Effects of phonological neighborhood density on phonetic variation: The curious case of French

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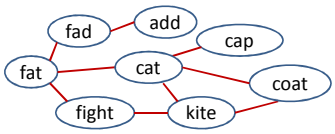
Introduction

- Effects of lexical neighbors during word processing
  - Co-activation of target word and its lexical neighbors during comprehension/production
  - What is often unclear is the nature of the effect of such co-activation in word processing
- In this project, we focus on a particular type of lexical neighbor, i.e. phonological neighbor

Phonological neighborhood

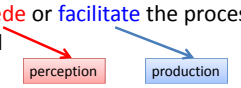
- Similar sounding words form phonological neighborhoods
  - Often defined by the 1-phoneme difference rule



Common measures:
- Neighborhood density (ND) = # of neighbors
- Neighborhood frequency (NFreq) = Avg. freq of neighbors

Effects of phonological neighbors (I)

- Phonological neighbors
  - Both compete with and bring more activation to the target word
  - Either impede or facilitate the processing of the target word



- Therefore, words with high ND tend to be
  - Harder to perceive but easier to produce

Effects of phonological neighbors (II)

- Interestingly, Gahl et al. (2012) found that words with high ND tend to be phonetically reduced in conversational speech
  - Phonetic variation reflects more of the needs of the production system
- However, most research on phonological neighborhoods are on English

When we look across languages…

- Effects of ND are not consistent cross-linguistically
  - In Spanish, words with high ND are easier to perceive but harder to produce (Vitevitch & Rodríguez 2005, Vitevitch & Stamer 2006, 2009)
    - Differences attributed to morphology and neighborhood structure

Language	Spoken word recognition	Word production	Phonetic variation
English	Inhibitory	Facilitative	Reduction
Spanish	Facilitative	Inhibitory	??

A more general problem

- Current literature on phonetic variation is also heavily based on English
- Phonetic variation patterns may be language-specific
  - Due to the interaction of language structure and language processing/production

Goal of this study

- To explore the effects of phonological neighborhoods in phonetic variation in French
- Why French?
  - Similar to English in many aspects
  - Another Romance language like Spanish
    - Different from English in morphology, speech rhythm, prosody, etc.
  - Comparable conversational speech corpus available

Neighborhood effects in French

- Inhibit spoken word recognition
- Effects on word production?
  - No direct evidence. More later.

Language	Spoken word recognition	Word production	Phonetic variation
English	Inhibitory	Facilitative	Reduction
Spanish	Facilitative	Inhibitory	??
French	Inhibitory	??	??

Corpus and dataset

- The Corpus of Interactional Data (CID, Bertrand et al. 2008)
  - 16 speakers, one-to-one conversations
  - 8 hours of conversations
- Target words
  - Monosyllabic monomorphemic content words
  - 2-4 phoneme long
  - Excluding tokens followed by vowel-initial words to eliminate possible effects of liaison and resyllabification

Neighborhood variables

- Two variables, both from the ClearPond database
  - Neighborhood density (ND)
  - Average neighbor frequency (NFreq)
- Raw density and neighbor frequency normalized by word length
  - K-ND
  - K-NFreq

Modeling

- Two mixed-effects regression models
  - Outcome variables
    - (log) word duration
    - Vowel dispersion

← Distance from center of vowel space normalized by vowel and speaker sex

  - Random effects: word and speaker
  - Fixed effects
    - K-ND, K-NFreq
    - Other control factors (frequency, predictability, word length, speech rate, speaker sex, phonotactic probabilities, baseline word duration[1], vowel duration[2], features of neighboring phones[2], etc.)

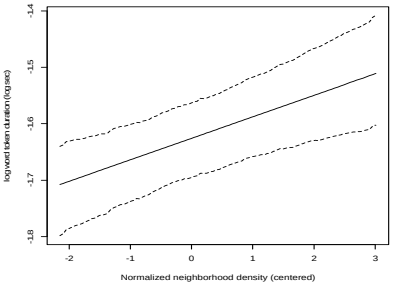
[1] word dur model only; [2] vowel model only.

Results: the word duration model

- Data size
  - 3861 tokens of 434 types
- Results
  - Significant positive effect of PND
    - β = 0.038, t = 3.00, p_{MCMC} < .001
    - Opposite direction as in English
  - Null effect of neighbor frequency
    - t = -1.16, p_{MCMC} > .1

Partial effect of K-ND on word duration

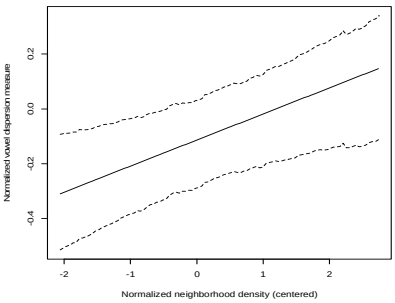
- While other factors are statistically controlled



Results: the vowel dispersion model

- Data size
  - Excluding words with nasalized vowels and central vowels, and vowel tokens <30ms or >300ms
  - 1978 tokens of 317 types
- Results
  - Significant positive effect of PND
    - β = 0.095, t = 2.54, p_{MCMC} = .005
    - Opposite direction as in English
  - Null effect of neighbor frequency
    - t = -0.724, p_{MCMC} > .1

Partial effect of K-ND on vowel dispersion



Revisiting the patterns

Language	Spoken word recognition	Word production	Phonetic variation
English	Inhibitory	Facilitative	Reduction
Spanish	Facilitative	Inhibitory	??
French	Inhibitory	??	Hyperarticulation

First puzzle

- How does neighborhood density affect word production in French?
  - Critical evidence still lacking, but not surprising if the overall effect is inhibitory
    - Vitevitch & Stamer (2006, 2009) found similar results in Spanish and attributed the effects to Spanish morphological structure
    - French and Spanish are more similar in morphology, compared to French and English
    - Morphologically and phonologically similar neighbors might comprise "strong" neighbors and impeded processing (Chen & Mirman 2012)
    - Sadat et al. (2012) presented some preliminary results which do suggest such a pattern

Possible interpretation (I)

- If words with high PND are in fact harder to produce (like Spanish),
  - there is no ground to expect PND to pattern with other facilitative factors (e.g. frequency) in phonetic variation.
  - Hyperarticulation in high-density words may be explained by offline restructuring of the stored phonological forms

But what if the effect of PND is indeed facilitative in French word production?

Possible interpretation (II)

- Higher activation leads to hyperarticulation?
  - Similar evidence from VOT: Longer VOT in words in minimal pair neighbors than those without. (Baese-Berk & Goldrick 2010; Peramunage et al., 2011).
  - Bell et al. (2009) proposed that words that are retrieved faster are also executed faster in order to keep planning and articulation in synchrony
    - Synchrony between planning and articulation may interact with speech rhythm and prosody, which is language specific

Conclusion

- The present study
  - found positive ND effects on word duration and vowel dispersion in French conversational speech
    - in opposite direction as the patterns observed in previous studies of English
  - Showed that both neighborhood effects and patterns of lexically-conditioned phonetic variation may vary considerably across languages

Future work

- We plan to further the current research by examining
  - ND effects in word production latency and accuracy in French
- Current results also call for more computational simulations for explaining the various neighborhood effects found across languages.

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