On the (in)variability in tongue root gestures for voicing in different aerodynamic settings: Ultrasound evidence from Russian

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Introduction: Laryngeal-based contrasts involve both laryngeal and supra-laryngeal gestural maneuvers to meet the 'Aerodynamic Voicing Constraint' (AVC; Ohala 1983, Solé 2018 for recent discussion); in order to maintain the vocal fold vibration, supra-glottal air pressure should be kept lower than sub-glottal pressure. However, for stop consonants, the air pressure tends to go up quickly due to the presence of the oral occlusion of the stops, resulting in the cessation of vocal fold vibration (Ohala 1983, Hayes and Steriade 2004, Kawahara 2006). To accommodate for such an aerodynamic challenge for stops, speakers employ various articulatory strategies (Fuchs et al. 2013 for review). One of the articulatory strategies is tongue root advancement; during the production of voiced stops, speakers often advance the tongue root to expand their pharyngeal cavity, thereby lowering the supra-glottal air pressure to maintain voicing. Such an aerodynamically-motivated tongue root gesture in stops has been observed crosslinguistically (e.g., Ahn 2015, 2016, 2017). On the other hand, a recent study showed that the tongue root advancement is not robust in Russian word-initial voiced stops (/d, dʲ/ vis-à-vis /t, tʲ/) due to the presence of contrastive palatalization, supporting the idea that the tongue root advancement is not universal but controlled (Matsui and Kochetov 2018).

Research questions: What remains unclear is to what extent the tongue root gesture can be variable as a function of various aerodynamic settings within a language and across languages. The current study thus offers a new piece of evidence from Russian as a follow-up study of Matsui and Kochetov (2018). Specifically, the tongue root position was further compared among voiced stops, voiceless stops, nasals and laterals.

Methods: Midsagittal ultrasound and acoustic data were recorded simultaneously. The participants were five native speakers of Russian as part of a larger study. The speech material included utterance-initial coronal stops (/t/, /d/) and sonorants (/l/ and /n/), which were embedded in the utterance initial context of /_ápa/ with initial stress (e.g., /tápa/). The palatalized series was also considered. The video frames corresponding with oral constriction offset were submitted to the Smoothing-Spline ANOVA (Davidson 2006) per individual speaker. Additionally, the Generalized Additive Mixed Models (Sóskuthy 2017) were applied using the aggregated data.

Results and discussion: The main results showed that, contrary to the working hypothesis, tongue root position did not vary as a function of aerodynamic load (see Figure for a representative SS-ANOVA plot); given the measurement point (oral constriction offset), the tongue root is not robustly advanced in voiced stops, compared with voiceless stops and sonorants. Instead, the tongue root position for /l/ is significantly distinguished from others. This observation for /l/ is in line with previous studies suggesting robust velarization (or pharyngealization) of non-palatalized /l/ in Russian (Litvin 2014).

Taken together, the results corroborate the view that tongue root advancement is not likely to be a common articulatory strategy for voicing in Russian (Matsui and Kochetov 2018). To put into a broader perspective, a general implication of the current results that, while the aerodynamic voicing constraint is a universal physiological constraint, the articulatory strategies of accommodating for the constraint, all of which are conspicuous, are language-specific.

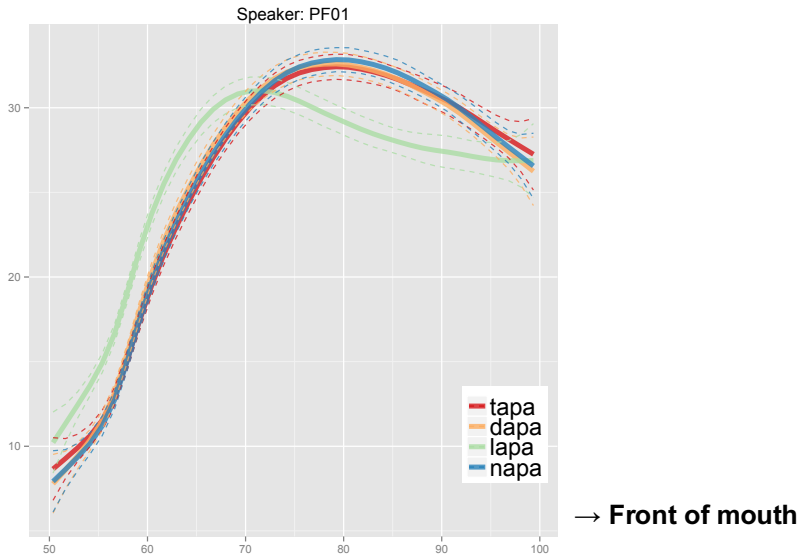

Figure: *A representative SS-ANOVA plot (in mm) for /t/ vs. /d/ vs. /l/ vs. /n/ at the point of the oral constriction offset, produced by a female Russian speaker.*

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