Speaker- and group-specific information in formant dynamics: a forensic perspective

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LabPhon 15 Satellite

Speech dynamics, social meaning, and phonological categories

UNIVERSITY of York

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voice and identity

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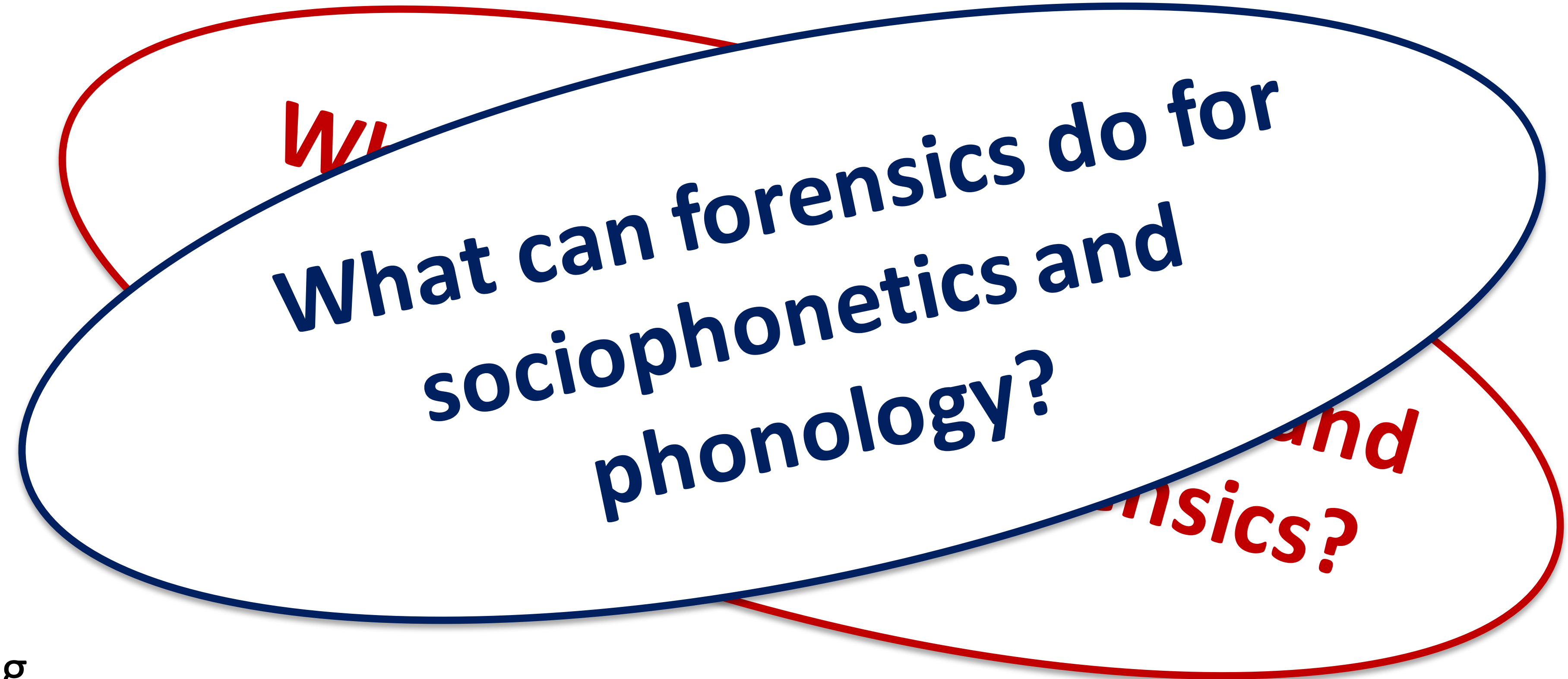


e.g.

Roberts (2012)

Rhodes (2012)

Harrison (2013)

Outline

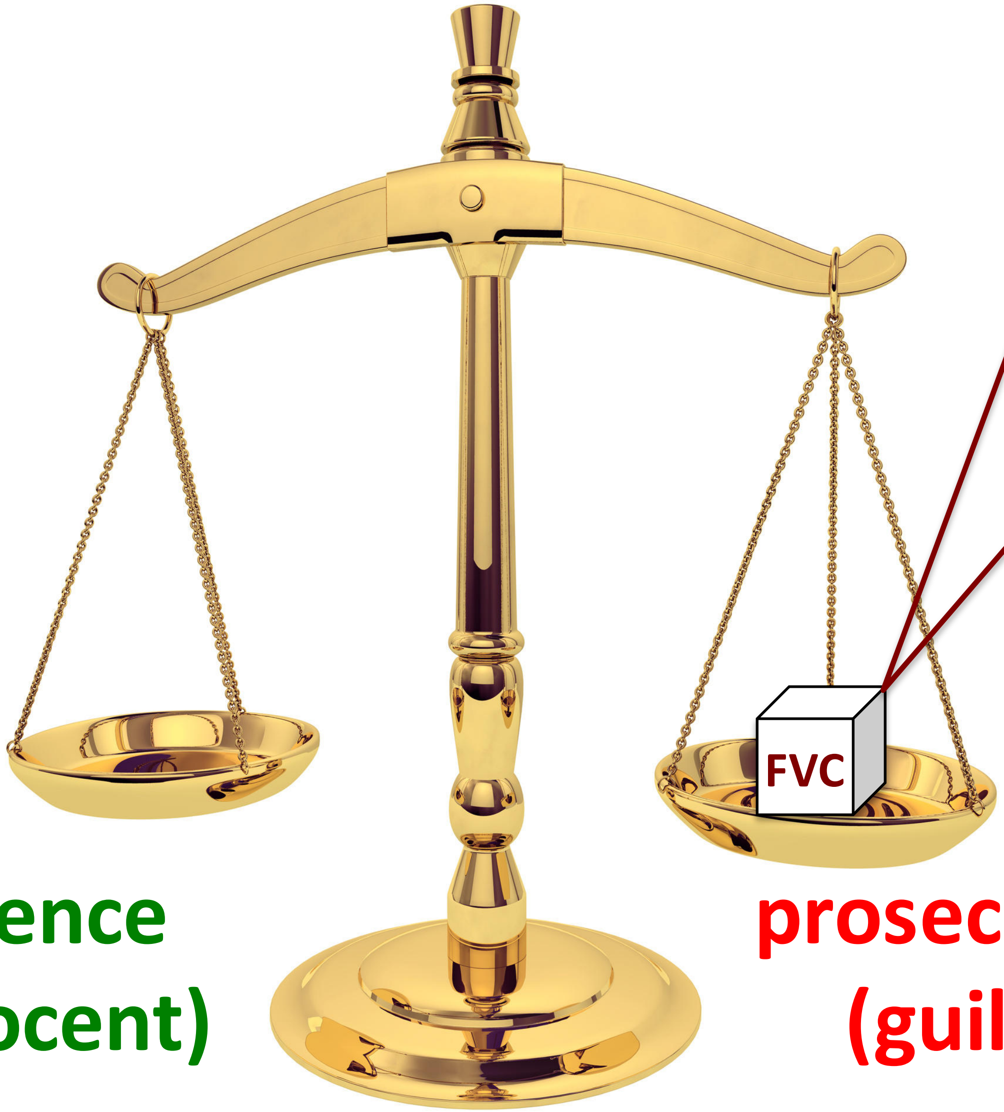
1. the forensic problem
2. formant dynamics in forensics
3. research questions
4. method
5. experiments:
   - speaker discrimination
   - group discrimination
6. discussion

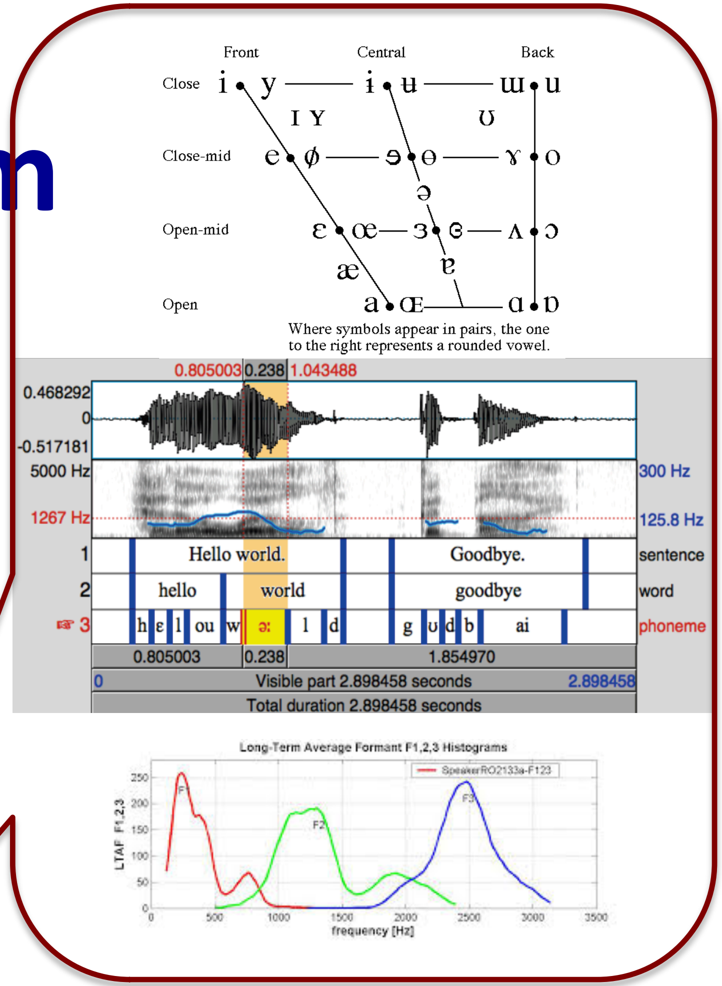
1. The forensic problem

- forensic voice comparison (FVC):

vs.

1. The forensic problem





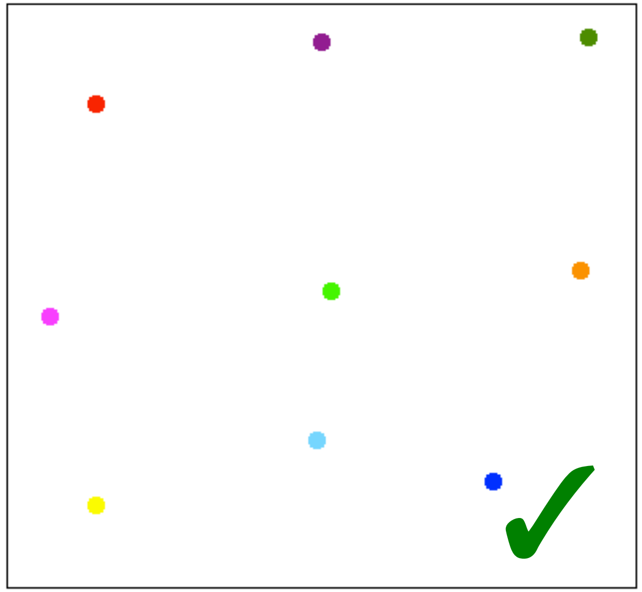
defence
(innocent)

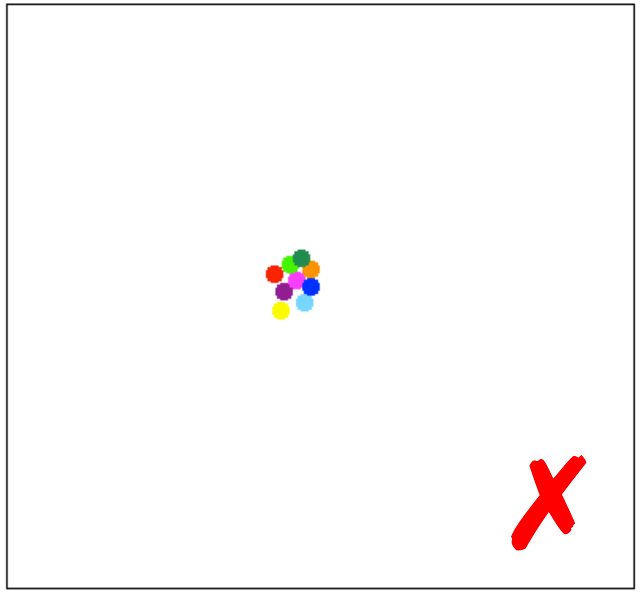
prosecution
(guilty)

1. The forensic problem

- properties of ideal features:
  - **high between-speaker variability**
  - low within-speaker variability

  - resistance to disguise
  - robustness in transmission
  - measurability
  - availability





from Nolan (1983)

1. The forensic problem

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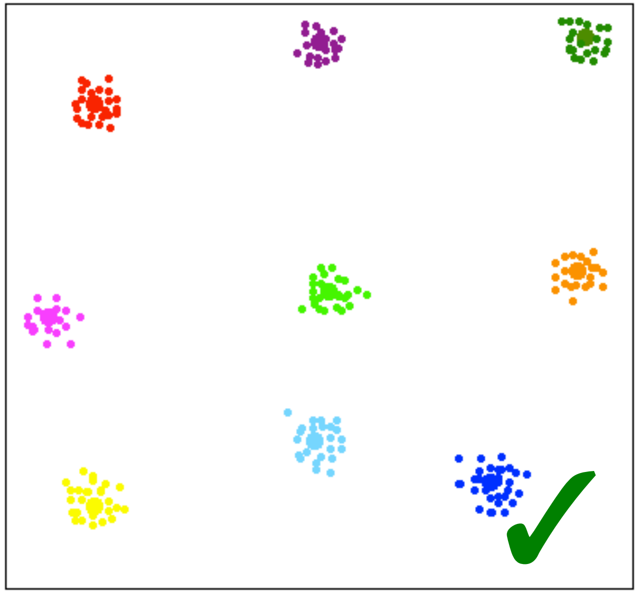
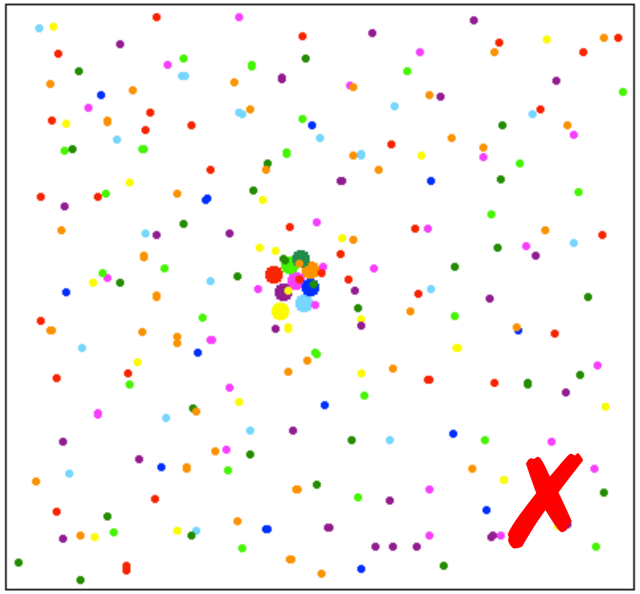




from Nolan (1983)

2. Formant dynamics in forensics

- commonly used in forensics for last 20 years
  - – starting with… Greisbach et al. (1995)
  - – McDougall (2006)
    - value of parametric representations
    - polynomials better than raw Hz input
  - – Morrison (2009)
    - comparison of different parametric representations

2. Formant dynamics in forensics

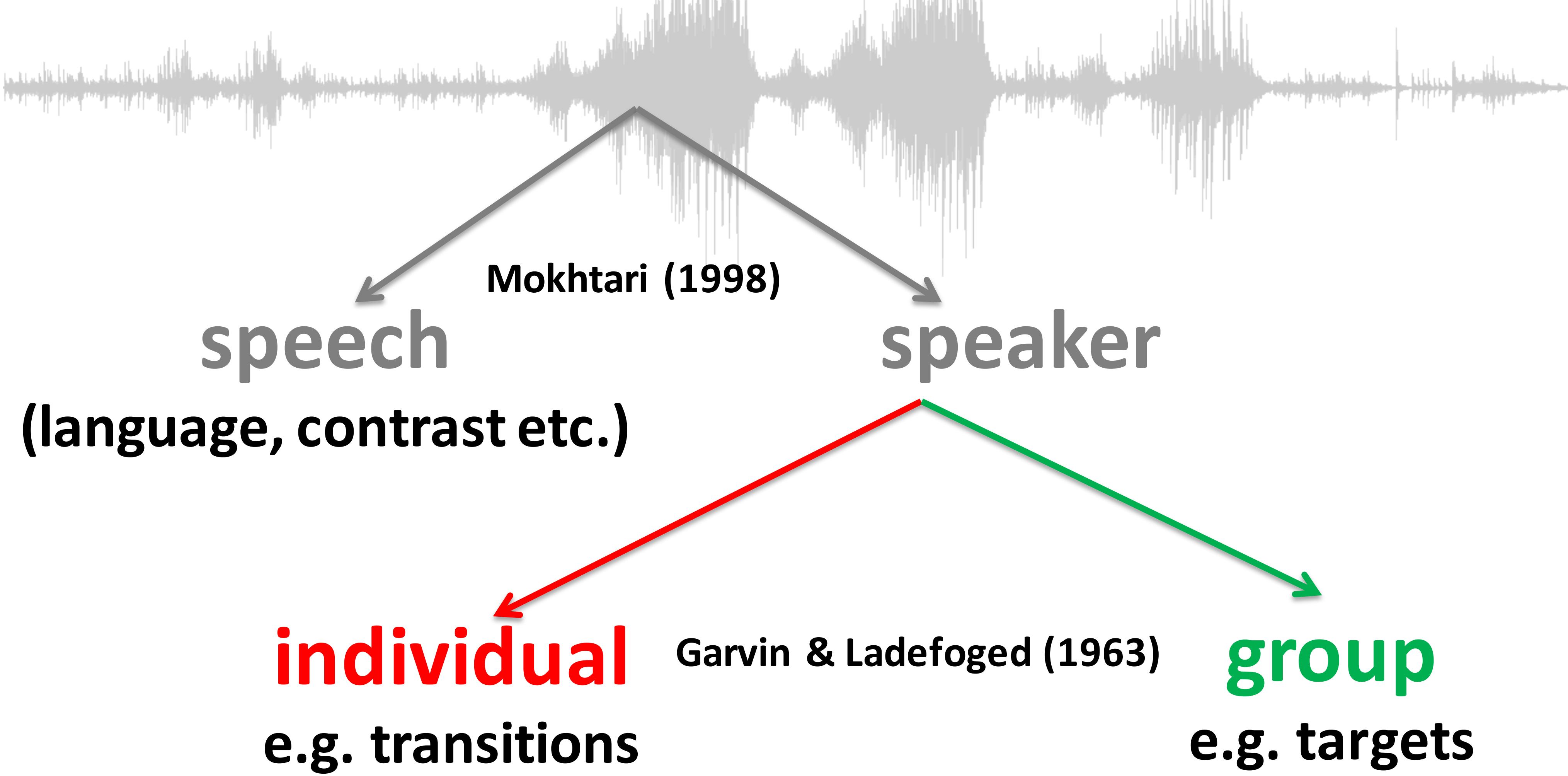
why dynamics?

- targets = learned by speech community
- transitions = “acquired ... by trial and error”
- “speakers' 'vocal signatures' lie in the rapid, transitional movements of the speech organs between sounds”

from Nolan (1997)/ McDougall (2004)

2. Formant dynamics in forensics

- so... phonology is all about targets?



2. Formant dynamics in forensics

- but… inconsistent with e.g. usage-based models?
  - any element of phonetic/ phonological structure can be learned & represented cognitively
  - thus potential for transitions to carry ‘group’ information

- formant dynamics increasingly used to explore group-patterns in sociophonetics

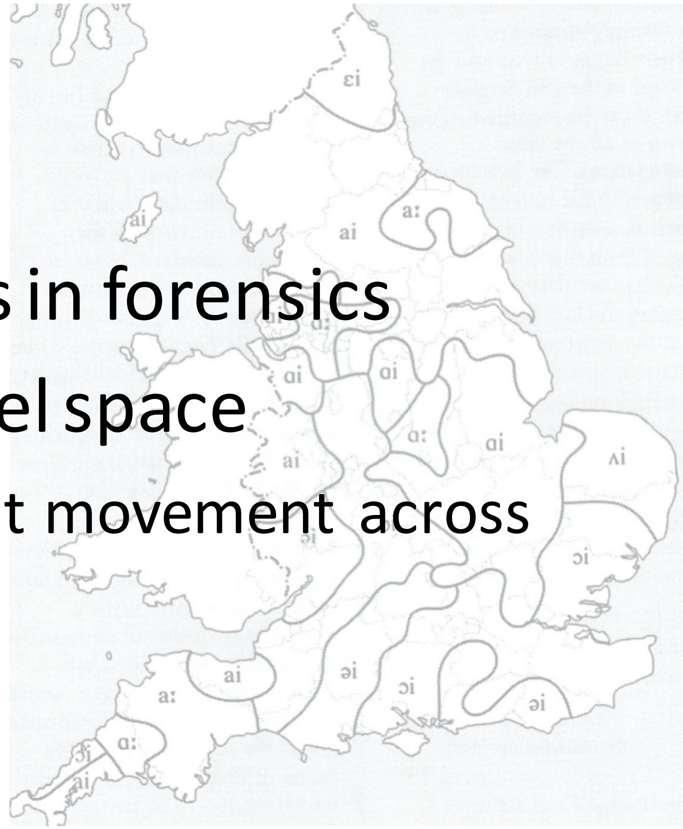
3. Research questions

- to what extent is **speaker**- and **group**-specific information encoded in the dynamics of formant trajectories?
  - implications for models of phonology
  - value of the forensic perspective

4. Method

variable

- PRICE /aɪ/
  - subject of considerable analysis in forensics
  - covers a wide range of the vowel space
    - potential for considerable formant movement across the duration of the vowel



4. Method: datasets

(1) Standard Southern British English (SSBE)

- DyViS corpus (Nolan et al. 2009)
- 97 male speakers
- 18-25 years
- mock police interview (map task)

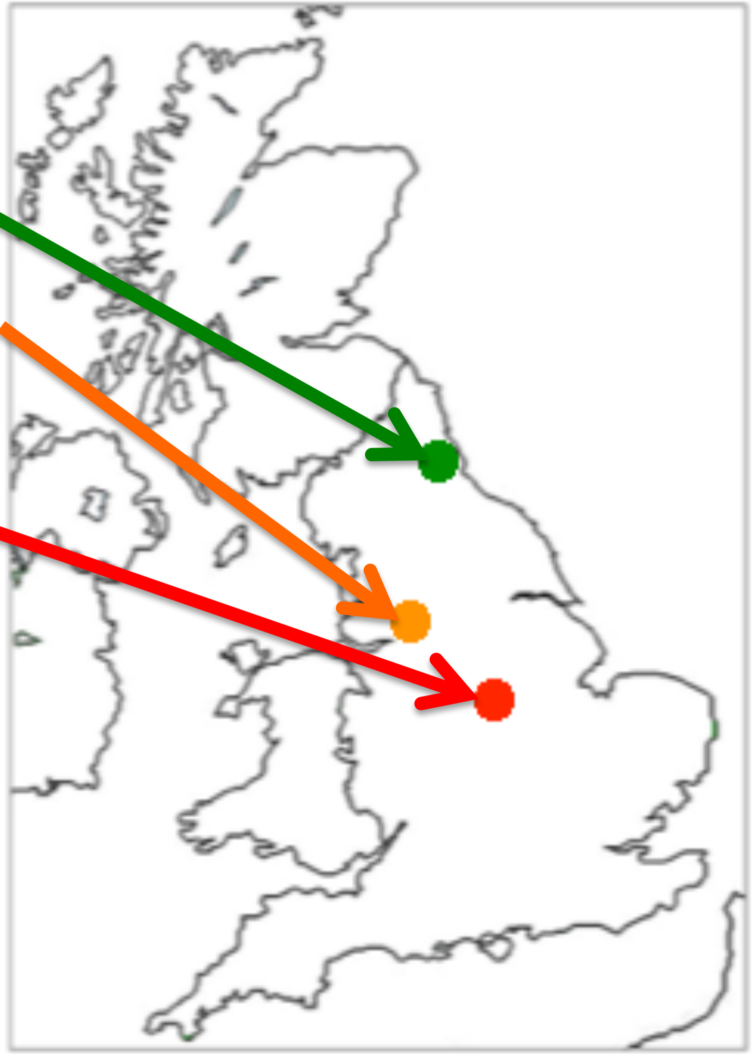
4. Method: datasets

(2) Newcastle (Milroy et al. 1994-97)

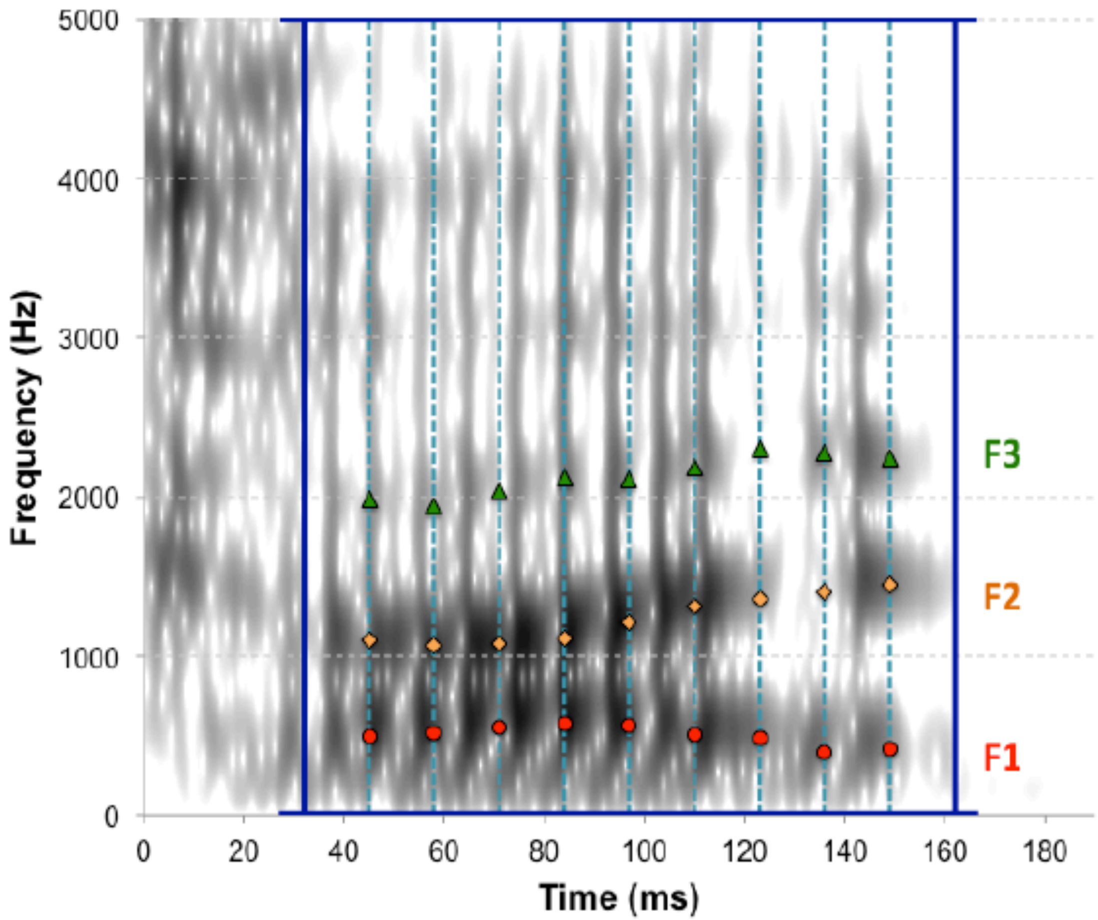
(3) Manchester (Haddican et al. 2013)

(4) Derby (Milroy et al. 1994-97)

- 8 male speakers
- 18-31 years
- sociolinguistic interviews in peer-group pairs



4. Method



dynamics

- c. 10 tokens/ sp
- measurements at +10% steps
- pre-testing for optimal fit
  - cubic polynomials
- 4 coefficients/ formant

statics

- +20% & +80% Hz values/ formant

5. Results: speaker discrimination

- SSBE speakers:
  - 20 test speakers
  - 57 reference speakers
- **same-** (**SS**) & **different**-speaker (**DS**) comps
- likelihood ratios (LRs) used for discrimination

$$\frac{p(E \mid H_p)}{p(E \mid H_d)}$$

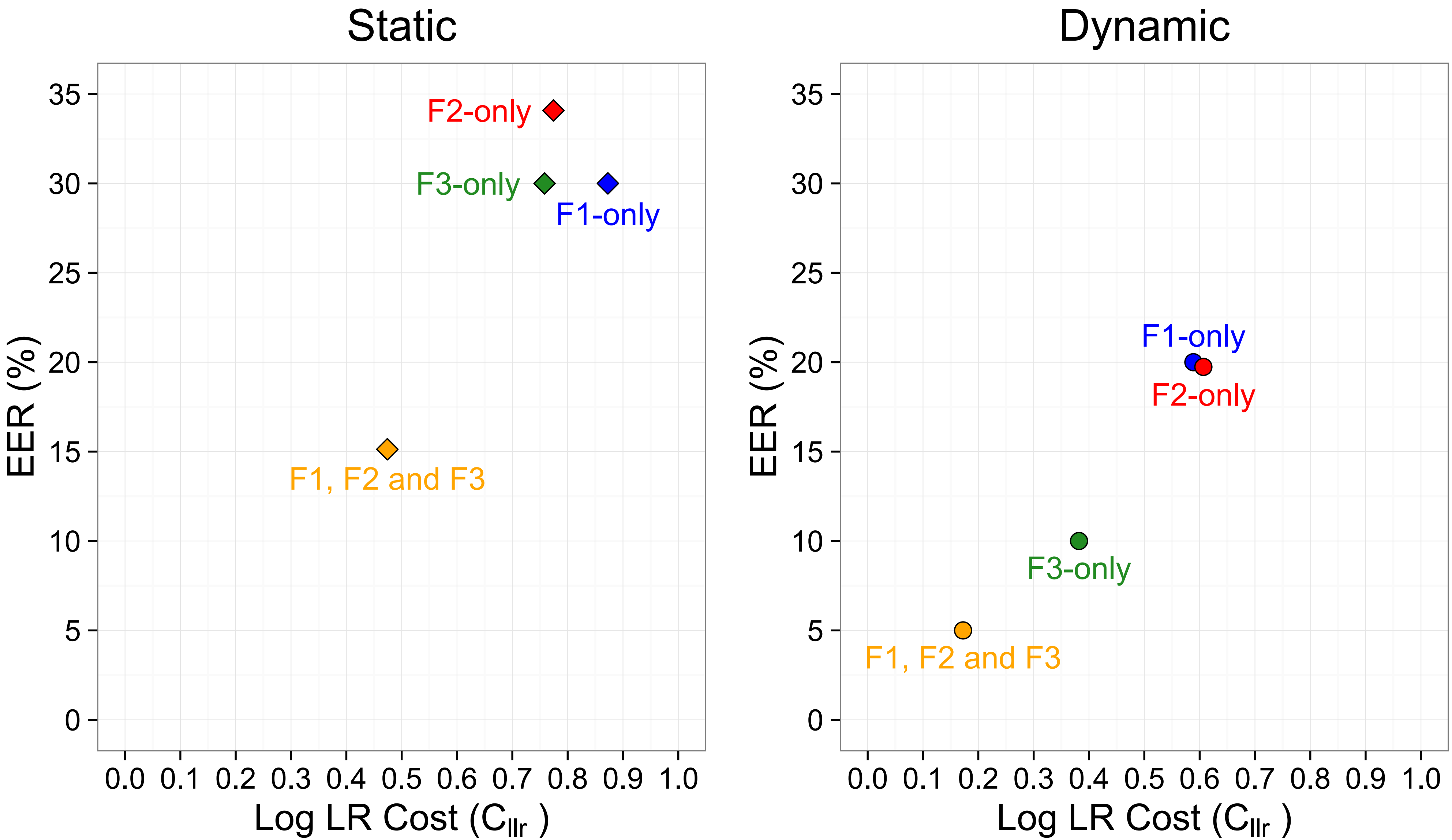
p = probability
E = evidence
| = 'given'
H_p = prosecution hyp
H_d = defence hyp

5. Results: speaker discrimination

- output = $\log_{10}$ LRs:
  - centered on 0 (no evidence)
  - > 0 = support for prosecution
  - < 0 = support for defence
- error metrics:
  - equal error rate (EER)
  - log LR cost function (C_{llr})

Closer to 0, the better the performance

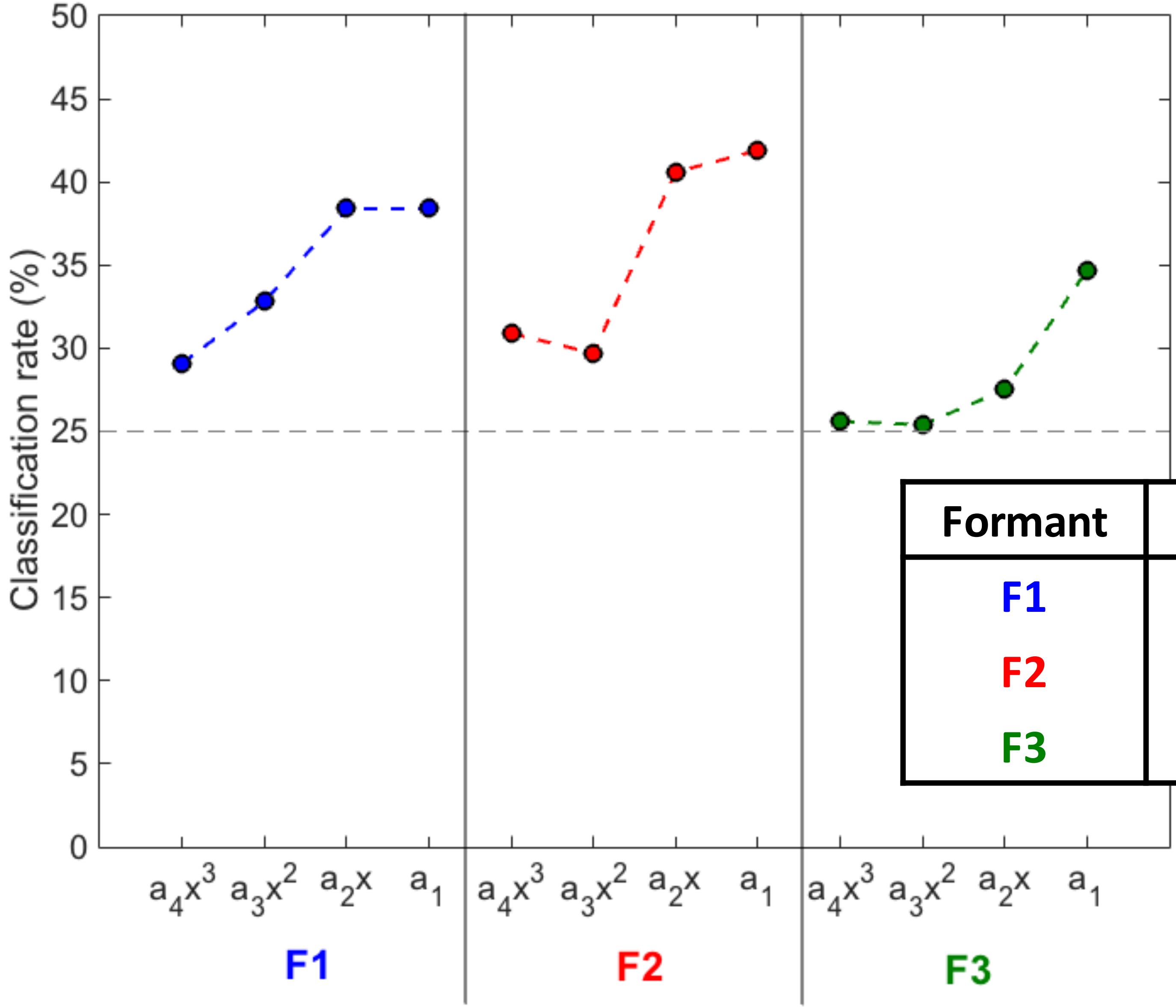
5. Results: speaker discrimination



5. Results: group discrimination

- predicting regional background
- cross-validated discriminant analysis:
  – each token assigned to 1 of 4 regional groups
  – models built on all data excluding target token
- generates classification rate based on posterior probability
- chance = 25% (1/4)

5. Results: group discrimination



Formant	Classification rate
F1	63.8%
F2	64.7%
F3	40.6%

6. Discussion

speaker discrimination

- formant dynamics contain considerable speaker-specific information:
  - better performance than static values
- higher formants = greater speaker-discriminatory power
  - speech-speaker dichotomy (Mokhtari 1998)
  - F1~F2 responsible for contrast

6. Discussion

group discrimination

- group-specific information isn't all about targets
  - individual cubic coefficients capable of predicting regional background above chance
  - all coefficients in combination outperform any one in isolation
- so… fine-grained phonetics clearly shared across speech communities

6. Discussion

- results challenge underlying phonological model for formant dynamics
  - groups = not all about targets
  - Individuals = not all about transitions
- need to rethink the dichotomies:
  - speech-speaker (Mokhtari 1998)
  - group-individual (Garvin & Ladefoged 1963)
  - maybe it's about continua?

7. Conclusion

- formant dynamics capable of encoding **both** speaker- and group-information
  - consistent with usage-based approaches?
- focus on the individual may help us better understand acquisition of variation
  - therefore a role for forensics (methodological and theoretical) in understanding phonology

Thanks!

Questions?

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