The Role of Information Structure and Foot Structure on the Kinematics of Unstressed Syllables

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Speakers vary their production along a continuum of hypoarticulation and hyperarticulation under different contexts [1]. One of those contexts is information structure. A large body of research has explored the acoustic effect of accentual lengthening on syllables when the word is contrastively focused [2]–[5]. Articulatorily, in a study examining the role of information structure on speech articulation in German, Mücke & Grice [6] found that supralaryngeal articulation can be modified by information structure alone rather than mediated by accentuation. However, no research to date has looked into how the articulation of such syllables is influenced by focus. Moreover, no articulatory research to date has explored how post-lexical foot structure influences the articulation of unstressed syllables.

This study aims to explore how supralaryngeal articulation of unstressed syllables varies by information structure and post-lexical foot structure. Two questions are to be answered: i) Is articulation of unstressed syllables affected by focus? ii) Does the foot structure play a role in hyper/hypoarticulation? While the first question is motivated by an empirical gap in the literature, the second explores a prediction from research on the prosodic hierarchy. Namely, greater articulatory effort is involved at higher levels of the prosodic hierarchy [6], [7]. Thus footed syllables should involve greater articulatory effort.

Movement of consonantal opening gestures in word-initial, unstressed syllables was investigated via an experiment using Electromagnetic Articulography (EMA). Three articulators (the lower lip, tongue tip, and tongue body) were examined. The effect of focus was investigated by different question-answer pairs, and the effect of foot structure was investigated by altering the stress pattern of the preceding word (‘trochee’: σσ́#**σ**, “permit **Pa**tricia” [pɚ(ˈmɪt # **pə**)$_F$(ˈtɹɪ.ʃə)$_F$] vs. ‘dactyl’: σ́σ#**σ**, “limit **Pa**tricia” [(ˈlɪ.mɪt)$_F$ # **pə**(ˈtɹɪ.ʃə)$_F$]). Four English native speakers were recorded. Four kinematic measures were taken: opening gesture duration (from the constriction to maximum opening), maximum displacement (distance travelled from constriction to maximum opening), peak velocity, and time-to-peak velocity (starting from the constriction). These measures were extracted using MVIEW [8] in MATLAB.

The overall results across speakers are displayed in Fig 1 and Fig 2. After eliminating mispronounced trials and outliers, a total of 627 tokens were examined. Both a pooled data analysis and a by-speaker analysis were performed. Each kinematic measure was examined via four-way ANOVA. In the by-speaker analysis, a series of two-way ANOVAs were performed for each articulator by speakers. The pooled results are shown in Table 1 with by-speaker results shown in Tables 2.

The pooled analysis showed that the four kinematic measures were all affected by both focus and foot structure. Within the contrastive focus and trochaic foot condition compared to other conditions, unstressed syllables were produced with overall greater opening duration and maximum onset consonant displacement, faster but less stiff movement of articulators when compared with broad and background conditions. The interaction between focus and foot was not significant. Inter-speaker variation was found for information structure, whereas the effect of foot structure was more consistent across speakers. Speakers F1, F2 exhibited more articulatory strengthening across focus conditions, while speaker M1 and M2 exhibited less. F1, F2 showed more strengthening in contrastive/broad focus whereas M1 showed more in broad focus.

The results show that supralaryngeal articulation in unstressed syllables is influenced by information structure and metrical foot structure, as predicted by focus-induced modification and prosodic strengthening respectively. Post-lexically unfooted syllables involve less articulatory effort in comparison with footed syllables.

Fig 1. Means and 95% CIs for the kinematic measures by information structure

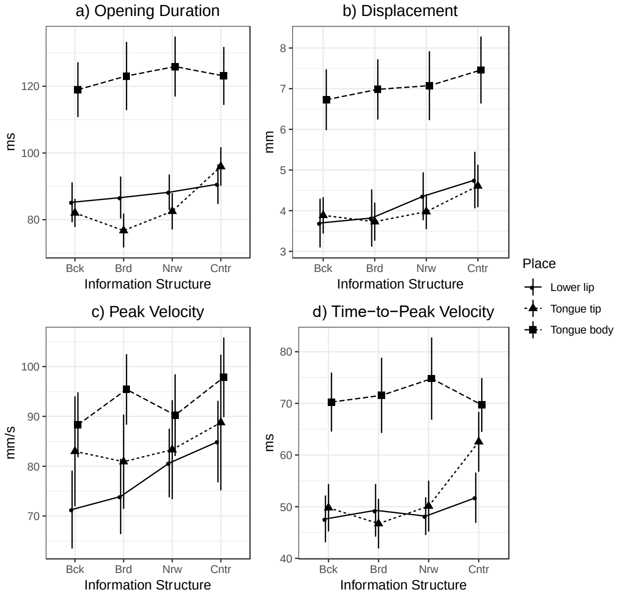

Fig 2. Means and 95% CIs for the kinematic measures by foot structure

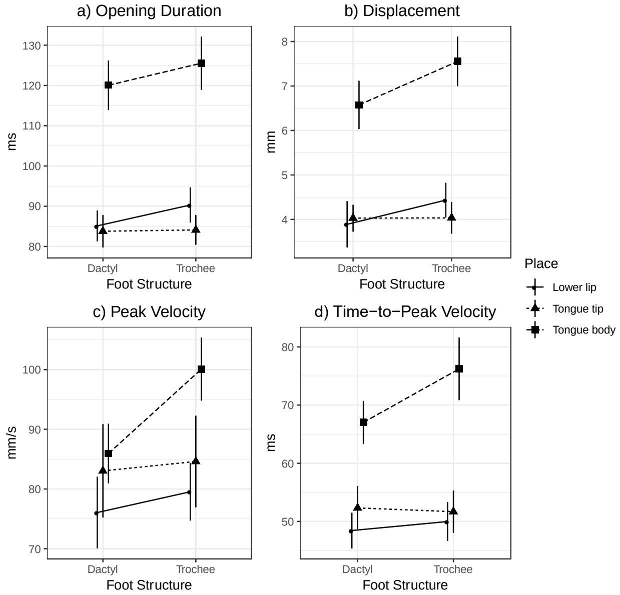

Table1. Results of overall statistical analysis
***: p < .001, **: p < .01, *: p < .05, only two-way interactions are reported

	Duration	***Displacement***	***Peak velocity***	***Time-to-peak velocity***
Main effects				
Info str. (*F(3, 531)*)	4.11**	7.23***	4.61**	3.21*
Place of Articulation (*F(2, 531)*)	177.185***	182.31***	21.97***	104.09***
Foot str. (*F(1, 531)*)	4.05*	10.96***	11.21***	5.38*
Speaker (*F(3, 531)*)	9.52***	71.08***	106.54***	28.12***
Interactions				
Info str. × Place (*F(6, 531)*)	1.90	0.49	1.02	3.22**
Place × Foot str. (*F(2, 531)*)	0.60	3.04*	4.08*	4.09*
Info str. × Foot str. (*F(3, 531)*)	0.68	1.42	0.78	1.76
Interactions with Speaker				
Info str. × Speaker (*F(9, 531)*)	2.45**	2.75*	1.95	1.68
Place × Speaker (*F(6, 531)*)	11.47***	30.64***	28.78***	12.89***
Foot str. × Speaker (*F(3, 531)*)	2.63*	0.81	1.58	7.21***

Table 2. Results of comparisons between information structures for each speaker.
**: p < .017; *: p < .05; Ø = background, B = broad focus, N = narrow focus, C = contrastive focus

Speaker	**C vs. ∅**				**N vs. ∅**				**B vs. ∅**			
	Longer	Larger	Faster	Less stiff	Longer	Larger	Faster	Less stiff	Longer	Larger	Faster	Less stiff
F1	/t/**	/t/**		/t/**								
F2		/p/**	/p/*			/p/**						
M1							/t/*		/k/**	/k/**	/t/*	
M2	/t/*											
Speaker	**C vs. B**				**C vs. N**				**N vs. B**			
	Longer	Larger	Faster	Less stiff	Longer	Larger	Faster	Less stiff	Longer	Larger	Faster	Less stiff
F1	/t/**	/t/**		/t/**	/t/**	/t/**		/t/**				
F2		/t/**	/t/*									
M1												
M2												

References

[1] Lindblom, B. (1990). Explaining Phonetic Variation: A Sketch of the H&H Theory. *Speech Production and Speech Modelling*, Dordrecht: Springer Netherlands, 403–439.

[2] Turk, A. E. and Sawusch, J. R. (1997). The domain of accentual lengthening in American English. *Journal of Phonetics, 25(1)*, 25–41.

[3] Turk, A. E. and White, L. (1999). Structural influences on accentual lengthening in English. *Journal of Phonetics*, *27(2)*, 171–206.

[4] Heldner, M. and Strangert, E. (2001). Temporal effects of focus in Swedish. *Journal of Phonetics*, *29(3)*, 329–361.

[5] Cambier-Langeveld, T. and Turk, A. E. (1999). A cross-linguistic study of accentual lengthening: Dutch vs. English. *Journal of Phonetics*, *27(3)*, 255–280.

[6] Mücke, D. and Grice, M. (2014). The effect of focus marking on supralaryngeal articulation – Is it mediated by accentuation? *Journal of Phonetics*, *44(1)*, 47–61.

[7] Cho, T. (2011). Laboratory Phonology. *The Continuum Companion to Phonology*, N. C. Kula, B. Botma, and K. Nasukawa, (Eds.) London/New York: Continuum, 343–368.

[8] Tiede, M. (last used on 2/21/2019). MVIEW: software for visualization and analysis of concurrently recorded movement data. New Haven, CT: Haskins Laboratories.