

# How coordination relations structure phonetic variation

Jason A. Shaw  
Yale University



# Collaborators



**Karthik Durvasula**



Shaw, J. A., Durvasula, K., & Kochetov, A. (submitted). The temporal basis of complex segments.



**Shigeto Kawahara**



Shaw, J. A., & Kawahara, S. (2018). The lingual articulation of devoiced /u/ in Tokyo Japanese. *Journal of Phonetics*, 66, 100-119.



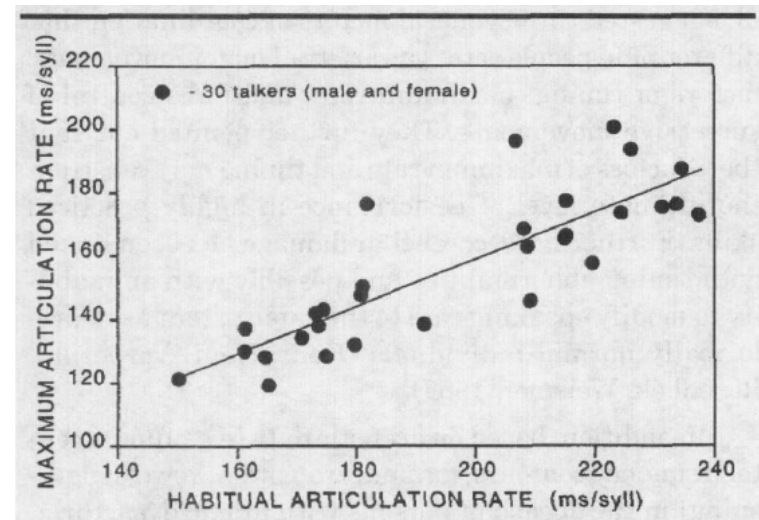
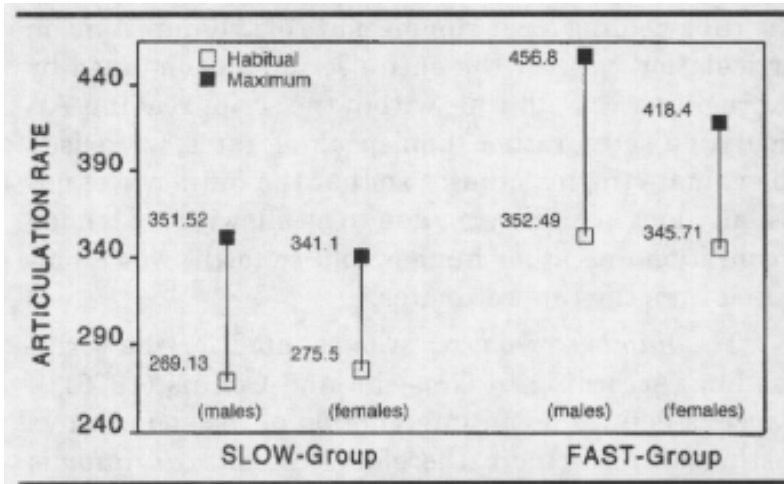
**Alexei Kochetov**



Kochetov, A. (2006). Syllable position effects and gestural organization: Articulatory evidence from Russian. In L. G. Goldstein, D. H. Whalen, & C. Best (Eds.), *Laboratory Phonology 8* (pp. 565-588). Berlin: de Gruyter.

# Speech timing is **variable**

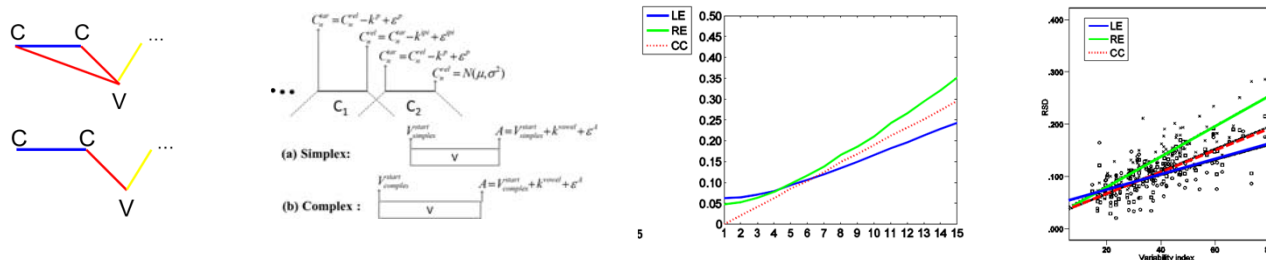
- Substantial talker variation in speech rate and other durational patterns (e.g., Crystal and House, 1983)
- Speech rate variation may have neuromuscular basis (Tsao & Weismer, 1997)



Tsao, Y.-C., & Weismer, G. (1997). Interspeaker Variation in Habitual Speaking Rate: Evidence for a Neuromuscular Component. *Journal of Speech, Language, and Hearing Research*, 40(4), 858-866.

# Gestural Coordination is **consistent** (across talkers within a language)

- Interspeaker variability (98 English speakers) can be derived from the same underlying pattern of coordination (Shaw & Gafos 2015).



Shaw JA, Gafos AI (2015) Stochastic Time Models of Syllable Structure. PLoS ONE 10(5)

- Languages that differ in syllable structure differ as well in how gestures are coordinated (e.g., Goldstein, Chitoran, Selkirk, 2007; Gafos et al., 2014; Hermes et al., 2013, 2017; Shaw et al., 2009, 2011; Marin 2014; Pouplier & Marin, 2010;)

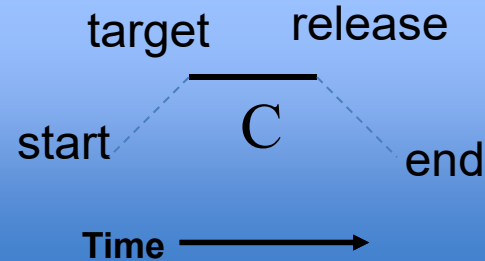
# Aims

- 1) Use variation in timing (absolute duration) to expose **phonologically relevant** patterns of coordination.
  - Generate predictions from stochastic models of gesture coordination (Shaw et al. 2011; Shaw & Gafos 2015).
- 2) Evaluate predictions against phonetic data.
  - English obstruent-glide clusters: /bj, pj, mj, vj/
  - Russian palatalized consonants /pʲ/ vs. sequences
  - Japanese consonant clusters formed by vowel deletion: e.g., /ʃt/ vs. /ʃʊt/

Shaw, J. A., Gafos, A. I., Hoole, P., & Zeroual, C. (2011). Dynamic invariance in the phonetic expression of syllable structure: a case study of Moroccan Arabic consonant clusters. *Phonology*, 28(3), 455-490.

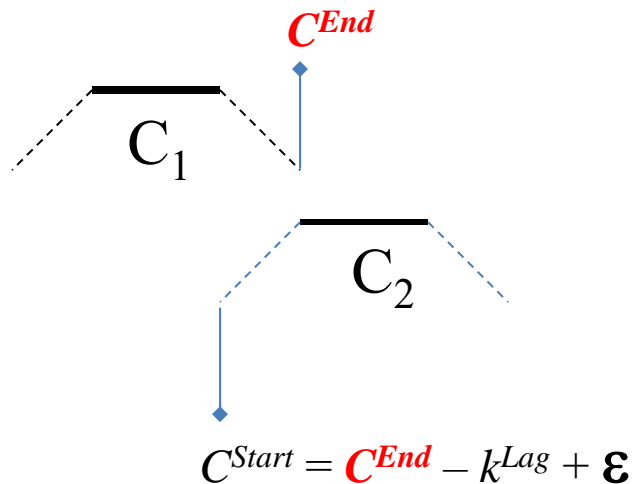
# Temporal basis of complex segments

**Gestures** are forces that drive articulators to phonologically relevant goals over time.

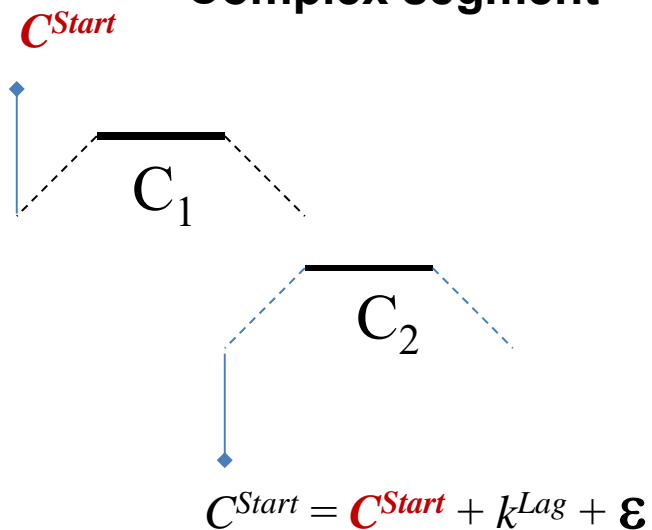


**H: complex segments** involve two gestures coordinated according to **start** landmarks

**Consonant sequence**

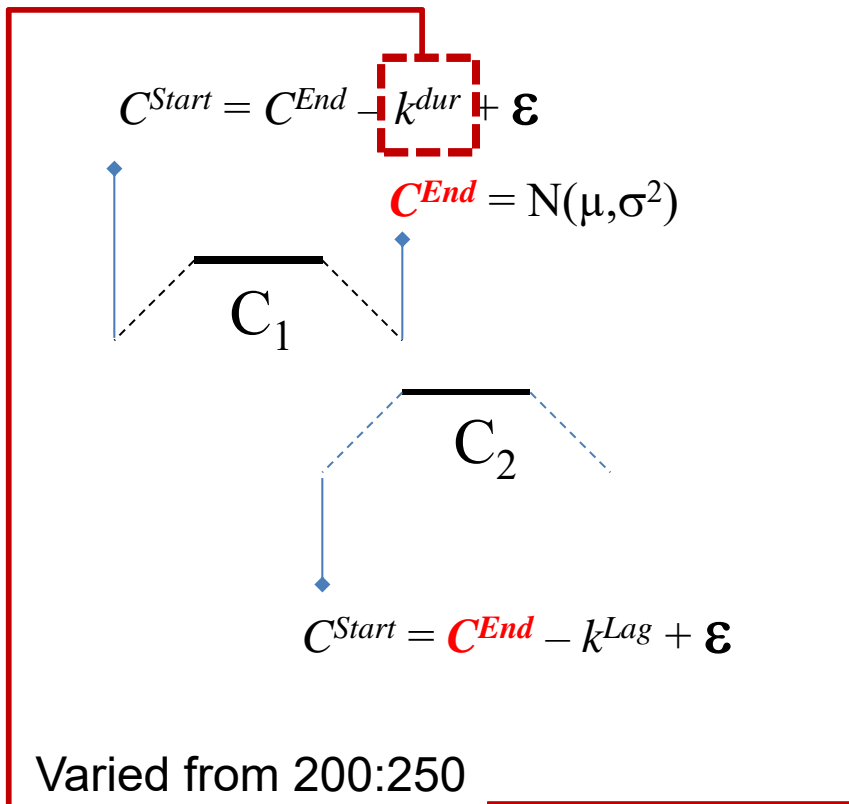


**Complex segment**



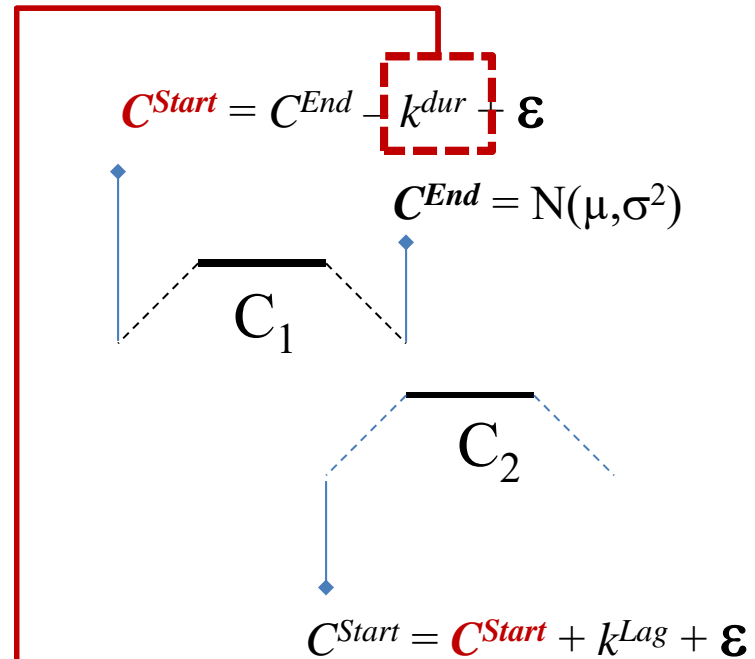
# Simulation algorithm (effect of $C_1$ duration on start lag)

Consonant sequence

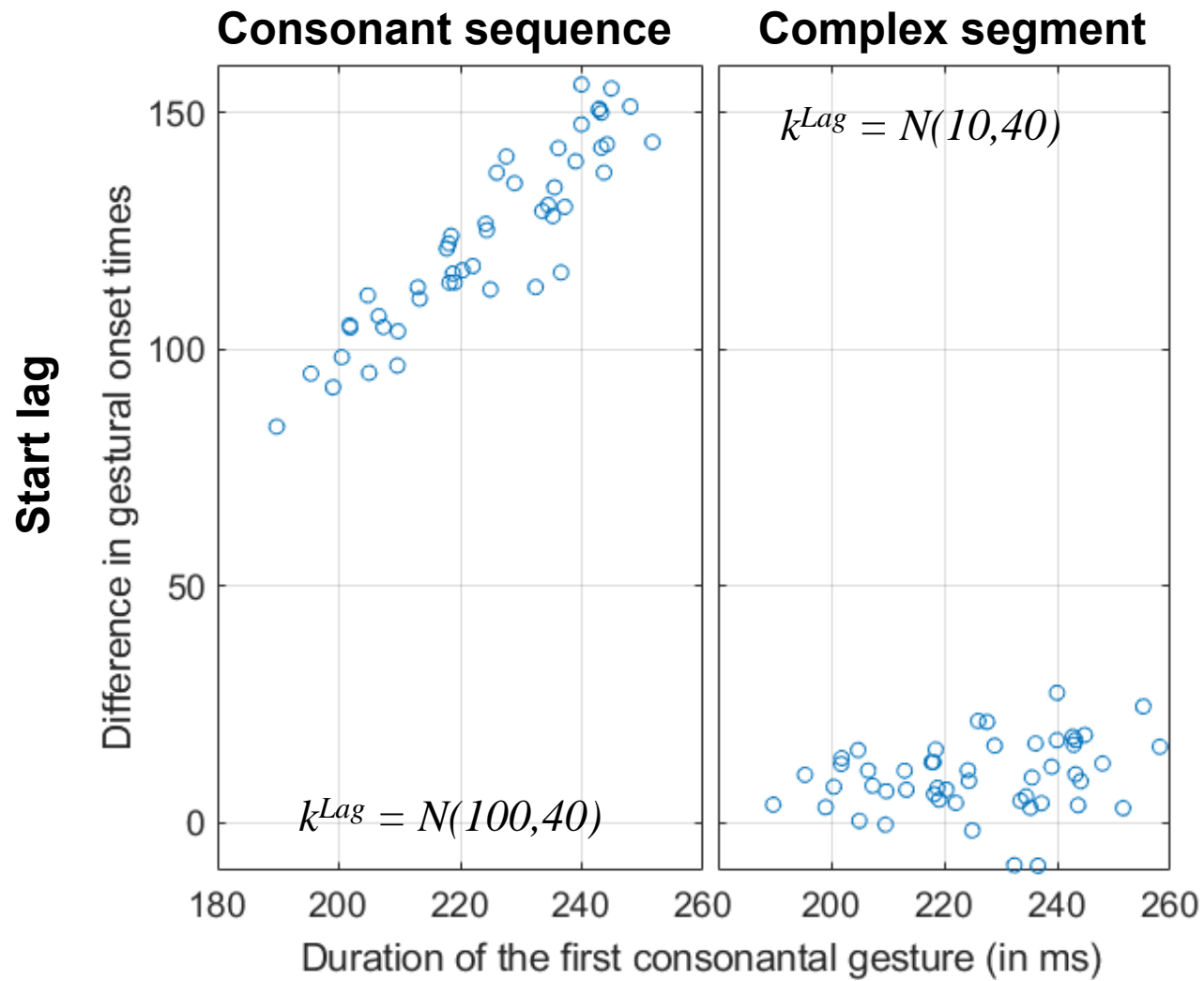


Varied from 200:250  
ms in 1 ms steps

Complex segment

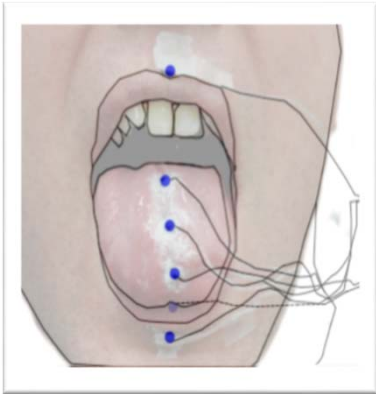


# Simulation results





# Data Methods and Analysis



Fleshpoint tracking using **EMA**

**Gestures** parsed according to primary articulator:  
e.g., tongue blade for [j]; lower lip for labials

**Start, Target, Release, End** determined by  
threshold of peak velocity

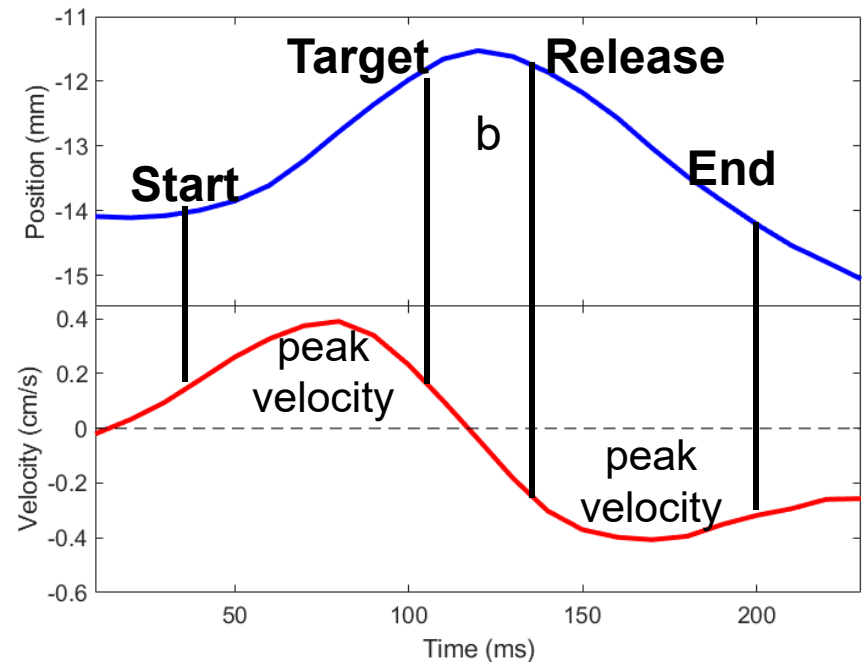
## Dependent measures

Gesture **duration** ( $k^{dur}$ ) = End – Start

**Plateau** ( $k^p$ ) = Release – Target

**Start lag** ( $k^{Lag}$ ) = Start(C2) – Start(C1)

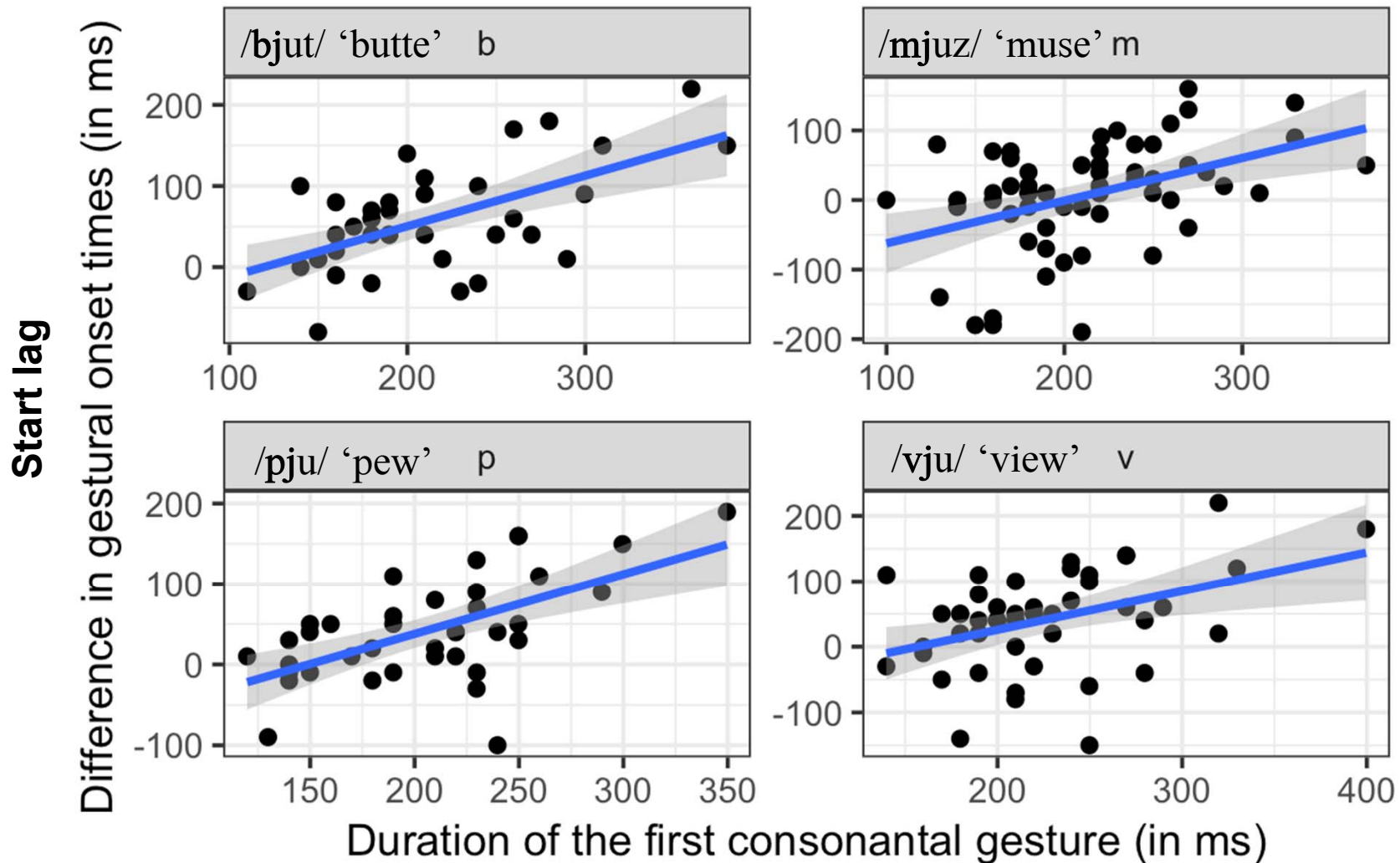
**IPI** ( $k^{ipi}$ ) = Target(C2) – Release(C1)



# English control data

(New experiment)

2 speakers;  
20-30 reps  
per item



# Russian data

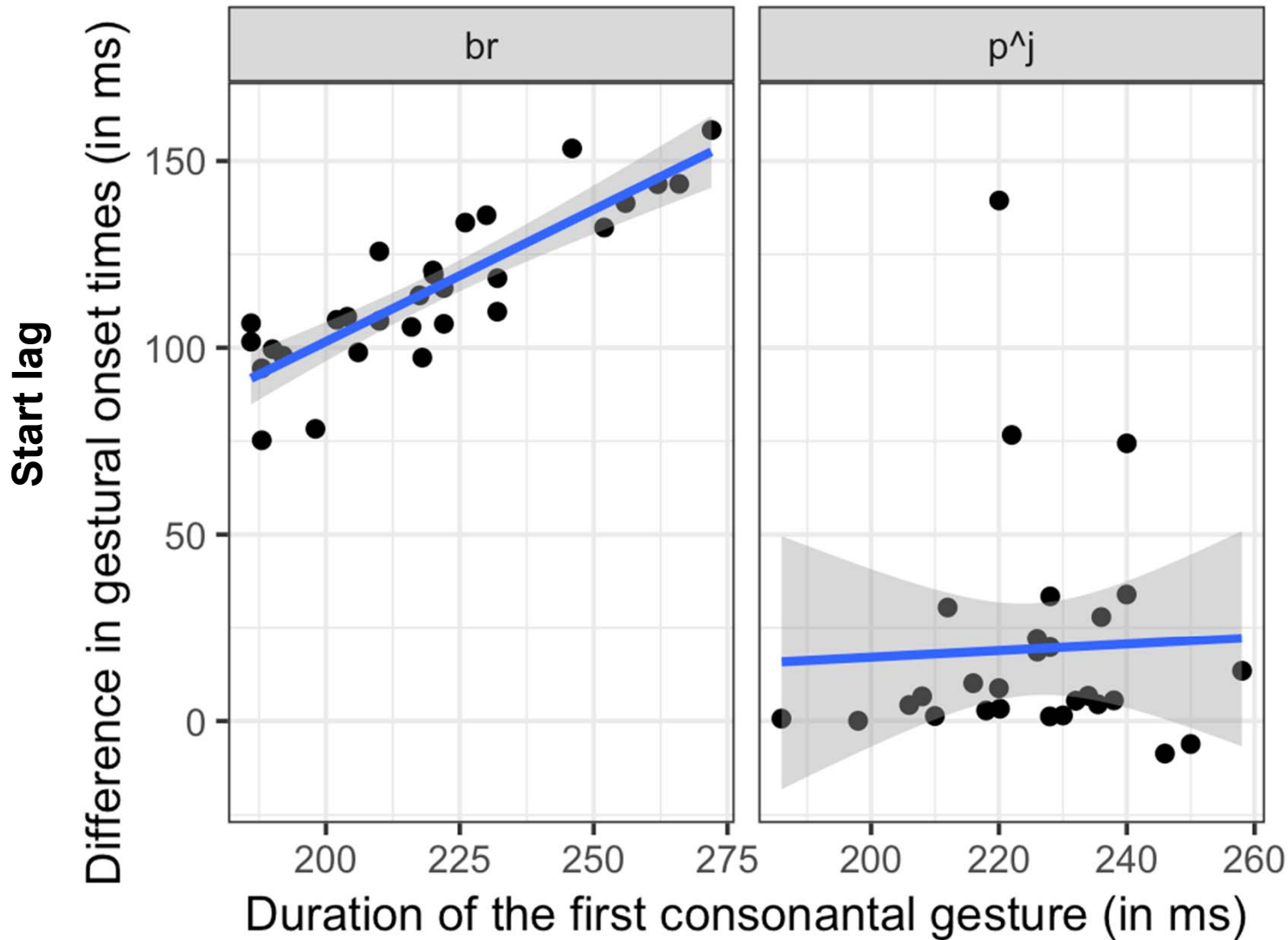
/brat#pʲatava/  
'брат пятого'

/brat#padaja/  
'брат падая'

(Kochetov 2006)

/tat#pʲapi/  
'тат пяпы'

/ta#pʲapi/  
'та пяпы'

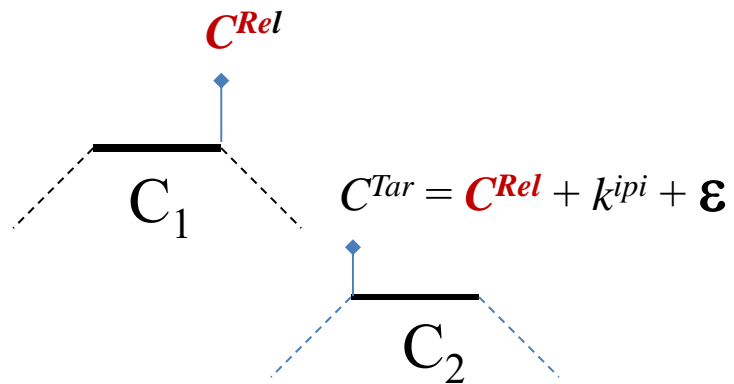


3 speakers;  
4-5 reps per  
item

# CC vs. CVC

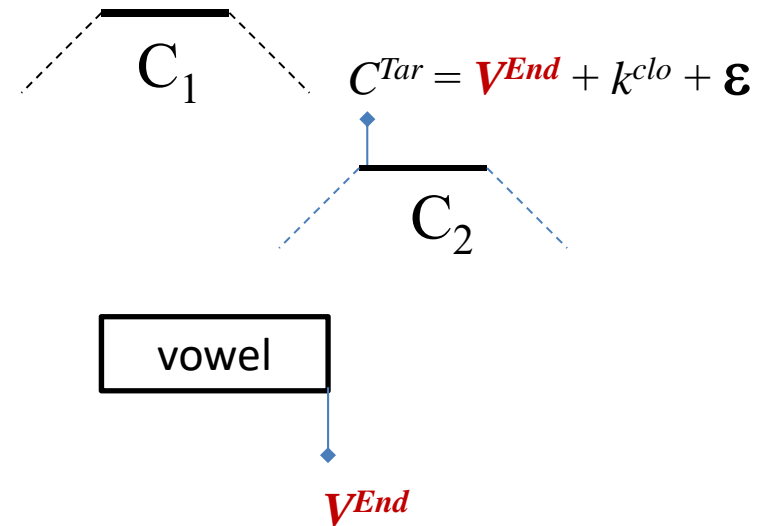
## CC sequence

$C_2$  is timed to the release of  $C_1$



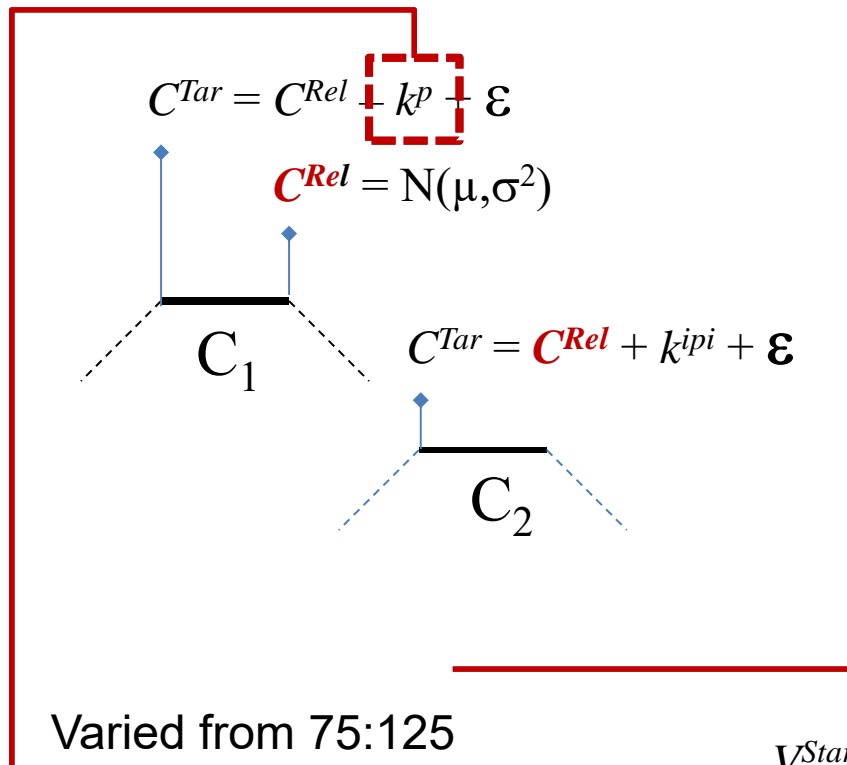
## CVC sequence

$C_2$  is timed to the end of V



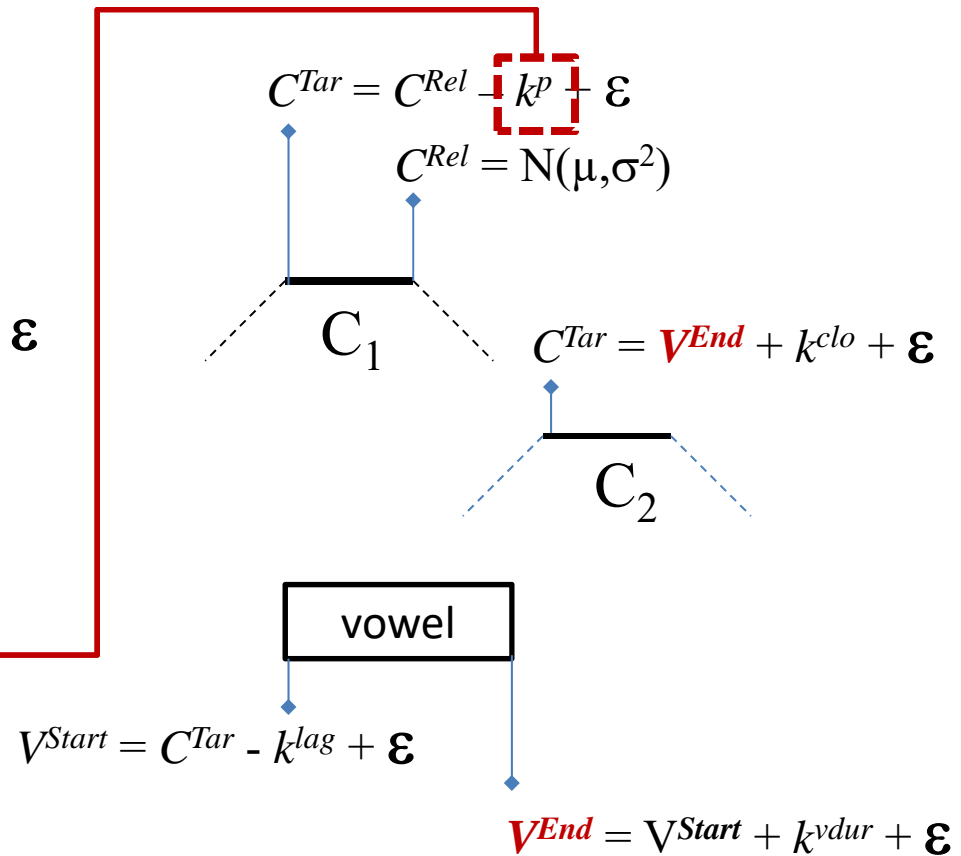
# Simulation algorithm (effect of $C_1$ plateau duration on IPI)

CC sequence

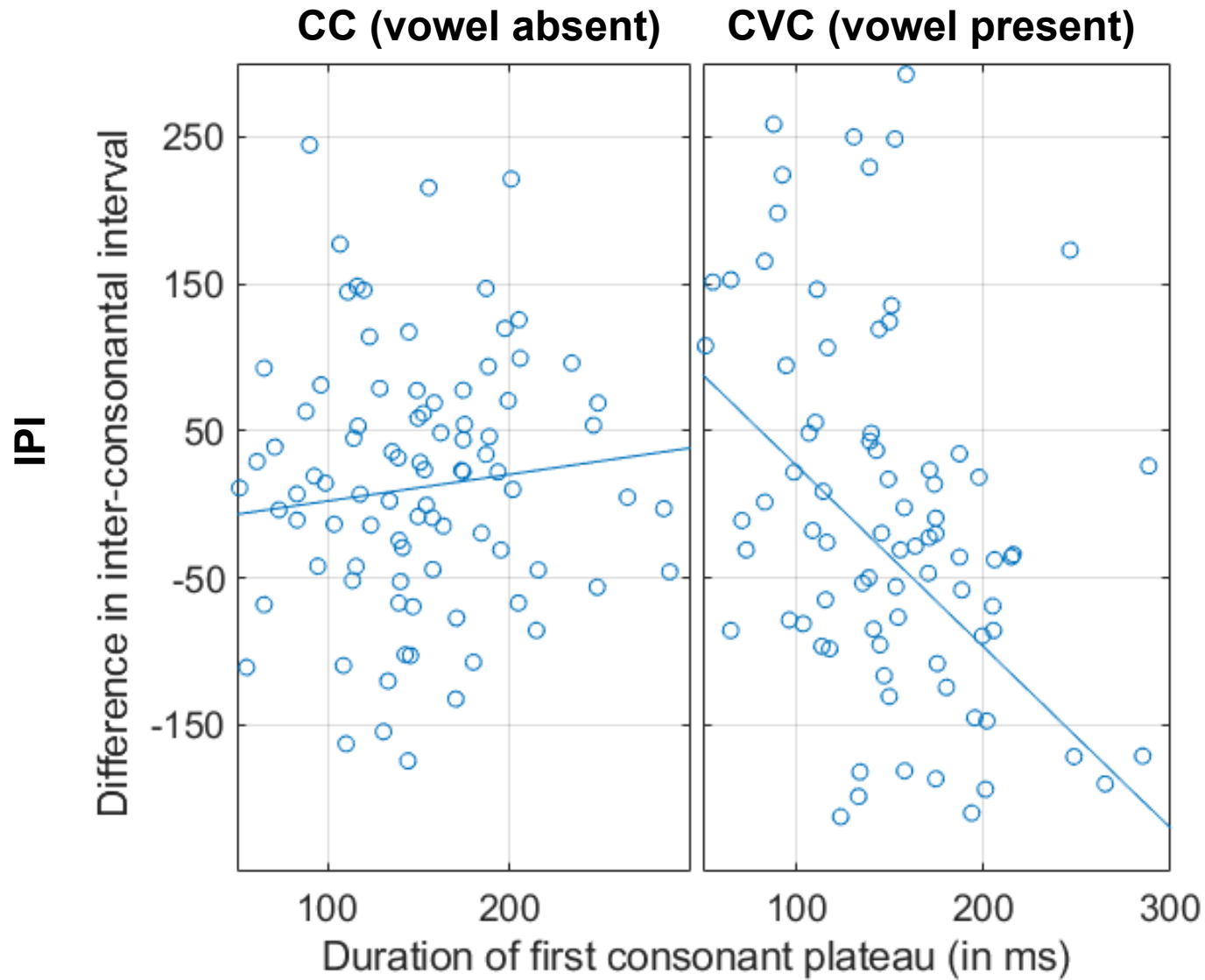


Varied from 75:125  
ms in 1 ms steps

CVC sequence



# Simulation results

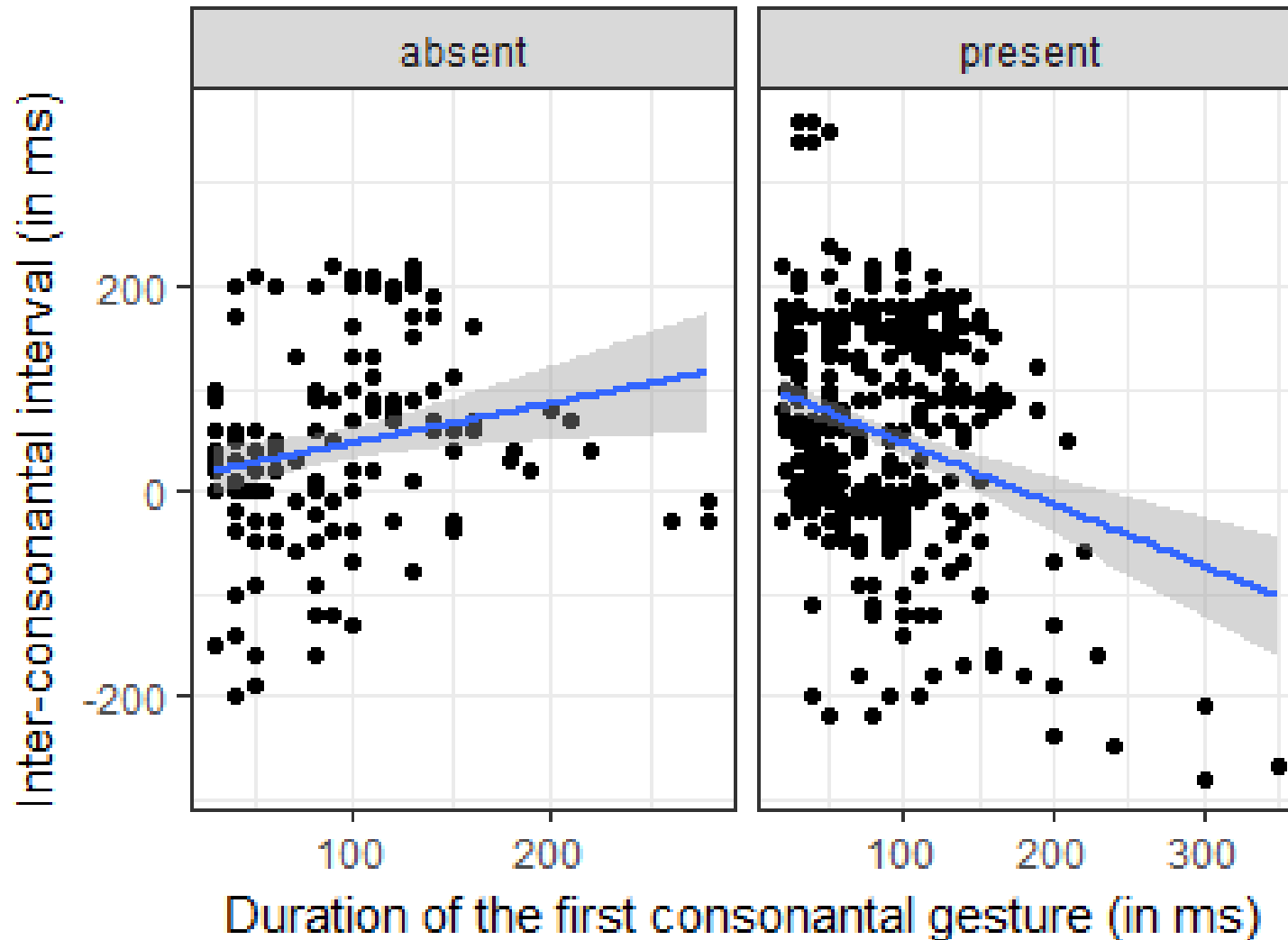


# Japanese data

[masta:] [ɸsoku]  
[staise:] [katstoki]

(Shaw & Kawahara 2018)

[masʉta:] [ɸʉsoku]  
[sʉtaise:] [katsʉtoki]



6 speakers;  
10-15 reps  
per item

# Phonologically structured variation

- Although simple, the models reveal how natural phonetic variation in timing (absolute duration) is structured by coordination relations.
- As one phonetic parameter varies in duration, coordination relations dictate how other parameters covary.
- The coordination relations modelled are phonologically relevant because they provide a temporal basis for contrast, e.g., C<sup>j</sup> vs. C<sub>j</sub> in Russian.