A New Way of Analyzing Vowels: Comparing Formant Contours Using Smoothing Spline ANOVA
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1. Introduction

- Formant values are typically measured at 1 or more single points.
- BUT: Vowels are dynamic, time-varying acoustic events.
- Formant trajectories may be important for conveying/perceiving contrast (e.g. Lindblom & Studdert-Kennedy 1967, Hillenbrand & Nearey 1999) or sociolinguistic info (Thomas 2000), and could factor into changes in progress (Majors 2005).

Smoothing Spline Analysis of Variance (SS ANOVA)

- method for statistical comparison of curves (Gu 2002; see Davidson 2006 for use of this technique in linguistic ultrasound research)
- tells you whether two curves are significantly different; confidence intervals indicate where the differences are

2. Procedures

- 8 speakers (6 from NJ, 1 Canadian, 1 Alabamian) produce 10 tokens each of several words containing vowels of interest: cot/cought, don/dawn; pan/pass/pad/pat; pin/pen. (each word embedded within a carrier phrase, Say ___ very loudly.)
- 50 point formant contours (F1,F2,F3) for each vowel extracted from sound files in Praat (Boersma & Weenink 2006).
- ANOVAs run on onset, midpoint, offset formant values for each vowel.
- Splines generated for each word and SS ANOVA run in S-PLUS.

3. Demonstration: Ash allophony

Allophones of [æ] may differ in nasality, lingual height/backness, and/or dynamic qualities (e.g. Labov 1994, Plichta 2002, De Decker & Nycz 2005).

- [C] has a "nasal system" typical of many NJ speakers (Ash 2002), though examination of trajectories reveal differences between pass and pad/pat.

- JD also shows pre-nasal [æ] "tensing"; the diphthongal quality of her vowel in pan is compared here to pad and pin.

- Another nasal system, though CS’s pre-nasal [æ] does not show the extreme movement of JD’s.

4. Demonstration: Low back vowel contrast

Based on point measurements at the onset and midpoint, both KB and KR show significant F1 and F2 differences between cot and caught. However, while KR’s formant trajectories for the two vowels are quite similar, KB’s low back vowels are not: her caught formants slope upward at a greater rate than those of her cot.

Future research: What role do trajectories have in low back merger? (Majors 2005)

5. Conclusions & Future Research

- smoothing splines enable us to compare average formant curves, instead of inspecting individual tokens (which may or may not be representative).
- Formant trajectories may differentiate allophones that are grouped together under certain single point analyses.
- SS analyses can inform single point measurements by identifying potentially important acoustic landmarks

Future research: To what extent are trajectory differences relevant to perception? (lots of conflicting work on this topic) How can these methods be used to analyze vowel-liquid and other difficult-to-segment sequences?

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