Patterns of *s*-retraction in Manchester English: Investigating categoricity with ultrasound

George Bailey & Stephen Nichols, University of Manchester

george.bailey, stephen.nichols @ manchester.ac.uk

1 Introduction

- We use ultrasound to investigate the realisation of the sibilant in the word-initial clusters /stɹ/ and /stj/, e.g. *street*, *student*.
- Attested in various varieties of English (e.g. Shapiro 1995, Lawrence 2000, Durian 2007, Bass 2009, Sollgan 2013, Wilbanks 2017).
- Well-studied in AmE but relatively under-studied in BrE and the focus has often been sociolinguistic rather than phonetic.
- Rôle of /ɹ/ has been foregrounded in many studies (e.g. Shapiro 1995).
- But it has been argued that /ɹ/'s influence may be more indirect (e.g. Lawrence 2000).

Is *s*-retraction categorical or gradient?
What degree of inter-speaker variation do we find?
How does *s*-retraction in BrE differ from AmE?

2 Methodology

2.1 Stimuli

/s/ e.g. *seep* | /ʃ/ e.g. *sheep*

/stɹ/ e.g. *street* | /stj/ e.g. *stupid* | /st/ e.g. *steep*

/tʃ/ e.g. *chap* | /tj/ e.g. *tune* | /ɹ/ e.g. *read* | /tɹ/ e.g. *treat*

2.2 Collection

- Midsagittal ultrasound with synchronised audio.
- Carrier sentence: 'I know [...] is a word'.
- 5 repetitions per token (130 sentences in total).
- 8 speakers of McrE (3M, 5F; aged 18–26).

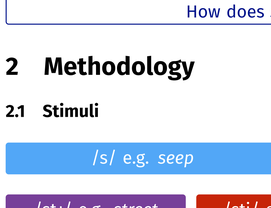
2.3 Processing and analysis

- Tongue splines tracked in AAA (Articulate Instruments Ltd. 2011).
- Analysis using `rticulate` and `tidymv` R packages (Coretta 2017, 2018).
- Generalised additive mixed models (GAMMs; Sóskuthy 2017).
- Complemented by acoustic measurements extracted in Praat (using two Praat scripts, including a modified version of DiCanio 2017).

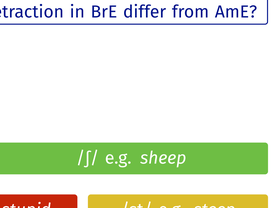
3 Articulation

3.1 GAMMs

We find both categorical and gradient speakers, as exemplified below by **M01** and **F01**.



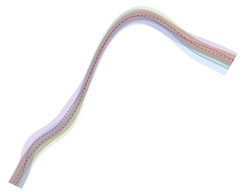
F. 1: GAMMs for **M01**



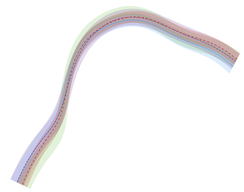
F. 2: GAMMs for **F01**

- **M01**: Tongue body for /stɹ/ and /stj/ completely overlapping with /ʃ/; tongue root somewhat intermediate.
- **F01**: Small distance between /s/ and /ʃ/; less "retraction" overall but /stj/ more /ʃ/-like than /stɹ/.

Four speakers (**F03, F06, F07, F08**) show almost complete overlap between all contexts (even underlying /s/ and /ʃ/).



F. 3: GAMMs for **F06**

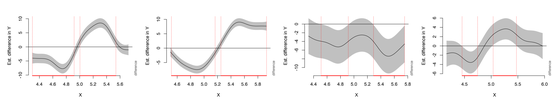


F. 4: GAMMs for **F08**

3.2 Difference smooths (DS)

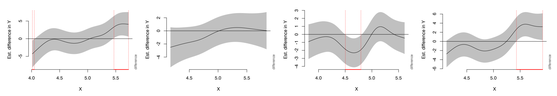
Red portions indicate significant differences between curves.
In short, more red, means more differentiation in tongue shape.

- /s/ and /ʃ/ completely different for **M01, M02**; less so for **M03, F01**.



F. 5: /s/–/ʃ/ DS for **M01** **F. 6:** /s/–/ʃ/ DS for **M02** **F. 7:** /s/–/ʃ/ DS for **M03** **F. 8:** /s/–/ʃ/ DS for **F01**

- But, for **F03, F06, F07, F08**, there is little-to-no difference in tongue shape between underlying /s/ and /ʃ/.



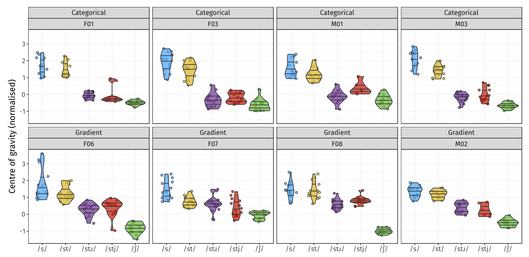
F. 9: /s/–/ʃ/ DS for **F03** **F. 10:** /s/–/ʃ/ DS for **F06** **F. 11:** /s/–/ʃ/ DS for **F07** **F. 12:** /s/–/ʃ/ DS for **F08**

- Is the acoustic contrast between /s/ and /ʃ/ still maintained despite this apparent lack of distinction in lingual articulation?

4 Acoustics

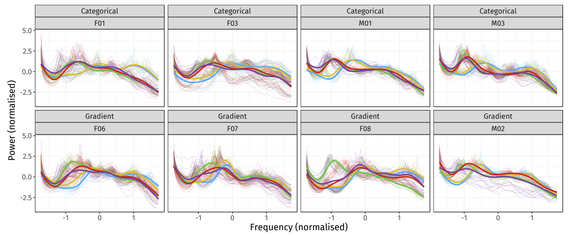
4.1 *S*-retraction

All speakers have an acoustic contrast between /s/ and /ʃ/ in CoG.



F. 13: CoG measures for sibilants for all speakers

This is also seen in the LPC-smoothed spectral slices.

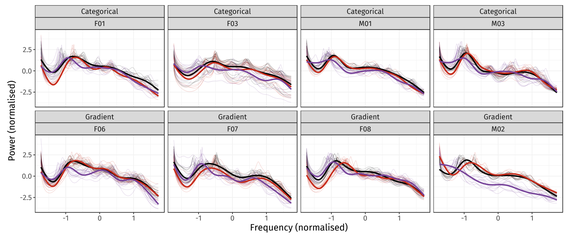


F. 14: LPC-smoothed spectral slices for sibilants for all speakers

- We see categorical "retraction" for four speakers (**M01, M03, F01, F03**):
  - /s/ v. /stɹ/~/stj/~/ʃ/.
- Gradient "retraction" for the rest (**M02, F06, F07, F08**):
  - /stɹ/ and /stj/ intermediate between /s/ and /ʃ/.
- Crucially, the acoustic analysis reveals that all speakers:
  (a) Have an acoustic contrast between underlying /s/ and /ʃ/.
  (b) Exhibit some degree of acoustic "retraction" in /stɹ/ and /stj/.

4.2 *T*-affrication

All speakers affricate /**t**/ before /ɹ/ without coalescence and before /j/ with coalescence.



F. 15: LPC-smoothed spectral slices for affricates for all speakers

- Comparable affrication of /**t**/ in both /stɹ/ and /stj/ environments.
- For most speakers, the fricated portions of pre-/ɹ/ affricated /**t**/ and coalesced /**tj**/ are identical both to each other and to underlying /**tʃ**/.
- Crucially, all speakers affricate /**t**/ in these environments.
- In addition, affricated /**t**/ in /**tɹ**/ and /stɹ/ clusters is still followed by a voiced /ɹ/ (i.e. /**t**/ and /ɹ/ don't coalesce and /ɹ/ isn't devoiced).

5 Discussion

5.1 Recapitulation

- Evidence of both categoricity and gradience in the degree of retraction in /stɹ/ and /stj/:
  - But speakers are either categorical in both or gradient in both.
  - Suggests that both are governed by the same underlying process.
- All speakers consistently affricate /**t**/ in /**tɹ**/ and /**tj**/ clusters:
  - Some evidence speakers can affricate /**t**/ with only minimal retraction of /s/.
  - But no evidence speakers retract /s/ without affricating /**t**/:
    ~ *[ʃtɹ]*eet*, *[ʃtj]*upid*.

5.2 Covert articulation of sibilants

- Although some speakers show no apparent articulatory difference between underlying /s/ and /ʃ/, the acoustic contrast is maintained.
- Rutter (2011) highlights the three phonetic parameters that define the /s/–/ʃ/ contrast (at least in English):
  - Tongue placement: alveolar for /s/, post-alveolar for /ʃ/.
  - Tongue shape: grooved for /s/, slit/flat for /ʃ/.
  - Lip shape: slight labialisation for /s/, strong labialisation for /ʃ/.

"It is also worth noting that changes in one of the phonetic parameters discussed above may not necessarily co-occur with changes in the other two" (Rutter 2011:31)

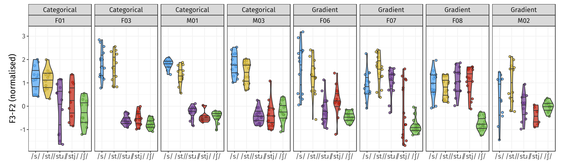
- Are these speakers achieving the same acoustic output through different articulatory means?
  - Cf. variation in /ɹ/ shape (Delattre & Freeman 1968, Mielke et al. 2016)

6 Conclusions

- Word-initially, /stɹ/ and /stj/ behave similarly, both in terms of *s*-retraction and *t*-affrication.
- This lends support to the idea that this is local assimilation with the affricated /**t**/ (contra Magloughlin & Wilbanks 2016).
- The /s/–/ʃ/ contrast is more complicated than a mere difference in place of articulation.
  - We find evidence speakers that are hitting an acoustic rather than articulatory target (Boersma 2011:§4).
  - This calls into question the suitability of "retraction" as a label for this phenomenon: s-hushing?
  - And highlights the importance of gathering simultaneous articulatory and acoustic data for a more complete picture.

7 Future work

- Look more closely at the tongue shape of /ɹ/ (cf. Mielke et al. 2010).
- Collect additional articulatory data, e.g. parasagittal ultrasound for grooved/slit tongue surface, video recording for lip-rounding.
  - See below for preliminary results on rounding using F3-F2 as a proxy.



F. 16: F3-F2 for sibilants for all speakers

- Explore word-internal retraction as well as the effects of stress, schwa-deletion, morpheme, word and prosodic boundaries and speech rate.
- Perform acoustic analysis on existing corpus of conversational data.

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References `http://tiny.cc/2018-mfm-str-ref`