Retraction on

An ultrasound-tongue-imaging study of *s*-retraction in Manchester English

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Introduction

[s]treet or [ʃ]treet?

Introduction

What we're looking at and how (and why!):

What: retraction of underlying /s/ to a more [ʃ]-like sound in /stɹ/ and /stj/ clusters, e.g. *street, string; stupid, student*

How: using ultrasound tongue imaging (with simultaneous acoustics)

Why #1: because although it's well-studied in American English, it is relatively under-studied in British English. BrE also has /stj/, which is absent in AmE

Why #2: characterised as /s/-**retraction** but this is based primarily on acoustic data. Ultrasound is important because acoustics does not have a one-to-one mapping with articulation (e.g. Mielke et al. 2016 on covert articulation of /ɹ/)

Background

- Attested throughout the **US** (e.g. Labov 1984; Durian 2007; Gylfadottir 2015; Wilbanks 2017) and the **UK** (Altendorf 2003; Bass 2009; Sollgan 2013; Glain 2014)
  - has also been studied in **New Zealand** (Lawrence 2000) and **Australia** (Stevens & Harrington 2016), although only the phonetic precursor to the change was found in the latter
- Quite often the focus has been on the sociolinguistic profile of this change
- Relatively less work on the phonetic realisation
  - Some studies have adopted a binary classification (Janda & Joseph 2003; Bass 2009)
  - But Labov (2001) argues that there are 4 variants differing in how [ʃ]-like they are

What /ɹ/ the reasons?

- The role of /ɹ/ has been foregrounded in many studies
  - Baker et al. (2011) find that even 'non-retractors' show a coarticulatory bias towards *s*-retraction in clusters with /ɹ/ i.e. /spɹ/, /skɹ/, /stɹ/
  - Shapiro (1995) claims that *s*-retraction in /stɹ/ clusters is a case of non-local assimilation with /ɹ/ based on the fact that /s/ doesn't retract in /st/ clusters, e.g. *steep*

- Alternatively, the role of /ɹ/ could be more indirect
  - Lawrence (2000) instead claims that this **is** local assimilation - /ɹ/ triggers affrication of /t/ to /tʃ/, which then triggers retraction of /s/
  - this explanation could be particularly appropriate in British contexts, where /t/ undergoes a similar process before /j/ for most speakers
  - e.g. *tune* /tjuːn/ > [tʃuːn] *stupid* /stjuːpɪd/ > [ʃtʃuːpɪd]?

Research questions

- Categoricity vs. gradience in /s/-retraction
  - is the surface realisation of /s/ in /stɹ/ and /stj/ the same as an underlying /ʃ/?
  - not just with respect to acoustics but also articulation
- What degree of inter-speaker variation do we find? To what extent do we find different ‘systems’ of /s/-retraction?
- How is BrE different from AmE with respect to /s/-retraction?
  - what happens in /stj/ (absent in AmE) and how comparable is it to /stɹ/?
  - is the affrication of /t/ in /stɹ/ and /stj/ the same as an underlying /tʃ/?
  - what does this suggest about the mechanisms that trigger this process? i.e. the role of /ɹ/

Methodology

Design of stimuli

9 word-initial contexts

Baselines for comparison:

underlying /s, ʃ/

/s/
e.g. *seep*

/ʃ/
e.g. *sheep*

Retracting environments:

/stɹ/
e.g. *street*

/stj/
e.g. *stupid*

+

/st/
e.g. *steep*

?

Pseudo distractors:

/tʃ/
e.g. *cheap*

/ɹ/
e.g. *read*

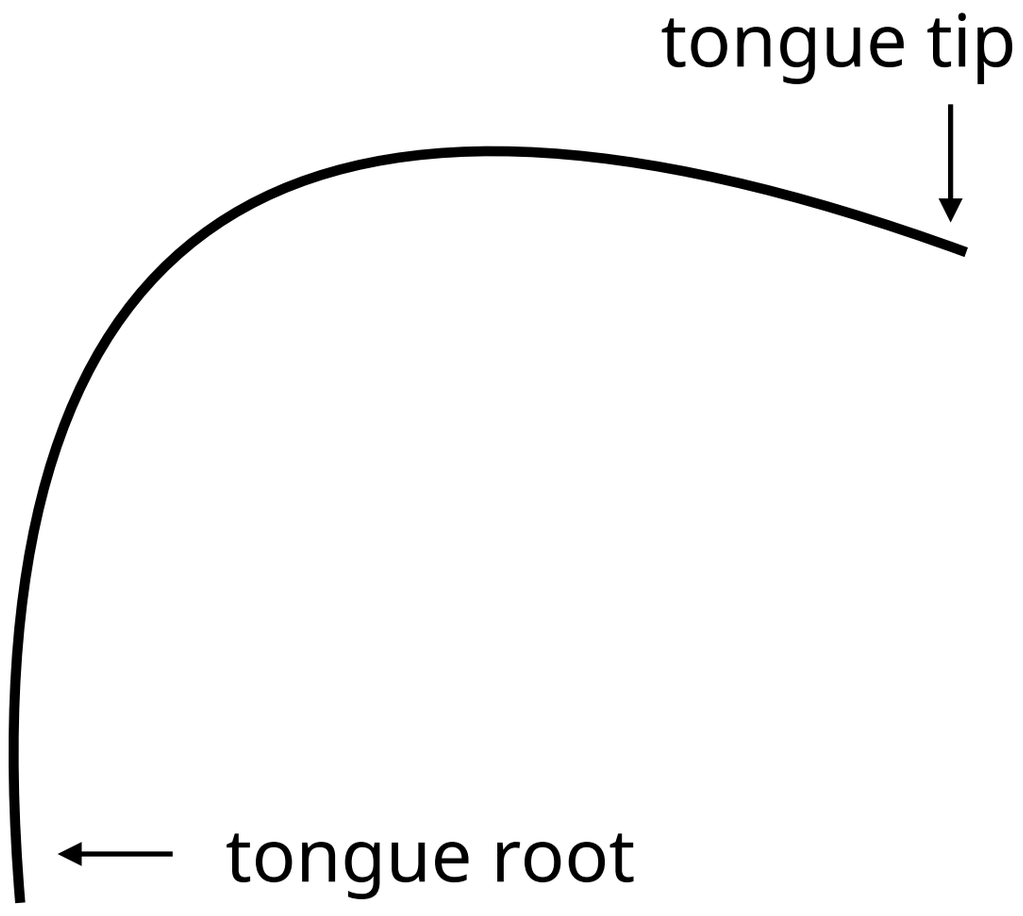
/tɹ/
e.g. *treat*

/tj/
e.g. *tune*

Useful for independent evidence of what happens to /tɹ/ and /tj/ outside of post-/s/ environments

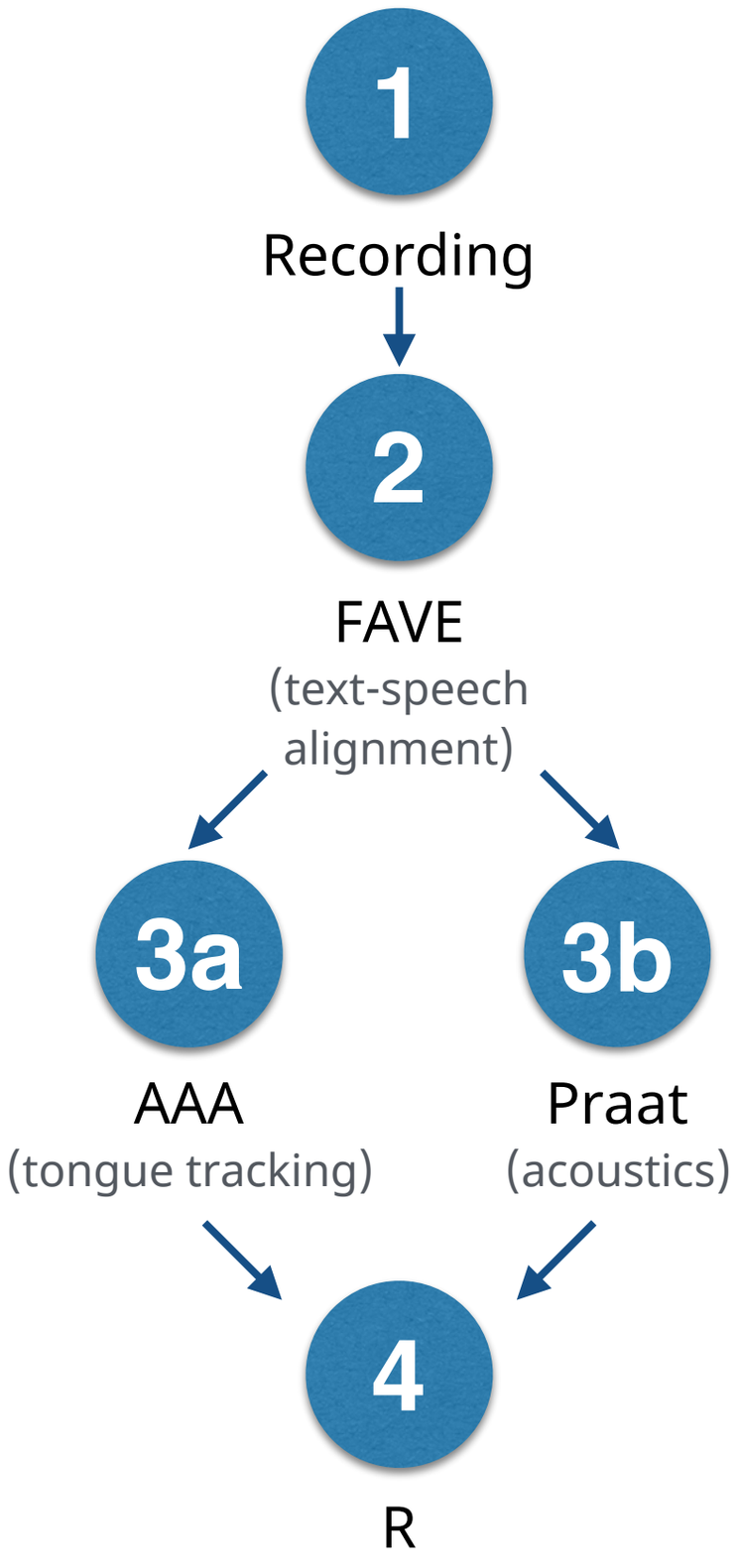
Ultrasound data collection

- Carrier sentence: ‘I know […] is a word’
- 5 repetitions per token (130 sentences in total)
- Synchronised audio recording (lavalier mic) and UTI (60fps)
- Stabilised with headcage
- Mid-sagittal view
- Currently 7 speakers (2M; 5F) aged 18-26
  - all born (or at least raised from age 4) in Greater Manchester, but in some cases parents aren’t from Manchester (or even England)



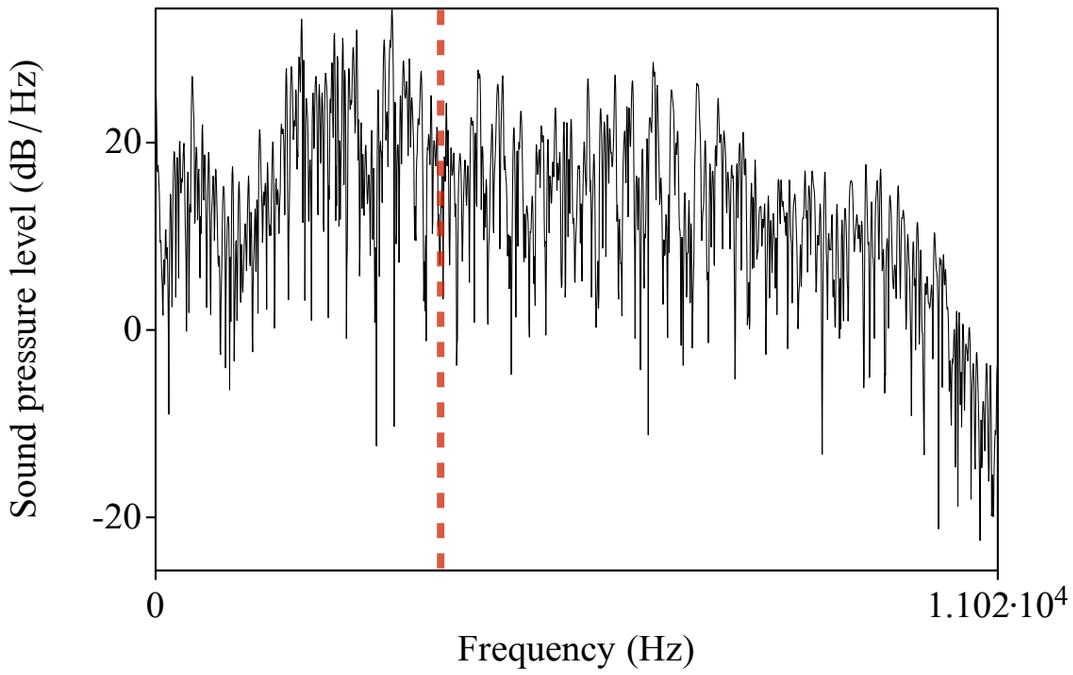
Ultrasound data analysis

- Forced alignment using FAVE (Rosenfelder et al. 2011)
  - manually-corrected, with further sub-segmentation e.g. *tree* T R IY1 -> T CH R IY1
- Tongue splines tracked and exported using AAA (Articulate Instruments Ltd. 2011)
  - 3 keyframes per segment - analysis conducted on keyframe 2 (segment mid-point)
  - analysis in R using `rticulate` (Coretta 2017) and `tidymv` (Coretta 2018) packages
- Modelled using GAMMs - Generalised Additive Mixed Models
  - ideal for modelling non-linear effects in dynamic (time/space) data (Sóskuthy 2017)

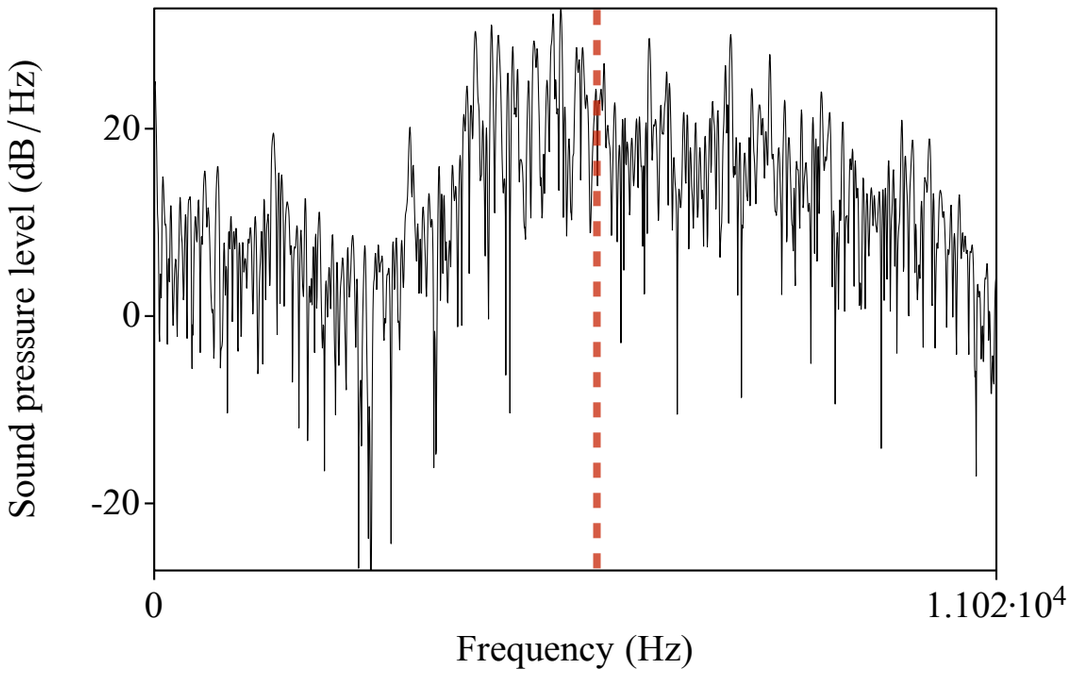


Acoustics

- To complement ultrasound data, acoustic analysis was performed in Praat
- **Centre of Gravity** (CoG) calculated for each fricative/affricate (DiCanio 2017)
  - lower value = more /ʃ/-like; higher value = more /s/-like (Jongman et al. 2000; Baker et al. 2011)



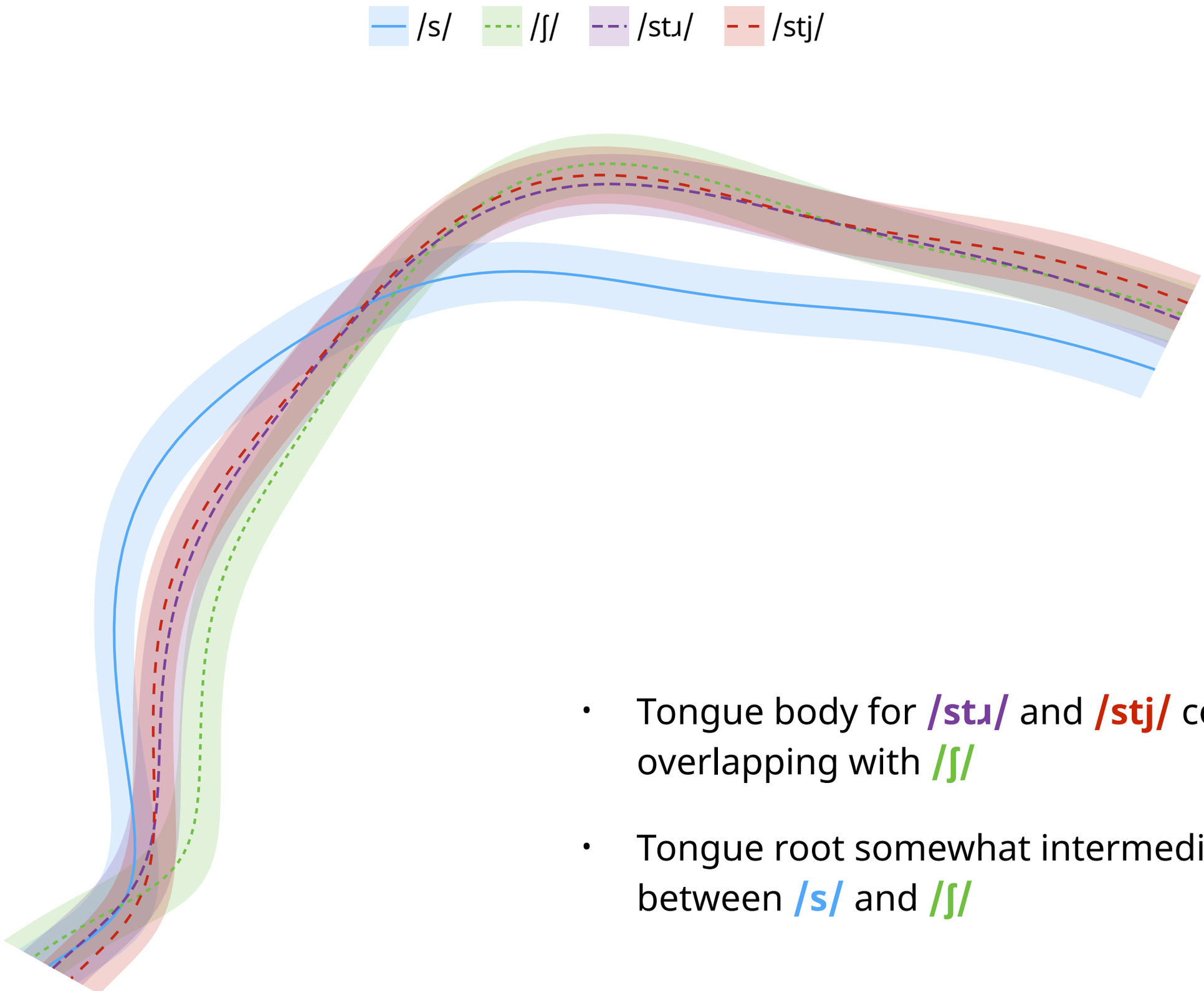
/ʃ/ CoG: 3749 Hz



/s/ CoG: 5743 Hz

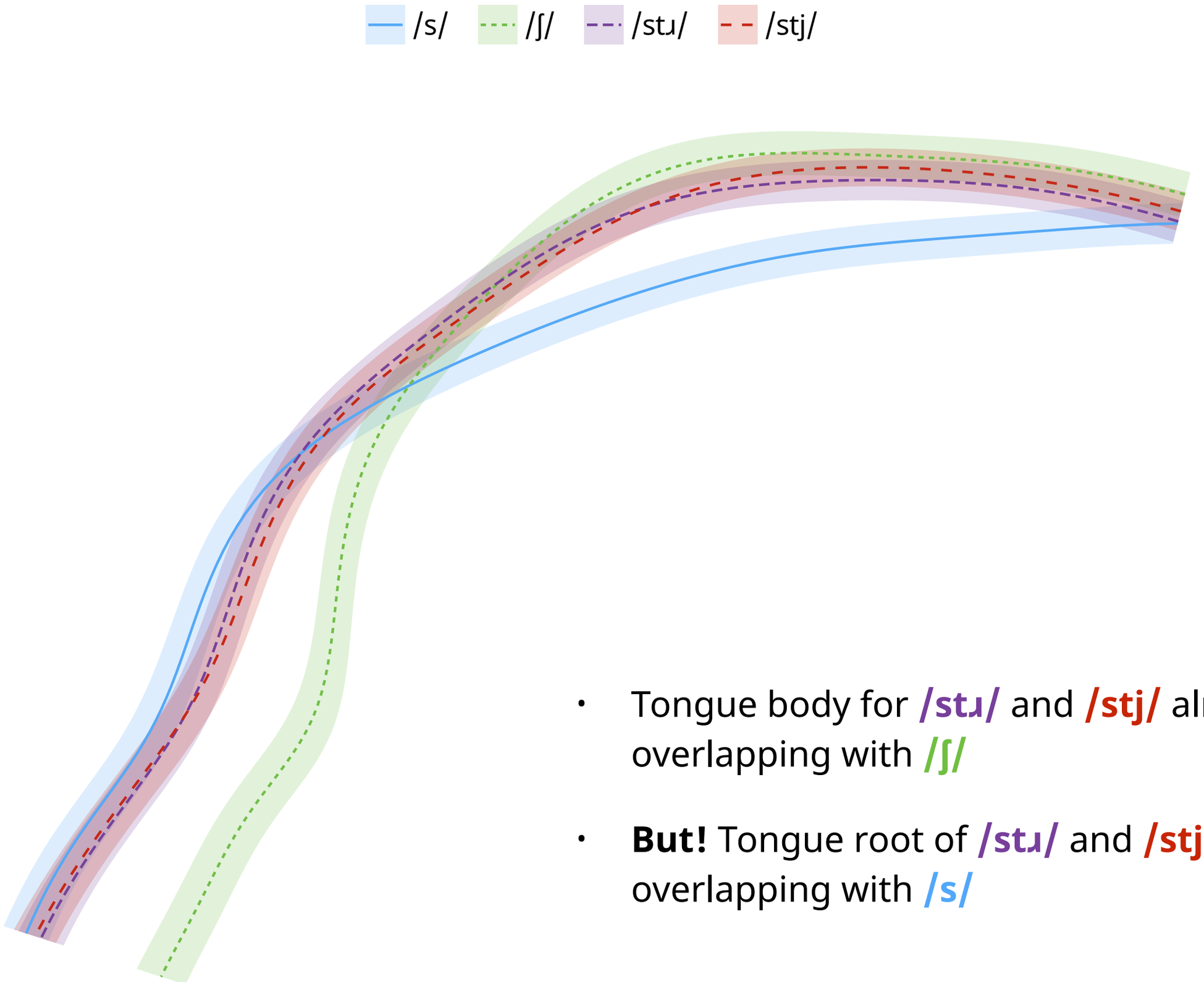
Articulation

Articulation - M01



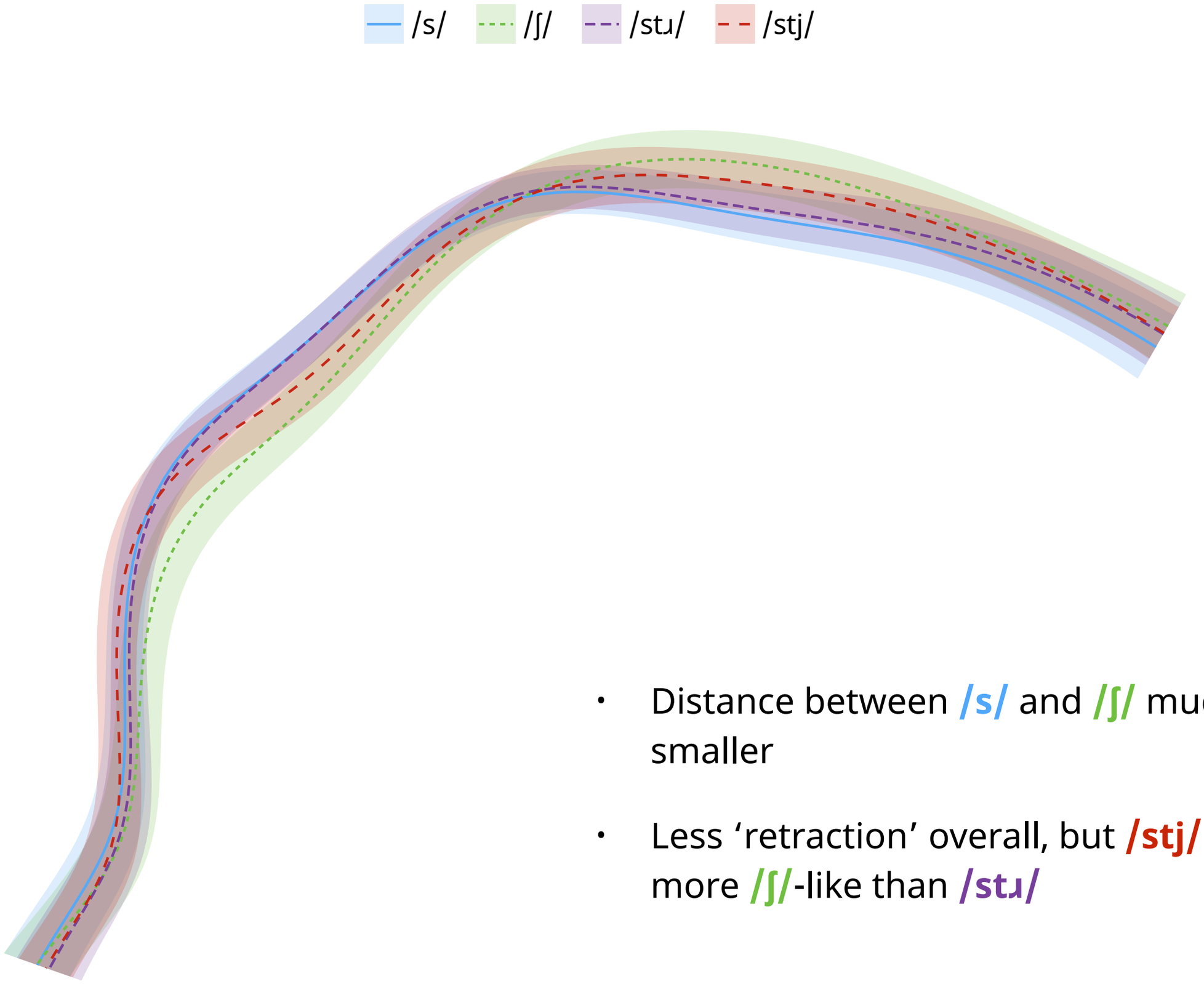
- Tongue body for **/stɹ/** and **/stj/** completely overlapping with **/ʃ/**
- Tongue root somewhat intermediate between **/s/** and **/ʃ/**

Articulation - M02



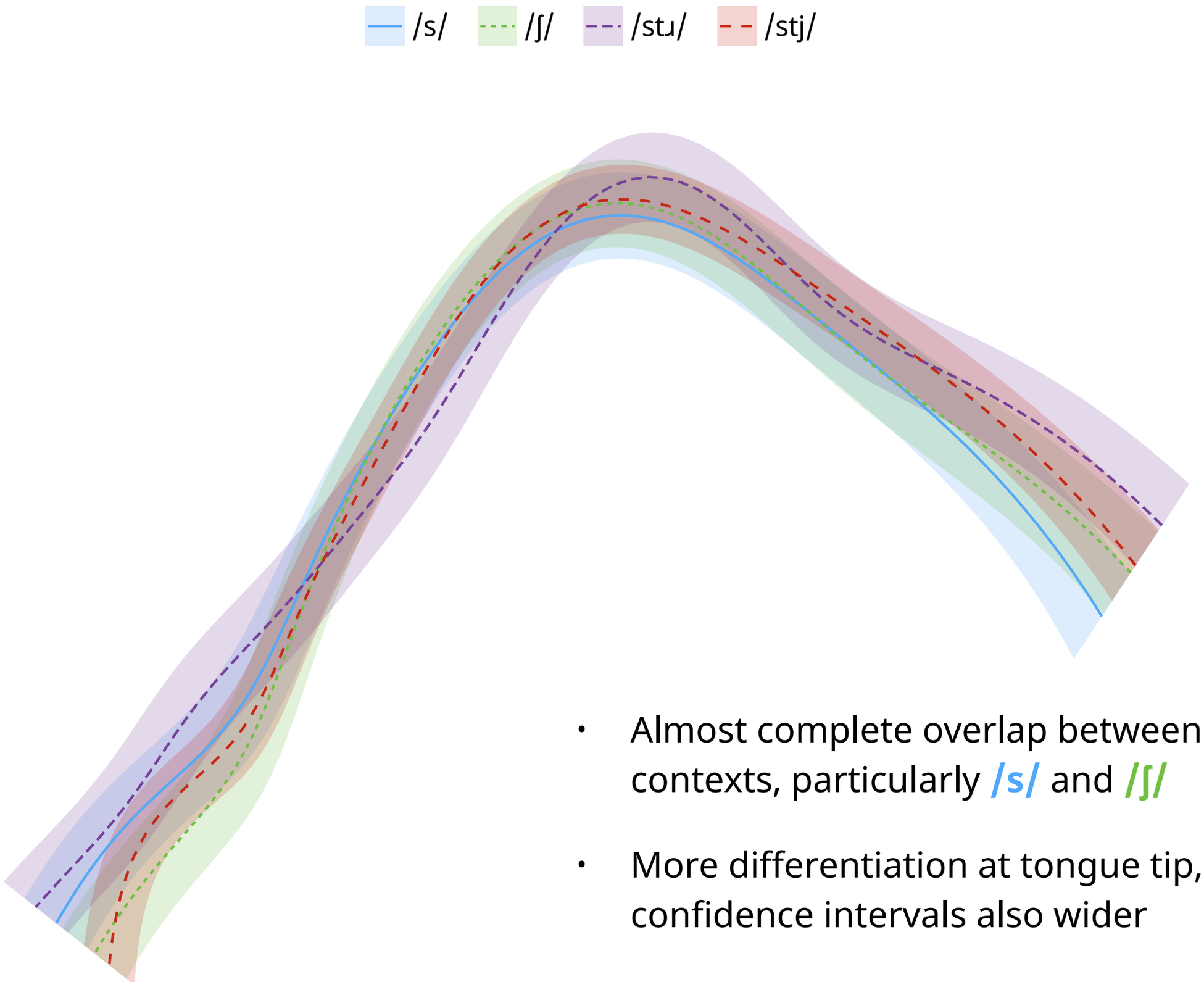
- Tongue body for **/stɹ/** and **/stj/** almost overlapping with **/ʃ/**
- **But!** Tongue root of **/stɹ/** and **/stj/** overlapping with **/s/**

Articulation - F01



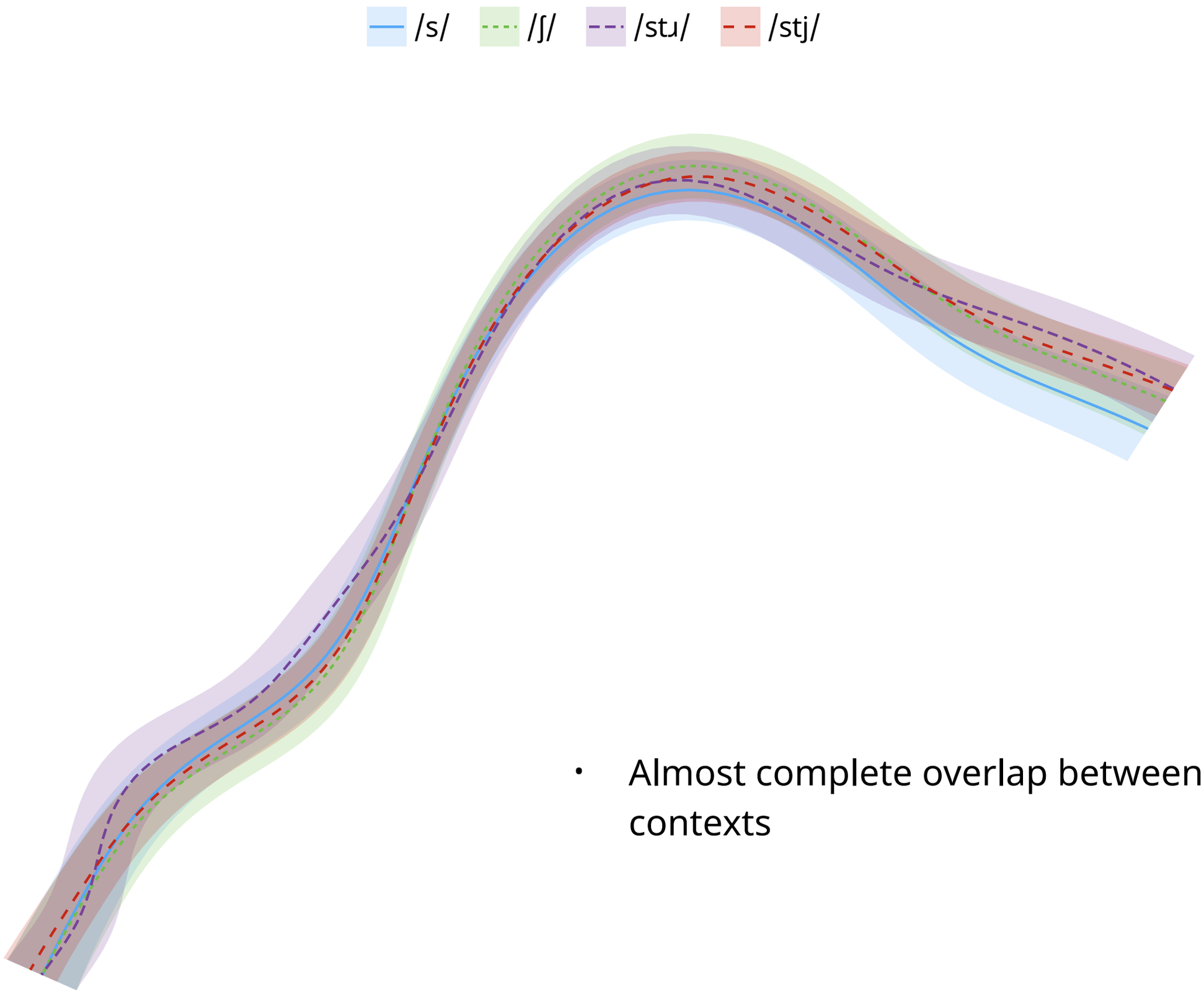
- Distance between **/s/** and **/ʃ/** much smaller
- Less ‘retraction’ overall, but **/stj/** more **/ʃ/**-like than **/stɹ/**

Articulation - F03



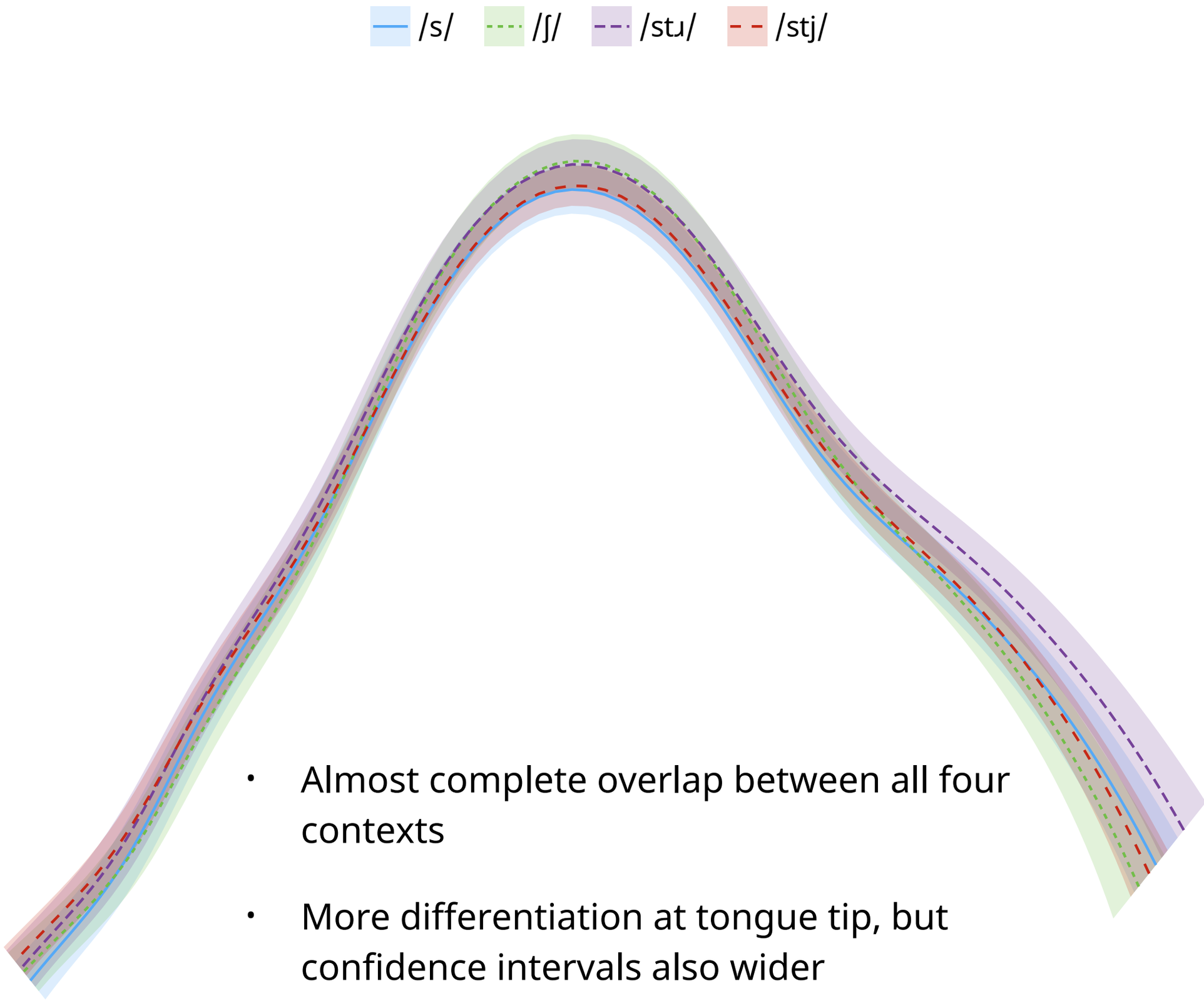
- Almost complete overlap between all four contexts, particularly **/s/** and **/ʃ/**
- More differentiation at tongue tip, but confidence intervals also wider

Articulation - F06



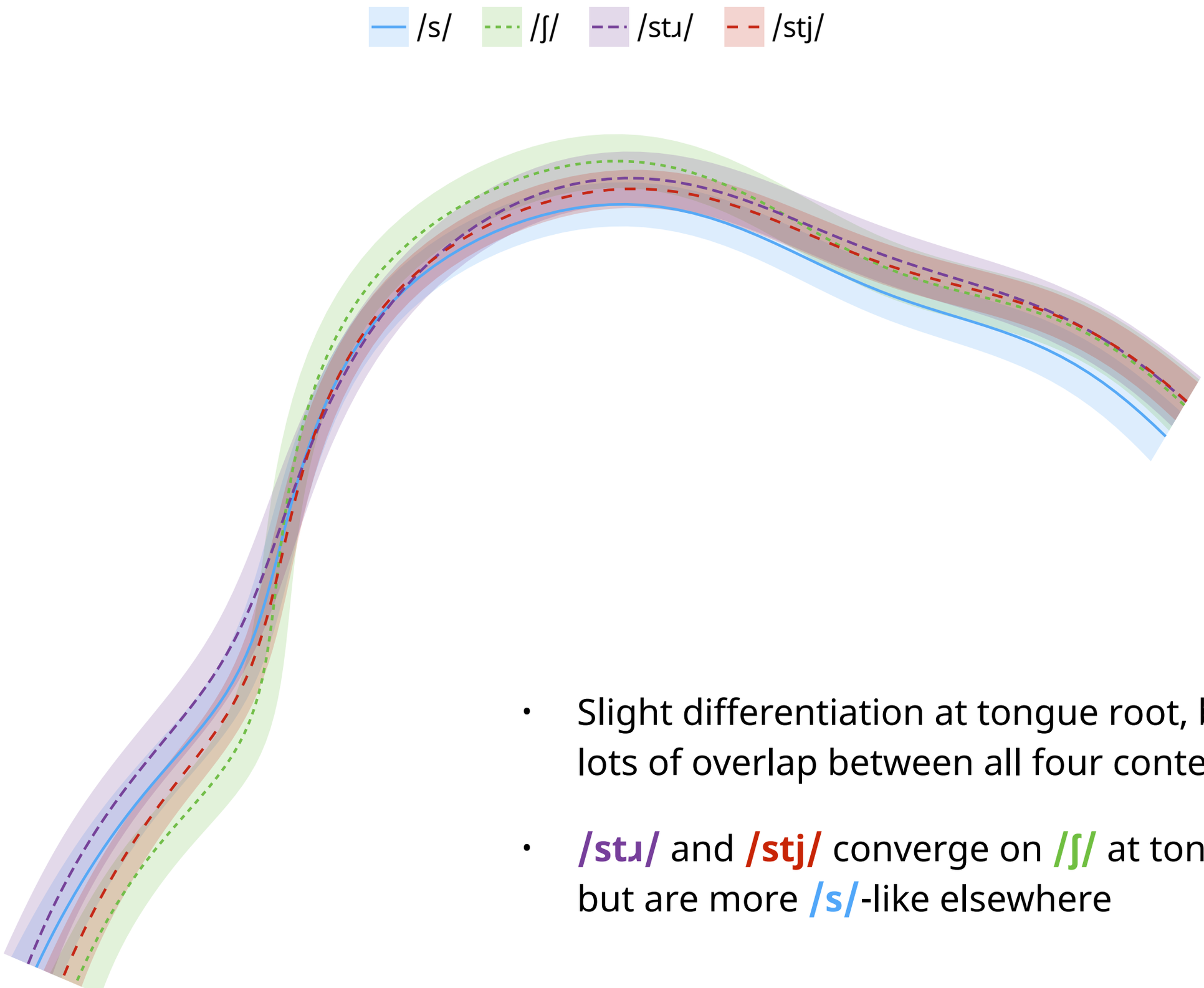
- Almost complete overlap between all four contexts

Articulation - F07



- Almost complete overlap between all four contexts
- More differentiation at tongue tip, but confidence intervals also wider

Articulation - F08



- Slight differentiation at tongue root, but again lots of overlap between all four contexts
- **/stɹ/** and **/stj/** converge on **/ʃ/** at tongue tip but are more **/s/**-like elsewhere

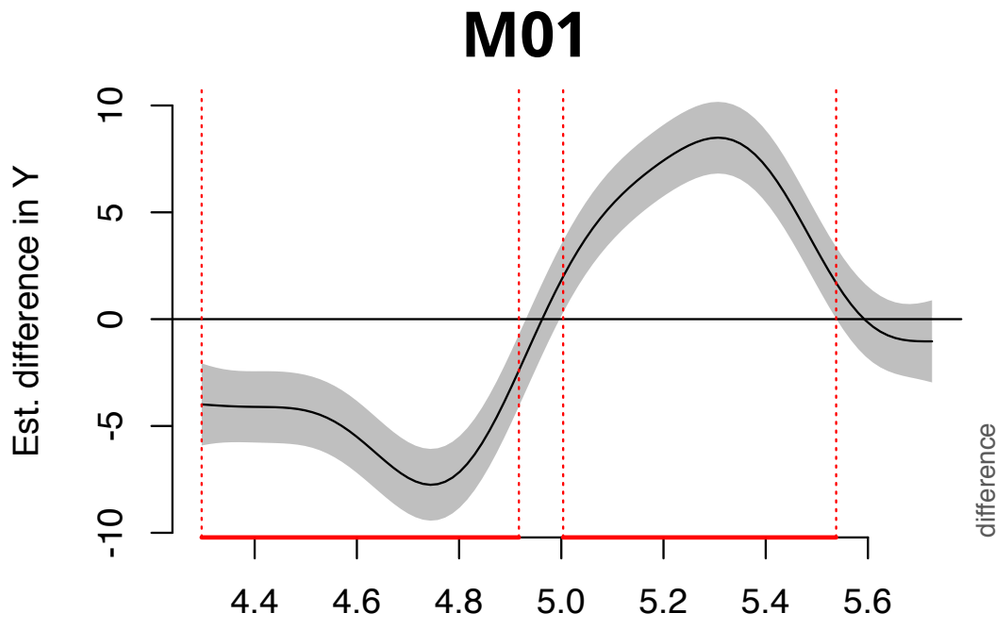
Interim summary

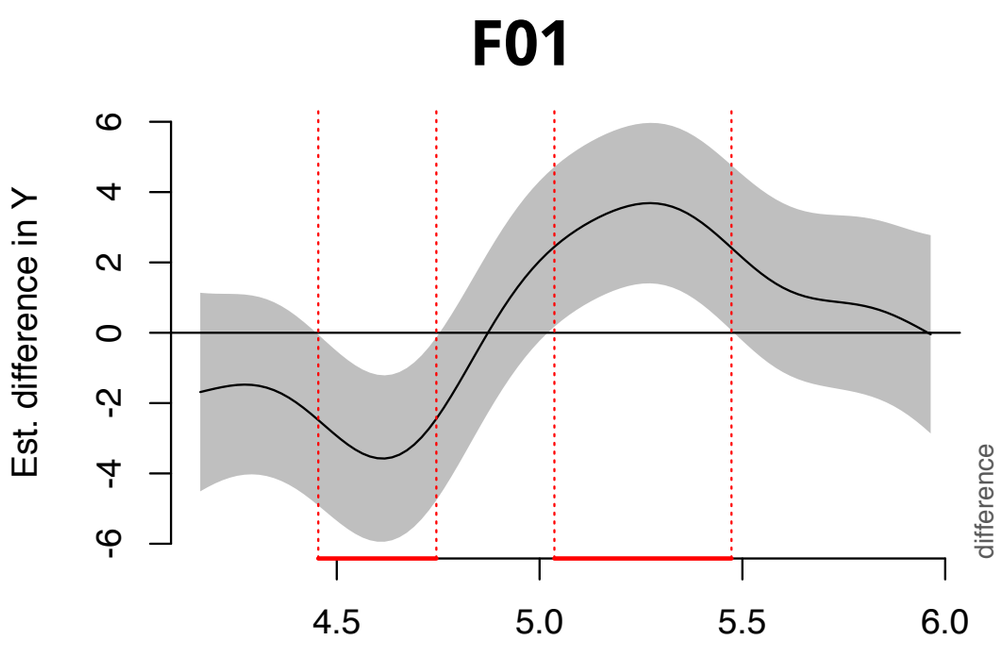
- M01 and M02 seem to exhibit ‘categorical’ retraction in that there are clearly two groups - **/s/** vs. **/ʃ/~/stɹ/~/stj/**
  - however, the tongue shapes of **/ʃ/**, **/stɹ/** and **/stj/** still differ at the root - to what extent can we call this categorical?
- Less evidence of categoricity for F01, F03, F06, F07, F08
  - but is that just because they have much less differentiation (sometimes none!) between **/s/** and **/ʃ/** to begin with?

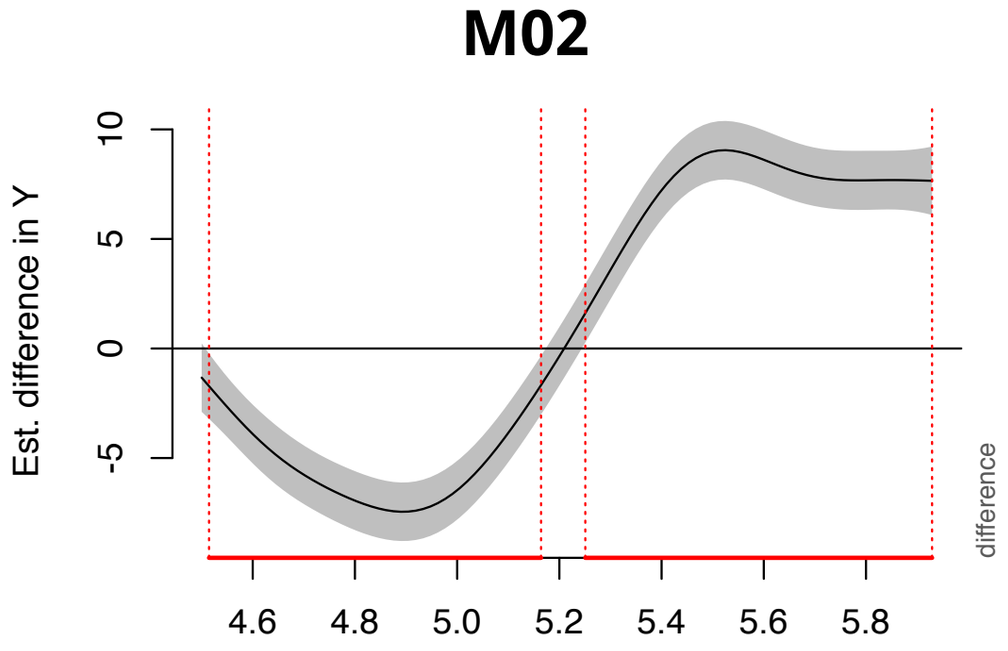
Difference smooths

Difference smooths between /s/ and /ʃ/

- red portions (where confidence intervals contain 0) indicate significant differences between the two curves
- more red = more differentiation in tongue shape
- /s/ and /ʃ/ completely different for M01 and M02; F01 to a lesser extent



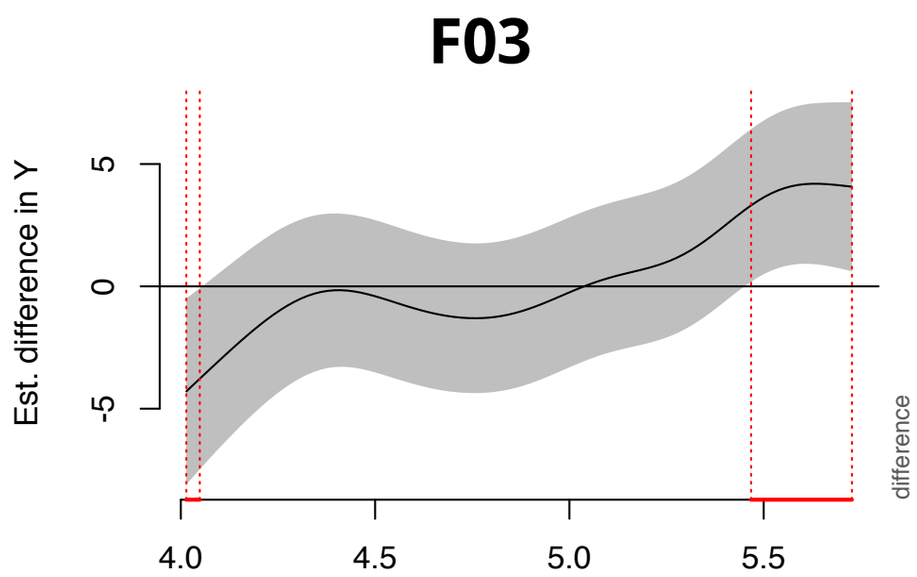


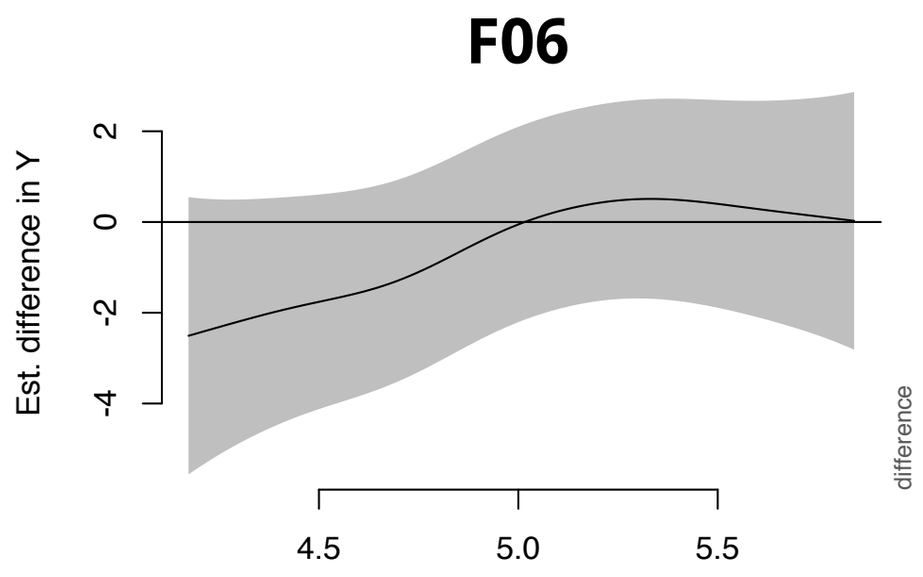


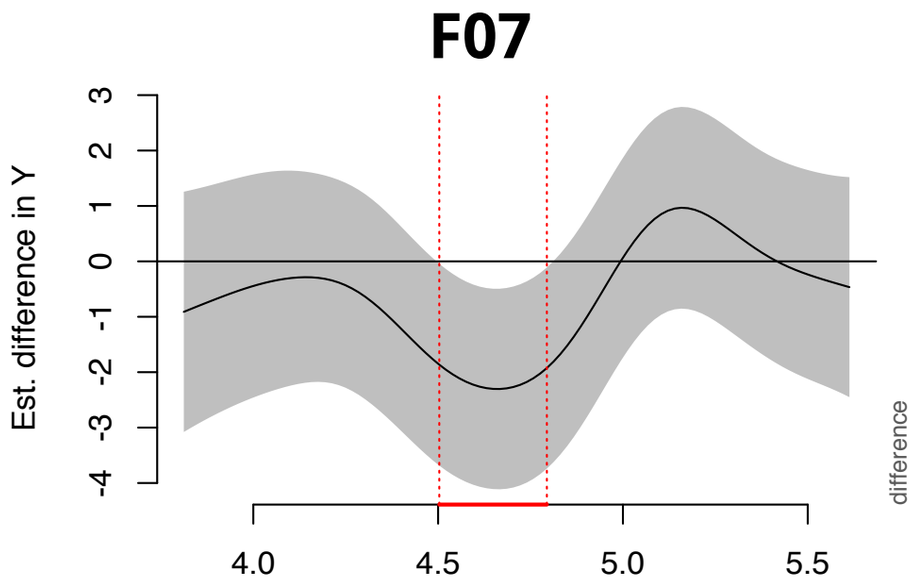
Difference smooths

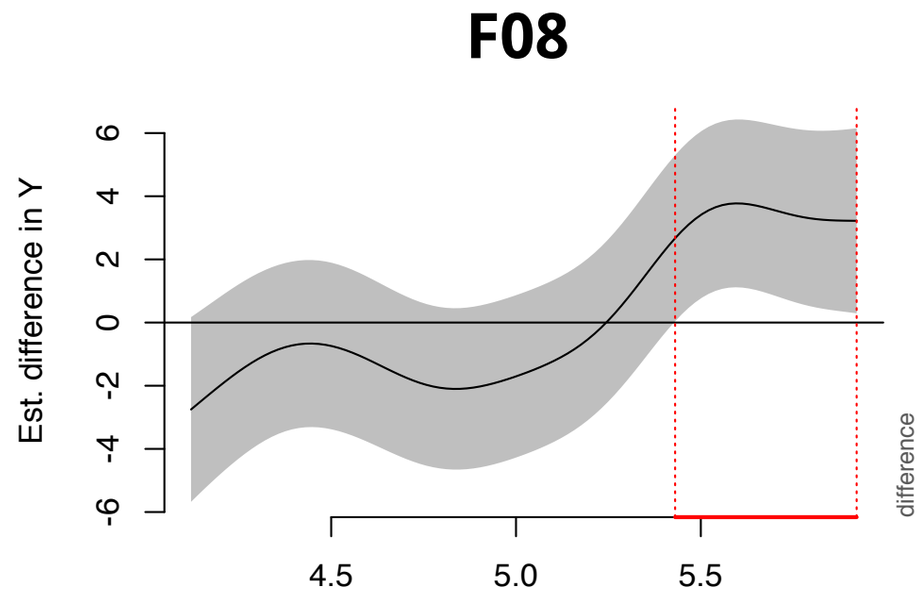
But for four speakers, there is little-to-no difference in tongue shape between underlying **/s/** and **/ʃ/**

- is the acoustic contrast between these two still maintained despite this apparent lack of articulatory distinction?









Acoustics

Part I: /s/-retraction

Centre of Gravity

- All speakers still have an acoustic contrast between **/s/** and **/ʃ/**
- Categorical ‘retraction’ for three speakers (F01, F03, M01)
  - i.e. **/s/** vs. **/stɹ/**, **/stj/**, **/ʃ/**
- Gradient ‘retraction’ for the rest
  - i.e. **/stɹ/** and **/stj/** intermediate between **/s/** and **/ʃ/**

Acoustics

- Crucially, the acoustic analysis reveals that:

  1. **all** speakers do have an acoustic contrast between **/s/** and **/ʃ/**
  2. **all** speakers exhibit some degree of acoustic ‘retraction’ in **/stɹ/** and **/stj/** (whether that be categorical or gradient)

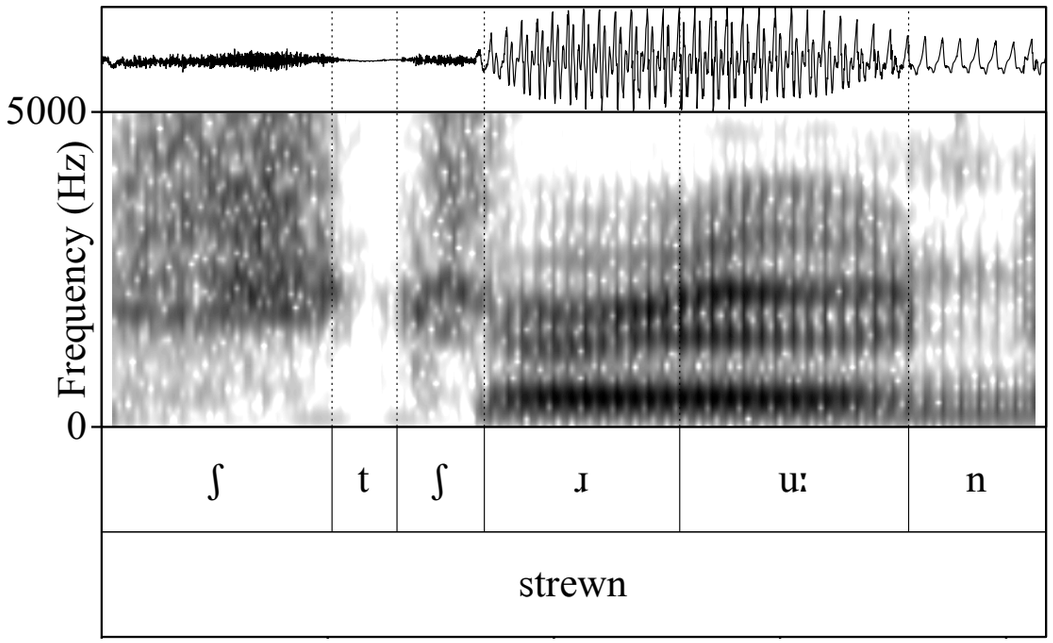
- …but in terms of articulation, remember that **some** of these speakers show no apparent lingual differentiation between these categories
  - this applies even to underlying **/s/** and **/ʃ/**!

Acoustics

Part II: /t/-affrication

Affrication?

M01: /stɹ/



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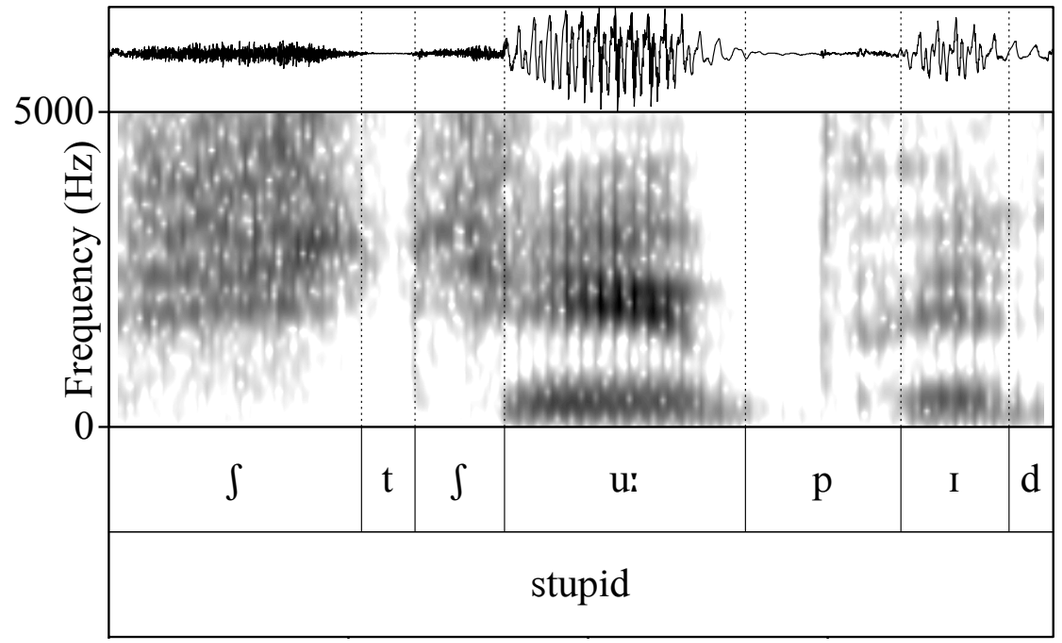
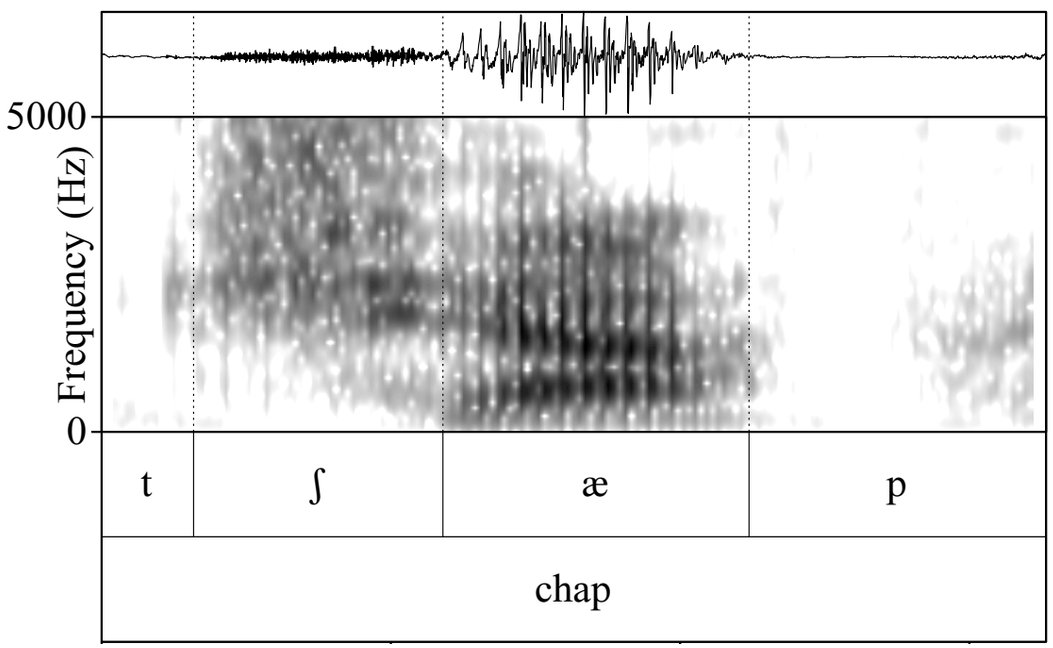
M01: /stj/



M01: underlying /tʃ/



- Comparable affrication of /t/ across both **/stɹ/** and **/stj/** environments
- Phonetically similar to underlying /tʃ/ (just shorter in duration)

Affrication?

Baseline of /ʃ/, e.g.

choose [tʃuːz]

shoes [ʃuːz]

- For most speakers, the fricated portions of pre-/ɹ/ affrication and /tj/-coalescence are identical both to each other and to underlying /tʃ/
- But *some* speakers do differentiate the affricated /t/ depending on whether it is followed by /j/ or /ɹ/ (see F07, M01, M02)
- Crucially, **all** speakers affricate /t/ - it's only the spectral properties of the fricated portion that are variable

Summary

Results summary

- Evidence of both categoricity and gradience in the degree of /stɹ/- and /stj/- retraction
  - however, speakers are either categorical in both or gradient in both - there is no evidence that for a single speaker retraction is more advanced in one than the other
  - suggests that retraction in both environments is governed by the same underlying process, or at least the same phonetic motivations

Results summary

- There is also inter- and intra-speaker variation in the spectral properties of affricated /t/ in /tɹ/ and /tj/ clusters, but crucially **all** speakers affricate /t/ in these environments
  - some evidence that a speaker can affricate /t/ with only minimal retraction of /s/
  - but no evidence that speakers retract /s/ without affricating /t/ e.g. *[ʃtjuːpɪd]

Results summary

- Even though some speakers show no apparent articulatory difference even between underlying /s/ and /ʃ/, the acoustic contrast is still maintained
- Rutter (2011) highlights the three phonetic parameters that define the /s/~/ʃ/ contrast:
  - 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)
  - speakers achieving the same acoustic output through different articulatory means? e.g. tongue shape, lip-rounding, or laminal vs. apical constriction, rather than place of articulation?
  - similar to covert articulation in /ɹ/, i.e. bunchers and retroflexers (Delattre & Freeman 1968; Mielke et al. 2016)

Conclusions

- The fact that /stɹ/ and /stj/ behave so similarly, both in terms of /s/-retraction but also the affrication of /t/, lends support to the idea that this is not a process of distant assimilation triggered directly by /ɹ/
- Evidence that the articulatory mechanisms behind the /s/~/ʃ/ contrast are more complicated than a simple retraction of the place of constriction - speakers are hitting an acoustic target rather than an articulatory target (Boersma 2011: §4)
  - calls into question the suitability of ‘retraction’ as a label for this phenomenon - …*esh*ification? /s/-hushing? cf. /s/-hissing
- Highlights importance of both articulatory and acoustic studies (ideally simultaneous), but in this case midsagittal ultrasound does not tell the whole story

Future work

- Tongue shape of /ɹ/
- Also look at pre-[p] and pre-[k] environments, e.g. *spoon, spring; school, screw*
- /ʃɹ/ environment, e.g. *shrew*
- Investigate word-internal retraction and the effect of morpheme boundaries, e.g. *posture, registry* etc.
- Investigate phrase-level retraction, e.g. *pass treats,* and the effect of prosodic boundaries and speech rate
- Perform acoustic analysis on conversational data (existing corpus of 32 sociolinguistic interviews from Manchester and other North West cities)
- Parasagittal ultrasound to investigate the other articulatory mechanisms of sibilant production e.g. grooved/slit tongue surface
- Video recording for lip-rounding

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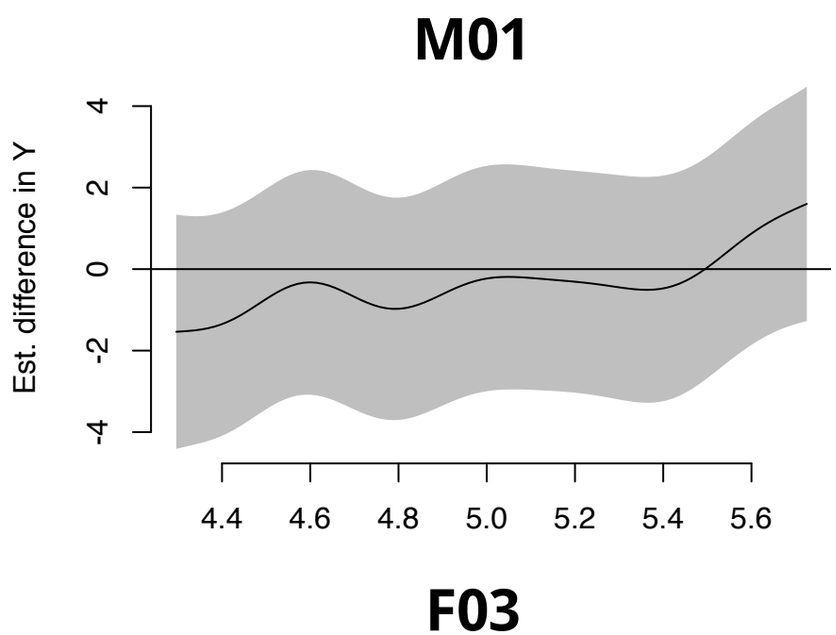
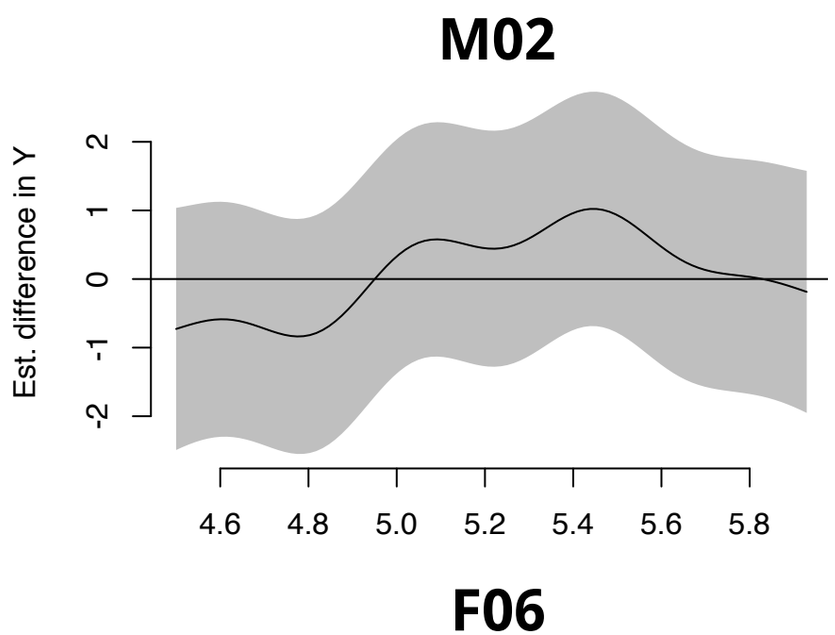
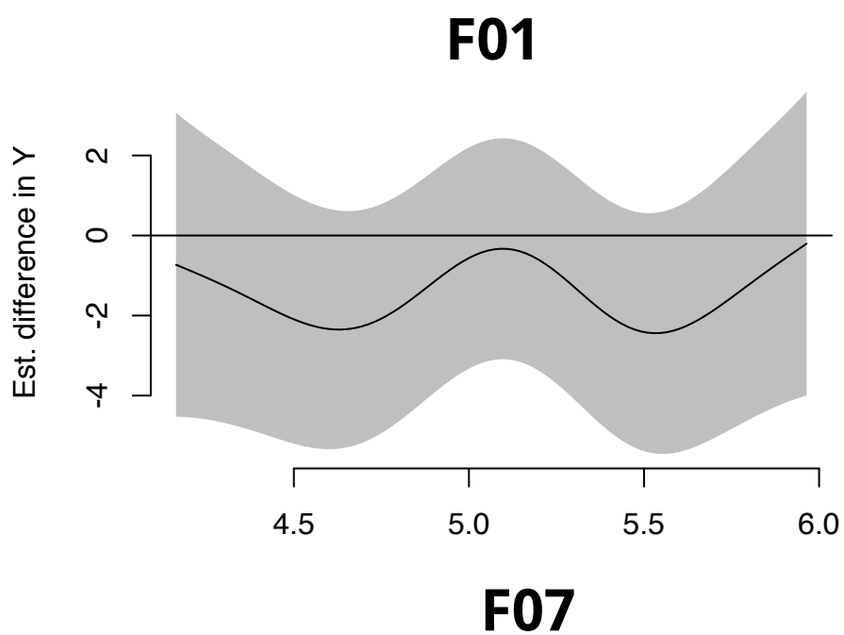
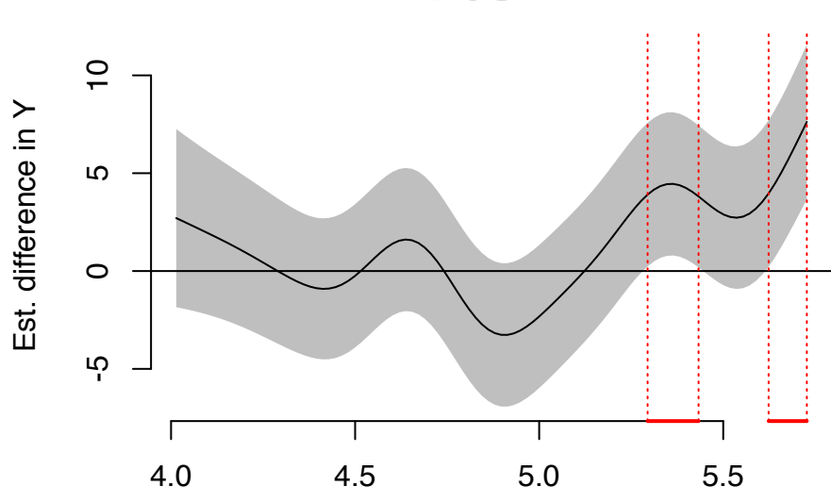
Difference smooths

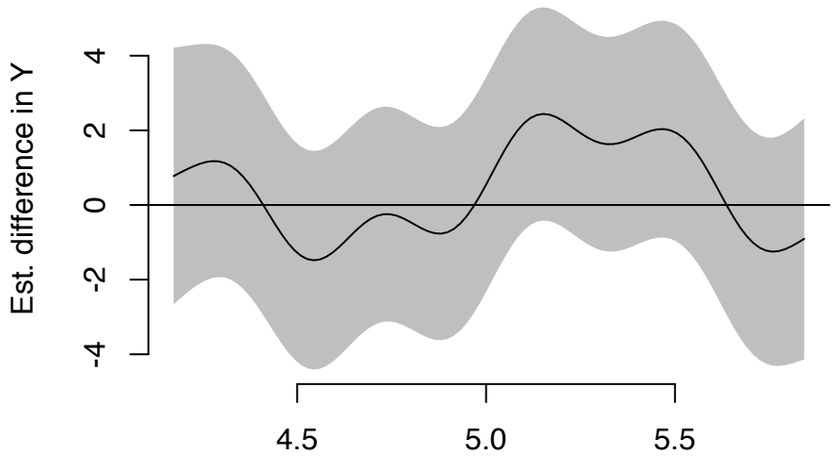
/stɹ/~/stj/

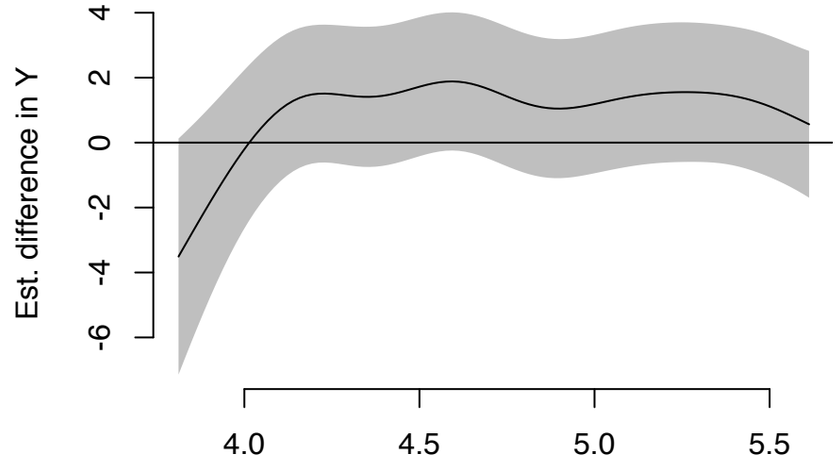


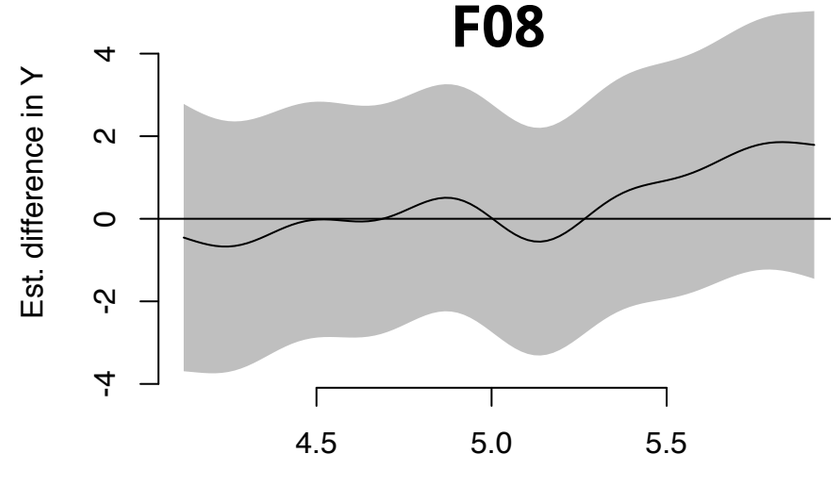












Implications

- Some phonetic tendency or bias for retraction of /s/ pre-consonantally:
  - Diachronic change in German of [s] —> [ʃ] / _C (Cercignani 1979)
    - e.g. *Stein* [ʃt], cf. English *stone* [st]
  - Similarly in certain varieties of Italian (see Spreafico 2016)
    - e.g. *sconto* ‘sale’ [sk] —> [ʃk]
  - Also diachronic change in Old English and German of [sk] —> [ʃ]
    - Proto-Germanic **skuldrô*

      —> English *shoulder* [ʃ], German *Schulter* [ʃ]

      —> Dutch *schouder* [sx]
- Perhaps there is a ‘gang effect’ where the bias towards pre-consonantal /s/-retraction combines with assimilation triggered by /t/-affrication before /ɹ/ and /j/
  - is this what leads to more substantial retraction, and possibly its stabilisation into a categorical rule in the phonology?