[ʃ]tranger things have happened

Stephen Nichols - George Bailey

University of Manchester - University of York

Glasgow University Laboratory of Phonetics - Lab Lunch

6 June 2019

Retraction in (str) and (stj) clusters in Manchester English

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What is *s*-retraction?

A process which turns **/s/** into a more **[ʃ]**-like sound

"Retraction" of the place of articulation from **alveolar** to **post-alveolar**

/stɹ/ e.g. *strewn*

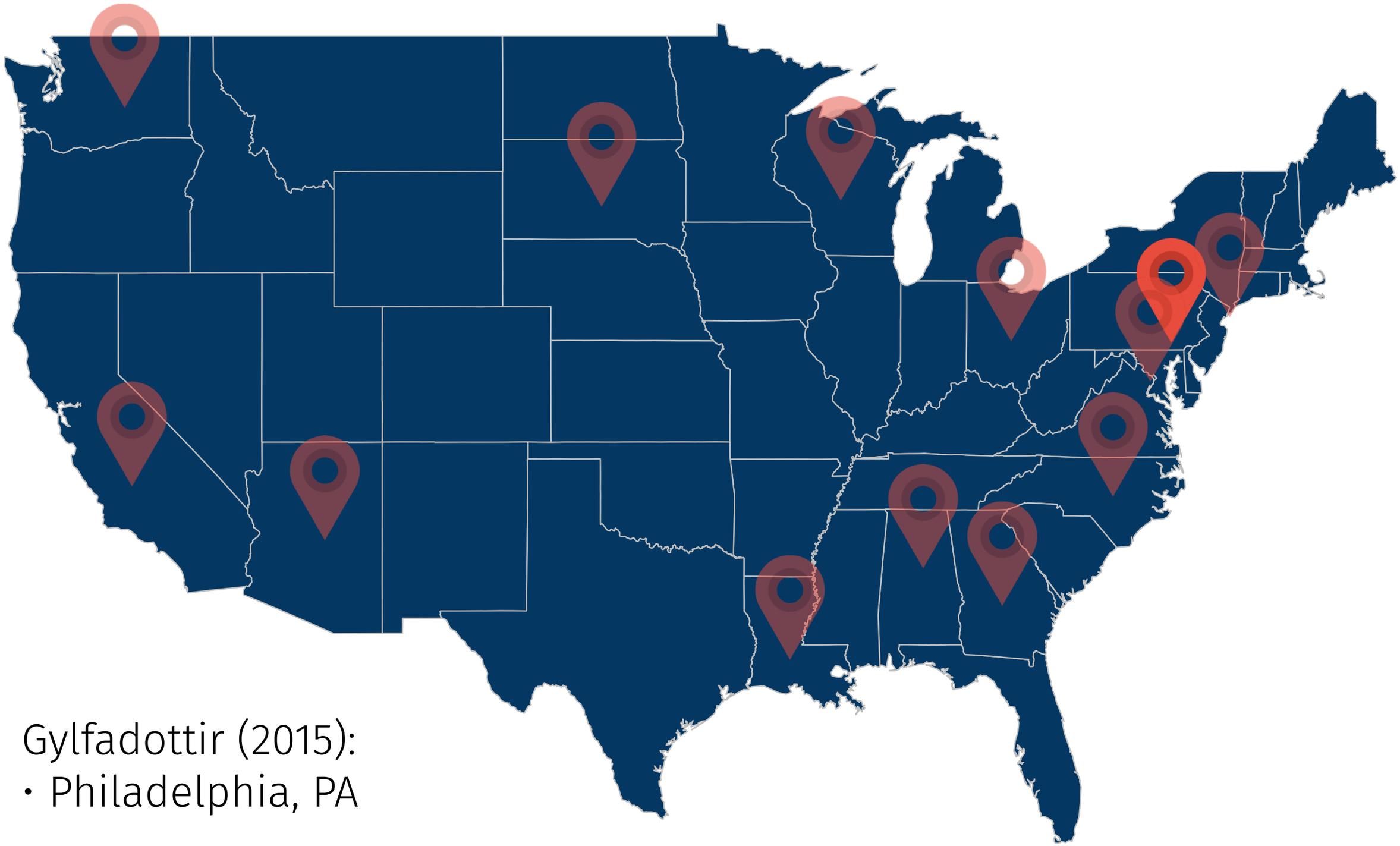
/stj/ e.g. *student*

Geographic spread

Durian (2007):

- Colombus, OH

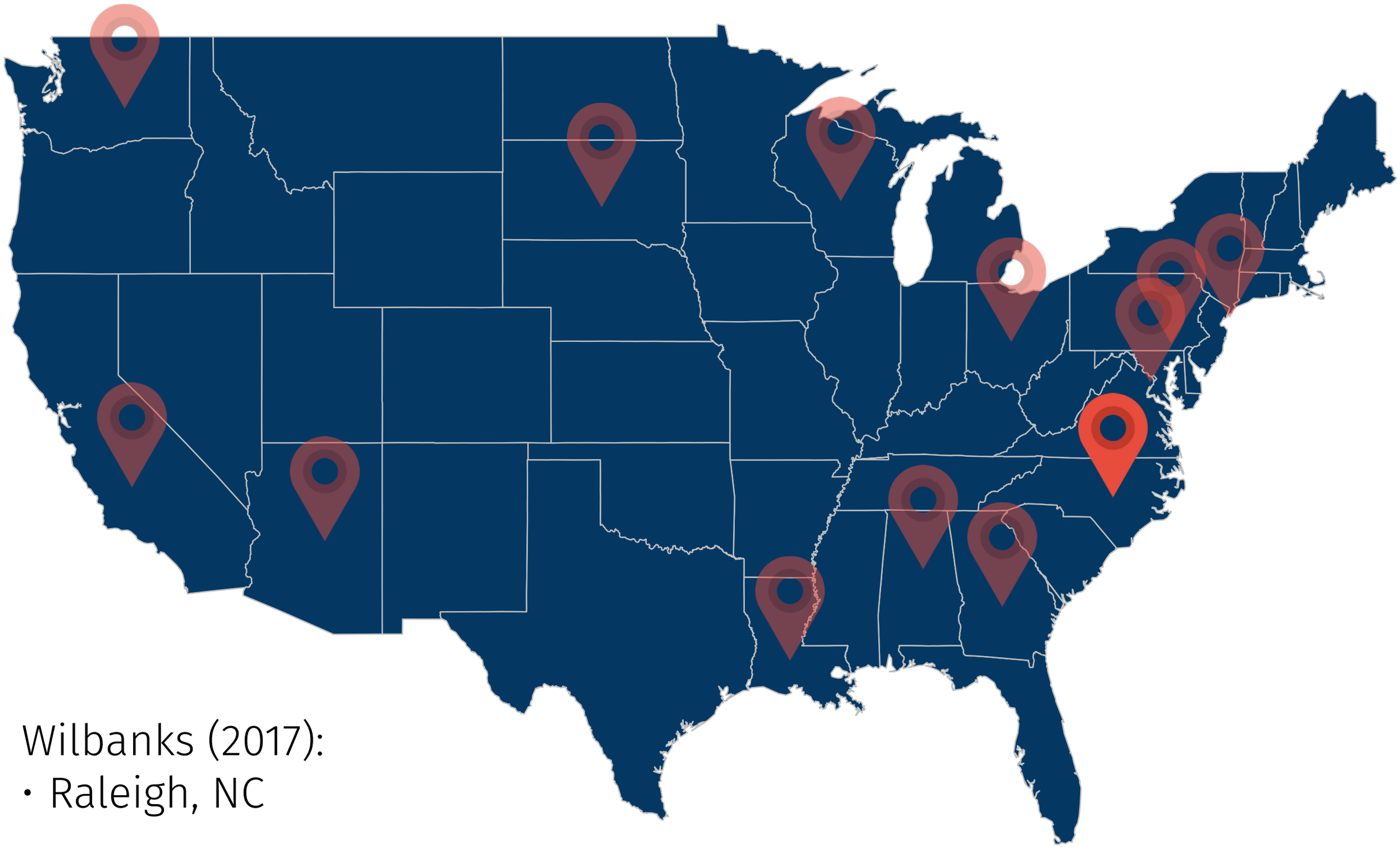
Geographic spread



Gylfadottir (2015):

- Philadelphia, PA

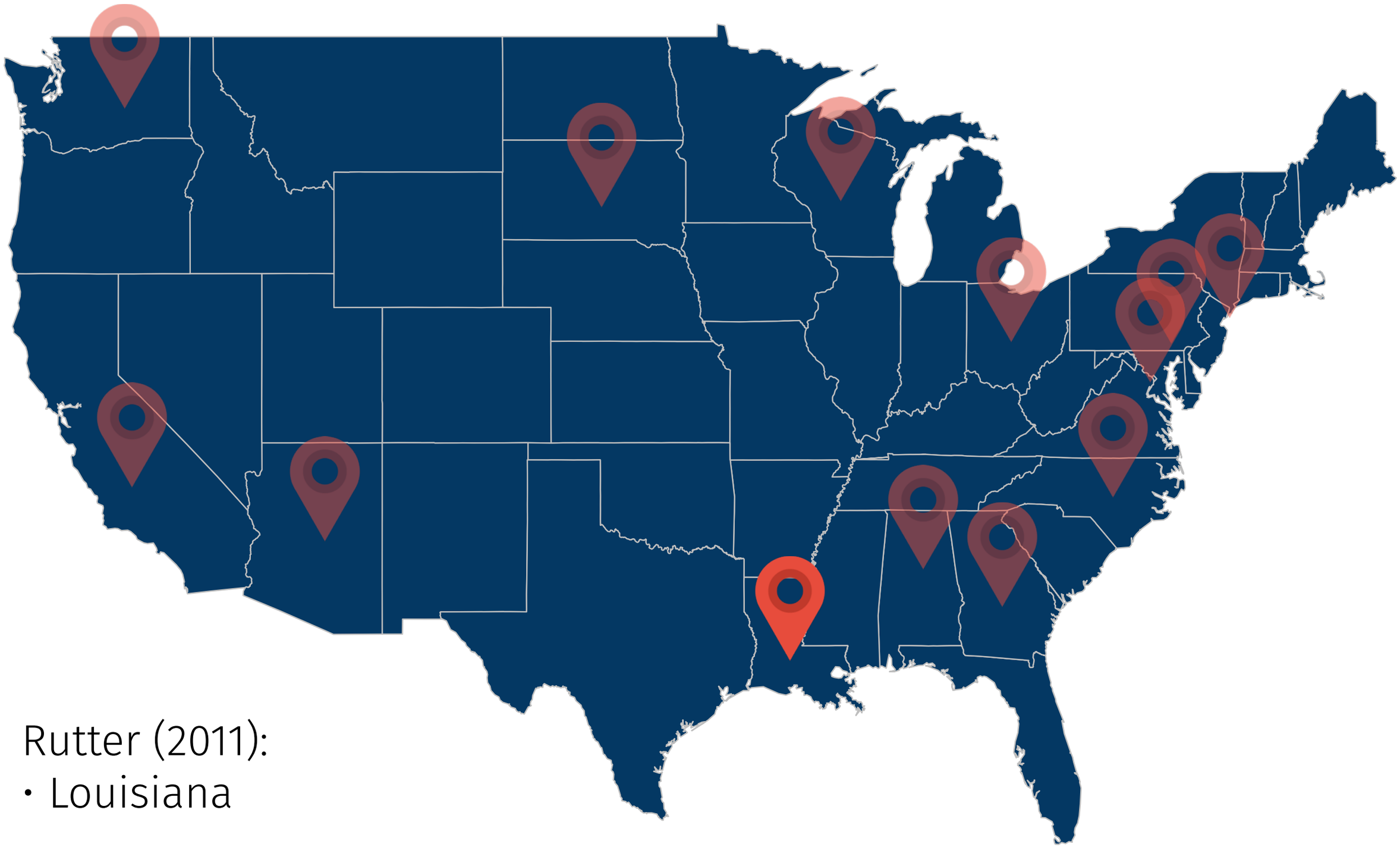
Geographic spread



Wilbanks (2017):

- Raleigh, NC

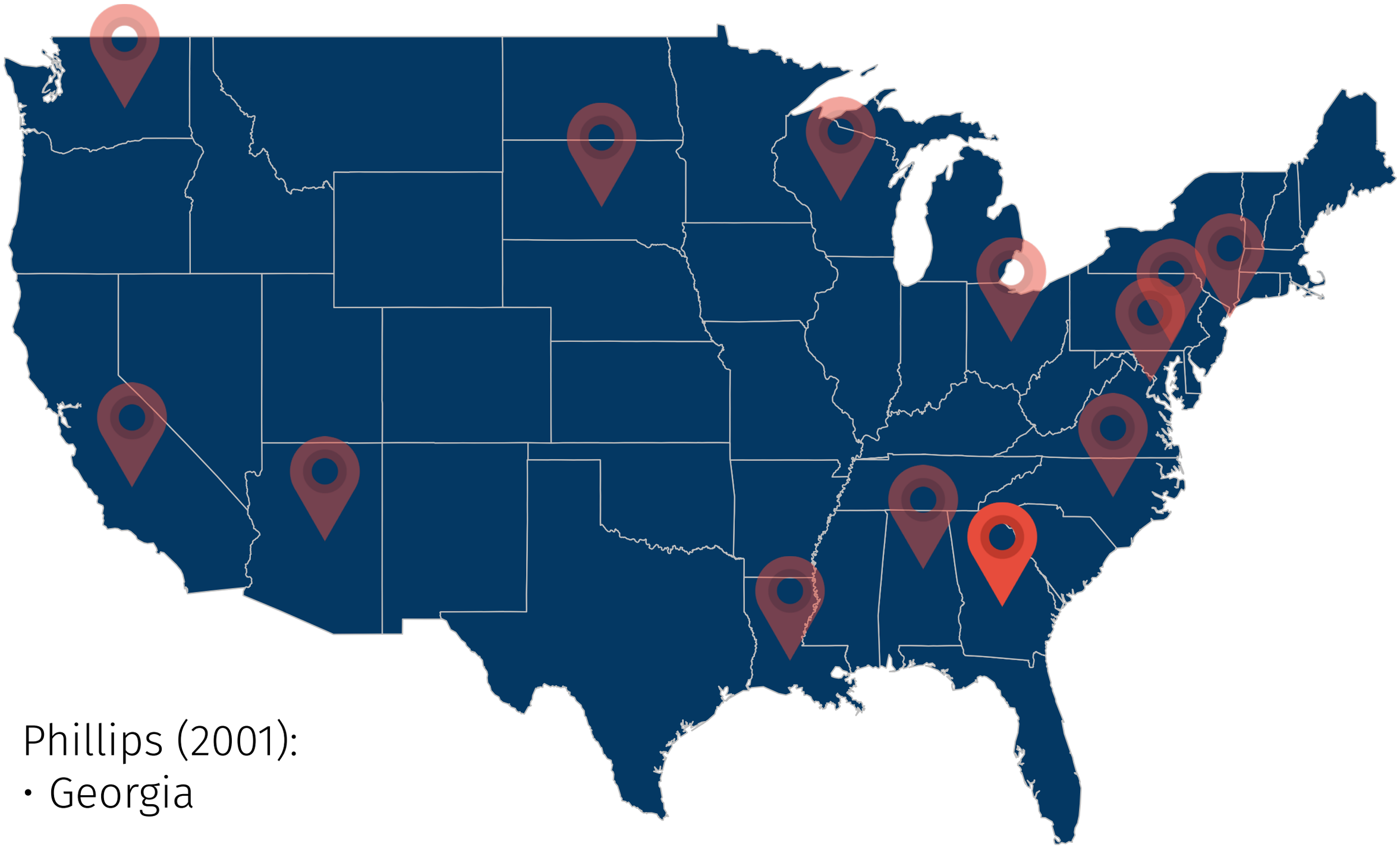
Geographic spread



Rutter (2011):

- Louisiana

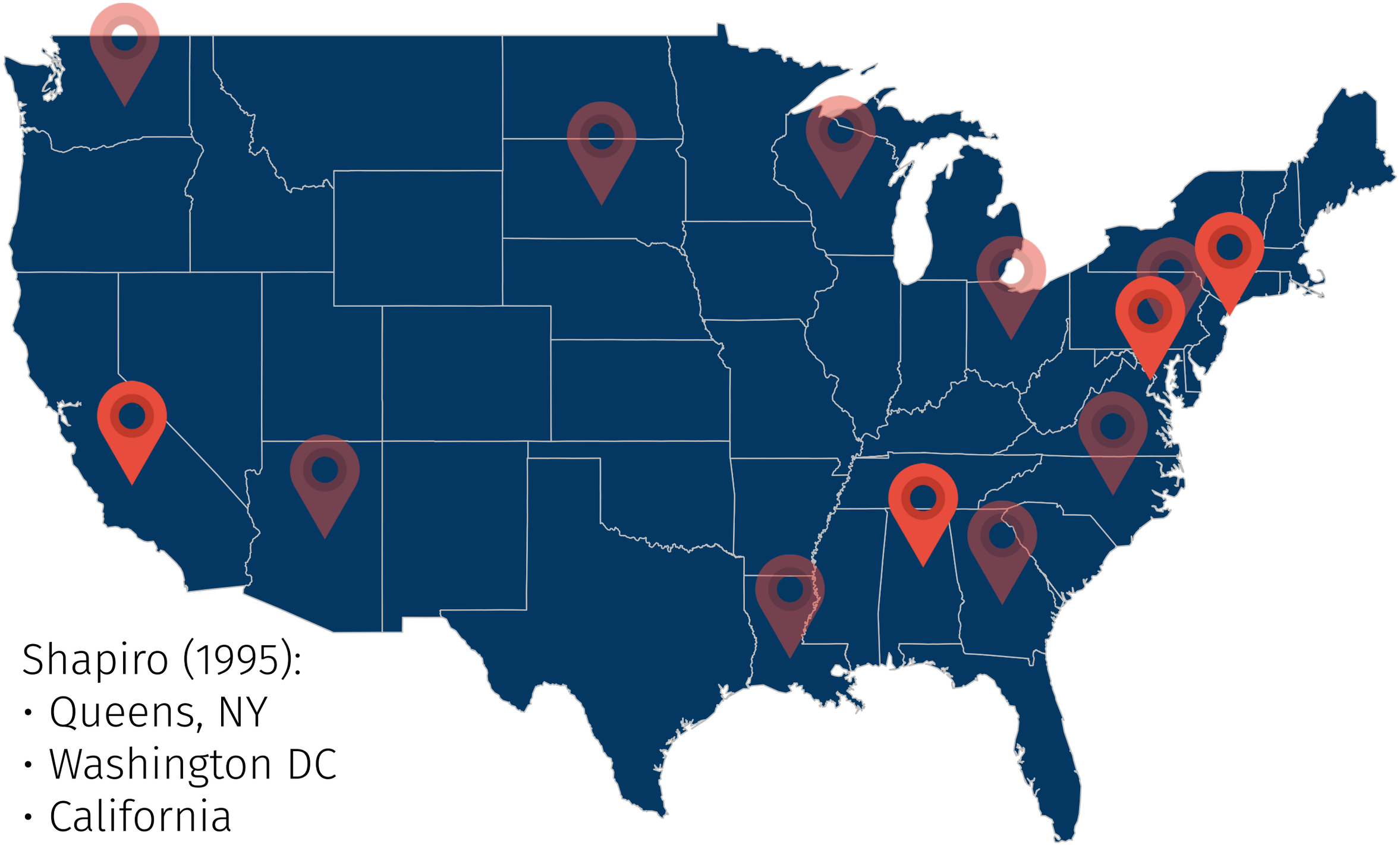
Geographic spread



Phillips (2001):

- Georgia

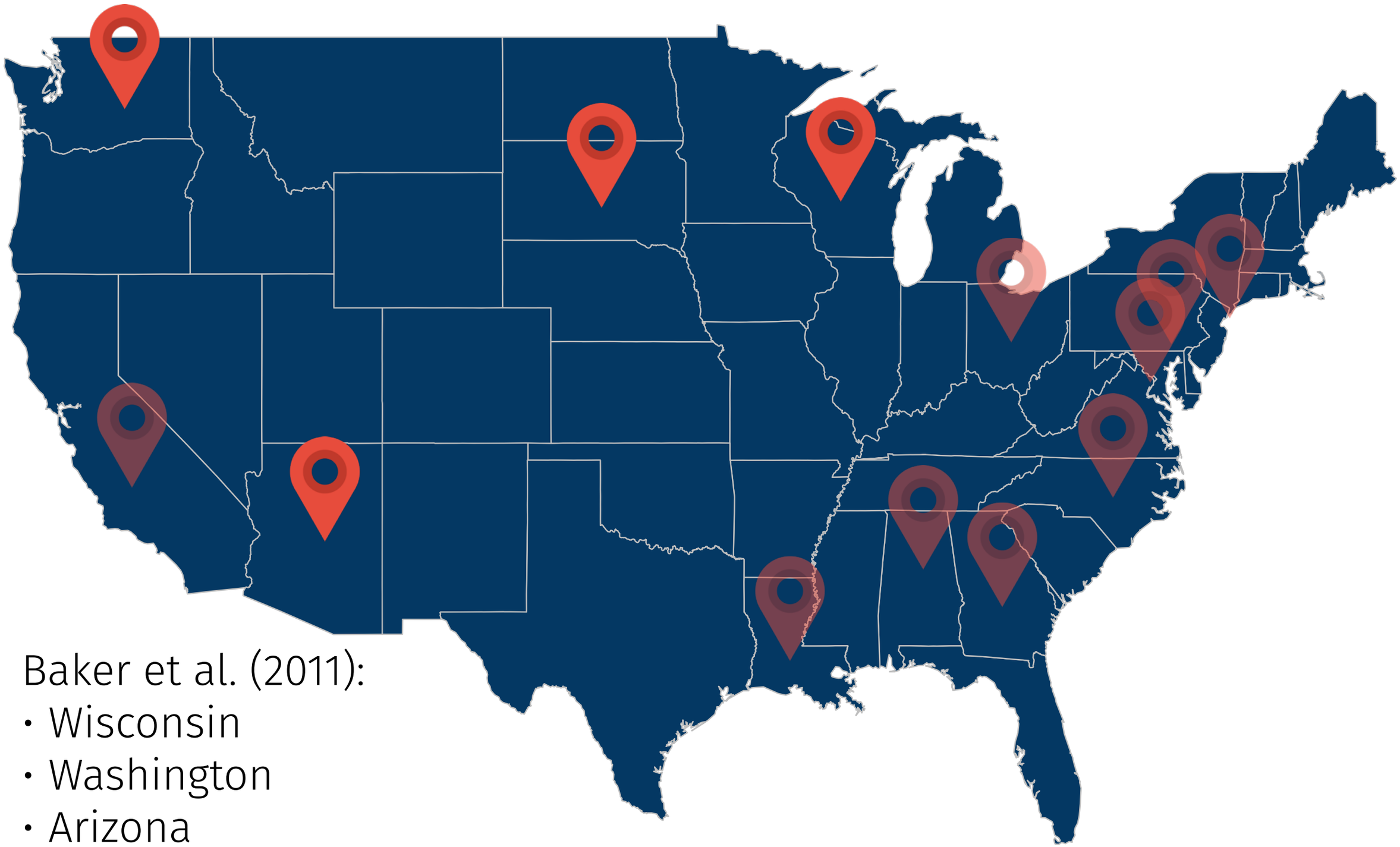
Geographic spread



Shapiro (1995):

- Queens, NY
- Washington DC
- California
- Birmingham, AL

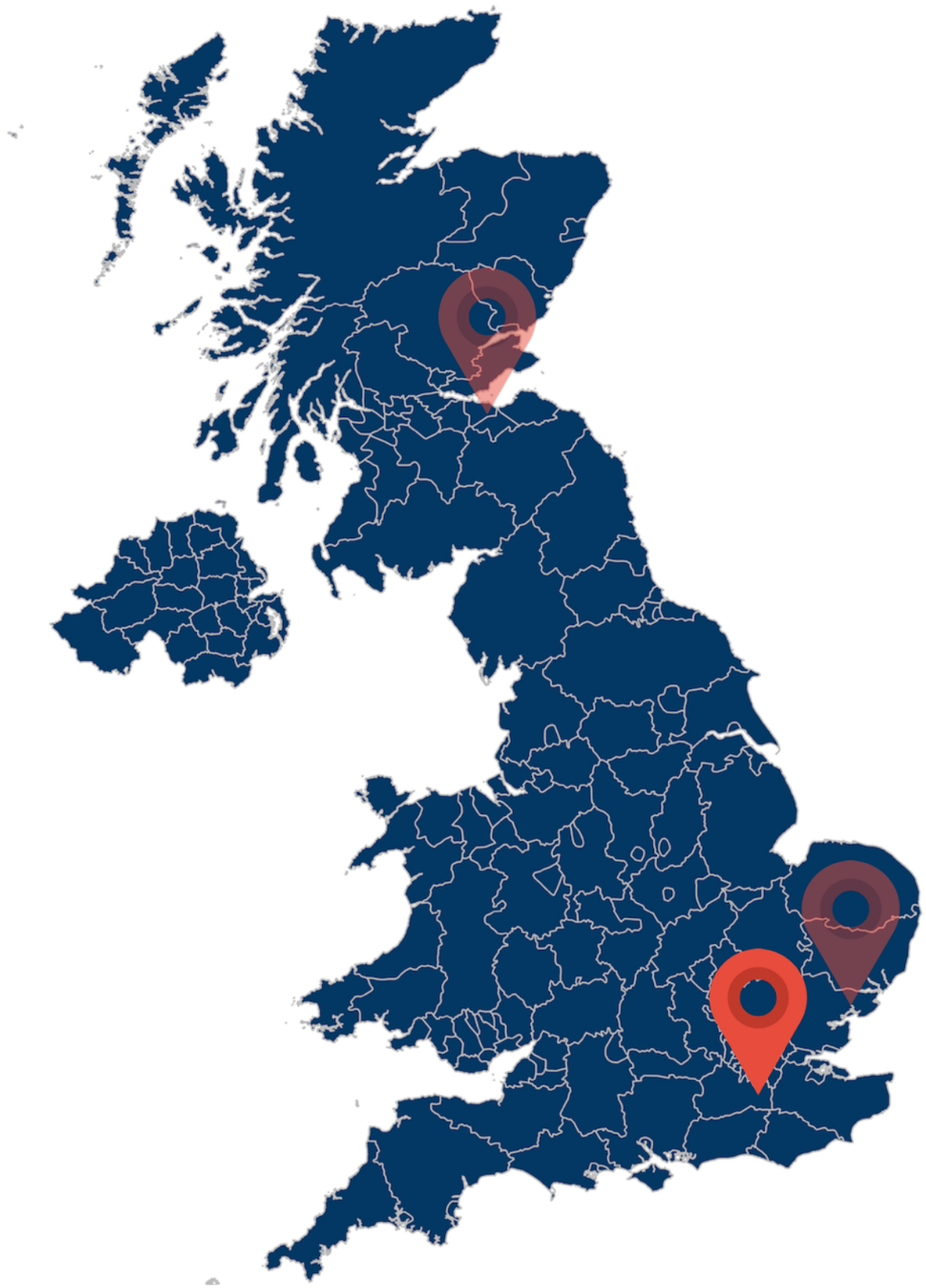
Geographic spread



Baker et al. (2011):

- Wisconsin
- Washington
- Arizona
- South Dakota

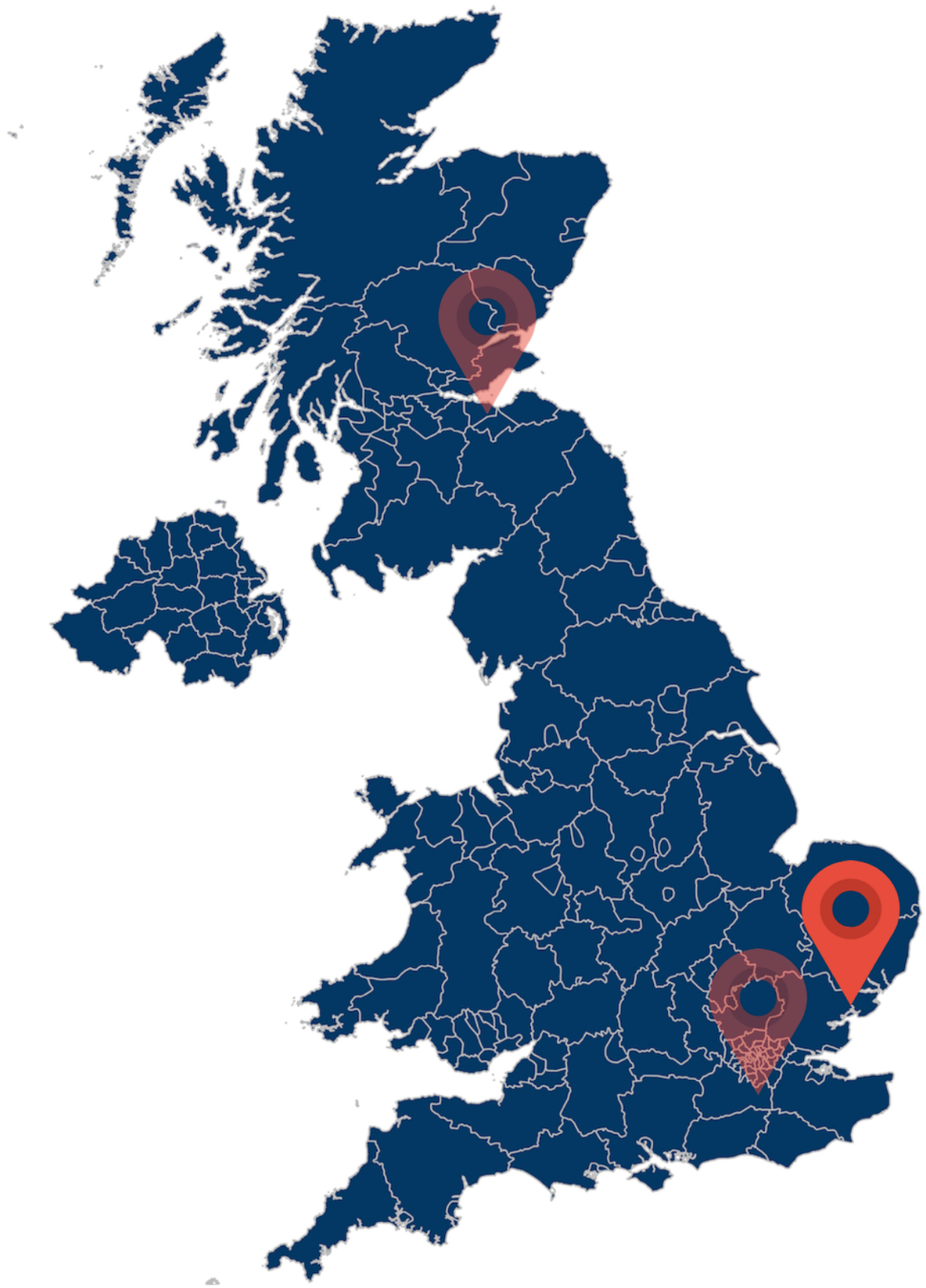
Geographic spread



Altendorf (2003):

- Estuary English

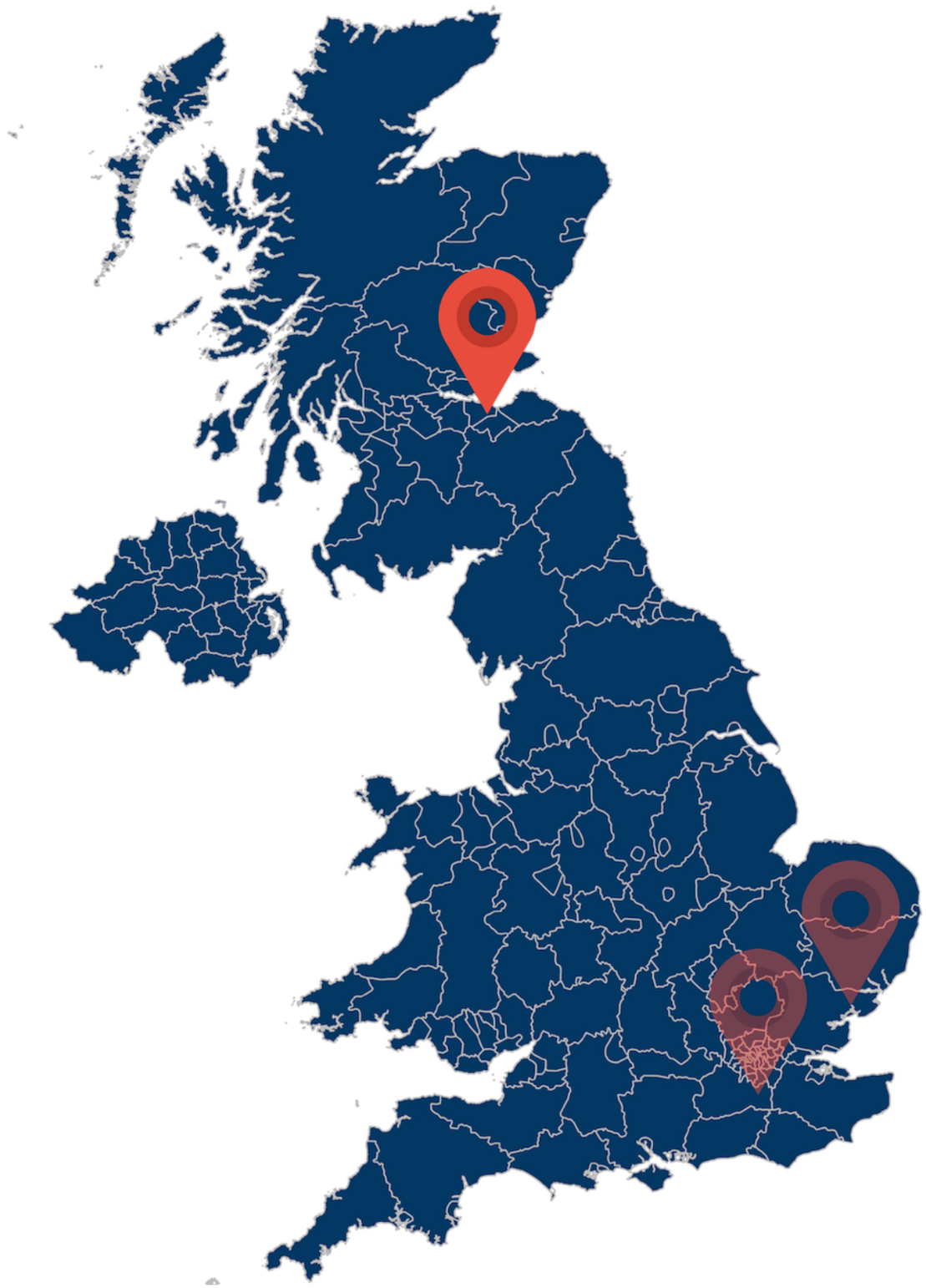
Geographic spread



Bass (2009):

- Colchester

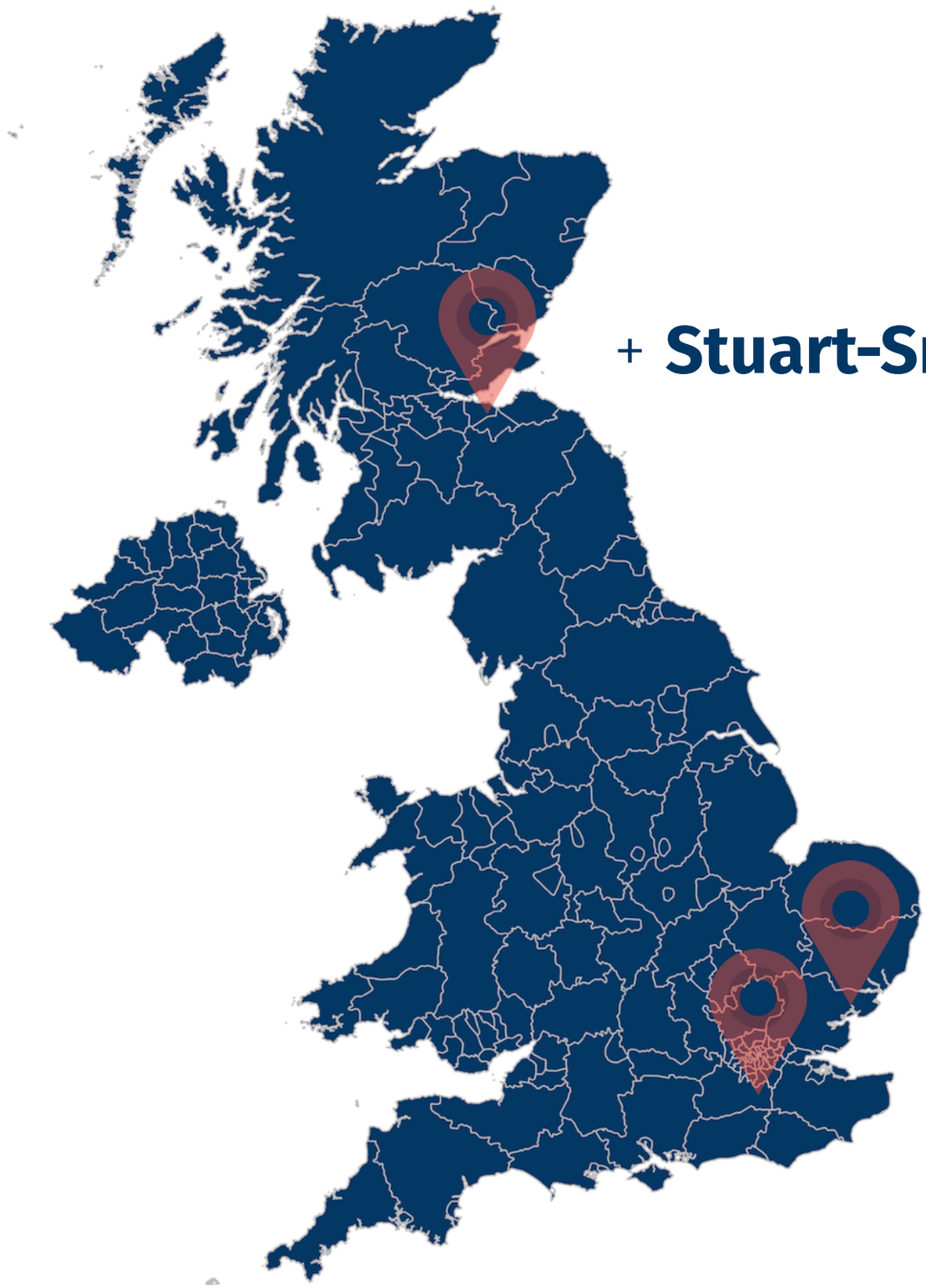
Geographic spread



Sollgan (2013):

- Edinburgh

Geographic spread



+ **Stuart-Smith et al. 2019!**

Geographic spread

This study:

Manchester

English

Phonetic realisation

- 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)
  - Rutter (2011) reports that a majority of retracted forms fall within a speaker's normal range for **[ʃ]**, with only limited evidence of intermediate forms
  - But Labov (2001) argues that there are 4 variants differing in how **[ʃ]**-like they are

RQ1

What is the exact phonetic nature of this process in BrE? Is the surface realisation of **/s/** in these contexts identical to an underlying **/ʃ/**?

Phonetic realisation

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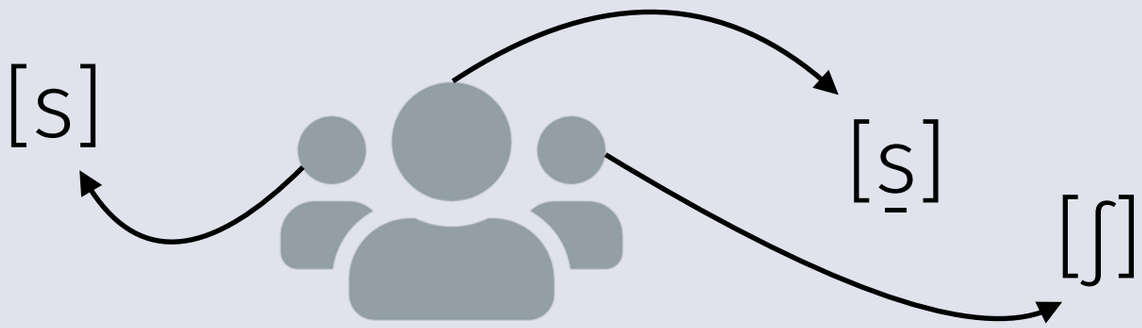
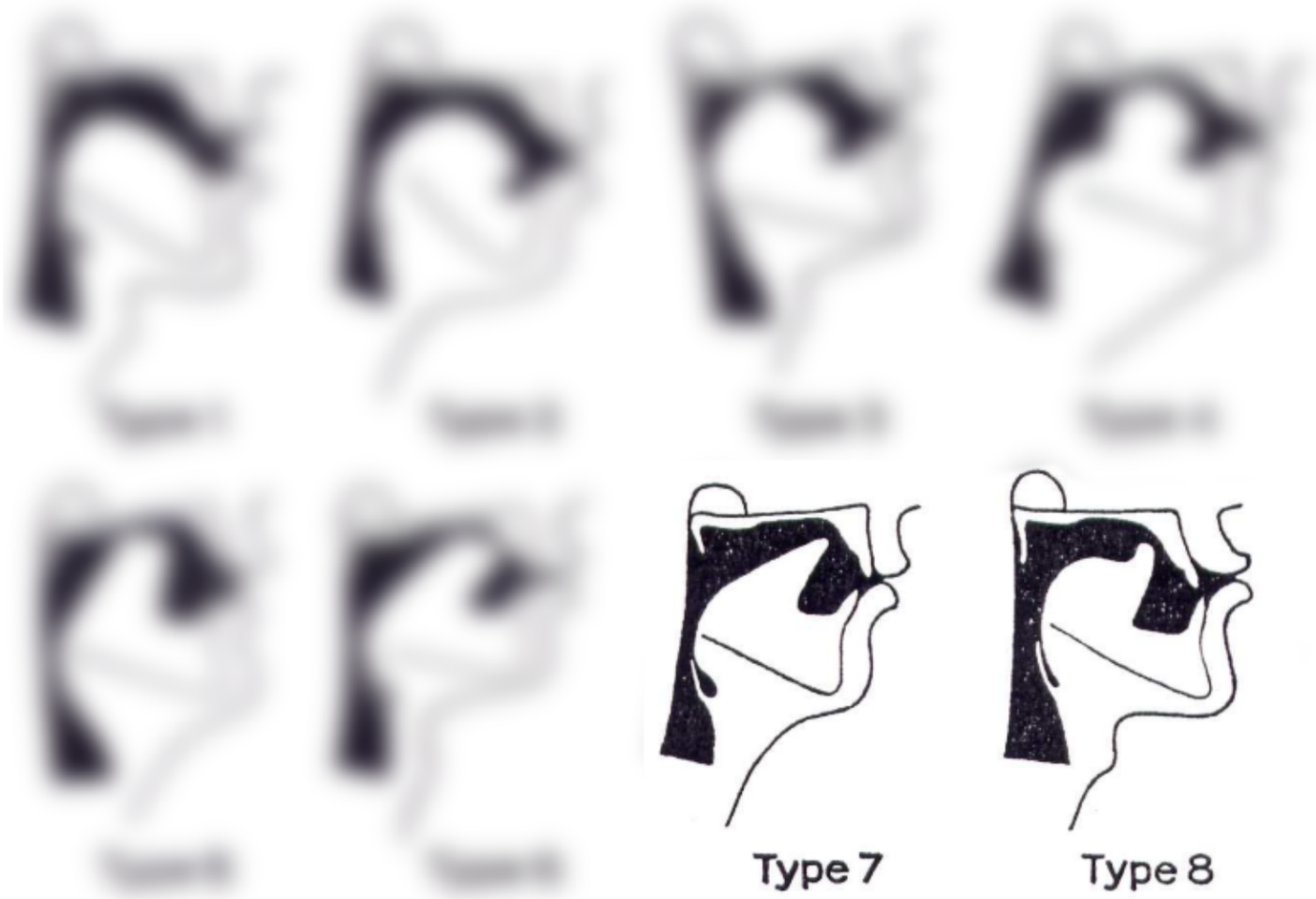
RQ1a

Is the magnitude of retraction subject to inter-speaker variation?



Articulatory mechanisms

- Characterised as **retraction**, based primarily on acoustic data
  - Notable exceptions are ultrasound studies by Mielke et al. (2010) and Baker et al. (2011)
- However, acoustics doesn't always have a one-to-one mapping with articulation
  - See e.g. Mielke et al. 2016 on **covert articulation** of **/ɹ/**



(Twist et al. 2007:208; figure adapted from Delattre & Freeman 1968:41)

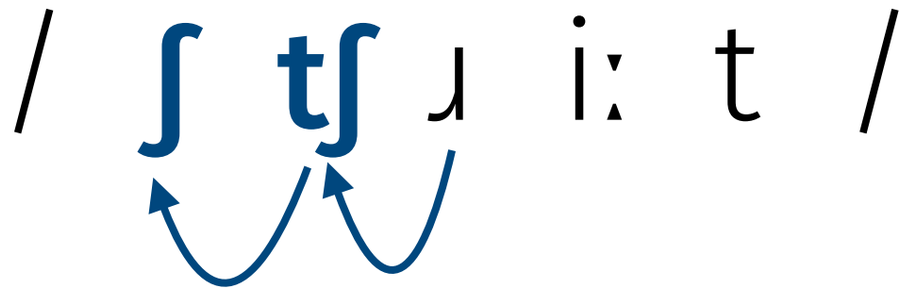
RQ2

What is the exact articulatory mechanism of s-retraction and how does this map onto the acoustic signal?

Phonetic motivations

Two competing accounts:

- **/s/** retracts far less in **/st/** clusters, e.g. *steep* (Shapiro 1995)
- coarticulatory bias towards retraction in other **/sCɹ/** clusters (Baker et al. 2011)
- alveolar realisations of **/ɹ/** rarely co-occur with retracted **/s/** (Sollgan 2013)



- **/t/** is always affricated when **/s/** is retracted in **/stɹ/** (Lawrence 2000)
- Pre-**/ɹ/** affrication of **/t/** is widespread in varieties of English (Cruttenden 2014:189-92)
- **/t/** also affricates before **/j/**, e.g. [tʃʉːn], accounting for retraction in **/stj/**

RQ3

Which of the two competing accounts of the triggering mechanisms finds the most empirical support in BrE?

This talk

- Two parts to this investigation of Manchester English

Individual variation in articulatory strategies

Variation and change in the **speech community**

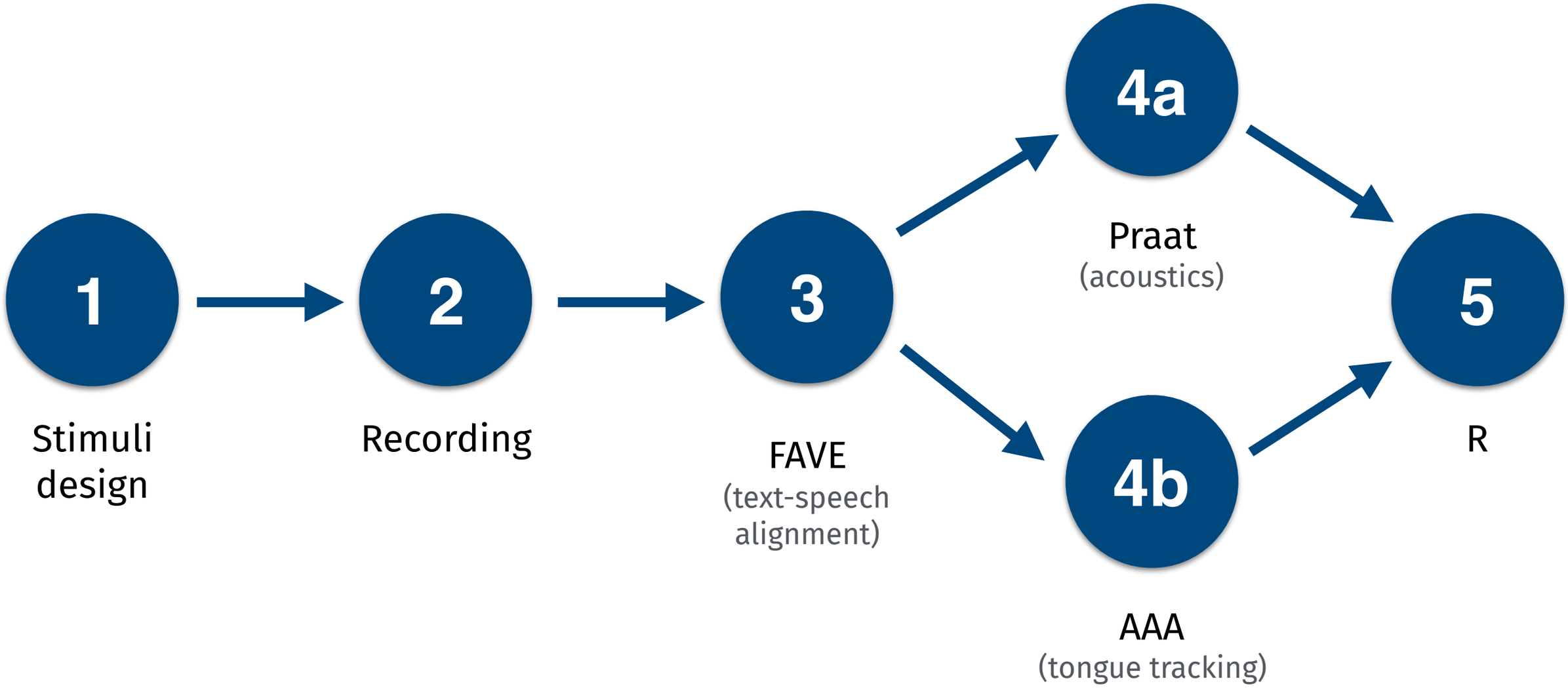
RQ4

What insight can we gain from a large-scale community-level study?

INDIVIDUAL VARIATION

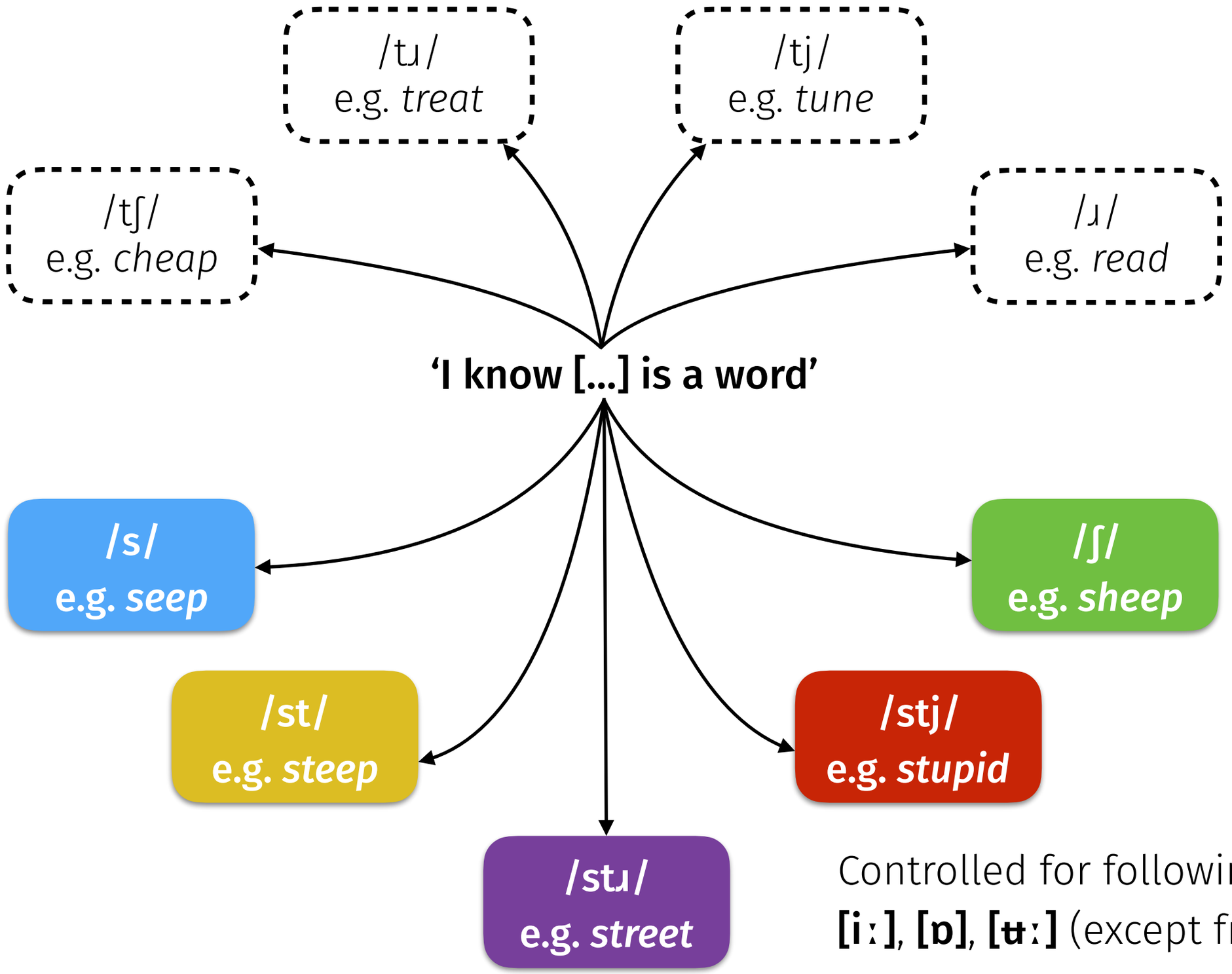
METHODOLOGY

Workflow


1
Stimuli design
2
Recording
3
FAVE
(text-speech alignment)
4a
Praat
(acoustics)
4b
AAA
(tongue tracking)
5
R

Stimuli

- Various word-initial contexts embedded in a carrier sentence

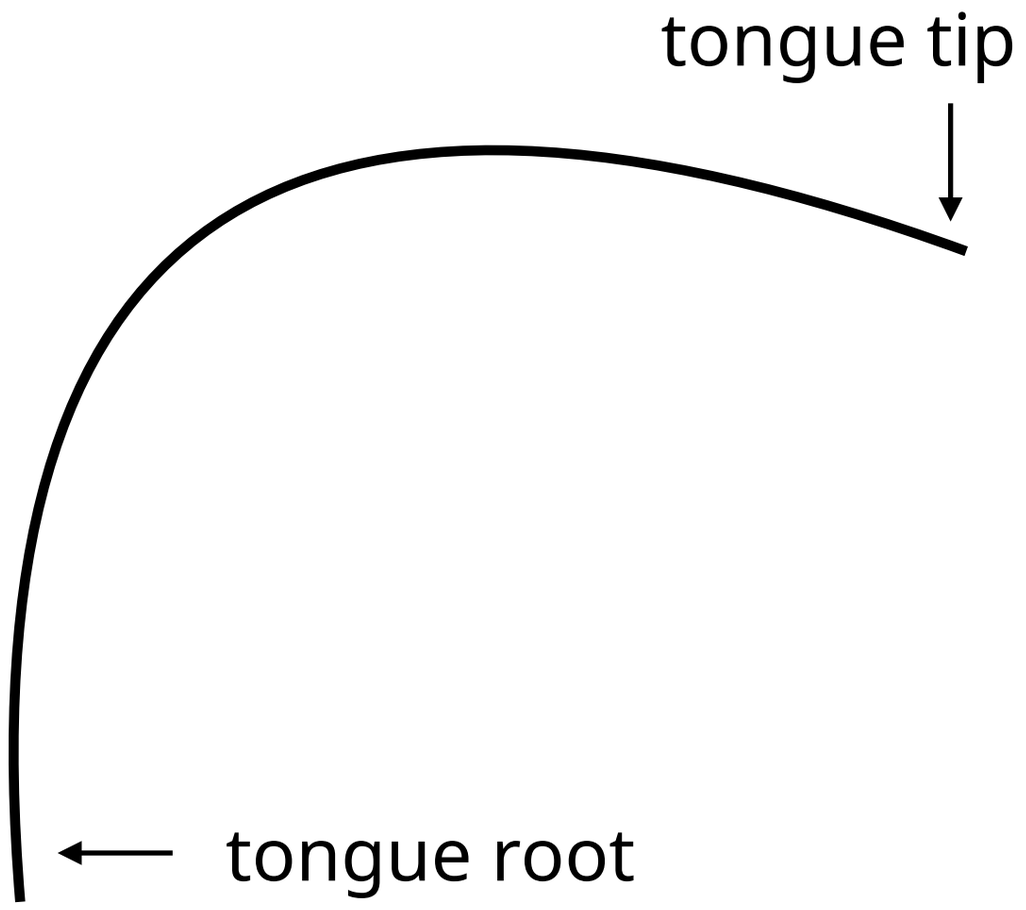


Controlled for following vowel:
[iː], **[ɒ]**, **[ʉː]** (except from **/(s)tj/**)

Recording

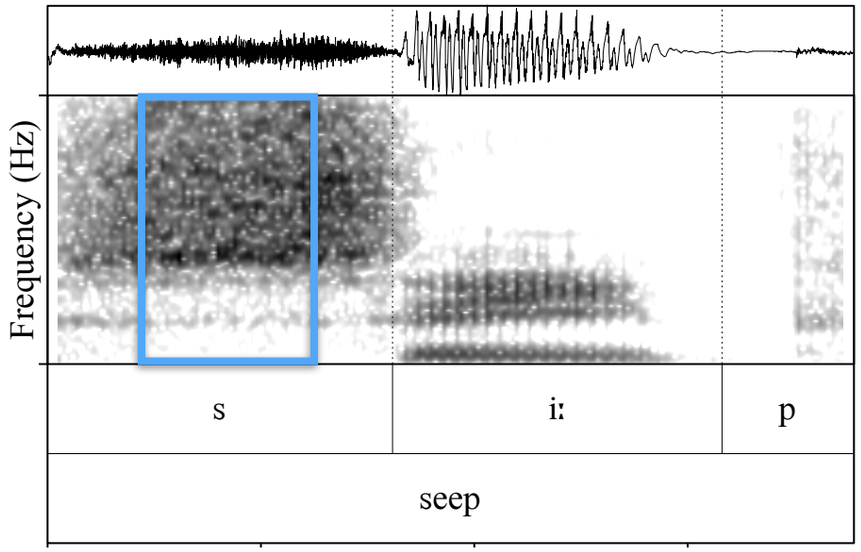
- Synchronised UTI (60fps) and audio recording (lavalier mic)
  - Mid-sagittal view
  - Stabilised with headcage
  - 5 repetitions per token (130 sentences in total)
- Currently 8 speakers (3M; 5F) aged 18-26

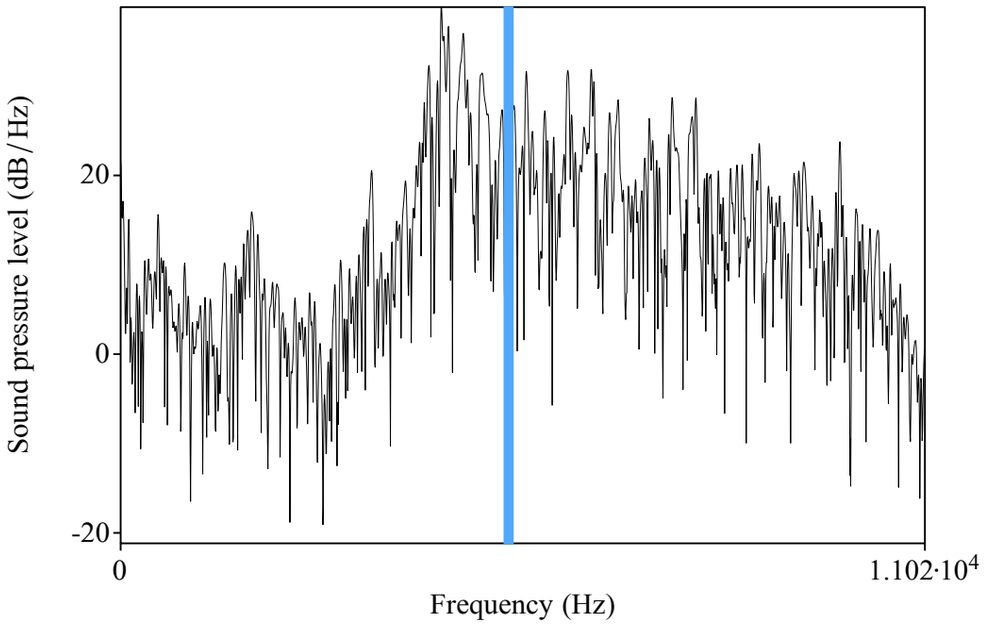
  - All born (or at least raised from age 4) in Greater Manchester
    - but in some cases parents aren't from Manchester (or even England)



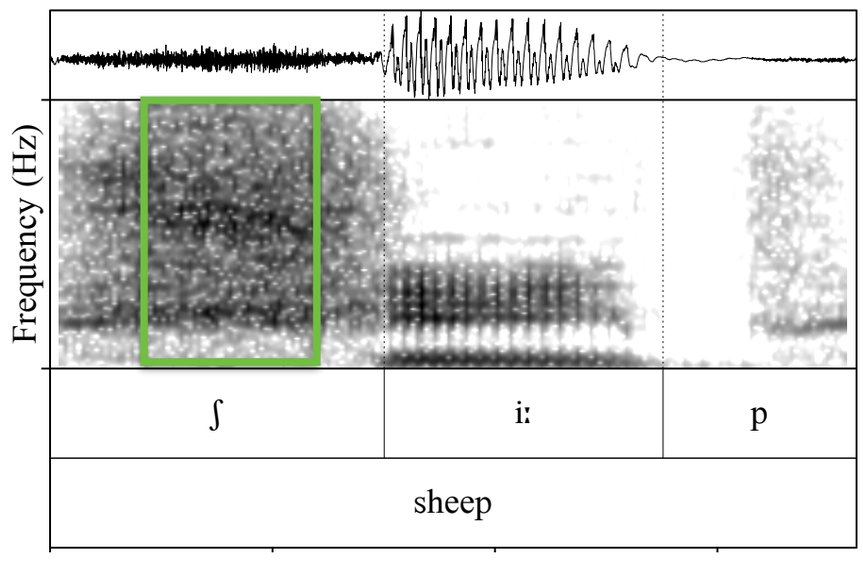
Acoustic data analysis

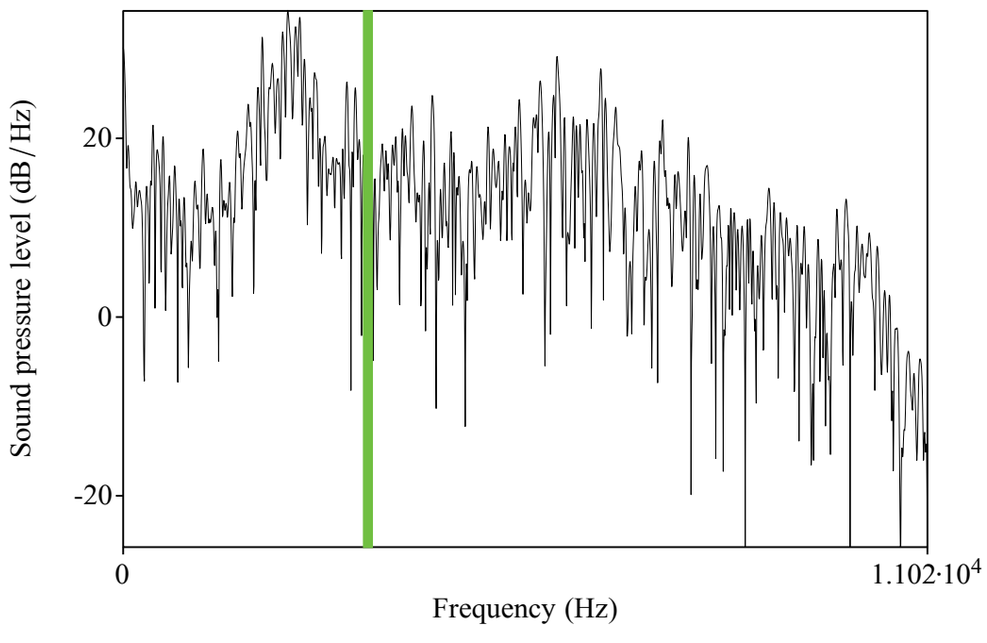
- For each fricative, we extract a “spectral slice” using a Praat script (DiCanio 2017):
  - Then calculate the **centre of gravity** (CoG) - a single-point spectral mean, where higher values are more /s/-like, and lower values are more /ʃ/-like (Jongman et al. 2000)





/s/ CoG: 5358Hz

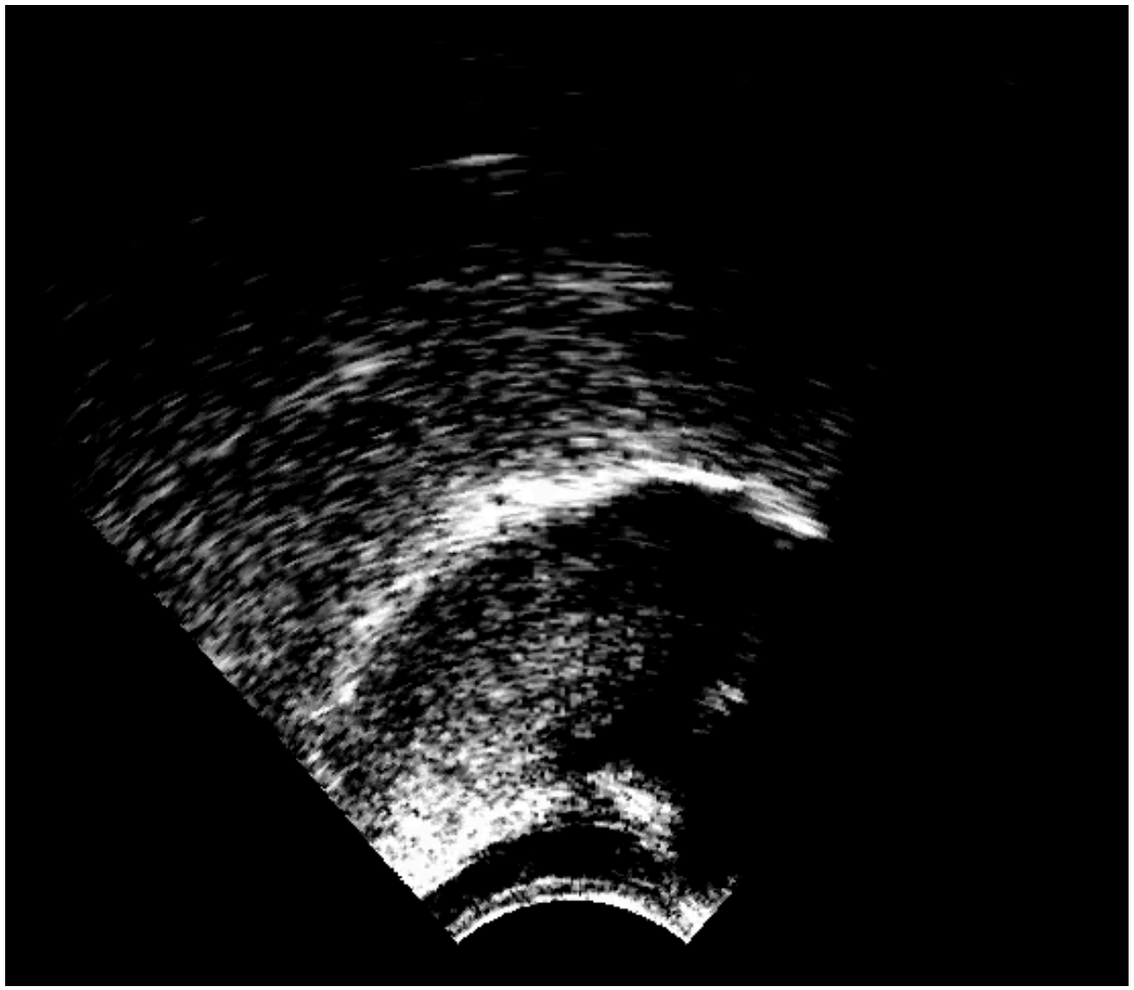




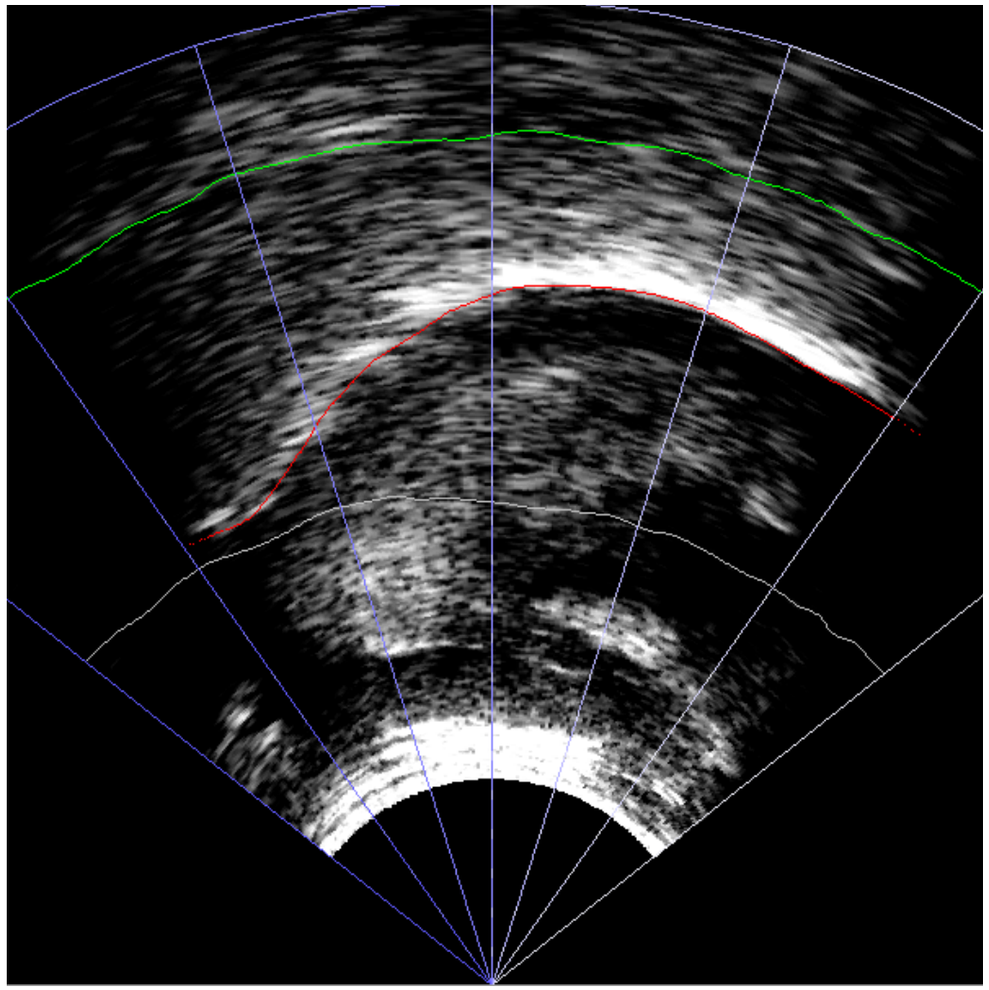
/ʃ/ CoG: 3307Hz

Articulatory data analysis

- Tongue splines tracked and exported using AAA (Articulate Instruments Ltd. 2011)

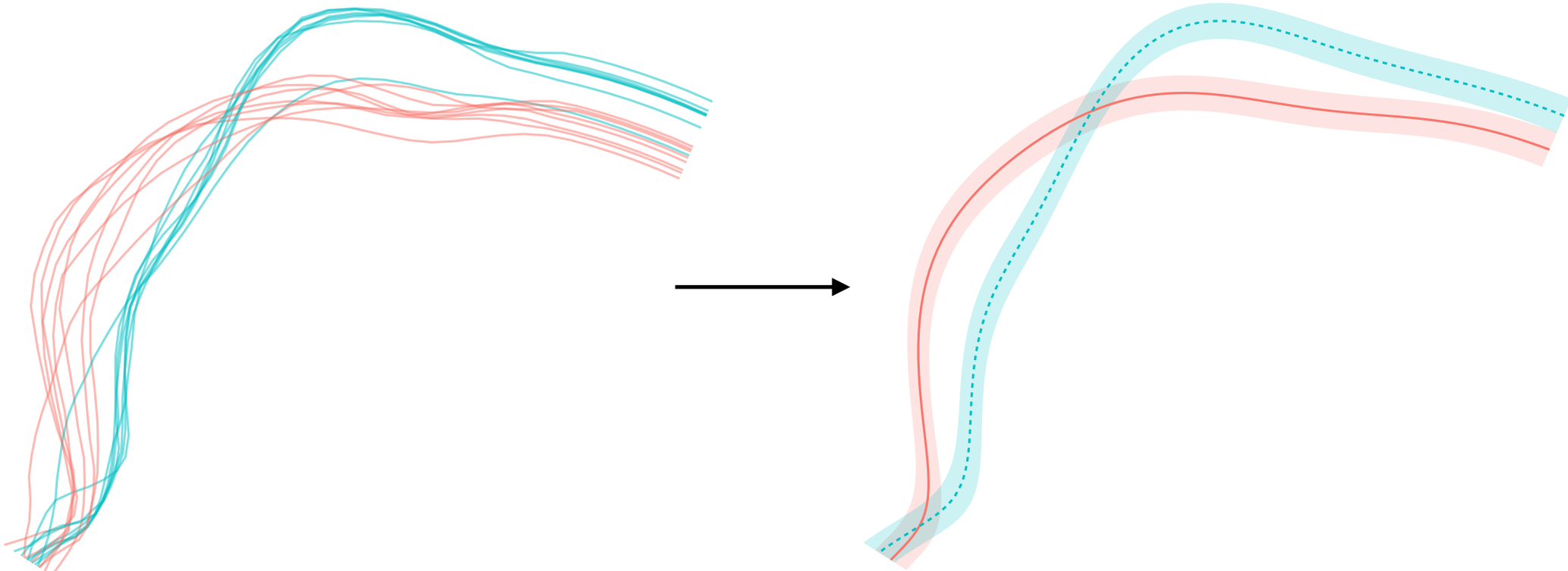


(example clip of ultrasound footage from AAA)



(with palate trace, tongue tracking and fan lines)

Statistical methods



- **Ultrasound**
  - Modelled with *GAMMs* (*generalised additive mixed models*) using `rticulate` and `tidymv` packages (Coretta 2017, 2018)
  - Ideal for modelling non-linear effects in dynamic (time/space) data (see Sóskuthy 2017 and references therein)
- **Acoustics**
  - *Mixed-effects linear regression* for CoG measures with `lme4` package (Bates et al. 2015)

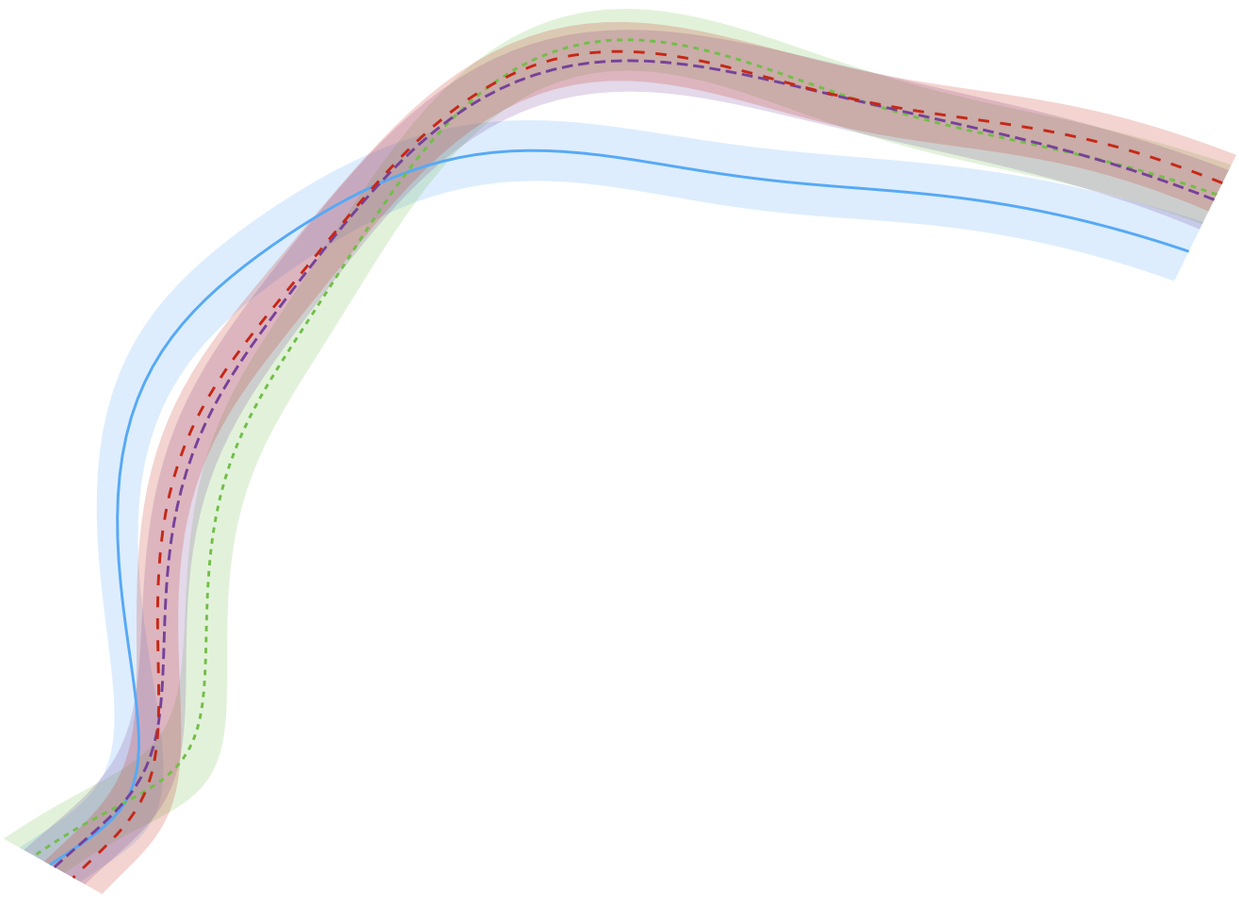
INDIVIDUAL VARIATION

ARTICULATION

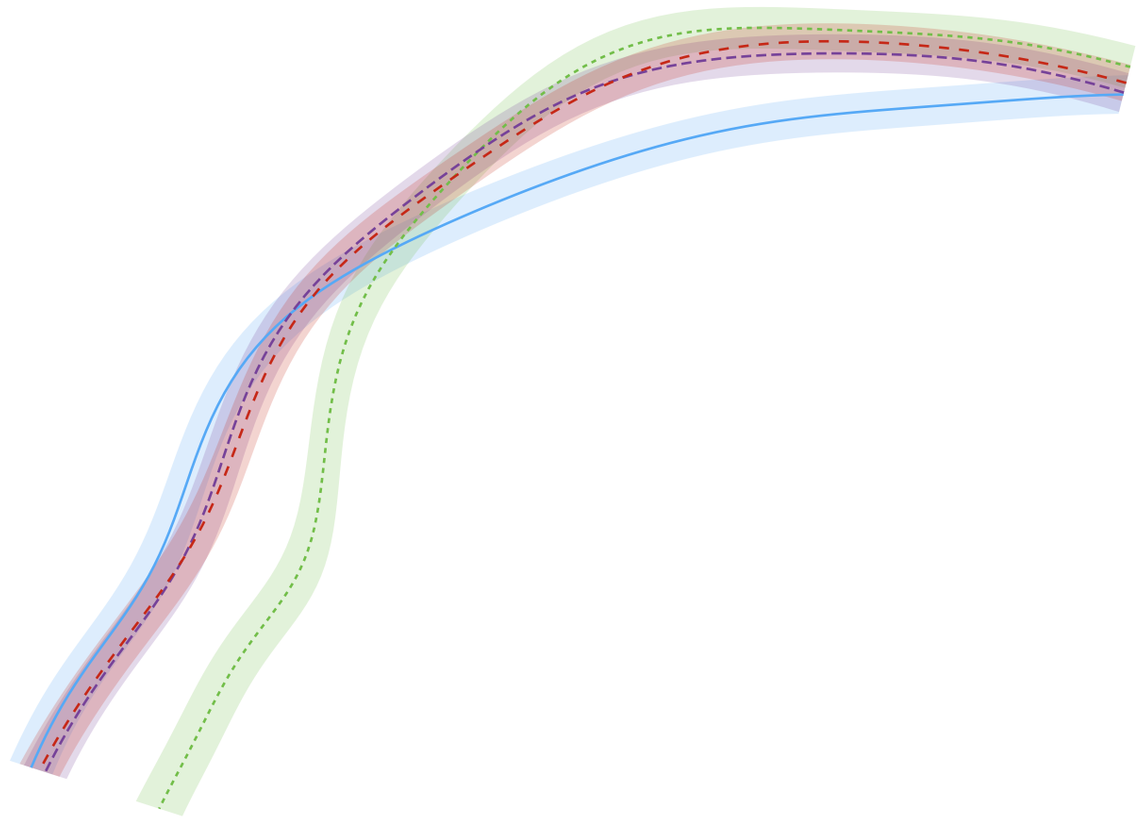
Articulation

/s/ /stɹ/ /stj/ /ʃ/

M01



M02

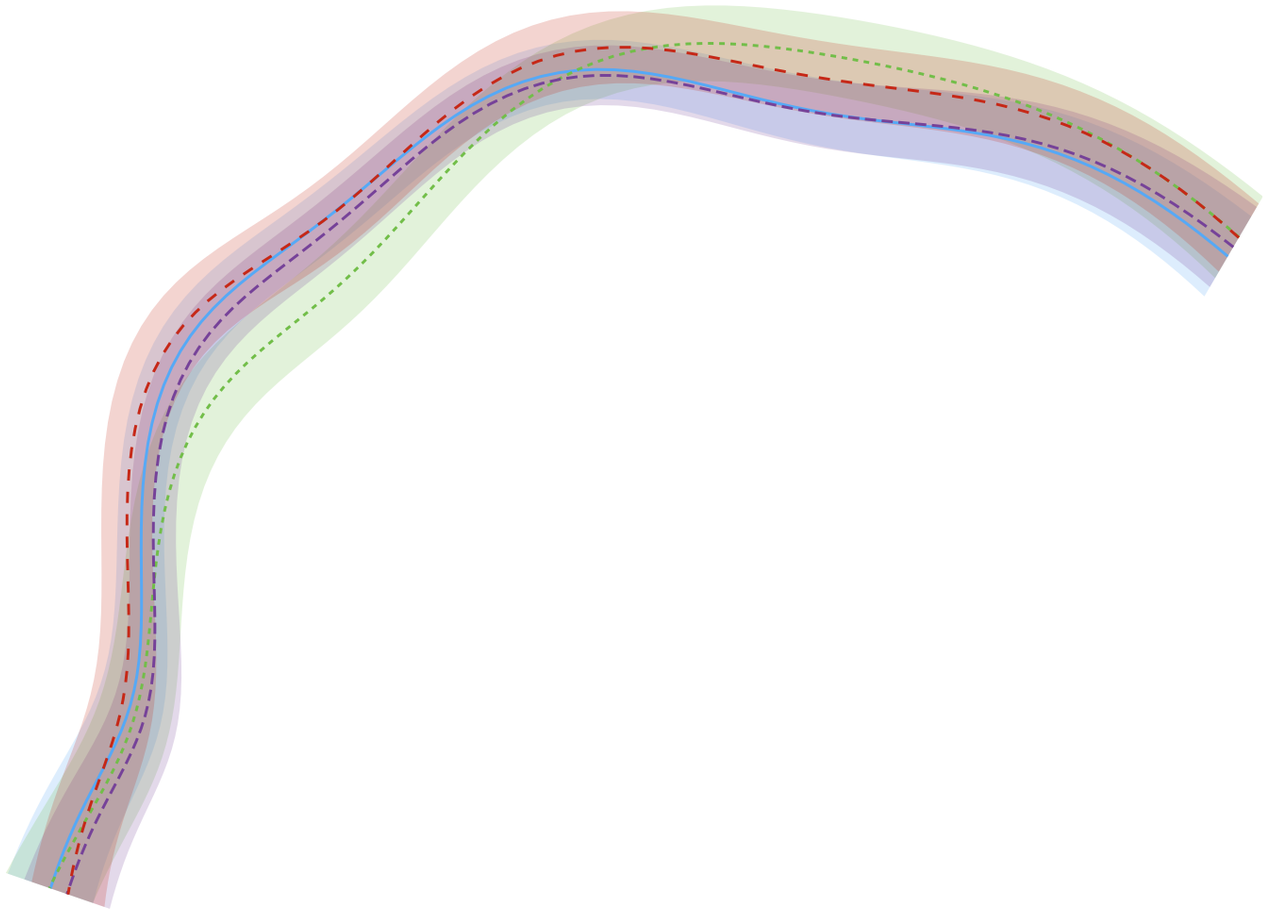


Clear bimodality for tongue body: /ʃ/-/stɹ/-/stj/ v. /s/

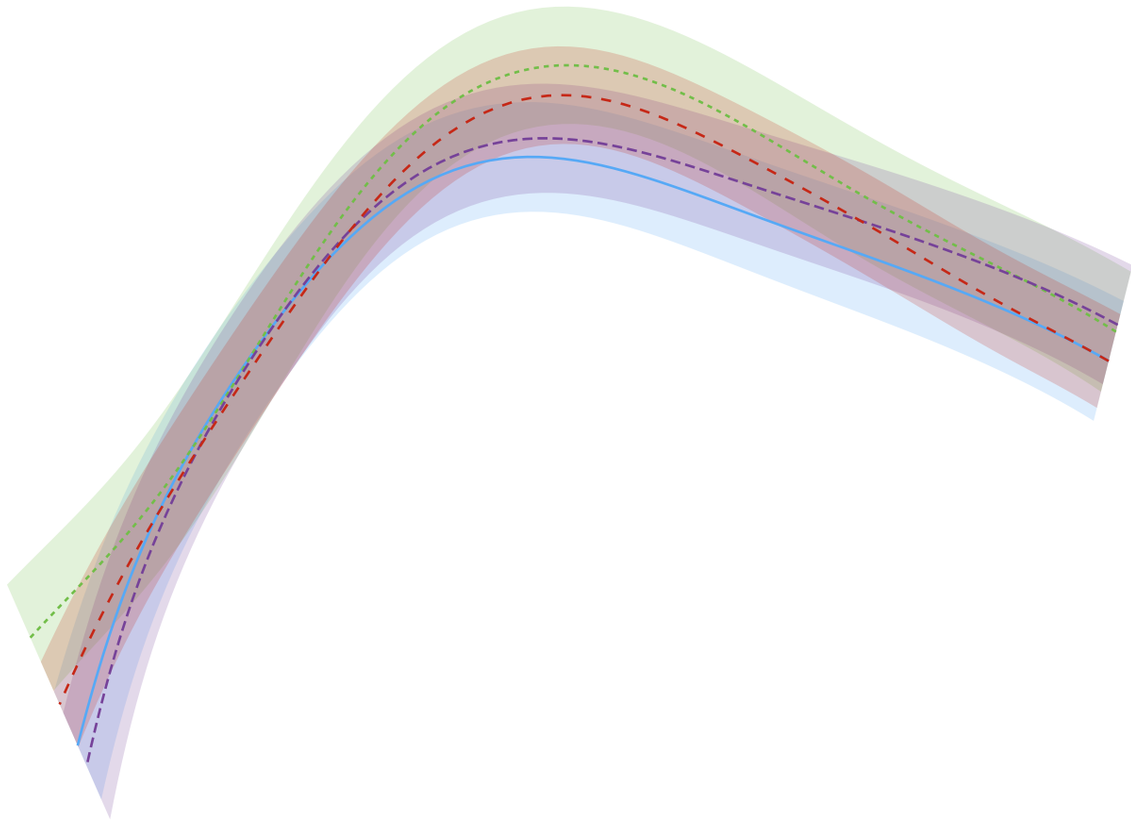
Articulation

/s/ /stɹ/ /stj/ /ʃ/

F01



M03



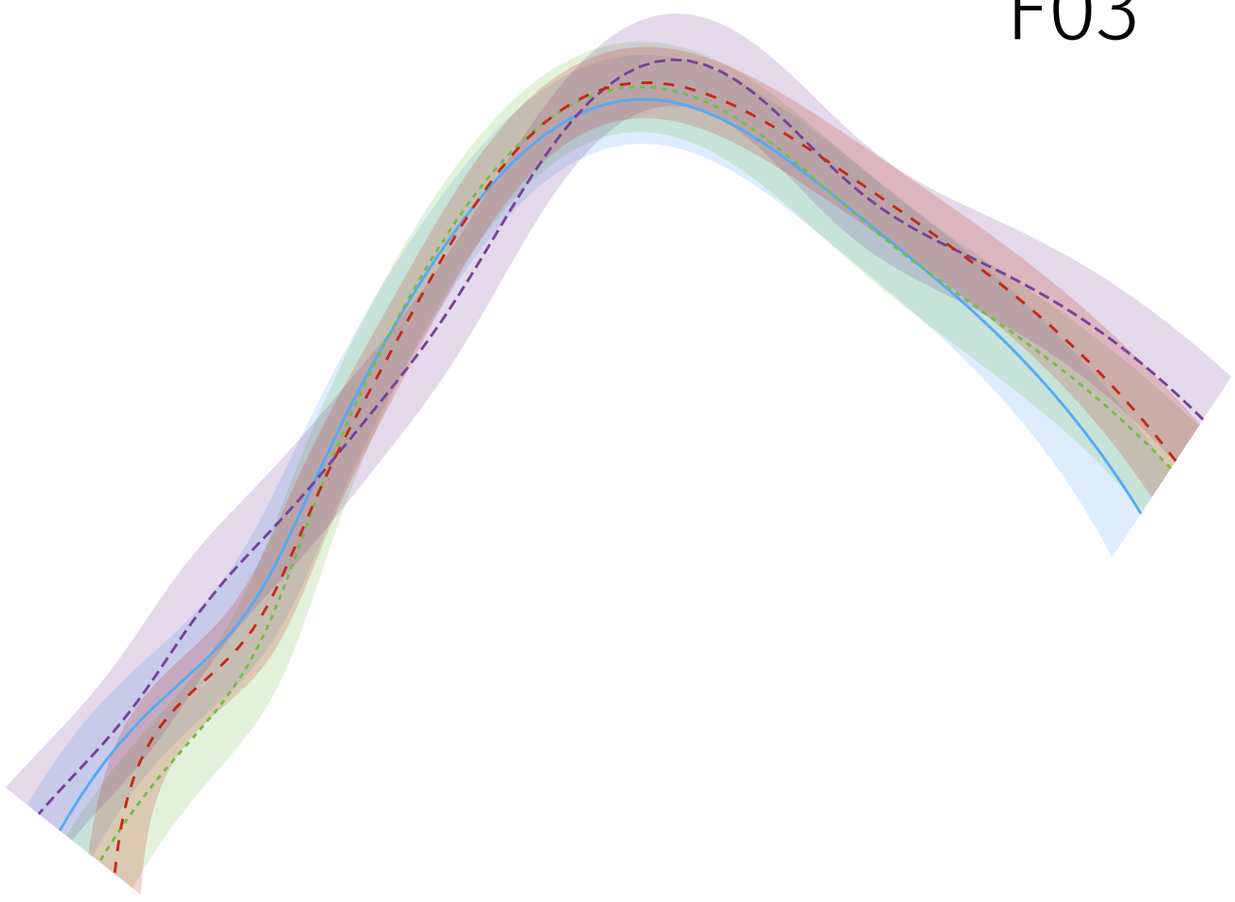
Tongue body for **/stj/** largely overlapping with **/ʃ/**

Though **/stɹ/** more similar to **/s/** than **/ʃ/**

Articulation

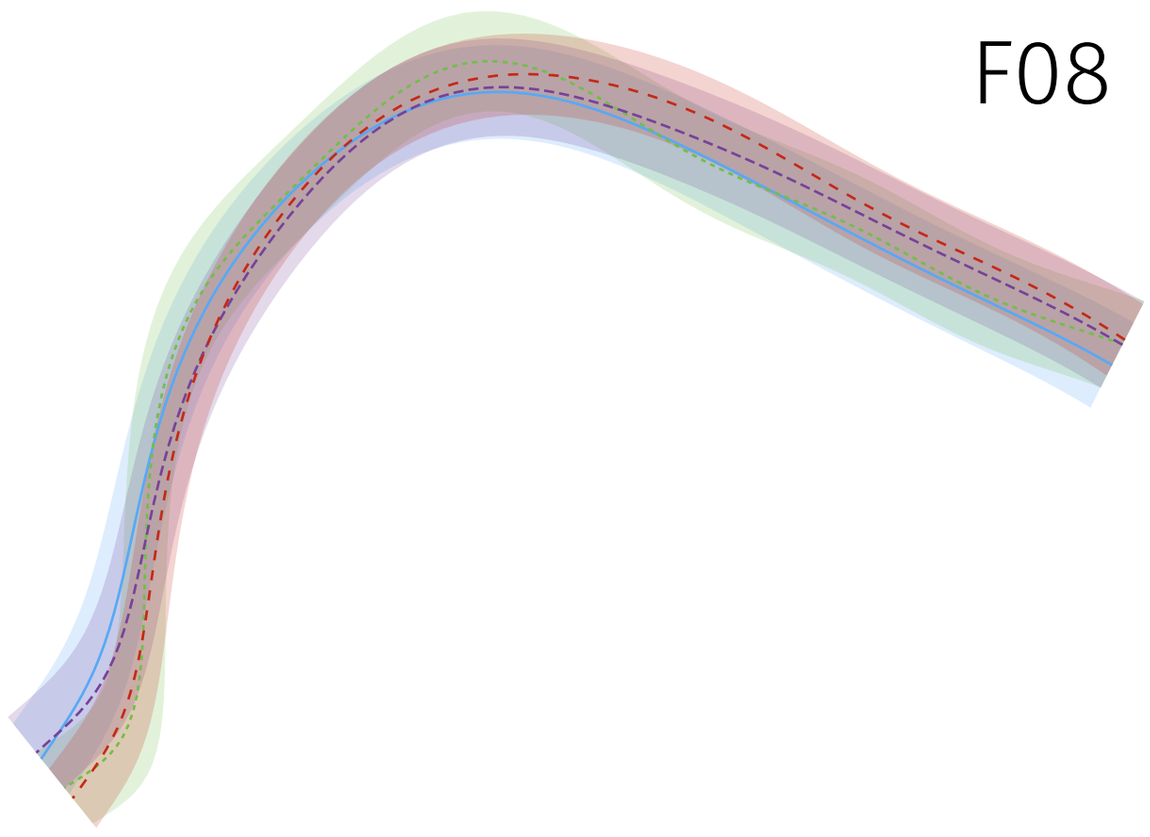
/s/ /stɹ/ /stj/ /ʃ/

F03



(also F06 and F07)

F08

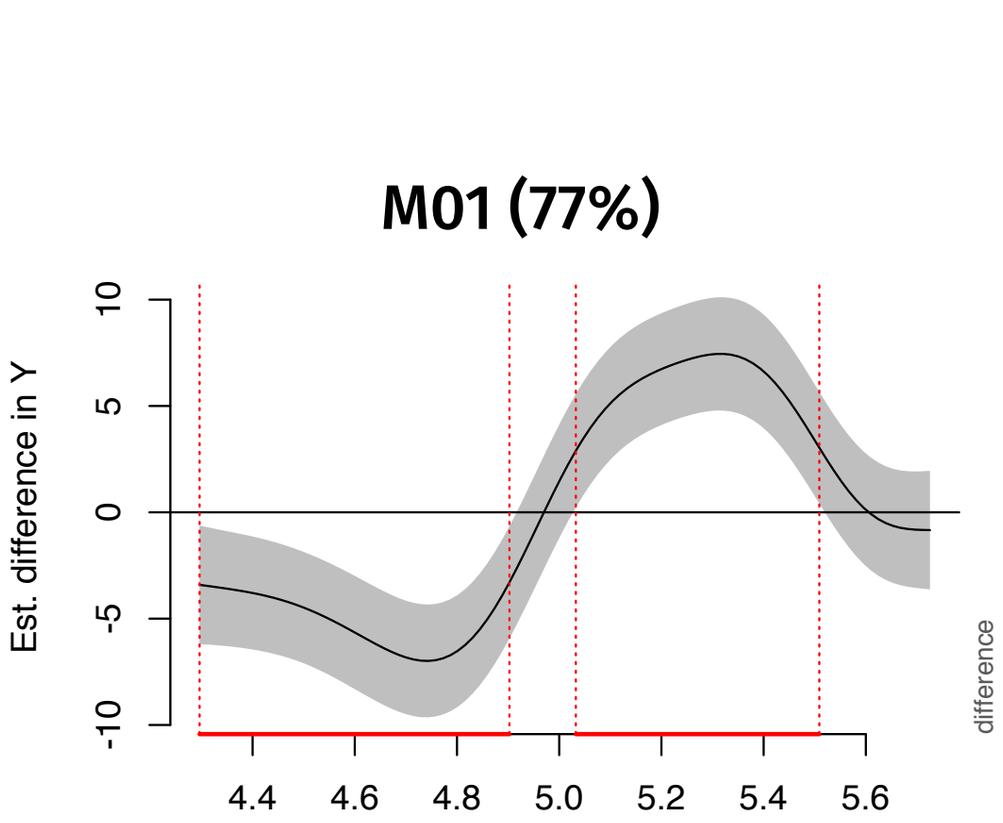


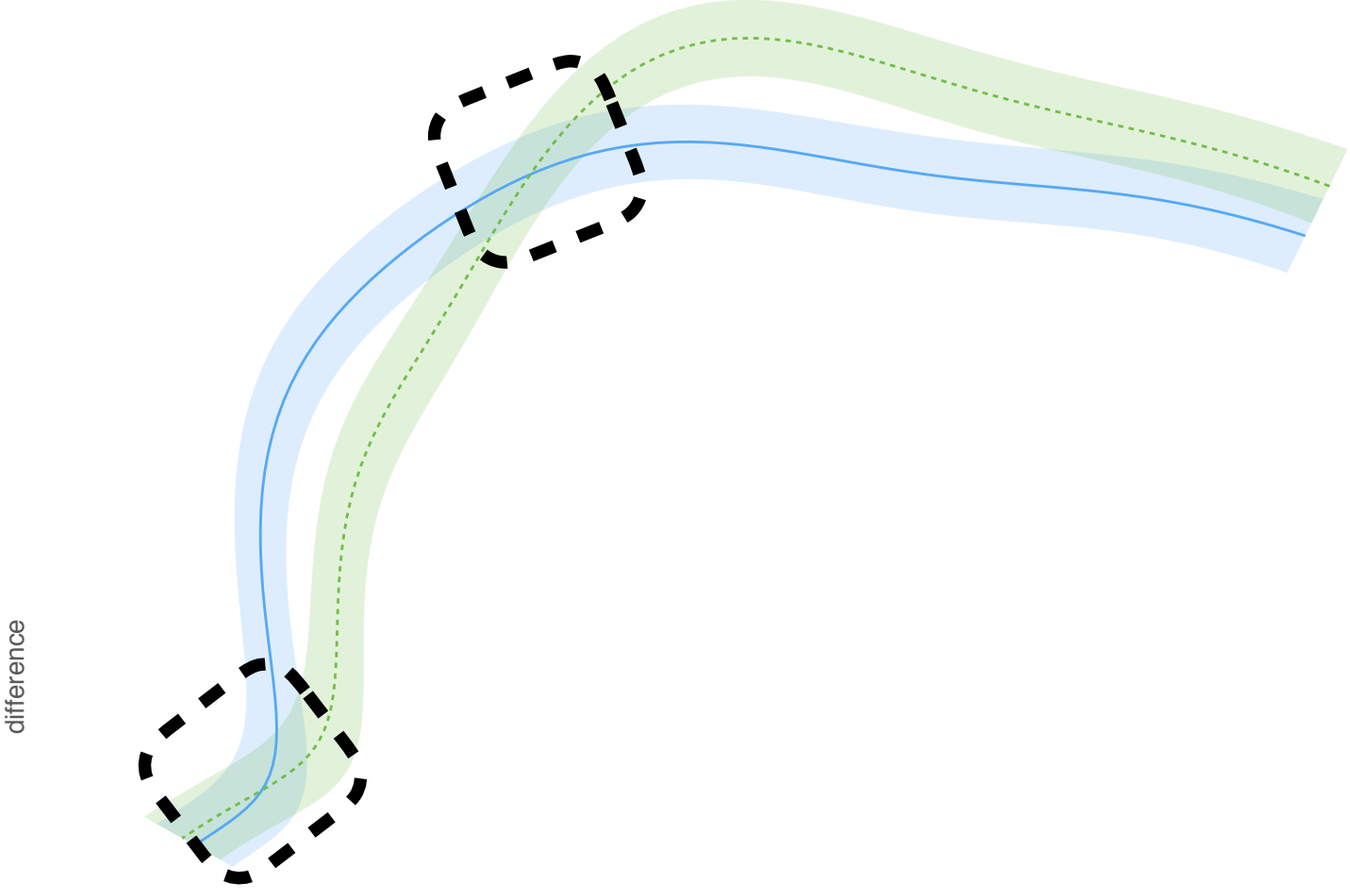
Almost complete overlap between all four contexts, even /s/ and /ʃ/

More differentiation at tongue tip (but confidence intervals also wider)

Difference smooths

- In addition to visual inspection of the splines, difference smooths can be used for pairwise comparisons of **/s/** and **/ʃ/** tongue shapes
  - Differences between the two curves are highlighted in red (where confidence interval of difference smooth does not contain 0)
  - Broadly speaking, more **red** = more differentiation in tongue shape





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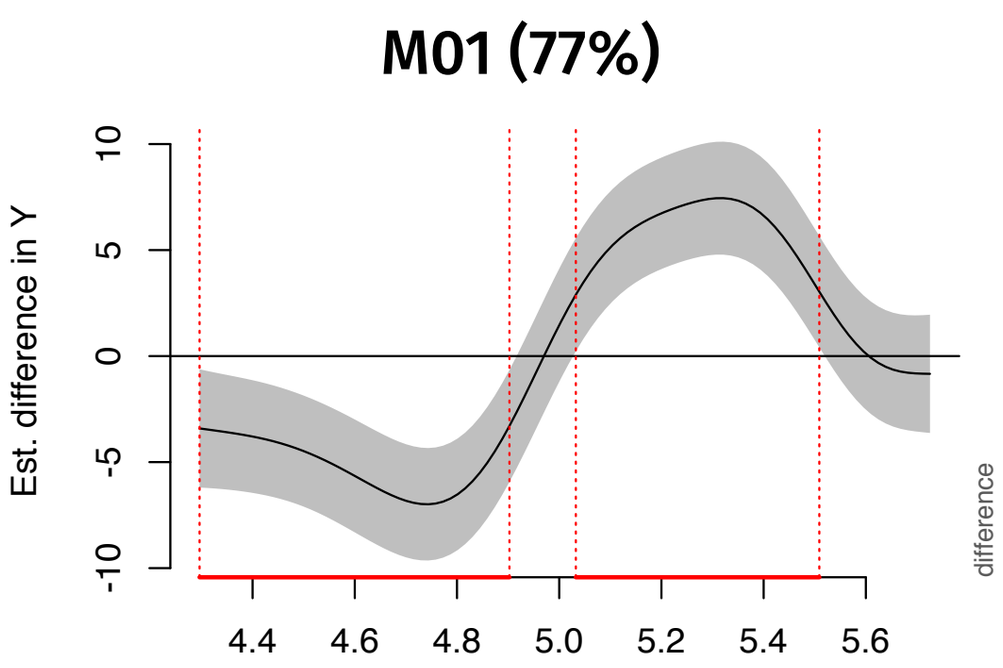
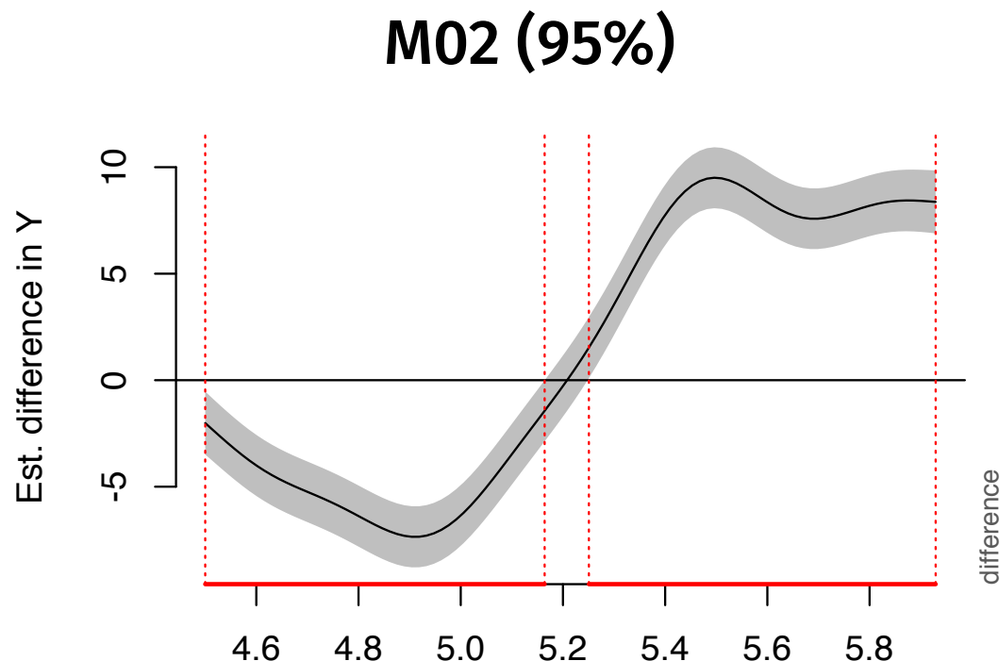
  - Differences between the two curves are highlighted in red (where confidence interval of difference smooth does not contain 0)
  - Broadly speaking, more **red** = more differentiation in tongue shape
  - **/s/** and **/ʃ/** completely different for M01 and M02





Difference smooths

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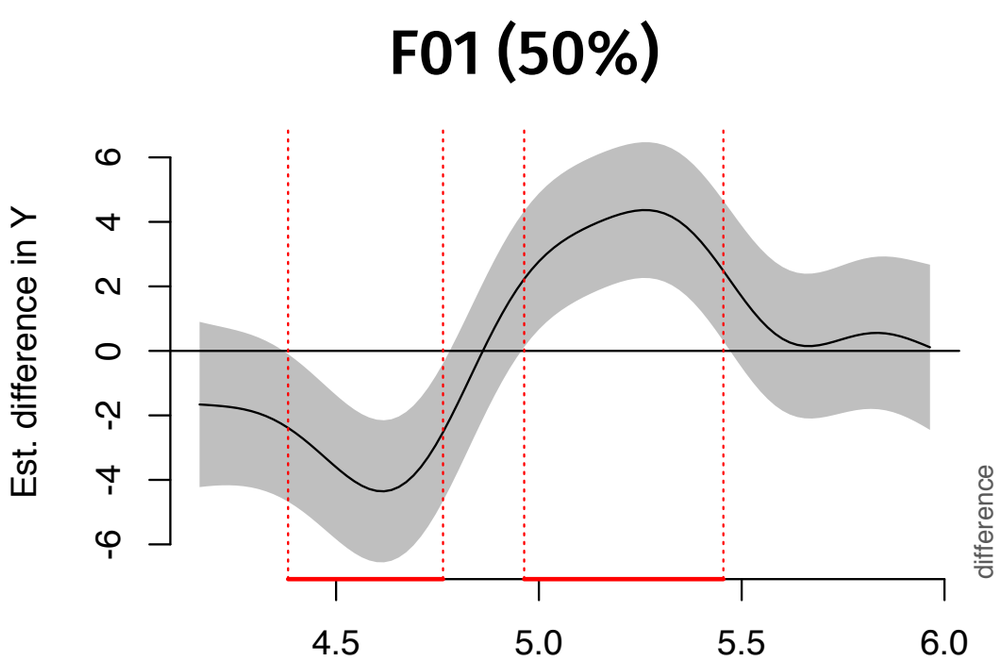
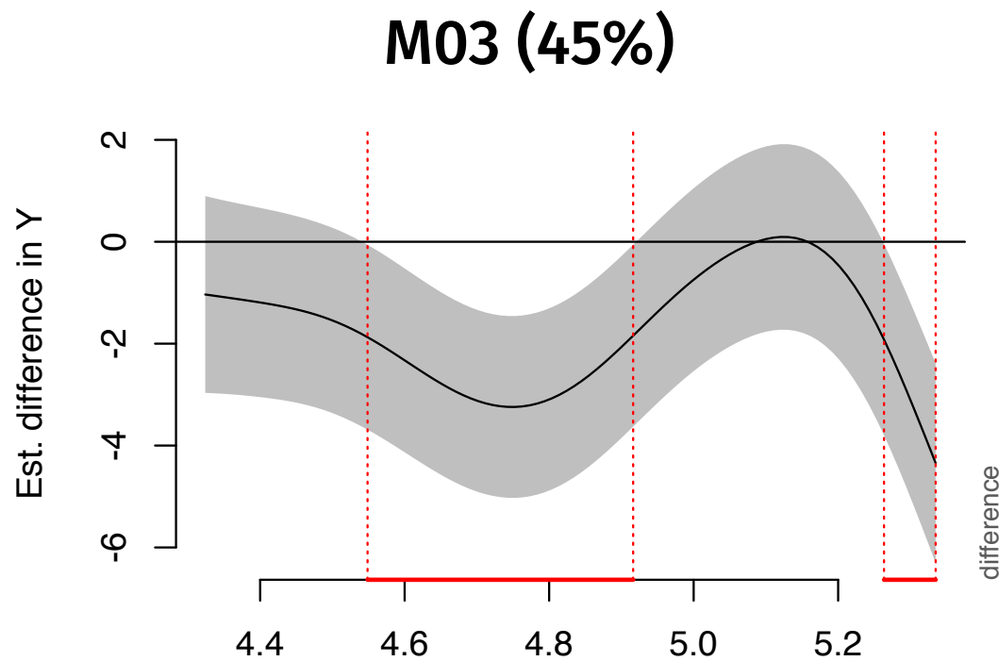
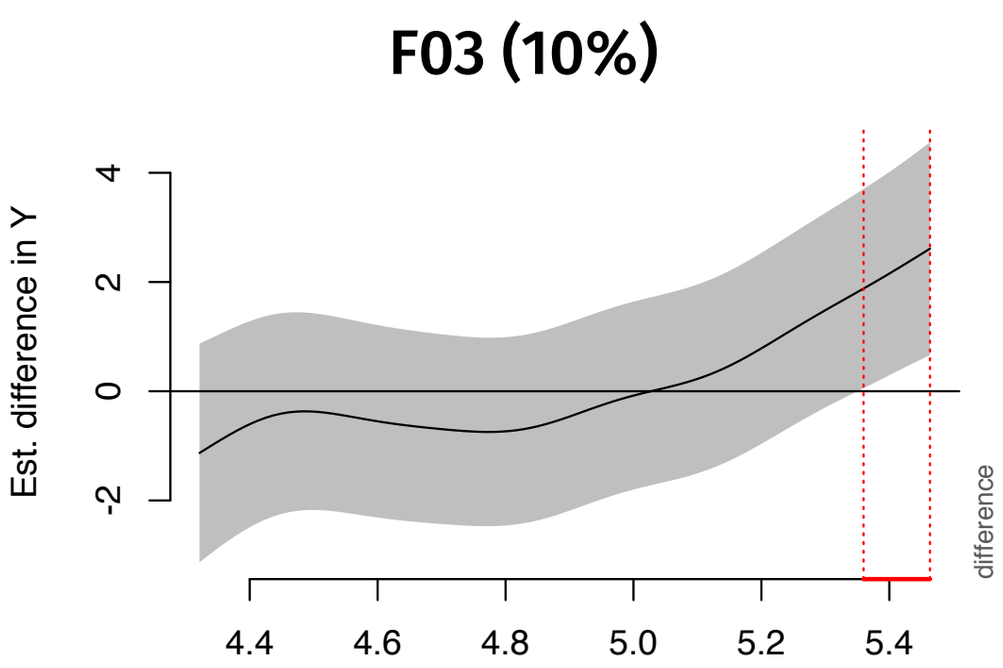
  - Differences between the two curves are highlighted in red (where confidence interval of difference smooth does not contain 0)
  - Broadly speaking, more **red** = more differentiation in tongue shape
  - **/s/** and **/ʃ/** largely distinct (but to a lesser extent) for F01 and M03

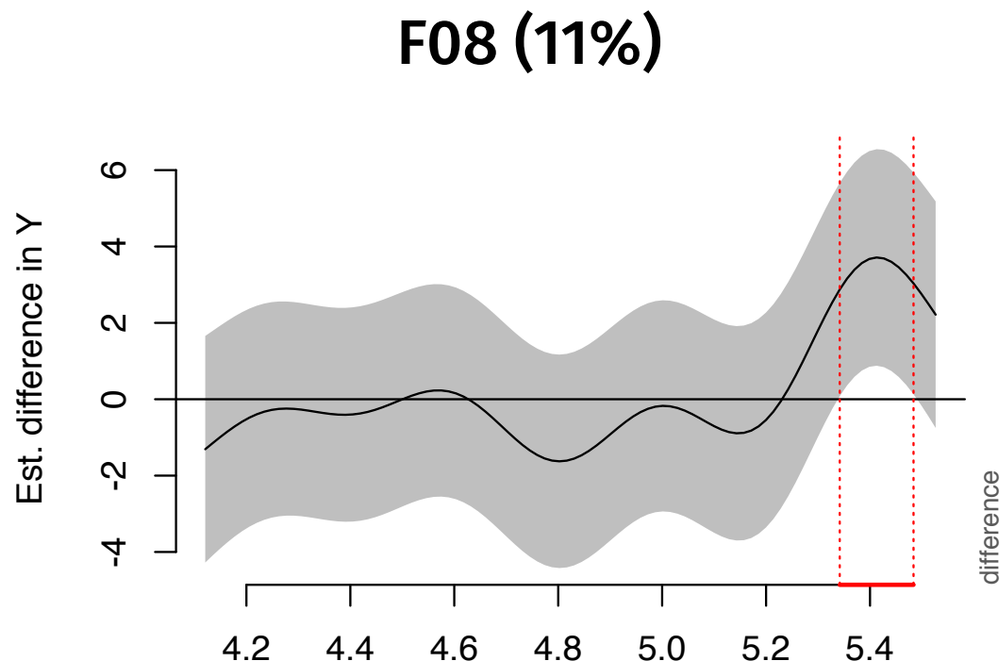




Difference smooths

- In addition to visual inspection of the splines, difference smooths can be used for pairwise comparisons of **/s/** and **/ʃ/** tongue shapes
  - Differences between the two curves are highlighted in red (where confidence interval of difference smooth does not contain 0)
  - Broadly speaking, more **red** = more differentiation in tongue shape
  - **/s/** and **/ʃ/** not at all different for F03 and F08 (also F06 and F07)

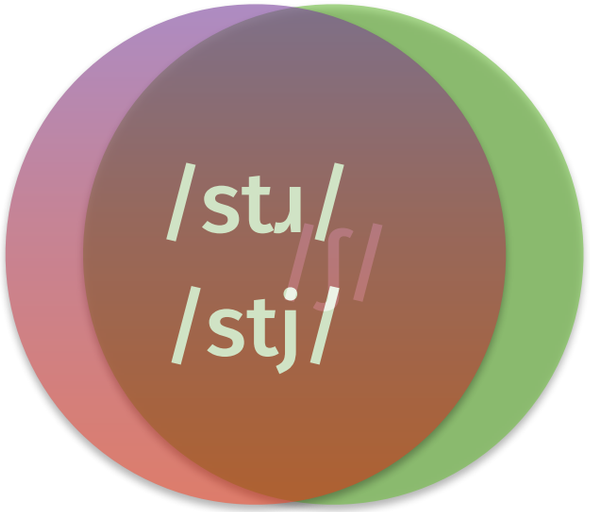




Interim summary

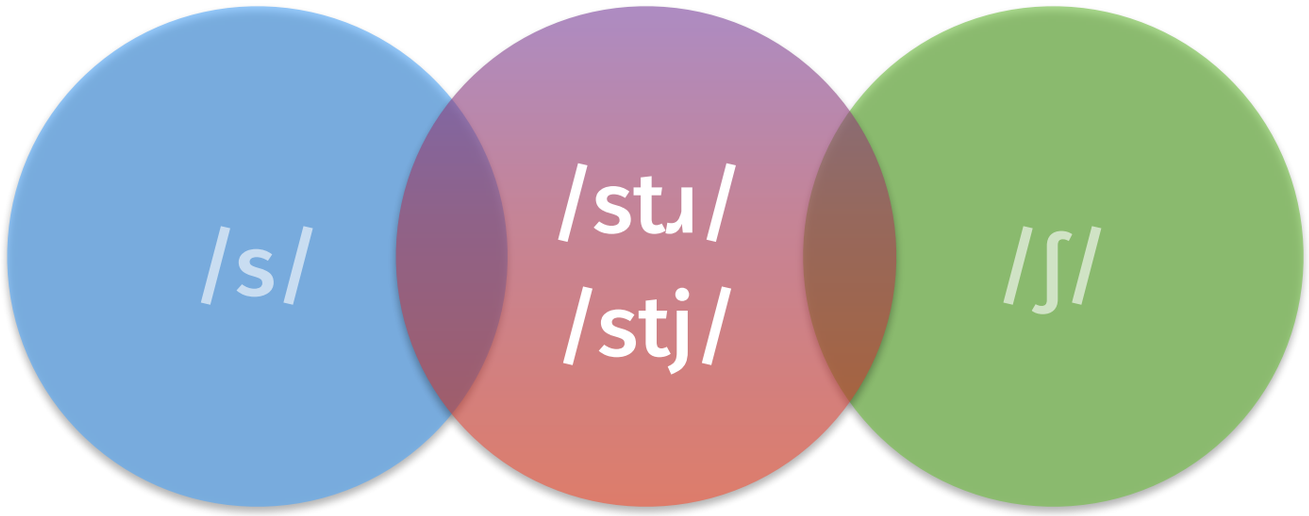
Some speakers exhibit clear tongue body retraction, such that there are two groups:

/s/ v. **/ʃ/**-**/stɹ/**-**/stj/**



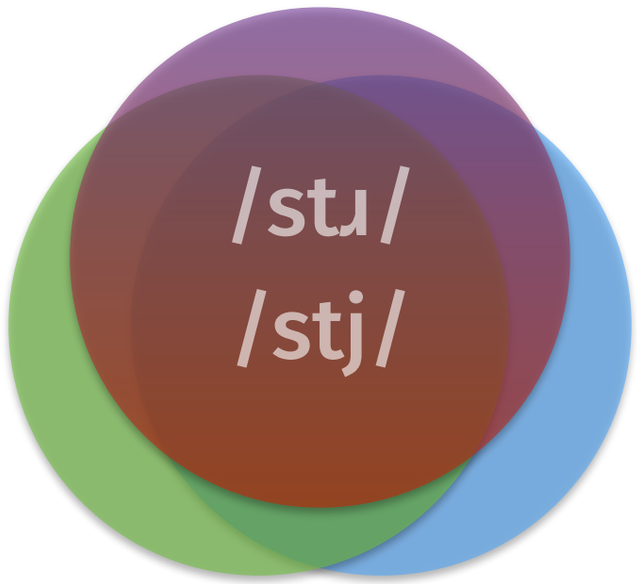
Interim summary

Others show a more intermediate pattern where the tongue body for **/stɹ/** and **/stj/** is somewhere between **/s/** and **/ʃ/**



Interim summary

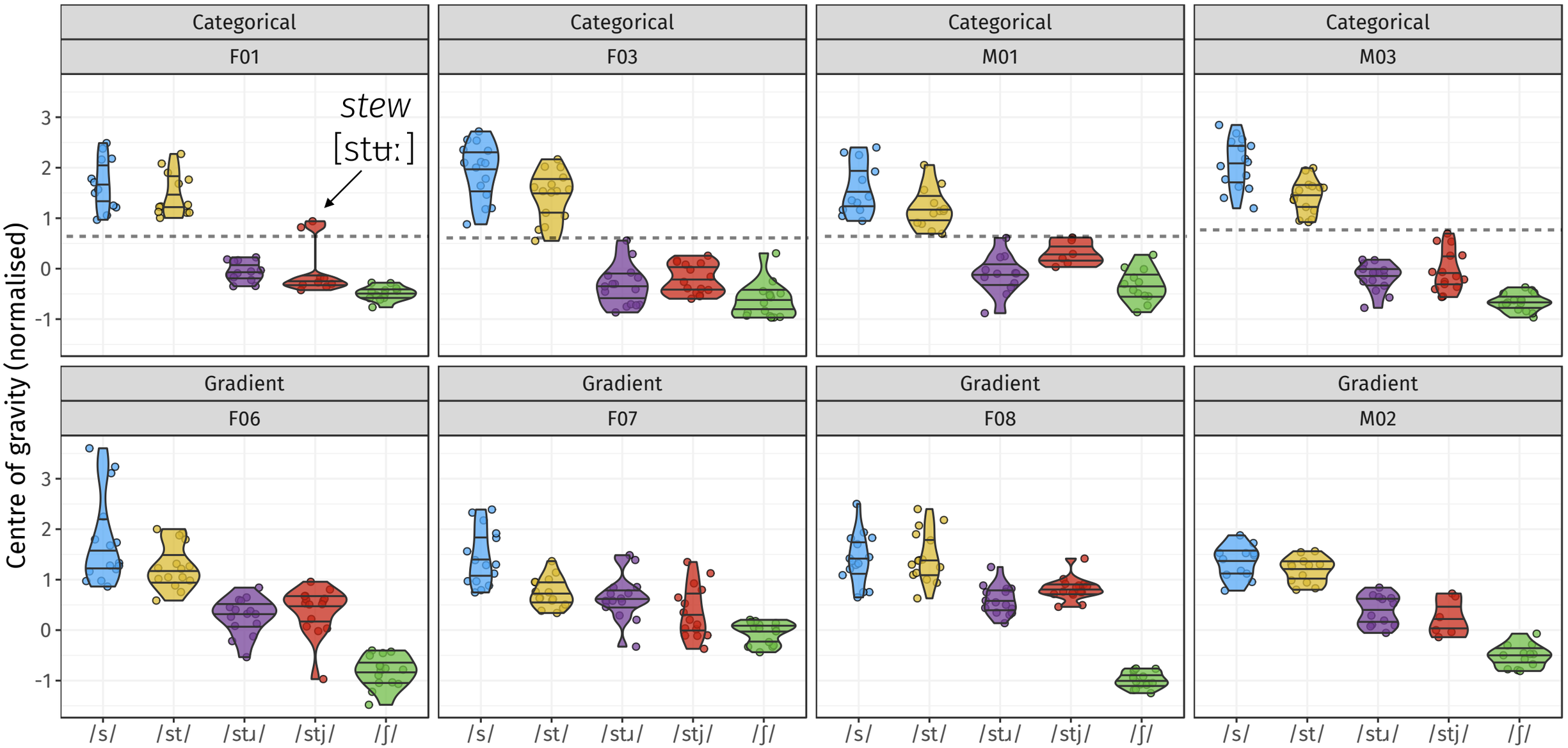
Finally, other speakers have no apparent lingual difference,
even between /s/ and /ʃ/



INDIVIDUAL VARIATION

ACOUSTICS

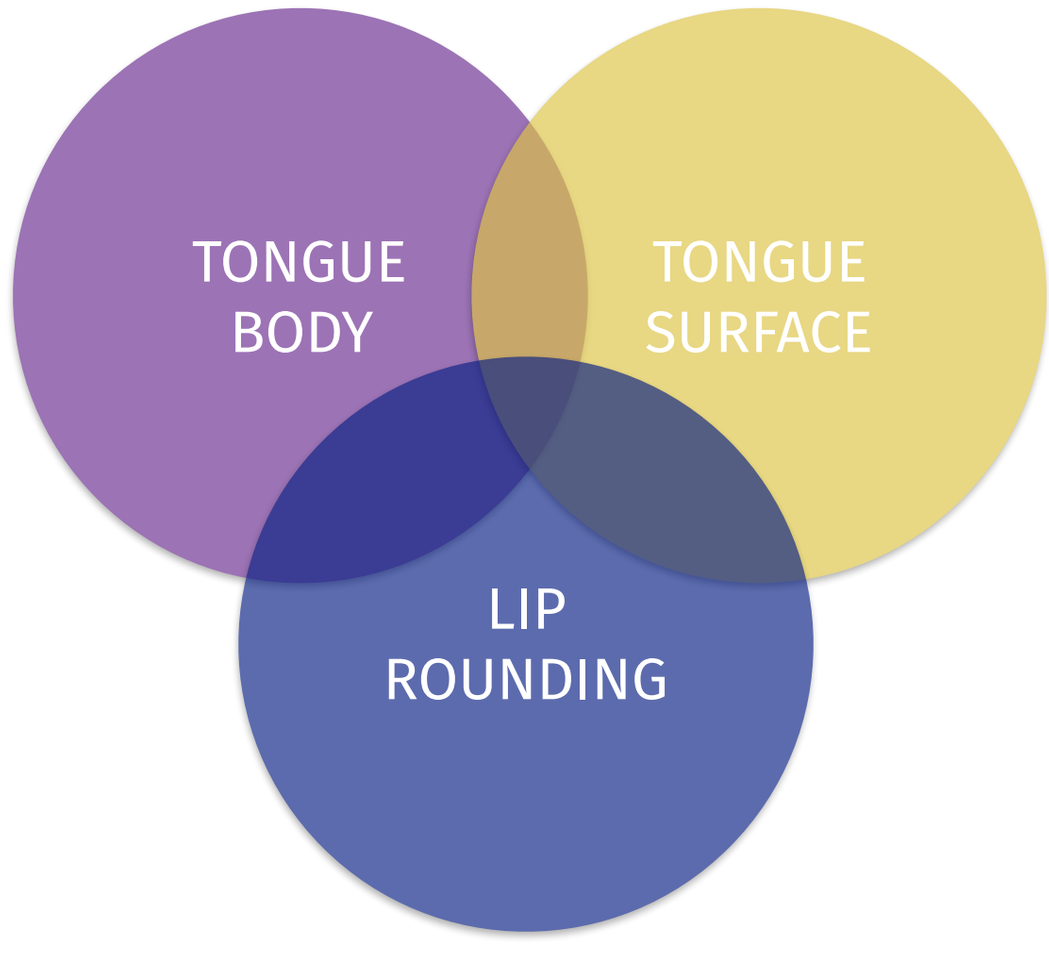
Centre of gravity



- All speakers still have an acoustic contrast between **/s/** and **/ʃ/**
- Categoricity/gradience determined by Tukey contrasts for post-hoc pairwise significance tests in linear regression models (i.e. whether or not **/stʉ/** and **/stj/** are significantly different from **/ʃ/**)

Covert articulation

- Even though some speakers show no apparent lingual difference, even between underlying /s/ and /ʃ/, the acoustic contrast is still maintained
- Rutter (2011) highlights the other phonetic parameters that could be involved in the /s/-/ʃ/ contrast:
  - **TONGUE BODY POSITION**
    - alveolar for /s/, post-alveolar for /ʃ/
  - **TONGUE SURFACE**
    - grooved for /s/, flat for /ʃ/
  - **LIP SHAPE**
    - strong labialisation for /ʃ/
  - Also **TONGUE TIP**
    - laminal v. apical constriction



COVERT ARTICULATION

- Even though some speakers show no apparent lingual difference, even between underlying /s/ and /ʃ/, the acoustic contrast is still maintained
- Rutter (2011) highlights the other phonetic parameters that could be involved in the /s/-/ʃ/ contrast:
  - **TONGUE BODY POSITION**
    - alveolar for /s/, post-alveolar for /ʃ/
  - **TONGUE SURFACE**
    - grooved for /s/, flat for /ʃ/
  - **LIP SHAPE**
    - strong labialisation for /ʃ/
  - Also **TONGUE TIP**
    - laminal v. apical constriction

'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)

COVERT ARTICULATION

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    - laminal v. apical constriction

Different articulatory strategies

Same acoustic output

The articulation-acoustics mapping

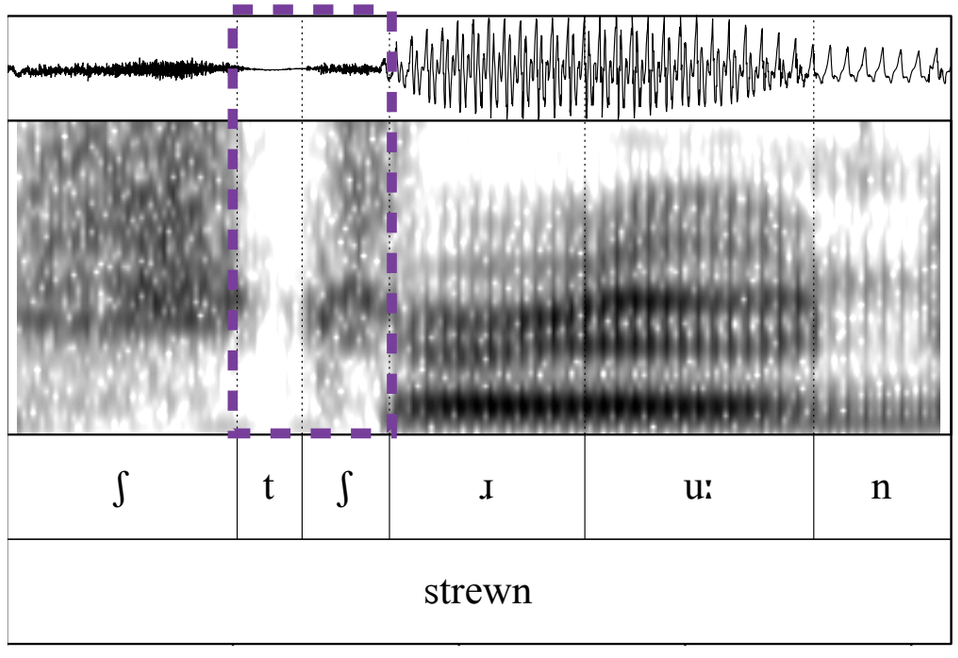
- No one-to-one mapping between articulation (ultrasound) and acoustics (CoG)

	ultrasound		acoustics (CoG)
M01	categorical	⟷	categorical
M02	categorical	⟷	gradient
M03	gradient	⟷	categorical
F01	gradient	⟷	categorical
F03	none	⟷	categorical
F06	none	⟷	gradient
F07	none	⟷	gradient
F08	none	⟷	gradient
??	gradient	⟷	gradient

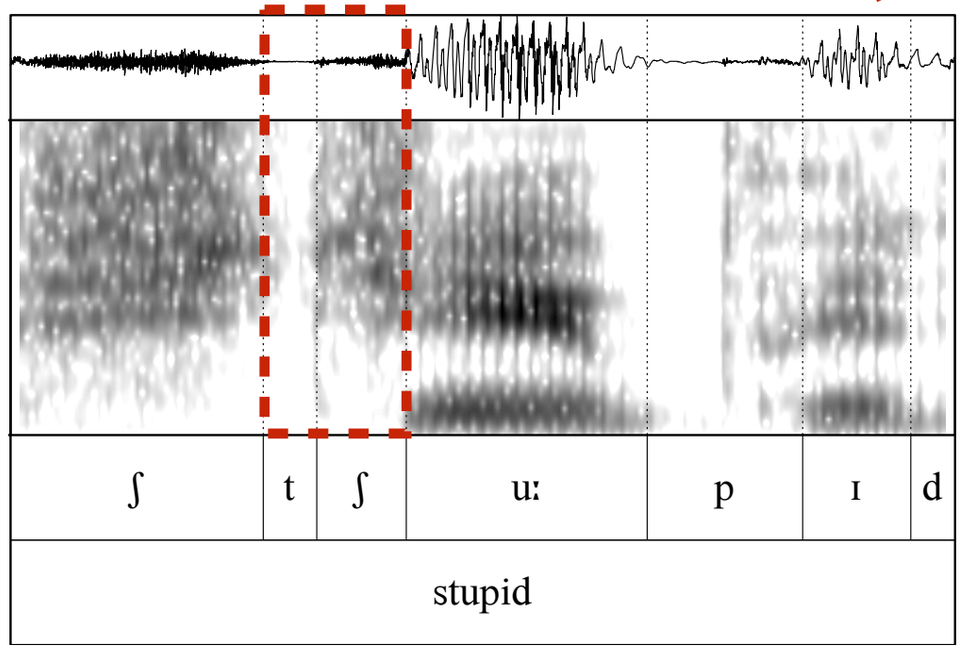
- Regardless of this mapping, **/stɹ/** and **/stj/** pattern together
  - And so there is likely a cause common to both

Affrication

M01: /stɹ/

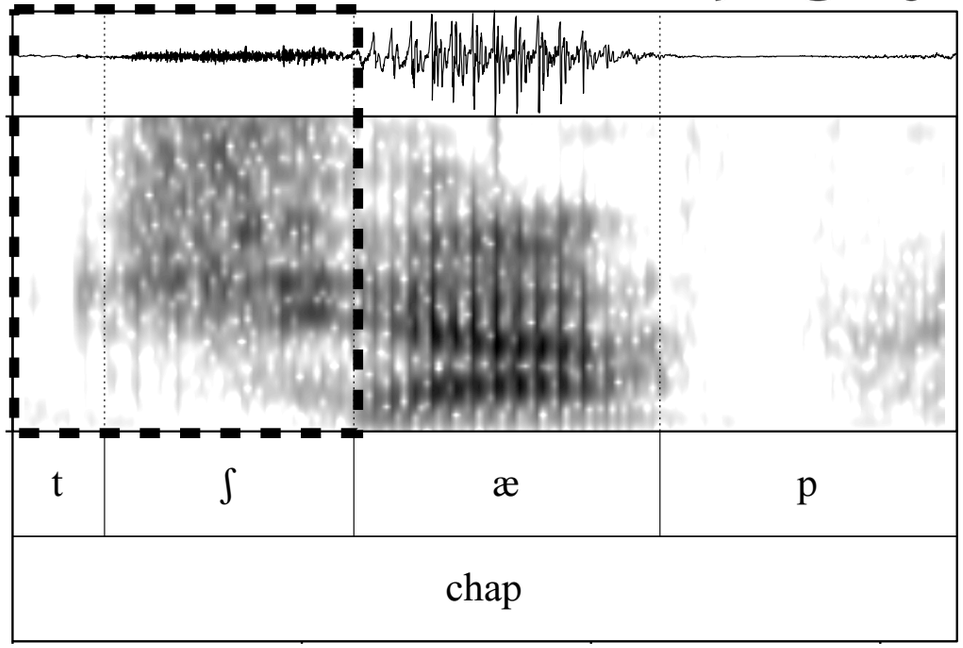


M01: /stj/



- All speakers exhibit comparable affrication of **/t/** in both **/stɹ/** and **/stj/**
- Phonetically similar to underlying **/tʃ/** (just shorter in duration)
- Some evidence that speakers can affricate **/t/** with only minimal *s*-retraction (e.g. F08)
  - But note that our speakers show no meaningful retraction of **/s/** without also affricating **/t/**
    - e.g. *[ʃtjʉːpɪd]

M01: underlying /tʃ/



RETRACTION AT THE COMMUNITY-LEVEL

(joint work with Maciej Baranowski and Danielle Turton)

Data collection

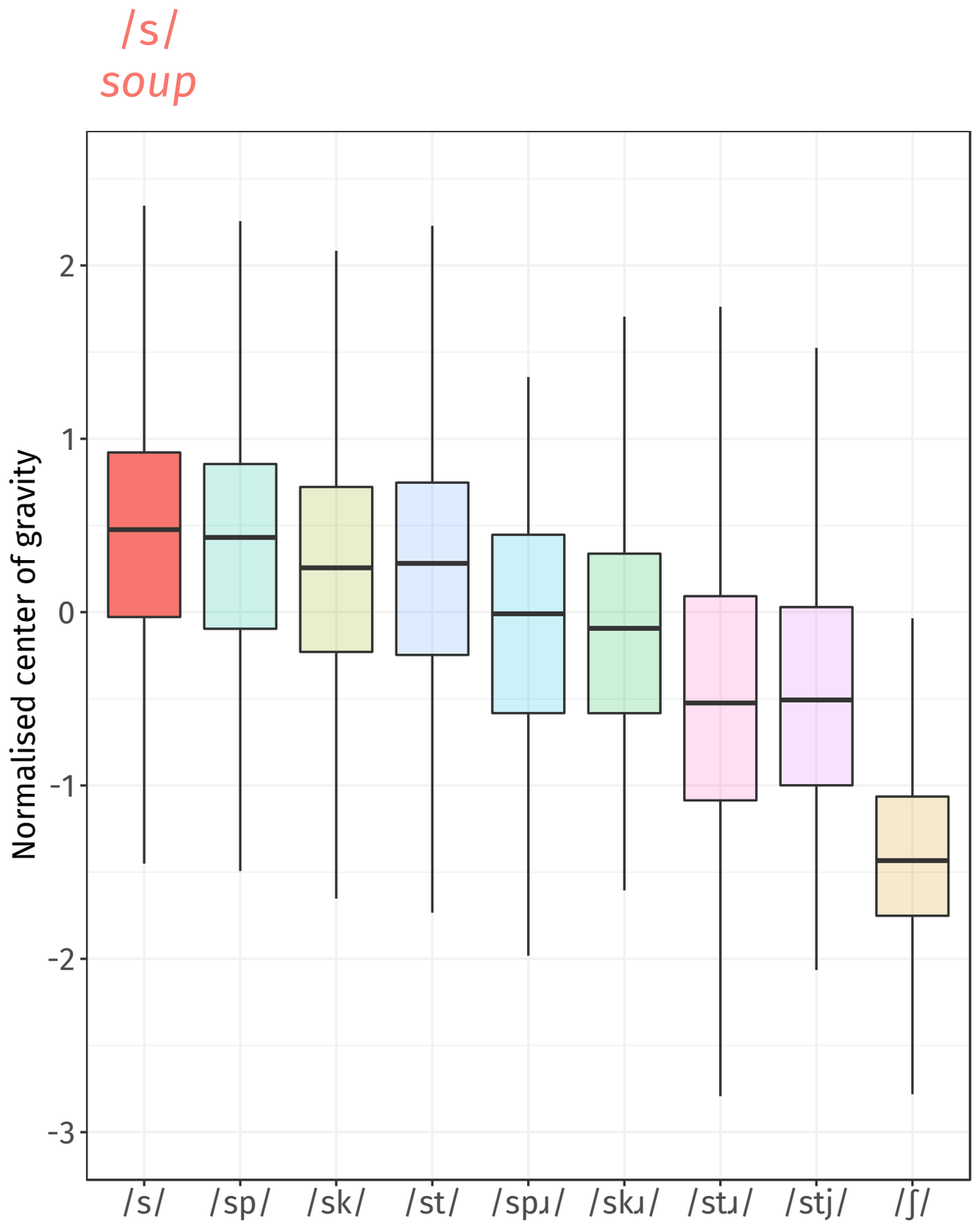
- Sociolinguistic interviews with **131 speakers** born and raised in Greater Manchester
- **Birth years** spanning almost a century, from 1907 to 2001
- **Socioeconomic status** determined based on occupation (3 levels: working class, middle class, upper middle class)
- ~**85,000 tokens** of sibilants across all environments

All onset types

- Hierarchy of retraction contexts as attested elsewhere (e.g. Baker et al. 2011)

- /ɹ/ causes some **low-level retraction** even in the absence of affrication, e.g. /spɹ/, /skɹ/

- First quantitative evidence of **retraction in /stj/** - e.g. *student, stupid* etc.



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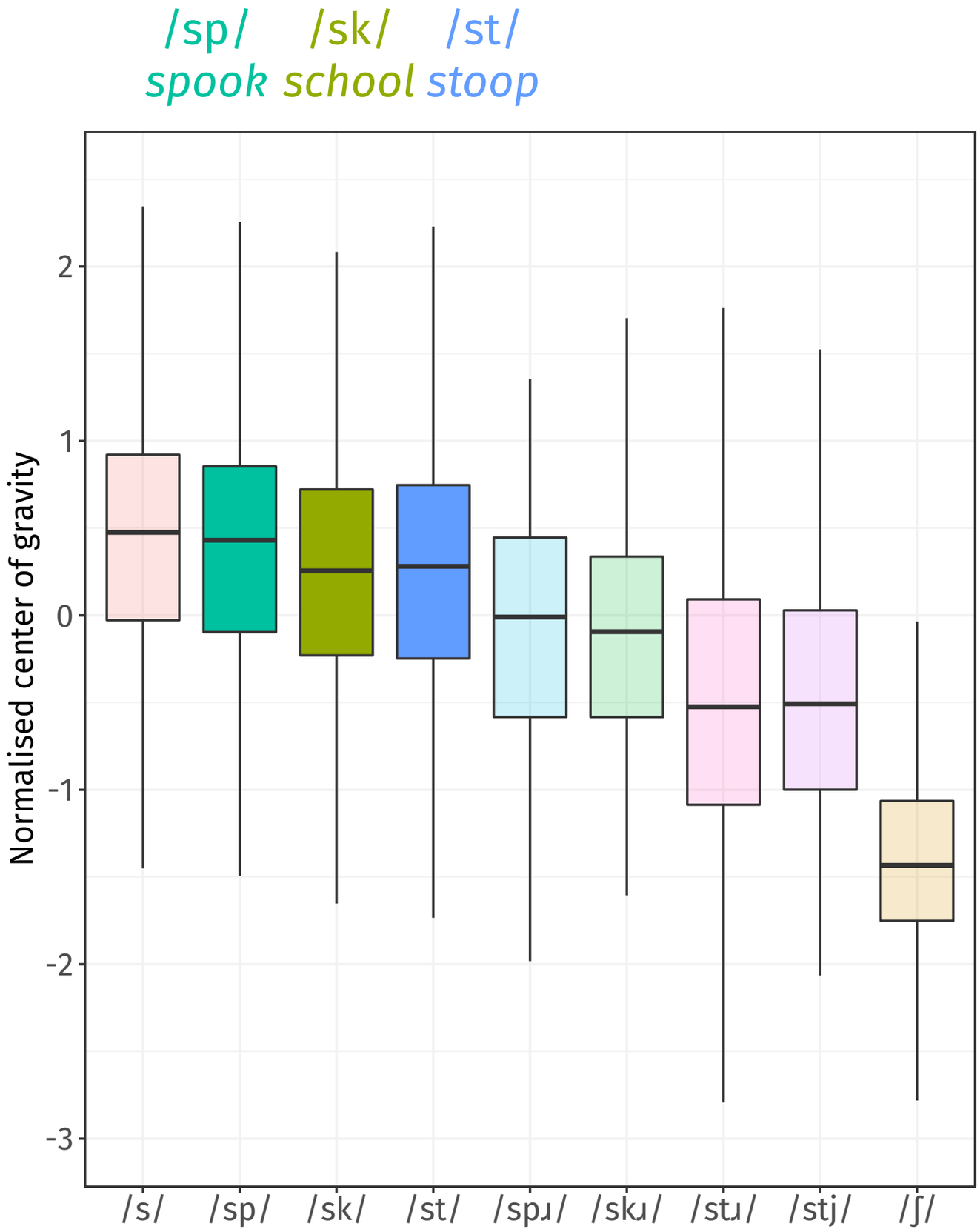

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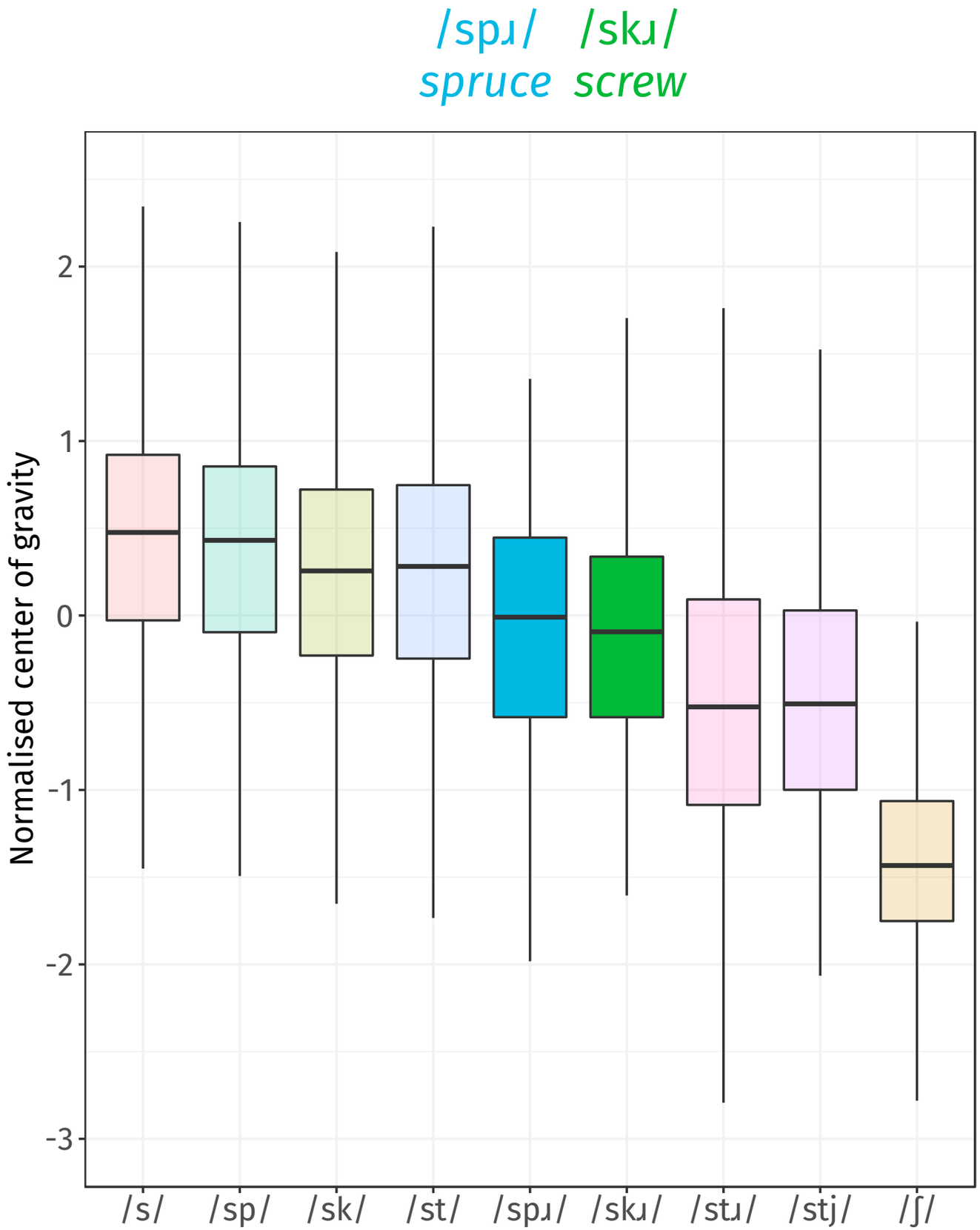

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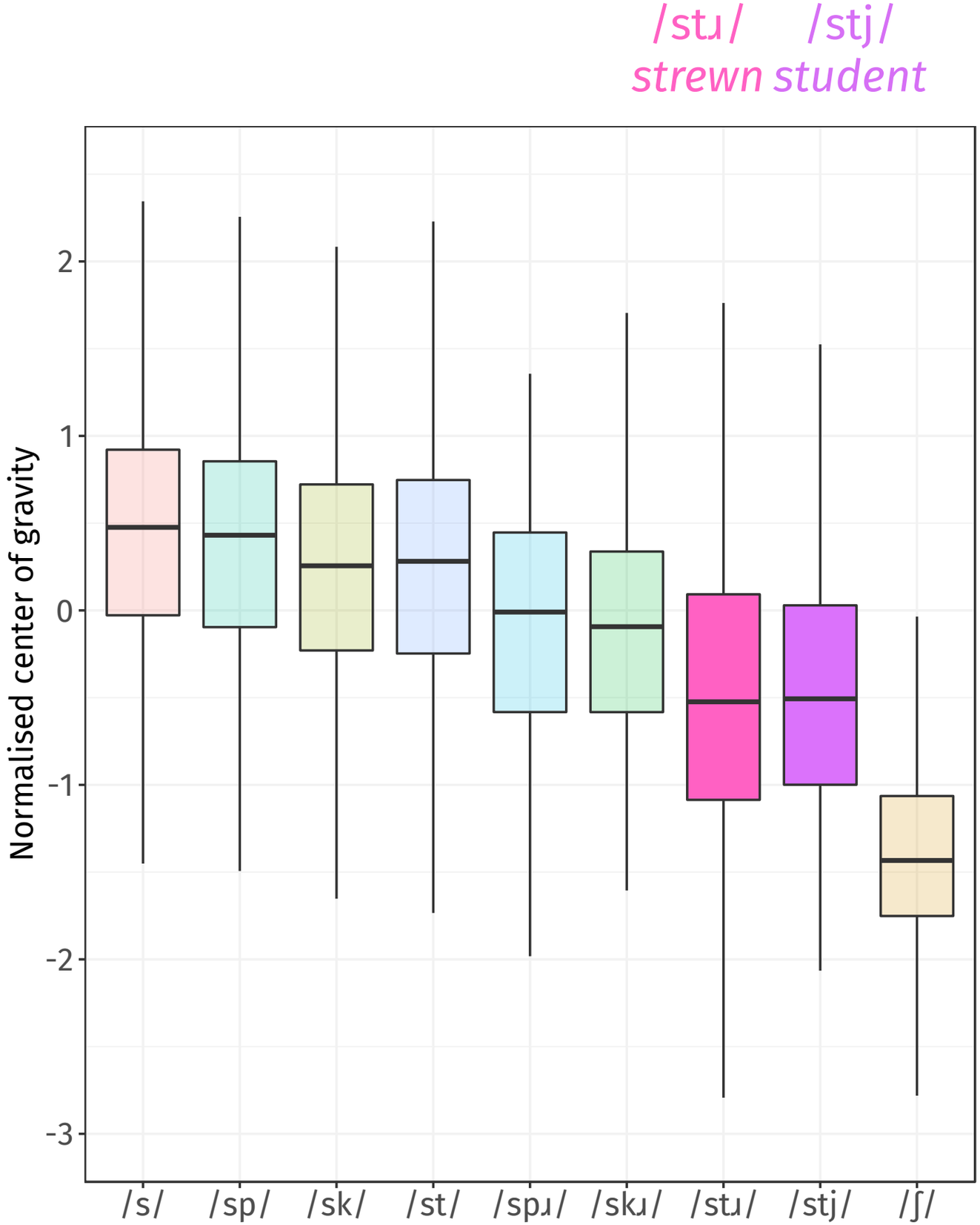

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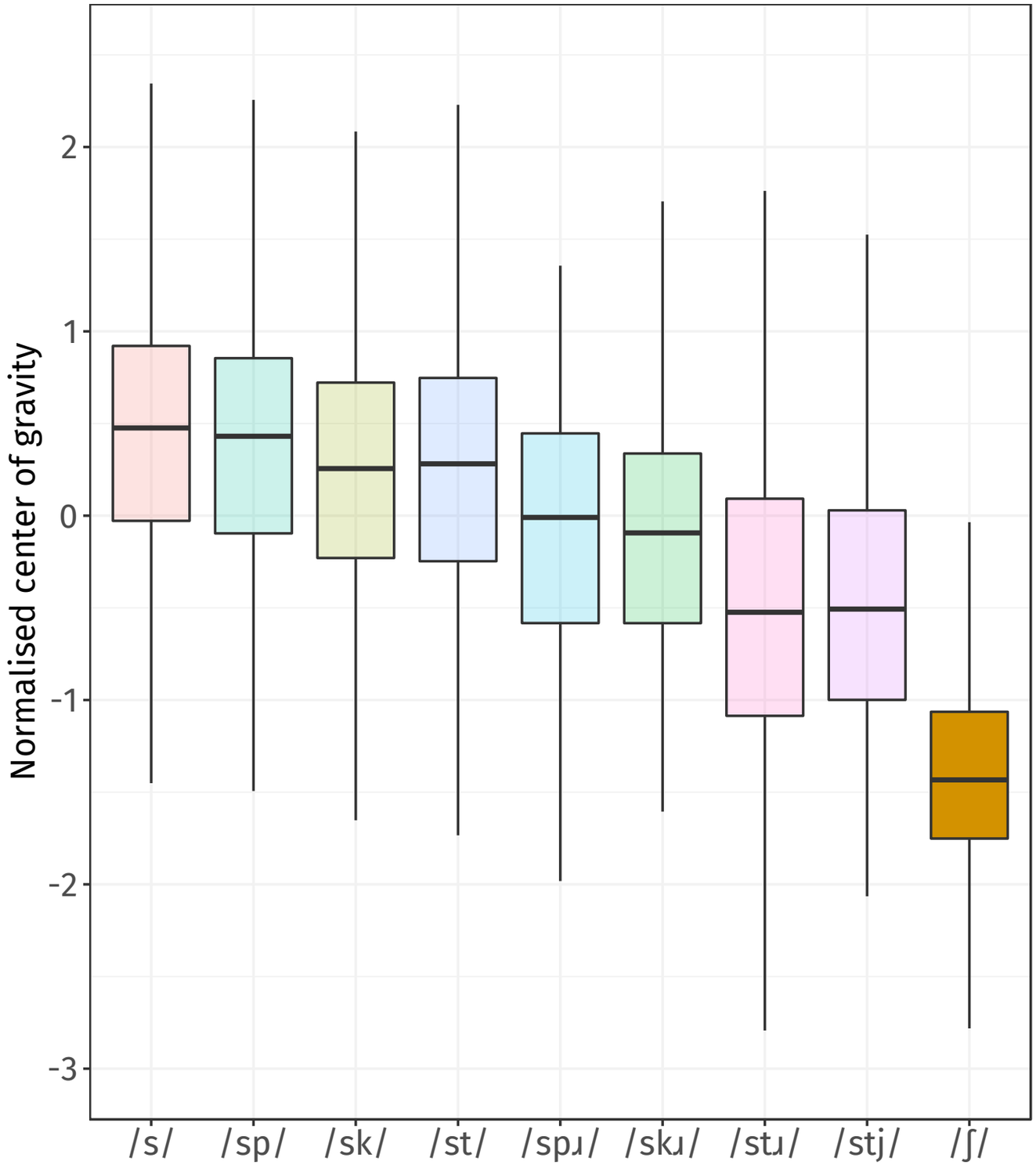
- /ɹ/ causes some **low-level retraction** even in the absence of affrication, e.g. /spɹ/, /skɹ/

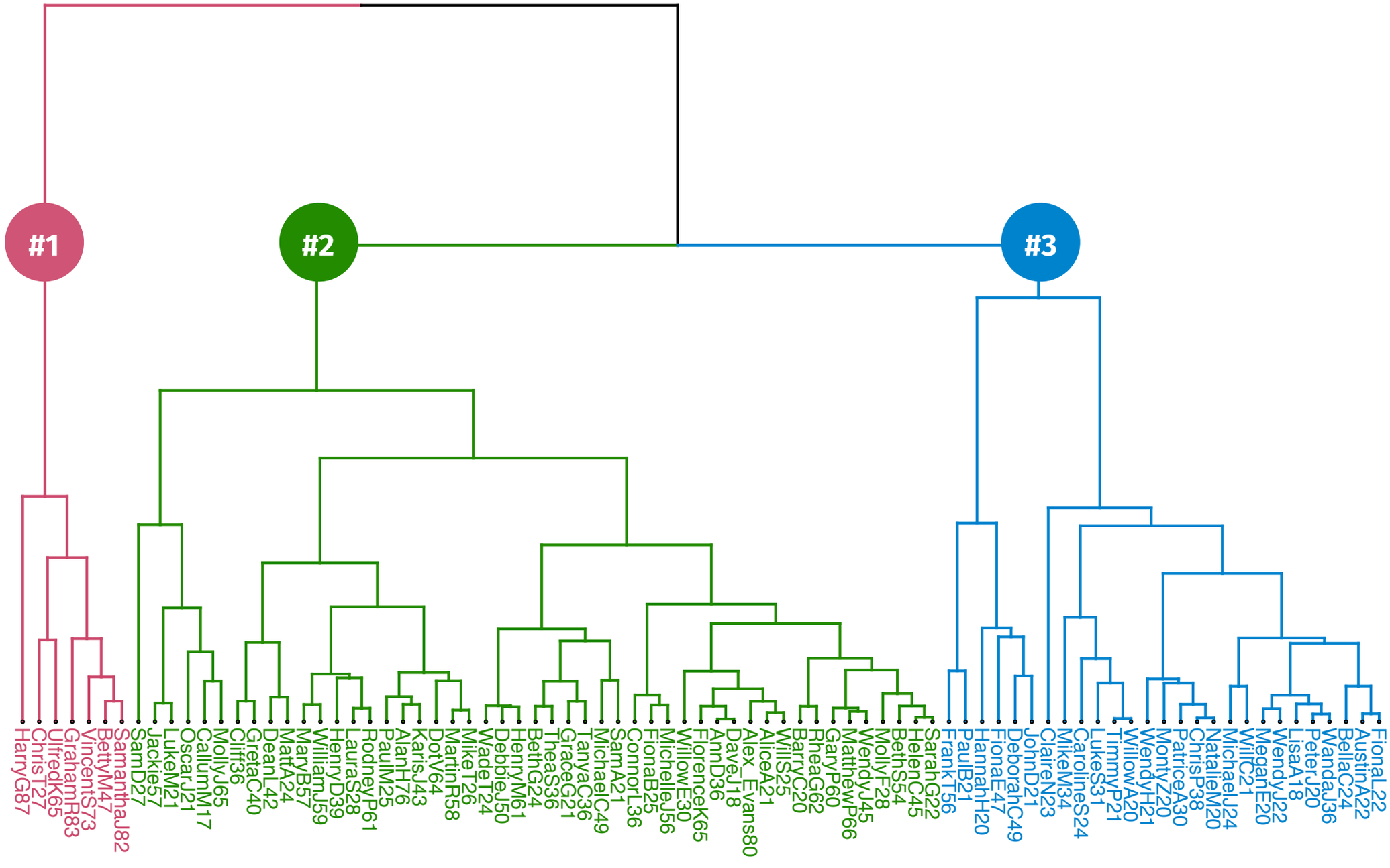
- First quantitative evidence of **retraction in /stj/** - e.g. *student, stupid* etc.

/ʃ/
shoe



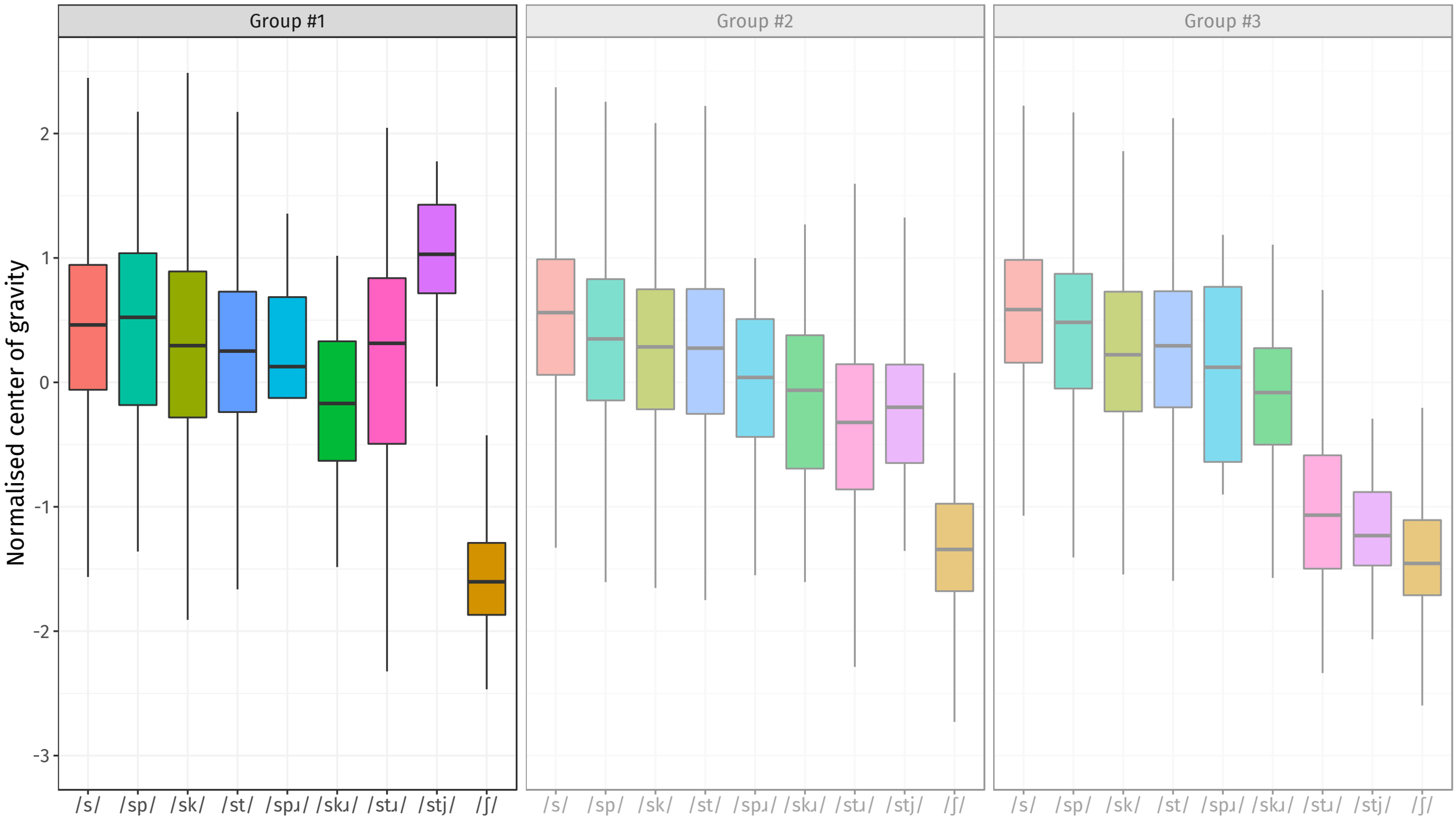
All onset types

- **Hierarchical cluster analysis** - objectively groups speakers based on distribution of CoG values across environments



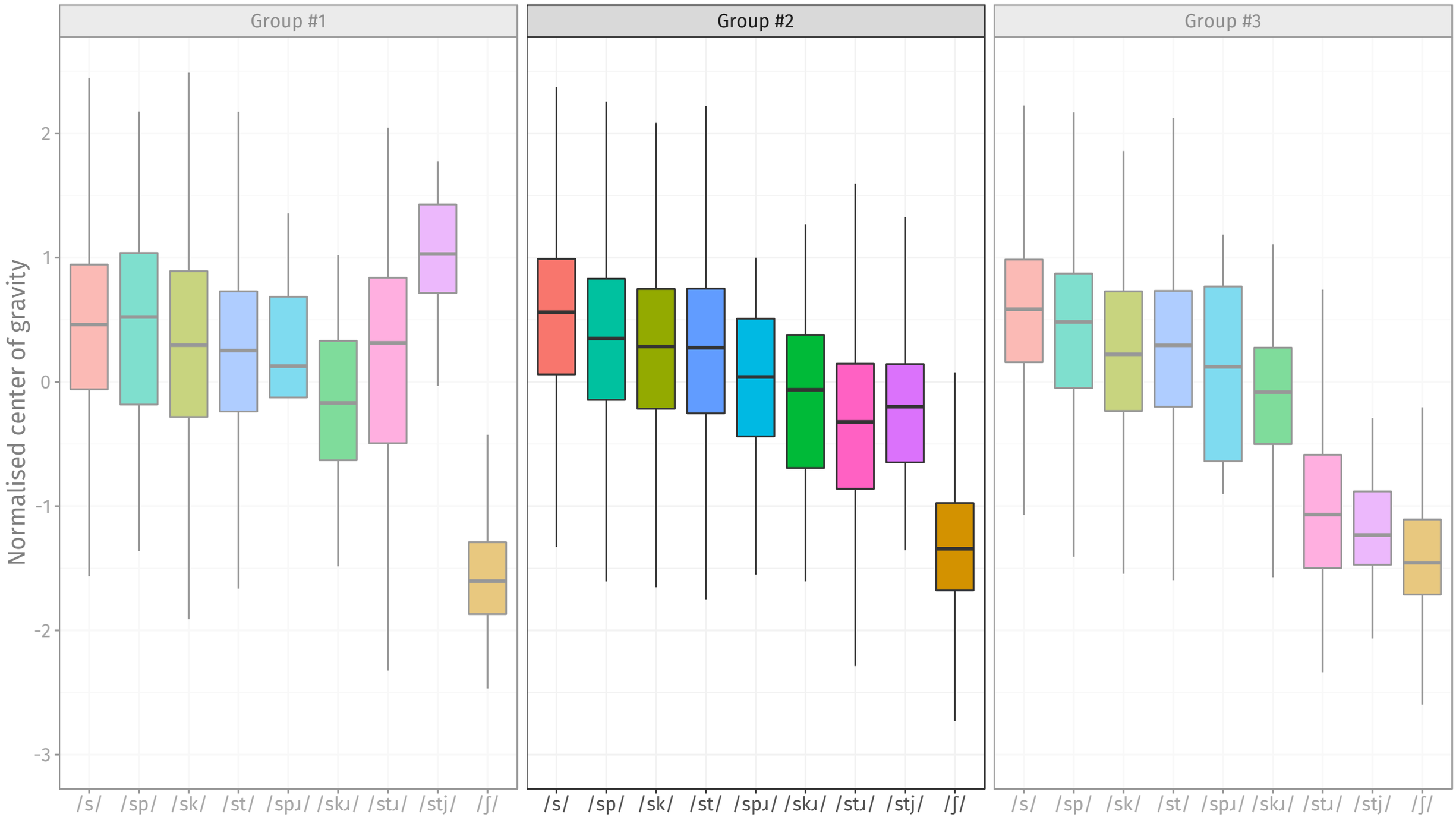
All onset types

Group #1 - no pattern of retraction



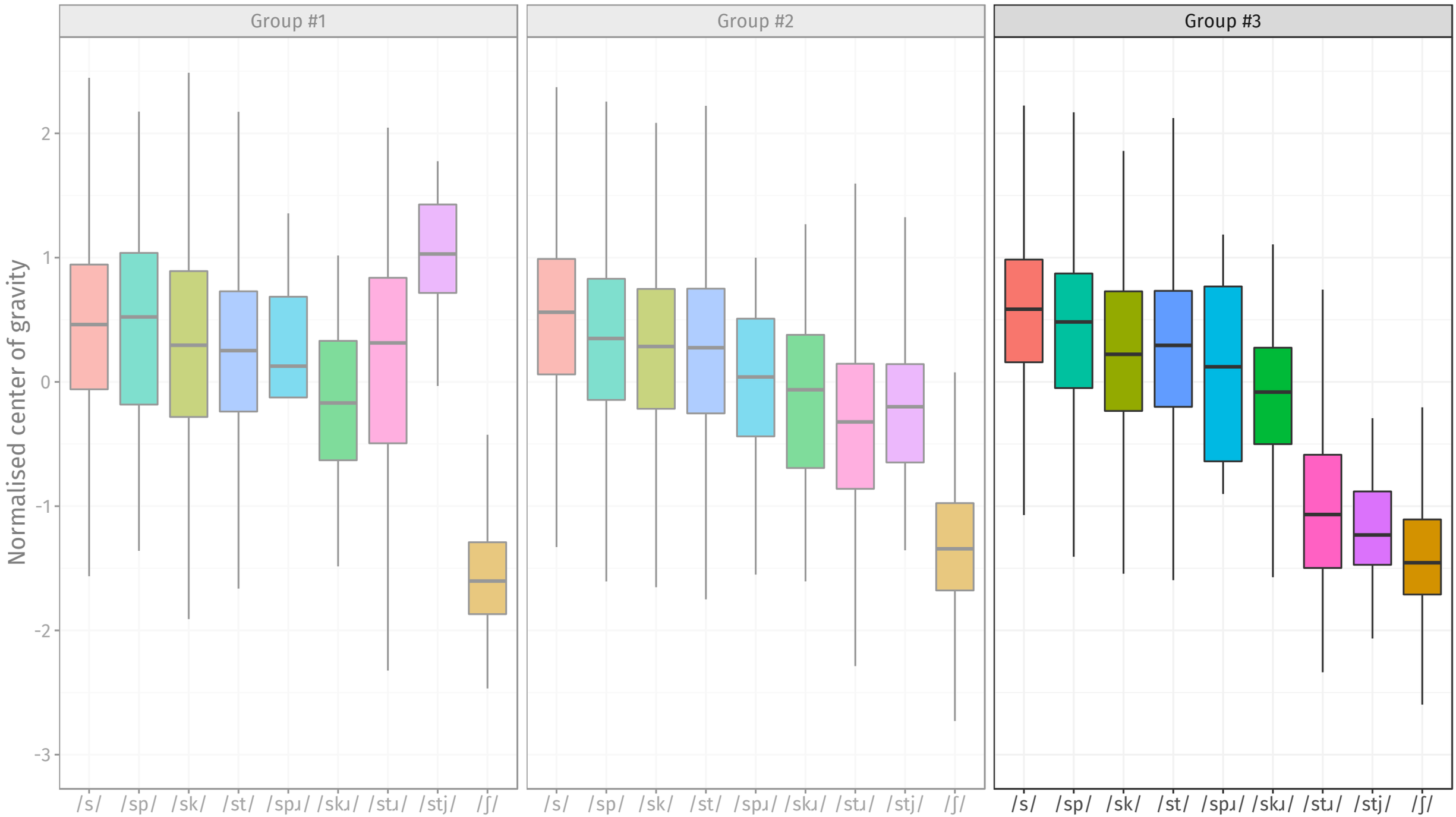
All onset types

Group #2 - emerging pattern of retraction



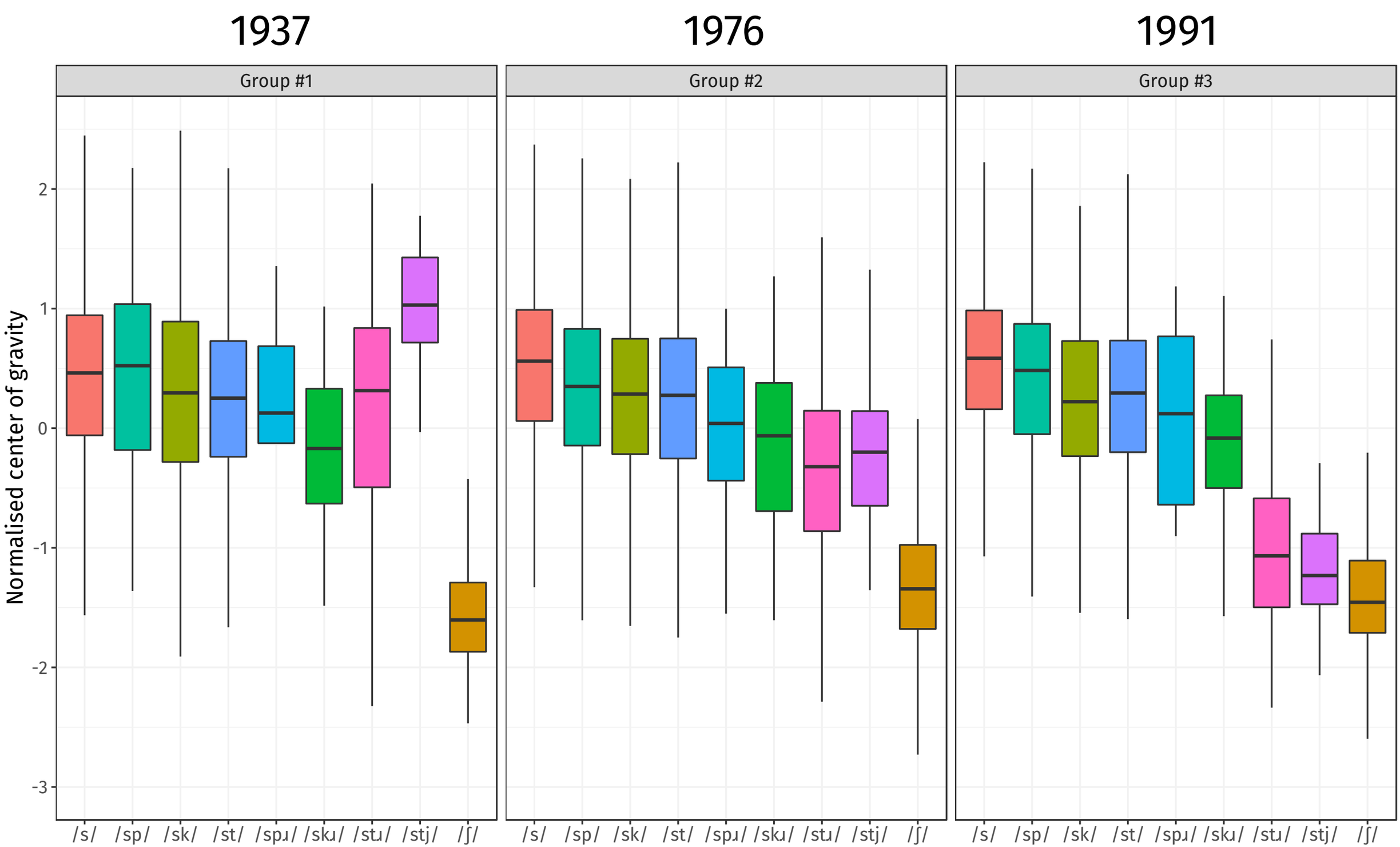
All onset types

Group #3 - /stɹ/ and /stj/ approaching /ʃ/

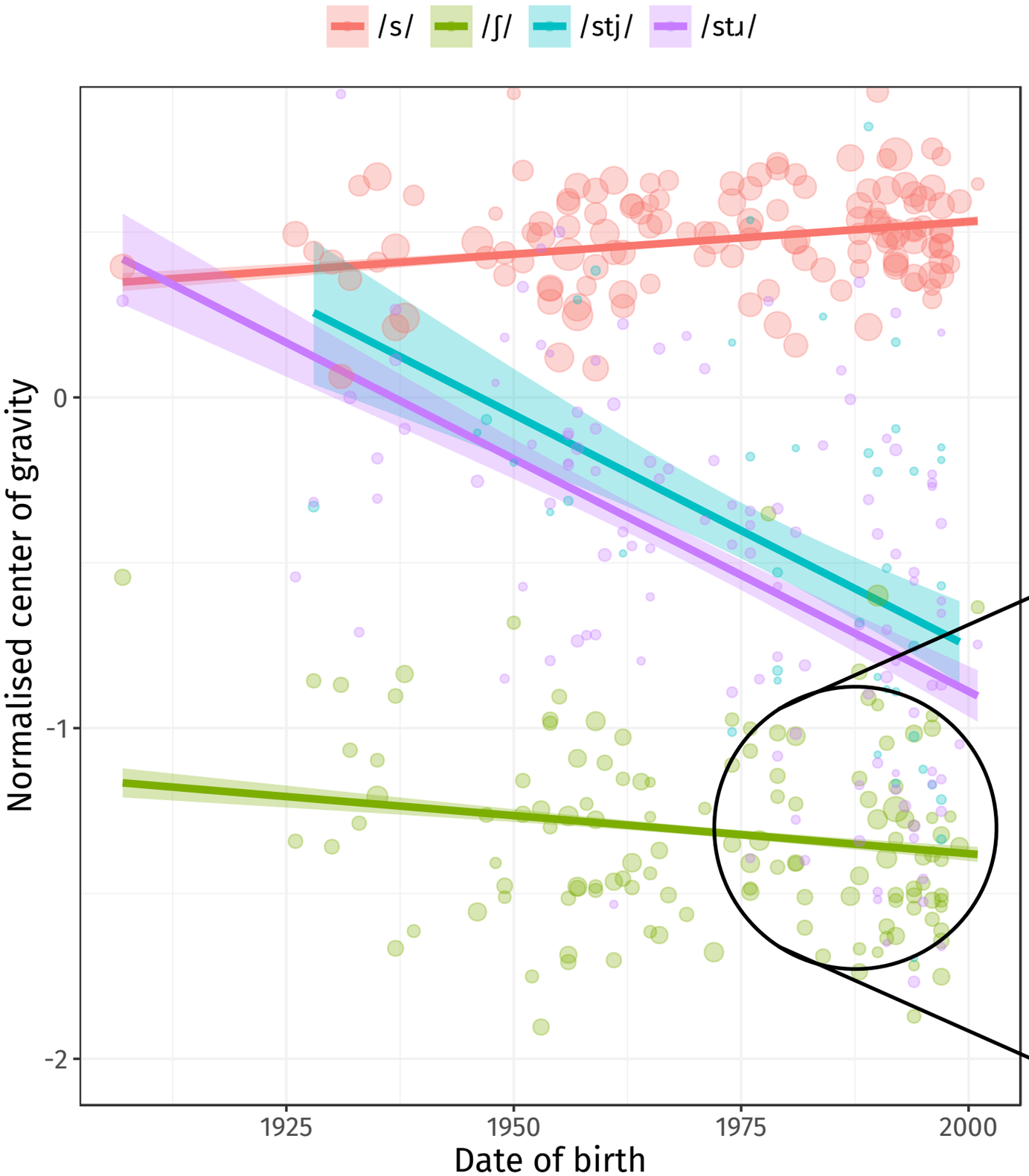


All onset types

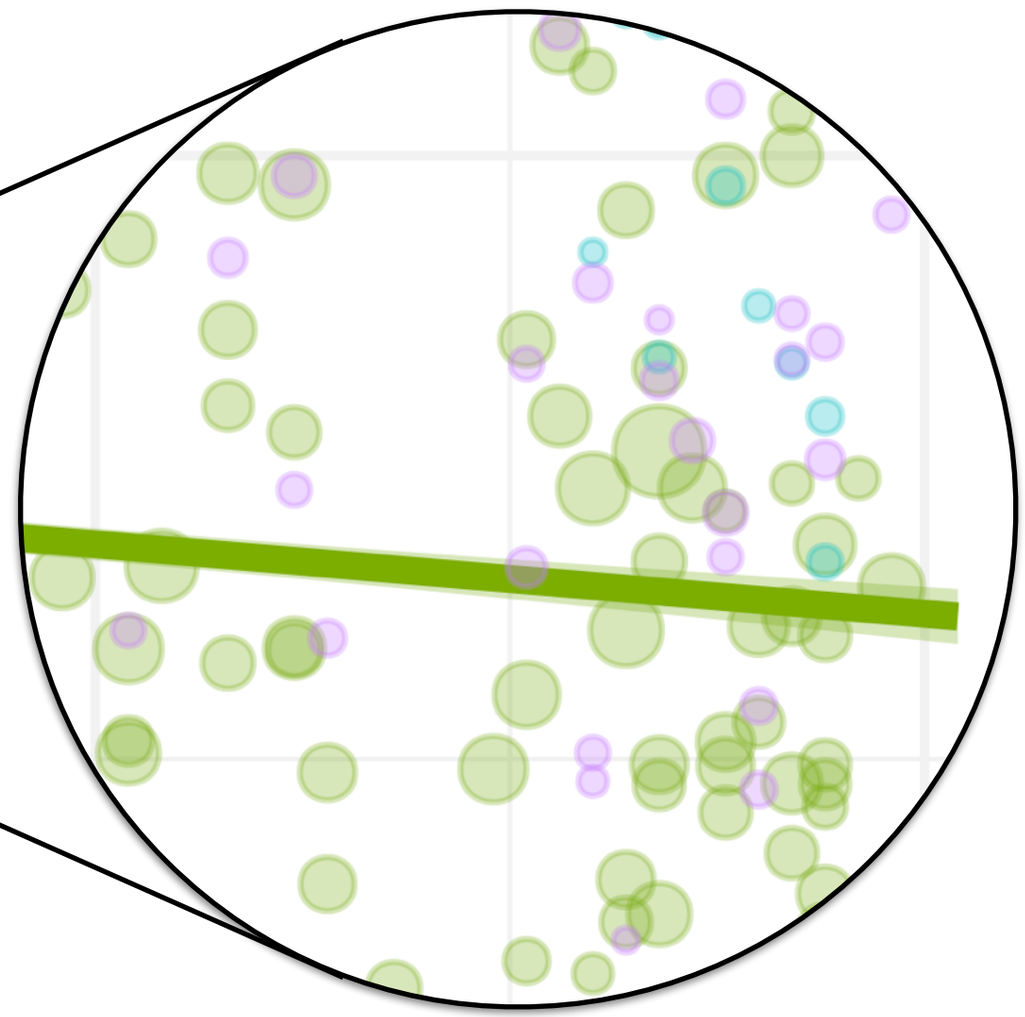
Average date of birth:



Apparent time change



- /stɹ/ and /stj/ **changing in parallel**
- Evidence that **affrication** plays a crucial role



CONCLUSIONS

Conclusions

- Evidence that the articulatory mechanisms behind the **/s/**-**/ʃ/** contrast are more complicated than a simple retraction of the place of articulation
  - Calls into question the suitability of “retraction” as a label for this phenomenon:
    - s-hushing? (i.e. hissing **/s/** > hushing **/ʃ/**)
- The **/stɹ/** and **/stj/** contexts behave similarly in terms of acoustic s-retraction
  - Both at the level of the individual and the community
- This lends support to the idea that retraction is triggered locally by affrication and not by **/ɹ/** in a case of non-local assimilation
  - In turn, the explanation proposed by Baker et al. (2011) for the actuation of this change does not find support in BrE

Next steps

- **The next steps:** collect direct articulatory data on these other mechanisms
  - Electromagnetic articulography (EMA)
  - Coronal UTI
  - Electropalatography (EPG)
  - Video recording for lip-rounding
  - Also: dynamic articulatory (and acoustic!) analysis of /stɹ/ and /stj/ clusters

- 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

Next steps

- **Electromagnetic articulography**
  - underway (as of yesterday!)

Thank you!

Acknowledgements

Thanks to **Stefano Coretta** for help with ultrasound; **Patrycja Strycharczuk** and **Ricardo Bermúdez-Otero** for their feedback; and **Jane Scanlon** for agreeing to be our first victim while we tried fitting the headcage; as well the audiences that have heard or seen previous iterations of this work, especially **BAAP**, **MFM** and **LAGB**.

🌎 http://personalpages.manchester.ac.uk/staff/stephen.nichols/
✉️ stephen.nichols@manchester.ac.uk

🌎 http://www-users.york.ac.uk/~gb1055/
✉️ george.bailey@york.ac.uk
🐦 @grbails

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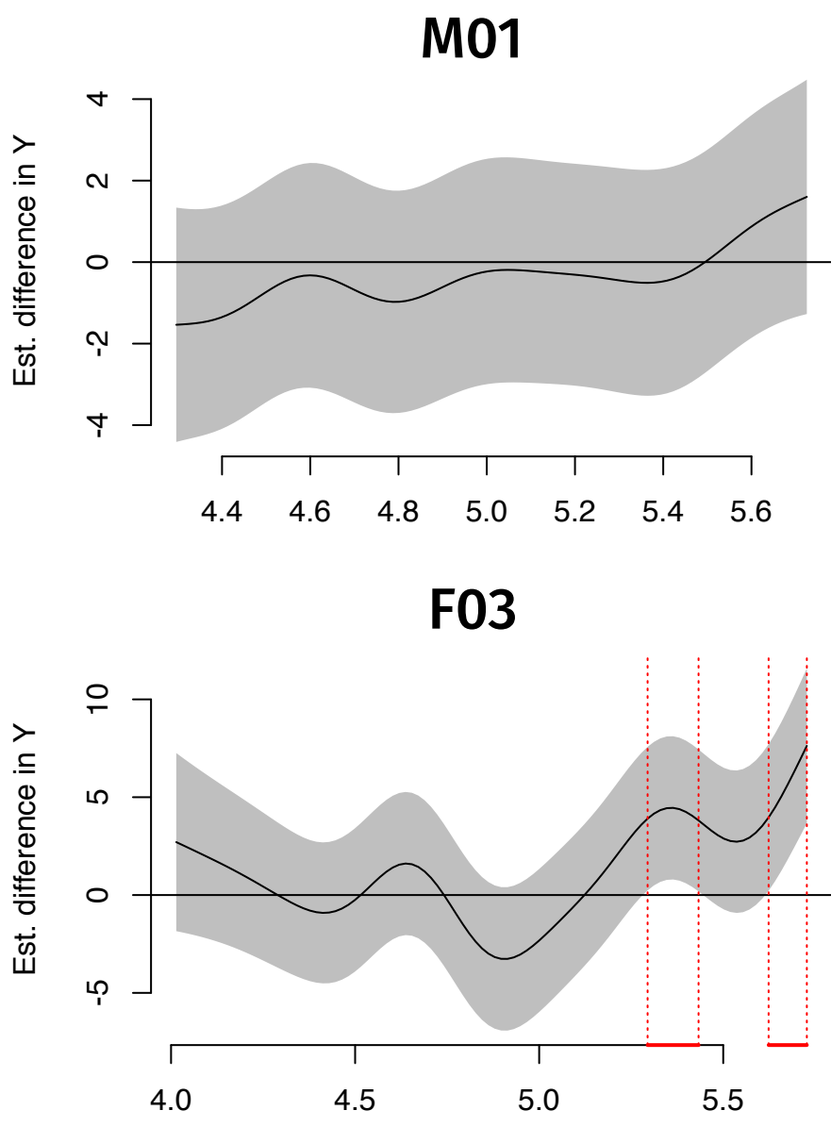
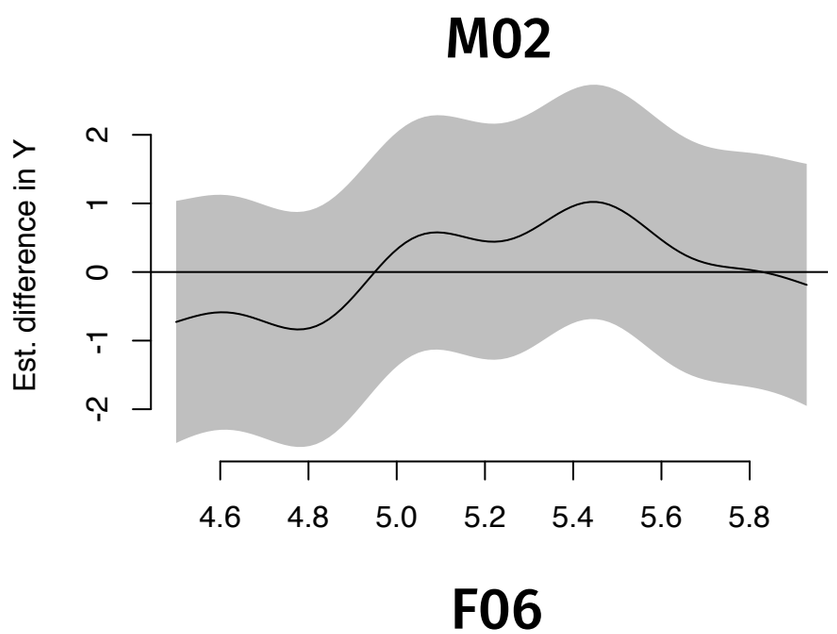
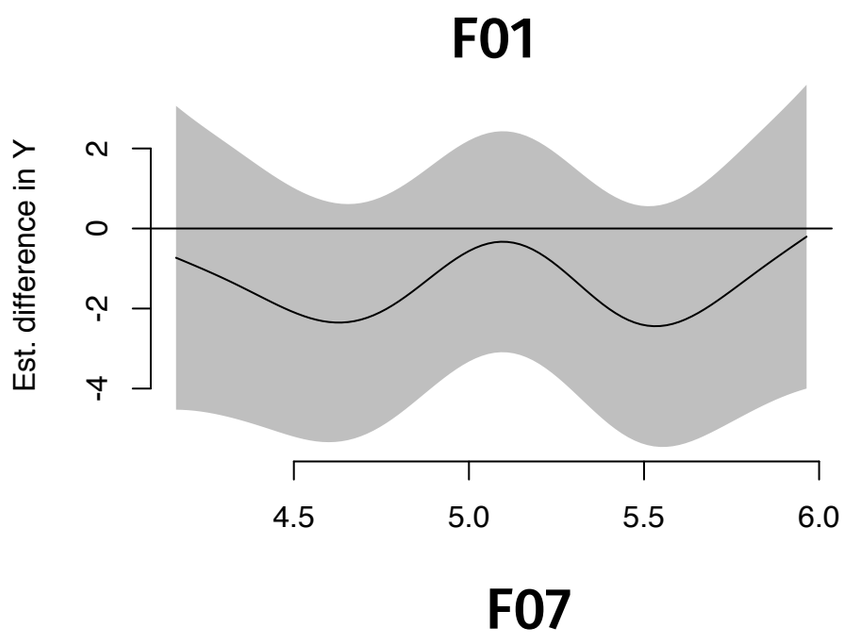
APPENDICES

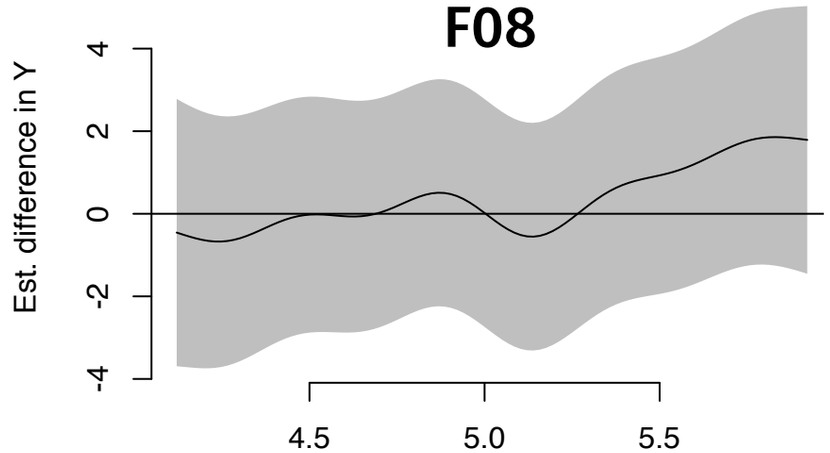
Difference smooths







/stɹ/-/stj/



Future articulatory work

- **Electropalatography (EPG)**
  - Provides direct measures of lingual-palatal contact
  - Mostly used for clinical purposes in speech and language therapy (see e.g. Dent et al. 1995, Timmins & Wood 2015, Wood et al. 2018)
  - Can be used to investigate the size and shape of oral constrictions in fricatives as well as the width/length of tongue grooving
- **Electromagnetic articulography (EMA)**
  - Can measure position and movement of various articulators (including lips)
  - Better than ultrasound, which is restricted to only one plane (see e.g. Strycharczuk et al. 2018 on lateralisation in /l/)
- **Coronal ultrasound**
  - Provides direct access to the sides of the tongue, and so could be used to investigate grooving

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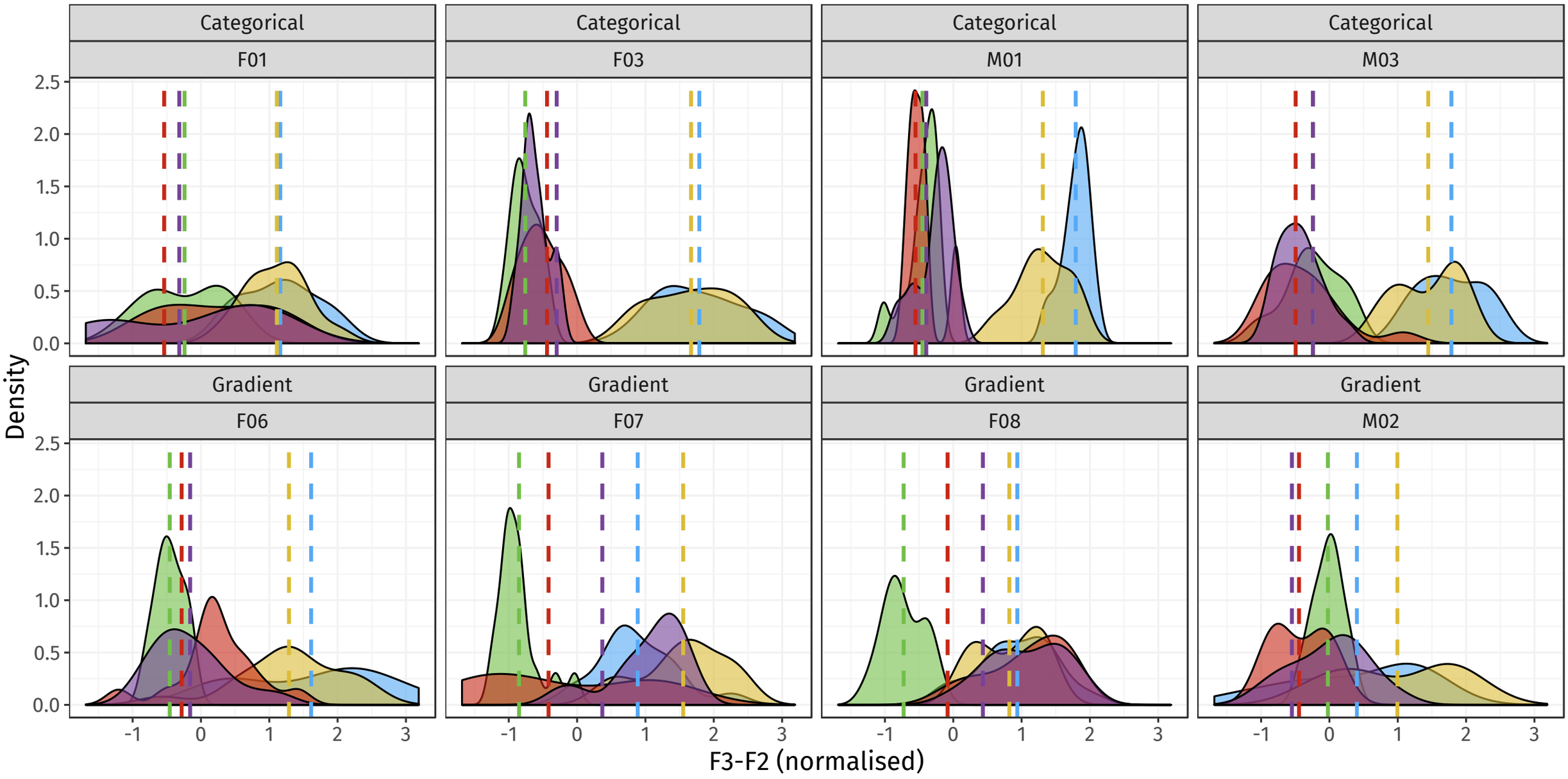
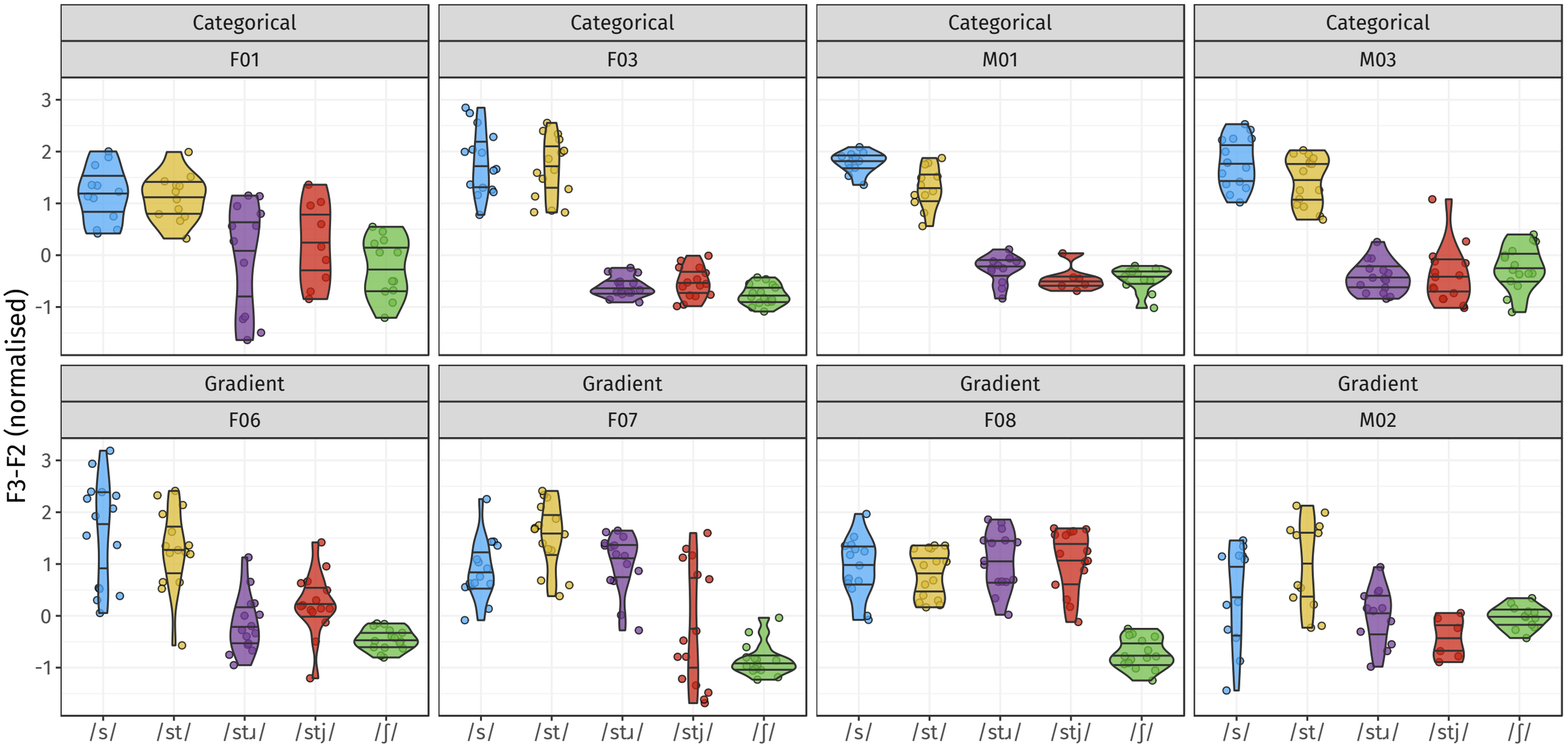
F3-F2 AND CENTRE OF GRAVITY



- F3-F2 can be used as a proxy for lip rounding (Stevens 2000:291)
- For some speakers, there is a clear relationship between CoG and lip rounding
  - More /ʃ/-like tokens exhibit lower CoG and more lip rounding
  - More /s/-like tokens show higher CoG but less lip rounding
- However, many speakers show no such pattern, with much higher within-category variation
- Perhaps because lip rounding isn't being used as a primary cue in sibilant production? (cf. Bang et al. 2018 on Seoul Korean)

F3-F2 AND CENTRE OF GRAVITY



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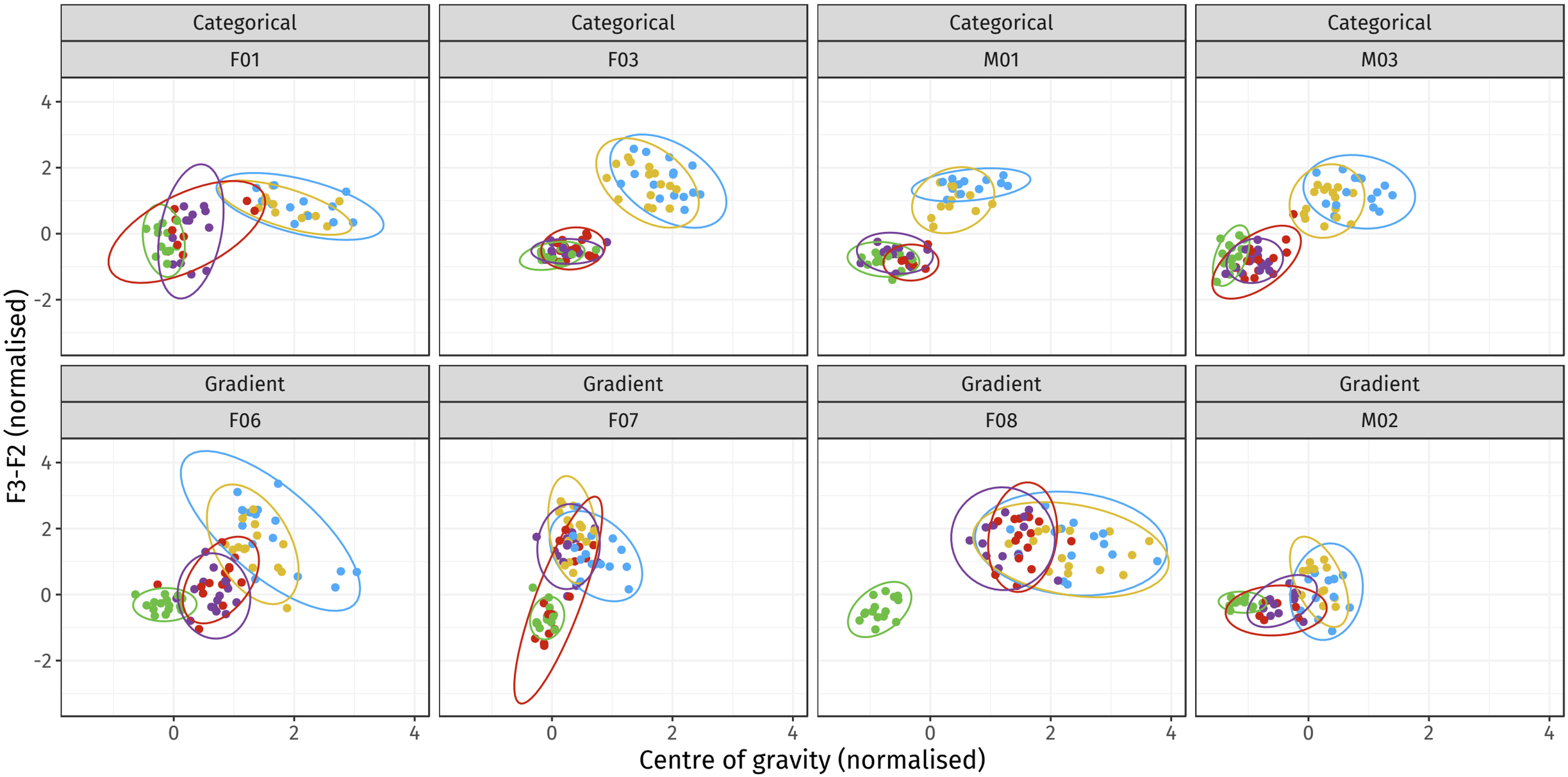

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Affrication

- Based on CoG, for most speakers, the fricated portions of pre-**/ɹ/** affrication and coalescence of **/tj/** 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)