Effects of phonological competition on speech production

Christine Mooshammer[a], Louis Goldstein[a,b], Mark Tiede[a,c], Hosung Nam[a], Manisha Kulshreshtha[a], Scott McClure[a,d], Raj Dhillon[a,d]

[a]Haskins Labs, New Haven, CT, tine@haskins.yale.edu [b]University of Southern California, Los Angeles, CA, [c]MIT Research Lab of Electronics, MA, [d]Yale University, CT

Introduction

- **Competition**: similar but not identical words are hard to say in sequence
- leads to higher error rates and longer planning and production time
- greater effects for sequences with mismatching codas (e.g. *top tock*) than mismatching onsets (e.g. *top cop*)

Explanations for higher error frequency:

1. higher activation for similar segments ==> temporal mis-selection ==> categorical substitution errors
2. frequency locking: change from a 2:1 to a 1:1 ratio, e.g.
   - cop cop: dorsal gestures are in a 1:1 ratio with labial gestures
   - top cop: apical and dorsal are in a 1:2 ratio with labial gestures

   ==> coproduced intrusion errors with continuously varying amplitudes (Goldstein et al. 2007, Pouplier & Goldstein 2005)

Aims of this study:

- **Connection between speech planning and speech errors**: do competition and/or frequency ratio properties also contribute to **planning** and **execution**?
- does the locus of equality matter, i.e. onset or coda?

Background

- two or more different words in a row take longer to initiate than repetitions of the same word (e.g. Sternberger et al. 1988)
- similar sequences take longer to initiate than dissimilar:
  - coda consonants: Meyer & Gordon (1985)
  - vowels: Yaniv et al. (1990)
- Locality: coda mismatch (*top tock*) vs. onset mismatch (*top cop*)
  - more errors for different codas because the initial consonant serves as pointer to words (Butterworth & Whittaker 1980)
  - Sequential cuing model: Sevald & Dell (1994)
    - higher *inhibition* for coda mismatch: because same onsets miscue the wrong coda, slowing down the production
    - *facilitation/no competition* for different onsets because after the coda nothing follows to be miscued

    ==> position matters: onsets cue onsets and codas, and codas cue codas

Materials and Methods

Two EMA experiments:

- speeded repetition task for measuring error frequency:
  - 7 speakers (2m, 5f)
  - word repetitions to a metronome, 20 sec., speeding up after 10 sec
- delayed naming task for measuring planning and production time
  - 7 speakers (2m, 5f)
  - preceding schwa
- 5 speakers: both experiments

Material:

- sequences of two words
- 7 repetitions for RT experiment
- conditions: same ("*top top*"), onset different ("*top cop*"), coda different ("*top tock*")

Table: conditions with examples and number of different word sequences

	Example	repetition task	naming task
same	*top top*	not analysed	10
onset different	*top cop*	4-12	10
coda different	*top tock*	2-17	9

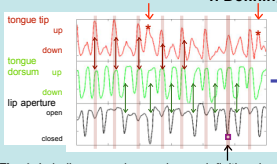
Measurements: Latencies and durations for the naming task

Results repetition task: error frequency

1. Defining errors (shown for *cod cob*)

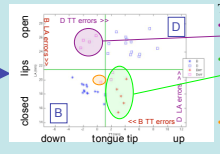
Measurements:

- Extrema labeling of intended gestures
- e.g. vertical tongue tip maximum during /d/ in *cod*
- "strobing" positions of alternating articulator
- e.g. lip aperture during /d/



positions of primary and unconstrained articulator

interquartile split mean plot per trial



Types of errors

- reductions: smaller amplitudes of intended gestures (full/partial)
- intrusions: excessive amplitudes of unconstrained articulator
  - full intrusions: amplitude within the range of intended gestures
- substitutions: full intrusion of unconstrained articulator and full reduction of constrained articulator

Fig. 1. Labeling procedure and error definition demonstrated for repetitions of *cod cob*

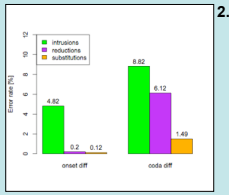


Fig. 2. Error frequencies

2. Error frequency and error types for sequences with mismatching onsets or mismatching codas

- for all error categories: significantly higher rates for repetitions of words with different codas (*top tock*) than for different onsets (*top cop*)
- intrusions:
  - most frequent error type (confirming Goldstein et al. 2007, Pouplier 2008)
  - full intrusions: 1.1 % different onset; 4.7 % different codas
- reductions:
  - higher number in coda might be due to very common /t/ deletion in this position ==> after exclusion 2.4 %
  - full reductions: very rare for different onsets (0.12 %) but 3.9 % for mismatching codas
- substitutions: very rare for word repetitions with mismatching onsets

Results naming task: planning and execution time

1. Planning time: LatG1pv (left)

- planning time is longer for sequences of different items than of same items
- no significant difference between mismatching onset and mismatching coda

⇨ same < OD=CD

2. Execution time (middle)

- The execution time was significantly longer for items with different codas (e.g. *cop cot*) than for same items (*cop cop*) and different onsets (*cop top*)
- no significant difference between sequences of same items and with mismatching onsets

⇨ same=OD < CD

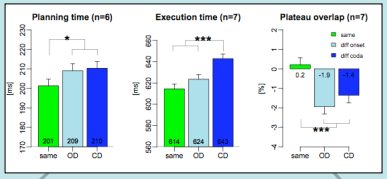
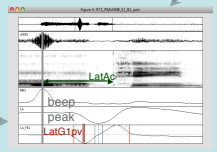


Fig. 3. Means and standard errors for planning time (left), execution time (middle) and overlap between medial consonants across words (right) for same words, words with different onsets and words with different codas.

3. Lag between medial consonants (right)

- e.g. /p#t/ in cop top
- smaller value (more negative) = longer lag between constriction target regions, normalized by sequence duration
- mean for sequences of identical words is around zero ==> coda of first word is released synchronously with the onset of the constriction target region of the second word
- lag between constriction target regions is significantly shorter between identical words than for words with different onsets or codas

⇨ same < OD=CD



Articulatory latency

- **LatG1pv**: from beep peak to velocity peak of first gesture (for /p/ measured at lip aperture signal)
- **LatAc**: from beep peak to the acoustic onset of the first sound, i.e. burst of initial stop

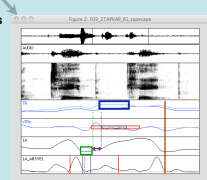
Plateau overlap between medial consonants

e.g. tape cape

- **Plateau2**: from gesture for bilabial stop in *tape*
- **Plateau3**: from gesture for the velar stop in *cape*
- **PlateauOverlap**: OffsetPlateau2-OnsetPlateau3
- Positive: overlap, negative: no overlap
- normalized by execution time

Execution time

- from the onset of the initial gesture to the closure of the final segment (ItemEnd)



Summary

Effect of similarity:

Identical words have

- shorter RT
- shorter execution durations (compared to mismatch in the coda)
- shorter lag between words

⇨ Repeating units is beneficial and speeding up performance

Locality effect: mismatch in coda vs. mismatch in onset

- no locality effect in latencies
- longer item duration for coda mismatch ("cop cot") than for onset mismatch ("cop top")
  - in agreement with Sevald & Dell (1994) & Munson & Babel (2002)
- higher intrusion, reduction and substitution rates for mismatch in coda than for mismatch in onset
  - for substitutions in agreement with Butterworth (1980)
  - for intrusions in agreement with Tiede et al. (this meeting)

⇨ item sequences with different codas ("cop cot") are more error prone and take longer to produce than different onsets ("cop top") but not longer to initiate

Discussion:

Why are sequences with mismatching codas more error prone?

1. Speakers don't care about correct production of codas
   - reason: for word recognition the word onset is more important
   - evidence: generally, assimilations and reductions are more frequent and temporal variation is higher in codas than in onsets
   - ↯ cannot explain **longer** execution time
   - ↯ cannot explain the higher number of intrusions and substitutions found in this study
2. More variability causes higher error rate
   - spatial variability is a precursor for frequency locking
   - more variability in the coda than in the onset

   ==> more frequent intrusion errors due to frequency locking
   - ↯ cannot explain **longer** execution time
3. Modifying/editing the motor plan takes more time for VC than for CV
   - VC coupling is less stable and takes longer to settle (see Nam 2007)
     - Editing CV coupling (in-phase): fast and stable
     - Editing VC coupling (anti-phase): slower and less stable

     ==> more spatial variability of C
   - evidence: VC universally dispreferred, later acquired

   ==> more intrusions since higher variability induces frequency locking

   ==> probably longer execution times as well

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Acknowledgments

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