

# Ultrasound imaging of Gengbe labial-velar stops

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## Gengbe

- **Gbe language:** Spoken in Togo and Benin
- **Labial Velars:** /gb/, /kp/, /Ngb/, /Nkp/
- **Participant:** 1 native speaker, 50s, from Batonou, Togo
- **Data Collection:** IU Speech Production Lab, Summer 2016, 1-hour session

## Methodology

- **Recording:** Simultaneous 4D Ultrasound, audio, and video, synchronized using a footpetal
- **Mid Sagittal Traces:** Manual tracing of 2D images
- **3D models:** Compilations of multiple 2D traces
- **Ultrasound:** Philips EpiQ 7G system, xMatrix x6-1 digital 3D transducer (secured under the chin), Articulate Instruments ultrasound stabilization headset (15.24 frames/second)
- **Audio:** SHURE KSM Mic (48kHz sampling rate)
- **Video:** Logitech C920 1080p (33 frames/second)

## 4D ultrasound: What can we see?

- Figure (1):** Preceding vowel matters
- Figures (2-3):** Similar dynamics (/k/, /kp/)
- Figures (4-6):** Similar constrictions (/aka/, /akpa/, /agba/)
- Figure (7):** Velar closure comes late in nasal (/Ngb/)

## What could differences indicate?

- **Ladefoged (1968):** Surveyed aerodynamics of 33 West African languages
- **31/33 languages:** Velaric ingressive mechanism
- **Question:** Is [kp] = [k]+[p]?

## Nasal + Labial-Velar

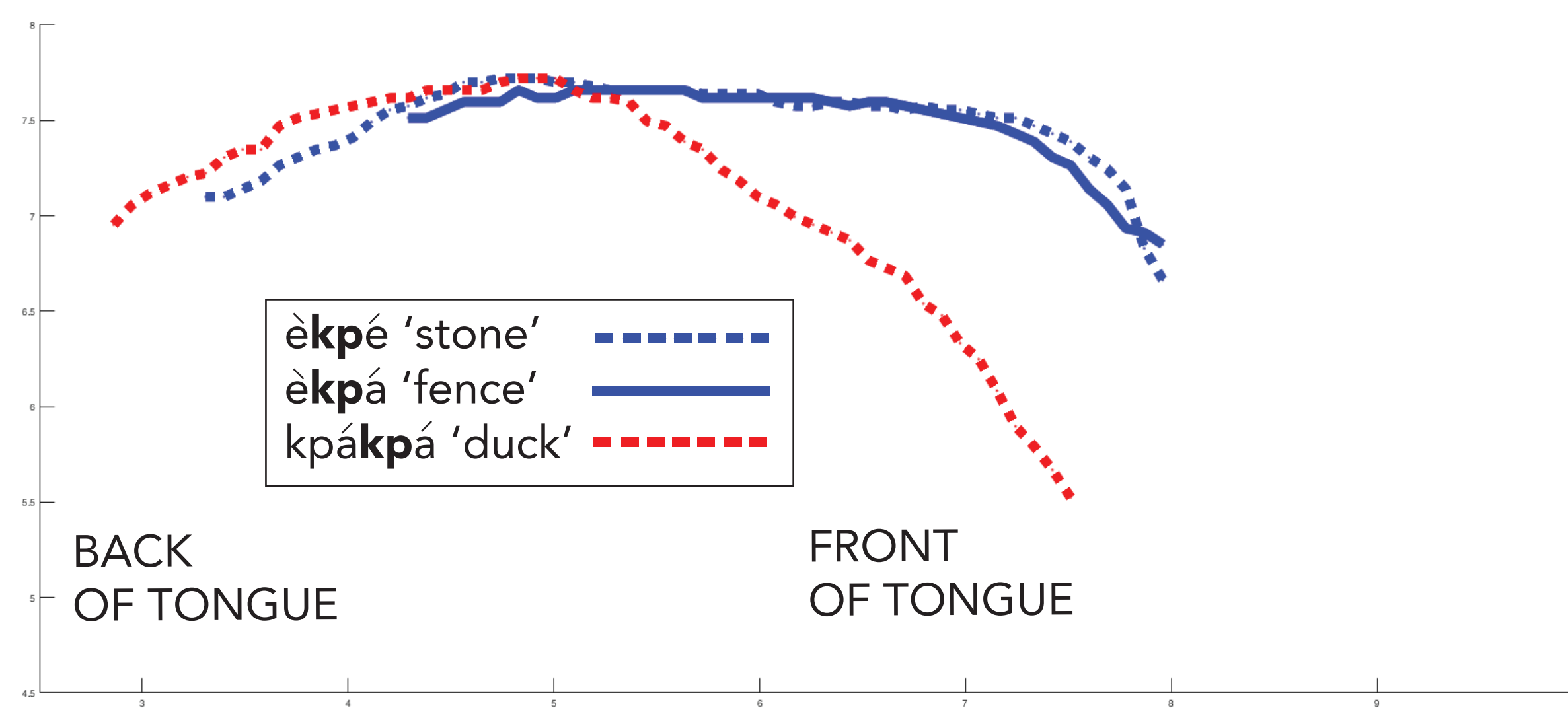
- **/kp/, /gb/:** Velar constriction precedes labial constriction in closure onset and release in Ewe (Maddieson, 1993)
- **/Nkp/, /Ngb/:** Languages vary [mkp], [ŋkp], [ŋmkp] (Cahill 1999)

## Acknowledgments

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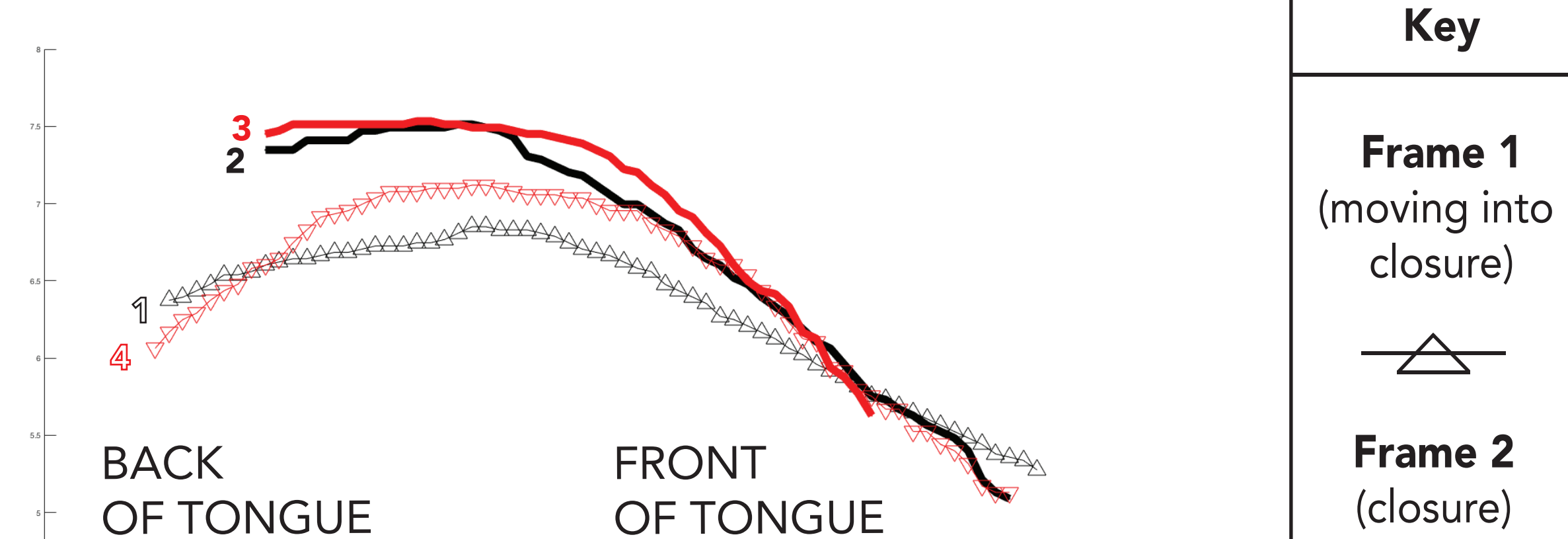
## Preceding vowel matters: /ekpe/, ekpa, /akpa/

**Figure 1.** Mid Sagittal traces: vowel context

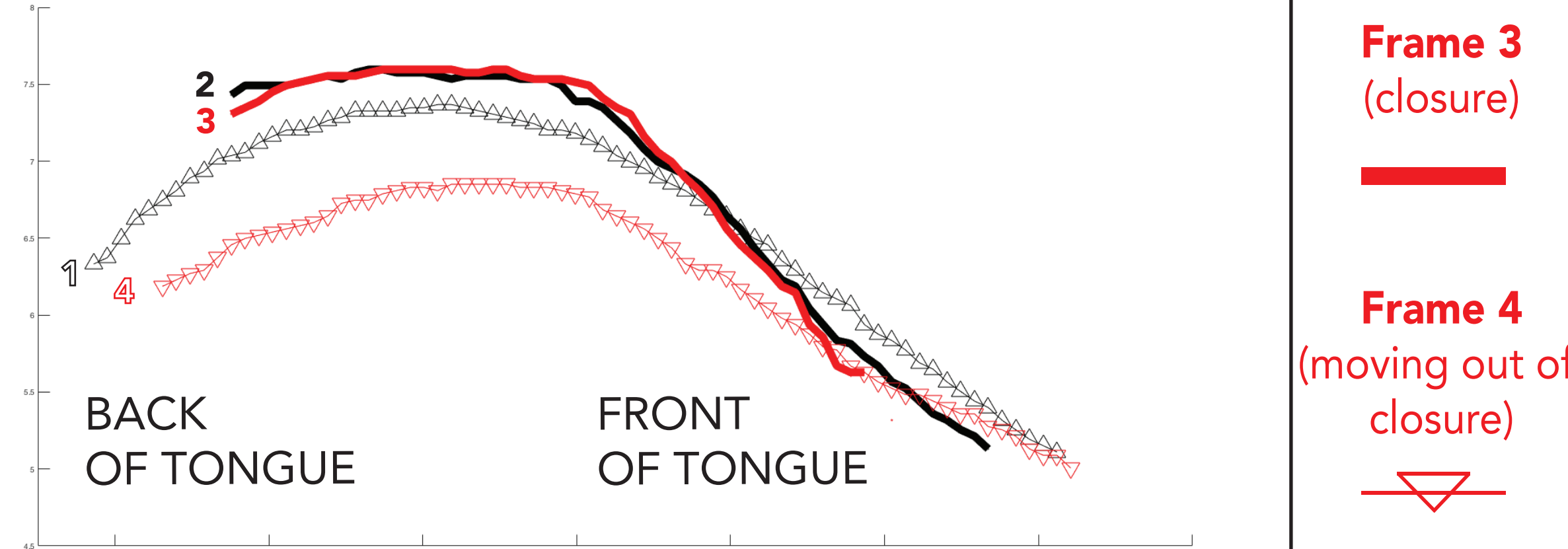


## Dynamics of velar closure: /aka/, /akpa/

**Figure 2.** Mid Sagittal traces: kákááná 'until'

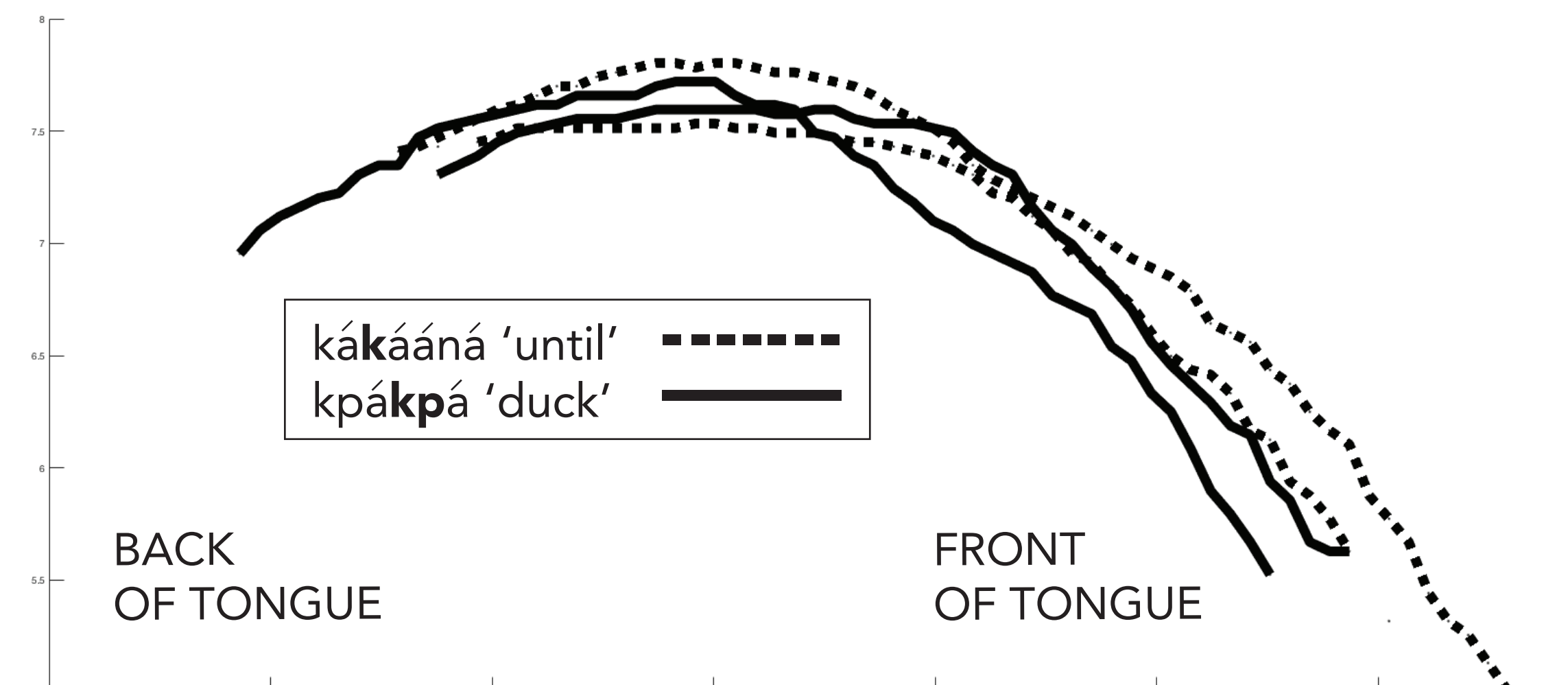


**Figure 3.** Mid Sagittal traces: kpákpá 'duck'

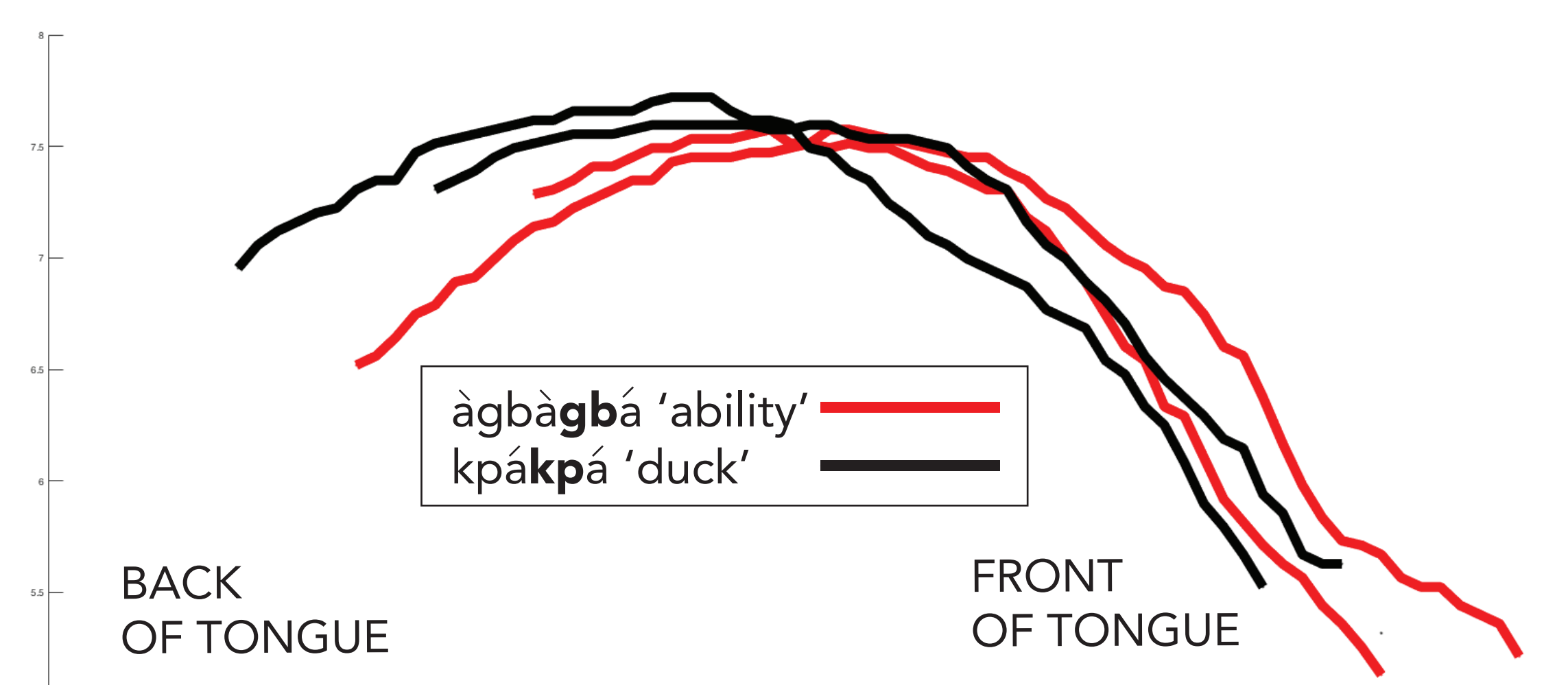


## Closure comparisons: /aka/, /akpa/, /agba/

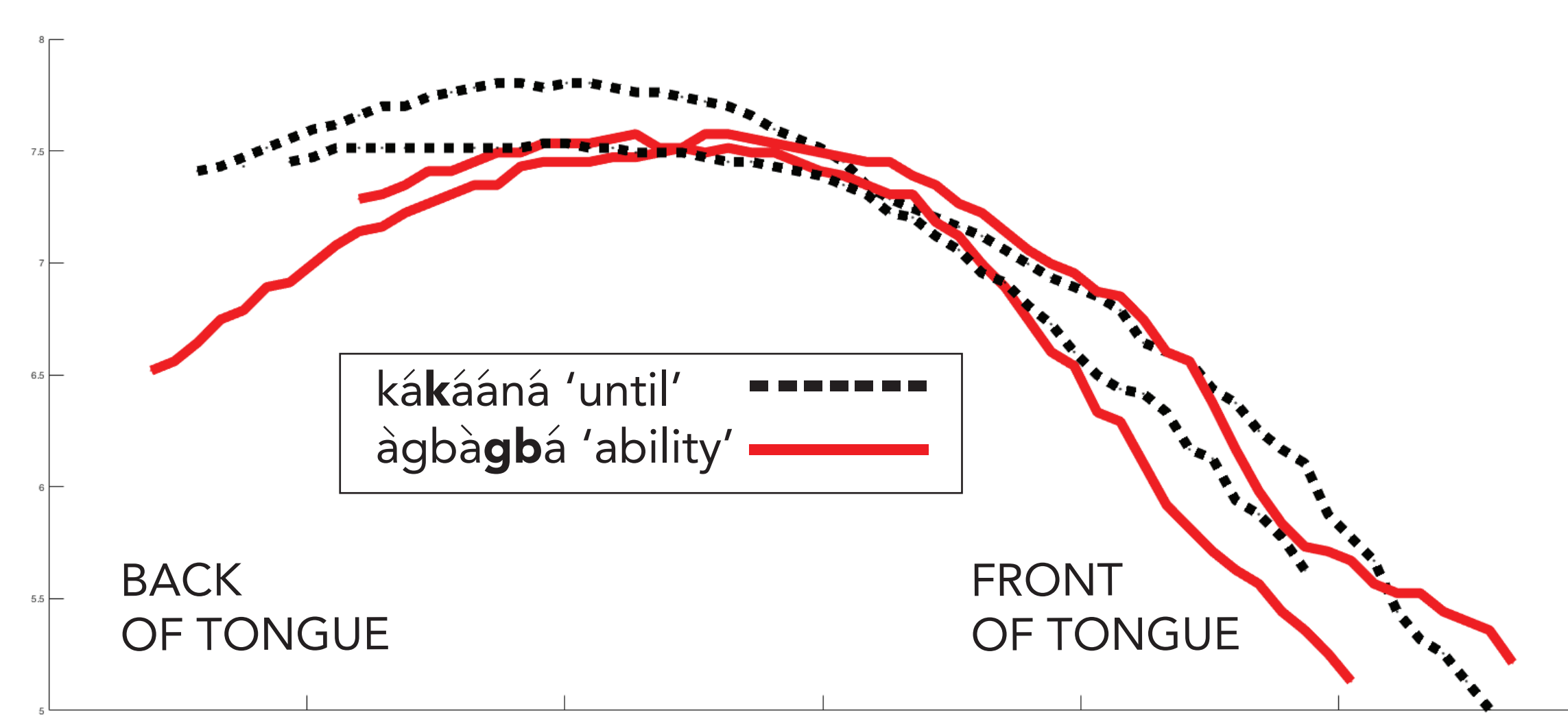
**Figure 4.** Mid Sagittal: kákááná 'until' vs. kpákpá 'duck'



**Figure 5.** Mid Sagittal: àgbàgbá 'ability' vs. kpákpá 'duck'



**Figure 6.** Mid Sagittal: àgbàgbá 'ability' vs. kákááná 'until'



## Trace Choice Criteria:

- 2 repetitions each
- Slice with most info about closure
- Highest trace during closure
- If 2 of the same height, longest trace

## Future Directions

- More languages
- More vowel contexts
- Airflow + Ultrasound + High Speed Camera
- Identify Measurable differences
- Comparison of tongue dynamics & aerodynamics to that of clicks

## References

- Ladefoged, P. (1968). *A Phonetic Study of West African Languages* (2nd ed.). Cambridge University Press.
- Maddieson, I. (1993). Investigating Ewe articulations with electromagnetic articulography. *UCLA Working Papers in Phonetics*, 85, 22-53.
- Cahill, M. (1999). Aspects of the phonology of labial-velar stops. *Studies in African Linguistics*, 28(2), 155-184.

## Figure 7. Timecourse of /Ngb/ 'reverse'

