Front Lax Vowel Trajectories in Two Dialects of American English

Vowel Trajectories in Piedmont, NC

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Main Ideas Behind This Talk

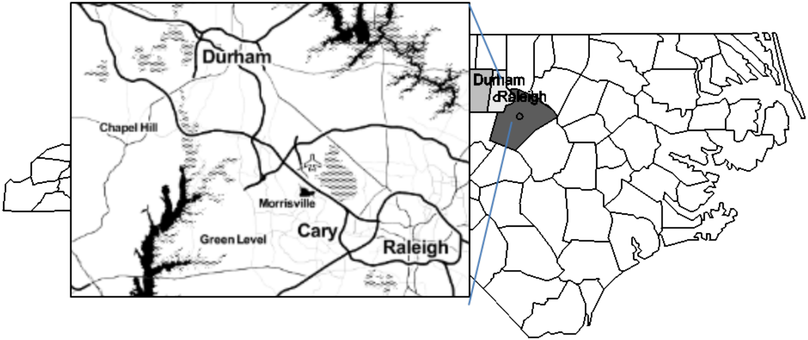
- A sociophonetic analysis of aspects of the Southern Vowel Shift and the African American Vowel Shift as spoken in Piedmont, North Carolina.[1]
- Uses functional data analysis to make principled comparisons of vowel trajectories to address research questions about the relatedness of these two dialects.
- Argues that such fine-grained measures make it easier to address these research questions than typical static measures do.

[1] This research is a result of a collaboration with Mary Kohn (Kansas State University) done at North Carolina State University.

Introduction

- Most vowel production studies focus on steady-state F1/F2 measurements, which have been useful for describing mergers and shifts, but:
  - Landmarks for measurement can be arbitrary and are chosen *a priori*.
  - This method doesn't incorporate dynamic information like formant trajectories or duration (cf. Koops 2010; Scanlon and Wassink 2010; Thomas 2002, pg. 172).
  - Dynamic information may be crucial for differentiating dialects (Hillenbrand et al., 1995; Jacewicz et al., 2011).
- Fine-grained acoustic analyses of inter- and intra-community comparisons can reveal what it means to "participate in a vowel system."

Research site: Piedmont, North Carolina



Background

Vowel systems in Piedmont, North Carolina:

- Front lax vowels, BIT, BET, and BAT, of African American and older generation Southern European-American speakers are thought to be aligned (raised and fronted) at **midpoint** and **nuclei** measurements respectively.
- These systems differ in that Southern European-American vowels are more subject to breaking resulting in greater **diphthongization** than African American vowels (Risdal and Kohn, 2013; Koops, 2010).
- The African American vowel system has remained relatively stable for significant portions of the 20^{th} century in this region whereas the Southern Vowel Shift is receding in Raleigh, NC (Kohn, 2013; Dodsworth and Kohn, 2012).

Stages of the Southern European-American Vowel Shift (SVS)

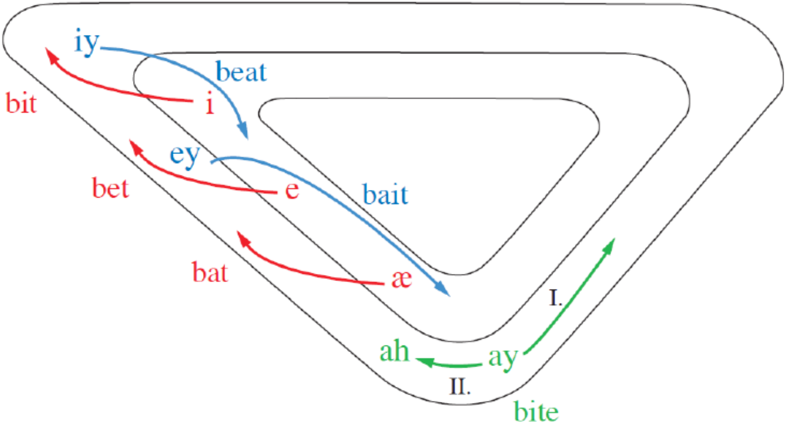
Adapted from (Fridland, 2012; Labov et al., 2006; Labov, 1991):

- **Stage 1** Monophthongization of BIDE [served as the trigger for the SVS]
- **Stage 2** Centralization of BAIT and peripheralization of BET
- **Stage 3** Centralization of BEET and peripheralization of BIT

- Stage 2 and 3 result in diphthongization of front lax vowels because raising/fronting primarily affects vowel nuclei.
- In Raleigh, stage 3—reversal of the front vowels BEET/BIT —never reached completion (Dodsworth and Kohn, 2012)

Southern European-American Vowel Shift (SVS)

(Labov, 1991; Labov et al., 2006)



The SVS and Front Lax Vowel Duration

Investigations of vowel duration in the SVS front lax vowels have largely taken place under controlled settings. Some general patterns are:

- The front lax vowels BET and BIT tend to be longer in duration compared to other regional dialects of American English (Clopper et al., 2005).
- Their nuclei become more peripheral, resulting in increased diphthongization, with duration (e.g., Koops, 2013).

Also of relevance is the well known relationship between vowel duration and vowel openness such that BIT $<$ BET $<$ BAT.

Hypotheses about the SVS in Raleigh, NC

Hypothesis 1

With respect to stages 2 and 3 of the SVS in Raleigh, we expect to see that BET will be more diphthongal than BIT among older-generation European-Americans.

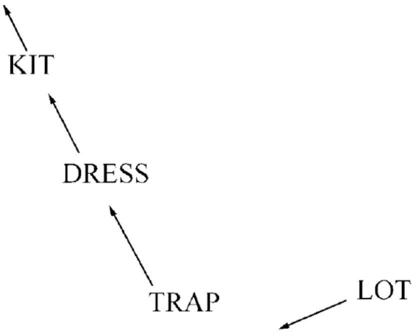
Hypothesis 2

Increased vowel duration will be associated with more diphthongal (peripheral) formant trajectories.

The African American Vowel System (AAVS)

- Front lax vowels raise and move forward along the vowel space diagonal. The raising of the front lax vowels in AAVS is associated with the SVS.
- Do AAVS front lax vowels undergo diphthongization in a manner similar to that of the SVS?

Reproduced from Thomas (2007, pg. 465):



Participation in the AAVS

- Not all Southern African Americans participate in the AAVS to the same degree (Kohn and Farrington, 2013).
- In this study, we investigate how participation in the AAVS is realized by individual speakers in Piedmont, NC where this variety is present alongside the similar SVS.
- "I **had** graduated with like a two-nine": play

AAVS implicational scoring (Kohn and Farrington, 2013)

Vowels	AAE (score 1, .5, 0)
BEET/BIT F1	Reversed
BEET/BIT F2	Reversed
BET/BAIT F1	Reversed
BET/BAIT F2	Reversed
BAT Raised	Closer to BET than BOT
BUT Raised	Above BOAT/BOWL
BOUGHT	Closer to BOAT than BOT
BOAT	Behind BOT on F2
BOOK	Behind BOT on F2
BOOT	Behind BOT on F2
BIDE	Glide weakened
PIN/PEN	Merged
	Total possible score: 12

Questions about the AAVS in Piedmont, NC

Research Question 3
: Do younger-generation African American speakers produce more monophthongal front lax vowels compared to European-American speakers?

Research Question 4
: Do individuals differ in terms of front lax vowel trajectories according to their use of other phonological features of the AAVS?

Data Collection

- Sociolinguistic interviews were done by researchers affiliated with the North Carolina Language and Life Project (NCLLP) (European-American English) and the Frank Porter Graham longitudinal language study at UNC-Chapel Hill (African American English).
- Primary stressed vowel tokens $\geq$ 60ms were extracted from force-aligned TextGrids (P2FA; Yuan and Lieberman, 2008) using a semi-automatic Praat script.[2]
- No preceding or following liquids, glides, nasals, or vowels.

[2] Written by Jeff Mielke and adapted for the present study.

Data Collection

- 26 African American speakers born around 1991 from Piedmont, NC and 8 Southern European-Americans born between 1941 and 1959 from Raleigh, NC.
  - AAVS scores ranged from 1 to 9.5 (M = 4.33). A subset of African American speakers divided into **high** (M = 6.12, n = 9) and **low** (M = 2.42, n = 7) AAVS groups.
- A total of 3906 vowel tokens extracted: 1121 BIT, 1010 BET, and 1775 BAT.
- 21 F1 and F2 equidistant measurements taken from each vowel from onset to offset which were then normalized using Lobanov's (1971) *z*-scoring method.

Modeling formant contours with functional analysis

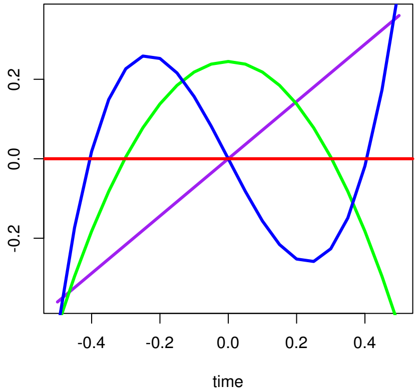
- We fitted measurements from each time-series vowel token to an orthogonal cubic polynomial. We then extracted the coefficients (i.e., parameters) from each function to make independent comparisons of contour shapes.
- Previous studies have used functional analysis to compare coefficients of similar data:
  - pitch contours (Grabe et al., 2007);
  - formant trajectories (Mielke, 2013; Morrison, 2009);
  - eye-tracking data (McMurray et al., 2010)—all of which follow smooth curves.
- Median R^2 values of .92 and .91 were achieved for F1 and F2 respectively indicating successful fits to the data.

Orthogonal polynomial functions and coefficients

Coefficients (parameters of the curves):

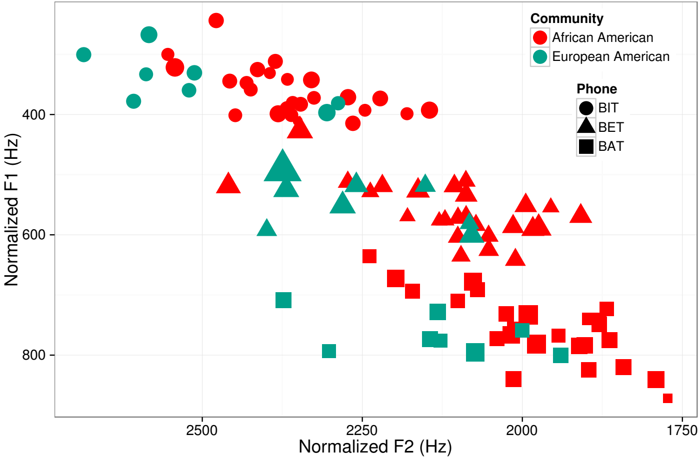
0. Constant: *Equivalent to F1/F2 values at midpoint*
1. Linear: *Slope*
2. Quadratic: *A single "curve" (with one turnpoint)*
3. Cubic: *The "curvilinear" shape of the formant contour (with two turnpoints & one inflection point)*

$$f(x) = ax^3 + bx^2 + cx + d$$



Speaker front lax vowel means and standard deviations

A traditional comparison of these two systems illustrates static differences in nuclei (European-American) and midpoint (African American) measures, but does not capture dynamic differences.



Hypotheses about the SVS in Raleigh, NC

Hypothesis 1

BET will be more diphthongal than BIT among older Raleigh European-Americans due to the advancement of stage 2 (BAIT/BET reversal) of the SVS relative to stage 3 (BEET/BIT reversal).

Hypothesis 2

Increased vowel duration will be associated with more diphthongal formant trajectories.

Trajectory shape and cubic coefficients: EAE speakers

F2 cubic coefficients correspond to the diphthongal shape which we expect to characterize front lax vowel peripheralization in the SVS.

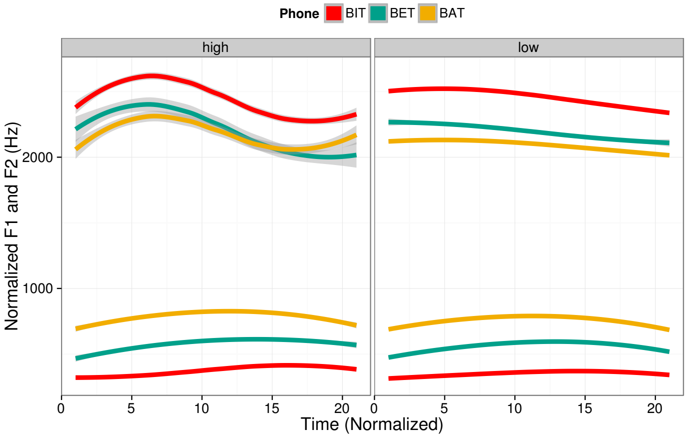


Figure: Aggregate BIT, BET, and BAT F1 and F2 trajectories for EAE speakers faceted by high and low F2 cubic coefficients.

F2 cubic coefficients & duration: Mixed Effects Model

A linear regression model confirms hypothesis 2, but shows that BET is not significantly more diphthongal than BIT where duration is an interaction term.[3]

Variable	*Estimate*	*StdError*	t-*values*
duration	0.123	0.016	7.528 ***
BET	−0.099	0.058	−1.706
BAT	−0.152	0.045	−3.350 ***
BET:duration	−0.034	0.026	−1.304
BAT:duration	−0.050	0.021	−2.411*

Table: Results of a mixed effects linear model predicting F2 cubic coefficients among EAE speakers. Reference level = BIT. *** = significant at $p < 0.001$; ** = 0.01; * = 0.05.

[3] Hypothesis 1 not confirmed.

Addressing questions about the AAVS & SVS

- We use orthogonal cubic polynomial fits to visually compare vowel trajectories for each community to address the question of how older-generation EAE speakers' front lax vowel contours compare to those of younger-generation AAE speakers in high and low AAVS groups.

Research Question 3

How do younger-generation African American speakers' front lax vowel contours compare to those of European-American speakers?

Front lax vowel trajectories: Group comparison

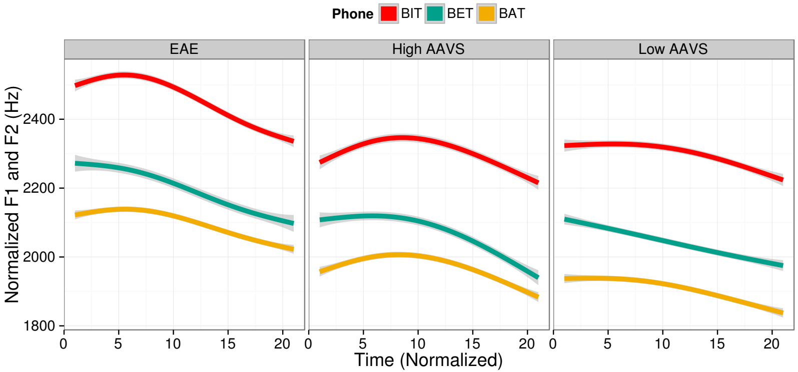


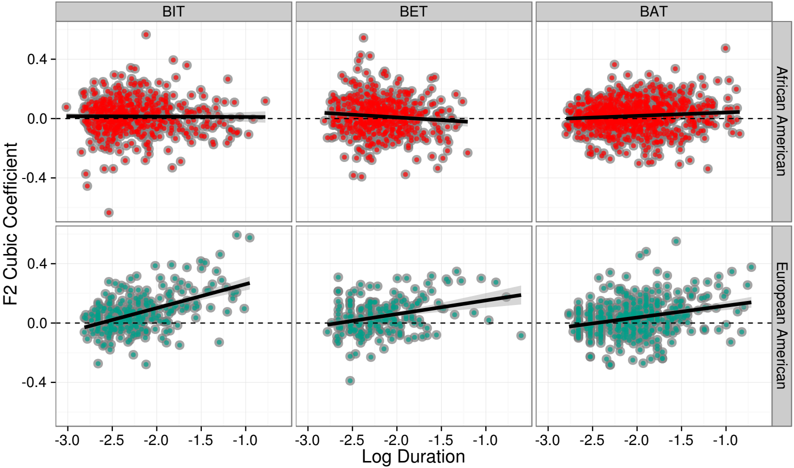
Figure: Front lax vowel contours from EAE and high and low AAVS speakers. Contours were smoothed in `ggplot2` using generalized additive model fits.

Front lax vowel trajectories: Group comparison

- EAE speakers have distinct contours for BIT, BET, and BAT, compared to AAE speakers who participate in the AAVS.
- High AAVS speakers have trajectories that conform to a quadratic function (parabolic shape) while the EAE speakers produce trajectories more consistent with a cubic function, a pattern consistent with descriptions of diphthongization.
- This finding aligns with previous studies that describe the AAVS front lax vowels as more monophthongal compared to EAE varieties of the SVS.

F2 spectral movement and duration: Group comparison

Curvilinear shape of front lax vowels increases along with duration for European-Americans, but not African Americans.



Front lax vowel trajectories: Group comparison

- The distinctive relationship between duration and diphthongization found in previous studies of the SVS is absent for the AAVS indicating that these two systems are qualitatively distinct.
- Although both EAE speakers and AAVE speakers front lax vowels have similarly low F1 values, the systems differ in the manner in which these targets are reached.

Question about individual variation & the AAVS

Research Question 4

Do individuals differ in terms of front lax vowel raising according to their use of other phonological features of the AAVS?

- To address the question of whether or not high participators achieve front lax vowel raising in the manner exploited by EAE speakers, we contrast constant and cubic coefficients from F1 and F2 polynomial fits respectively for both groups of AAE speakers.

F1 Constant & F2 Cubic Coefficients: High & Low AAVS

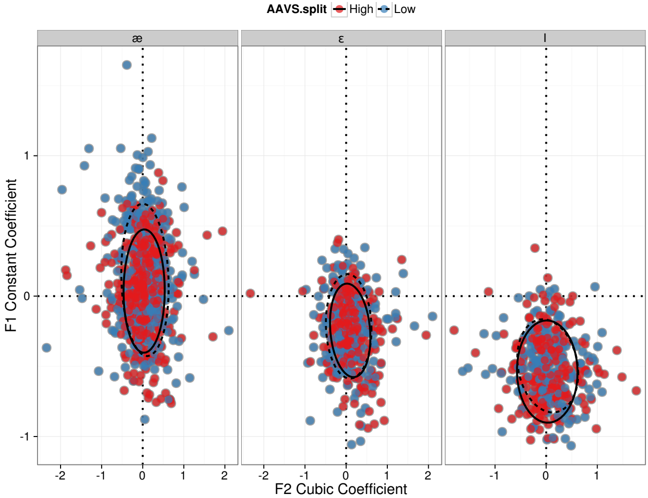


Figure: High and low AAVS speakers' F2 cubic by F1 constant coefficients for BIT, BET, and BAT. Ellipses represent 95% confidence intervals. Black dotted lines delimit quadrants.

AAVS: Within-Group Comparisons

- Visual inspection of the 95% confidence interval ellipses suggests that high AAVS speakers have more F1 constant coefficients concentrated in the lower range for at least BAT which translates to a higher degree of front lax vowel raising.
- Although high AAVS participants may exhibit lower F1 values for BAT compared to low AAVS speakers, it is not apparent that their trajectories are more diphthongal in shape than low AAVS participants as indicated by the distributions of F2 cubic coefficients.

Conclusions

Complex relationships between formant trajectory shapes and vowel duration emerge:

- BIT and BET are equally diphthongal among European-American speakers. All front lax vowels are diphthongal at longer durations.
- African American and European-American English speakers differ in formant contours and this difference is captured by F2 cubic polynomial coefficients and vowel duration.

Conclusions

- There are no differences in F1/F2 trajectory shapes between African Americans speakers participating in the AAVS and those who don't.
- Although both systems raise front lax vowels, the dynamic quality and the interaction with duration associated with raising is distinct.
- Given differences in the quality of raising, how related are these two systems in actuality?

Conclusions

- The present study demonstrates that functional data analysis has a place as a valuable tool for analyzing vowel trajectory information within sociophonetics.
- This method of analysis allows researchers to move closer to capturing fine-grained, sociolinguistically important cues by reducing the dimensionality of a large number of vowel measurements.
- Information outside of steady-state F1/F2 measurements are essential to vowel perception and the possibility to more easily examine dynamic qualities of vowels should encourage sociophoneticians to rely less on the "target" model of production.

Acknowledgments

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