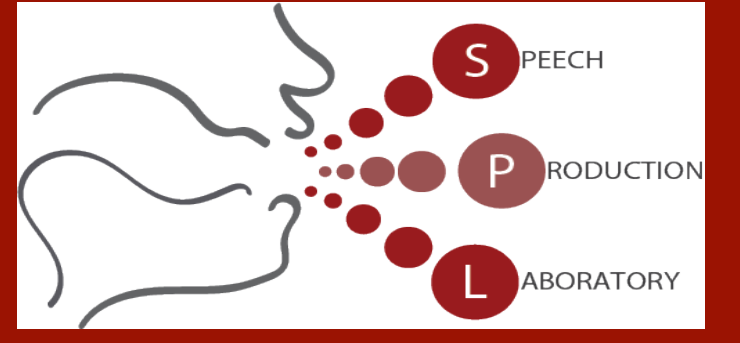# The mechanics of palatalization: A dynamic account

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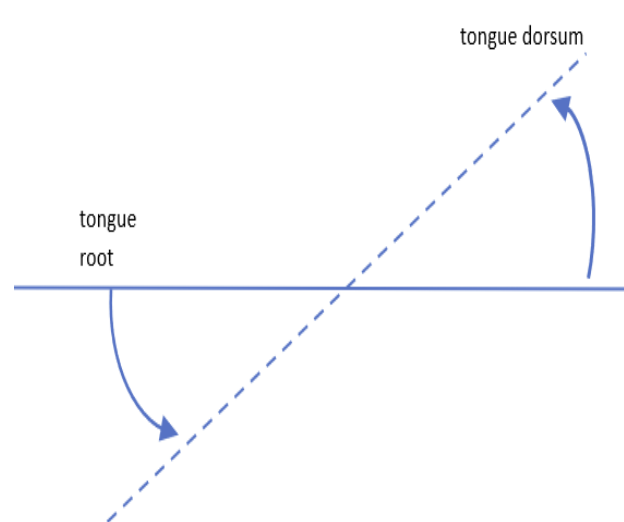**mcavar@iu.edu, charles.84@me.com**

Introduction

- We investigate the formation and progression of the palatalization gesture using a 3D/4D ultrasound in phonemic prepalatals [ɕ, t͡ɕ], and allophonic secondarily palatalized labials and dentals [pʲ, tʲ] in Polish.
- We track over time the changes in the vertical position of the three parts of the tongue (front, middle, and back) separately to test two hypotheses:
  - (H1) Apart from the changes in the dorsal area, the tongue root area is systematically involved in the palatalization gesture.
  - (H2) The tongue root area movement occurs before the tongue dorsum's movement.
- Iskarous (2005) identifies two types of gestures: an arch and a pivot, and Kim *et al.* (2019) add a third type, a shift. Our question was:
  - (Q3) What type of gesture is palatalization?

Methods

- Tongue articulatory data was collected via **real-time 3D ultrasonography**, using the Philips EpiQ-7G machine and a Philips xMatrix x6-1 digital 3D/4D transducer, cf. Csapó & Lulich (2015) and Lulich *et al*. (2018). The probe was stabilized under the jaw with an Articulate Instruments **headset** (Scobbie et al. 2008).
- **Audio signal** was recorded with a SHURE KSM32 microphone simultaneously with the ultrasound recordings (used to identify the ultrasound frames for the analysis).
- The data were collected in the **Speech Production Lab at IU**, Bloomington.
- 10 native speakers of Polish.
- Ultrasound files were analyzed with a custom MATLAB toolbox, "WASL".
- The surface of the tongue was identified automatically using an **objective algorithm** (Karthick *et al*. 2020) and, in 5-10% of cases, manually corrected.
- Tokens were nonce words of the form $C_1V_2C_1V_2C_1$. We analyze **word-initial C_1**.
- The midsagittal contour was **divided evenly into three sections**, roughly corresponding **to the tongue blade, dorsum, and root.**
- In each studied frame, we measured the **displacement in height** (y-values) of the tongue contour **relative to the first frame of the analyzed fragment**. We did it for each part of the tongue separately (blade, dorsum, root) to understand the relative timing of the involvement of each section of the tongue in the movement.
- This difference in raising between each frame and the initial frame is visualized as a line plot, where the *y*-axis is the displacement, and the *x*-axis is the frames over time.
- The **plots were then manually analyzed** to identify the points where the height of the tongue surface **suddenly drops or rises**. In the <u>dorsum area</u>, palatalization is marked by a <u>sudden increase</u> of the y-value. In <u>the tongue root</u> area, the beginning of the gesture is marked by a <u>sudden drop</u> in the y-value.

Three gesture types (Iskarous 2005, Kim et al. 2019)

- An arch: 'squeezing' the tongue from both sides, which results in the elevation of the central part of the tongue.
- In the pivot-type gesture, the paths of individual flesh points are curved and rotate along an arch, with the tongue forming a pivot point akin to a fulcrum.
- A shift: all elements of the articulator are exactly shifted in the same direction (Kim et al. 2019).
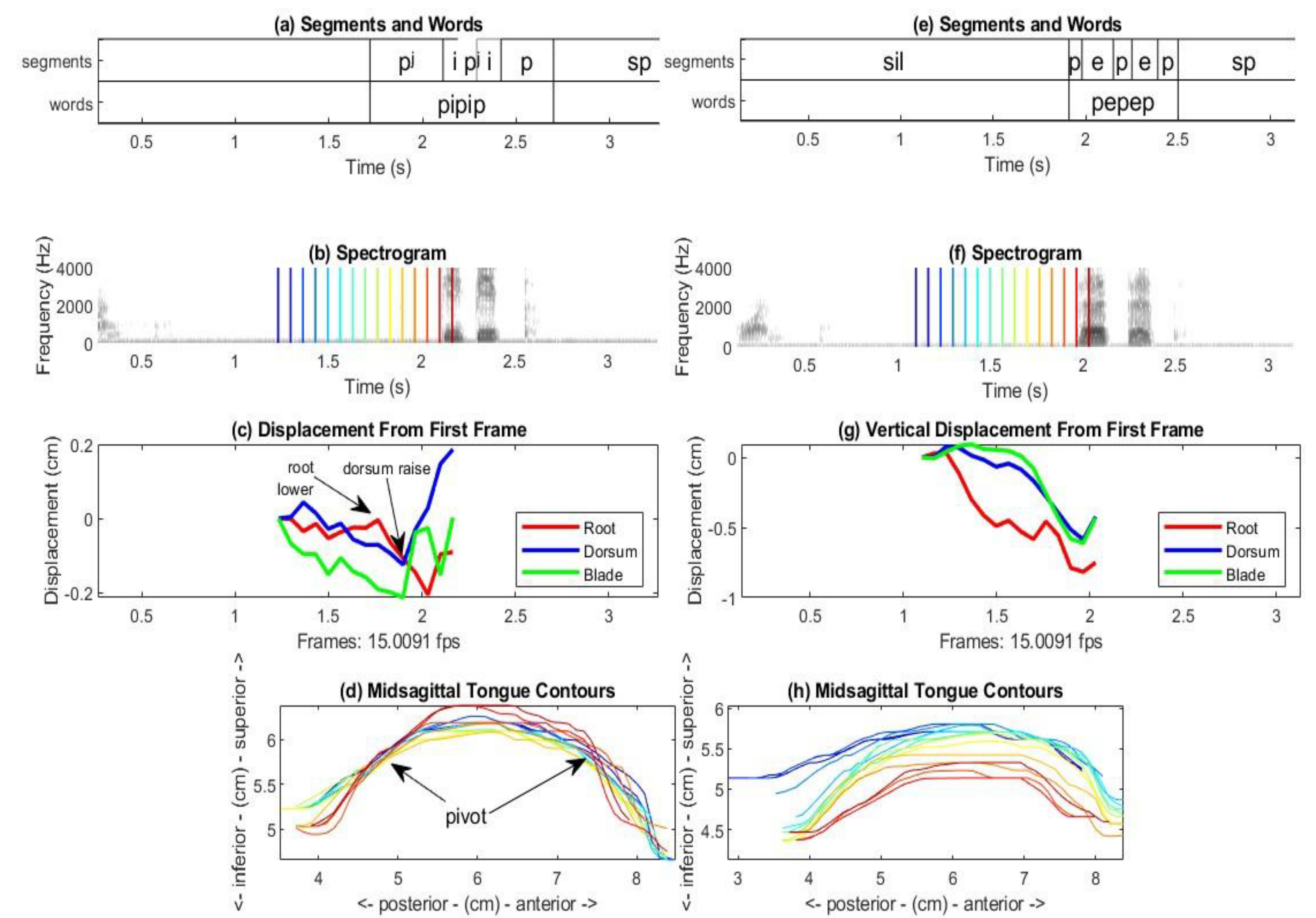
Discussion/Conclusions

- The characteristics of the palatalization posture: the advancement of the tongue root, advancement of the dorsum, and often but not always lowering of the blade relative to the dorsum.
- Tongue root lowering is consistently present in palatalization (H1).
- Tongue root lowering in all recordings we have analyzed (both phonemic and allophonic) precedes the raising of the tongue dorsum (H2).
- Tongue dorsum raising in palatalization often starts simultaneously with the end of the tongue root lowering (marked as the visible raising of the root following the initial root lowering.)
- In most cases, palatalization showed a clear pivot pattern where the tongue root lowers and the dorsum is elevated (Q3).
- Some speakers showed an additional pivot between the dorsum and tongue blade, with the dorsum raising and the blade lowering (Q3).
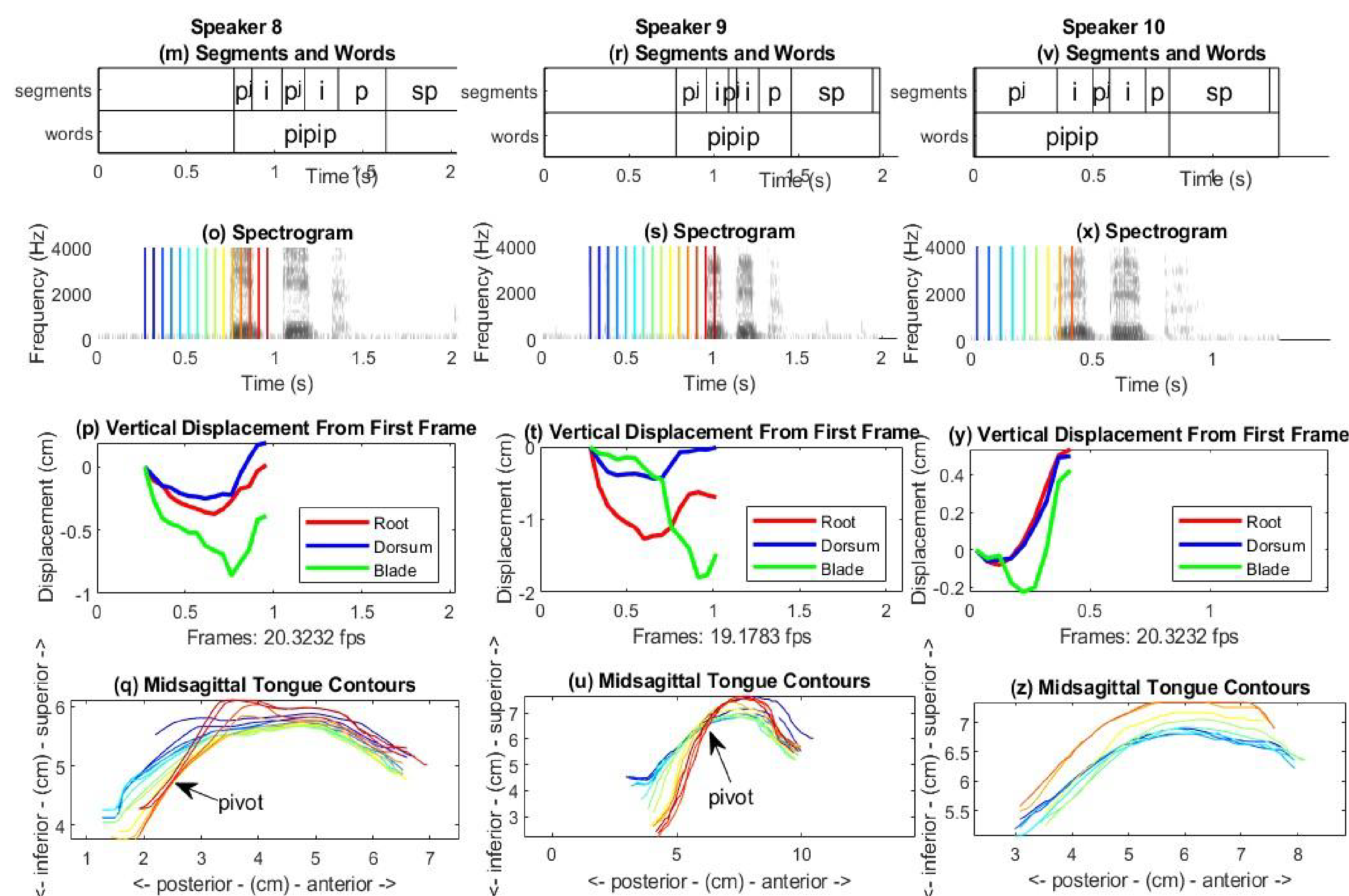
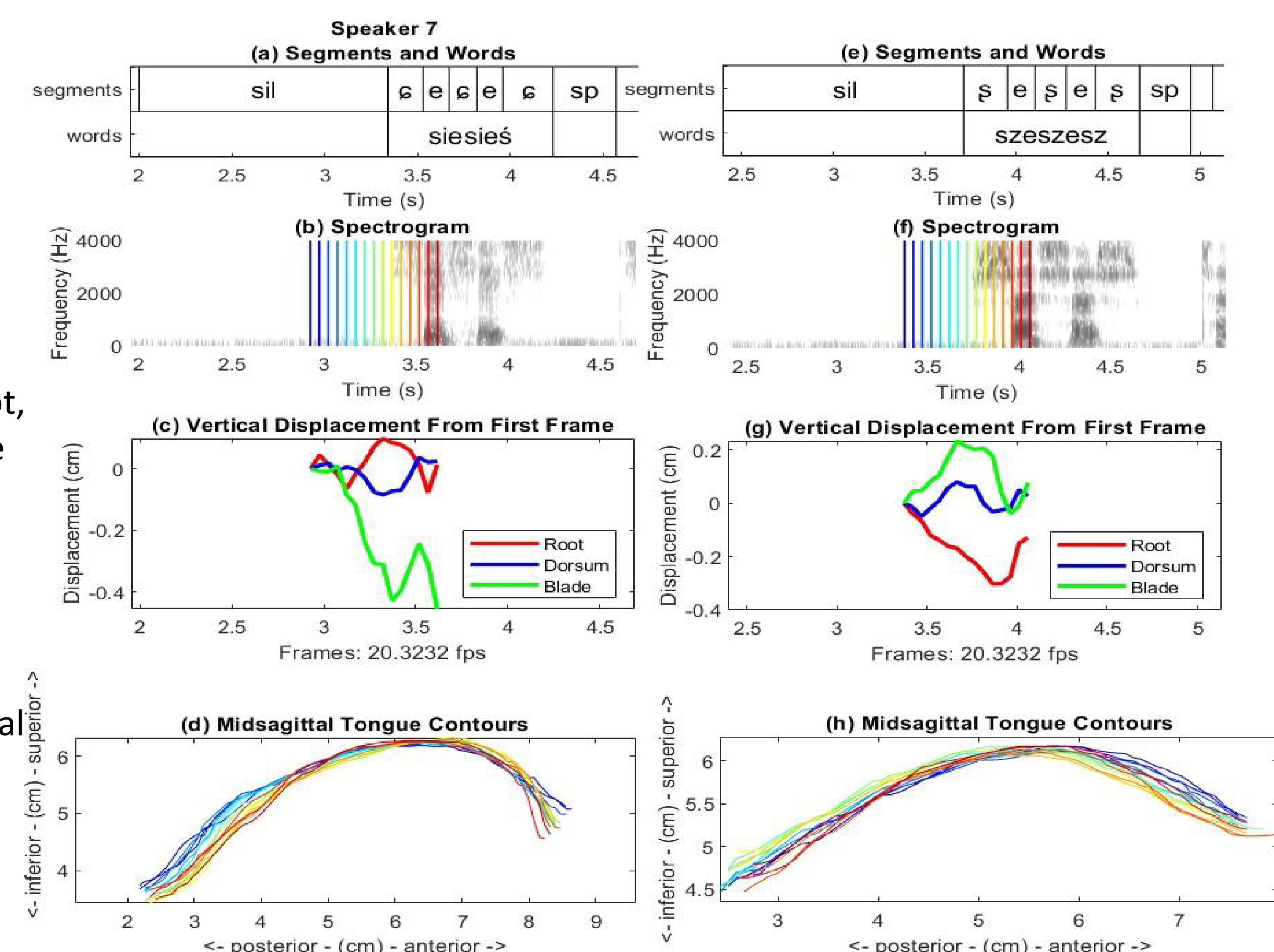## Acknowledgments

Palatalized vs non-palatalized segments

Allophonic palatalization in labials

Phonemic palatalization

Selected references

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