Dialectal and social factors affect the phonetic bases of English /s/-retraction

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/s/-retraction in English

• Retraction of /s/ to [ʃ]-like sound in /str/, e.g. string, street

• Sound change which varies by dialect:
  • occurs in some dialects of English, e.g. London, Philadelphia, NZ English
  • but not others, e.g. RP, Australian English
e.g. Baker et al (2011); Stevens and Harrington (2016)

• varies by individual speaker within dialect
/s/ and phonetic context

Phonetic bases of /s/-retraction:
spectral energy
/s/ >

Figure 2: Baker et al 2011
/s/ and phonetic context

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/s/ > /sp sk st/

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/s/ > /sp sk st/
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Figure 2: Baker et al 2011
/s/ and phonetic context

Phonetic bases of /s/-retraction:
spectral energy
/s/ > /sp sk st/
  > /spr skr/
  > /str/

Figure 2: Baker et al 2011
/s/-retraction and gender

• English sibilants often show higher frequency variants in female than male speakers

• Sound changes arising from language-internal factors, such as phonetic factors, are often led by female speakers

• In a non-retracting variety of Australian English:
  • women showed higher frequency /s/ than men
  • no evidence for more acoustic /s/-retraction in women than men

Stevens and Harrington (2016)
Research questions

• How does phonetic context affect /s/ across English?
• What is the evidence for /s/-retraction across English?
• Do English dialects show a dichotomous pattern of /s/-retraction/non-retraction, or a continuum?
• What role does gender play in /s/-retraction across English?
August 2017 – July 2020
http://spade.glasgow.ac.uk/
• to develop user-friendly software for large-scale, ethically non-invasive, automated acoustic analysis of speech datasets

• to use this software to investigate how Old and New World English has changed over time and space

• to lay the groundwork for automated speech analysis for anyone working with spoken language
~ 43+ datasets, 4 countries, 115 years
• heterogeneous corpus formats
Sample for this study: New World

Canada
ICECAN Corpus
28: 18m, 10f

Northern Cities, e.g. New York, Philadelphia
Santa Barbara Corpus
20: 9m, 11f

West coast/California
Santa Barbara Corpus
46: 20m, 26f

Columbus, Ohio
Buckeye Corpus
40: 20m, 20f

Raleigh, North Carolina
Raleigh Corpus
101: 50m, 51f

235 speakers
Sample for this study: New World

Canada
ICECAN Corpus
28: 18m, 10f

Northern Cities, e.g. New York, Philadelphia
Santa Barbara Corpus
19: 8m, 11f

West coast/California
Santa Barbara Corpus
43: 20m, 23f

Columbus, Ohio
Buckeye Corpus
40: 20m, 20f

Raleigh, North Carolina
Raleigh Corpus
101: 50m, 51f

reported to show /s/-retraction

235 speakers
West, e.g. west coast
SCOTS Corpus
38: 19m, 19f

Glasgow
Sounds of the City
70: 35m, 36f

Highlands, Islands and North
SCOTS Corpus
54: 22m, 34f

East, e.g. Edinburgh
SCOTS Corpus
22: 11m, 11f

Sample for this study: Old World

www.google.com/maps/

185 speakers
Phonetic context (onset)

All instances of stressed, word-initial /s/:

- /s/, e.g. seat
- /sp sk st/, e.g. speech, skip, steep
- /spr skr/, e.g. spread, scream
- /str/, e.g. street
- /ʃ/ e.g. sheet

Prediction for spectral frequency:
/s/ > /sp sk st/ > /spr skr/ > /str/ > /ʃ/
Acoustic measures

- Downsampling to 16kHz
- High-pass filtered 1kHz
- Central 50% of the sibilant interval (from force-alignment) Baker et al. 2011
- Peak and **Spectral Centre of Gravity (CoG)** from Long Term Average Spectrum in Praat
- Duration of sibilant interval

Initial token count: 111,683 from 420 speakers in 6 corpora from 9 dialects.
Data analysis using Polyglot

• Each audio corpus (soundfiles + time-aligned transcripts) imported into Polyglot database
• Sibilant measurement scripts run using Polyglot
• The speed of this scaled-up automated analysis is already impressive:
  ➢ e.g. the 232-hour Raleigh corpus took only 4.2 hours to import and extract measures
  ➢ https://spade.glasgow.ac.uk/iscan-presentation-and-tutorial-at-nwav-2018

Polyglot continues SCT, see McAuliffe et al 2017, *Interspeech*
Data reduction

Post-hoc data reduction to remove likely erroneous tokens/measures and outliers e.g. removed tokens with peak/CoG < 2400Hz
Token count: 111,683 > 100,246
Statistical analysis

Linear Mixed Effects modelling

1. phonetic context and /s/:
   \[ \text{CoG} \sim \text{Duration} + \text{Onset} + \text{Corpus} + \text{Gender} + (1|\text{Word}) + (1|\text{Speaker}) \]
   - all factors significant

2. dialect, gender, phonetic context on /s/:
   \[ \text{CoG} \sim \text{Duration} + \text{Onset*Corpus} + \text{Onset*Gender} + \text{Corpus*Gender} + (1|\text{Word}) + (1|\text{Speaker}) + (\text{Onset}|\text{Speaker}) \]
   - significant: Duration; Onset*Corpus; Onset*Gender
Data reduction

Trimmed residuals after modelling (e.g. Baayen, 2008: 279) (Token count 100,246 > 98,486)

Residual diagnostics for the models before (upper) and after (lower) removal of residuals > 2.5 st. dev.
/s/ and phonetic context

- /s/ > /sC/ > /sCr/ = /str/ > /ʃ/
  
  [sC = /sp st sk/, sCr = /spr skr/]

Cf Baker et al (2011); Stevens and Harrington (2016)
/s/ by dialect and phonetic context

![Graph showing the estimate of CoG (Hz) for different dialects.](image)

- **Onset**
  - /s/
  - /str/
  - /ʃ/

N = 76,440
• /s/ is higher frequency in US than Scottish and Canadian English

N = 76,440
• /ʃ/ varies across dialects of English
• /str/ shows substantial variation across dialects

N = 76,440
- /str/ is often close to /s/

N = 76,440
• /str/ is always much higher than /ʃ/
In **US** dialects, large differences in lowering of */str/* with respect to */s/*
In **Scottish** and **Canadian** dialects, smaller differences between /str/ and /s/ /s/ is lower in frequency overall.

\[ \text{N} = 76,440 \]
/s/-retraction and gender

- Females show higher frequency than males

N = 76,440
/s/-retraction and gender

- Females show higher frequency than males
- But they also show greater lowering for /str/

N = 76,440
/s/-retraction and gender

- Females show higher frequency than males
- But they also show greater lowering for /str/
- Or – males show less lowering for /str/...

N = 76,440
/s/-retraction and gender

- Females do show greater lowering for /str/
- But /str/ is higher than /sCr/ for males
- Gender difference is located at /str/

N = 98,486
/s/-retraction and gender

- Females do show greater lowering for /str/
- But /str/ is higher than /sCr/ for males
- Gender difference is located at /str/

N = 98,486
/s/-retraction and gender

- Females do show greater lowering for /str/
- But /str/ is higher than /sCr/ for males
- Gender difference is located at /str/

N = 76,440
/s/-retraction in individuals within dialects

retracting pattern shared by many Raleigh and Glasgow speakers.

N = 76,440
/s/-retraction in individuals within dialects

non-retracting pattern in individual speakers in West US and Northern Cities dialects
/s/-retraction in individuals within dialects

Both retracting and non-retracting patterns seen in some individuals in all dialects.
Discussion
How does phonetic context affect /s/ across English dialects?

• spectral frequency of /s/ shows some similarities to previous studies (e.g. Stevens and Harrington 2016):
  • lower for /sC/ clusters
  • even lower for /sCr/ clusters
• but also differences:
  • /str/ does not show the lowest frequency
  • there is no overlap with /ʃ/

➤ Large-scale automated analysis confirms and extends perspective
What is the evidence for /s/-retraction across English?

• Some dialects show acoustic retraction of /str/
• Large differences in degree of /s/-retraction by dialect, and for this sample, by country
• Impression of /s/-retraction depends on which dialects are considered – evidence for both continuum and dichotomy

Scaling up analysis across dialects, with consistent measures, allows identification of new patterns
What role does gender play in /s/-retraction across English?

- Female speakers show consistently higher frequency sibilants than male speakers.
- No significant interaction of gender by dialect.
- How does this fit with previous findings of social gender within dialects? (Stuart-Smith et al 2007; Levon et al 2017; Becker and Stoddard this session)
- Just regional dialect, not social factors included in models.

/str/ is special in terms of gender...
Future directions for /s/-retraction

• Continue to expand dialect sample...

• Speaker normalisation by alternative measures representing /s str sh/, e.g. ratio measure (cf Stevens and Harrington 2016)

• Different acoustic measures for /s/ (cf Jesus and Shadle 2002; Jannedy and Weirich 2016)
The method/tool so far...

- Scale, coverage, speed, consistency of measures
- These initial results from the early stage software confirm usefulness

Key current issue for software development:
- Ethically non-invasive data checking, i.e. phonetic checking of search results for private corpora with restricted permissions
under development...

- Screenshot of ‘inspection’ interface for Integrated Speech Corpus Analysis tool (ISCAN) (featured at Thursday’s workshop)

- Depending on user permissions, item from a search can be inspected by:
  - waveform + spectrogram
  - and/or transcript
  - and/or soundfile
Thank you!
Please let us know if you would like us to work with your data
http://spade.glasgow.ac.uk/