Large-scale automatic acoustic analysis of word-final /r/ in Scottish English

Jane Stuart-Smith*, Rachel Macdonald*, James Tanner~ & the SPADE Consortium

*Glasgow University Laboratory of Phonetics (GULP), ~McGill University

R-atics 6, 7th - 8th November 2019
Laboratoire de Phonétique et Phonologie
UMR 7018 – CNRS/ Université Sorbonne Nouvelle - Paris 3
/r/ in Scottish English

• formerly Scots showed taps or trills in all positions (Grant, 1931; in Johnston, 1997)

• taps and some trills still used in all positions by older Scots speakers, and intervocalically in Scottish Standard English (Jauriberry et al 2015; Meer et al 2019)

• approximant [ɹ] typical of Scottish Standard English, and is spreading into Scots (Johnston, 1997, Lawson et al 2013)

• retroflex approximant [ɻ] possible in certain contexts in some Northern, Highland and Insular dialects (Mather & Speitel, 1986)
Rhoticity in Scottish English

- Scottish English typically considered ‘rhotic’, /r/ articulated in e.g. *car, card, better* (Wells 1982)
- weakening of coda /r/ started in late 19\textsuperscript{th} century in Glasgow/west (Stuart-Smith/Lawson 2017)
- derhoticisation now typical of working-class Central Belt speech (Stuart-Smith et al 2014)
- contrasts with auditorily-strong /r/ in middle-class speakers (Lawson et al 2013; Lawson et al 2014)
- loss of rhoticity in Edinburgh and Scottish-English border, contact with Anglo-English speakers (Schützler 2015, Llamas 2010)
Acoustics of (Scottish) rhotics

- approximants show lowering/low F3
- taps and trills show high/flat F3
- weakened taps, also uvularised vowels, show high/rising F3

articulatory-acoustic-auditory rhoticity continuum:
  - greater delay to tongue gesture ~ higher F3 ~ weaker-sounding /r/
  - earlier tongue body maximum ~ lower F3 ~ stronger-sounding /r/

(Lawson et al 2018)
Research questions

• How are the acoustics of Scottish rhotics influenced by:
  o Linguistic
  o Dialectal
  o Social factors?

• What is the evidence for change in Scottish rhotics over time?
Sample for this study: Scotland - SCOTS corpus only (for now)

Highlands, Islands and Insular
15: 5m, 10f; 731 obs

Northern
21: 10m, 11f; 1203 obs

Glasgow
25: 11m, 14f; 1612 obs

Edinburgh
31: 13m, 18f; 2120 obs

South
12: 7m, 5f; 1386 obs

104 speakers
7052 tokens
Data analysis using Integrated Speech Corpus ANalysis (ISCAN)

• SCOTS audio corpus (soundfiles + transcripts) imported into Polyglot database using ISCAN (McAuliffe et al 2019)

• dynamic formant measurements taken using ISCAN (Thomas et al 2019)

• The speed of this scaled-up automated analysis is impressive: the 107-hour SCOTS corpus took < 1 hour to extract formant tracks for 10477 tokens from 135 speakers
Acoustic analysis

• all instances of word-final /r/ > 49ms
• 21-point formant tracks of segmented /r/: F1, F2, F3; B1, B2, B3
• removed young children
• removed words with following /r l w/
• pruned likely erroneous measures with reference to max/min hand-measured formants Lawson et al (2018)

> 7052 tokens from 104 speakers
Discrete Cosine Transformation (DCT)

- 21-point F3 track compressed into three DCT coefficients:
  - $F3k0$, reflecting the mean value for the track
  - $F3k1$, reflecting the degree and direction of the slope of the track
  - $F3k2$, reflecting the curvature of the trajectory
‘with the door and’ (Edinburgh woman)
DCT of /r/ in door

original F3 Hz track

DCT k0/k1/k3

DCT smoothed track (over original Hz track)
Linear mixed effects modelling

- **k0, k1 and k2 DCT coefficients**

Fixed factors:
- speech Rate (deviation from mean), (log)Duration, (log word)Frequency;
- Stress (e.g. *car vs better*), Following context (e.g. *car #, car could, car and*),
- Gender; Dialect area; Decade of Birth
- Duration*Rate, Rate*Stress, Rate*Following, Gender*DoB, Gender*Dialect*Stress, Gender*Dialect*Following

Random intercepts: Word and Speaker
Results
Final Models – fixed factors

• k0 (mean): Duration, Gender, Dialect area, Decade of Birth

• k1 (slope): Rate, Duration, Following context, Dialect area, Gender, Stress*Dialect area, Gender*Following context

• k2(curve): Duration, Gender, Stress, Following context

(Word and Speaker random factors retained for all models)
F3: Gender and Following context

Female speakers show higher mean F3 trajectory than males
F3: Gender and Following context

rising F3 trajectory for prepausal and preconsonantal context
F3: Gender and Following context

but flatter trajectory for prevocalic context especially for male speakers
F3: Gender by stress and dialect area

Stressed

- e.g. car, door

Unstressed

- e.g. better

Glasgow unstressed shows slightly flatter F3 trajectory
F3: Gender by stress and dialect area

Stressed
e.g. *car*,
*door*

Unstressed
e.g. *better*

Southern F3 trajectory low rising more for males than females
F3: Gender by stress and dialect area

Stressed
e.g. car, door

Unstressed
e.g. better

Northern males also more low rising F3 trajectories than females
Edinburgh males show higher, rising F3 trajectory than females, and males from other dialect areas.
**F3: Gender by stress and dialect area**

Highland-Island-Hebrides females show higher F3 trajectories than females from other dialect areas. HII males also show higher rising trajectory for unstressed.
F3: Gender and Decade of Birth

female F3

male F3

1910-1940
F3: Gender and Decade of Birth

Speakers born after World War II show similar F3 trajectory to those born after World War I.
F3: Gender and Decade of Birth

Speakers born most recently show lower/rising F3 trajectories, especially the females
Discussion
How are the acoustics of Scottish rhotics influenced by...

**Linguistic factors?**

• All aspects of F3 trajectory are sensitive to duration, and slope also to speech rate
• unstressed rhotics show less humped trajectories
• prevocalic word-final /r/ show flatter trajectories
  ➢ flattening of the F3 trajectory, if also high, is consistent with taps, and also with weakened, and/or uvularised, tap gestures
How are the acoustics of Scottish rhotics influenced by...

**Dialectal factors?**

- Dialect differences are evident in the mean and slope of the rhotic trajectory
- and also interact with syllable stress
  - likely reflect subtle differences in articulation by dialect
  - and different rhotic gestures arising from different implementation of stress by dialect
How are the acoustics of Scottish rhotics influenced by...

**Social factors?**

- overall female speakers show higher mean F3 rhotic trajectory than males
- but there are also gendered differences by dialect and following context

➢ rhotics provide yet another example of how speakers align with and overcome the expected acoustic patterning from physiological constraints
What is the evidence for change in Scottish rhotics over time?

• mean of F3 trajectory drops in speakers born in/from 1980s
• across all dialects of Scottish English
• especially in female speakers

➤ consistent with a general shift in Scottish English from trills/taps (higher F3) to more approximants (lower F3) over the century as proposed by Johnston 1997
Next steps for this study

• Add other Scottish corpora to allow for consideration of social class, ethnicity, speech style, and a fuller consideration of time, for rhotics

• Analyse the dynamic contribution of F1 and F2 to differences and similarities in rhotics (c.f., Heselwood, 2009; Heselwood & Plug, 2011)

• Shift modelling strategy to Bayesian, to permit maximal fixed and random effects structures, plus greater access to variability within and across dialects and speakers
Thank you!
Please let us know if you would like us to work with your data
http://spade.glasgow.ac.uk/
Thanks to Wolf Fruh for help with DCT
References


