Stable timing between articulatory gestures and syllable pulses

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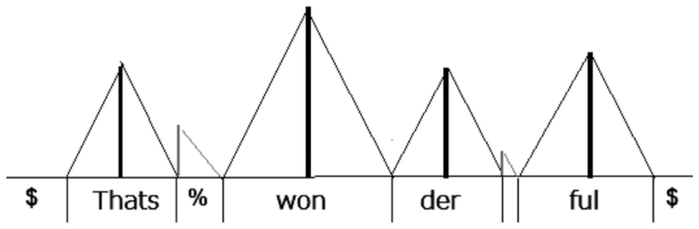
C/D Model

Converter: converts metrical tree into syllable triangles (below, Erickson & Fujimura 2015)
Distributor: distributes gestures according to syllable structure

Triangle height = prominence
= maximum jaw opening

Triangle base = abstract duration



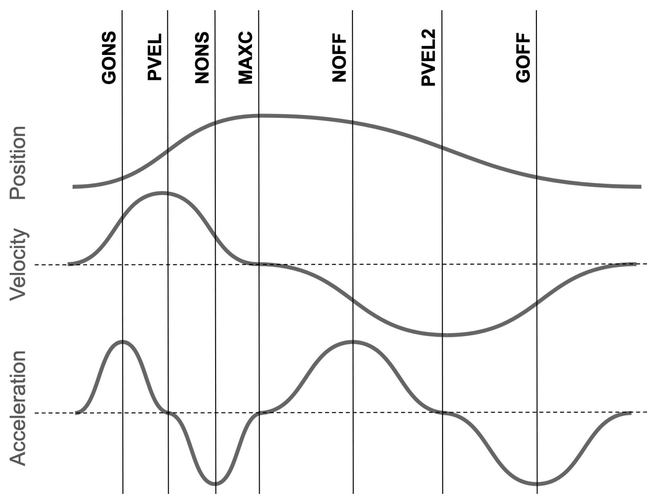
"Shadow angle": largest possible without overlap; stable throughout an utterance

Consonants are coordinated to triangle edges, hence to syllable pulse (vertical)

Contrasts with Articulatory Phonology: pairwise gestural coupling, modulated in planning oscillators (mu-gestures) or warping time in production (pi-gestures)

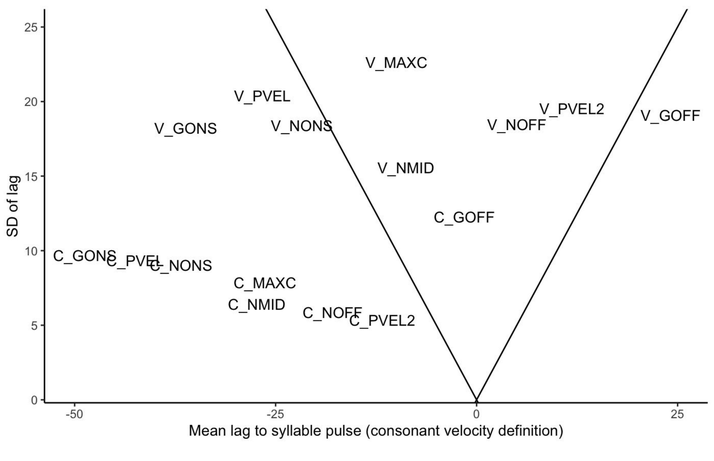
Hypothesis & Method

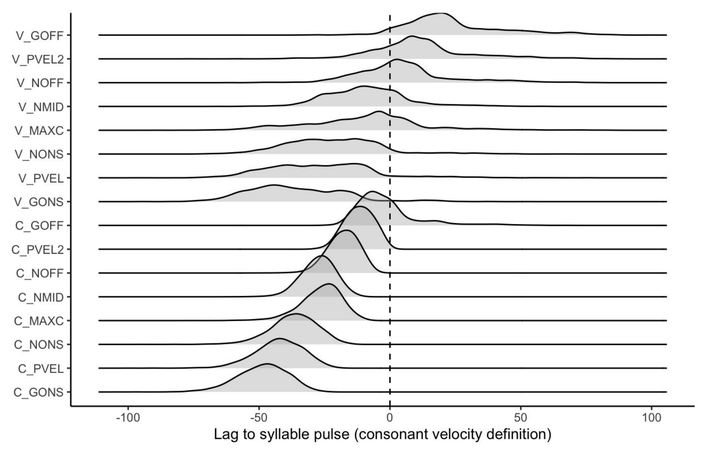
- Hypothesis from C/D Model: articulatory gestures should exhibit *more stable timing* to the syllable pulse than to each other
  - Temporal lag between articulatory landmarks, and landmark-to-pulse
- Syllable pulse identified as in Erickson & Fujimura (2015):
  - Midpoint of onset PVEL2 & coda PVEL
- Automated labeling procedure:
  - CVC words
  - Window from acoustics
  - Record timestamps for: onset, coda, vowel, and jaw
  - Landmarks from acceleration



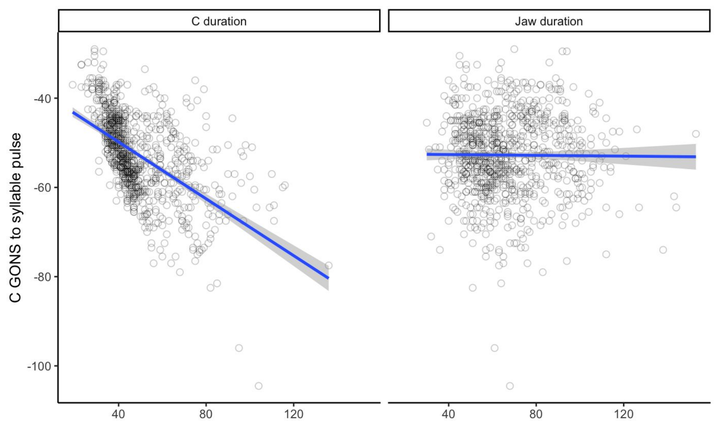
Results

Landmark-to-pulse lag values

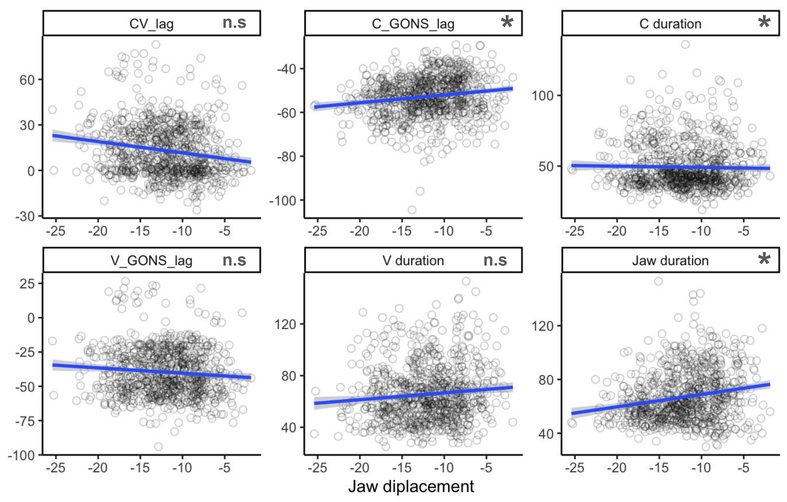




CGONS-to-pulse ~ C duration, not jaw duration



Jaw displacement ~ C, not V landmarks



C-V lag is comparable to V-to-pulse lag

Lag	mean, SD	RSD	Residual SD
CGONS-VGONS	10.87±18.54	170.59	17.35
CNMID-VGONS	-8.84±18.02	-203.78	15.90
CGONS-Pulse	-48.71±9.69	19.89	8.61
VGONS-Pulse	-36.17±18.22	50.37	16.17

Summary

- Most results follow from "pulse" being defined by C_PVEL2
- Comparison to C-V lag:
  - C-to-pulse is most stable (definition)
  - V-to-pulse similarly stable to C-V lag

Data: X-ray Microbeam Database

- Fleshpoint tracking, 1mm gold pellets on various articulators
- 57 speakers * 18 word types → 7578 tokens
  - Automated procedure wasn't reliable: only 2097-4806 measured values
- CVC monosyllables with 5+ productions
  - *one, five, four, nine, back, both, but, cash, coat, light, long, much, right, ship, shoot*
  - 9 unique onsets, 7 vowels, 9 codas

Conclusions

- Pulse largely behaves as C_PVEL2
  - Might not be as noisy as an onset-oriented account
- Can we identify a syllable pulse *independent* of consonant landmarks?
  - Polysyllabic words: would be nice, but unstressed syllables often lack distinct jaw excursion
- Triangle *edge*, not pulse–need unambiguously adjacent triangles