Articulatory and acoustic evidence for syllable structure effects on reaction times

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In memoriam
Cathe Browman

Introduction: Syllable structure and planning time

Earlier study (Nam 2007):

- longer reaction times for VC than for CV syllables

Experiment:

- combinations of P, T, K and I, A
- presented on a screen in vertical order (in order to avoid lexical or syllabary effects)
- simple reading task
- 2 Korean and 2 AmEngl. subjects

Nam (2007)

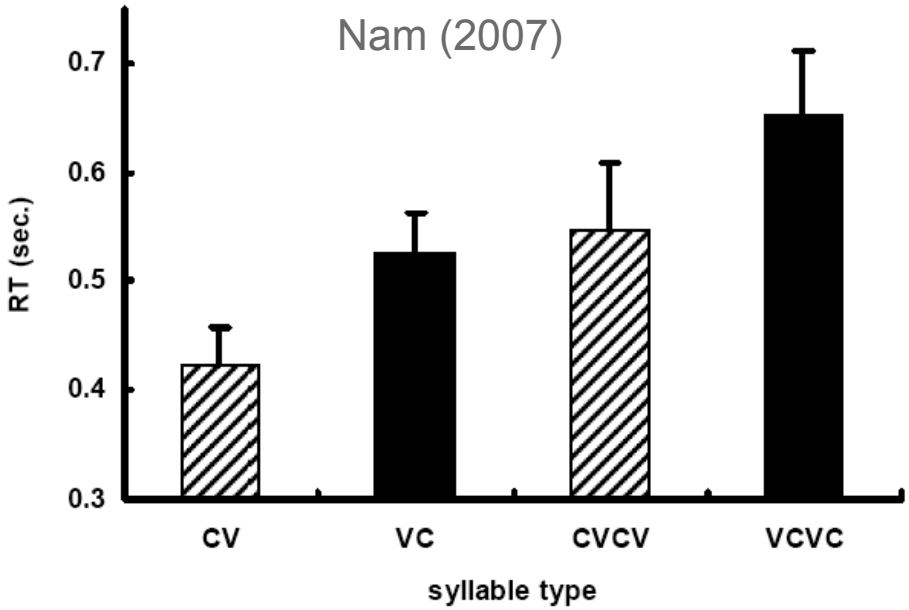


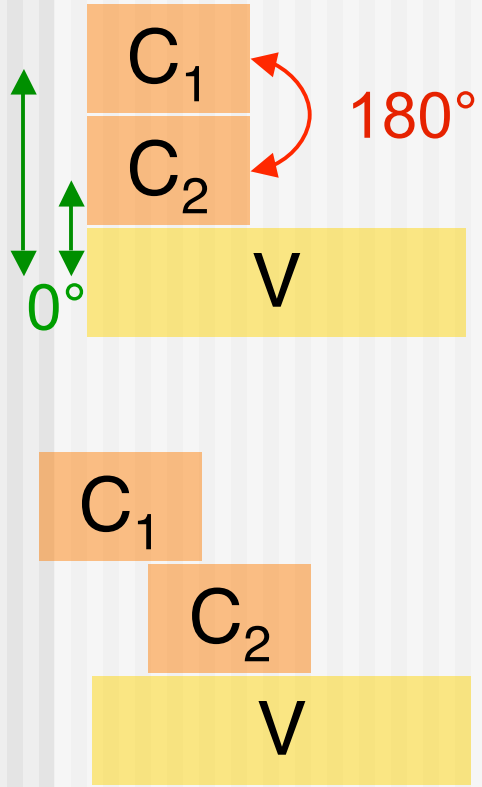
Figure 9. Mean of reaction time for each syllable type. Oblique-lined bars are for CV type and black bars for VC type. RT denotes reaction time.

Introduction: Nam (2007)

- modeled by settling time differences for CV vs. VC phasing
- Assumptions
  - basic units: gestures
  - gestures are phased with each other ('glue')
  - limb coordination: two preferred modes
    - in-phase (0°) (most stable)
    - anti-phase (180°)
    - other modes can be learned

  - phasing of planning oscillators within syllables:
    - CV: in-phase (0°)
    - VC and CC: anti-phase (180°)

Introduction: C-center effect



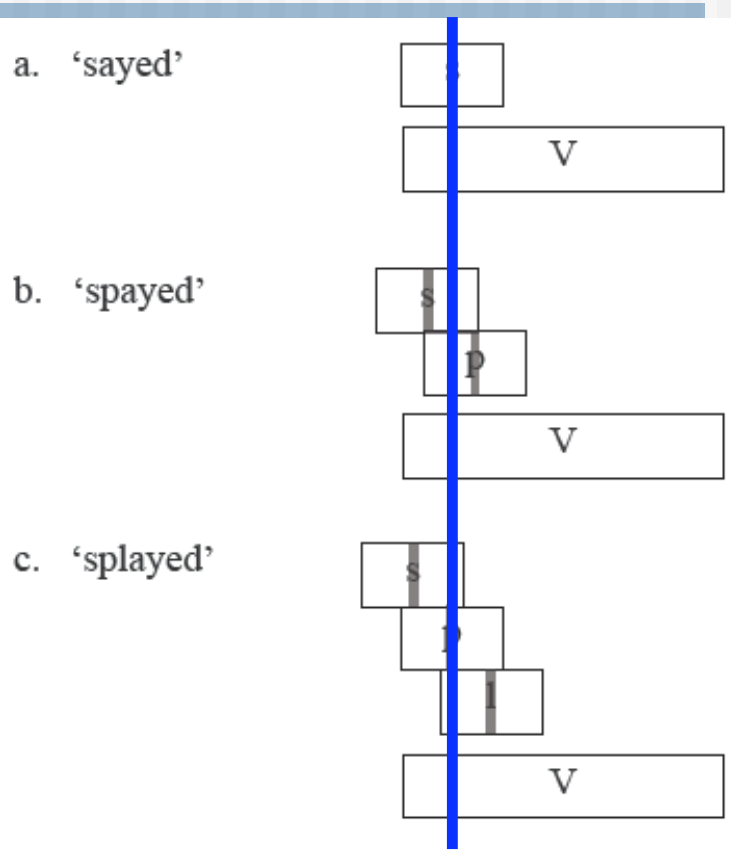
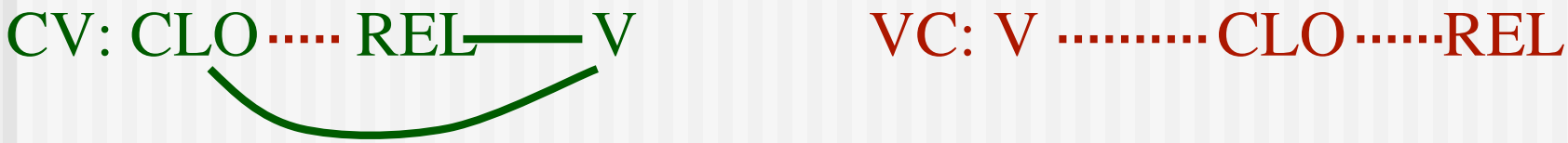


Figure 3. Gestural representation from X-ray micro-beam data in Honorof and Browman (1995) for consonant vowel sequences in 'sayed', 'spayed'

Introduction: Nam (2007)

Nam's simulation study:

- C: constriction (CLO) and release (REL) gesture
  (see e.g. Steriade 1993, Browman 1994)
- anti-phase between CLO and REL



==> C-center effect for CLO-REL-V

Introduction: settling time

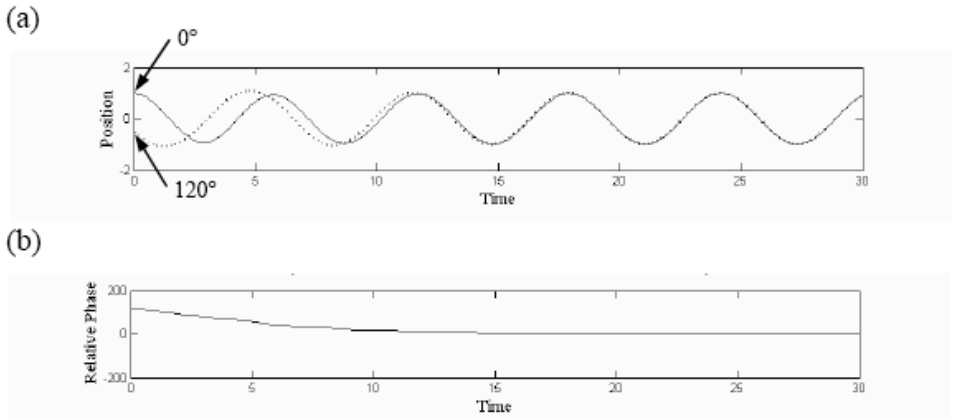
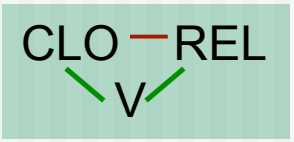


Figure 6 (a). A pair of oscillators coupling at relative phase 0° over time: an oscillator (solid) begins at 0° phase and the other (dotted) at 120°. (b) The relative phase over time.

- settling time: time it takes for two planning oscillators to show a specific mode (here in-phase)
- settling time depends how constrained the phasing relations are and on the type (in-phase settles faster)
- the less constrained the longer it takes for the oscillators to settle

⇒ VC takes longer to settle compared to CV
⇒ longer planning and reaction times



- this also implies shorter latencies for complex onsets because of the even more constrained phasing relations

Introduction: cluster effect

- Evidence for cluster effect:
  - shorter latencies for clusters found in Kawamoto & Kello (1999), Kessler, Treiman & Mullinex (2002) and others
  - Rastle et al. (2005):
    - delayed naming task
    - cluster effect only for stops but not for fricatives
    - explanation: shortening of consonants in clusters. For stops a shortening of closure duration causes an earlier acoustic onset (burst)

    ==> cluster effect only in the acoustic domain, not in the articulatory domain

Introduction: onset consonant

RT and type of onset consonant

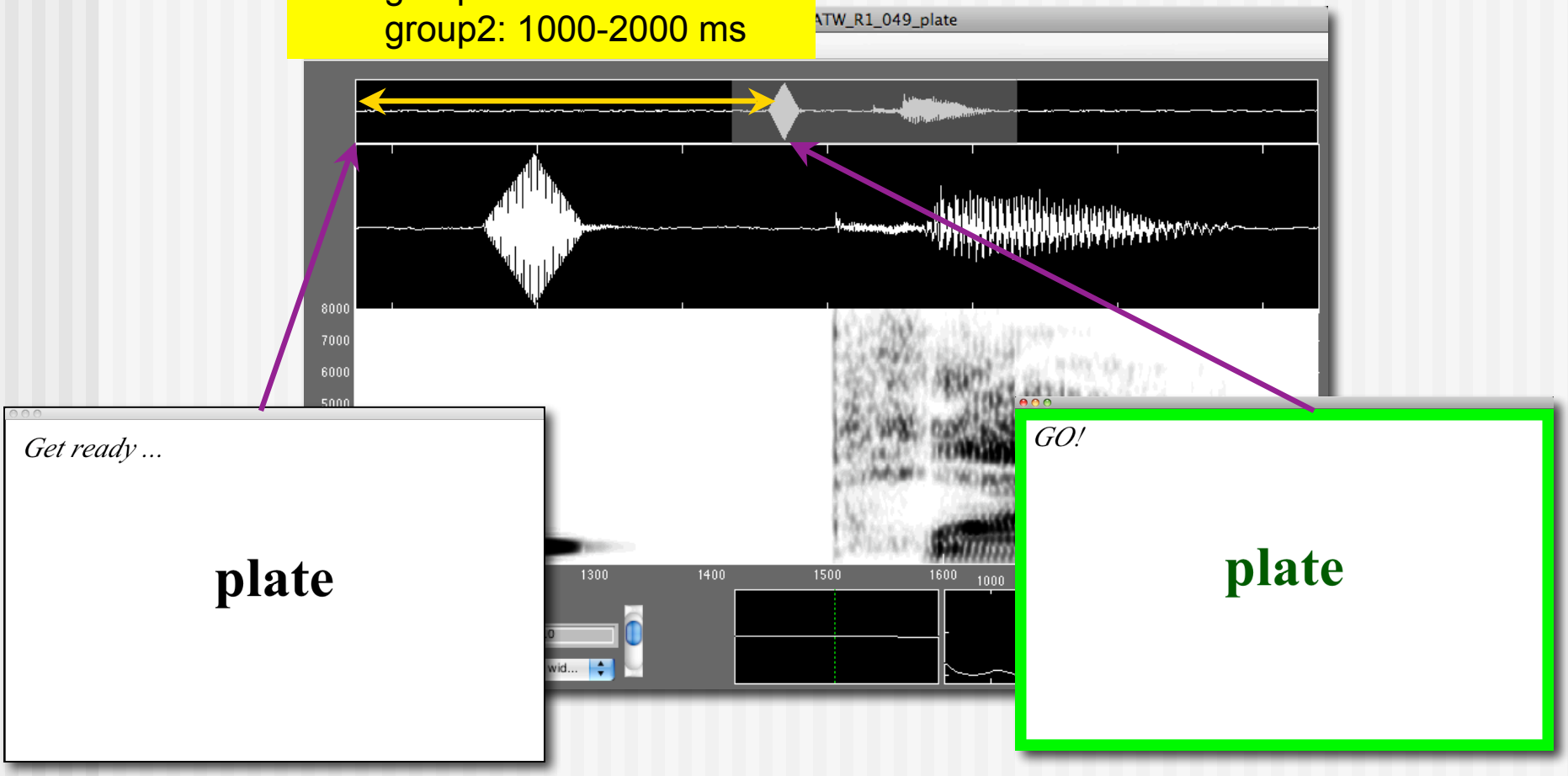
- fricatives < sonorants < stops (e.g. Rastle et al. 2005, Kessler, Treiman & Mullinix 2002 and others)
- Explanation by Rastle et al.:
  - biomechanical and aerodynamic constraints of initial consonants
  - speaker anticipates higher/different aerodynamic demands for the fricative by initiating the movement earlier

Aims

- Replicating Nam's results by acoustic and articulatory data
  - CV < VC
- testing the following predictions
  - CCV<CV(C) (cluster effect)
  - CV <CVC (coda effect)
- shorter RT for fricatives also for articulation?

Simple delayed naming task

Random delay:
group1: 1000-1600 ms
group2: 1000-2000 ms

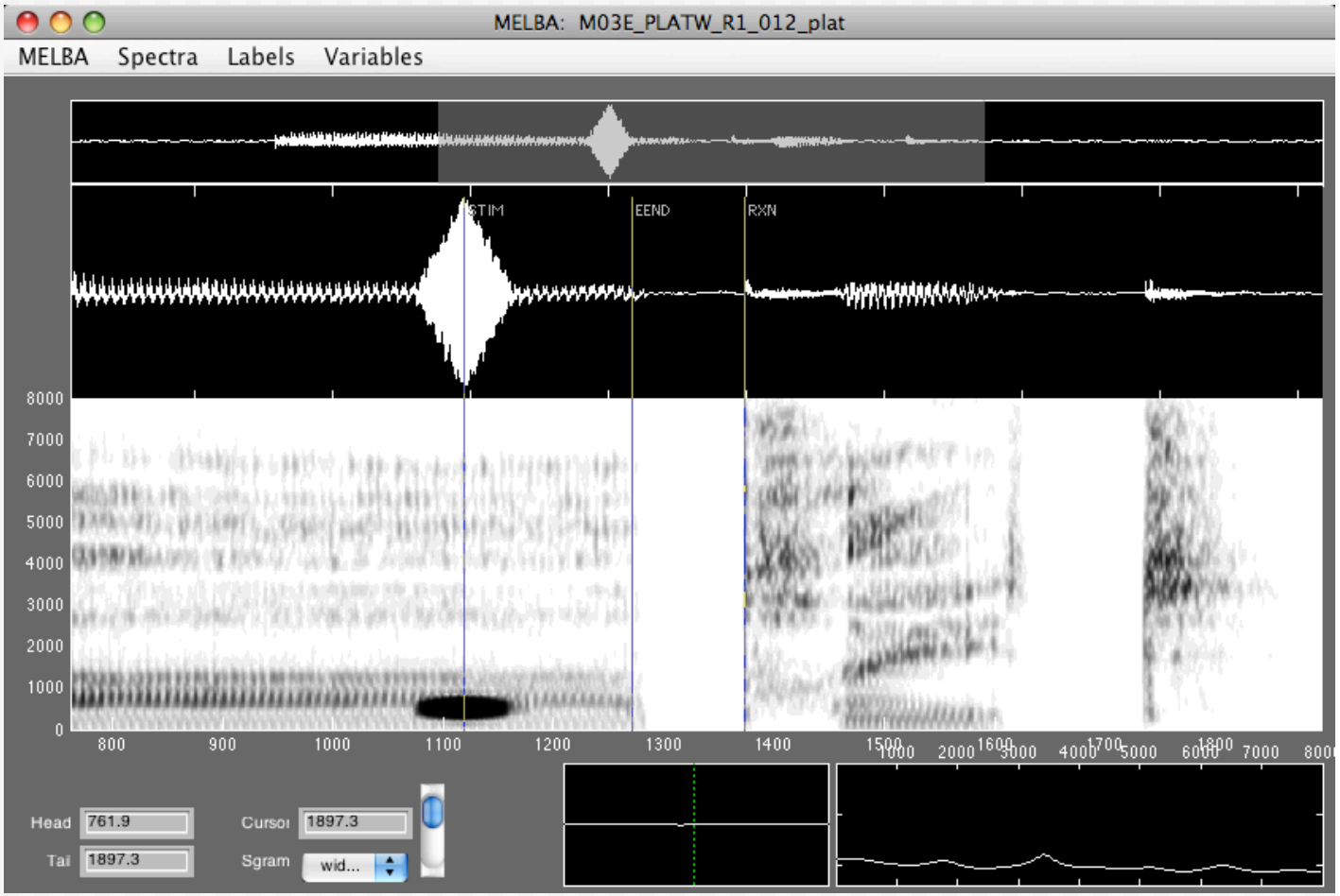


Postvocalic delayed naming task

Instruction:

Get ready (say "uh")

for detecting the onset of stops



Experiments

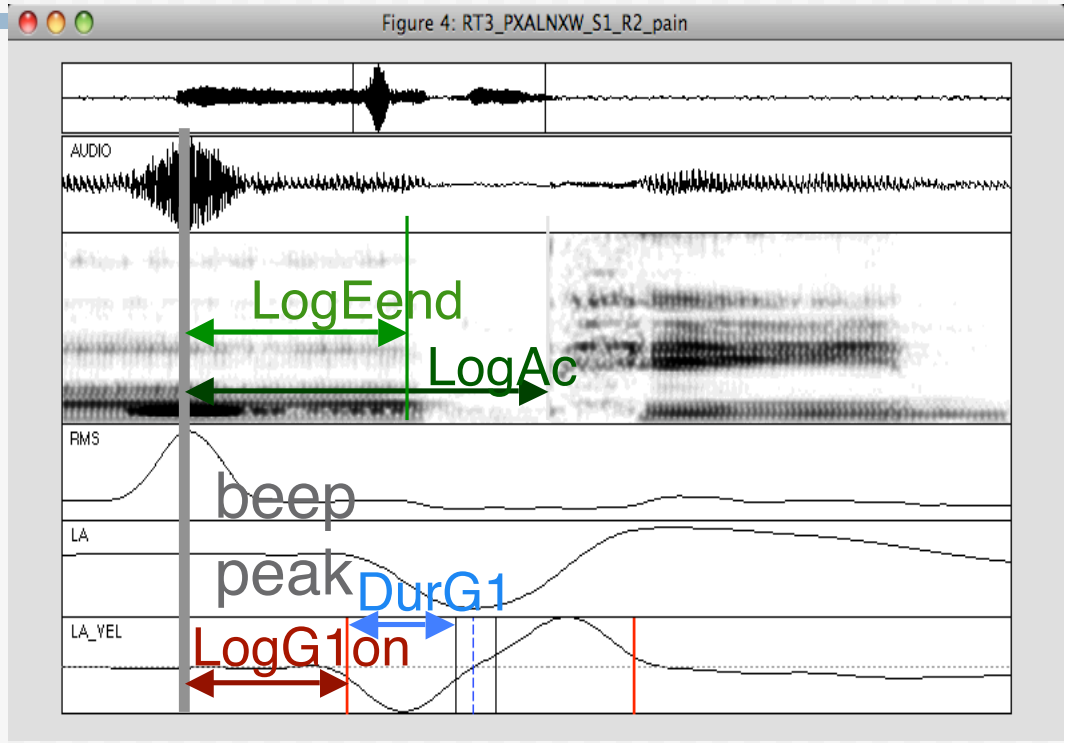
- Acoustic-only
  - simple and post-vocalic delayed naming
  - 20 speakers of American English (12 female, 8 male)
  - words with varying syllable structures:
    - V, VC, CV, CVC, CCV, CCVC
    - V: /ei/ (‘pay’) /i:/ (‘pea’)
    - C: /p, t, k, s, l/
    - clusters /sl, sp, st, sk/
    - group2: additionally /pl/
- EMMA
  - post-vocalic delayed naming only:
  - 4 speakers (F02, F09, F11, M02)
  - 3 sensors on the tongue, 2 on the lips, 1 on the lower incisors
  - additionally:
    - CCVC, CVCC with short vowels
    - clusters /pl, kl/

Labeling and measurements

- **LogEend**: from beep peak to the end of the stationary phase of the preceding vowel (only for post-vocalic condition)
- **LogAc**: from beep peak to the acoustic onset of the first sound

Additionally for EMMA:

- **LogG1on**: from beep peak to onset of first gesture (for /p/ measured at lip aperture signal)
- **DurG1**: Duration of the first gesture

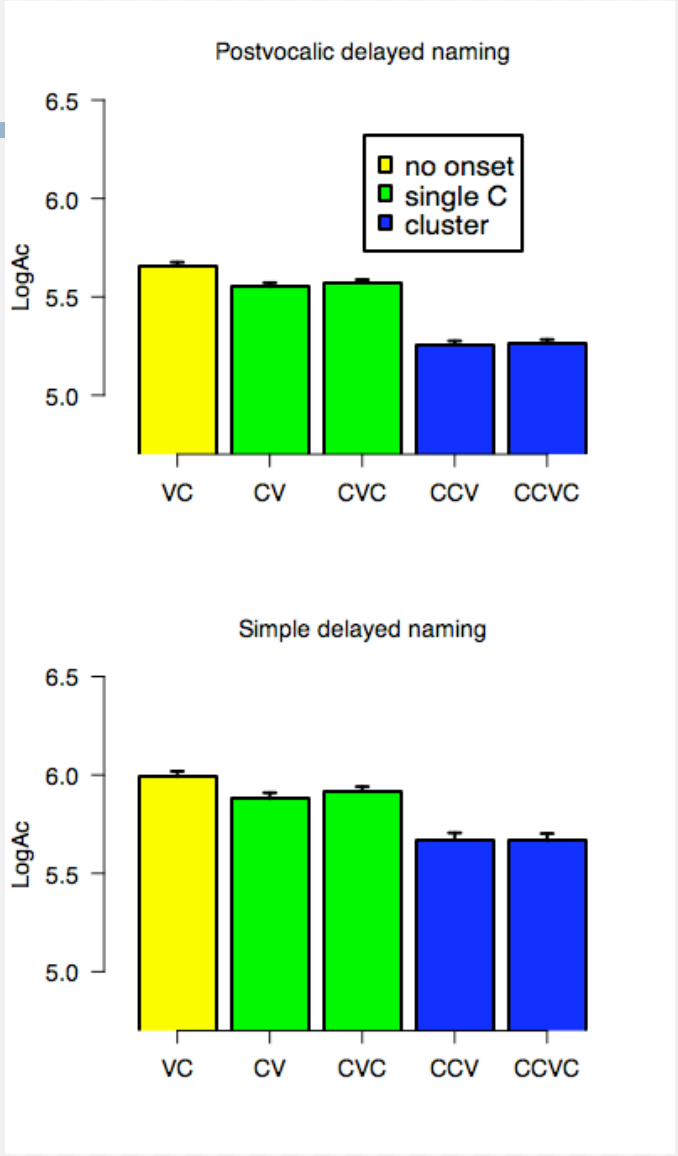


/s, t, l/: tongue tip
/k, V/: tongue rear
/p/: lip aperture

Acoustic only results: syllable structure

Significant effects of **syllable structure** on reaction time (LogAc)

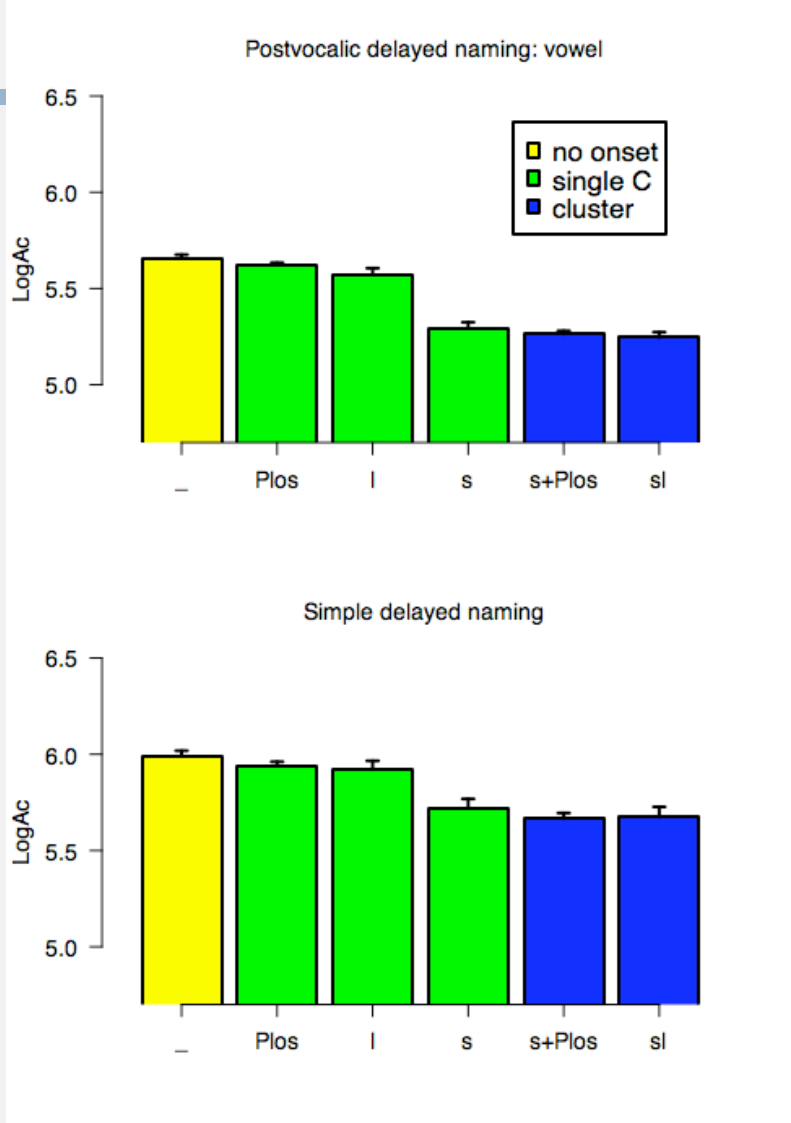
- VC>CV, CVC > CCV, CCVC
  - post-vocalic: F(4, 76)=149, p<0.001
  - simple: F=(4, 76)=105, p<0.001
- CV=CVC: no effect of coda consonant



Acoustic only results : onset type

Significant effects of **onset identity** on reaction time (LogAc)

- V, Plos, /l/ > /s/,/sC/
  - post-vocalic: F(5, 95)=130, p<0.001
  - simple: F=(5, 95)=101, p<0.001
- cluster effect caused by /s/?

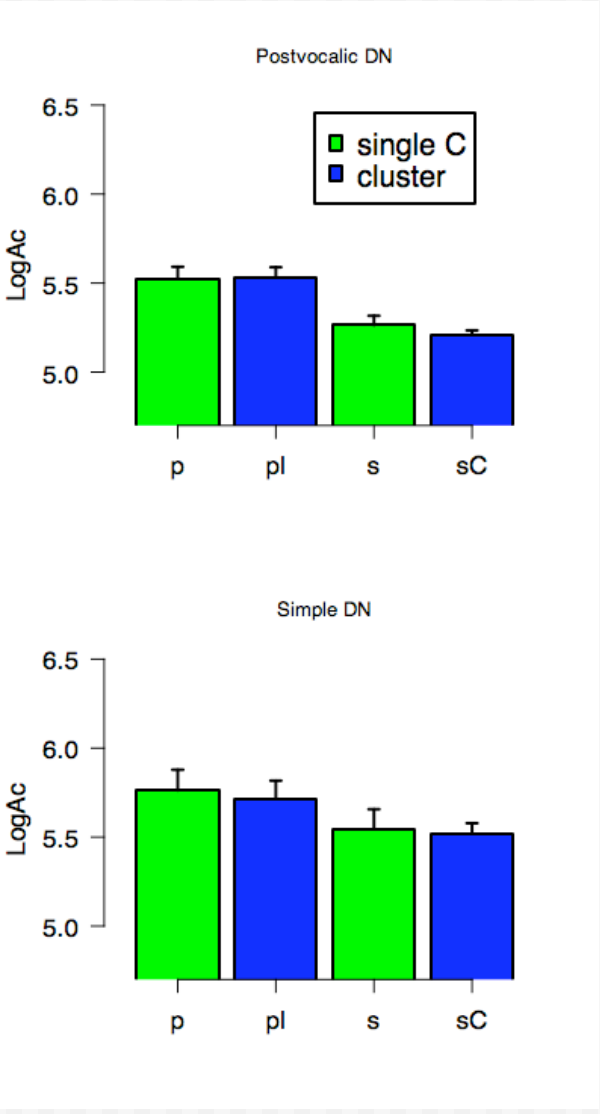


Results acoustic only: cluster effect

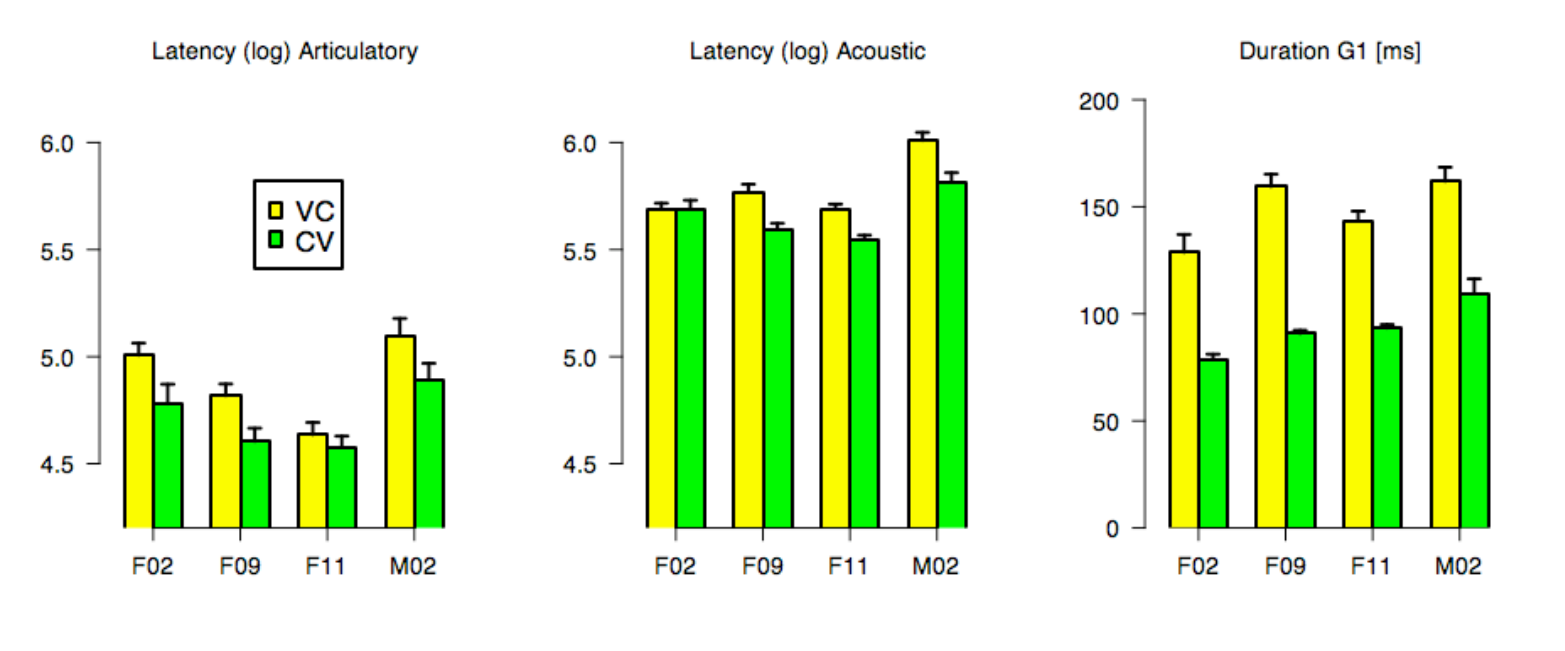
Rastle et al. (2005): cluster effect only for stop+C clusters, not fricative + C

(subset of data: 11 speakers)

- /p/>/s/, no cluster effect
  - post-vocalic: F(3, 30)=40, p<0.001
  - simple: F=(3, 30)=43, p<0.001 (not sig. for t-tests)



Articulatory results: CV vs. VC



(subset: only items with stops)

- LogG1on: later articulatory onset for VC syllables
  (sig. for speakers F02, F09 and M02)
- LogAc: later acoustic onset for VC syllables
  (sig. for speakers F09, F11 and M02)
- DurG1: longer durations of the initial gesture for VC syllables (sig. for all speakers) because vocalic gestures are generally slower

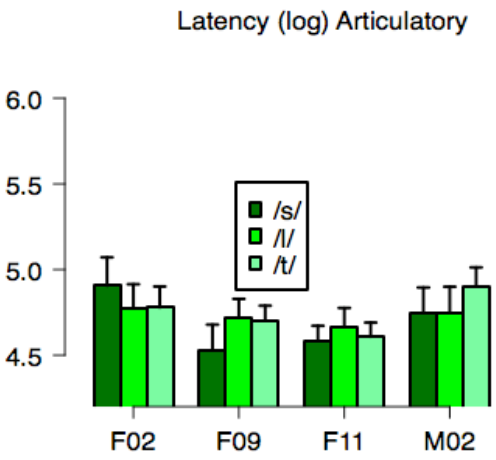
Articulatory results: fricative vs. stop

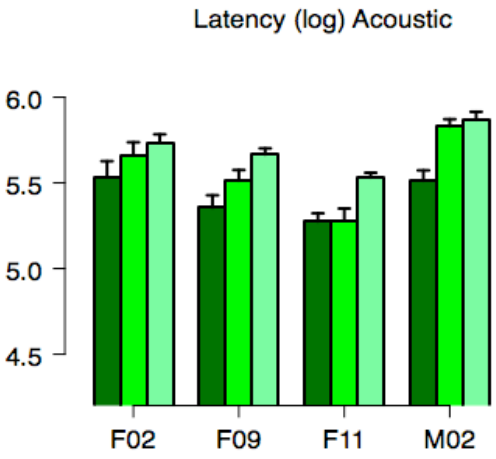
- acoustic only: RT for /s/ shorter than /l/ and stops
- BUT: no systematic effect for LogG1on

explained by:

- **/s/:** target achievement <u>after</u> the acoustic onset
- **stops**: target achievement <u>before</u> the acoustic onset
- **/l/**: target achievement and acoustic onset at the same time

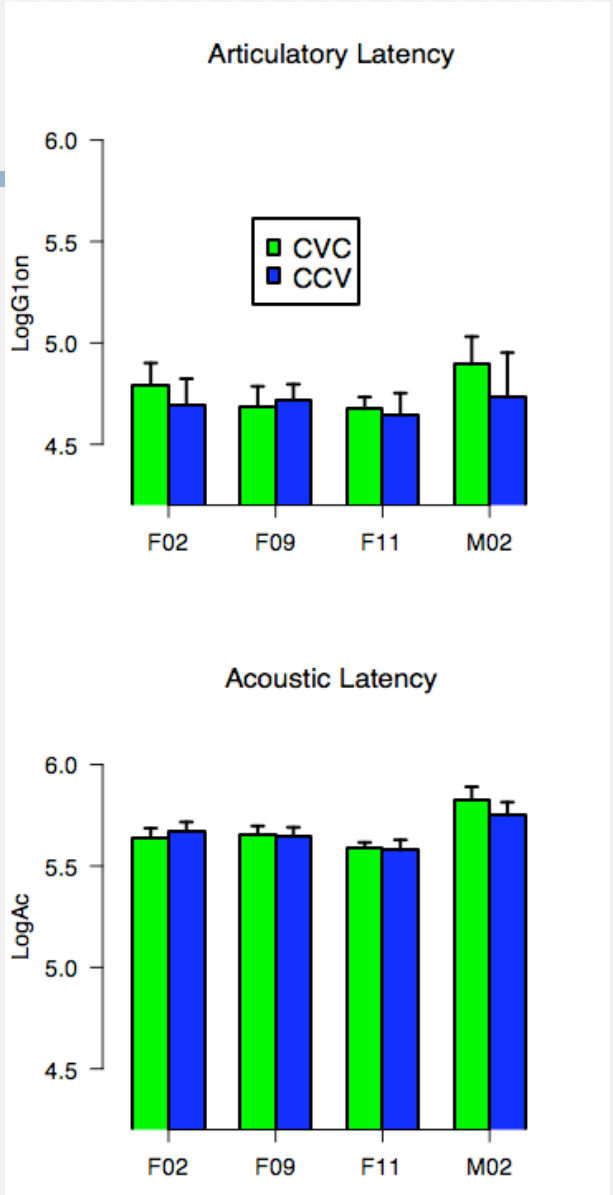
⇒ no anticipation of aerodynamic demands for the fricative (suggested by Rastle et al. 2005)





Articulatory results : clusters vs. singletons

- subset of data: only items starting with stops (e.g. *pain* vs. *play*)
- no systematic effects for onset complexity for acoustic and articulatory latencies
- similar results for clusters starting with /s/



Summary

- Syllable effects:
  - ✓ CV < VC in acoustic and articulatory domain (confirming Nam 2007)
  - × no coda effect
  - × no cluster effect (contrary to Rastle et al. 2005)
- Onset consonant:
  - ✓ shorter acoustic latency for /s/ than for other consonants
  - × but not in the articulatory domain
  - no planning effect but discrepancy between acoustic and articulatory onsets for different manners of articulation

Discussion: cluster effect?

Why couldn't we replicate Rastle et al.'s results?

- cluster effect for stops but not for fricatives
- acoustic only (latencies in ms):

	stop		stop+l	fric.	fric.+C
Rastle et al. (2005)	300	7	293	231	232
here: postvocalic DN	256	-1	257	196	186
here: simple DN	341	21	320	273	270

- larger difference for simple DN task but
- here: only 11 subjects and smaller number of items
  - ⇨ lack of statistical power

Discussion: cluster effect?

Articulatory domain

- only 4 speakers!!! postvocalic condition only

	stop	stop+l	fric.	fric.+C
Rastle et al. (2005)	300 7	293	231	232
here: acoustic RT	291 6	285	232	236
here: articulatory RT	123 4	119	123	129

- articulatory difference small and inconsistent
  - ✓ 2 speakers stop>stop+l
  - × 2 speakers stop<stop+l
- rather no cluster effect on the articulatory level
- more articulatory data needed!

Discussion: cluster effect?

Possible explanation for the missing cluster effect (and also missing coda effect):

- ? negative results in current study: because of delayed naming task ("all planning is already completed")
- BUT: persistent VC>CV differences point to a planning effect, which cannot be attributed word frequency

Right now: simple naming and picture naming tasks

Conclusion

- nice replication of Nam's results
- first effort we know of to investigate these RT phenomena kinematically
- directions for further research:
  - simple naming and picture naming

Thanks for your attention

Acknowledgments

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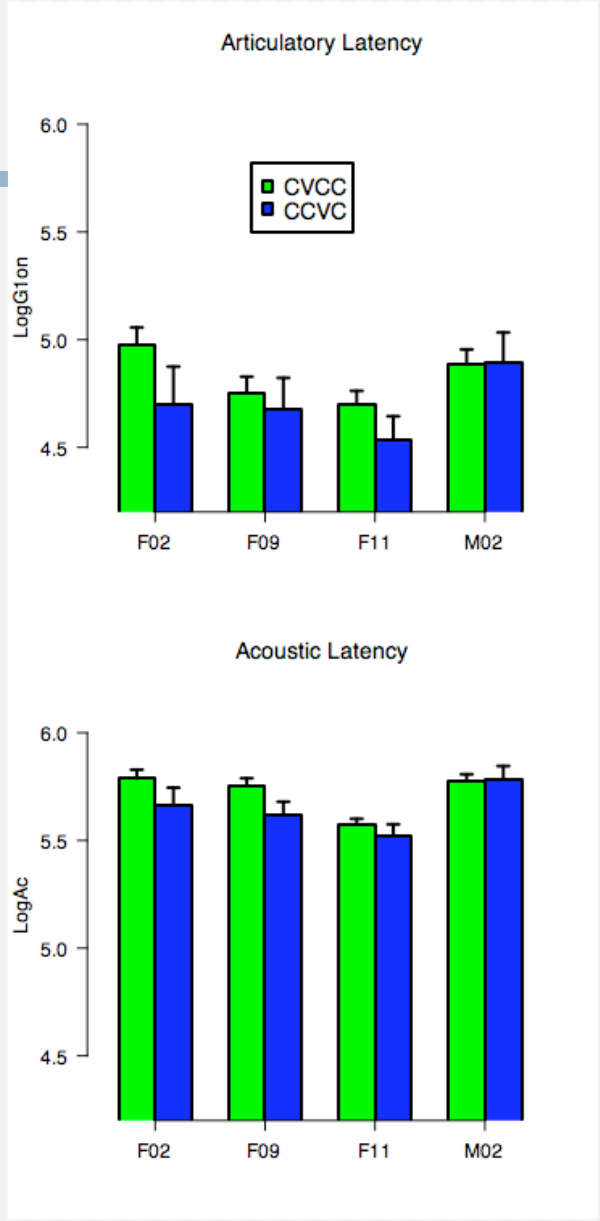
Additional results articulation: clusters vs. singletons

- subset of data: only items starting with stops and short vowels (e.g. *kelp* vs. *clap*)
- for 3 speakers: tendency of shorter acoustic and articulatory RT for complex onsets
- but not significant



Word frequency

pay < ape (following word freq. pred.)
8.0 1.1 word freq.
tea < eat (contrary word freq. pred.)
3.2 6.7 word freq.
(word frequencies: log from Switchboard corpus)