Focus-induced articulatory prominence on velum actions in nasal geminates

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INTRODUCTION

How do speakers control the spatiotemporal properties of articulatory actions to realize prosodic salience?

Articulation of **single oral** consonants under focus have been found to be generally *larger and longer* (e.g., [1]).

But, what is the articulatory implementation of focus in **multi-gesture structures** with *non-oral* gestural components (e.g., velum or larynx gesture)?

And, do (non-lexical/juncture) **geminates** exhibit these same focus effects as singletons, given that they are *already long?*

We examine **nasal geminates** to examine the articulation of prominence in:

- Oral actions
- Velum actions
- Relative timing between oral & velum gestures

Q. What are the dynamical mechanisms underlying the articulation of focal prominence in nasal geminates (as compared to nasal singletons)?

METHOD

Stimuli

- Korean nasal singletons and geminates
- Target nasal consonant sequences are created by a noun + number classifier combination

Singletons:	Onset	V # **n**V
	Coda	V**n** # pV
Juncture geminate:		V**n** # **n**V

Prosodic Condition

No focus vs. (Accentual Phrase) Boundary initial focus

Independent Variables

- Nasals (singleton onset & coda, juncture geminate)
- Focus condition (no focus, focus)

Data

- Real-time MRI data of the midsagittal vocal tract from one native Korean speaker
- Obtained kinematic trajectories of **Tongue Tip (TT)** gestures & **Velum (VEL)** lowering/raising gestures

Data Analysis

- Region-of-interest image sequence analysis [2]
- Centroid tracking analysis [3]

MEASUREMENTS

Duration

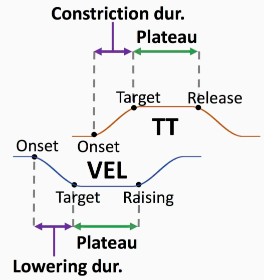
Plateau duration
↳ Target to oral release/velum raising onset

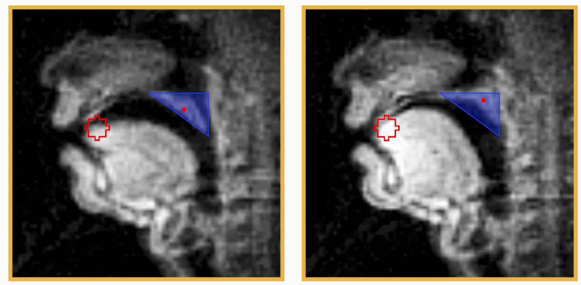
Oral constriction/Velum lowering duration
↳ Movement onset to target achievement

Magnitude

Estimation of TT constriction degree
↳ Mean pixel intensity (red ● ROI)

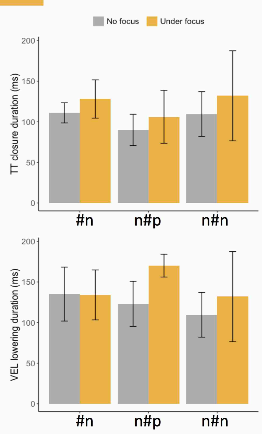
VEL lowering & raising magnitude
↳ Vertical centroid displacement (blue ◥ ROI)





RESULTS – DURATION

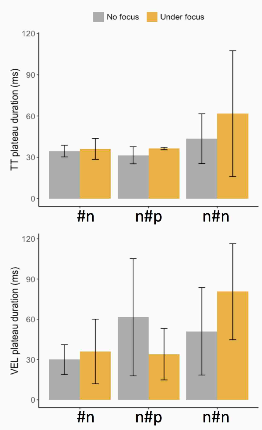
Formation duration



Under focus:
TT closure duration is slightly lengthened in general

onset **n** geminate **nn** → no change in VEL lowering dur.
coda **n** → VEL lowering duration lengthens

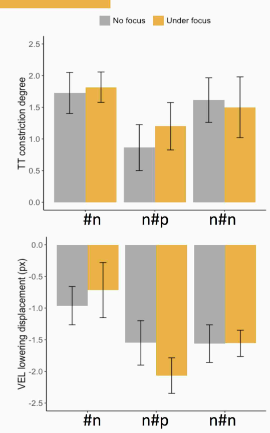
Plateau duration



Under focus:
(for both TT and VEL plateau duration)

singletons → no change (or shortening)
geminates → lengthening

RESULTS – MAGNITUDE



Inherent TT constriction degree:

coda **n** < onset **n**, geminate **nn**

No focus effect in general

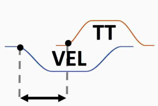
Inherent VEL lowering magnitude:

onset **n** < coda **n**, geminate **nn**

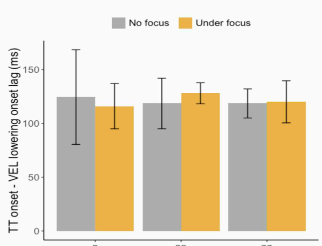
Under focus:
onset **n** → decrease lowering
coda **n** → increase lowering
geminate **nn** → no change

UNDER FOCUS	Singleton onset	Singleton coda	Juncture geminate
gestural formation	no lengthening	mixed	no lengthening
plateau	no lengthening	no lengthening/shorter	lengthening
magnitude	no effect	increased	no effect
onset to raising lag	no effect	no effect	longer

RESULTS – TEMPORAL LAG

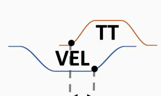


Onset-to-onset lag (VEL*on* to TT*on*)

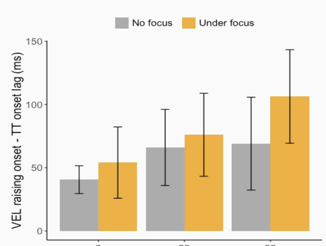


Temporal lag is **stable** with or without focus
This lag is also **stable** across singletons and geminates

VEL lowering begins about 120 ms before TT onset



Onset-to-raising lag (TT*on* to VEL*end*)



Under focus:
Temporal lag increases most notably in geminates

TT onset to VEL raising onset lag:

onset **n** < coda **n**, geminate **nn**

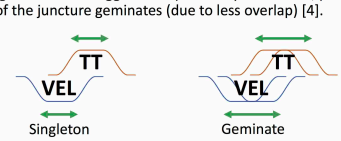
CONCLUSION

Plateau duration best distinguishes geminates from singletons.

Geminates have longer **lag between TT onset and VEL raising** (an index of nasality) than singletons under focus. (But no change in onset lags.)

Under focus, these features become lengthened substantially in geminates.

- This lengthening under focus suggests the possibility of a subtle, prosodically driven **degemination** of the juncture geminates (due to less overlap) [4].



Focal prominence in geminates is not realized in *the spatial domain* nor at the left edge of or between the component [n] gestures, but is rather realized in *the temporal domain*, specifically associated with the region of the gestural plateaus.

REFERENCES

[1] Cho, T., & Keating, P. 2009. Effects of initial position versus prominence in English. *Journal of Phonetics*, *37*(4), 466-485. **[2] Lammert, A., Ramanarayanan, V., Proctor, M., & Narayanan, S. 2013.** Vocal tract cross-distance estimation from real-time MRI using region-of-interest analysis. In *INTERSPEECH* (Lyon, France), 959–962. **[3] 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,* 114(4), EL290–EL296. **[4] Byrd, D., Lee, S., & Campos-Astorkiza, R. 2008.** Phrase boundary effects on the temporal kinematics of sequential tongue tip consonants. *The Journal of the Acoustical Society of America*, *123*(6), 4456-4465.

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