

Articulation and acoustics of Brazilian Portuguese palatal laterals

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Background: Of the four lateral approximant sounds with symbols in the IPA, /l/ is the most commonly studied. Most of the literature is focused on the production of English /l/. Little is known about /ɫ, ʎ/ or /ɮ/, perhaps because they are comparatively infrequent in the languages of the world. Consequently, our general understanding of lateral speech sounds is incomplete. To expand our view of lateral production, this study focuses on the palatal lateral approximant /ɫ/.

Brazilian Portuguese provides a robust platform for investigating the palatal lateral approximant. There is a total of four phonetic studies on this sound in this language. The first is a master's thesis on the acoustics of the palatal lateral that reported formant frequencies and trajectories (Silva, 1996). The second is an articulatory-acoustic study that used ultrasound images to connect formant characteristics to articulation (Casero *et al.*, 2016). Two later articulatory-acoustic studies using 3D/4D ultrasound conducted by Charles & Lulich (2018, 2019) compared the articulation of the palatal lateral to the alveolar lateral /l/, the palatalized alveolar lateral /ɫ/, and the palatal glide /j/. They found that while the palatal lateral and the palatalized alveolar lateral were produced similarly, they were distinct from the palatal glide. These studies were limited to a single variety (*Paulistano*), therefore there is no information about the dialectal variation of the palatal lateral. The current study investigates the production of the palatal lateral in 7 dialects of Brazilian Portuguese.

Methods: The subjects were adult native speakers of Brazilian Portuguese. The stimuli were comprised of 49 real words, 10 of which contained the palatal lateral. The /ɫ/ was in word initial and intervocalic positions and in the context of both front and back vowels. Each word was displayed to the subjects in the carrier phrase *Eu digo ___ para você* 'I say ___ for you' and read aloud by the subjects one at a time. The list was repeated 3 times, resulting in a total of 30 palatal lateral tokens per subject.

3D/4D ultrasound images were recorded with a Philips EpiQ-7G machine and a Philips xMatrix x6-1 digital 3D/4D transducer. Parameter settings were adjusted to image the necessary portions of the tongue at the highest frame rate possible (see Lulich *et al.* 2018 for parameter details). Frame rates varied between 15 and 20 fps. An Articulate Instruments Ltd headset stabilized the probe against the skin under the lower jaw. Audio signals were recorded simultaneously at a sampling rate of 48kHz with a SHURE KSM32 directional dynamic microphone.

A palate impression was collected and scanned with a NextEngine Desktop 3D Scanner. The palate image was manually registered within each subject's ultrasound image based on a recording of a swallow of water. The coordinates were visually verified with frames containing moments linguo-palatal contact during consonants like alveolar stops /t, d/.

Digital three-dimensional surfaces representing the tongue surface were generated with the new automatic tracing algorithm presented in Karthik *et al.* (In Review). Briefly, this algorithm searches for steep contiguous borders between high intensity and low intensity pixels on a frame-by-frame basis. The frame that fell during or closest to the target lateral segments was selected for analysis. The resultant surfaces were analyzed qualitatively for of tongue shape and position in contraposition to the palate. All palatal lateral tongue surfaces for each speaker were averaged to generate a single representative surface.

Results and discussion: The tongue shapes and positions were similar across tokens, across speakers, and to previous reports. There was a coronal constriction between the anterior portion of the tongue and the palate near the alveolar ridge. The posterior

portion of the tongue was advanced, and as a result, the tongue body had a high position in close proximity to the hard palate. Additionally, the posterior profile of the tongue was narrowed open the lateral interdental channels.

Figure 1 represents the average tongue surface from a male speaker from the city of São Paulo. The speaker in Figure 2 is a female from the city of Belém. These dialectal regions are geographically and linguistically distant from one another, yet both speakers exhibit the descriptions provided above.

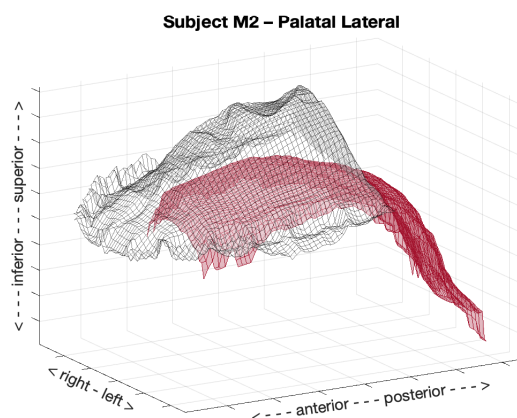


Figure 1: Average palatal lateral tongue surface for male from São Paulo

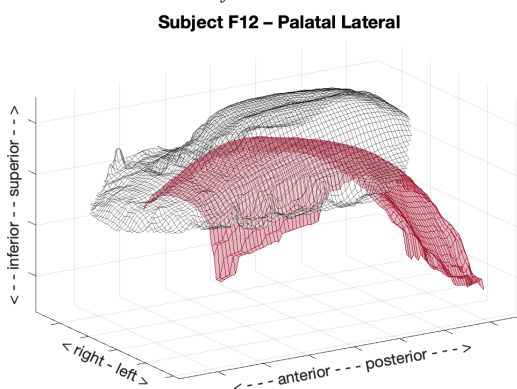


Figure 2: Average palatal lateral tongue surface for female from Belém

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