Hyperarticulation Correlates with Phonetically Specific Lexical Competition

THE UNIVERSITY OF ARIZONA

Noah Nelson

LSA Annual Meeting
7 January 2016

What We're Talking About

- Lexical-Phonetic Interactions: lexical properties can affect the phonetic realizations of words
- Lexical Competition: similar words compete for activation
- Hyperarticulation: exaggeration of phonetic properties

Road Map

- Background: previous research correlating hyperarticulation with lexical competition
- The Present Study: corpus research probing various notions of lexical competition and their correlations with hyperarticulation
- Summary, discussion, and future directions

BACKGROUND

Lexical Competition

- Operationalizations of lexical competition:
  - Phonological neighborhood density (e.g. Wright 1997, 2004; Vitevitch 2002; Scarborough 2003, 2004; Gahl et al. 2012; Wedel, Sharp & Nelson in prep)
  - Phonetically specific minimal pairs (e.g. Baese-Berk & Goldrick 2009; Kirov & Wilson 2012; Schertz 2013; Buz et al. 2014; Wedel, Sharp & Nelson in prep)

Phonological Neighborhood Density

- Tally of all words formed via the addition, deletion, or substitution of any single phoneme anywhere in the word (Luce & Pisoni 1998)
  - Target = *pat* /pæt/
  - Addition = *spat* /spæt/ *pant* /pænt/
  - Deletion = *at* /æt/
  - Substitution = *patch* /pæt͡ʃ/ *rat* /ɹæt/
- This is a broad measure of lexical competition

Phonetically Specific Minimal Pairs

- Two words that differ in a particular segment, along a particular phonetic dimension
  - e.g., VOT of word-initial stops in English
  - Target word = *pat* /pæt/
  - Minimal pair = *bat* /bæt/
- This is a narrow measure of lexical competition

Between the Broad and the Narrow

- How specific does competition have to be to induce hyperarticulation?
  - Position of competition
    - Does competition *anywhere* in the word lead to hyperarticulation of specific phonemes?
  - Type of competition
    - Does *any* kind of competition within a given slot lead to hyperarticulation?

Between the Broad and the Narrow

- Two studies probing these questions for VOT of initial stops in English
  - Kirov & Wilson (2012)
    - cooperative forced choice paradigm of Baese-Berk & Goldrick (2009)
    - hyperarticulation effect limited to first-segment competitors
    - hyperarticulation induced by voicing and place competitors. Effect of manner for /p/ but not /t/ or /k/

Between the Broad and the Narrow

- Two studies probing these questions for VOT of initial stops in English
  - Schertz (2013)
    - clarification of misheard speech paradigm (cf. Ohala 1994)
    - hyperarticulation effects limited to first-segment competitors
    - *contrastive* hyperarticulation of VOT induced by voicing competitor, no effect of place or manner.

Questions and Limitations

- Differences in results between studies?
- Competitor included in the immediate context
- Laboratory studies with targets produced in phrase-final position or isolation
- Segment position confounded with voicing (VOT) minimal pair competitor
- Phonetic competition of VOT confounded with phonological competition of the voicing feature

THE PRESENT STUDY

Research Questions

- How phonetically specific does lexical competition have to be in order to induce hyperarticulation of VOT?
  1. Relative segmental position of competition
     - Is competition within the first segment *per se* enough to induce hyperarticulation of VOT?
  2. Relative similarity of competitor
     - Is hyperarticulation of VOT induced by competition at the phonological level (voicing) or the phonetic level (VOT)?
- Can lexical competition effects be found "offline" in conversation?

Methods

- Use metrics of lexical competition targeting relative position and type of competition between words to predict VOT in conversational English using LME
- What we need…
  1. VOT data from conversations
  2. Various metrics of competition between words

VOT Data*

- Subset of Buckeye Corpus: 24 speakers, 13 female, 11 male; 14 under age 30, 10 over 40
  - Pitt et al. (2005, 2007)
- Measurements for stop-initial content words (noun, verb, adjective, adverb) of one or two syllables with initial stress
  - "VOT/length ratio": Ratio of VOT to total stop duration

* Measurements originally made for another study: Wedel, Sharp, & Nelson (in prep)

Metrics of Competition

- Phonological neighborhood density
- Phonetically specific minimal pairs
- Set of modified neighborhood densities targeting:
  - relative position of competition (Study 1)
  - relative type of competition (Study 2)

- All based on phonemic forms from the Carnegie Melon University pronouncing dictionary (Weide 1994)

Linear Mixed Effects Models*

- Back-fit base models of control predictors without any neighborhood density measures
- Created a new model with a single neighborhood density measure added
- Used log-likelihood test to evaluate whether that measure improved model fit (see, e.g., Seyfarth 2014)
- Repeated for each neighborhood density measure

* all models were implemented in R (R Core Team 2014)

Base Models

- Voiced Stops
  - Fixed Effects
    - Stop Phoneme
    - Following Liquid
    - Backward Cond. Prob.
    - Previous Mention
    - Phonotactic Prob.
  - Random Effects
    - Speaker
      - + Stop Phoneme
    - Word
- Voiceless Stops
  - Fixed Effects
    - Stop Phoneme
    - Following Liquid
    - Backward Cond. Prob.
  - Random Effects
    - Speaker
      - + Stop Phoneme
    - Word

STUDY 1: Position of competition

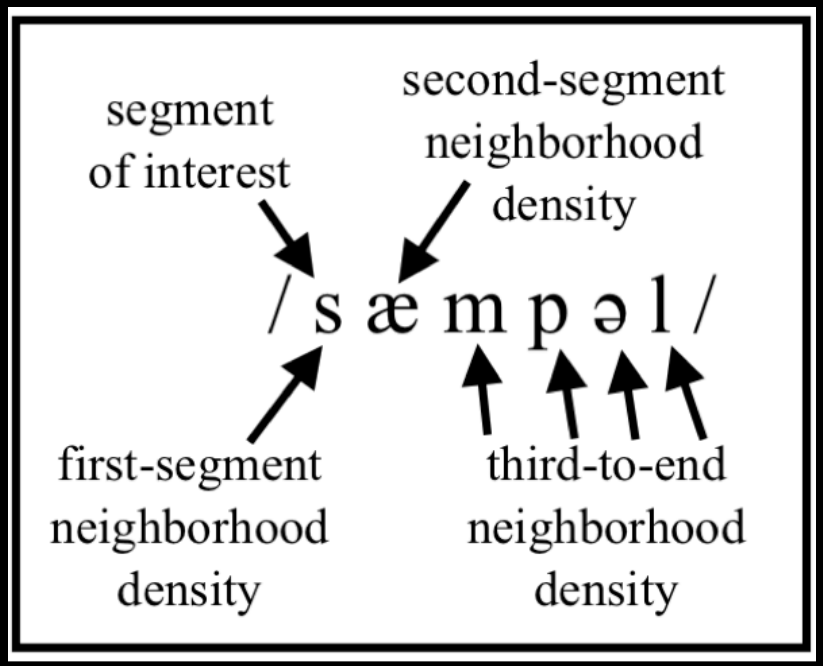
Modified Neighborhood Densities

I. Position of competition (3 modified neighborhood densities)

1 First segment only

2 Second segment only

3 The rest of the word



Results

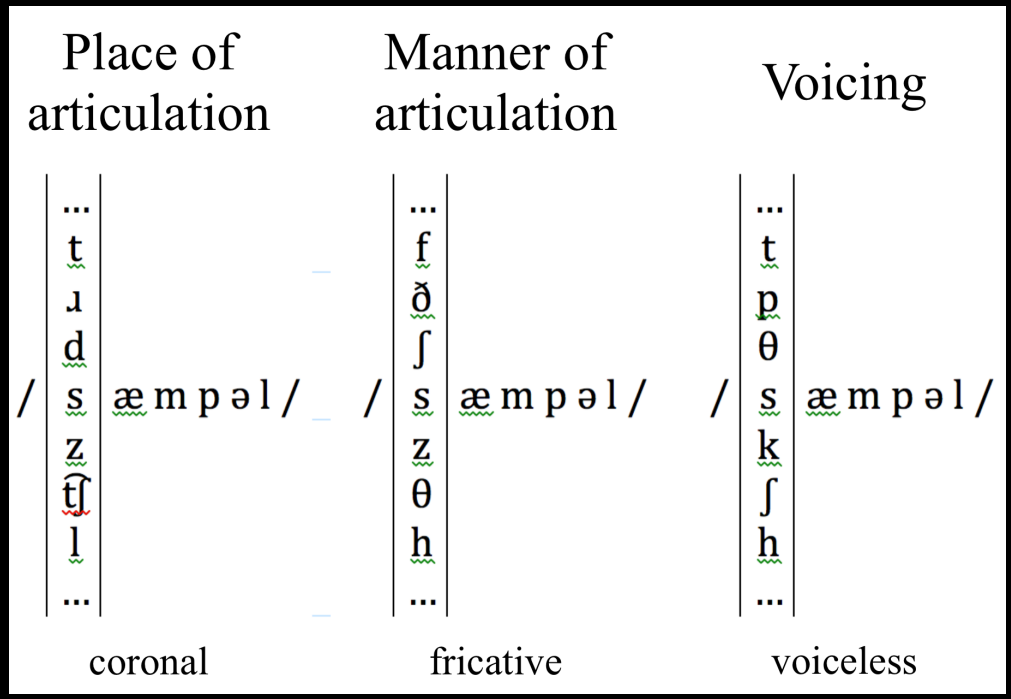
- Did the relative position of competition significantly impact hyperarticulation?

	Neighborhood density measure	χ^2(df)	*p*-value
voiceless stops	first-segment	0.61(1)	0.44
	second-segment	0.40(1)	0.53
	third-to-end	< 0.1(1)	0.98
voiced stops	first-segment	0.80(1)	0.37
	second-segment	1.43(1)	0.23
	third-to-end	2.03(1)	0.15

STUDY 2: Type of competition

Modified Neighborhood Densities

I. Type of competition (6 modified neighborhood densities)
   1 Place
      - *match*
      - *mismatch*
   2 Manner
      - *match*
      - *mismatch*
   3 Voicing
      - match
      - mismatch



Results

- Did sign

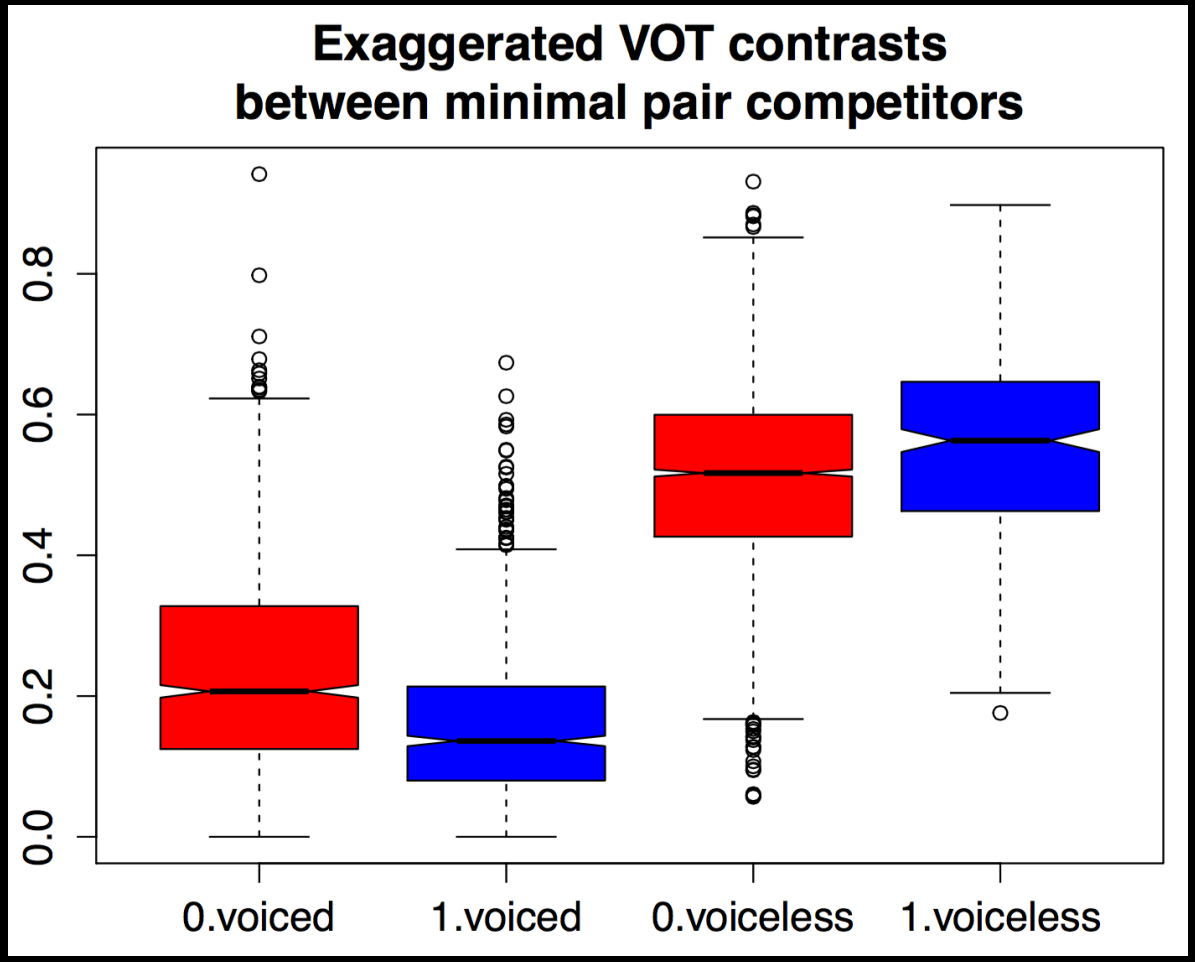
	Neighborhood density measure	χ^2(df)	*p*-value
voiceless stops	place-match	1.64(1)	0.20
	place-mismatch	1.49(1)	0.22
	manner-match	1.78(1)	0.18
	manner-mismatch	< 0.1(1)	0.96
	voice-match	0.98(1)	0.32
	voice-mismatch	< 0.1(1)	0.87
voiced stops	place-match	3.49(1)	0.06 (~)
	place-mismatch	0.03(1)	0.87
	manner-match	0.44(1)	0.51
	manner-mismatch	0.92(1)	0.34
	voice-match	0.37(1)	0.55
	voice-mismatch	0.63(1)	0.43

Results

- What about phonological neighborhood den… pair…

	Neighborhood density measure	χ^2(df)	*p*-value
voiceless stops	phonological neighborhood density	0.51(1)	0.47
	phonetically specific minimal pair	4.44(1)	0.04 (*)
voiced stops	phonological neighborhood density	2.46(1)	0.12
	phonetically specific minimal pair	6.53(1)	0.01 (*)

Results



RED = no minimal pair

BLUE = minimal pair exists

Summary

- The existence of a phonetically specific minimal pair competitor for VOT correlates with an exaggeration of the VOT contrast
  - Longer VOT for voiceless stops
  - Shorter VOT for voiced stops

- No other measure of lexical competition correlated significantly with hyperarticulation, though they all trended in the right direction

Discussion

- In this dataset, contrastive hyperarticulation of VOT correlated with phonetically specific lexical competition only
  - Segmental position alone was not enough
  - Phonological voicing competition *per se* was not enough
    - This may have to do with the number of features differentiating the target and the competitor
      - see Kirov & Wilson (2012, 2013) for discussion of this idea

Future Directions

- What about other phonetic contrasts?
  - Phonetic specificity limited to VOT?
  - Vowels: formants, duration

- What about other languages?
  - Languages with more balanced phoneme inventories may provide better testing grounds for competition effects

THANK YOU!

References

Baese-Berk, M. & Goldrick, M. (2009). Mechanisms of interaction in speech production. *Language and Cognitive Processes,* 24, 527-554.

Buz, E., Jaeger, T. F., & Tanenhaus, M. K. (2014). Contextual confusability leads to targeted hyperarticulation. In TBA (eds.) Proceedings of the 36th Annual Meeting of the Cognitive Science Society (CogSci14), TBA. Austin, TX: Cognitive Science Society.

Gahl, S., Yao, Y., & Johnson, K. (2012). Why reduce? Phonological neighborhood density and phonetic reduction in spontaneous speech. *Journal of Memory and Language*, 66, 789-806.

Goldinger, S., & Summers, W. V. (1989). Lexical neighborhoods in speech production: A first report. In *Research on Speech Perception Progress Report* (331-342). Bloomington.

Kirov, C. and Wilson, C. (2012). The Specificity of Online Variation in Speech Production. 34th Annual Meeting of the Cognitive Science Society, Sapporo, Japan.

Luce, P. A., & Pisoni, D. B. (1998). Recognizing spoken words: The neighborhood activation model. *Ear and Hearing*, 19, 1-36.

Munson, B. (2007). Lexical access, lexical representation, and vowel articulation. In J. Cole & J. Hualde (Eds.), *Laboratory Phonology 9* (201-228) New York: Mouton de Gruyter.

Pitt, M., Johnson, K., Hume, E., Kiesling, S., & Raymond, W. (2005). The Buckeye Corpus of Conversational Speech: Labeling Conventions and a Test of Transcriber Reliability. *Speech Communication*, 45, 90-95.

References (cont.)

Pitt, M., Dilley, L., Jonson, K., Kiesling, S., Raymond, W., Hume, E., & Foler-Lussier, E. (2007). Buckeye Corpus of Conversational Speech (2nd release) Department of Psychology, Ohio State University, Columbus, OH.

R Core Team. (2014). R: A language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria. http://www.R-project.org/.

Schertz, J. (2013). Exaggerating featural contrasts in clarifications of misheard speech in English. *Journal of Phonetics*, 41(3-4), 249–263.

Seyfarth, S. (2014). Word informativity influences acoustic duration: Effects of contextual predictability on lexical representation. *Cognition*, 133, 140-155.

Vitevitch, M. S. (2002). Naturalistic and experimental analyses of word frequency and neighborhood density effects in slips of the ear. *Language and Speech*, 45, 407–434.

Wedel, A., Sharp, R., & Nelson, N. (in preparation).

Weide, Robert L. (1994). CMU Pronouncing Dictionary.
http://www.speech.cs.cmu.edu/cgi-bin/cmudict.

Wright, R. (1997). Lexical competition and reduction in speech: A preliminary report. *Indiana University research on spoken language processing progress report no. 21* (471–485).

Wright, R. (2004). Factors of lexical competition in vowel articulation. In J. Local, R. Ogden, & R. Temple (Eds.), *Papers in laboratory phonology VI* (26–50). Cambridge: Cambridge University Press.

VOT Data: Exclusions

- Words without a clearly identifiable burst following stop closure
- Words that began an utterance or followed a pause or disfluency
- Words without a clearly identifiable beginning of stop closure due to a preceding stop consonant
- Words for which the orthographic form is the same as another word (e.g., *tear*)
- Words homophonous with function words
- Words that appear in high frequency discourse markers

Base Models

- Back-fit for each of voiced and voiceless stops separately from models containing the following control factors (fixed effects):
  - stop phoneme identity
  - speech rate
  - lexical frequency
  - conditional bigram probabilities
  - syntactic category
  - number of syllables
  - previous mention
  - following liquid
  - phonotactic probability
- Random Intercepts for Speaker and Word
  - Random slope on Speaker for stop phoneme identity

Base Model (Voiced)

Order dropped	Control factor	χ^2(df)	*p*-value
1	Word frequency	0.42(1)	0.52
2	Syllables	1.78(1)	0.18
3	Speech rate	2.49(1)	0.11
4	Forward cond. bigram probability	2.92(1)	0.09
N/A	Stop phoneme	72.86(2)	$p < 0.001$ ***
N/A	Following liquid	60.66(1)	$p < 0.001$ ***
N/A	Backward cond. bigram probability	4.40(1)	0.036 *
N/A	Previous mention	4.62(1)	0.032 *
N/A	Phon. probability	3.87(1)	0.049 *

Base Model (Voiceless)

Order dropped	Control factor	χ^2(df)	p-value
1	Previous mention	0.01(1)	0.93
2	Forward cond. bigram probability	0.20(1)	0.66
3	Syllables	0.28(1)	0.59
4	Word frequency	0.86(1)	0.35
5	Speech rate	1.74(1)	0.19
6	Phon. probability	2.06(1)	0.15
N/A	Stop phoneme	73.13(2)	$p < 0.001$ ***
N/A	Following liquid	28.69(1)	$p < 0.001$ ***
N/A	Backward cond. bigram probability	10.31(1)	$p < 0.01$ **