Gradience and categoricity in *s*-retraction: An ultrasound study of Manchester English

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1 Introduction

1.1 This poster

- We use ultrasound to investigate the realisation of the sibilant in the word-initial clusters /**st͡ɹ**/ and /**stj**/, e.g. *street*, *student*.

[s]treet	[ʃ]treet
[s]tudent	[ʃ]tudent

1.2 Previous work

- Well-studied with /**st͡ɹ**/ in AmE but relatively under-studied in BrE.
- BrE also has /**stj**/, which is absent in AmE (at least in these contexts).
- Has been characterised as **retraction**, based primarily on acoustic data.
- However, acoustics doesn't have a one-to-one mapping with articulation (e.g. Mielke et al. 2016 on covert articulation of /**ɹ**/).
- Attested in various varieties of English (e.g. Shapiro 1995, Lawrence 2000, Durian 2007, Bass 2009, Sollgan 2013, Wilbanks 2017).
- Focus has often been sociolinguistic rather than phonetic aspects.
  - But see Stevens & Harrington (2016) for work on the phonetic origins.

1.3 Phonetic motivations

- The rôle of /**ɹ**/ has been foregrounded in many studies:
  - Shapiro (1995) claims *s*-retraction is triggered non-locally by /**ɹ**/.
  - Baker et al. (2011) find that even "non-retractors" show coarticulatory bias towards retraction in clusters containing /**ɹ**/, e.g. /**spɹ**/.
- However, some have argued that /**ɹ**/'s influence may be more indirect:
  - Lawrence (2000) claims that this is local assimilation with /**ɹ**/ causing affrication of /**t**/ to /**tʃ**/ leading to *s*-retraction.
  - This could be particularly appropriate for BrE where /**t**/ undergoes a similar process before /**j**/ for most speakers.

1.4 Research questions

- Is *s*-retraction categorical or gradient?
- What degree of inter-speaker variation do we find?
- How does *s*-retraction in BrE differ from AmE?
  - What happens in /**stj**/ and how comparable is it to /**st͡ɹ**/?
  - What does this suggest about the triggering mechanism(s)? (i.e. /**ɹ**/)

2 Methodology

2.1 Stimuli

- 9 word-initial contexts.
- Baselines for comparison:

/s/ e.g. *seep*	/ʃ/ e.g. *sheep*

- Retracting environments:

/st͡ɹ/ e.g. *street*	/stj/ e.g. *stupid*	/st/ e.g. *steep*

- Pseudo-distractors:

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

2.2 Collection

- Midsagittal ultrasound with simultaneous, synchronised acoustics.
- Carrier sentence: 'I know [...] is a word'.
- 5 repetitions per token (130 sentences in total).
- 7 speakers of McrE (2M, 5F; aged 18–26).

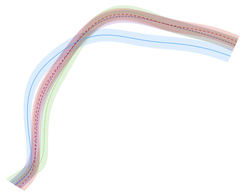
2.3 Processing and analysis

- Tongue splines tracked in AAA (Articulate Instruments Ltd. 2011).
- Analysis using `rticulate` and `tidymv` R packages (Coretta 2017, 2018).
- Modelled using Generalised Additive Mixed Models (GAMMs):
  - Ideal for modelling dynamic data (see Sóskuthy 2017 and refs therein).
- Complemented by Centre of Gravity (CoG) measurements for each fricative/affricate extracted in Praat (DiCanio 2017).
  - A lower value is more /ʃ/-like; a higher value is more /s/-like (Jongman et al. 2000, Baker et al. 2011).

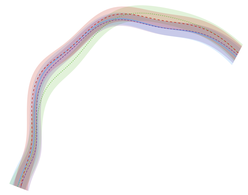
3 Articulation

3.1 GAMMs

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



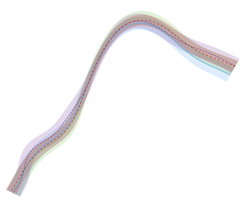
F. 1: GAMMs for **M01**



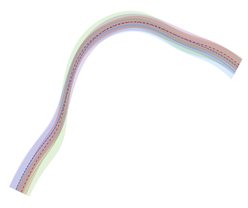
F. 2: GAMMs for **F01**

- **M01**: Tongue body for /st͡ɹ/ 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 /st͡ɹ/.

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



F. 3: GAMMs for **F06**

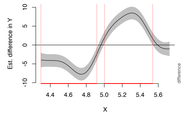


F. 4: GAMMs for **F08**

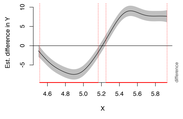
3.2 Difference smooths (DS)

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

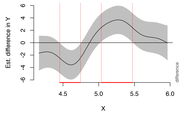
- /s/ and /ʃ/ completely different for **M01** and **M02**; less so for **F01**.



F. 5: /s/–/ʃ/ DS for **M01**

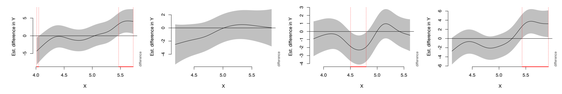


F. 6: /s/–/ʃ/ DS for **M02**



F. 7: /s/–/ʃ/ DS for **F01**

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



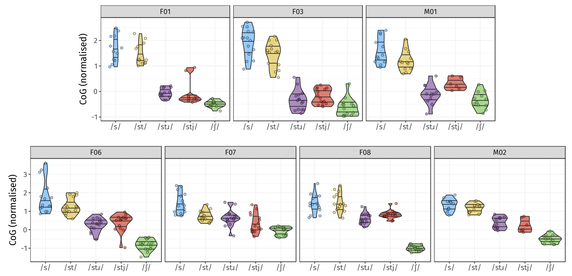
F. 8: /s/–/ʃ/ DS for **F03** **F. 9:** /s/–/ʃ/ DS for **F06** **F. 10:** /s/–/ʃ/ DS for **F07** **F. 11:** /s/–/ʃ/ DS for **F08**

- 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. 12: CoG measurements for acoustically categorical (top row) and gradient (bottom row) speakers

- We see categorical "retraction" for three speakers (**M01, F01, F03**):
  - /s/ v. /st͡ɹ/~/stj/~/ʃ/.
- Gradient "retraction" for the rest (**M02, F06, F07, F08**):
  - /st͡ɹ/ 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 /st͡ɹ/ and /stj/.
- Remember, some speakers show no apparent lingual difference between these categories, even between underlying /s/ and /ʃ/!

4.2 *T*-affrication

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

- Comparable affrication of /**t**/ in both /st͡ɹ/ 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 /**t͡ɹ**/ and /st͡ɹ/ 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 /st͡ɹ/ 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 /**t͡ɹ**/ and /**tj**/ clusters:
  - Some evidence speakers can affricate /**t**/ with only minimal retraction of /s/.
  - But no evidence speakers retract /s/ without affricating /**t**/: ~ *[ʃt͡ɹ]*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?
  - E.g. tongue shape, lip-rounding, laminal v. apical constriction rather than place of articulation.
  - Cf. variation in /**ɹ**/ shape (Delattre & Freeman 1968, Mielke et al. 2016)

6 Conclusions

- Word-initially, /st͡ɹ/ 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).
  - Not a process of distant assimilation triggered directly by /**ɹ**/.
- The /s/–/ʃ/ contrast is more complicated than a mere difference in place of articulation.
  - Evidence speakers are hitting an acoustic rather than articulatory target (Boersma 2011:§4).
  - Calls into question the suitability of "retraction" as a label for this phenomenon: *s*-hushing?
  - Highlights the importance of gathering simultaneous articulatory and acoustic data.

7 Future work

- Look more closely at the tongue shape of /**ɹ**/ (cf. Mielke et al. 2010).
- Explore word-internal retraction and the effects of stress and morpheme boundaries.
- Investigate phrase-level retraction and the effect of prosodic boundaries and speech rate.
- Consider interaction with schwa-deletion, e.g. *history* /hɪstəɹi~hɪstɹi/.
- Collect additional articulatory data, e.g. parasagittal ultrasound for grooved/slit tongue surface, video recording for lip-rounding.
- Perform acoustic analysis on existing corpus of conversational data.

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

Appendix `http://tiny.cc/2018-baap-str-app`