Tongue root advancement and vowel duration: a gradient effect?

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Background

- Correlates of voicing
  - shorter VOT (Westbury, 1983; Davidson, 2016; Abramson & Whalen, 2017)
  - tongue root advancement TRA (Westbury, 1983; Ohala, 2011)
  - correlation VOT ~ TRA (Ahn, 2015)
  - longer vowel duration (House & Fairbanks, 1953; Peterson & Lehiste, 1960; Chen, 1970; Klatt, 1973; Lisker, 1974; Fowler, 1992; Lampp & Reklis, 2004)
- *Relation between vowel duration and TRA*

Background

- **Voicing effect** (VE): vowels are longer when followed by voiced stops
  - *Italian*: voicing effect of 35 msec (Farnetani & Kori, 1986)
  - *Polish*: mixed results
    - Keating (1984): no effect
    - Nowak (2006) PhD dissertation: 4.5 msec effect
- Timing of laryngeal and tongue activity
  - simultaneous UTI + EGG + audio

Methods (a summary)

- **Participants**: 4 Italians (2 F, 2 M), 4 Polish (2 F, 2 M)
- **Procedure**:
    - simultaneous ultrasound tongue imaging and audio recording
    - stabilisation headset (Articulate Instruments Ltd™, 2008)
- **Materials**:
    - $C_1V_1C_2V_1$
        - C_1 = /p/, V_1 = /a, o, u/, C_2 = /t, d, k, g/
        - *pata*, *pada*, *paka*, …, *poto*, *podo*, …
        - stress on first syllable
    - frame sentence
        - *Dico X lentamente*, 'I say X slowly'
   - *Mówię X teraz*, 'I say X now'
        - no pauses between words

Results: Vowel duration
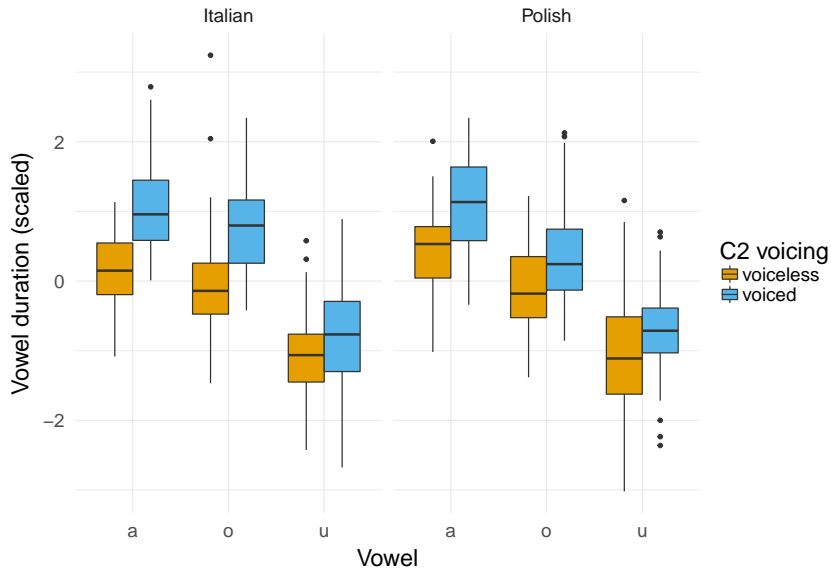
Results: Vowel duration

- Linear mixed-effects models (Bates et al., 2015; Kuznetsova et al., 2016)

- **Italian**

    - `voicing + place + vowel + sentence duration + voicing:vowel`
    - `(1+voicing|speaker) + (1|word)`
    - β = 22 msec, χ^2(3) = 15.8, p = 0.0012434

- **Polish**

    - `voicing + place + vowel + sentence duration + voicing:vowel + place:vowel`
    - `(1+voicing|speaker) + (1|word)`
    - β = 12 msec, χ^2(3) = 12.39, p = 0.0061556

Results: Vowel duration

By−speaker random coefficients
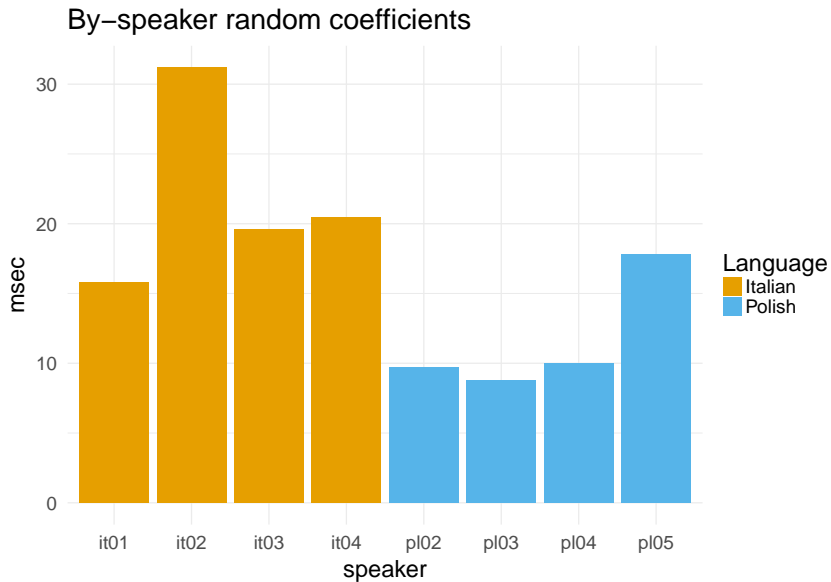
Results: Tongue contours

- **Midsagittal tongue contours**
    - polar coordinates (Heyne & Derrick, 2015b,a; Mielke, 2015)
    - two timepoints:
        - at acoustic closure onset
        - at maximum displacement (within closure, Strycharczuk & Scobbie, 2015)
- **Generalised additive mixed effects models** (Wood, 2006; Sóskuthy, 2017; van Rij et al., 2017)
    - `rticulate` R package (Coretta, 2018a,b)
- **General trends**
    - idiosyncratic use of TRA
    - 2 speakers with relatively greater TRA

Results: Tongue contours

Discussion

- Results summary
  - **effect of voicing on vowel duration**
    - Italian: +22 msec
    - Polish: +12 msec
  - **tongue contours**
    - 4 of 8 speakers (IT01, IT02, IT03, PL05) show TRA at maximum displacement
    - 2 of 8 (IT01, IT02) also at closure onset
  - 2 speakers (IT02, PL05) with stronger VE and greater TRA

Discussion

- **New proposal**: *Longer vowel duration allows for greater tongue root advancement.*

- Similar reasoning to that of Halle & Stevens (1967)

  - longer vowels allow for laryngeal adjustments from spontaneous voicing of vowels to obstruent voicing of voiced consonants.

- If the new proposal is correct, we might see a positive correlation between vowel duration and degree of TRA.

Correlation between tongue root advancement and vowel duration
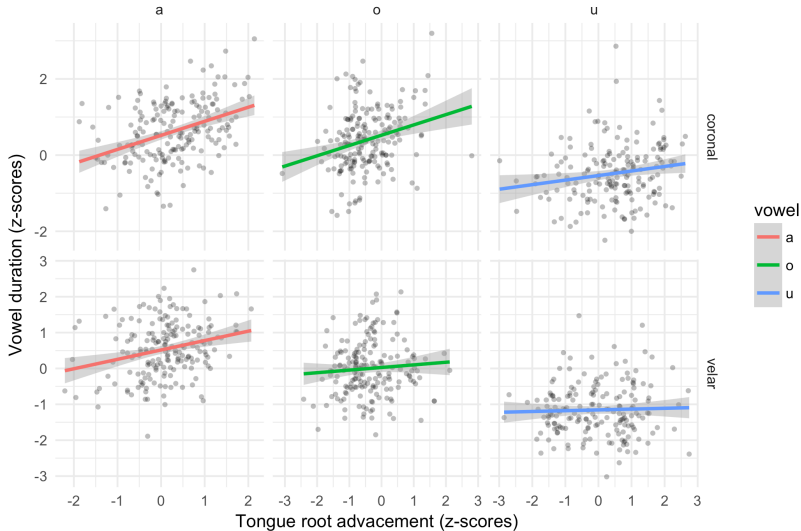
References

Abramson, Arthur S. & Douglas H. Whalen. 2017. Voice Onset Time (VOT) at 50: Teoretical and practical issues in measuring voicing distinctions. *Journal of Phonetics* 63. 75–86.

Ahn, Suzy. 2015. The role of the tongue root in phonation of American English stops. Paper presented at Ultrafest VII.

Articulate Instruments Ltd™. 2008. Ultrasound stabilisation headset users manual: Revision 1.4. Edinburgh, UK: Articulate Instruments Ltd.

Bates, Douglas, Martin Mächler, Ben Bolker & Steve Walker. 2015. Fitting linear mixed-effects models using lme4. *Journal of Statistical Software* 67(1). 1–48.

Chen, Matthew. 1970. Vowel length variation as a function of the voicing of the consonant environment. *Phonetica* 22(3). 129–159.

Coretta, Stefano. 2018a. rticulate: Ultrasound Tongue Imaging in R. R package version 1.3.1.9000. https://github.com/stefanocoretta/rticulate.

Coretta, Stefano. 2018b. Using generalised additive models (GAM) with polar coordinates for assessing tongue contours. https://github.com/stefanocoretta/rticulate.

Davidson, Lisa. 2016. Variability in the implementation of voicing in American English obstruents. *Journal of Phonetics* 54. 35–50.

Farnetani, Edda & Shiro Kori. 1986. Effects of syllable and word structure on segmental durations in spoken Italian. *Speech communication* 5(1). 17–34.

Fowler, Carol A. 1992. Vowel duration and closure duration in voiced and unvoiced stops: There are no contrast effects here. *Journal of Phonetics* 20(1). 143–165.

Halle, Morris & Kenneth Stevens. 1967. Mechanism of glottal vibration for vowels and consonants. *The Journal of the Acoustical Society of America* 41(6). 1613–1613.

Heyne, Matthias & Donald Derrick. 2015a. Benefits of using polar coordinates for working with ultrasound midsagittal tongue contours. *The Journal of the Acoustical Society of America* 137(4). 2302–2302.

Heyne, Matthias & Donald Derrick. 2015b. Using a radial ultrasound probe's virtual origin to compute midsagittal smoothing splines in polar coordinates. *The Journal of the Acoustical Society of America* 138(6). EL509–EL514.

House, Arthur S. & Grant Fairbanks. 1953. The influence of consonant environment upon the secondary acoustical characteristics of vowels. *The Journal of the Acoustical Society of America* 25(1). 105–113.

Keating, Patricia A. 1984. Universal phonetics and the organization of grammars. *UCLA Working Papers in Phonetics* 59.

Klatt, Dennis H. 1973. Interaction between two factors that influence vowel duration. *The Journal of the Acoustical Society of America* 54(4). 1102–1104.

Kuznetsova, Alexandra, Per Bruun Brockhoff & Rune Haubo Bojesen Christensen. 2016. `lmerTest`: Tests in linear mixed effects models. https://CRAN.R-project.org/package=lmerTest. R package version 2.0-33.

Lampp, Claire & Heidi Reklis. 2004. Effects of coda voicing and aspiration on Hindi vowels. *The Journal of the Acoustical Society of America* 115(5). 2540–2540.

Lisker, Leigh. 1974. On "explaining" vowel duration variation. In *Proceedings of the Linguistic Society of America*, 225–232.

Mielke, Jeff. 2015. An ultrasound study of Canadian French rhotic vowels with polar smoothing spline comparisons. *The Journal of the Acoustical Society of America* 137(5). 2858–2869.

Nowak, Pawel. 2006. *Vowel reduction in Polish*: University of California, Berkeley dissertation.

Ohala, John J. 2011. Accommodation to the aerodynamic voicing constraint and its phonological relevance. In *Proceedings of the 17th International Congress of Phonetic Sciences*, 64–67.

Peterson, Gordon E. & Ilse Lehiste. 1960. Duration of syllable nuclei in english. *The Journal of the Acoustical Society of America* 32(6). 693–703.

Sóskuthy, Márton. 2017. Generalised additive mixed models for dynamic analysis in linguistics: a practical introduction. arXiv preprint arXiv:1703.05339.

Strycharczuk, Patrycja & James M. Scobbie. 2015. Velocity measures in ultrasound data. Gestural timing of post-vocalic /l/ in English. In *Proceedings of the 18th International Congress of Phonetic Sciences*, 1–5.

van Rij, Jacolien, Martijn Wieling, R. Harald Baayen & Hedderik van Rijn. 2017. itsadug: Interpreting time series and autocorrelated data using GAMMs. R package version 2.3.

Westbury, John R. 1983. Enlargement of the supraglottal cavity and its relation to stop consonant voicing. *The Journal of the Acoustical Society of America* 73(4). 1322–1336.

Wood, Simon. 2006. *Generalized additive models: An introduction with R*. CRC Press.