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

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

CV: CLO–––– REL V
VC: V ……… CLO–––– REL

==> C-center effect for CLO-REL-V
Introduction: settling 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

Get ready ...

plate

GO!

plate
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 LogG1 on explained by:
  - /s/: target achievement after the acoustic onset
  - stops: target achievement before 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):

<table>
<thead>
<tr>
<th></th>
<th>stop</th>
<th>stop+l</th>
<th>fric.</th>
<th>fric.+C</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rastle et al. (2005)</td>
<td>300</td>
<td>293</td>
<td>231</td>
<td>232</td>
</tr>
<tr>
<td>here: postvocalic DN</td>
<td>256</td>
<td>257</td>
<td>196</td>
<td>186</td>
</tr>
<tr>
<td>here: simple DN</td>
<td>341</td>
<td>320</td>
<td>273</td>
<td>270</td>
</tr>
</tbody>
</table>

- 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

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<tr>
<td>here: acoustic RT</td>
<td>291</td>
<td>6</td>
<td>285</td>
<td>232</td>
</tr>
<tr>
<td>here: articulatory RT</td>
<td>123</td>
<td>4</td>
<td>119</td>
<td>123</td>
</tr>
</tbody>
</table>

- 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

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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)