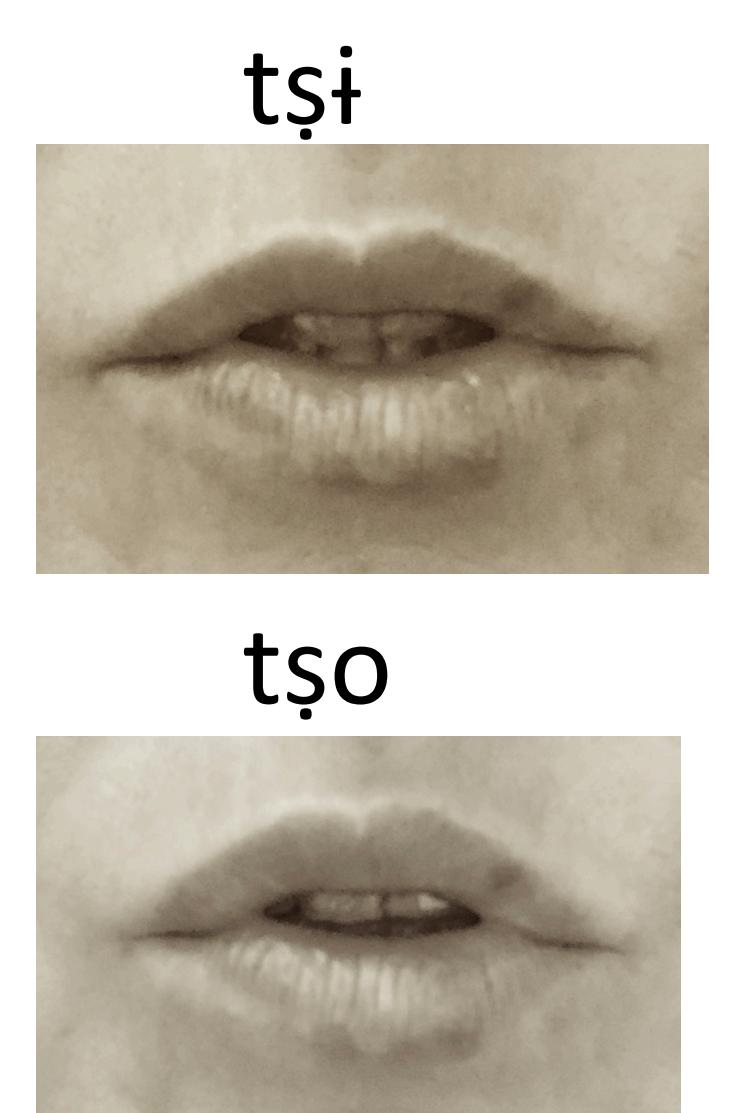
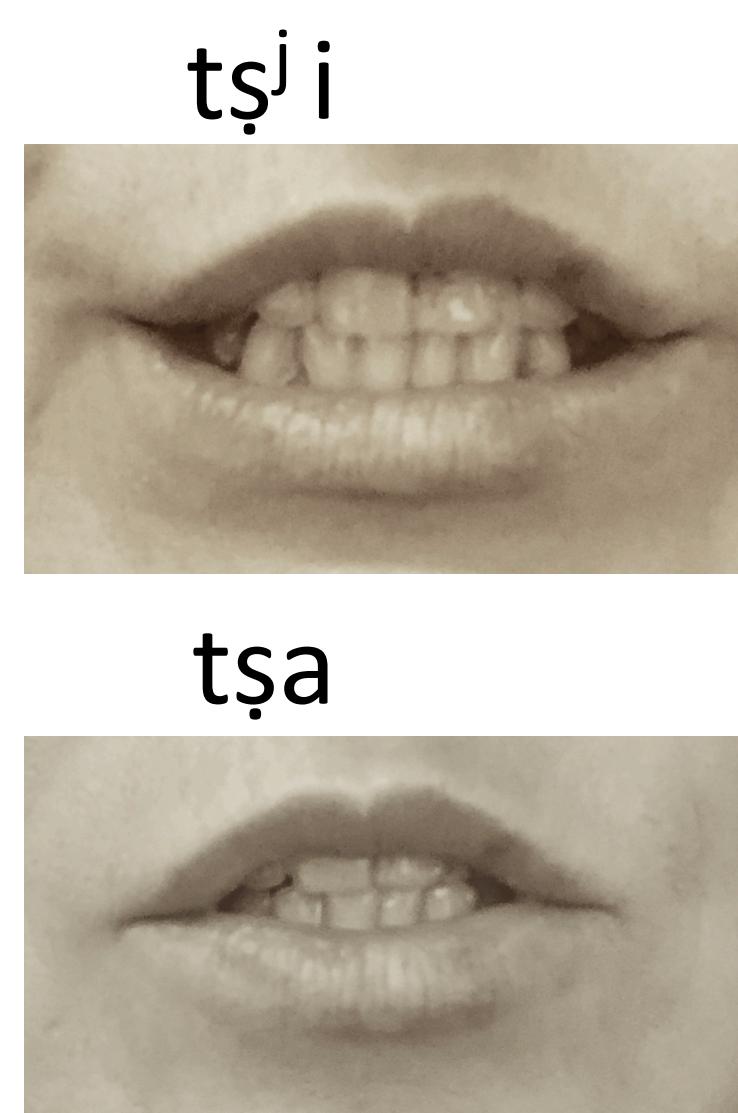
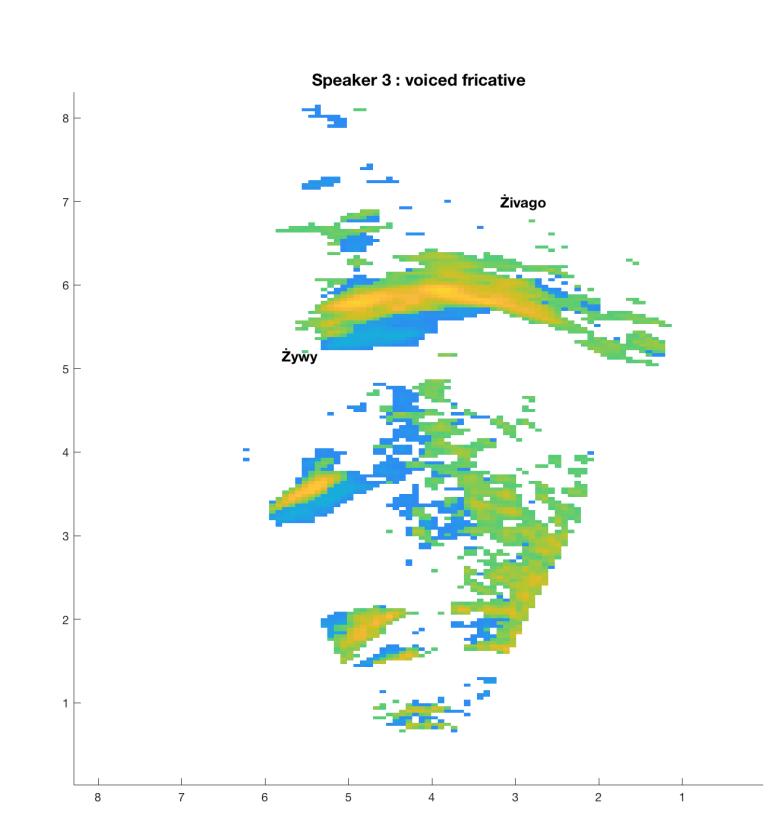
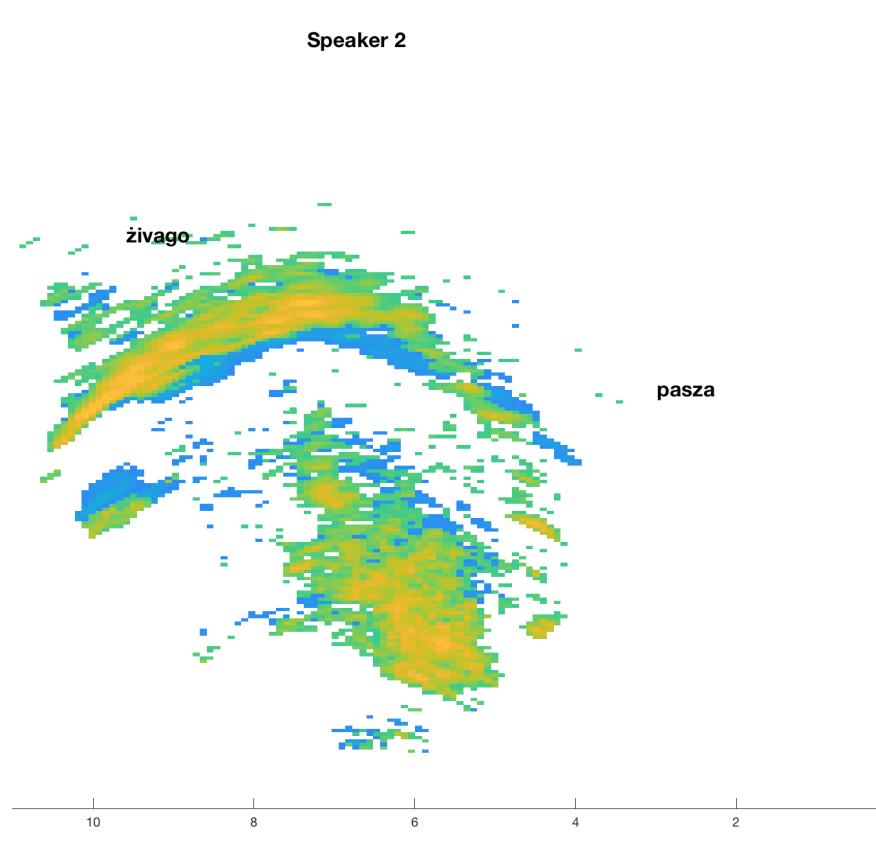
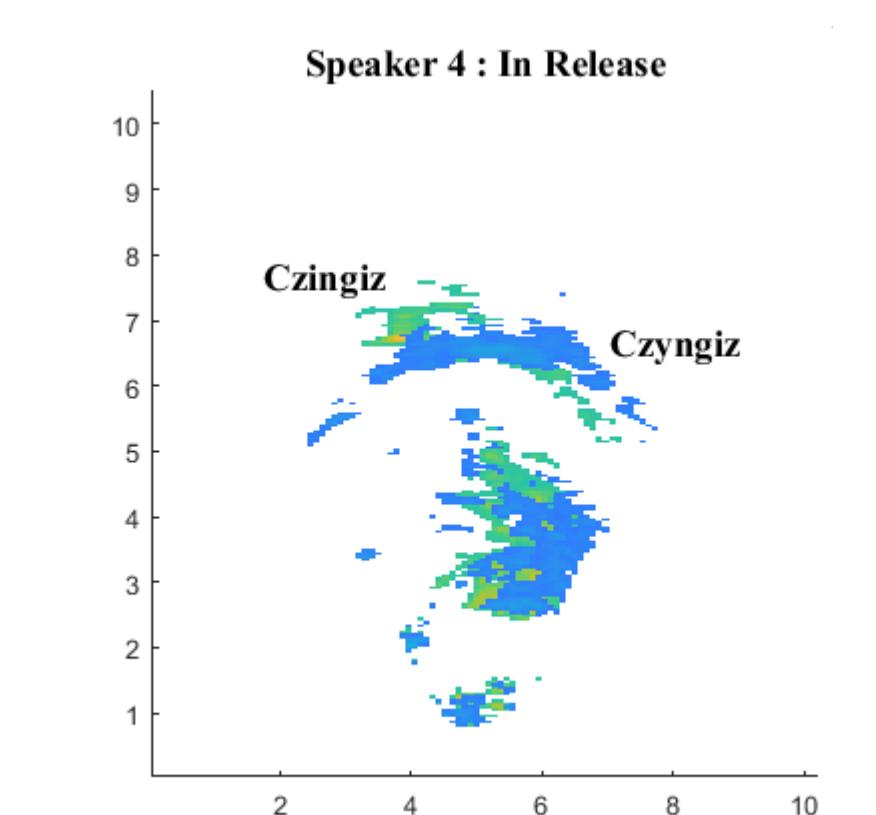
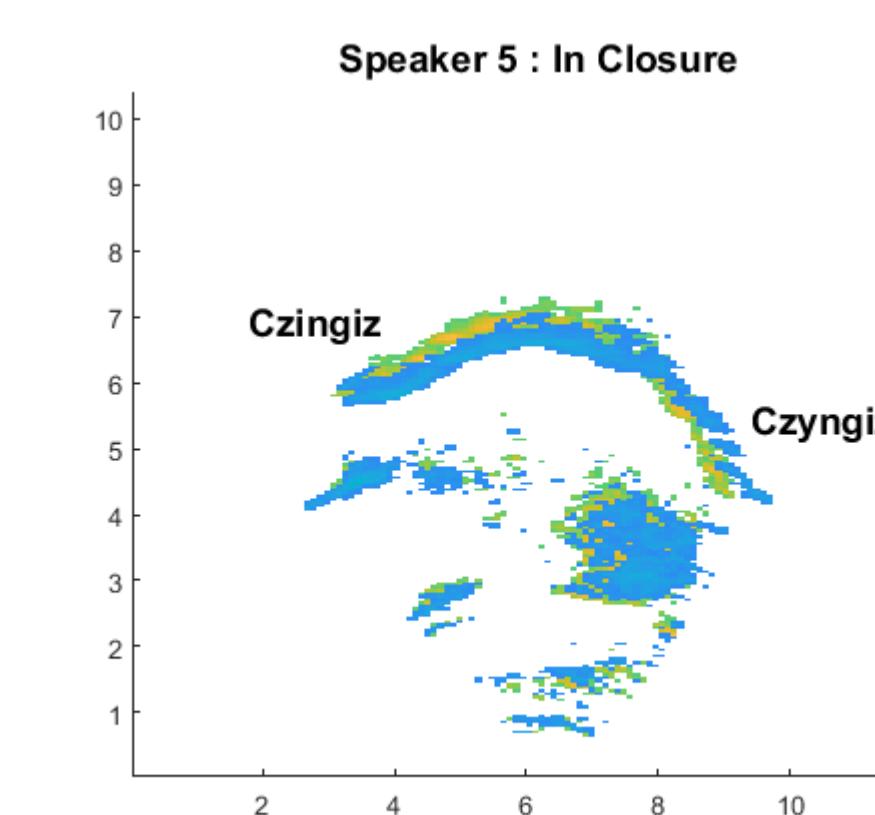
Hard posteriors in non-palatalizing vowel contexts



Soft posteriors in different vowel contexts

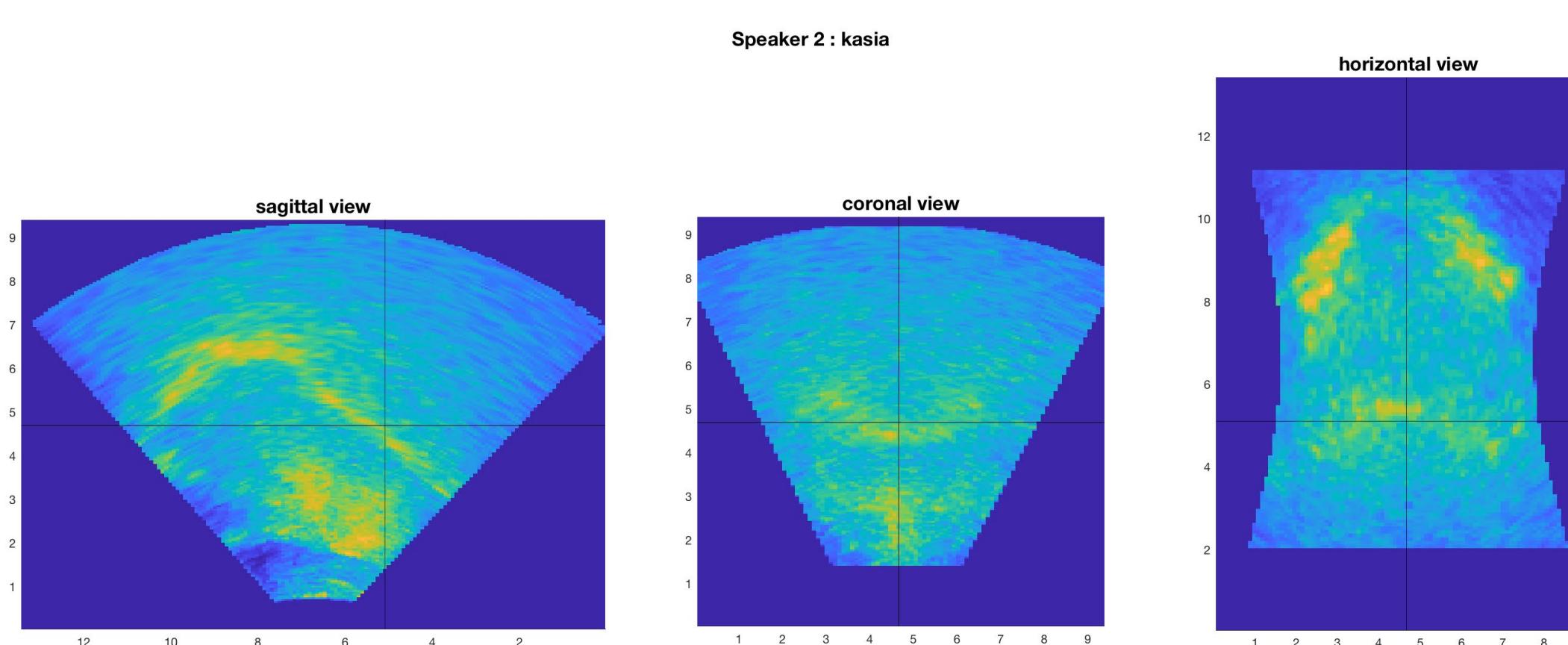


Neutral versus palatalized ‘hard’ posteriors

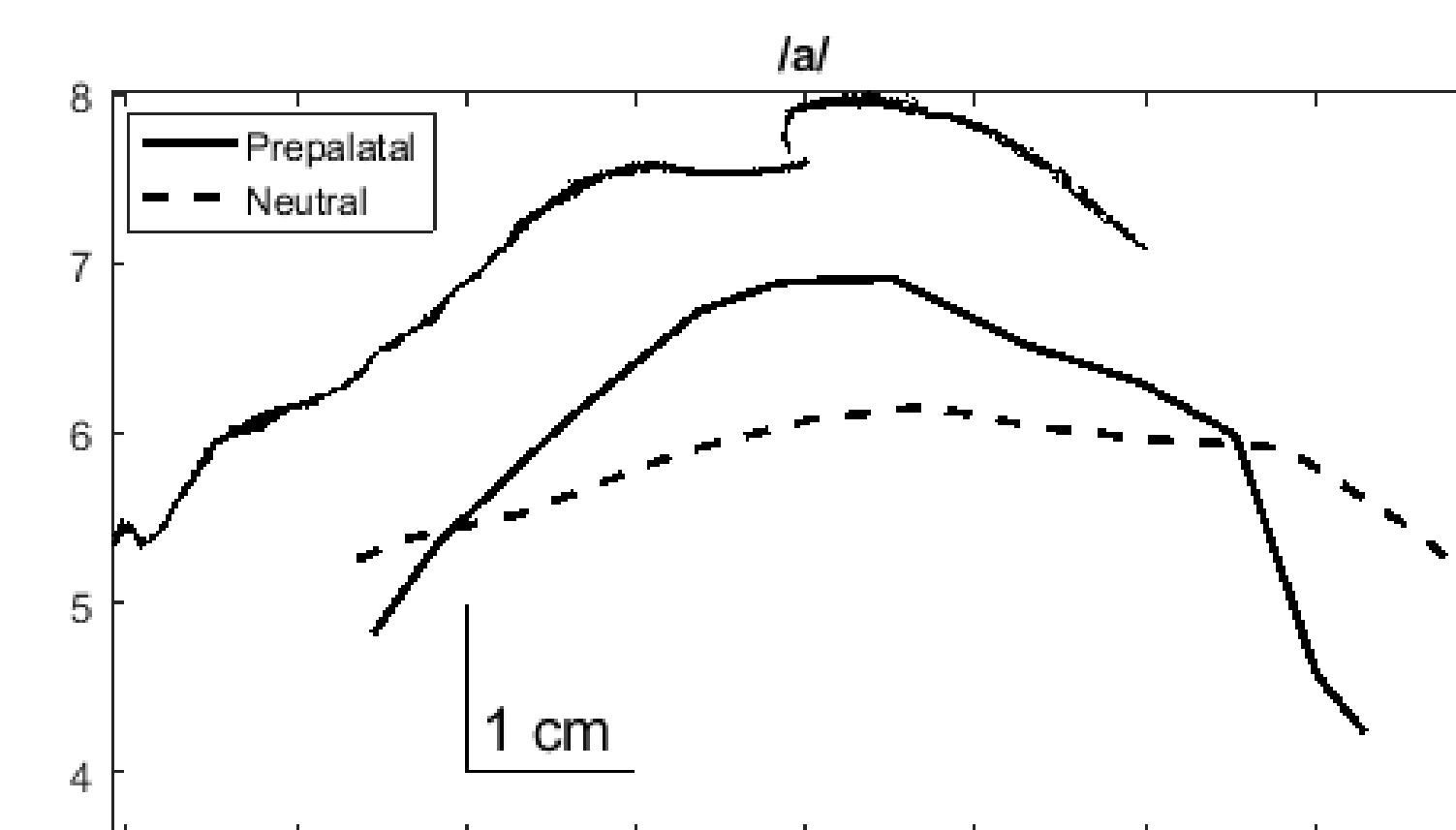


Results

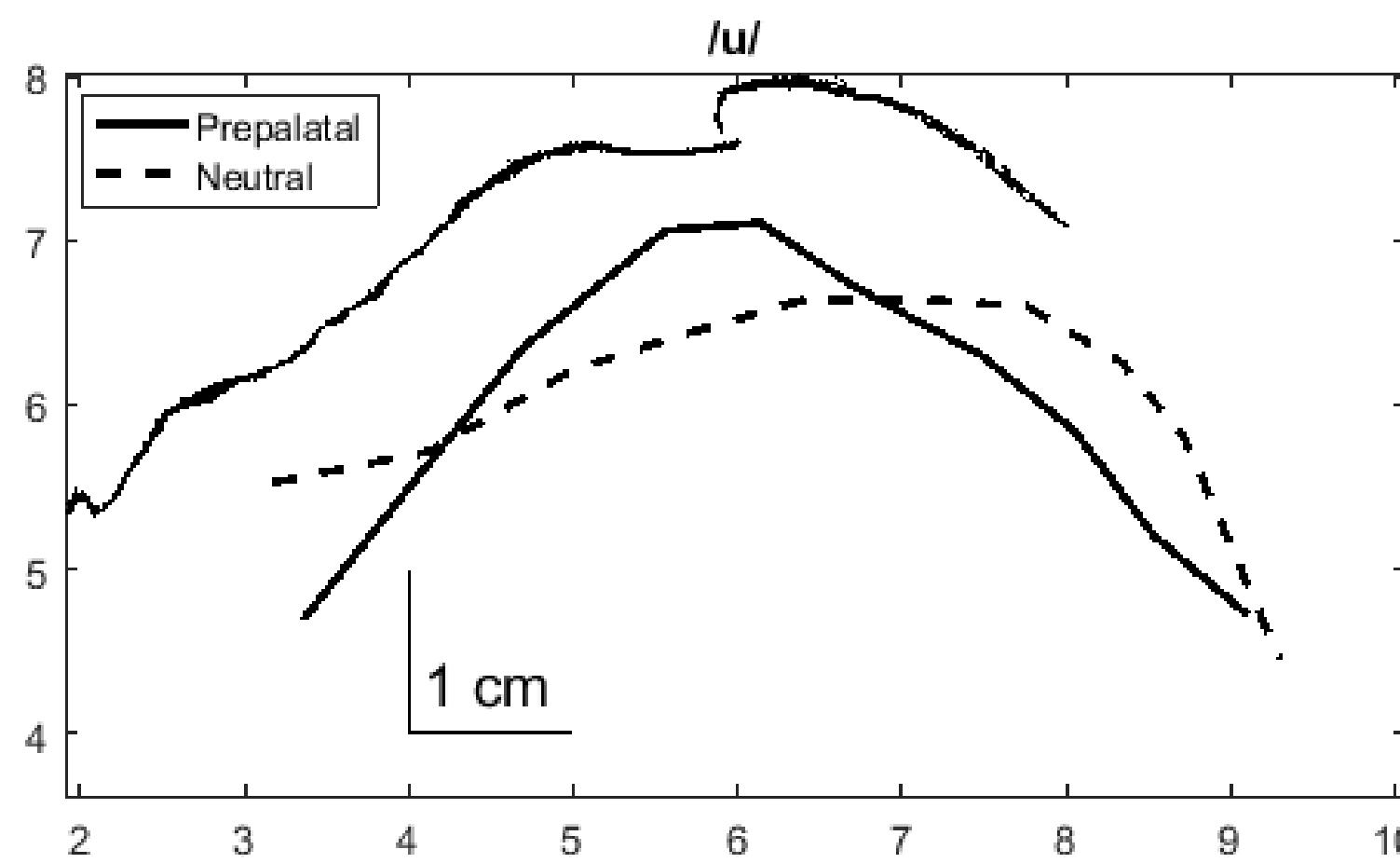
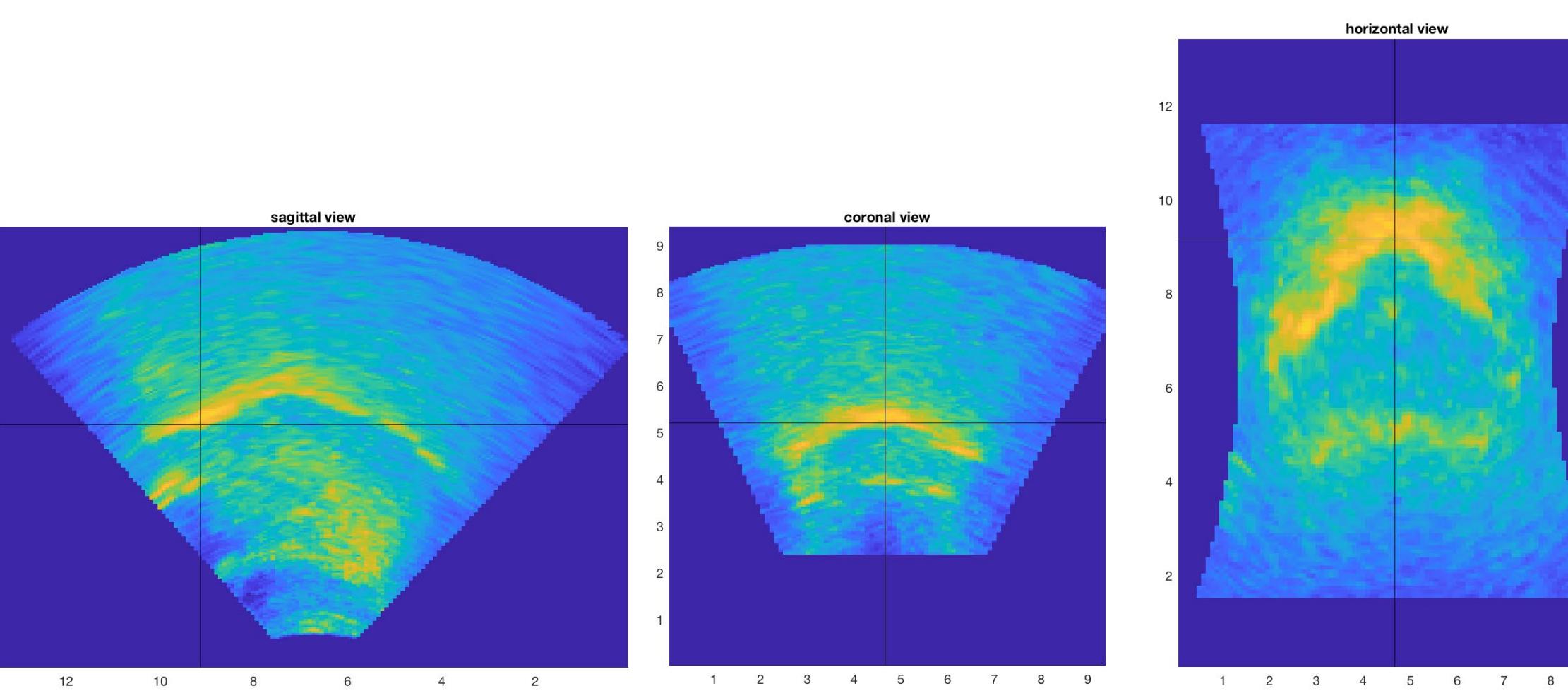
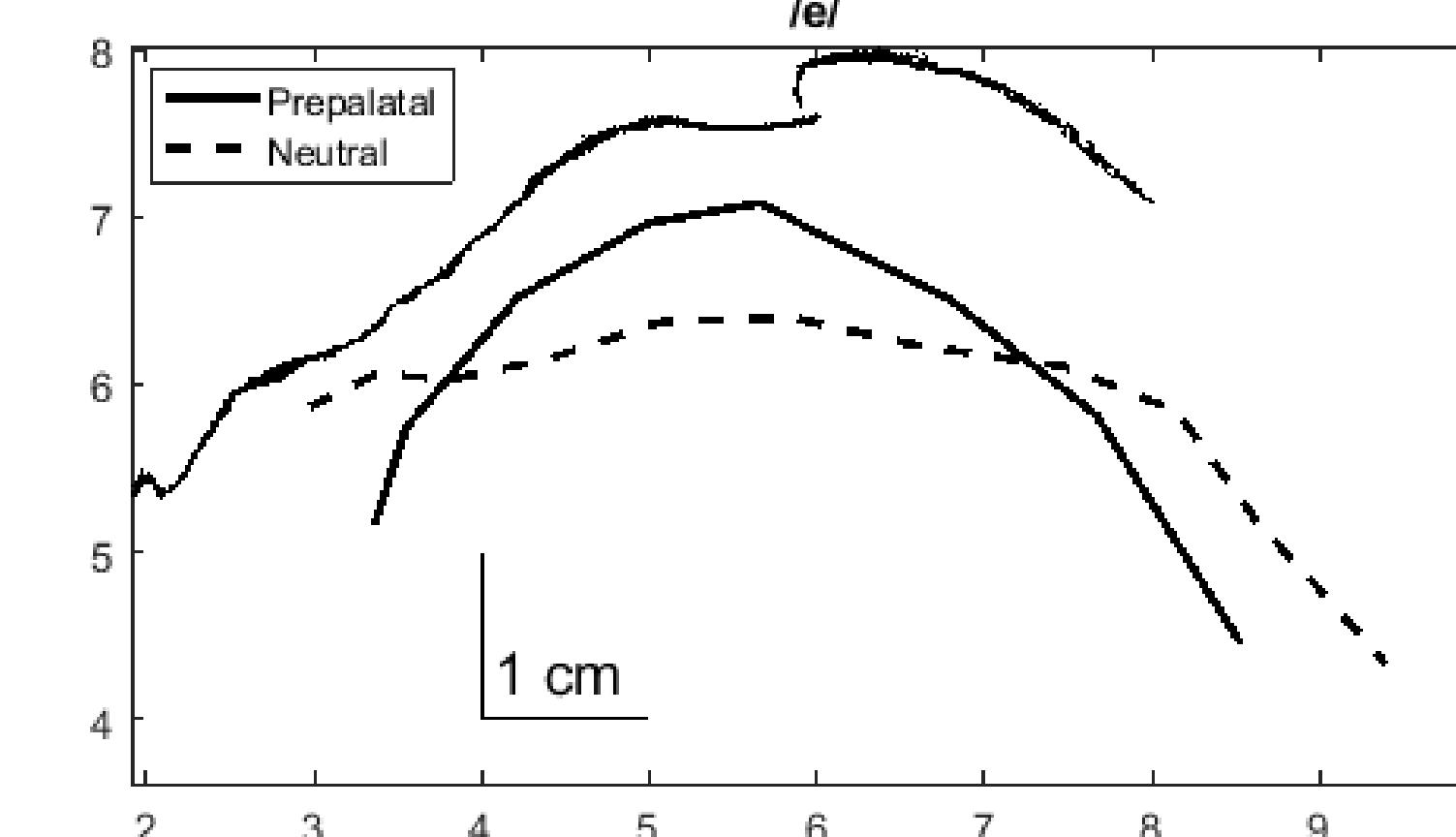
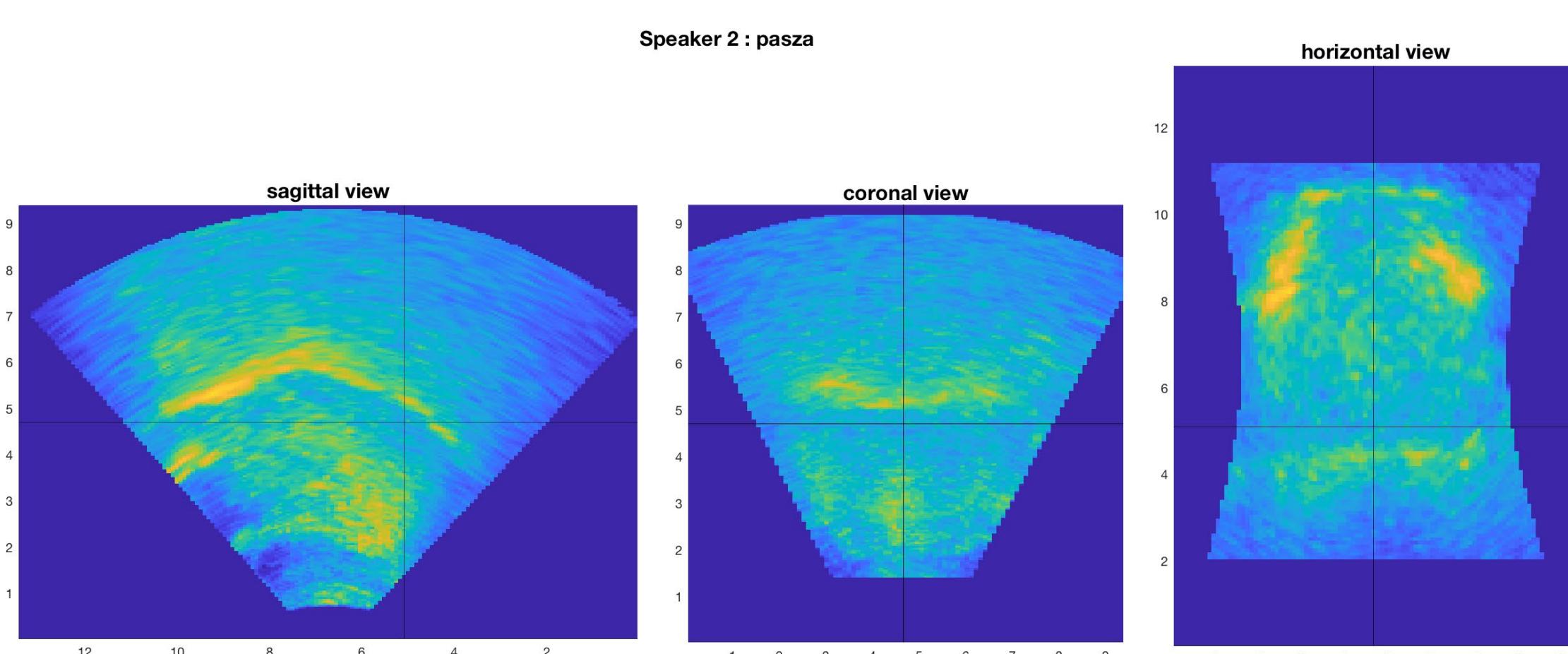
Coronal view: soft posteriors



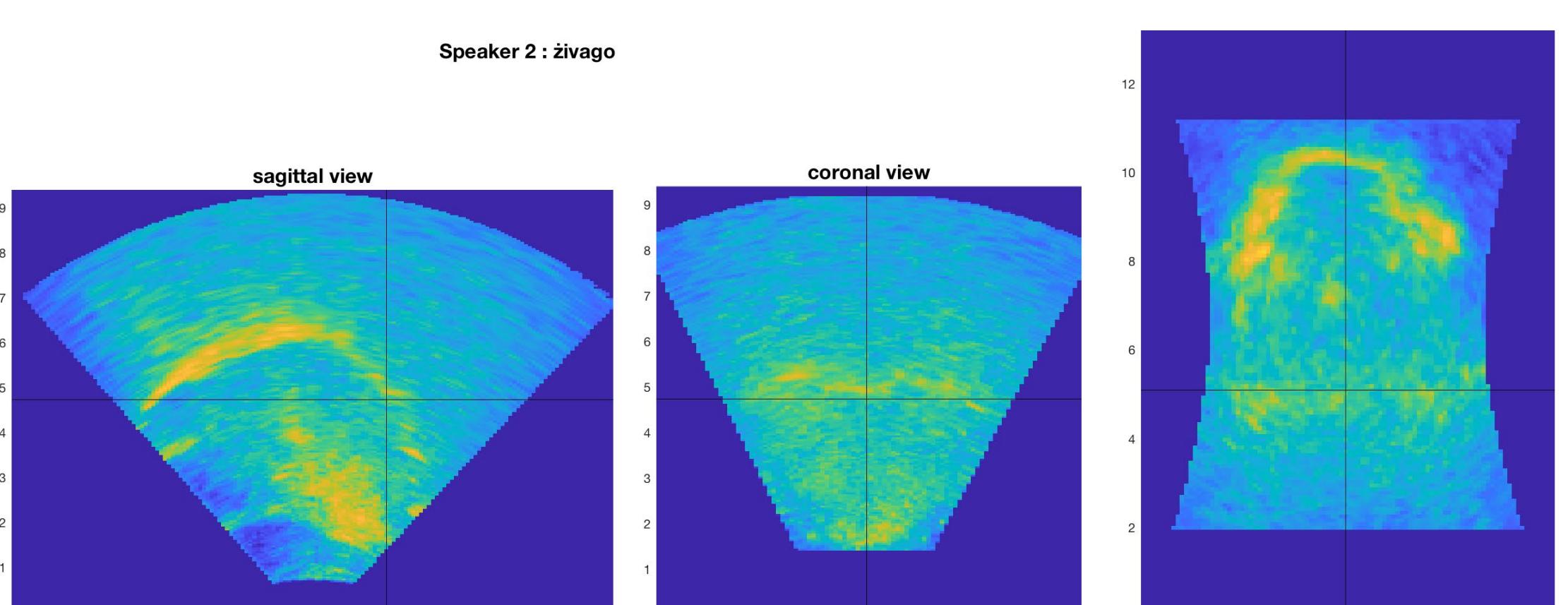
Vowel allophony in the soft posteriors context



Coronal view: hard posteriors



Coronal view: palatalized 'hard' posteriors (allophonic effect)



In the context of [i]:

- Occasionally as much tongue body raising as in prepalatals (some variation).
- Sublaminal cavity.
- Lip rounding.
- Minimal groove in the tongue root area.
- Advancement of the tongue root (more variation than in prepalatals)

Conclusions/Future Directions

- The study shows that the three series do not differ significantly in terms of the place of articulation.
- "Hard" and "soft" posterior consonants of Polish differ in the position of the tongue root and the relative volume of the laryngeal cavity.
- With some intra- and inter-speaker variation, the secondarily palatalized allophones of "hard" posteriors tend to show tongue root advancement resulting in the fronting and raising of the tongue body and the tongue shape very similar to that of prepalatals.
- We conclude that the existing acoustic difference between the prepalatals and palatalized "hard" posteriors can be attributed to the differences in the lip shape: prepalatals are articulated with strong spreading of the lips, which is not the case for "hard" posterior series – whether in non-palatalizing or palatalizing contexts.

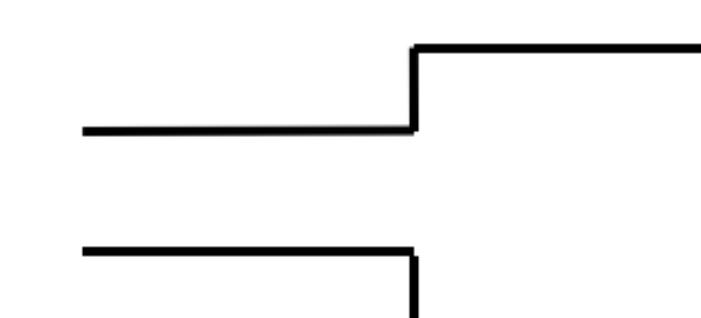
Discussion

Soft posteriors:

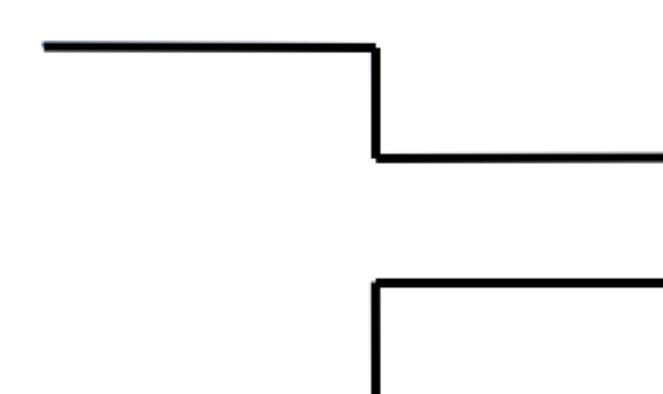
- More raising than in the hard posterior.
- The highest point in the comparable position as for the hard counterpart.
- Longer constriction.
- Tongue root advancement.
- Pronounced long groove along the center of the tongue in the tongue root area
- Lip spreading

Hard posteriors:

- They are not retroflex.
- Less raising than in the soft posterior.
- The highest point in the comparable position as for the prepalatal.
- Shorter constriction.
- Tongue root more retracted than in prepalatals.
- No or minimal tongue groove in the tongue root area/blade.
- Tip of the tongue pointing down.
- Sublaminal cavity.
- Lips protruded and rounded.



Idealized prepalatal consonant configuration with the expansion of the pharyngeal cavity and/or narrowing of the oral cavity



Idealized hard posterior consonant configuration with the expansion of the oral cavity and/or narrowing of the pharyngeal cavity

References

- Koneczna, H., & Zawadowski, W. 1951. *Przekroje rentgenograficzne głosek polskich*. Warszawa: Państwowe Wydawnictwo Naukowe.
- Sawicka, I. 1995. Fonologia. In: Wróbel, H. (ed.), *Fonetyka i fonologia*. Kraków: Wydawnictwo Instytutu Języka Polskiego PAN.
- Verperian, H.K., Wang S., Chung M.K., Schimek, E.M., Durtuchi R.B., Kent, R.D., Ziegert A.J., & Gentry L.R. 2009. Anatomic development of the oral and pharyngeal portions of the vocal tract: An imaging study. *Journal of the Acoustical Society of America*, 125(3):1666–1678. doi: 10.1121/1.3075589.
- Wierzbowska, B. 1967. Opis fonetyczny języka polskiego. Warszawa: Państwowe Wydawnictwo Naukowe.
- Wiśniewski, M. 1997. *Zarys fonetyki i fonologii współczesnego języka polskiego*. Toruń: Wydawnictwo Uniwersytetu Mikołaja Kopernika.

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