Phonology has an Early Influence on Sound Change
Josef Fruehwald, NELS 43
Model Description

1 Data

y is F1.

$$y_{1,2...n} \tag{1}$$

J is a vector of speaker indices.

$$J_{1,2...n} \tag{2}$$
$$j = J_i \tag{3}$$

K is a vector of context indices.

$k = 1$ Surface /d/
$k = 2$ Surface /t/
$k = 3$ Flapped /d/
$k = 4$ Flapped /t/

$$K_{1,2...n} \tag{4}$$
$$k = K_i \tag{5}$$

W is a vector of word indices.

$$W_{1,2...n} \tag{6}$$
$$m = W_i \tag{7}$$

D is a vector of durations. Original msec measures have been log2 transformed and centered around the median.

$$D_{1,2...n} \tag{8}$$
$$d = D_i \tag{9}$$
$$\tag{10}$$

B is a vector of dates of birth for each speaker.

$$B_{1,2...max(J)} \tag{11}$$
$$b = B_j \tag{12}$$
$$\tag{13}$$

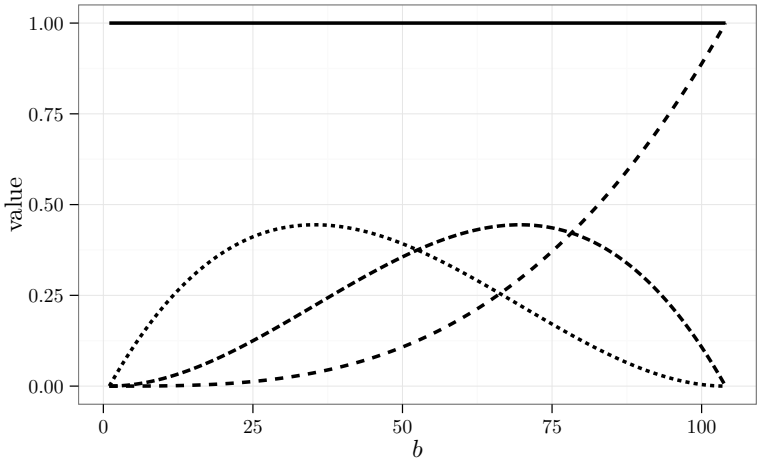

Figure 1: b-spline basis

x is the b-spline basis represented in Figure 1.

$$x_{1...max(B),1...4} \tag{14}$$

2 The Model

The change over time is modeled with the b-spline basis by multiplying it by a matrix of weighting coefficients, β.

$$\beta_{1...4,1...max(K)} \tag{15}$$

$$\gamma_{bk} = x \times \beta \tag{16}$$

We want to fit the following model represented in Figure 2 for every speaker.

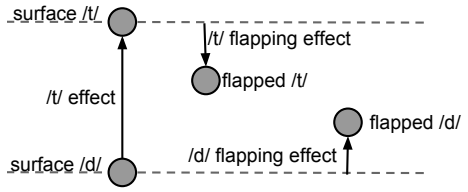

Figure 2: Speaker Model

$$
\begin{aligned}
\gamma^s_{jk} &\sim \mathcal{N}(\gamma_{bk}, \sigma_k) && (17)\\
\mu^s_{jk=1} &= \gamma^s_{jk=1} && (18)\\
\mu^s_{jk=2} &= \gamma^s_{jk=1} + \gamma^s_{jk=2} && (19)\\
\mu^s_{jk=3} &= \gamma^s_{jk=1} + \gamma^s_{jk=3} && (20)\\
\mu^s_{jk=4} &= \gamma^s_{jk=1} + \gamma^s_{jk=2} + +\gamma^s_{jk=4} && (21)
\end{aligned}
$$

We also want to estimate word-level effects.

$$\mu^w_m \sim \mathcal{N}(0, \sigma^w) \quad (22)$$

We'll also estimate a duration effect, β^d, and speaker-level duration effects, β^{ds}_j.

$$\beta^{ds}_j \sim \mathcal{N}(\beta^d, \sigma^d) \quad (23)$$

Finally, the data is estimated as,

$$y_i \sim \mathcal{N}(\mu^s_{jk} + \mu^w_m + (\beta^{ds}_j \times d), \sigma^s_j) \quad (24)$$

Where, σ^s_j is a speaker specific dispersion parameter.

Any parameters for which a prior has not been explicitly defined in this description was either given a $\sim U(0, 100)$ in the case of variance parameters, or $\sim \mathcal{N}(0, 1000)$ for all others.

3 Implementation

This model was estimated by Hamiltonian Monte Carlo, using Stan.

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University of Pennsylvania

Which comes first?

Does gradient phonetic change feed subsequent categorical phonological change? Is apparent phonological change the accumulation of gradient phonetic errors in production or perception?

Test Case: /ay/ Raising

/ay/ raises in Philadelphia before voiceless consonants only, and exhibits opacity in contemporary speech.

bite	bʌit	baid	*bide*
biting	bʌirɪŋ	bairɪŋ	*biding*

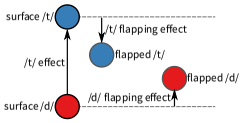
Data and Model

/ay/ nucleus measurements taken from the Philadelphia Neighborhood Corpus.

	/t/	/d/	total
surface	2157	757	2914
flap	320	354	674
total	2477	1111	3588

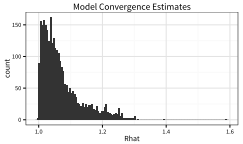
301 speakers born between 1888 and 1991.

Basic Model:



Full model includes speaker level effects, duration effects, and by-word effects.

Implemented in Stan, estimated via Hamiltonian Monte Carlo, relatively well converged.



References

Baker, A., Archangeli, D., & Mielke, J. (2011). Variability in American English s-retraction suggests a solution to the actuation problem. *Language Variation and Change*, *23*, 347–374.

Bermúdez-Otero, R. (2007). 21 Diachronic Phonology. In P. de Lacy (Ed.), *The Cambridge Handbook of Phonology* (pp. 497–517). Cambridge: Cambridge University Press.

Blevins, J. (2004). *Evolutionary phonology: The Emergence of Sound Patterns*. Cambridge: Cambridge University Press.

Fruehwald, J. (2008). The Spread of Raising: Opacity, Lexicalization, and Diffusion. *Penn Working Papers in Linguistics*, *14*(1), 83–91. Retrieved from http://repository.upenn.edu/pwpl/vol14/iss1/11/

Joos, M. (1942). A phonological dilemma in Canadian English. *Language*, *18*, 141–144.

Labov, W. (2001). *Principles of linguistic change. Volume 2: Social Factors*. Language in Society. Oxford: Blackwell.

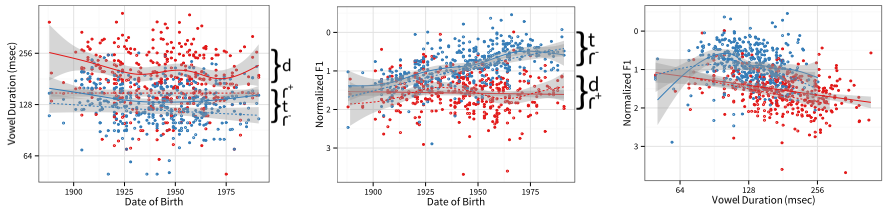
Labov, W., & Rosenfelder, I. (2011). *The Philadelphia Neighborhood Corpus*.

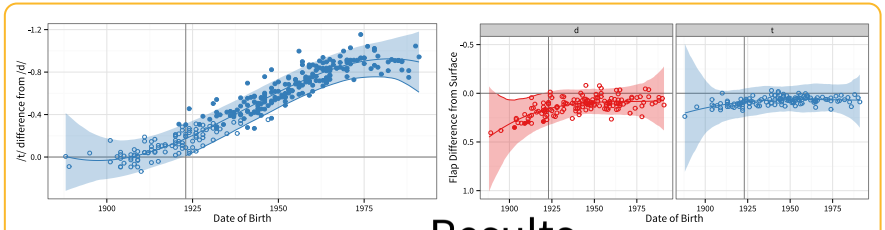
Moreton, E., & Thomas, E. R. (2004). Origins of Canadian Raising in voiceless-coda effects: a case study in phonologization. In J. Cole & J. V. Hualde (Eds.), *Papers in Laboratory Phonology 9*. Cambridge: Cambridge University Press.

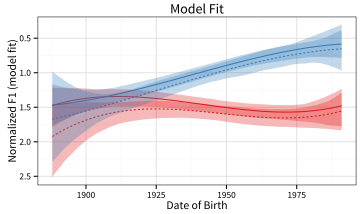
Ohala, J. (1981). The listener as a source of language change. In C. S. Masek, R. A. Hendrick, & M. F. Miller (Eds.), *Papers from the Parasession on Language and Behavior*. Chicago: Linguistics Society.

Stan Development Team. (2012). *Stan: A C++ Library for Probability and Sampling*. Retrieved from http://mc-stan.org

t,r⁻ d,r⁺







Results

It does not appear that /ay/ before flaps has ever patterned differently from /ay/ before surface /t/ and /d/. To the extent differences are observed, they run counter to predictions based on phonetic bias.

At all times in the change, /ay/ raising has occured to a degree proportionate to the underlying voicing of the following segment, not proportionate to the phonetic properties of its context.

A model where /ay/ raising began due to phonetic biases, then generalized along phonological lines is not supported. Rather, the phonological generalization appears to be concurrent with the phonetic shift.