

# Ultrasound Imaging of [d], [ɖ], and [gb] in Gengbe

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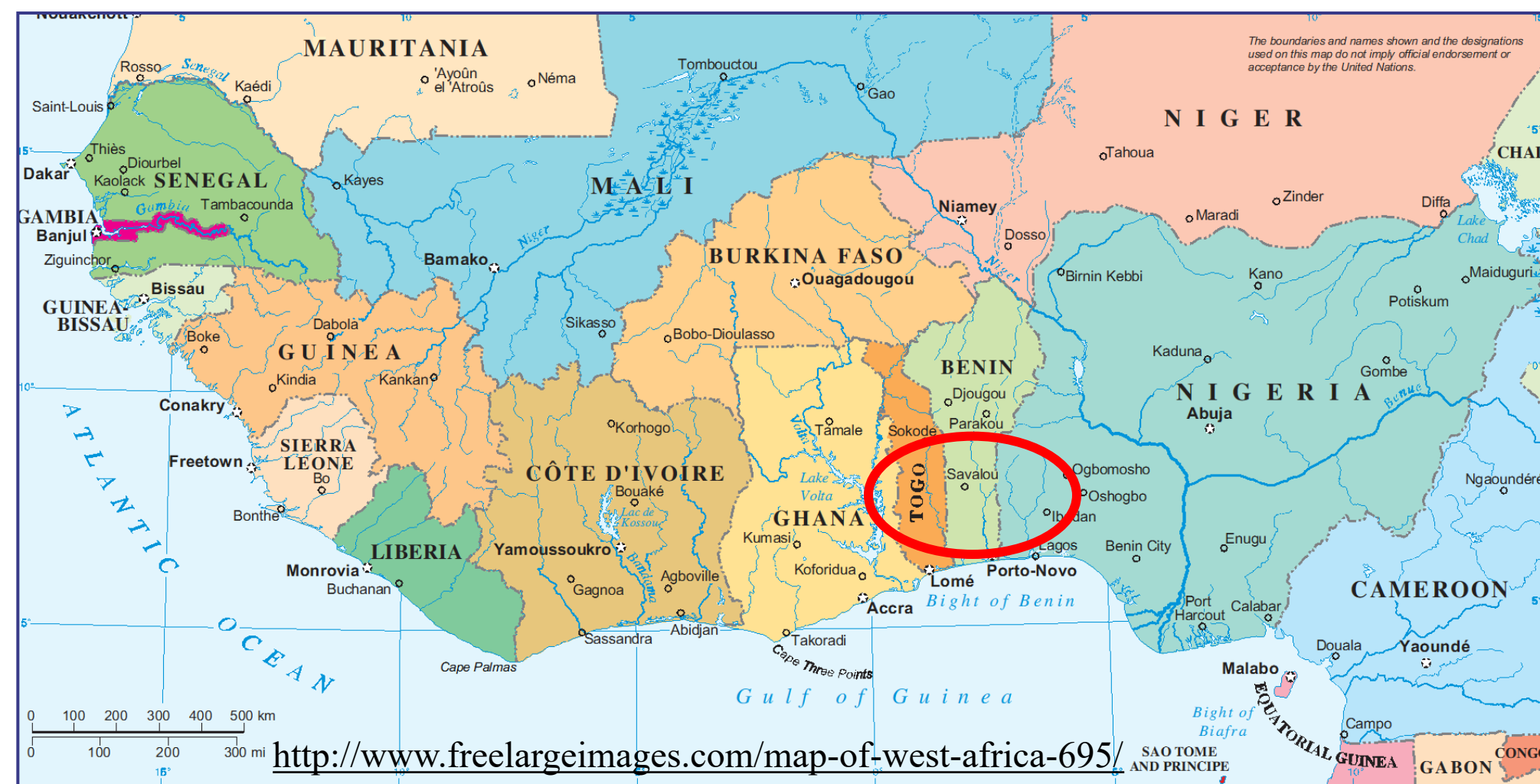


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Goal: use 4D ultrasound capabilities under development in the Speech Production Laboratory to image the articulation of uncommon/complex speech sounds.

## Gengbe

- Gengbe is a Gbe language spoken in Southern Togo and Benin (appr. 300,000 speakers).<sup>1</sup>
- Little previous work on Gengbe<sup>2</sup>; more on Ewe.<sup>3,4,5</sup>



	Bilabial	Labio-Dental	Dental	Alveolar	Alveo-Palatal	Retroflex	Palatal	Velar	Glottal
Nasal	m			n			ɲ	ŋ	
Plosive	p b			t d		ɖ	k g		
Fricative	ɸ β	f v		s z	ʃ		x	h	ɦ
Approximant							j		
Flap				r					

Others: [gb], [kp], [dʒ], [tʃ], [w], [w̥], [j], [ɥ], [ɥ̥], [ɣ̃], [l], [l̥], [r].

## Methods

Palate Impressions were made using dental alginate & digitized with a NextEngine 3D laser scanner; data were saved in binary STL format.

### Ultrasound Recordings

- Ultrasound images were recorded with a Philips EpiQ 7G system using an xMatrix x6-1 digital 3D transducer secured under the chin using an Articulate Instruments ultrasound stabilization headset.
- Recording rates varied between about 9 and 16 volumes per second.

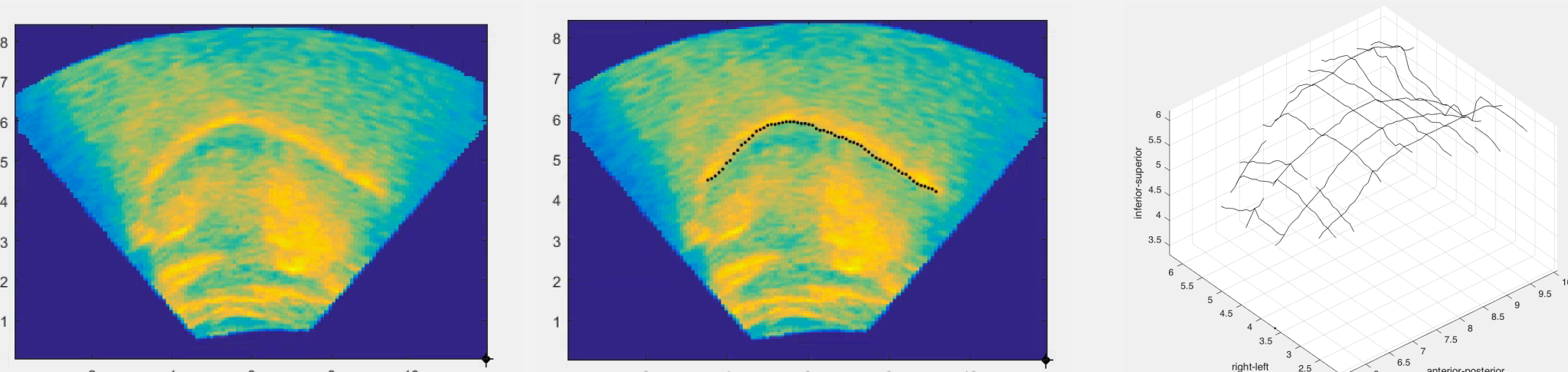
### Joint Palate-Ultrasound Analysis

- Fully uncompressed DICOM ultrasound files were transferred to a Windows 7 computer & exported to binary FLD file format using Philips QLab software.
- Ultrasound/palate files were analyzed w/ a custom MATLAB toolbox.
- Palate manually rotated/translated to subjectively align w/ tongue data.

Audio Recordings: a SHURE KSM microphone, 48kHz sampling rate.

### Audio-Ultrasound Synchronization

- Audio and ultrasound recordings were begun and ended by pressing a foot pedal connected to both the ultrasound system and the Windows computer.

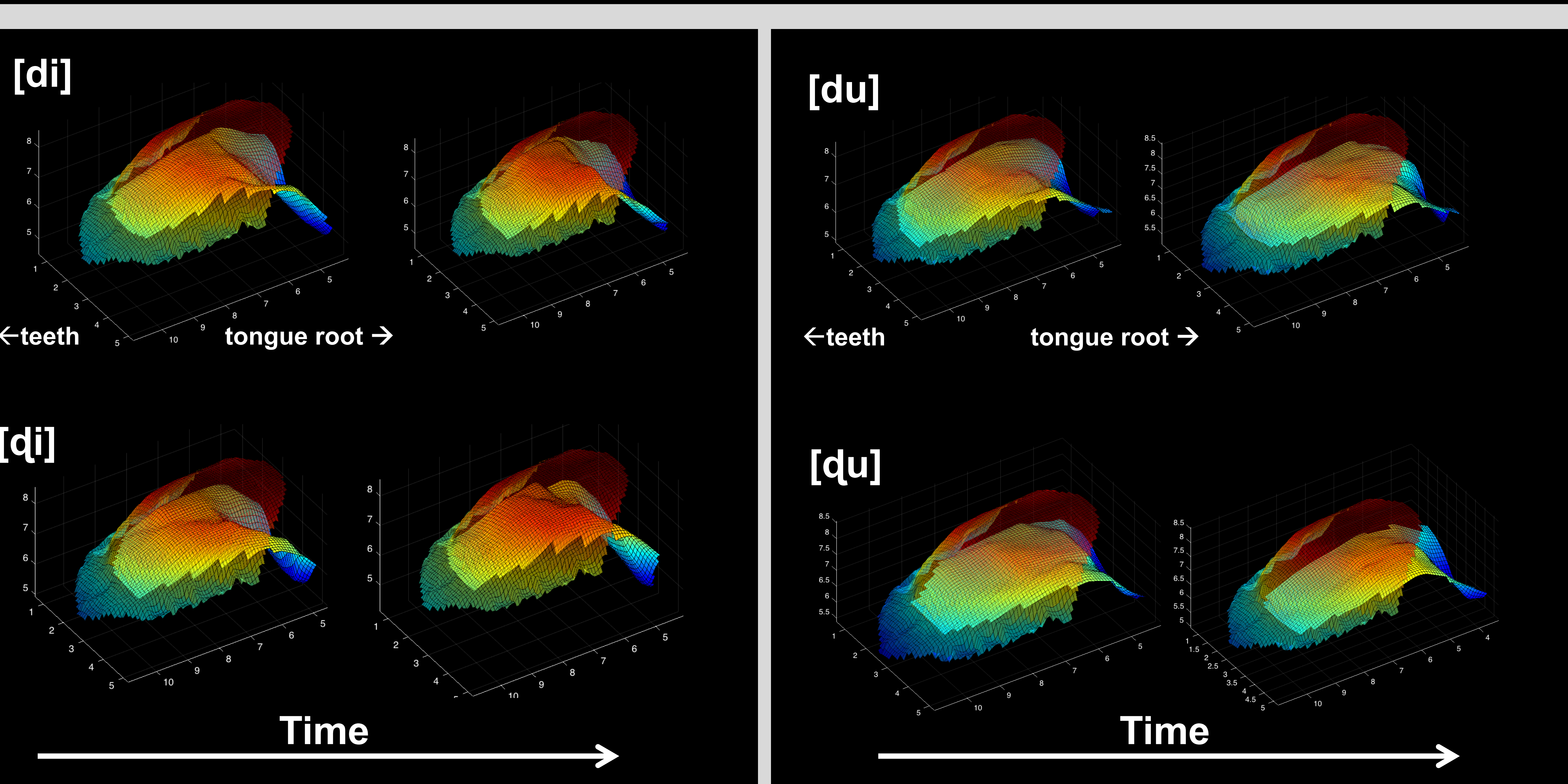
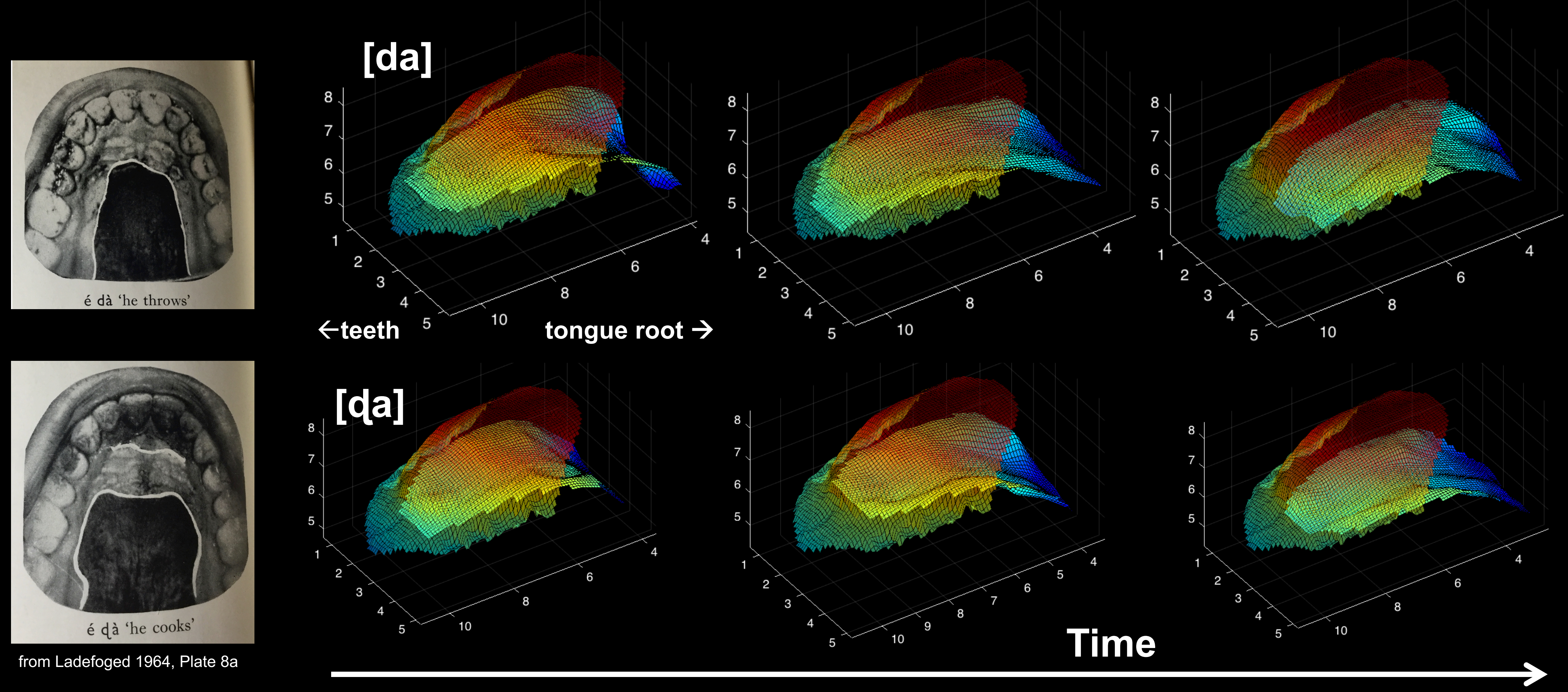


## DATA/FINDINGS - [d] and [ɖ]

In one session (≈1hr.), we recorded to tokens of:

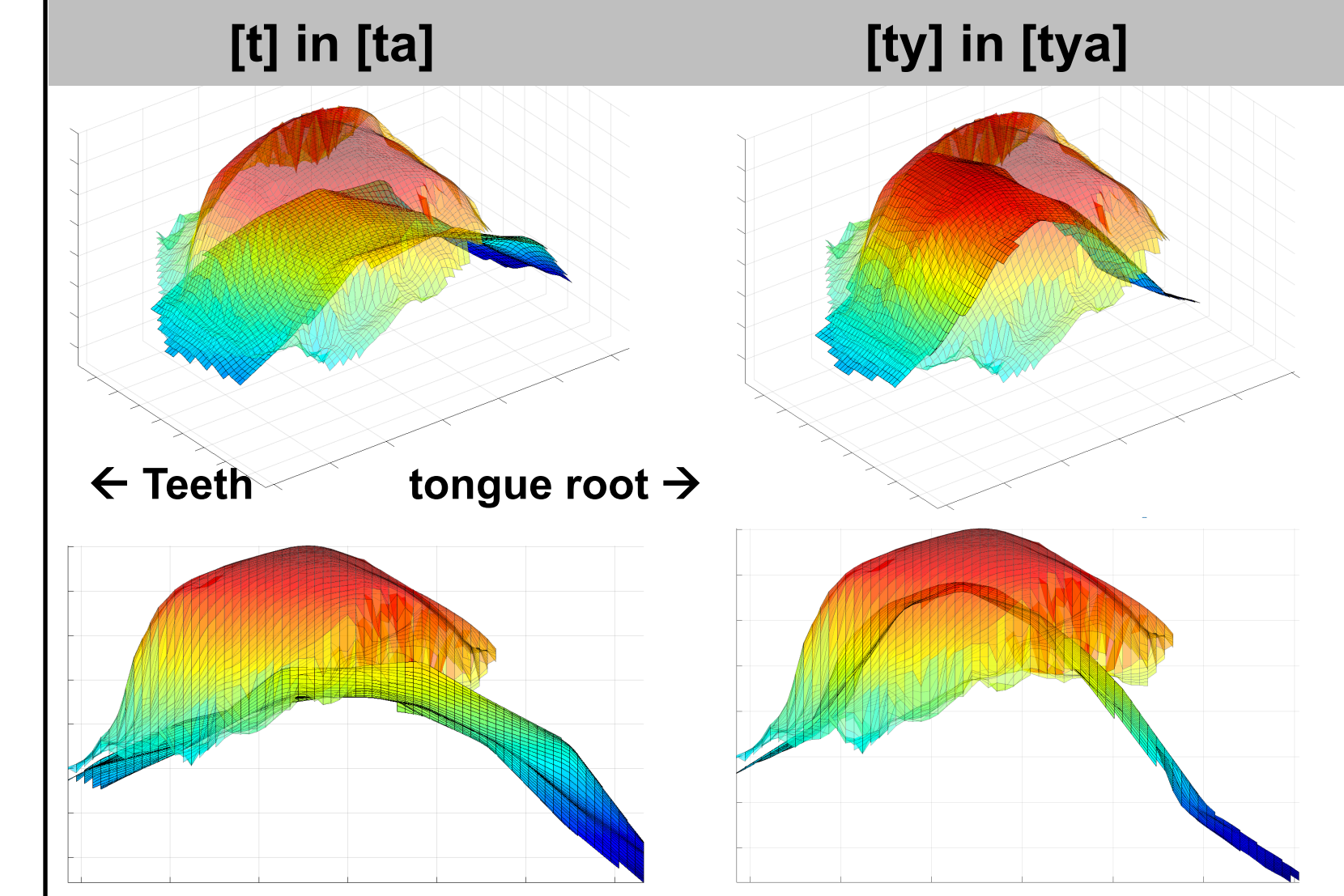
- Initial coronals /d/, /ɖ/, /t/, /n/ in verbs before /a/, /i/, /u/, /e/, /o/.
- Same verbs in a frame sentence.
- Coronal series – in nouns, intervocalic, before /a/, /i/, /u/ in a frame sentence followed by the indefinite determiner ɖé
- Intervocalic labial-velars in all available vowel contexts (/a/ /i/ /e/ /o/)
- Initial labial-velars in all available vowel contexts (/a/ /e/ /o/)
- Syllabic Nasal + labial-velar combinations

- Ladefoged (1964/1968) about /d/ and /ɖ/ in Ewe: “d is articulated with the blade of the tongue against the teeth and alveolar ridge, whereas ɖ is articulated with the tip of the tongue against the alveolar ridge” (p. 20)
- For our consultant: similar pattern in [a] context.
- Elsewhere, the contrast is truly minimal. This (sort of) matches pilot perception data: no confusion for speaker; nearly at-chance perception for trained speech scientists (one a speaker of Marathi, Gujarati).<sup>6</sup>



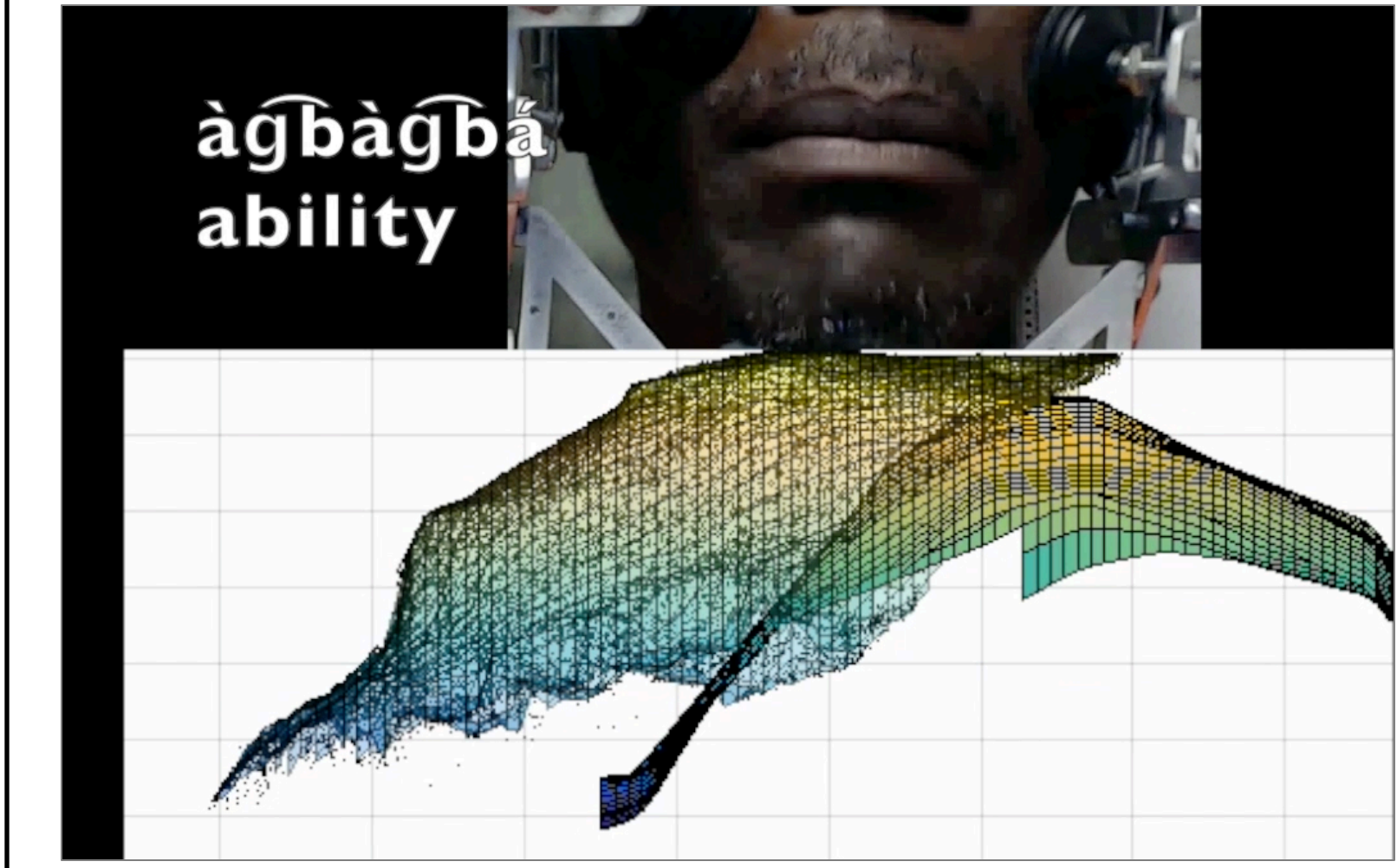
## COMPARATIVE DATA

- A point of comparison: clear distinction between plain and palatalized sounds in San Juan Quiajihje Chatino.<sup>7</sup>
- Note: Described as an apico-dental/laminal alveolar contrast elsewhere.<sup>8,9,10</sup>



## [gb]

- Labial velars: of great interest, in part because of articulatory complexity (two closures).<sup>11</sup>
- We use ultrasound to capture the velar closure, video to capture the labial one. (sample on iPad)



- Due to temporal resolution of US, we don't see the exact moments of closure/release.
- We are working on this, but typical description: velar closure and release before labial one.<sup>11,12,13</sup>

## References

1. Lewis, M. P., G. F. Simons, & C. D. Fennig (eds.). (2015). *Ethnologue: Languages of the World*, 18<sup>th</sup> edition. Dallas, Texas: SIL International. Online version: <http://www.ethnologue.com>. 2. Bole-Richard, R. (1983). *Systématique phonologique et grammaticale d'un parler Ewe: le Gen-Mina du Sud- Togo et Sud-Bénin*. Paris: Editions L'Harmattan. 3. Ladefoged, P. (1964/1968). *A phonetic study of West African languages: An auditory-instrumental study (No. 1)*. New York, NY: Cambridge University Press. 4. Maddieson, I. (1993). Investigating Ewe articulations with electromagnetic articulography. *UCLA working papers in phonetics*, 85, 22-53. 5. Ansre, G. (1961). The tonal structure of Ewe (Masters Thesis, The Kennedy School of Missions of The Hartford Seminary Foundation: Hartford, Connecticut). 6. Abell, A. (unpublished). Dental or retroflex, that is the question: A study of voiced coronal stops in Mina [Gengbe]. *Term paper, IUB Field methods course Spring 2015*. 7. Cavar, M., K. Berkson, M. Nelson, & H. Cruz. (2016). Laminal sounds in San Juan Quiajihje Chatino: A Phonetic and 3D ultrasound study. *Presentation, 21<sup>st</sup> Annual Mid-Phon*. Ann Arbor, MI. 8. Boas, F. (1913). Notes on the Chatino language of Mexico. *American Anthropologist*, 15(1), 78-86. 9. Cruz, H. (2015). *Linguistic poetic and rhetoric of Eastern Chatino of San Juan Quiajihje* (Doctoral dissertation). 10. Cruz, E., & Woodbury, A. C. (2014). Finding a way into a family of tone languages: The story and methods of the Chatino Language Documentation Project. *Language Documentation & Conservation* 8: pps 490-524. [4] McIntosh, J. D. (2011). Grammatical sketch of Tetepec Chatino. available at <https://repositories.lib.utexas.edu/handle/2152/ETD-UT-2011-05-3026>. 11. Cahill, M. (1999). Aspects of the phonology of labial-velar stops. *Studies in African Linguistics*, 28(2), 155-184. 12. Connell, B. (1994). The structure of labial-velar stops. *Journal of Phonetics* 22(4): 441-476. 13. Ladefoged, P. & I. Maddieson. (1996). *The sounds of the world's languages*. Cambridge, MA: Blackwell.

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