

An ultrasound study of cavity expansion during Canadian French voiced obstruents

Marc Brunelle, Daniel Schweizer, Suzy Ahn, Anika Audet

University of Ottawa

Vocal fold vibrations are more difficult to achieve during obstruents than sonorants because of the aerodynamic voicing constraint (AVC), i.e., the fact that a build-up of air pressure in the supraglottal cavity during oral closures reduces the transglottal airflow and thus hinders vocal fold vibrations (Ohala 1983; 2011). The AVC can be circumvented by a number of voicing adjustment gestures that expand the supraglottal cavity actively (pharyngeal expansion by tongue-root advancement, larynx lowering) or passively (reduction of muscle contraction in the supraglottal tract), or allow air to leak out of the supraglottal cavity (oral or nasal leakage) (Kent & Moll 1969; Perkell 1969; Bell-Berti 1975; Westbury 1983; Westbury & Keating 1986).

To our knowledge, there has only been one study of voicing adjustment strategies in French (Solé 2011; 2018). This study found that French initial voiced stops are often realized with nasal leakage and cavity expansion. However, since it was based on aerodynamic measures, it is unclear which cavity expansion strategy was employed. In the current study, we look at the vertical displacement of the larynx and at pharyngeal expansion in Canadian French 1) to determine if these voicing adjustments are used significantly, 2) to assess the amount of interspeaker variation and 3) to establish if there is a correlation between the use of voicing adjustment gestures, closure voicing amplitude during voiced obstruents and the prevalence of certain types of voicing interruptions (Davidson 2016).

To answer our research questions, we recorded laryngeal and lingual ultrasound videos with 10 native speakers of Canadian French as they read a list of sentences containing phrase-medial sonorants, voiced and voiceless fricatives and voiced and voiceless stops. Laryngeal ultrasound videos were recorded first, followed by lingual ones. The laryngeal ultrasound videos were analyzed to detect the vertical movement of the larynx using optical flow analysis (Moisik *et al.* 2014; Witsil 2019). Established lingual ultrasound techniques were used to look at the position of the tongue-root and infer pharyngeal expansion (Ahn 2015; 2017; 2018a; 2018b; Ahn & Kwon 2019).

Results from 10 speakers reveal that there is generally larynx lowering in voiced obstruents (but consistently lower than 1 mm). The larynx is gradually lowered during all or most of the voiced closure, reaches its lowest position near the release and reverts to its default position during the following vowel. SSANOVA plots show a significant pharyngeal expansion by tongue-root advancement in voiced stops and fricatives. Tongue body lowering is also found, especially in voiced bilabial stops. Despite individual variation, this suggests that Canadian French resorts to both larynx lowering and oral cavity expansion to circumvent the AVC in voiced obstruents.

References

- Ahn, Suzy. 2015. Tongue root contributions to voicing in utterance-initial stops in American English. *Proceedings of Meetings on Acoustics* 25.060008.
- . 2017. Tongue position as an articulatory property of voicing in Brazilian Portuguese and Thai. *The Journal of the Acoustical Society of America* 142.2585-85.
- . 2018a. The role of tongue position in laryngeal contrasts: An ultrasound study of English and Brazilian Portuguese. *Journal of Phonetics* 71.451-67.
- . 2018b. *The Role of Tongue Position in Voicing Contrasts in Cross-Linguistic Contexts*: New York University.
- Ahn, Suzy & Harim Kwon. 2019. Tongue root configuration during Seoul Korean stops: An ultrasound study. *The Journal of the Acoustical Society of America* 146.3080-80.
- Bell-Berti, Fredericka. 1975. Control of pharyngeal cavity size for English voiced and voiceless stops. *The Journal of the Acoustical Society of America* 57.456-61.
- Davidson, Lisa. 2016. Variability in the implementation of voicing in American English obstruents. *Journal of Phonetics* 54.35-50.
- Kent, R. D. & K. L. Moll. 1969. Vocal- Tract Characteristics of the Stop Cognates. *The Journal of the Acoustical Society of America* 46.1549-55.
- Moisik, Scott, Hua Lin & John H. Esling. 2014. A study of laryngeal gestures in Mandarin citation tones using simultaneous laryngoscopy and laryngeal ultrasound(SLLUS). *Journal of the International Phonetic Association* 44.21-58.
- Ohala, John J. 1983. The origin of sound patterns in vocal tract constraints. *The production of speech*, ed. by P. MacNeilage, 189-216. New York: Springer.
- . 2011. Accommodation to the Aerodynamic Voicing Constraint and its Phonological Relevance. Paper presented to the ICPhS, 2011.
- Perkell, Joseph S. 1969. *Physiology of speech production: Results and implications of a quantitative cineradiographic study*. MIT research monograph, No 53.
- Solé, Maria-Josep. 2011. Articulatory adjustments in initial voiced stops in Spanish, French and English. Paper presented to the Proc. ICPhS, 2011.
- . 2018. Articulatory adjustments in initial voiced stops in Spanish, French and English. *Journal of Phonetics* 66.217-41.
- Westbury, John R. 1983. Enlargement of the supraglottal cavity and its relation to stop consonant voicing. *Journal of the Acoustical Society of America* 73.1322-36.
- Westbury, John R. & Patricia A. Keating. 1986. On the naturalness of stop consonant voicing. *Journal of Linguistics* 22.145-66.
- Witsil, AJ. 2019. Imagefx: extract features from images. R package version 0.3. 0.