Velum-oral timing and its variability in Korean nasal consonants

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INTRODUCTION

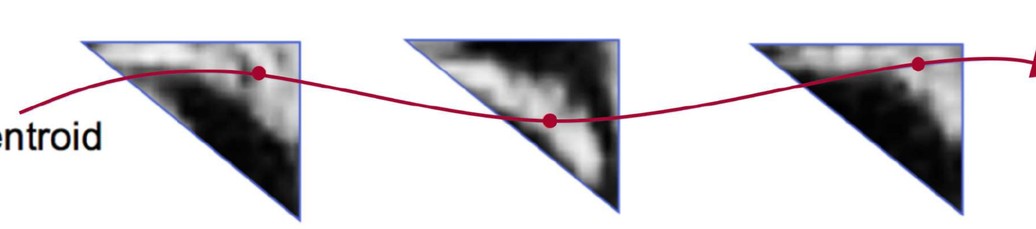
Studies on intergestural timing provides an opportunity to understand not only the coordination patterns [1, 2] but also the flexibility of these coordination [3, 4].

For example for *within-segment* intergestural timing, largely fixed timing relations are exhibited across contextual variations due to its tight coupling structures. But…

For within-segment **timing variability**, will the variability change as a function of syllable position or will it remain stable due to the relatively fixed within-segment timing relations?

To investigate this, we examine timing variability across prosodic modulations in multi-gestural segments, focusing on velum and oral gestures in Seoul Korean nasal sequences.

METHODS



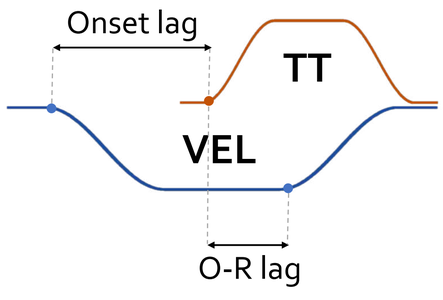
Data acquisition
Real-time Magnetic Resonance Imaging speech production data of the midsagittal vocal tract (temporal resolution: 12ms/frame)

Subjects
Five native Seoul Korean speakers[1)]

Stimuli
Syllable-onset nasals (/#n/), syllable-coda nasals (/n#p/, /n#t/), & juncture geminate nasals (/n#n/) across three boundary/focus conditions (Wd, AP, & AP+focus; 7/8 reps each)

Data analysis
Velum (VEL): Velum centroid tracking analysis [5]
Tongue Tip (TT): Region-of-interest image sequence analysis [6]

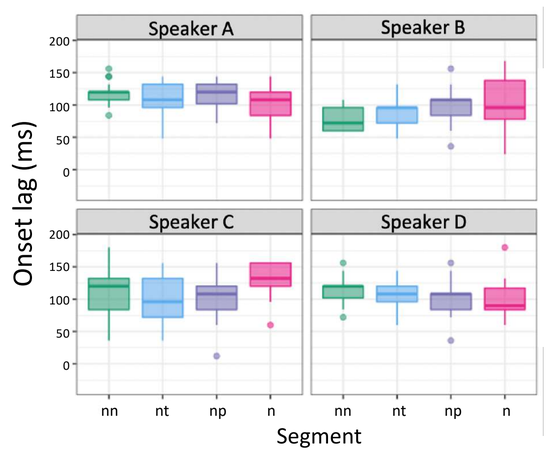
Measurements
Onset lag: the interval from the VEL lowering onset to the TT onset
O-R lag: the interval from TT onset to VEL raising onset (≈ articulatory duration of consonant nasalization)



Statistical testing
Linear mixed effects models for mean lags, and Coefficients of Variation (CoV) [7] using modified signed-likelihood ratio test [8] for comparing variances.

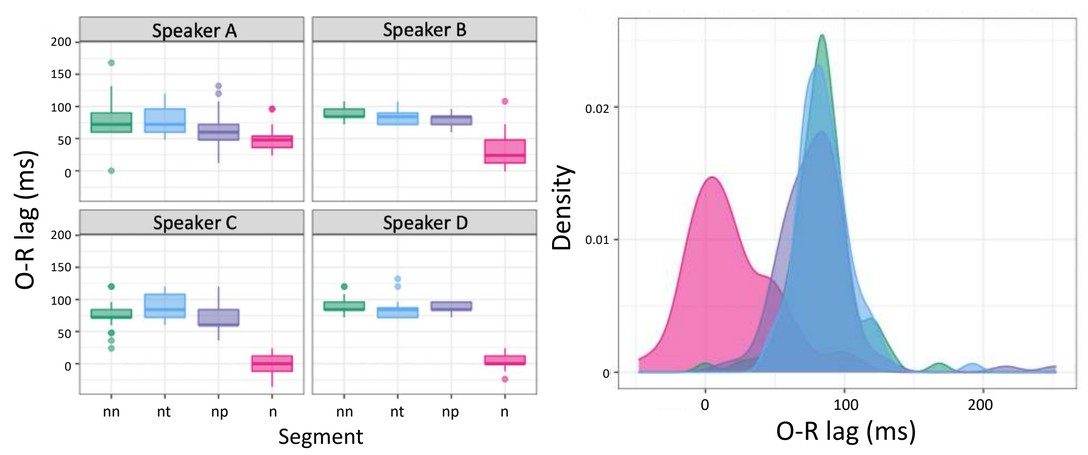
1) Out of five total subjects, one speaker's data are omitted due to a lack of quantifiable VEL gestures in onset nasals (/#n/).

RESULTS



Onset lags: onset nasals ≈ coda nasals ≈ geminate nasals
- The positive lag indicates that VEL precedes TT

Greater timing variability in the onset nasals
- CoV: onset /n/ > coda /n/ & geminate /n#n/



O-R lags: onset nasals (near-zero) < coda & geminate nasals
- A near-zero O-R lag is indicative of almost no *consonant nasality*

Greater timing variability in the onset nasals
- CoV: onset /n/ > coda /n#p/ > coda /n#t/ & /n#n/

CONCLUSION

This study reveals articulatory grounding for phonological phenomena commonly observed in Korean such as *onset denasalization* or *nasal weakening* [9, 10].
- Korean onset nasals have **a shorter duration of nasality** than the coda nasals and are associated with **greater variability**.

In sum, intergestural timing is not merely a matter of contextual overlap, but rather syllable structure and variability in coupling relations are intrinsic to the representational specification for these segment-sized gestural molecules.

References
[1] Byrd, D., Tobin, S., Bresch, E., & Narayanan, S. 2009. Timing effects of syllable structure and stress on nasals: a real-time MRI examination, *Journal of Phonetics,* 37(1):97-110 **[2] Cho, T. 2006**. Manifestation of prosodic structure in articulatory variation: Evidence from lip kinematics in English, *Laboratory Phonology,* 8:519-548 **[3] Shaw, J. A., Durvasula, K., & Kochetov, A. 2019.** The temporal basis of complex segments, *Proceedings of the International Congress of Phonetic Sciences* Melbourne:676-680 **[4] Oh, M., Byrd, D., Goldstein, L., & Narayanan, S. 2019.** Vertical larynx actions and larynx-oral timing in ejectives and implosives, *3rd Phonetics and Phonology in Europe.* Lecce, Italy **[5] Oh, M., & Lee, Y. 2018.** ACT: An Automatic Centroid Tracking tool for analyzing vocal tract actions in real-time magnetic resonance imaging speech production data, *Journal of the Acoustical Society of America,* 144(4), EL290-EL296 **[6] Lammert, A., Ramanarayanan, V., Proctor, M., & Narayanan, S. 2013.** Vocal tract cross-distance estimation from real-time MRI using region-of-interest analysis, *INTERSPEECH.* Lyon, France, 959-962 **[7] Marwick, B., & K. Krishnamoorthy. 2019.** cvequality: Tests for the Equality of Coefficients of Variation from Multiple Groups. R software package version 0.1.3. Retrieved from https://github.com/benmarwick/cvequality, on 09/18/2020 **[8] Krishnamoorthy, K., & Lee, M. 2014.** Improved tests for the equality of normal coefficients of variation. *Computational Statistics*, 29(1-2), 215-232 **[9] Kim, Y. S. 2011.** *An Acoustic, Aerodynamic and Perceptual Investigation of Word-initial Denasalization in Korean.* PhD dissertation, University College London **[10] Yoshida, K. 2008.** Phonetic implementation of Korean denasalization and its variation related to prosody. *IULC Working Papers*, *8*(1)

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