DyViS

UNIVERSITY OF CAMBRIDGE

Distinguishing speakers using formant dynamics in read and spontaneous speech: a study of British English /uː/

Kirsty McDougall
Department of Linguistics
University of Cambridge
kem37@cam.ac.uk

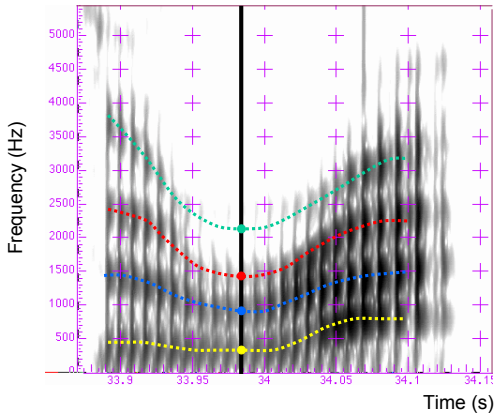
E·S·R·C ECONOMIC & SOCIAL RESEARCH COUNCIL

Dynamic features of speech and speaker identification

- More information than static (e.g. vowel midpoint)
- Reflect movement of a person's speech organs as well as dimensions
  - people move in individual ways for skilled motor activities - walking, running, … and speech
- can view speech as achievement of a series of linguistic 'targets'
- speakers likely to exhibit similar properties at 'targets' (e.g. segment midpoints), but move between these in individual ways

→ examine formant frequency dynamics

Formant dynamics



- Looking beyond midpoint to formant contours for potentially speaker-distinguishing information…

Previous work

- Studies of formant dynamics → greater levels of speaker discrimination than static features
- Greisbach *et al*. 1995, Ingram *et al*. 1996, Rodman *et al.* 2002
- McDougall (2004, 2005, 2006) study of AusEng /aɪk/
- McDougall (2005) study of SSBE intervocalic /r/ sequences

Outstanding issues

- How to capture dynamic information most efficiently, e.g. characterise with polynomial or other equations using regression? (cf. McDougall 2005, 2006)
- Effect of different speaking contexts
- Effect of different linguistic conditions
- More sounds and sequences
- Larger populations

A study of Standard Southern British English /uː/

- Study of 20 speakers' /uː/ formant dynamics (larger than previous studies)
- /uː/ undergoing change in SSBE (ref. earlier DyViS presentation, IAFPA '07) – expect variability among speakers
- observation of considerable between-speaker variation in formant dynamics when taking static measurements

Research Questions

- How well do the formant dynamics of /uː/ in SSBE discriminate speakers?
- Do the formant dynamics of /uː/ discriminate speakers in read and spontaneous speech?

  i.e. is speaker-specific information preserved across speaking conditions?

Subjects

- 20 speakers from DyViS database at Cambridge
- male
- Standard Southern British English
- aged 18-25

Data 1: read speech

- DyViS Task 4 (read sentences)
- 6 tokens of /uː/ per speaker
- nuclear-stressed in h_d context:

  He hates contracting words, but he said a WHO'D today

Data 2: spontaneous speech

- DyViS Task 2
  (telephone call with ‘accomplice’)
- studio quality recording
- 6 tokens of /uː/ per speaker
- $C_{[+stop]}\_C_{[+stop]}$ contexts:
  *C**oo**per, c**oo**t, H**oo**per, p**oo**dles, sc**oo**ter, s**u**pervisor*

Peter Beard

barber

visit steak house together

Barbara Detman

hairdresser

keeps poodles

drives a scooter

Eugene Burke

barber

supervisor

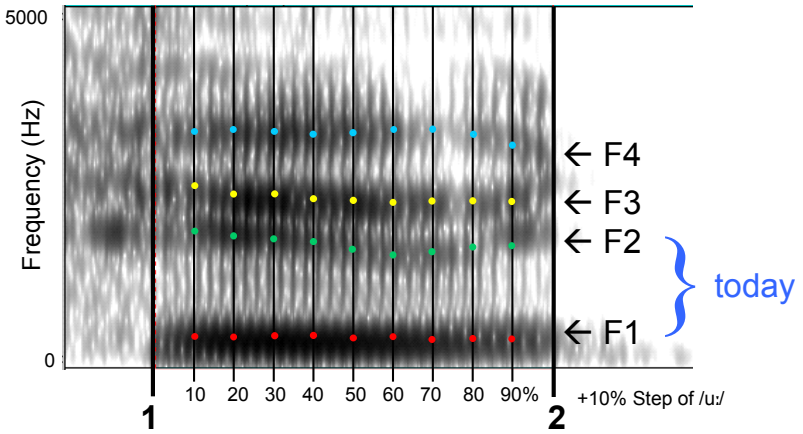
lives in Dexter

play sports together

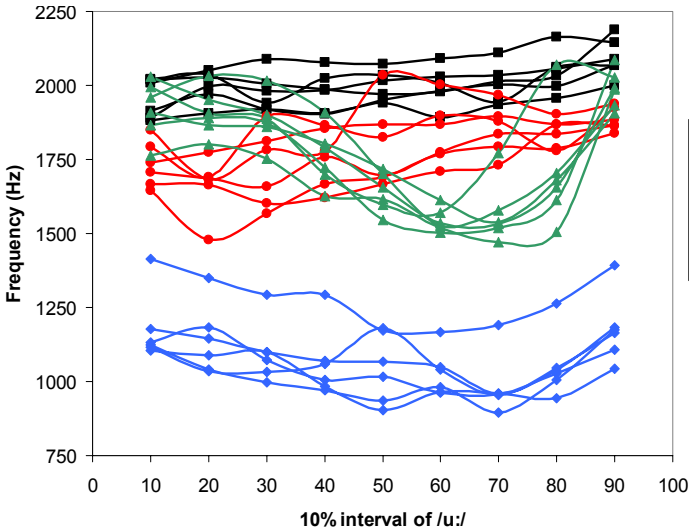
Extract from Subject 1 telephone call

Measurements

Token of /uː/ by S10 – read speech



Results - read speech, e.g. 4 speakers - F2



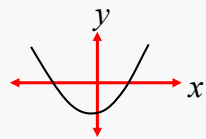
6 tokens
per speaker

Polynomial fittings

F1 and F2 contours approximated with polynomial equations to reduce the number of dimensions

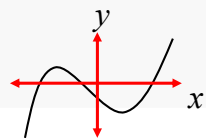
Quadratic

$$y = a_0 + a_1 x + a_2 x^2$$



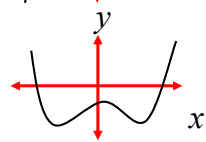
Cubic

$$y = a_0 + a_1 x + a_2 x^2 + a_3 x^3$$

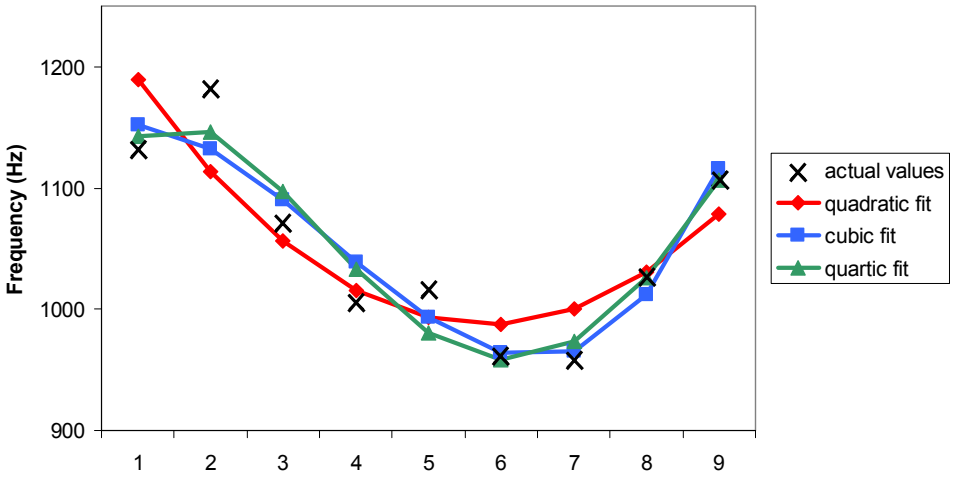


Quartic

$$y = a_0 + a_1 x + a_2 x^2 + a_3 x^3 + a_4 x^4$$



F2 of token 1, S1
- polynomial fittings



Procedure

- fit F1 and F2 contours of each token with polynomial equations (with *Matlab*)
- test the reliability of the polynomial coefficients in distinguishing speakers using Discriminant Analysis
  → correct classification percentage (leave-one-out method)

DA on polynomial coefficents

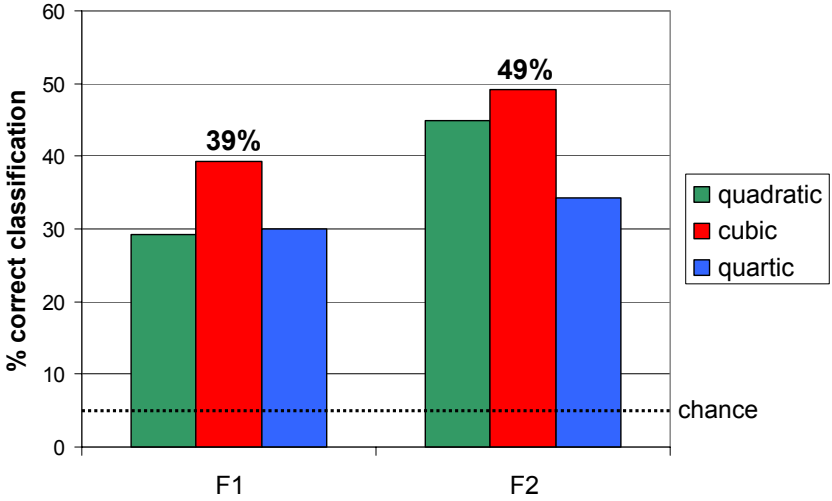
- Discriminant analyses run to compare read speech and spontaneous data sets
- Separate tests on F1 & F2 with the predictor variables:

  Quadratic - 3 coefficients

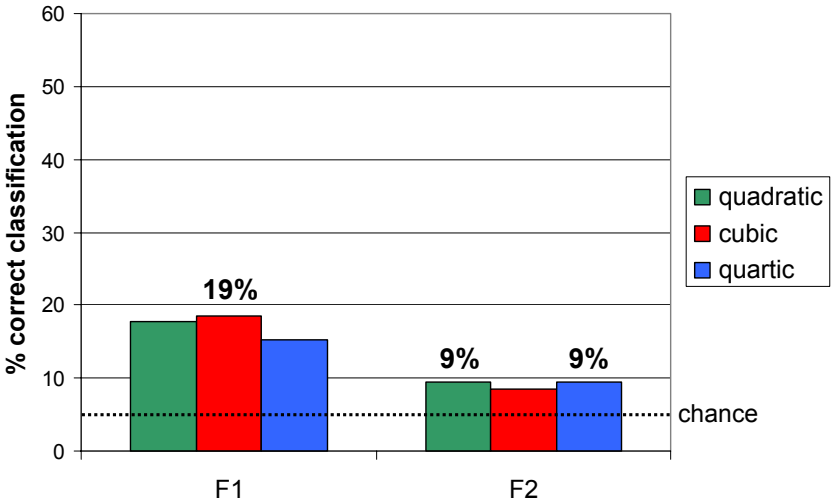
  Cubic - 4 coefficients

  Quintic - 5 coefficients

Classification rates – read speech



Classification rates – spontaneous speech



Discussion

Read speech:

- /uː/ offers good levels of discrimination (N.B. 20 speakers)
- cubic approximation best for F1 and F2

Spontaneous speech:

- large reduction in accuracy of discrimination for /uː/ formant dynamics
- discrimination still better than chance, especially in F1 (19%)

Discussion

Possible reasons for reduction in accuracy:

- increased variability due to spontaneous condition - /uː/ in different locations in utterances, receiving different levels of stress
- /uː/ in range of consonantal contexts in spont. data: *C**oo**per, c**oo**t, H**oo**per, p**oo**dles, sc**oo**ter, s**u**pervisor* (all h_d in read speech)

Difficult to separate these sources of variability
→ controlled set of consonantal and prosodic contexts in read speech would be helpful

Discussion

- /uː/ contexts: *C**oo**per, c**oo**t, H**oo**per, p**oo**dles, sc**oo**ter, s**u**pervisor*

Preceded by /k, h, p, sk, s/

Followed by /p, t, d/

- Hypothesise: demi-syllable or complete word is the appropriate domain for examination of speaker-specific aspects of formant dynamics
- Intuitively assumed this in earlier experiments - /aɪk/ (McDougall 2004, 2005)

Forensic Implications

- Casework situations – generally examining spontaneous speech
- Formant dynamics of SSBE /uː/ offer some speaker-specific information in spontaneous speech
- Likely to be important to compare tokens in like consonantal and prosodic contexts

Conclusion

- Formant dynamics useful to examine for speaker differences since they reflect differences among speakers in vocal tract dimensions and in articulatory strategies
- F1 and F2 of /uː/ yield individual variation in shape and frequency of formant contours
  - contours approximated with polynomial equations (quadratic, cubic, quartic)
- Speaker-distinguishing potential of polynomial coefficients quantified with Discriminant Analysis

Conclusion

- /uː/ in read speech (hVd) achieved promising levels of discrimination
  39% F1, 49% F2 – cubic approximations
- /uː/ in spontaneous speech less successful
  19% F1 (cubic), 9% F2 (quadratic & quartic)
  - probably due to range of consonantal and prosodic contexts
- Further work to include examination of formant dynamics in spontaneous speech in more tightly controlled contexts

Acknowledgements

- UK Economic and Social Research Council for funding the DyViS Project 'Dynamic Variability in Speech: A Forensic Phonetic Study of British English' [RES-000-23-1248]
- BT for a donation towards the telephone investigation
- Members of the DyViS project
- Toby Hudson, Gea de Jong and Caroline Williams for assistance with recording subjects, script-writing and measurement
- Geoffrey Potter for technical assistance

DyViS

UNIVERSITY OF CAMBRIDGE

Distinguishing speakers using formant dynamics in read and spontaneous speech: a study of British English /u:/

Kirsty McDougall
Department of Linguistics
University of Cambridge
kem37@cam.ac.uk

E·S·R·C ECONOMIC & SOCIAL RESEARCH COUNCIL