Using acoustic trajectory information in studies of merger

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NWAV 38, Ottawa
October 23, 2009

Summary

- Detailed acoustic study of a Seattle African American speaker shows she does not differentiate *pin* and *pen* classes by formant values at vowel midpoint.
- Direction of glide for *pin* and *pen* is the same; however, speaker differentiates *pin* and *pen* classes by degree of gliding and by duration.
- Some evidence that Seattle African Americans utilize degree of gliding to distinguish *pin* and *pen*.

Goals of study

- To evaluate the efficacy of using Euclidean distance as a summary statistic for vowel analysis, particularly for studies of merger.
- To identify the role of spectral change in the speech of a Seattle African American.
- To compare the results of a spectral change analysis with a conventional analysis of vowel measures at midpoint.

Background

- Merged *pin-pen* is described as a relatively uniform feature of African American English (AAE) throughout the U.S. (Labov et al. 2006, Thomas 2007).
- However, the status of merger is usually examined impressionistically (Brown 1990; Edwards 1997; Gordon 2000) or through spectral qualities of the *pin* and *pen* classes at a single measurement point (Thomas 2001).
- Degree of gliding is sometimes a distinguishing factor in the production of vowel classes in English that appear spectrally merged (Milroy and Harris 1980, Labov et al. 1991), and spectral change can be an important factor in vowel identification (see Morrison 2008), but it has not yet been utilized in studies of *pin-pen* merger.
- Study utilizes acoustic trajectory information indicative of gliding for an analysis of *pin* and *pen* classes.

Case study – J (African American, F, 66)

J's metalinguistic commentary (from MS interview w/ J):

> J: "But another thing that we do is, we don't, is that we say, we don't make a difference between *pin* and *pen* up here - it's all *pin*."
> …
> Interviewer: "For the whole - for the whole Northwest?"
> J: "I *know* it's for this area, around here."

Methods

- Data taken from interviews conducted by J
- J and interlocutors raised through adolescence in Yesler Terrace neighborhood, Seattle, Washington
- Measured and coded 128 tokens of *pin* and *pen* classes[1]
- Vowel measures: F1 and F2 at 20% point of vowel, midpoint, and 80% point of vowel (Morrison 2008)
- Coded each token for vowel class (*pin*, *pen*); interlocutor ethnicity (African American, Caucasian), duration (ms), preceding POA (bilabial, alveolar, etc.); auditory impression (monophthongal, diphthongal)
- Calculated Euclidean distance for each token
- Ran t-tests for vowel F1,F2 at midpoint; regressions of vowel F1, F2, Euclidean distance, duration, and auditory impression (details in Results)

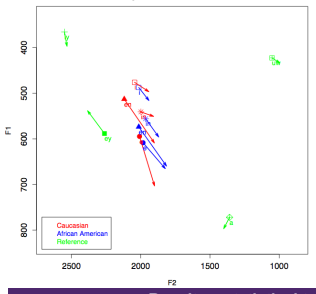
What is Euclidean distance?

- *Euclidean distance* (aka *Cartesian distance*) is a combination of a vowel's movement along F1 and F2
- Calculation: $\sqrt{(\Delta F1)^2 + (\Delta F2)^2}$; ΔF1, ΔF2 calculated as difference between formant values at 20% and 80% points of vowel
- Can be interpreted as a rough measure of the degree of gliding for a vowel
- Needed in cases where it is not clear whether ΔF1 or ΔF2 differentiate a pair of vowel classes

[1] i.e., (i) and (e) classes with following alveolar nasal; excluded words with 3 or more syllables, tokens with preceding liquids, and proper names.
[2] Also tested for number of syllables and voicing of preceding segment in regressions (Brown 1990), but were not significant throughout analyses.

Results – vowel plot

Figure 1. J, F, 66



- Length of arrow reflects degree of gliding.
- Direction of glide for *pin* and *pen* is the same.
- However, there appears to be a clear difference between *pin* and *pen* for degree of gliding; *pen* has a longer glide than *pin*.

Results – statistical tests

Test 1: T-tests of *pin* and *pen* F1, F2 at midpoint *[Conventional measure of merger]* → F1, F2 not found to be significant ("merger")

Test 2: Regression of *pin* and *pen* F1, F2 at midpoint *[Conventional measure of merger, but controls for interlocutor ethnicity, phonological environment]* → F1, F2 not found to be significant ("merger")

Test 3: Regression of Euclidean distance, duration on *pin* and *pen* *[Alternative measure of merger, controlling for interlocutor ethnicity, phonological environment]*

- Regression of Euclidean distance: *pin* 95 Hz shorter than *pen* (p=0.001)
- Regression of duration: *pin* 30 ms shorter than *pen* (p=0.001)
- *pin* and *pen* Euclidean distances are more distinct than in non-prenasal contexts (p=0.044) *[see Fig. 2]*

Test 4: Regression of auditory impression on *pin* and *pen* → *pen* is more likely to be diphthongal than *pin* (p=0.027); same interaction effect as Test 3 *[see Fig. 3]*

Figure 2. Mean Euclidean distance (Test 3)

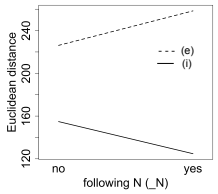
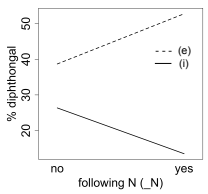


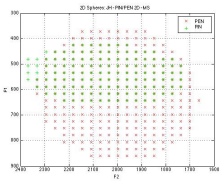
Figure 3. Auditory judgment (Test 4)



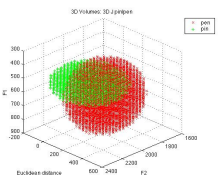
Overlap analysis

Spectral Overlap Assessment Metric (SOAM) (Wassink 2006) allows multidimensional calculation of overlap between vowel distributions

Figure 4. SOAM output - J



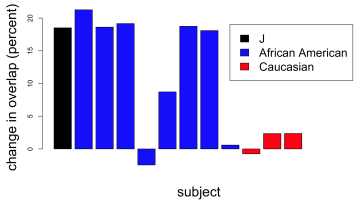
2D: *pin/pen* overlap based on F1 and F2 at midpoint



3D: *pin/pen* overlap based on F1 and F2 at midpoint, distance (i.e., accounts for spectral changes)

- Calculated overlap for 12 Seattle speakers (9 African American, 3 Caucasian) using VOIS3D software
- Calculated change in overlap percentage between 2D and 3D ((% 2D overlap)-(% 3D overlap)) *[Rough measure of contribution of glide length to pin/pen distinction]*

Figure 5. Change in overlap for individual speakers



- Majority of African Americans show a difference between 2D and 3D overlap; none of the Caucasians show a difference.

Suggests that Seattle African Americans differentiate *pin* from *pen* somewhat by the amount of glide, while Seattle Caucasians don't.

Conclusions

- The acoustic difference between *pin* and *pen* for speaker J is relatively robust. Euclidean distance and duration are related (correlation: .762, p=0.000); both acoustic cues are present simultaneously.
- Auditory analysis supports acoustic analysis - Euclidean distance corresponds with judgment of diphthongized vowel.
- Study shows that spectral change can differentiate *pin* and *pen* where one-point spectral measures cannot.
- Additionally, study suggests that differentiation of *pin* and *pen* by degree of gliding is particular to local variety of AAE.

Acknowledgments

This presentation is made possible through NSF grant #BCS-0643374. Thanks to the English in the Pacific Northwest team, to the UW Socio Brownbag, the UW Phonetics Lab, and to Jean Harris.

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