

## Background

- Spoken word recognition is remarkably successful in spite of variation in pronunciation.
- One type of variation that has been of considerable interest is regressive place assimilation, where the variation can be extreme enough to yield a phonologically significant change (*green ball* → *greem ball*).
- How do listeners recognize the intended word, *green* given *greem*?
- Experimental work has addressed this issue by testing theoretical proposals that explain how assimilated variants are recognized (Gaskell & Marslen-Wilson 1996, 1998; Gow 2003; Johnson, 1997; Lahiri, 1999).

## Present study

Obtaining a better understanding of assimilation and other types of pronunciation variation provides a check on theorizing and aids in evaluating the adequacy of theoretical accounts.

**QUESTION:** What types of variation do talkers produce in contexts where regressive place assimilation could potentially occur?

To address this question, *phonological* and *acoustic-phonetic* variation were studied in a large corpus of conversational speech.

- 1) *Phonological* analyses provide information about perceived category membership of a segment (e.g.,  $n \rightarrow m$ ).
- 2) *Acoustic-phonetic* analyses reveal the degree of physical evidence supporting category membership.

## Method

- We used the Buckeye Corpus of conversational American English ([www.buckeyecorpus.osu.edu](http://www.buckeyecorpus.osu.edu)), in which talkers freely converse with an interviewer.
- 19 talkers (~19 hrs. of speech) from Columbus, OH.

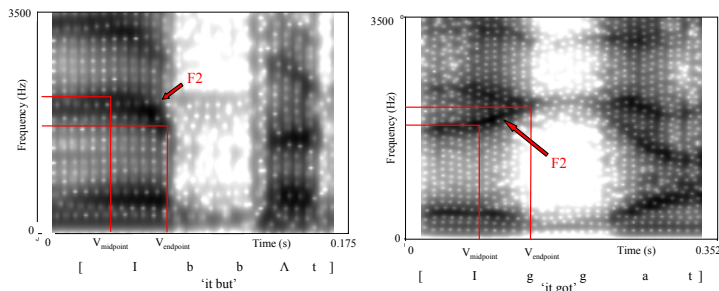
### Phonological analysis

- Labeling of speech was performed using auditory and spectrographic information.
- We examined the extent of *phonological* variation of word-final coronals /t/, /d/, and /n/ in *assimilable environments* (N = 4349):

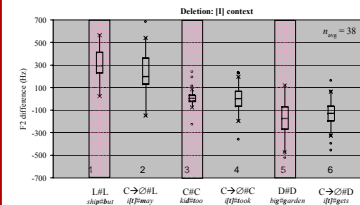
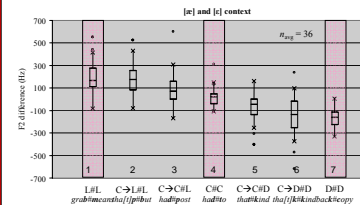
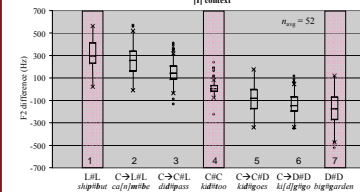
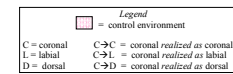
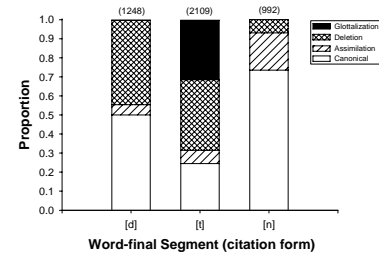
$$\left. \begin{array}{l} \{t, d, n\} \# \{p, b, m\} \\ \{t, d, n\} \# \{g, k\} \end{array} \right\} \begin{array}{l} \text{(coronal \# labial)} \\ \text{(coronal \# dorsal)} \end{array}$$

### Acoustic-phonetic analysis

- The direction and extent of an F2 transition to a stop from a preceding segment serves as a clear measure of place assimilation. This was determined by calculating the *F2 difference* at the midpoint and end of the vowel preceding the stop.
- In order to evaluate the relative degree of place assimilation for coronals, the F2 difference for word-final coronals in assimilable environments were compared with word-final consonants in *control environments*:
  - {g, k, ng} # {g, k} (dorsal # dorsal)
  - {t, d, n} # {t, d, n} (coronal # coronal)
  - {p, b, m} # {p, b, m} (labial # labial)
- F2 transition measurements were made for two preceding vowel contexts:
  - high, front vowel ([I])
  - non-high, front vowel ([æ] or [e])



## Frequency of Variant Realization



## Results: Phonological analysis

- Assimilation was the least frequent form of variation (9%).
- Deletion (32%) and glottalization (15%) were relatively more frequent.
- Canonical pronunciations predominated (43%).
- These results suggest that even in a highly constrained environment (word-final coronals in assimilable contexts), variation takes many forms.

## Results: Acoustic-phonetic analysis

### [t] context

- Control environments (pink bars) serve as referents to evaluate the degree of assimilation.
- Coronals assimilate almost fully in both following labial (#L) and dorsal (#D) control environments (1 vs. 2; 6 vs. 7).
- The extent of assimilation for coronals that do not assimilate (3 and 5) falls in between that of assimilated coronals (2 and 6) and the coronal (#C) control context (4).

### [æ] and [e] context

- Coronals assimilate to a similar degree in this vowel context (1 vs. 2; 6 vs. 7).
- Assimilation was similarly graded across contexts, with the median progressively decreasing from labial to dorsal place of articulation.
- Is there similarly strong acoustic evidence of segment identity when segments were deleted?

### Deletion

- F2 differences for deleted cases in both the labial and dorsal contexts are slightly less extreme than control contexts (1 vs. 2, 5 vs. 6).
- Even when the segment is imperceptible, remnants of the segment remain.
- The divergence in F2 is comparable whether the coronal is deleted or assimilated.

## Summary and Conclusions

- Pronunciation variation is complex, even in environments where only assimilation might be assumed to occur. More extreme types of variation, such as deletion and glottalization, are common, while assimilation is relatively rare.
- The extent of place assimilation varies continuously across contexts, for both assimilable and deleted cases.
- Place assimilation is frequently complete. This suggests that little or no evidence of the underlying segment remains, and that such evidence is unreliable for segment identification.
- Theories of spoken word processing must overcome:
  - The graded nature of place assimilation.
  - The many forms of variation that occur in assimilable contexts.