Auditory confusability vs. phonological neighborhoods in language production

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Introduction:

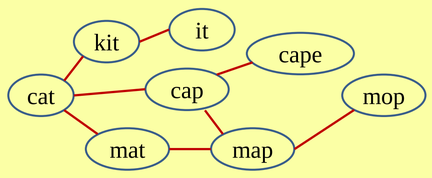
Lexical Competition and Phonological Similarity

Hearing or saying any one target word causes other words in the lexicon to be jointly activated, resulting in **lexical competition**.

Similarity in phonological form is one dimension that causes words to be jointly activated. **Phonological similarity** has been operationalized as **phonological neighborhood density** (Luce & Pisoni, 1998).

Phonological neighborhood density give rise to seemingly contradictory observations.

Phonological Neighborhood Density (PND):
The number of words differing from a target by one phoneme, often weighted by the relative frequency of target and neighbors.
(Luce & Pisoni, 1998; Goldinger, Luce & Pisoni, 1989).



Parts of a phonological neighborhood: *cap* has 3 neighbors, *mop* has 1 neighbor

PND affects…

..auditory word recognition:

High PND inhibits auditory recognition: Neighbors act as competitors and are confusable with one another.

..spoken word production:

High PND facilitates word naming: Neighbors act as supporters.

..auditory and visual lexical processing more generally:

Cf. Chen & Mirman, 2012 for a review and modeling account of effects of competition in models of joint activation.

Claim

Estimates of Phonological Neighborhood Density capture two distinct lexical properties: **Perceptual confusability** and **segment overlap**, i.e. overlap in production units.

A visual analogy

Perceptual confusability

The Mona Lisa: Low visual salience (shades of brown), but little competition from "neighbors" (similar paintings known to first author).

Segment overlap

Three paintings by Keith Haring: High perceptual salience, lots of competition from paintings using similar components.

fish	*cat*
Highly confusable segments, few neighbors	Highly salient segments, many neighbors in the lexicon

Goals of the current study:

Separate effects of perceptual similarity and lexical competition due to segmental overlap.

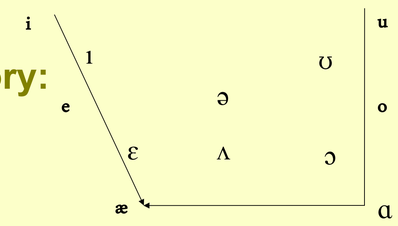
Model the effects of each of these on spoken word production.

Show that seemingly contradictory observations about PND reflect different lexical processes, different tasks.

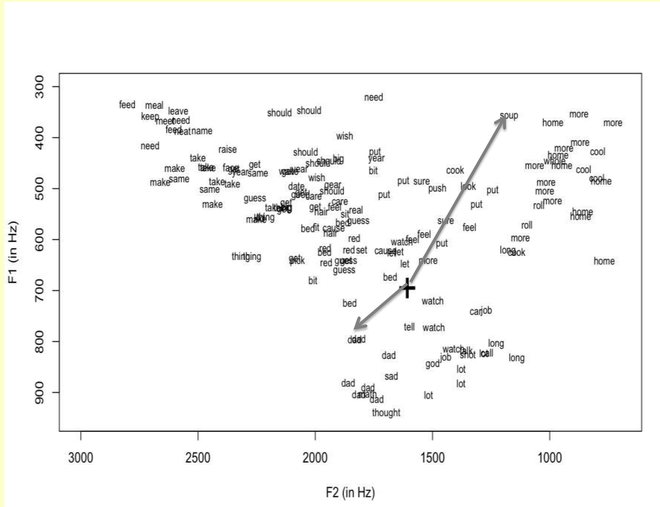
Empirical background:

Vowels

…in theory:



…and in reality:



Variability and overlap in the realization of vowels by a single talker: F1/F2 plot of vowels in CVC words excised from running speech (the Buckeye corpus, Pitt et al.) shows vowel categories overlapping.

The + sign represents the center of F1/F2 space, as the average F1/F2 values for the low central vowel [ʌ] as in *mud*.

Arrows indicate **vowel dispersion, i.e. distance from center.**

Vowel dispersion is positively correlated with **intelligibility** (e.g. Bradlow et al.).

Vowel dispersion is negatively correlated with lexical frequency (e.g. Munson, 2004).

Effects of PND on the realization of vowels

Two sets of seemingly contradictory results:

(1) E.g. Munson (2004), Wright (1997, 2004):

High PND is associated with <u>increased</u> dispersion, perhaps compensating for inhibitory effects of PND on auditory recognition.

This pattern is expected if one assumes that pronunciation variation reflects perceptual factors, such as speakers' desire for intelligibility (e.g. Lindblom 1990).

(2) Gahl, Yao & Johnson (2012):

High PND is associated with <u>decreased</u> dispersion, perhaps reflecting facilitative effects of PND on lexical access and retrieval, analogous to effects of lexical frequency.

A measure of perceptual similarity of words:

Perceptual confusability: "**Phi density**"
Strand & Sommers, 2011

Based on Phi-square (Iverson et al. 1998), indexing similarity of response distributions, e.g. responses in a phoneme identification task. Example: distribution of responses to [f] and [s] is more similar than [f] and [n].

Phi Density = The summed confusability of a target word with <u>all</u> other words in the lexicon (Strand & Sommers, 2012).

E.g. *mad | bet + mad | sock + ...*
$(\varphi\ (m|b) * \varphi\ (\bar{æ}|\varepsilon) * \varphi\ (d \mid t)\ )+$
$(\varphi\ (m|s) * \varphi\ (\bar{æ}|a) * \varphi\ (d \mid k) + \ldots.$

Data: Vowel dispersion measurements

(1) Single-word production: The data analyzed in Wright (1997, 2004).
(2) Conversational speech: The Buckeye corpus of conversational speech (Pitt et al.).

Method: Mixed-effects regression models

..of (1) and (2),
…using decorrelated measures of Phonological neighborhood size and Phi Density,
…along with other predictors of vowel dispersion (as in Gahl et al., Munson, 2004) as fixed effects, Word and Talker as random effects.

Results

In single-word production, perceptual confusability is associated with significant <u>increase</u> in dispersion; no significant effect of PND.
In connected speech, no significant effect of perceptual confusability; High Phonological Neighborhood Density is associated with <u>decrease</u> in dispersion.

Conclusions

Some effects attributed to PND (the conversational speech data) are likely due to lexical neighbors, as previously thought, whereas others (the single-word naming data) are due to auditory confusability, rather than PND.
Differences across data sets likely reflect differences in task characteristics, including temporal and attentional demands.

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