

An articulatory study of /s/-retraction

How does **this change** behave
across word boundaries?

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UKLVC14 - University of Edinburgh
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What is **this** change?

- **/s/-retraction**: a process that turns **/s/** into a more **[ʃ]**-like sound (e.g. **[ʃ]treet**)
- sound change in progress in many varieties of English

e.g. Columbus, OH (Durian 2006); Philadelphia, PA (Gylfadottir 2015); Raleigh, NC (Wilbanks 2017); Louisiana (Rutter 2011); Georgia (Philips 2001); Austin, TX (Ahlers 2020); Estuary English (Altendorf 2003); Colchester (Bass 2009); Edinburgh (Sollgan 2013); Scotland (Stuart-Smith et al. 2019); Glasgow (Thielking 2023); Manchester (Bailey et al. 2022)

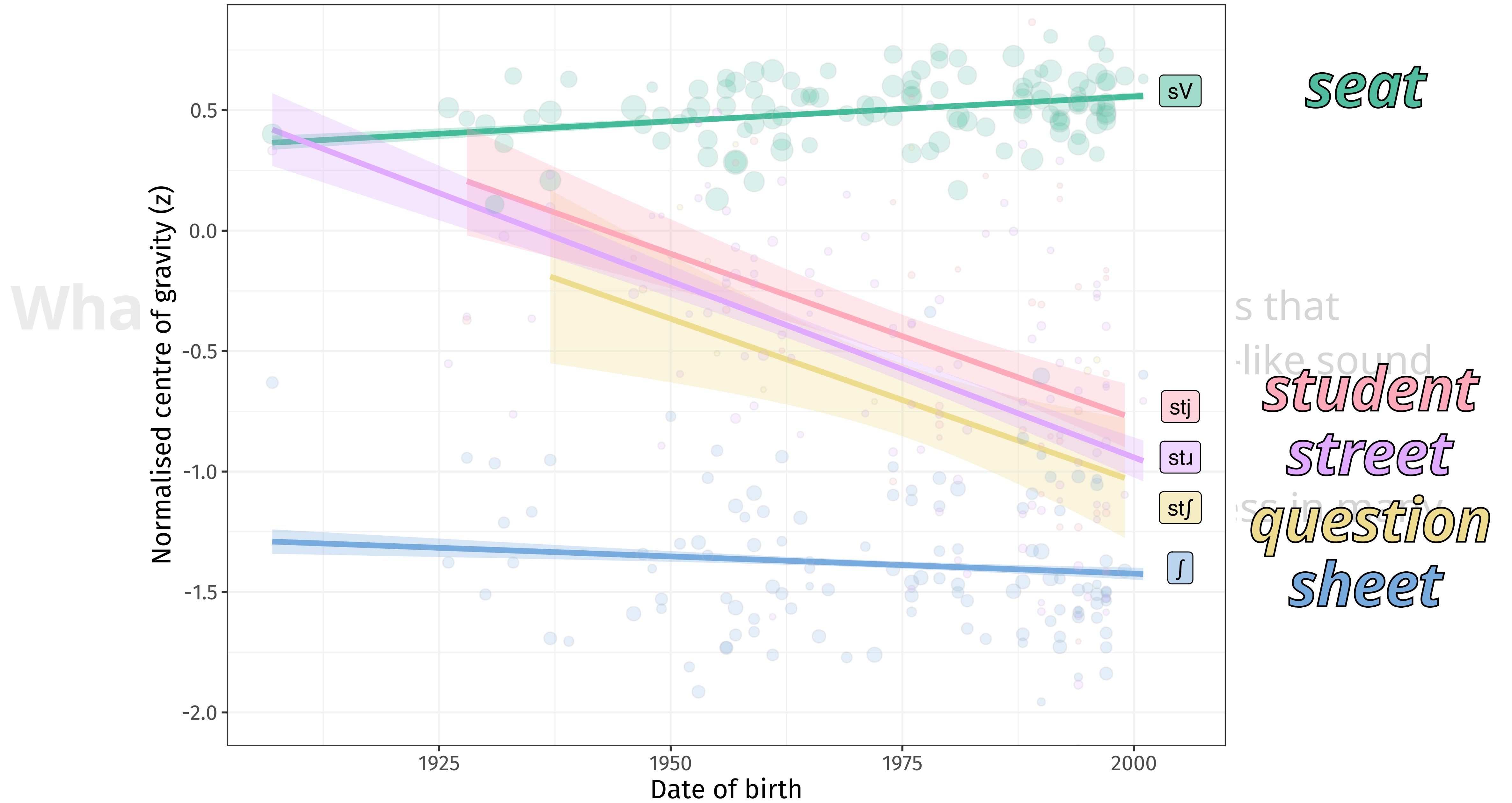
b. 1932

b. 1997



What is **this** change?

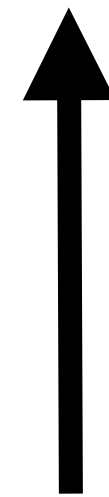
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What is this change?

- **/s/-retraction:** a process that turns /s/ into a more [ʃ]-like sound (e.g. [ʃ]treet)
- sound change in progress in many varieties of English

What is **this change**?



but it also happens
across word boundaries!

- **/s/-retraction**: a process that turns */s/* into a more [ʃ]-like sound (e.g. [ʃ]treet)
- sound change in progress in many varieties of English
- studies have focused on word-internal retraction

Opening the envelope of variation



Opening the envelope of variation

- Studying a wider range of environments will lend insight into a number of questions, including the role of /ɹ/ (vs. affrication) in triggering retraction (Shapiro 1995; Lawrence 2000; Baker et al. 2011; Bailey et al. 2022)

(#)stj

e.g. student

(#)stɹ

e.g. street

stʃ

e.g. mischief

s#tɹ

e.g. this trick

s#tj

e.g. nice tune

s#tʃ

e.g. glass chunk

s#ɹ

e.g. this rock

s#j

e.g. press you

z#dʒ

e.g. wise job

z#dj

e.g. these dunes

z#dɹ

e.g. his drink

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s#j

e.g. press you

z#dʒ

e.g. wise job

z#dj

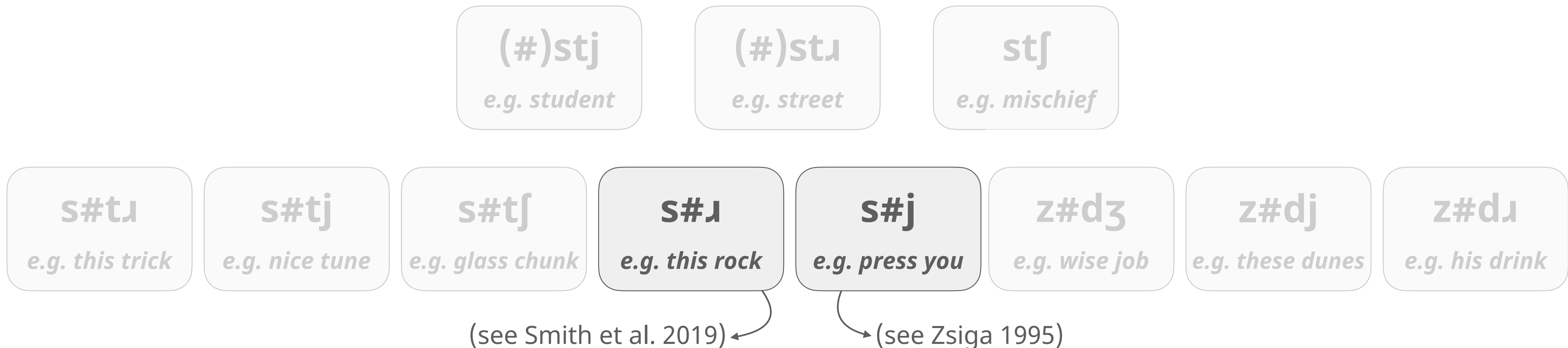
e.g. these dunes

z#dɹ

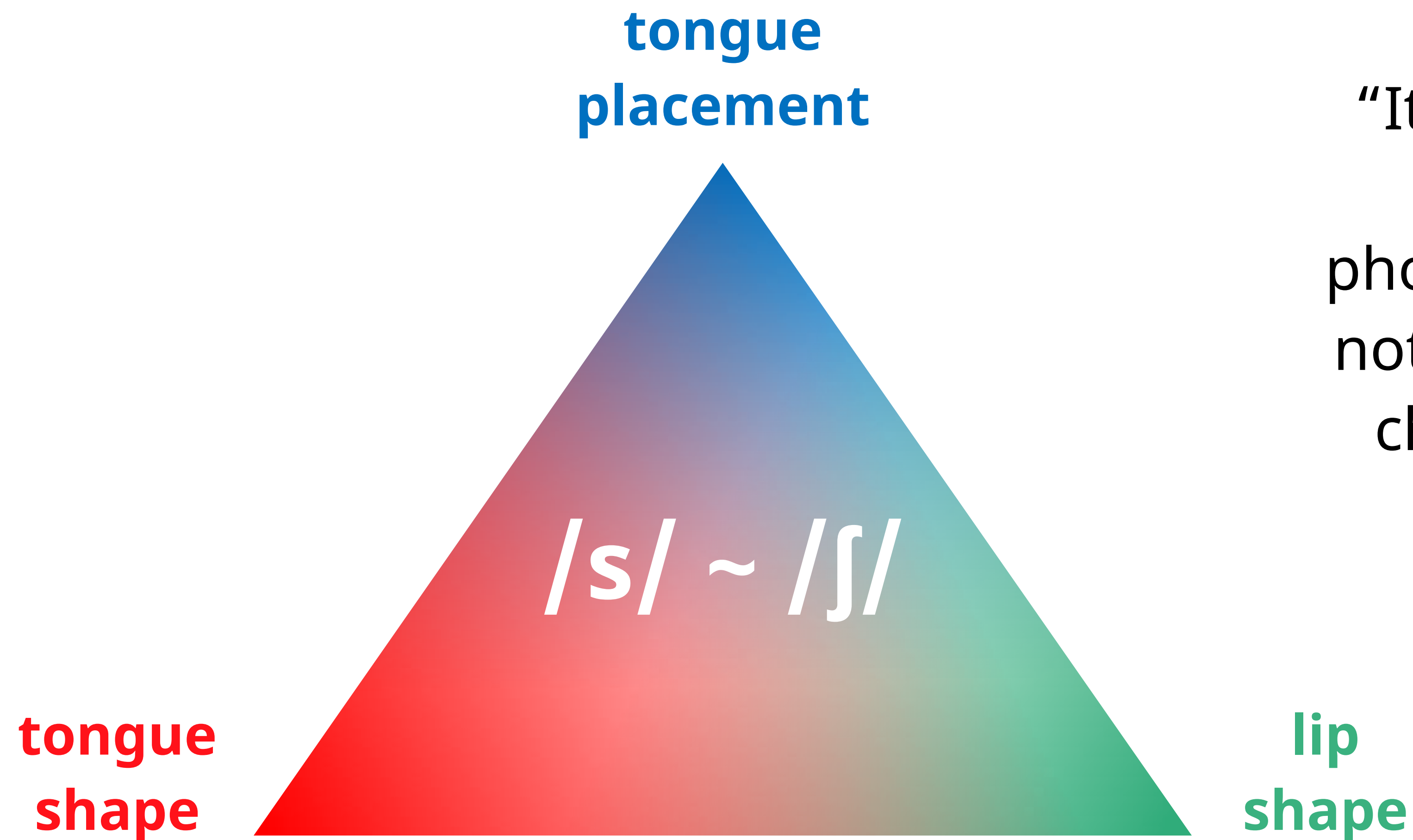
e.g. his drink

Opening the envelope of variation

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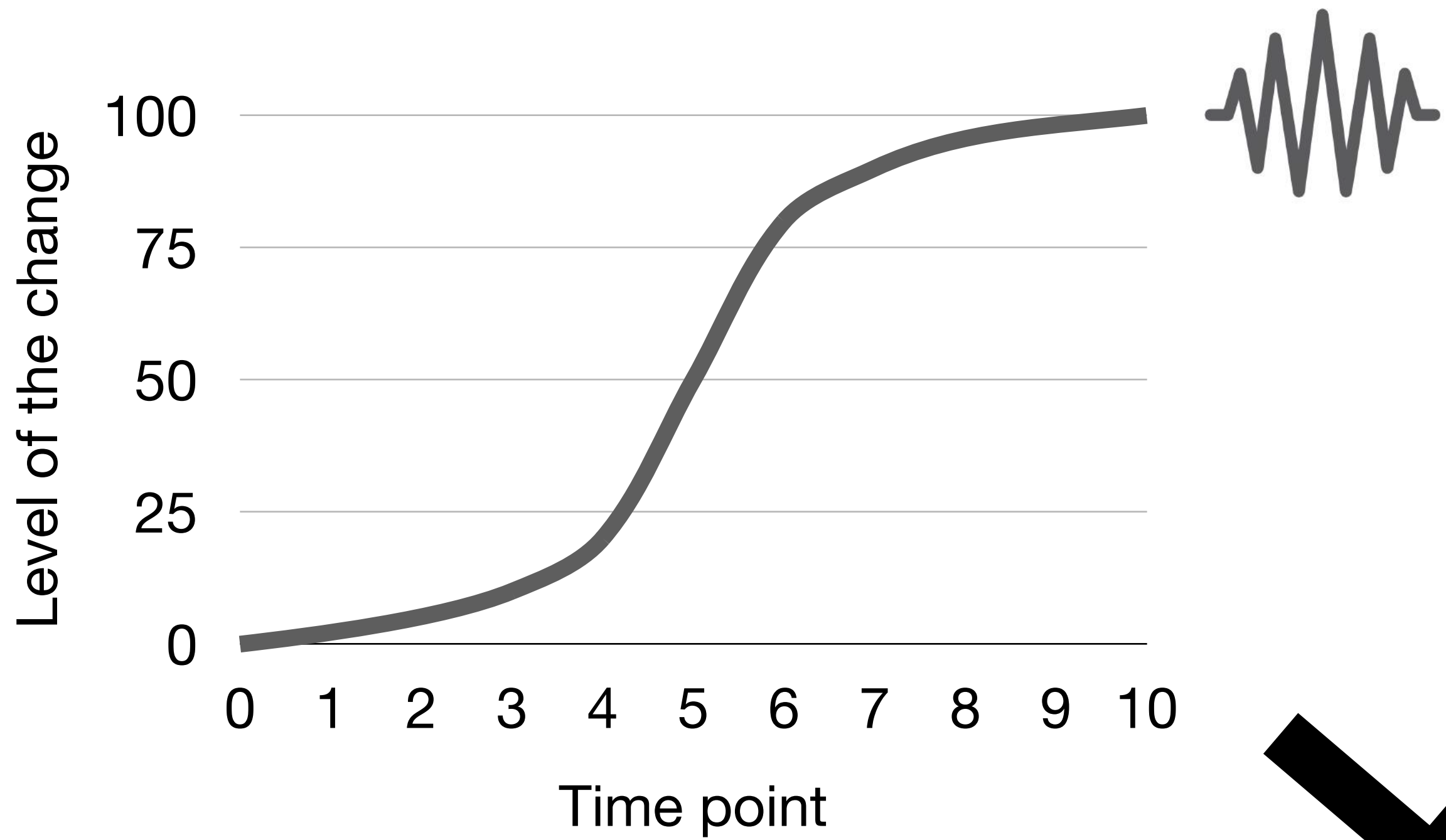


Articulation of the /s/~/ʃ/ continuum isn't just a move from alveolar to postalveolar **place of articulation** – it can also involve **tongue grooving** and **labialisation**



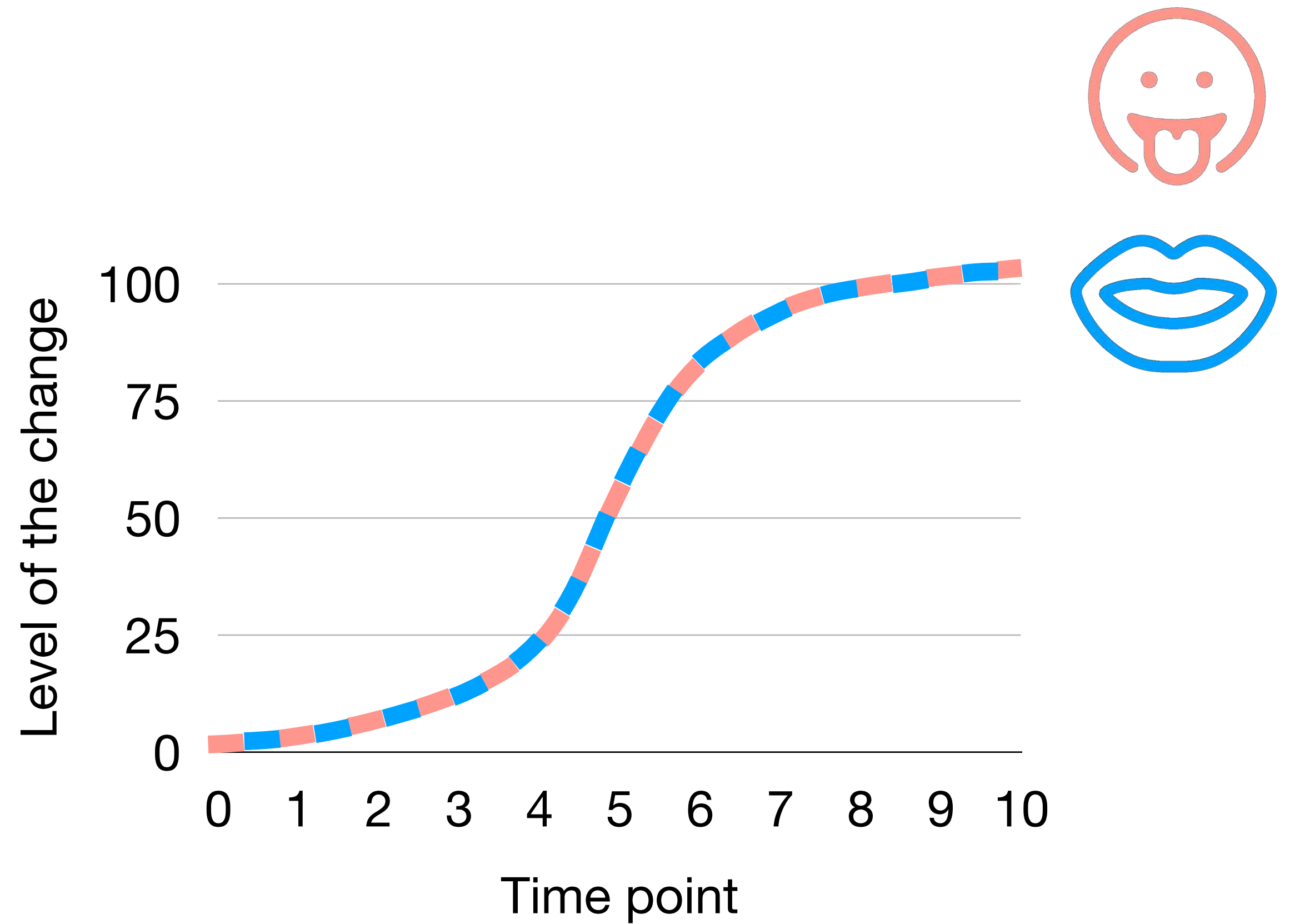
“It is also worth noting that changes in one of the phonetic parameters [...] may not necessarily co-occur with changes in the other two”

– Rutter 2011: 31

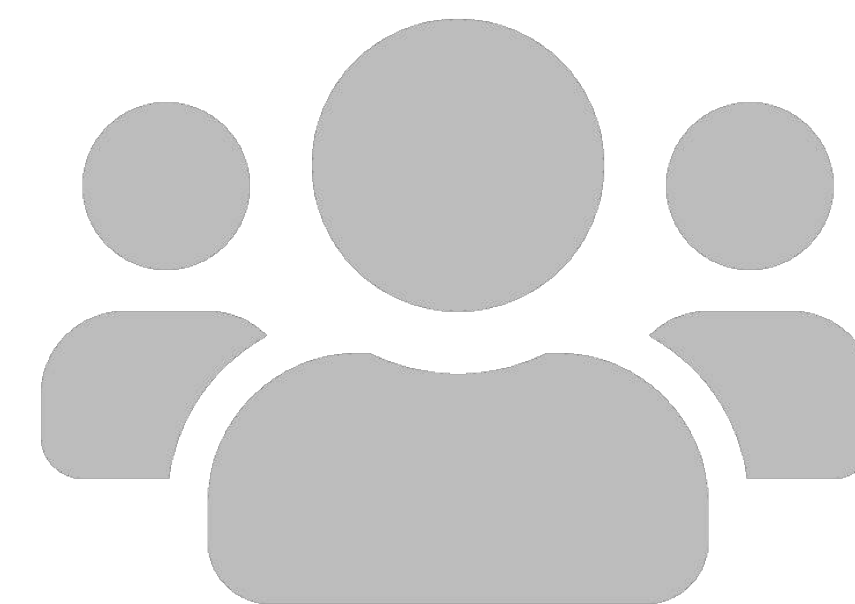
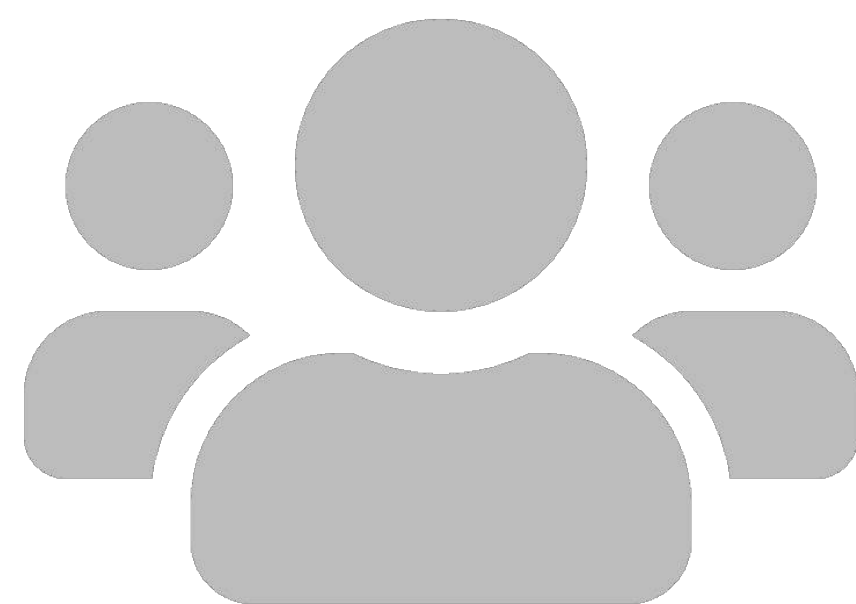
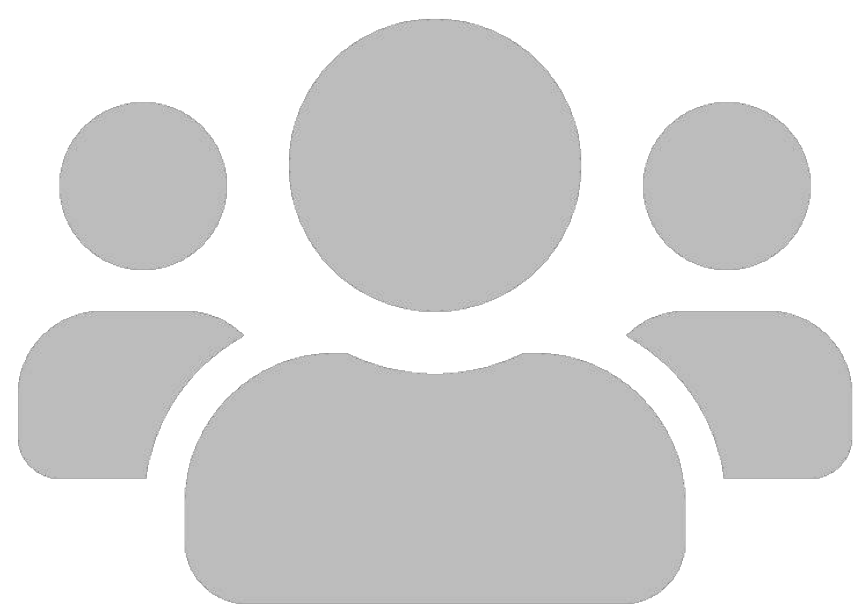
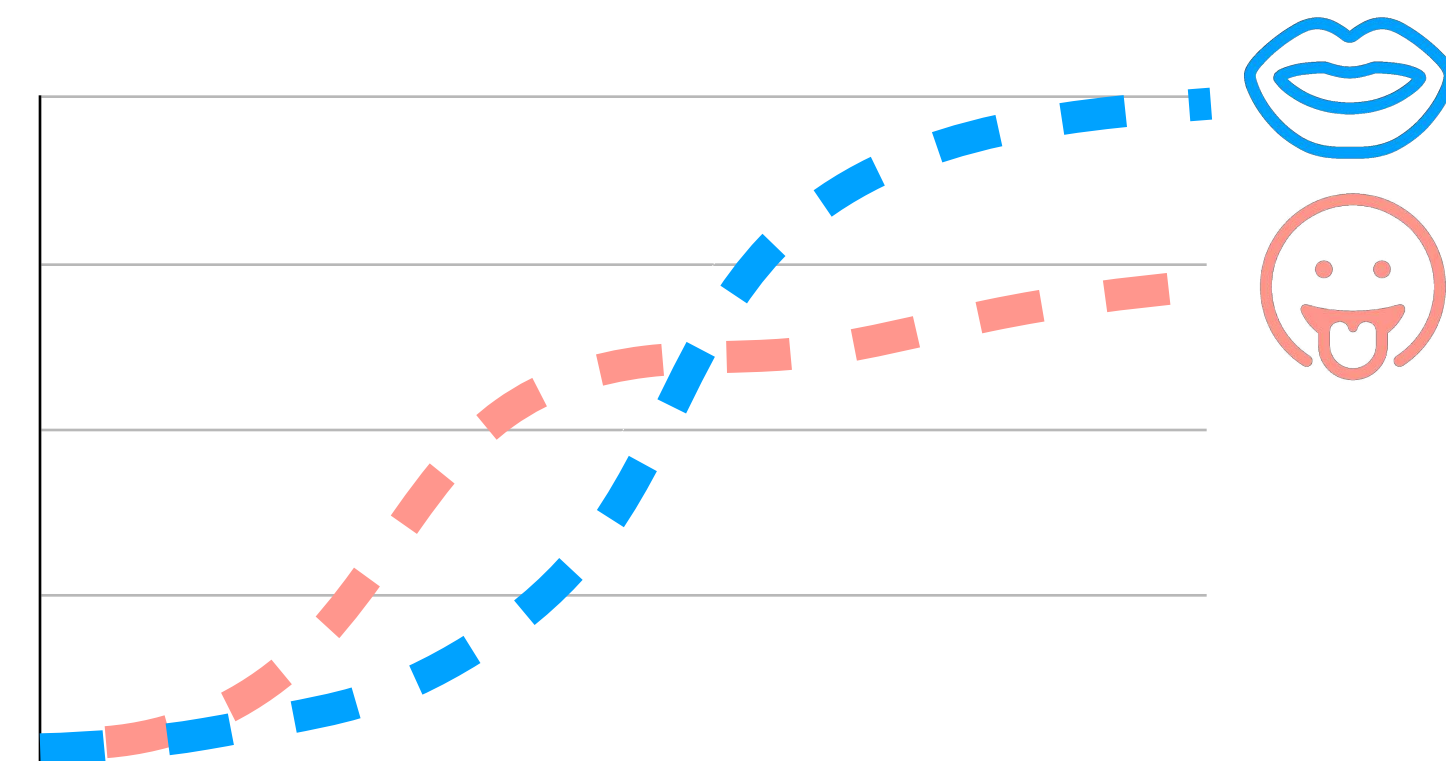
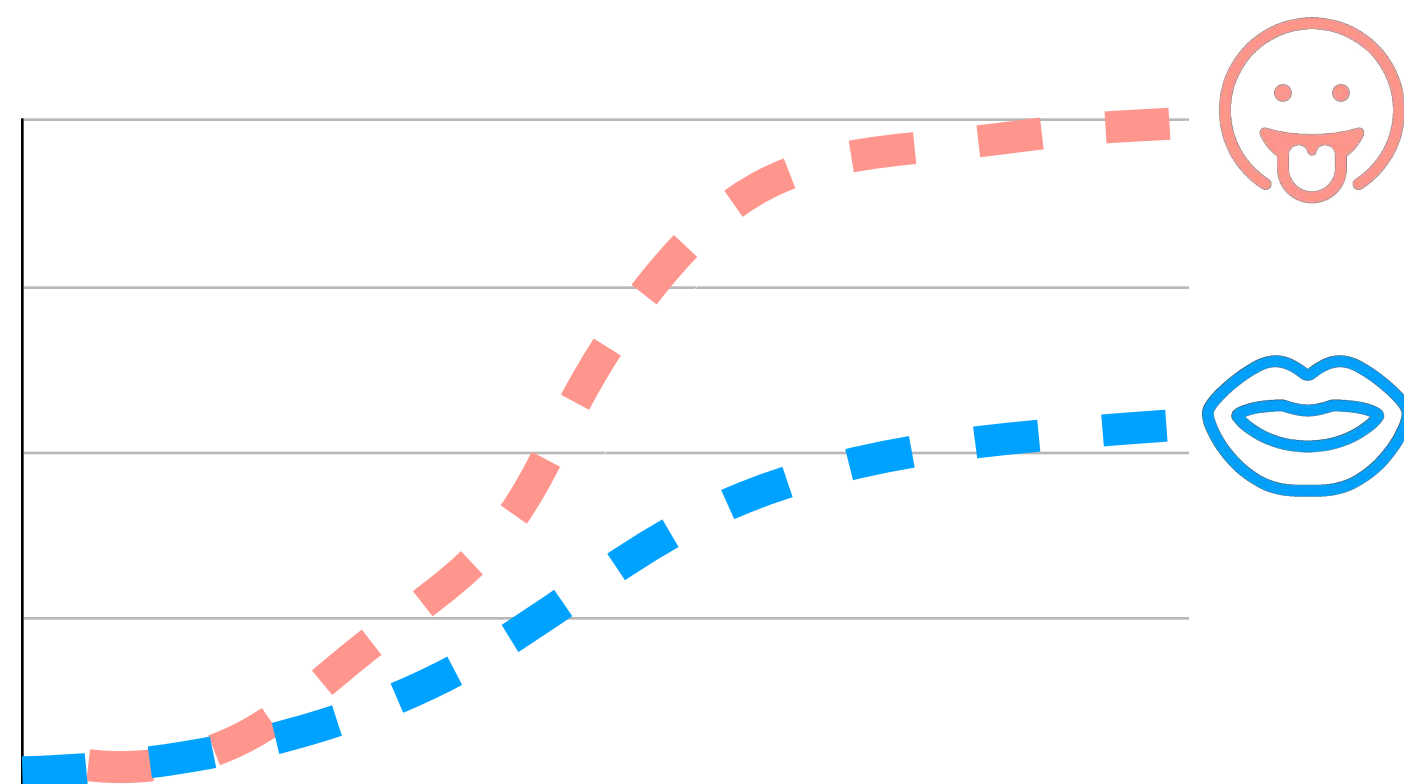
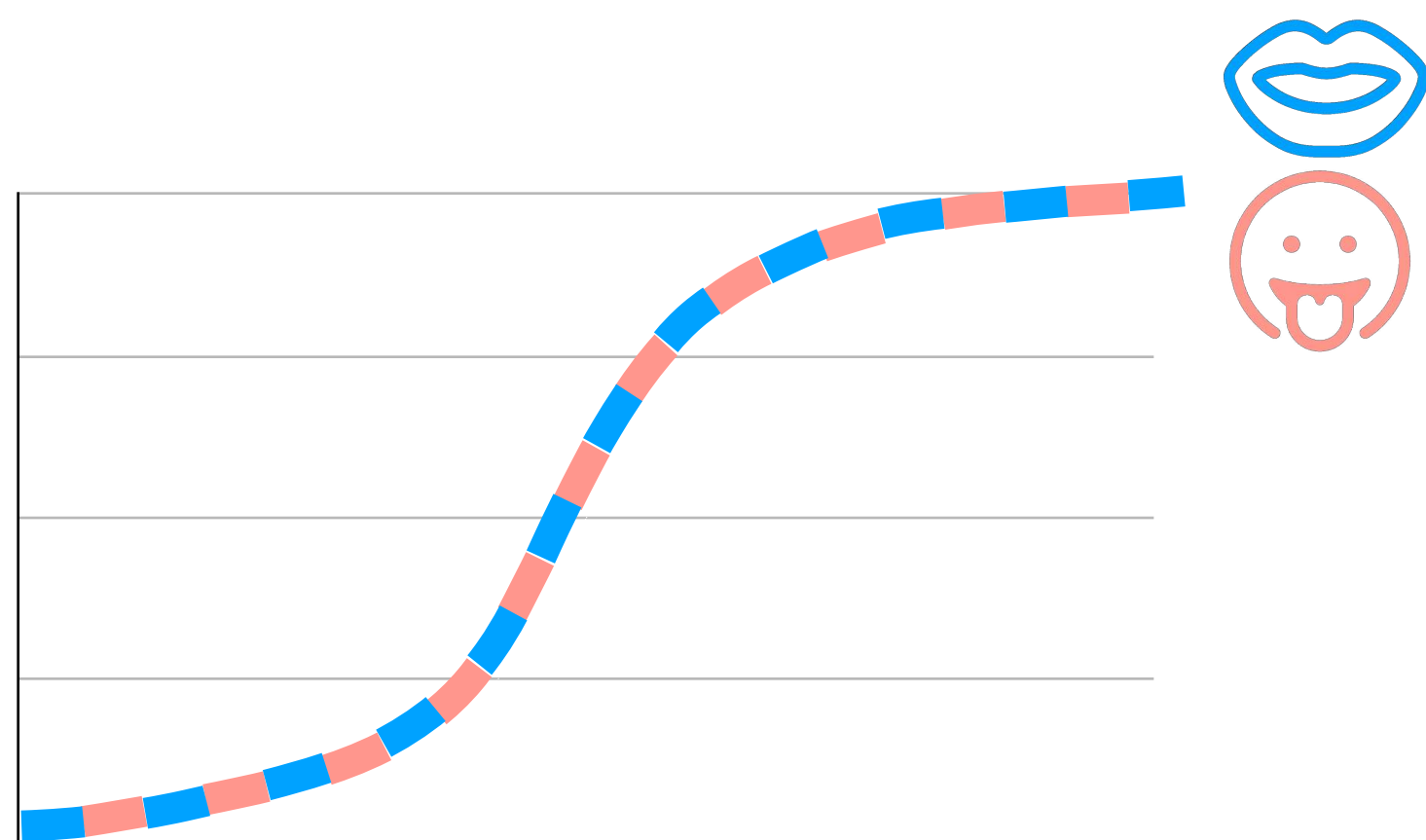


Tracking the acoustics of a sound change

Tracking the articulatory gestures involved in sound change



Articulatory variation, individuals, and the community



Methods

Data collection

- Similar to other articulatory work on /s/-retraction (Smith et al. 2019; Thielking 2022), we collect simultaneous:



ultrasound tongue
imaging of the
midsagittal plane

+



front-facing
lip camera
recording

+

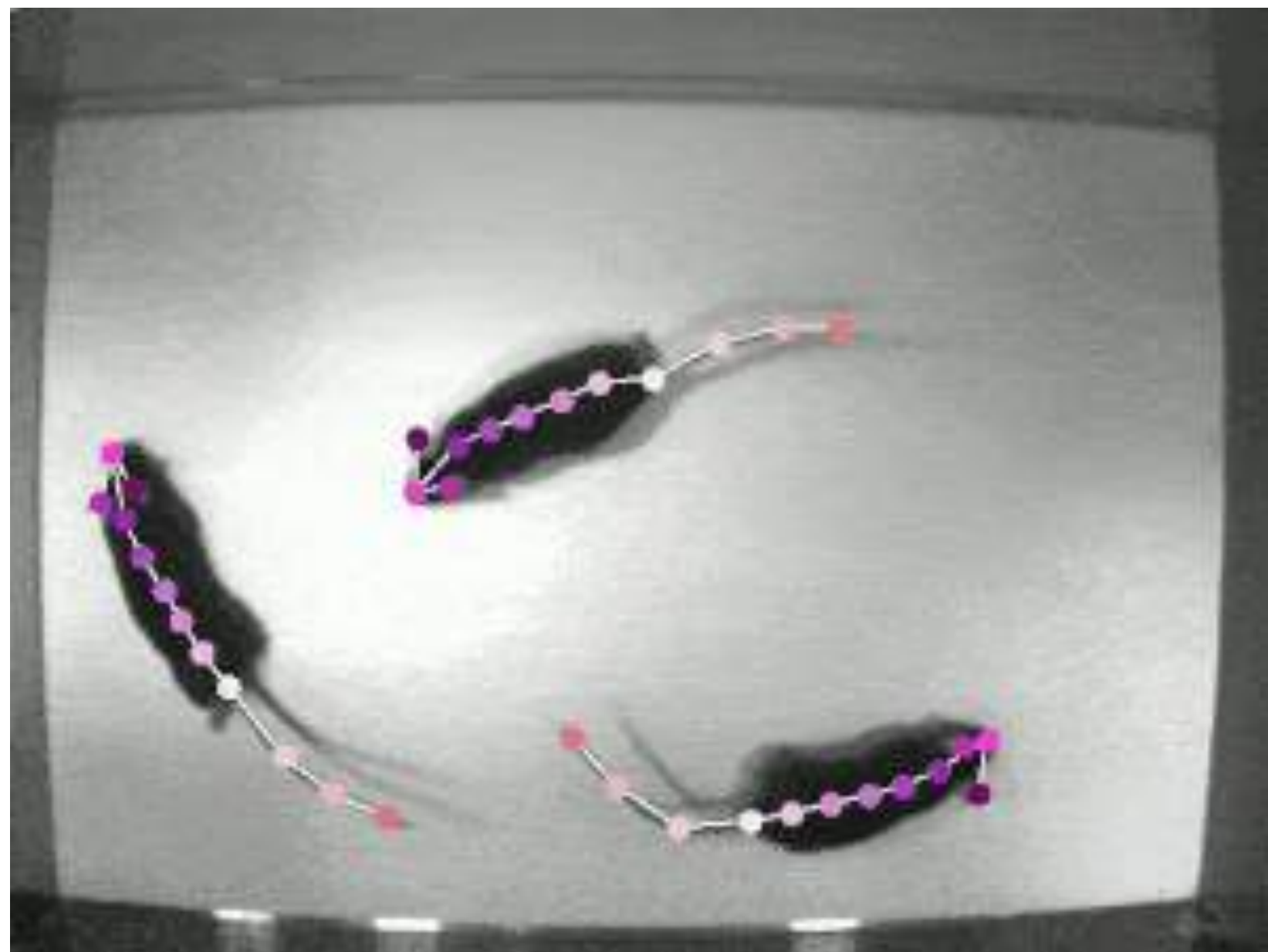
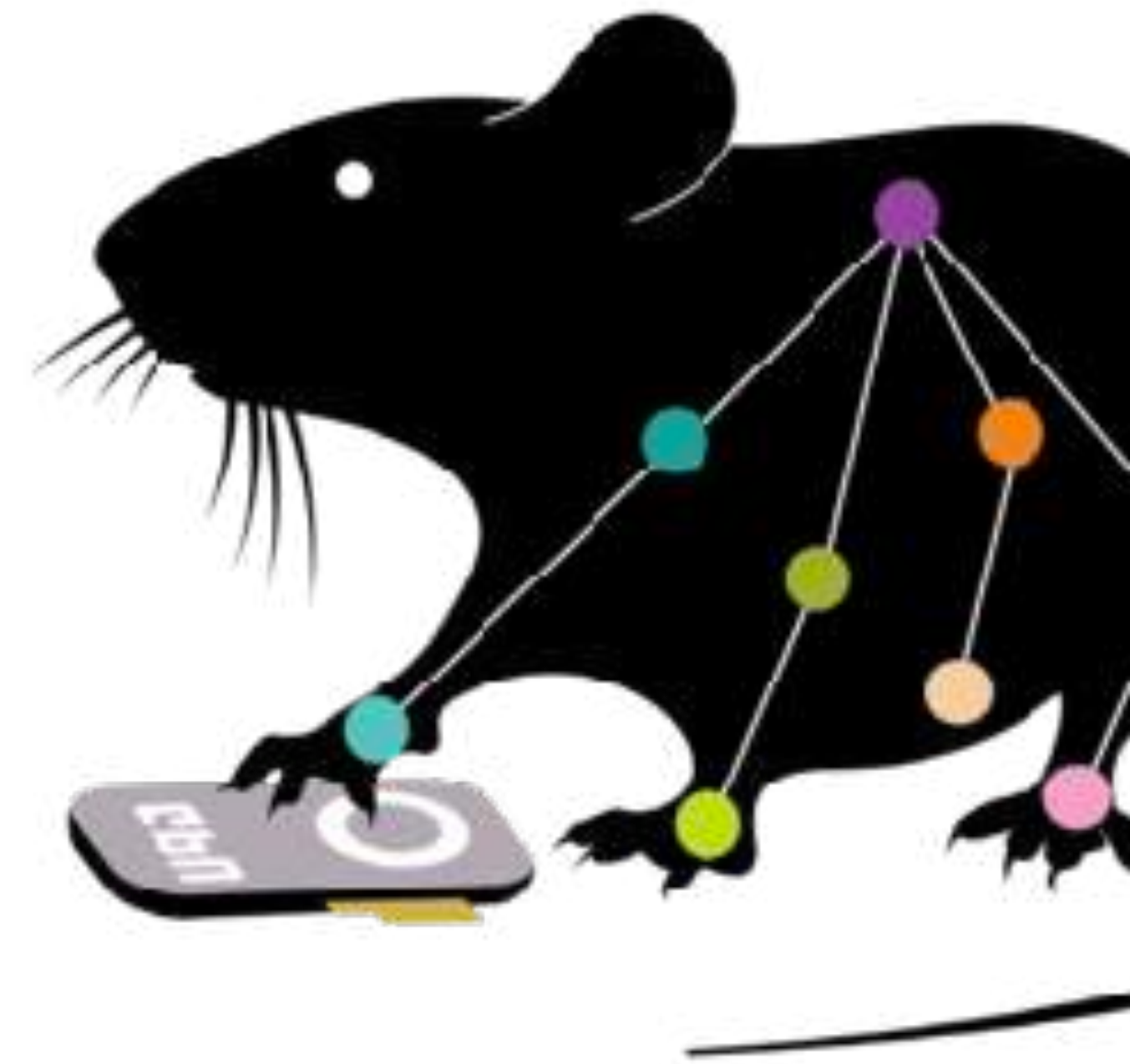


audio recording

Methods

Data processing

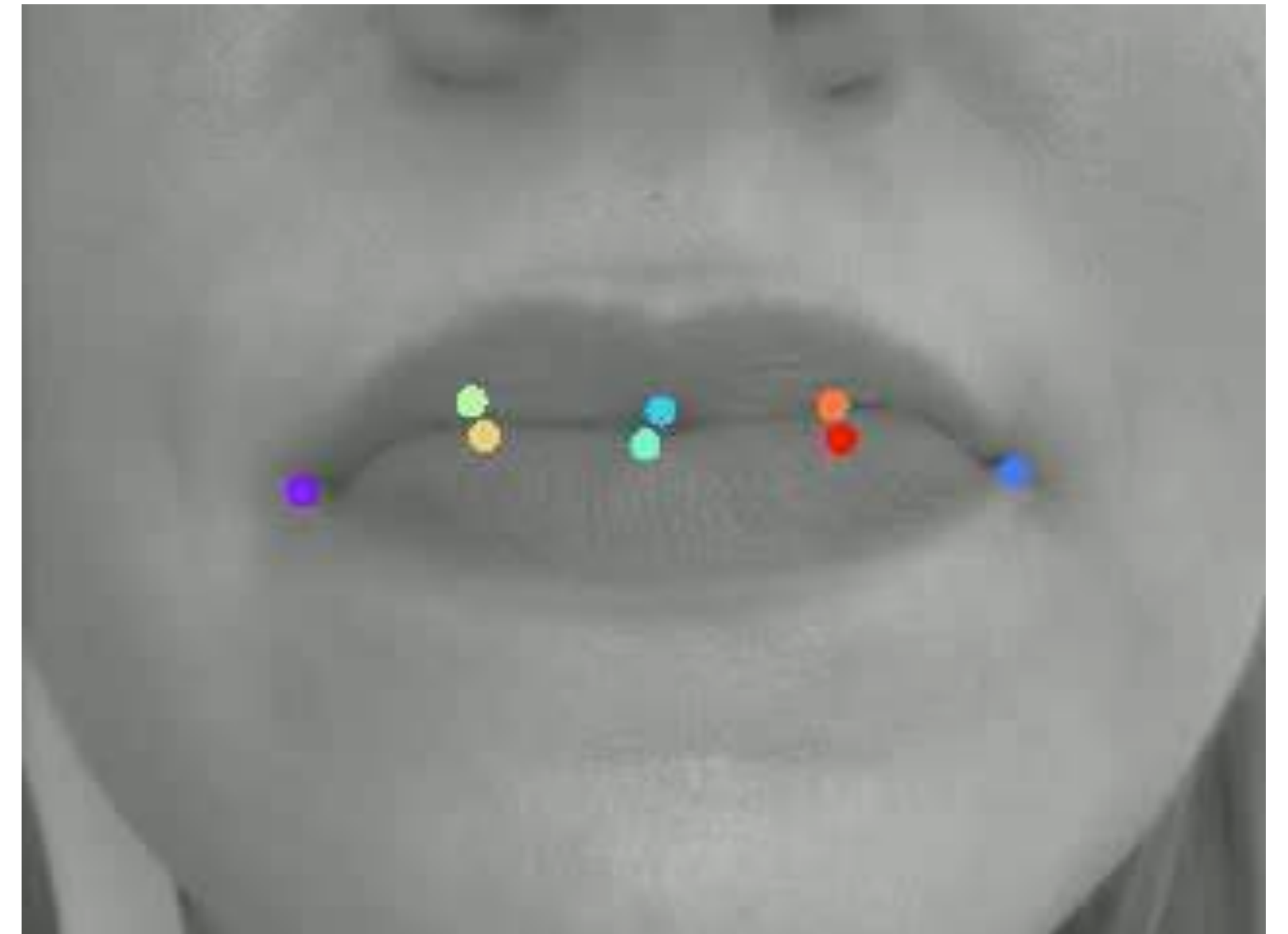
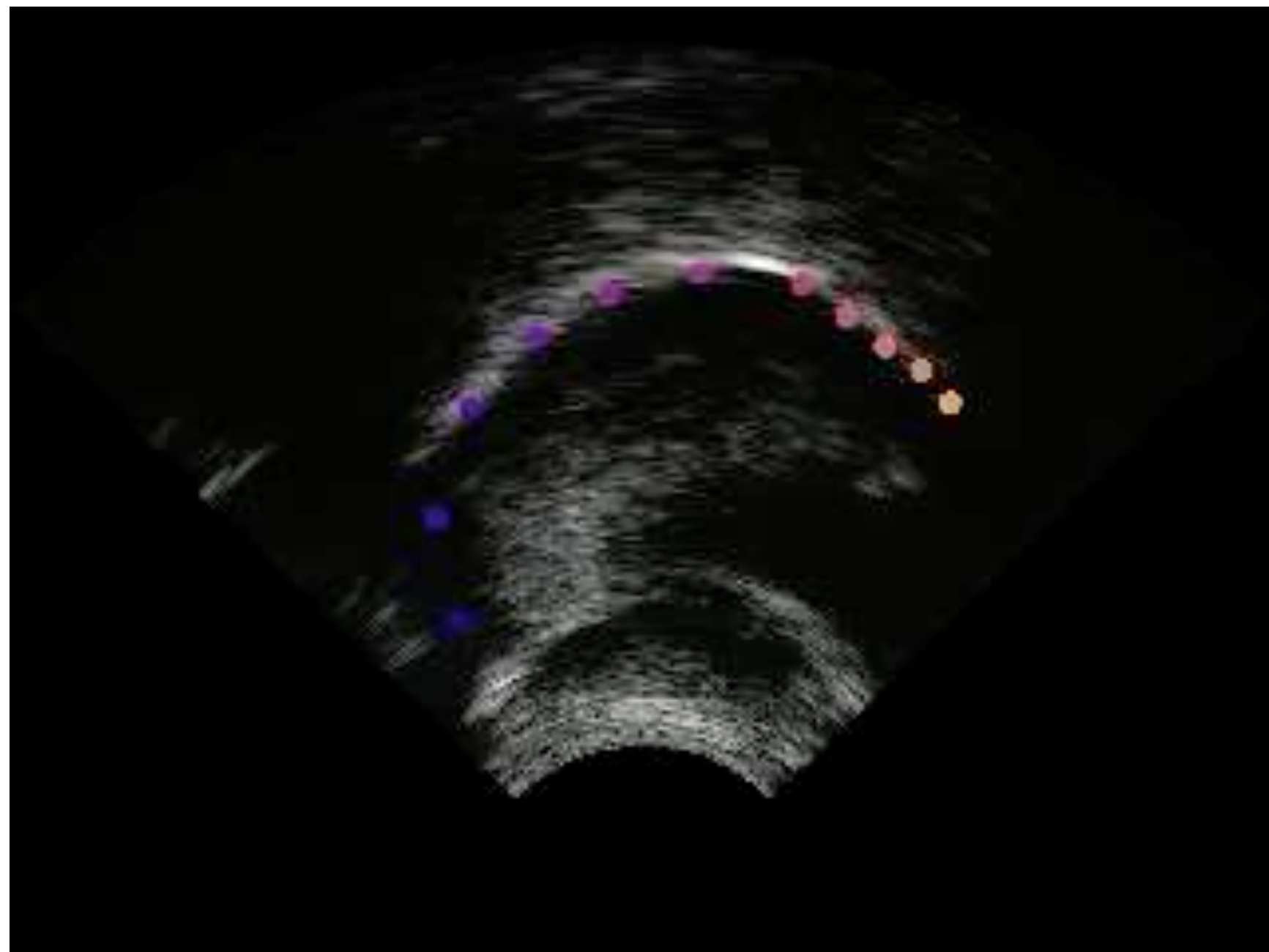
- **DeepLabCut** - new method of processing ultrasound recordings using machine learning and markerless pose estimation (Wrench & Balch-Tomes 2022)



Methods

Data processing

- **Pre-trained model** for tracking 11 points along the surface of the tongue
- **Self-trained models** for tracking 8 points along the upper/lower lip



Methods

Stimuli design

post-lexical retraction

I said...

		<i>/ʃ, ʒ/</i>	<i>/tʃ, dʒ/</i>	<i>/tɹ, dɹ/</i>	<i>/tj, dj/</i>	<i>/ɹ/</i>	<i>/j/</i>
thi <i>/s/</i>	<i>/uː/</i>	shoe	chew toy	trooper	tube / tune	room	youth
	<i>/iː/</i>	sheep	cheese	tree	—	reed	yeast / year
	<i>/ɒ/</i>	shop	chopper	trolley	—	rock	yacht
the <i>/z/</i> e	<i>/uː/</i>	jus (PL)	jewels	druids	dunes / dukes		
	<i>/iː/</i>	gilets	jeeps	dreams	—		
	<i>/ɒ/</i>	genres	jobs	drops	—		

Methods

Stimuli design

word-initial retraction

I said...

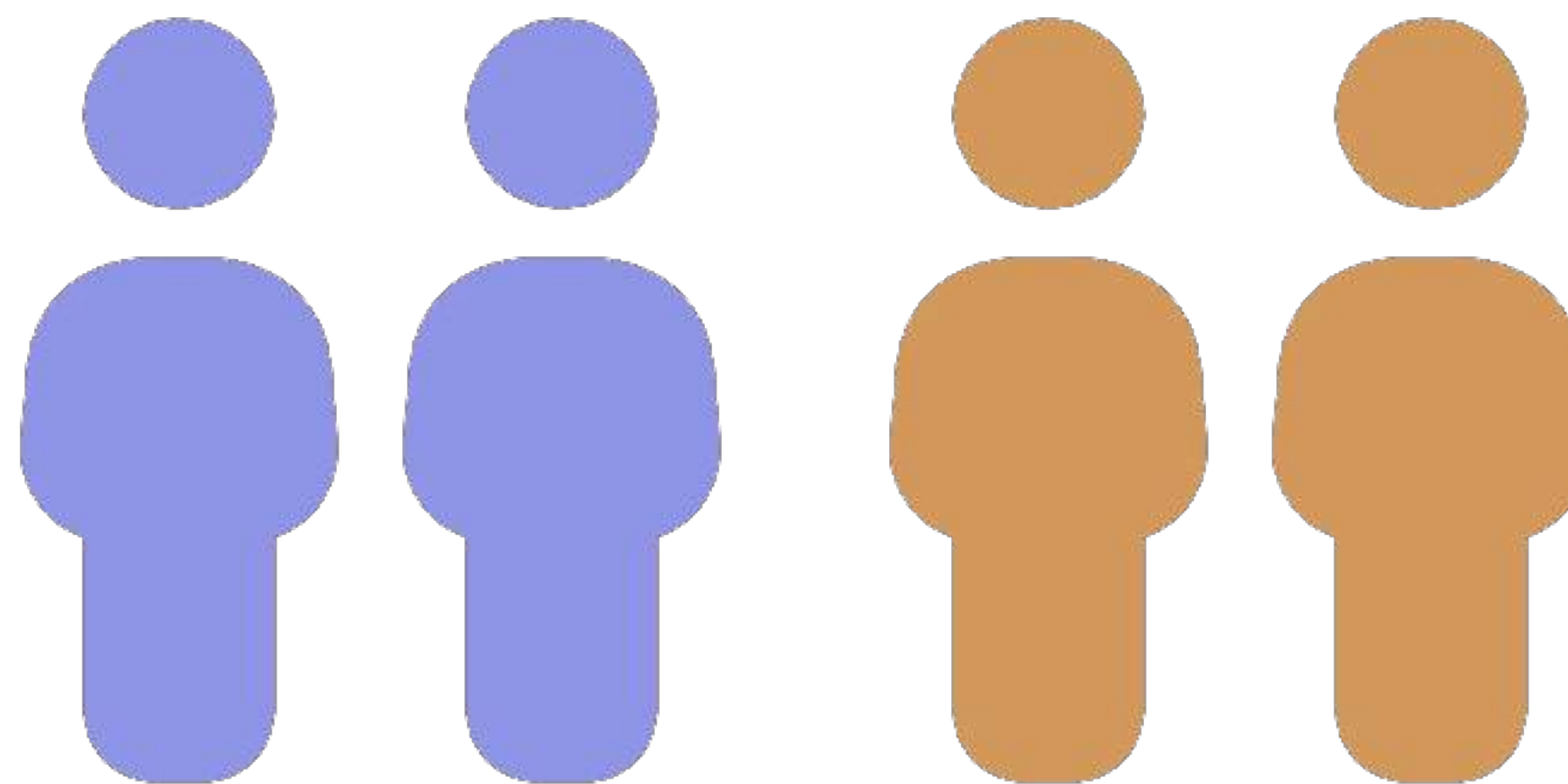
		<i>/s/</i>	<i>/stʌ/</i>	<i>/stj/</i>	<i>/ʃ/</i>
th/ə/	<i>/uː/</i>	soup	stroop test	student / stupid	chute
	<i>/iː/</i>	seat	street	—	sheet
	<i>/ɒ/</i>	sock	strop	—	shot
		<i>/z/</i>			<i>/ʒ/</i>
	<i>/uː/</i>	zoo			jus
	<i>/iː/</i>	zine			gilet
	<i>/ɒ/</i>	zombie			genre

Methods

Population sample

- 4 speakers recorded and analysed so far
 - 2x M from Manchester
 - 2x F from Blackburn
 - all aged 28–30

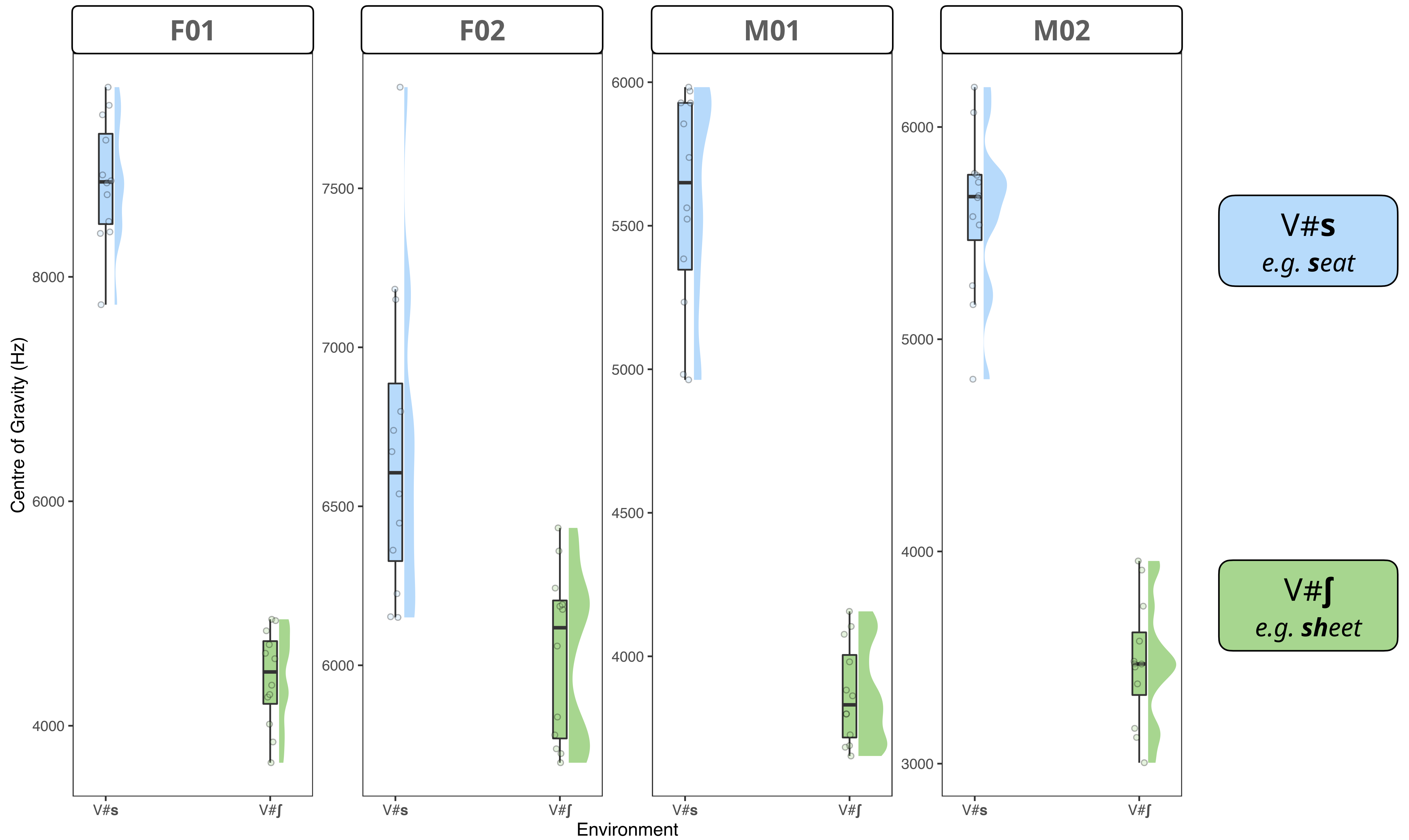
- Highly complex time-series dataset: roughly 1 million rows of observations *per speaker*

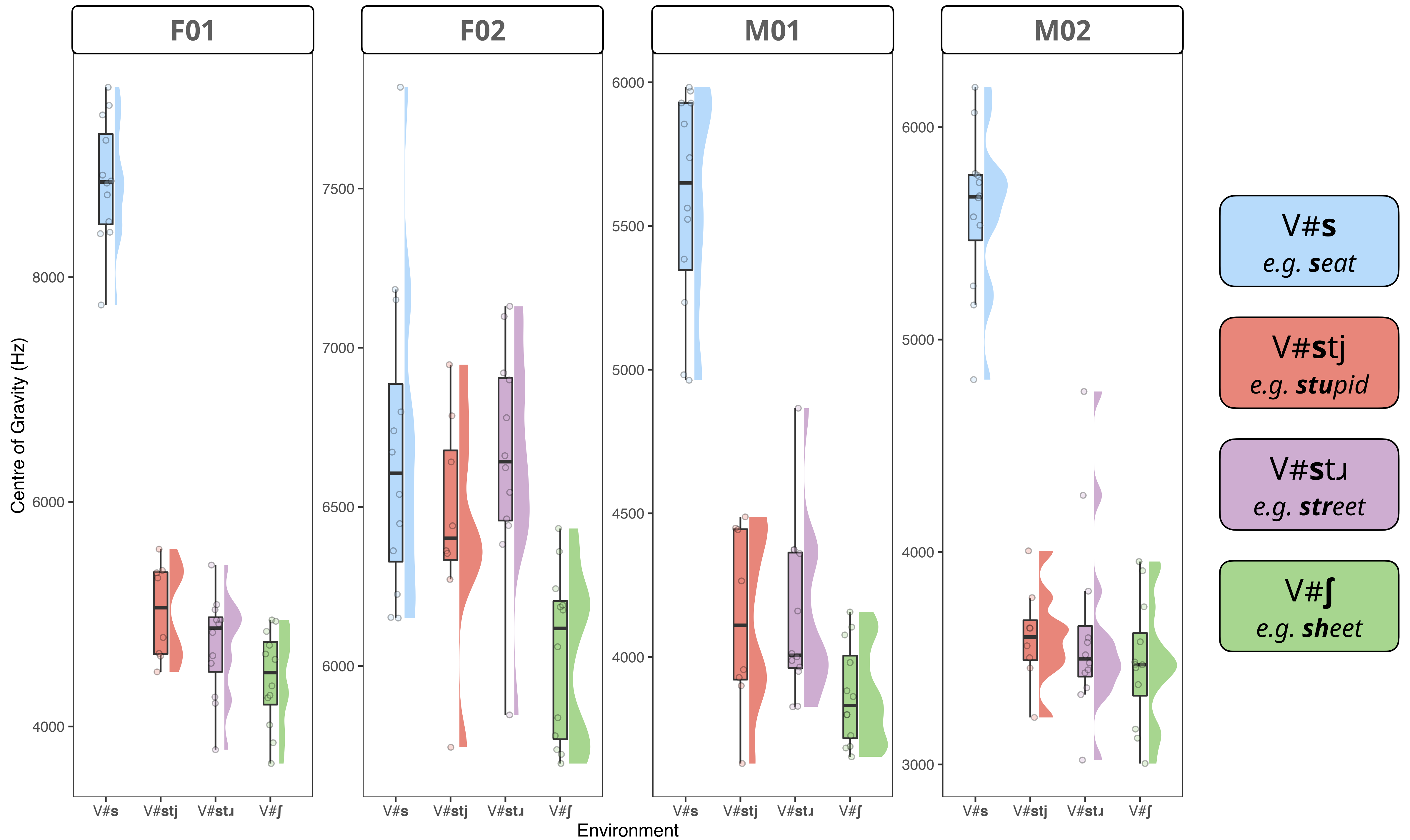


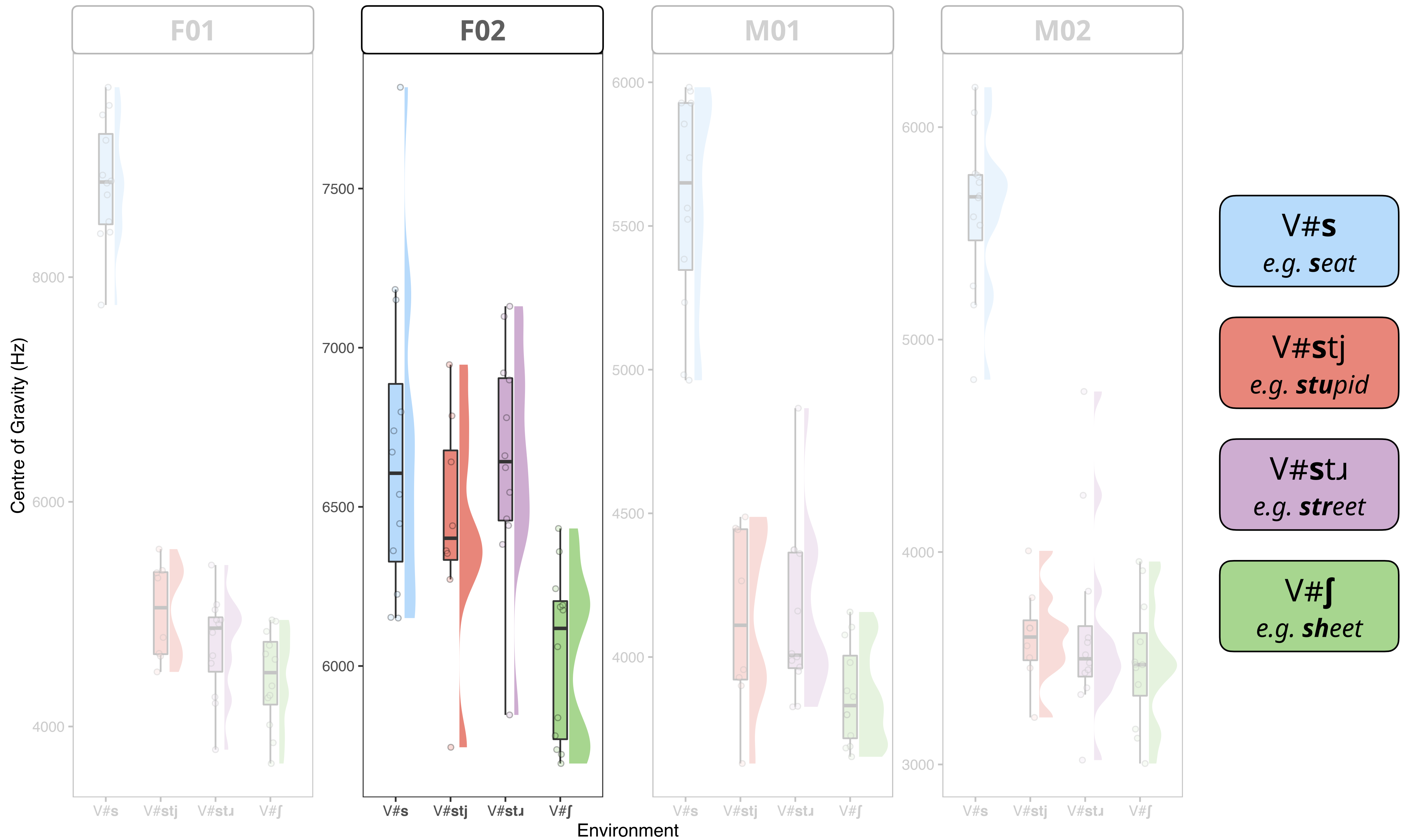
Acoustics

word-internal retraction





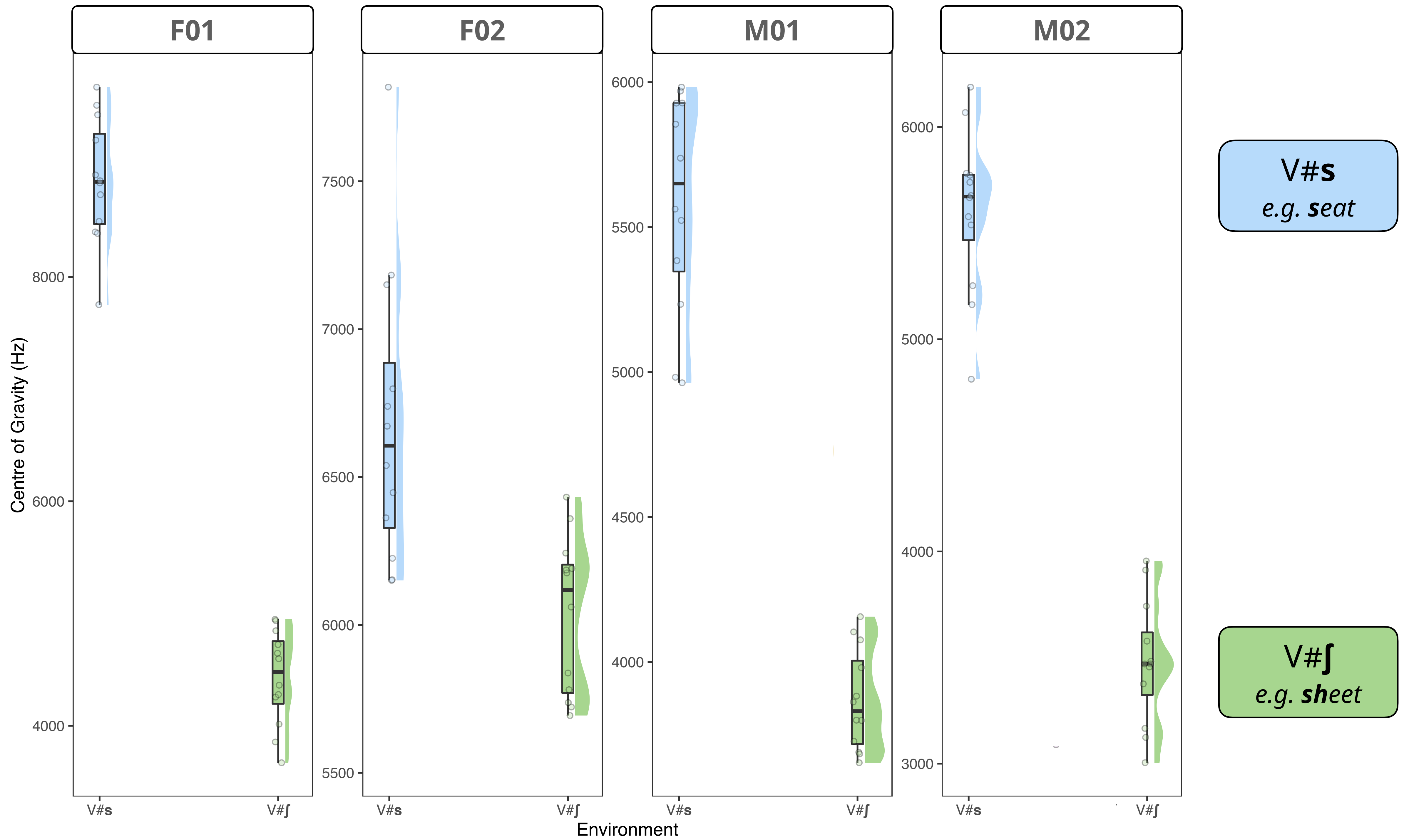


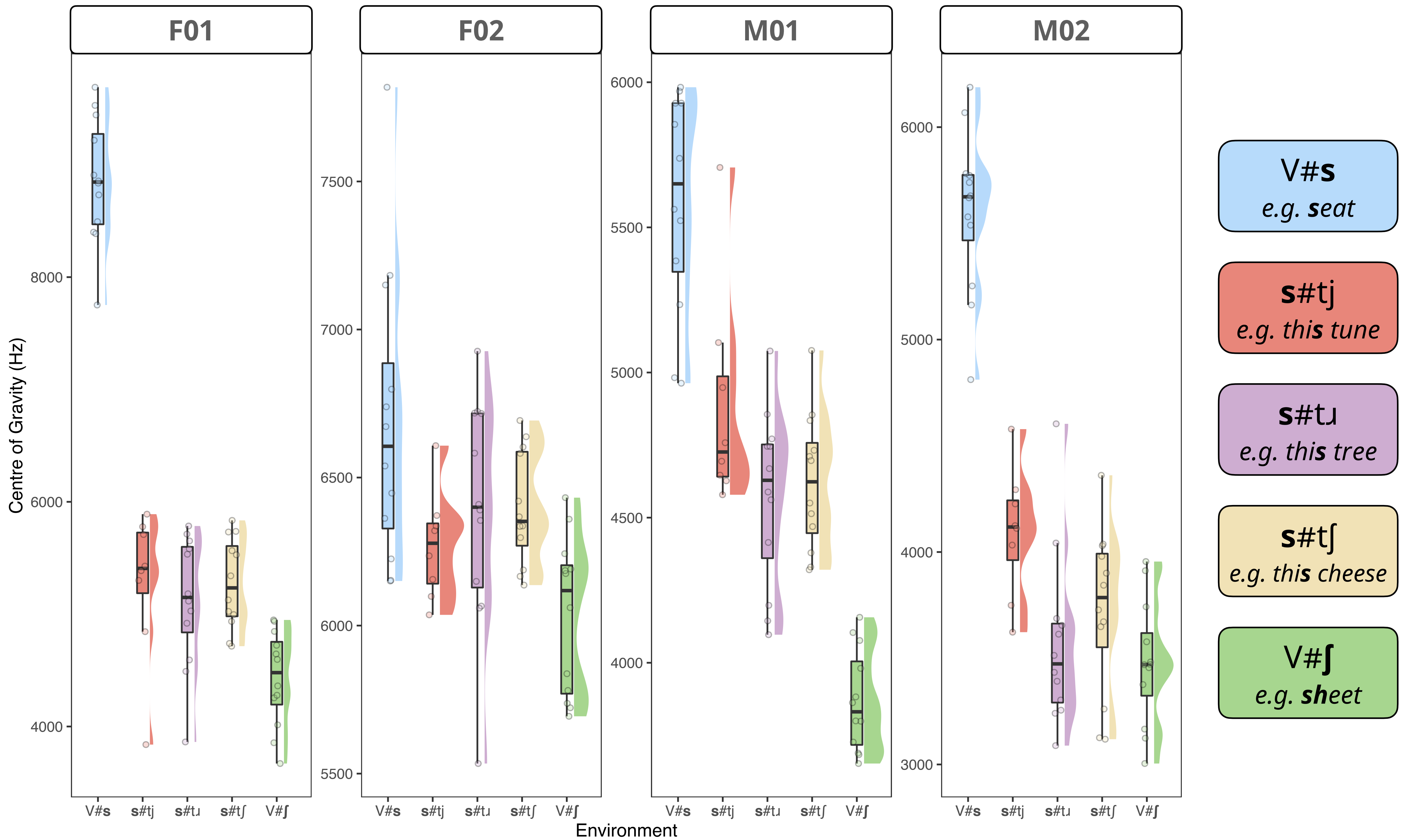


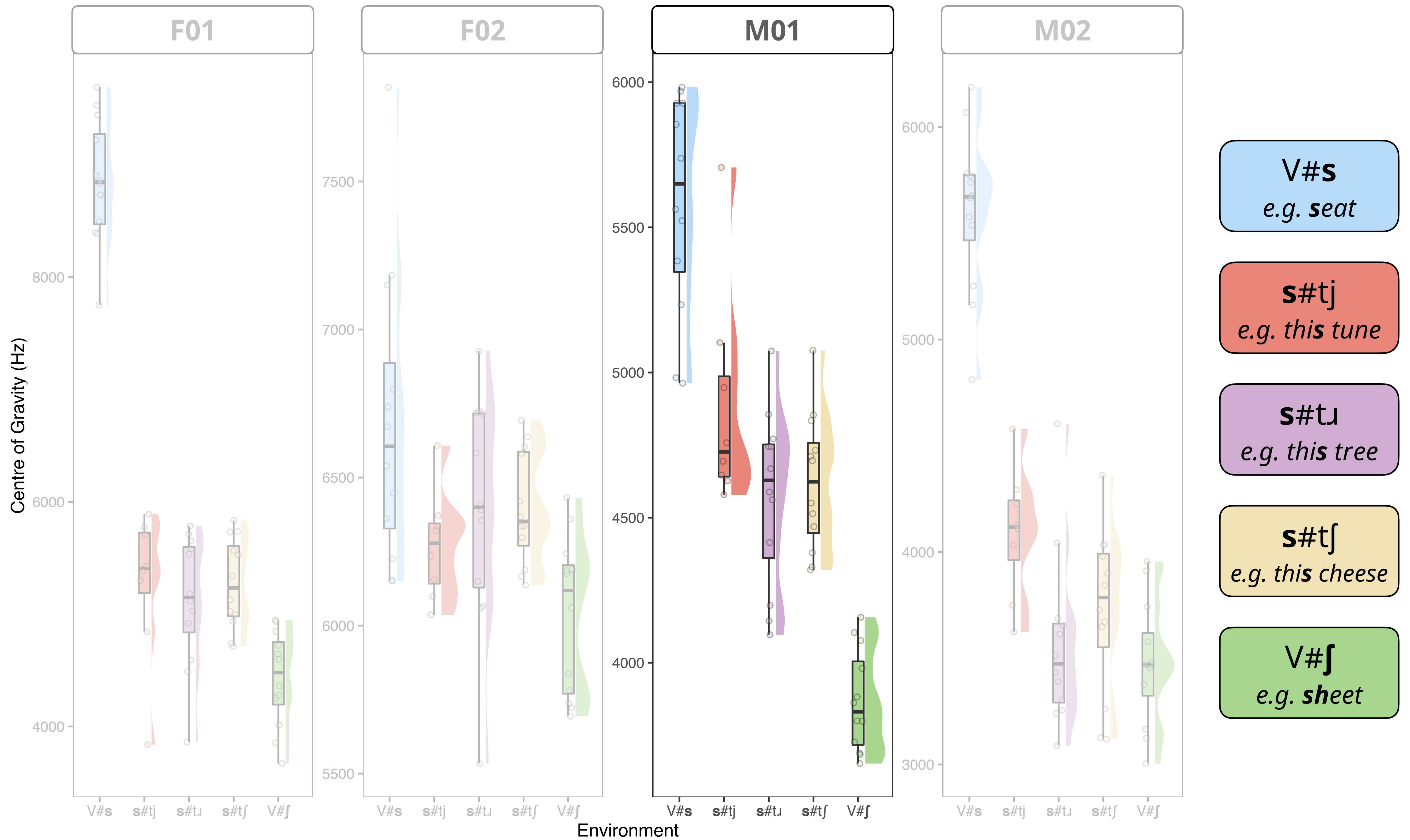
Acoustics

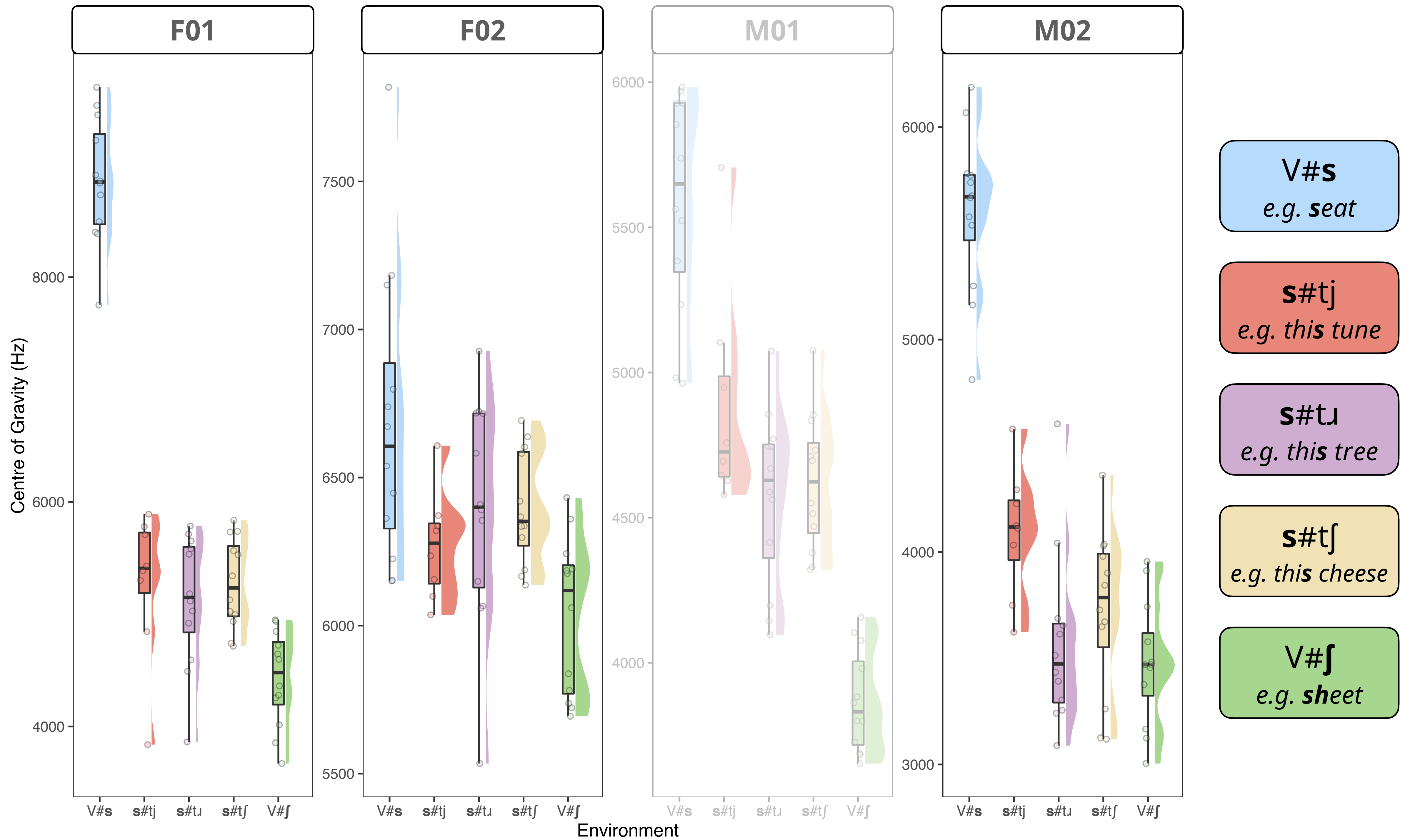
post-lexical retraction

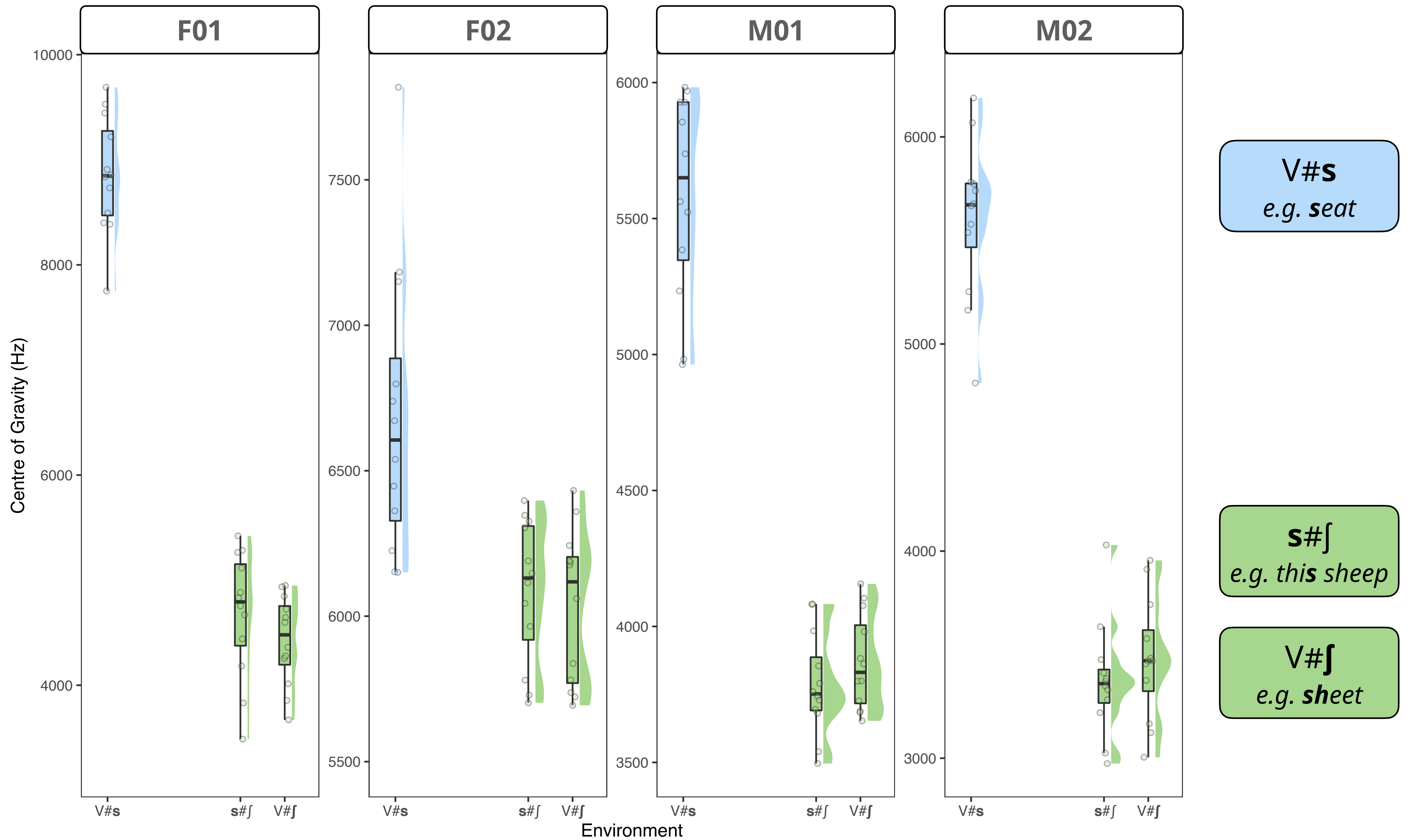


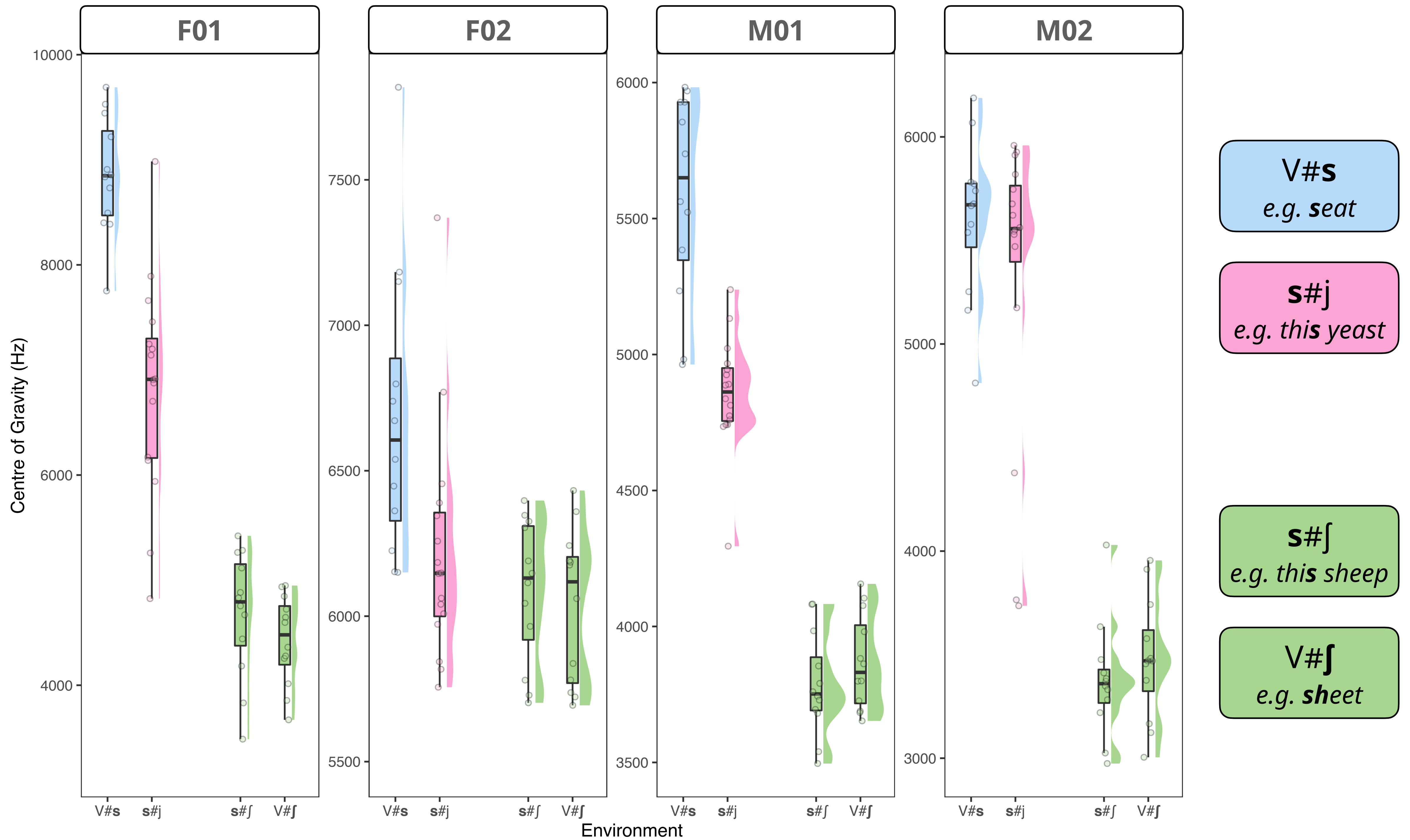


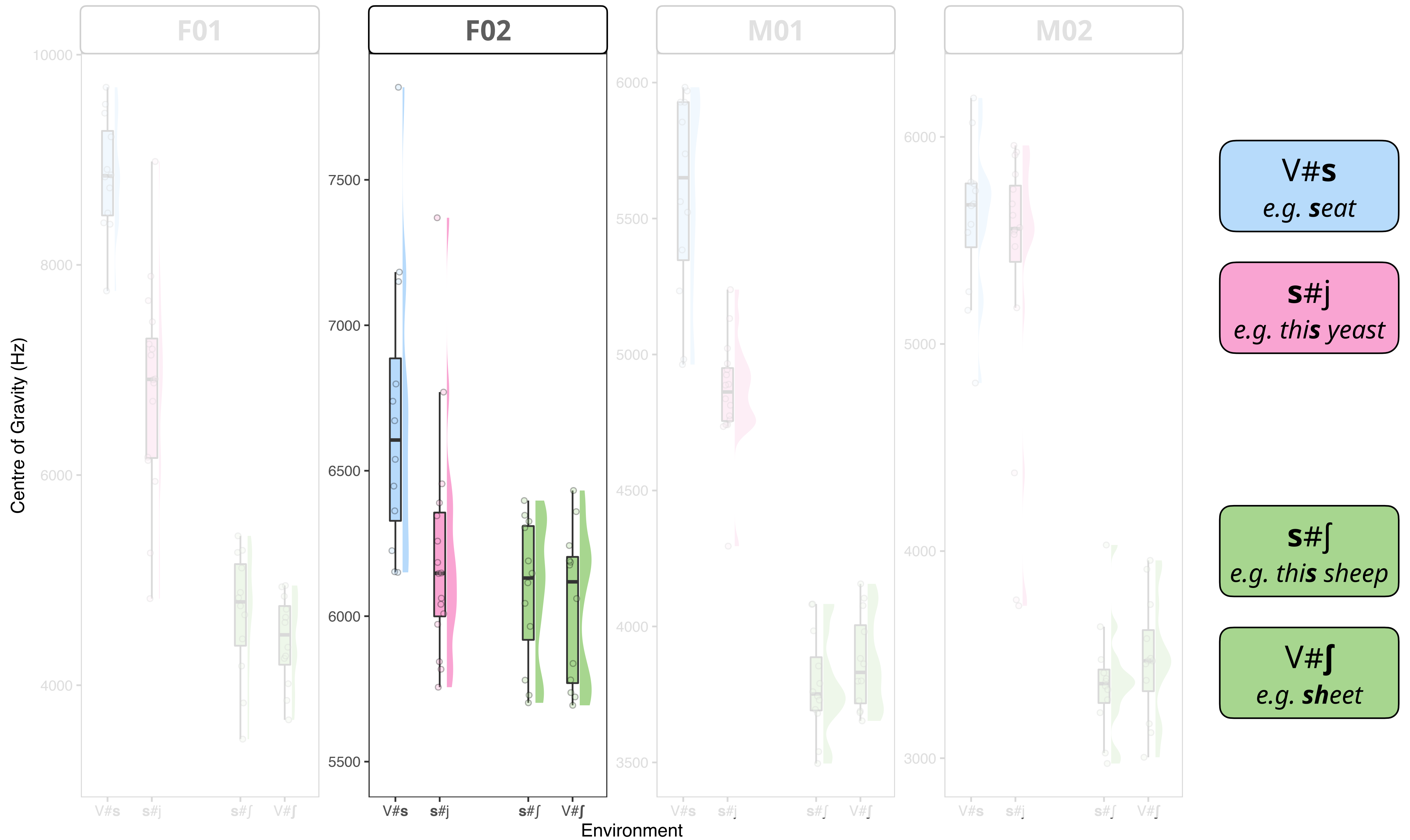


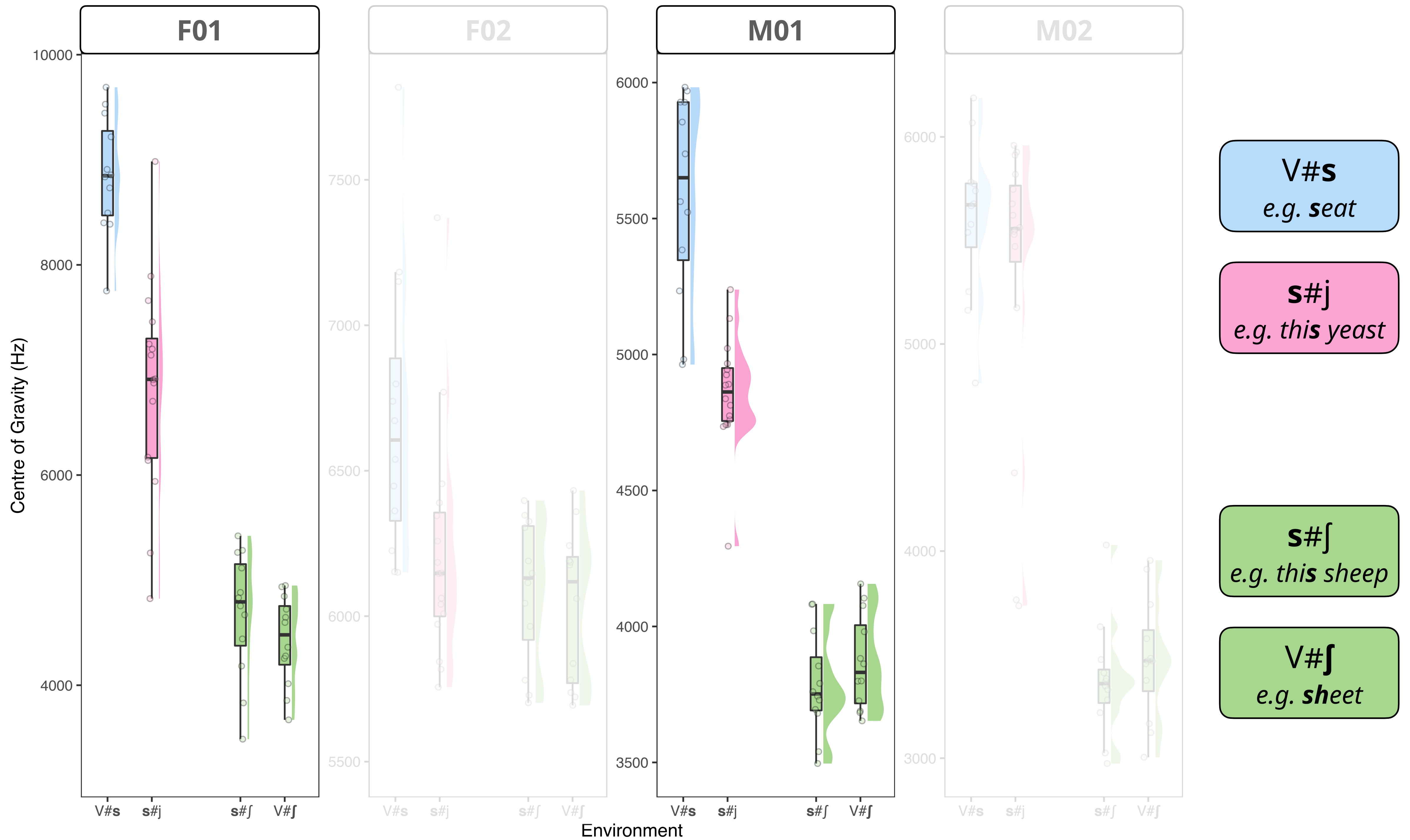


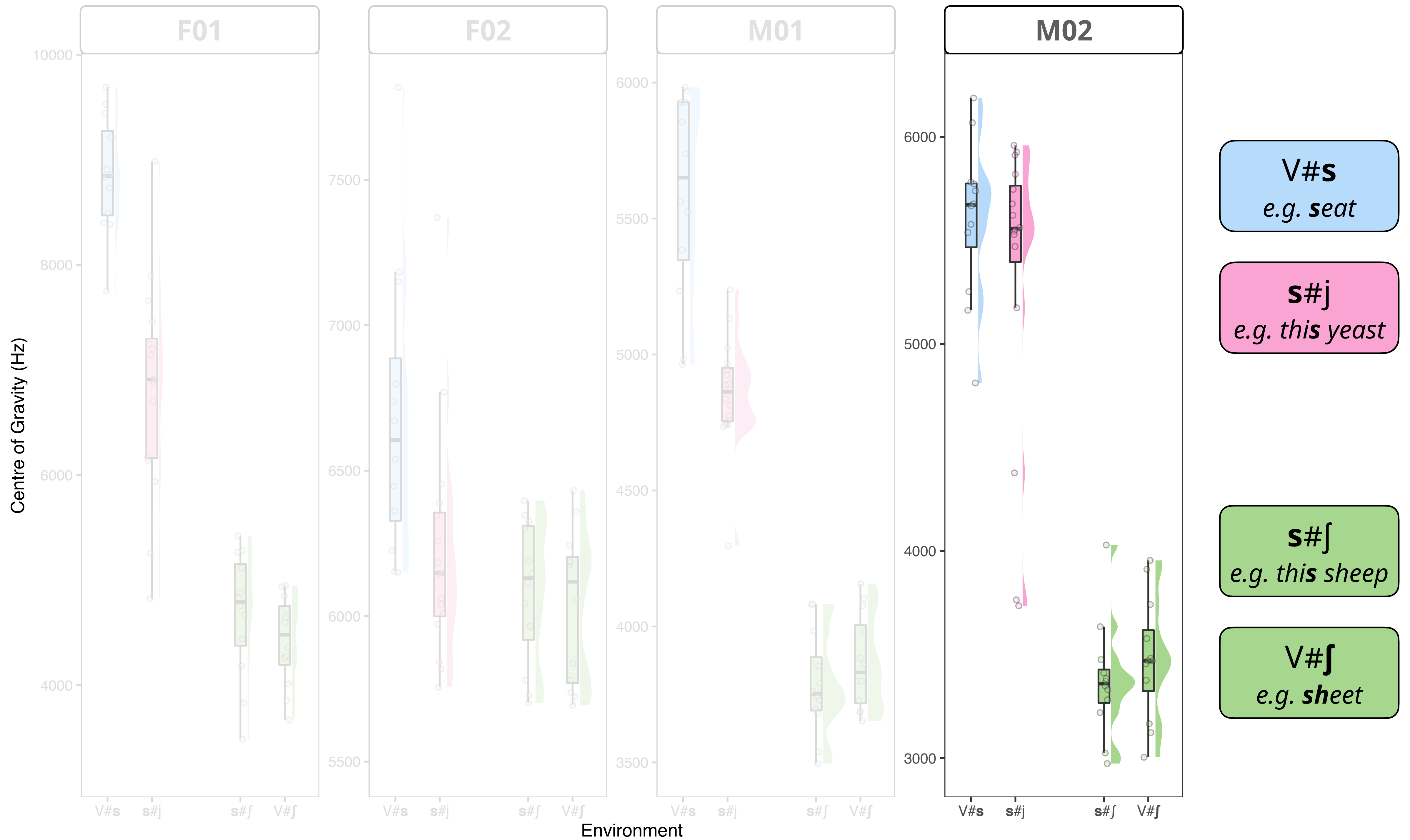


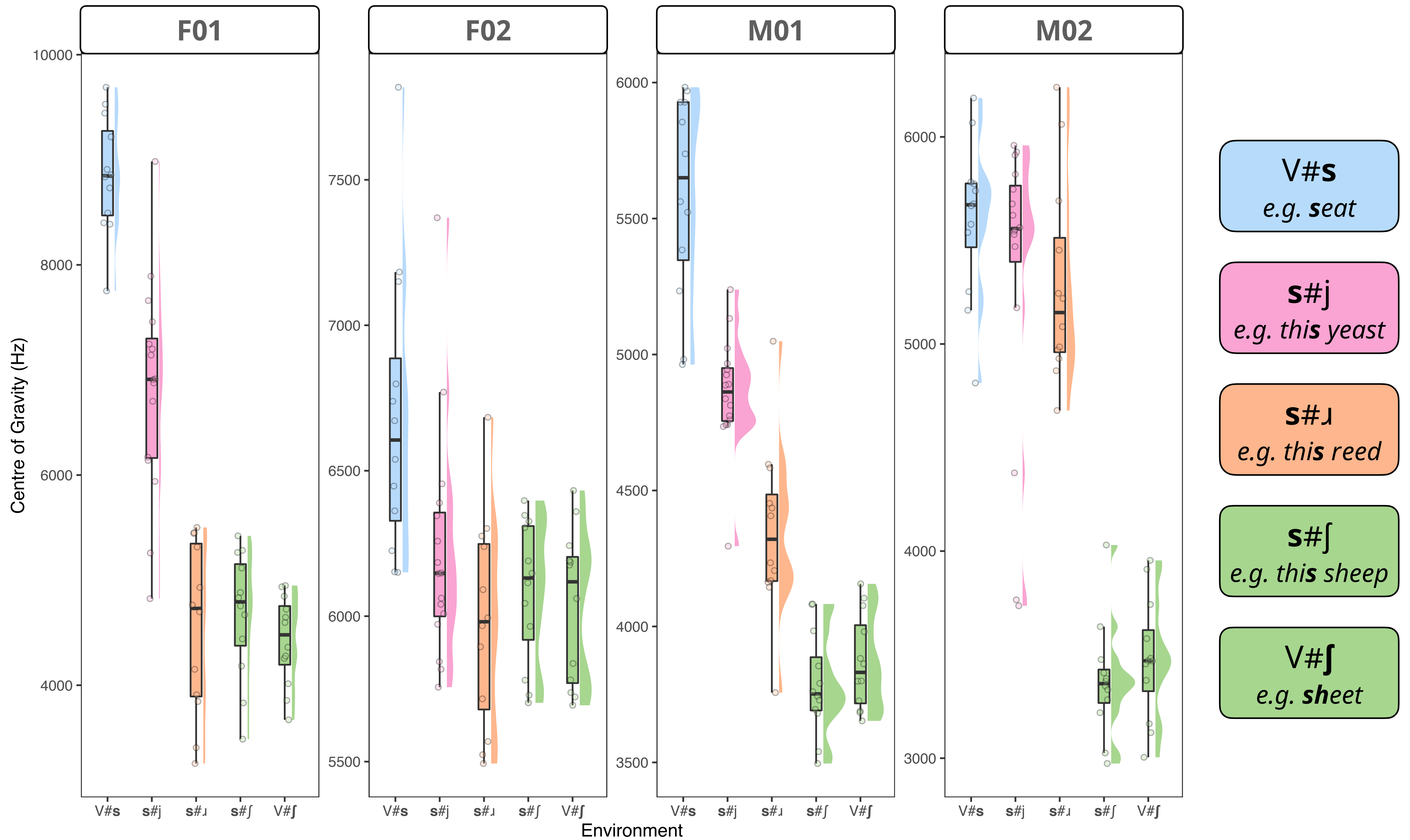


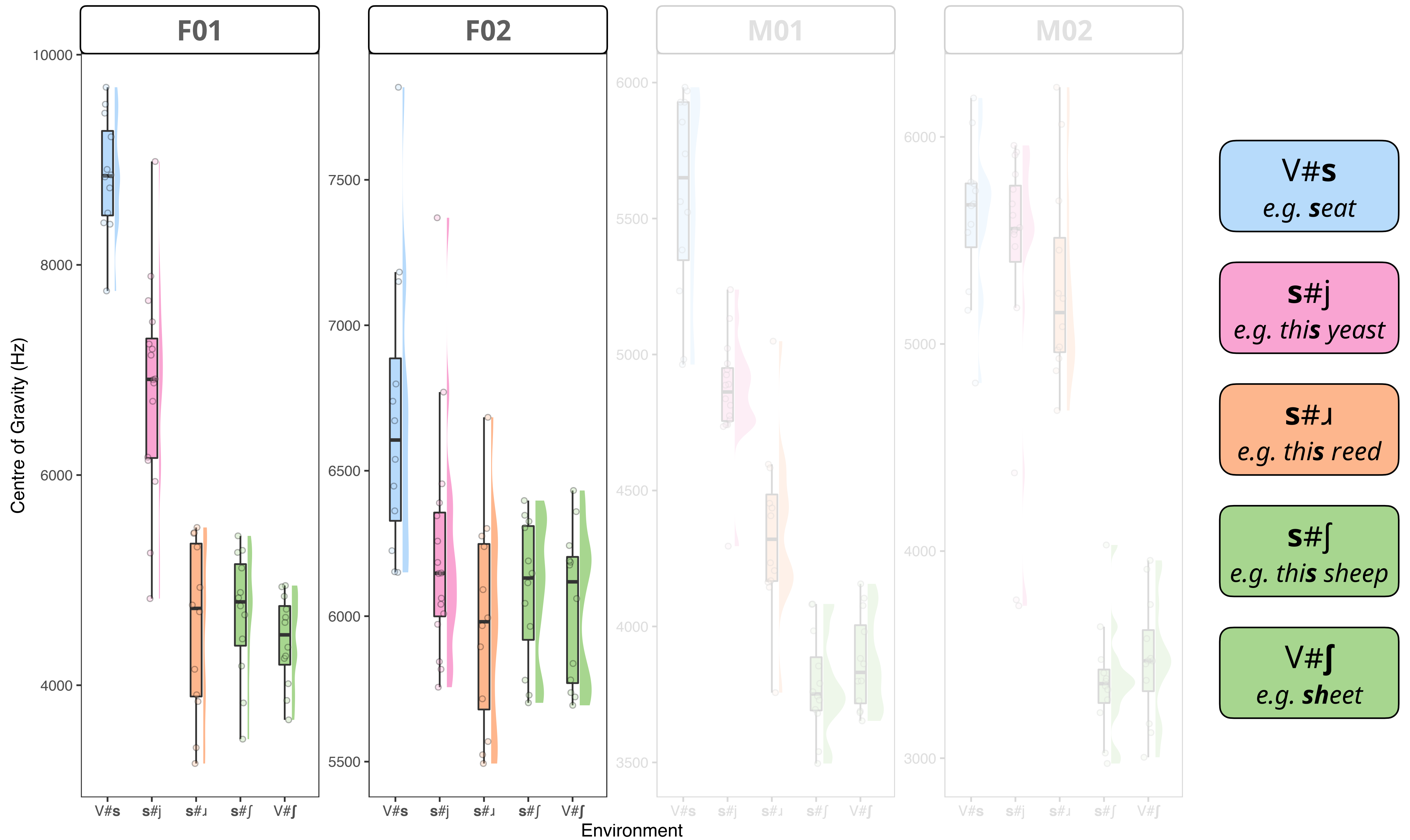


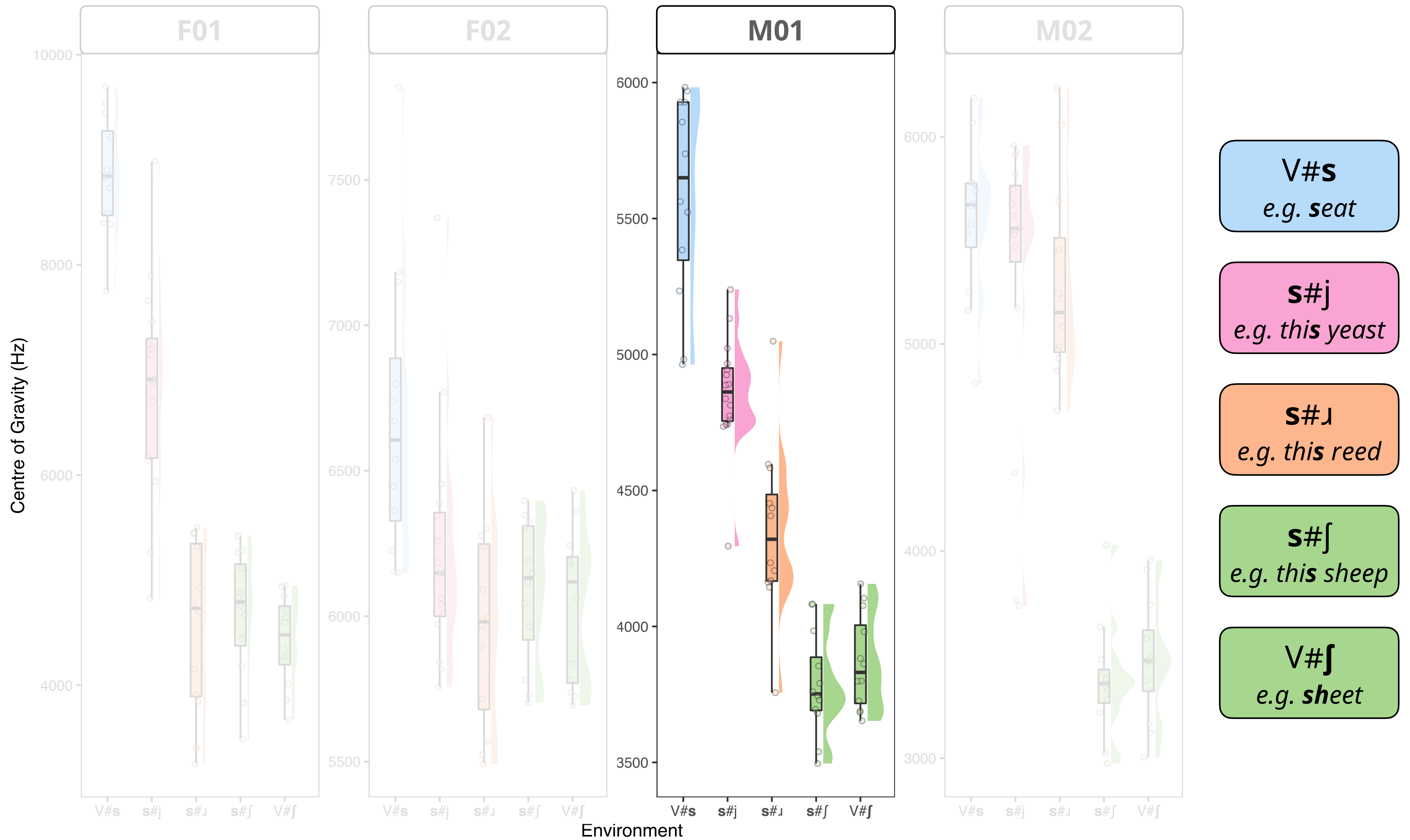


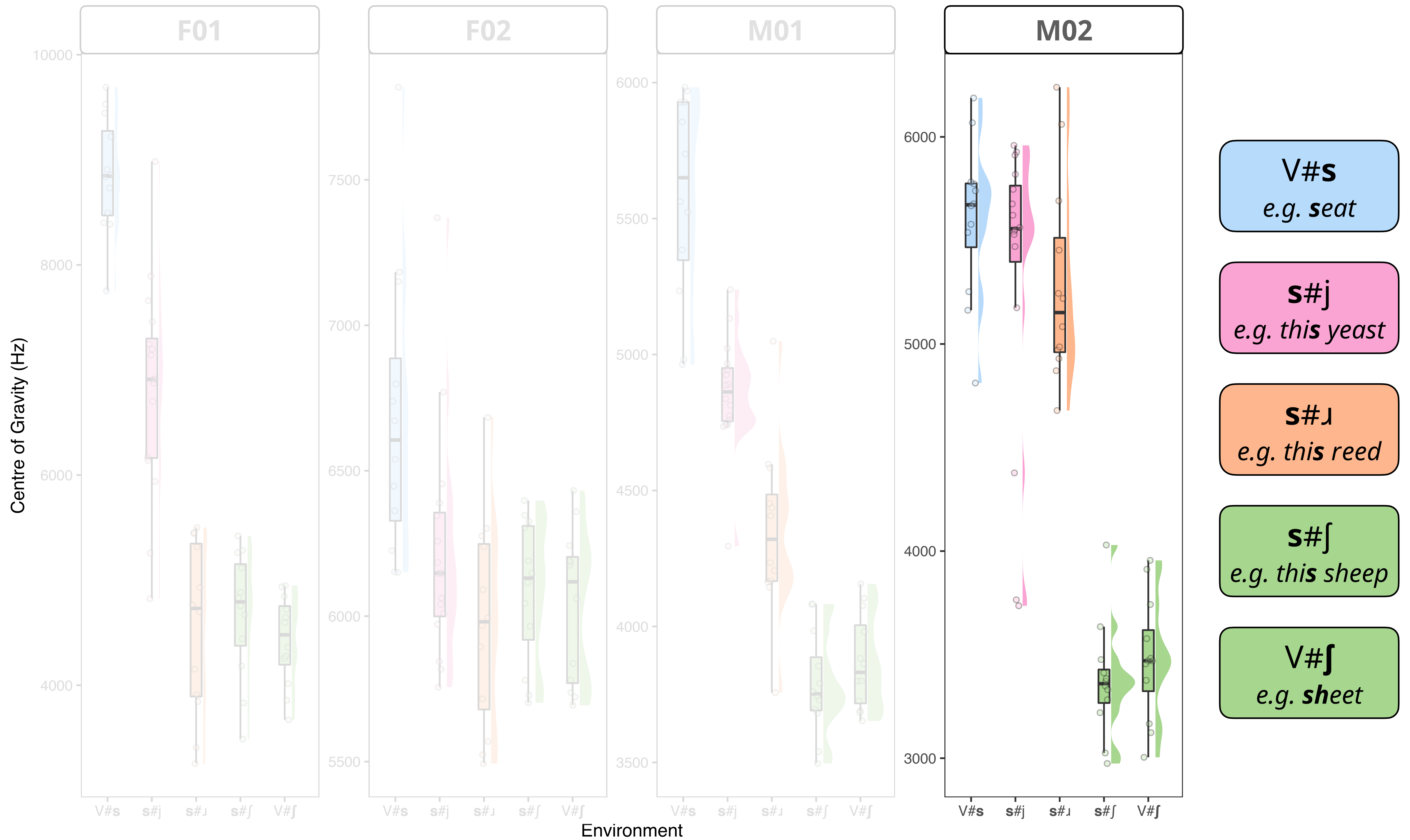








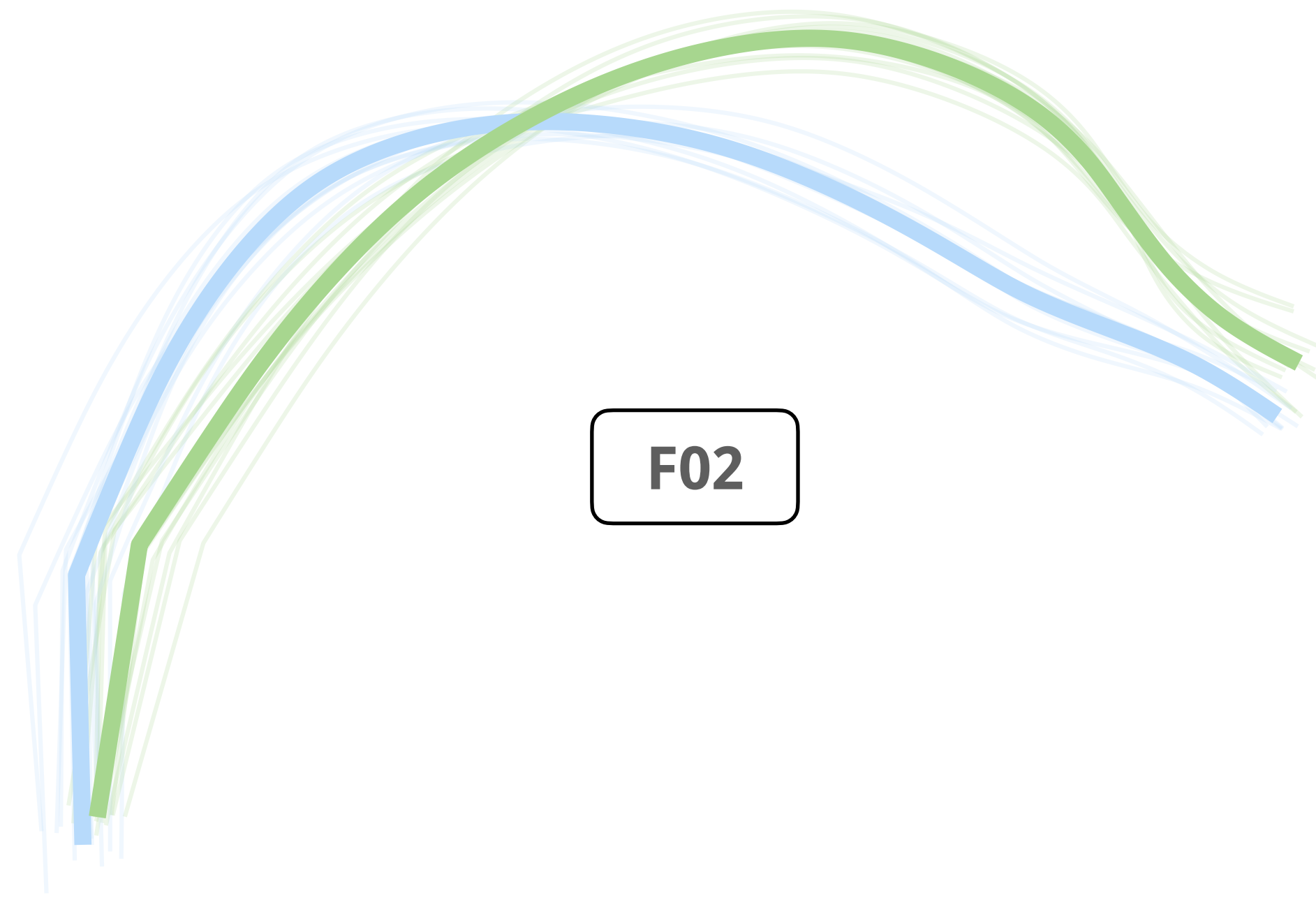




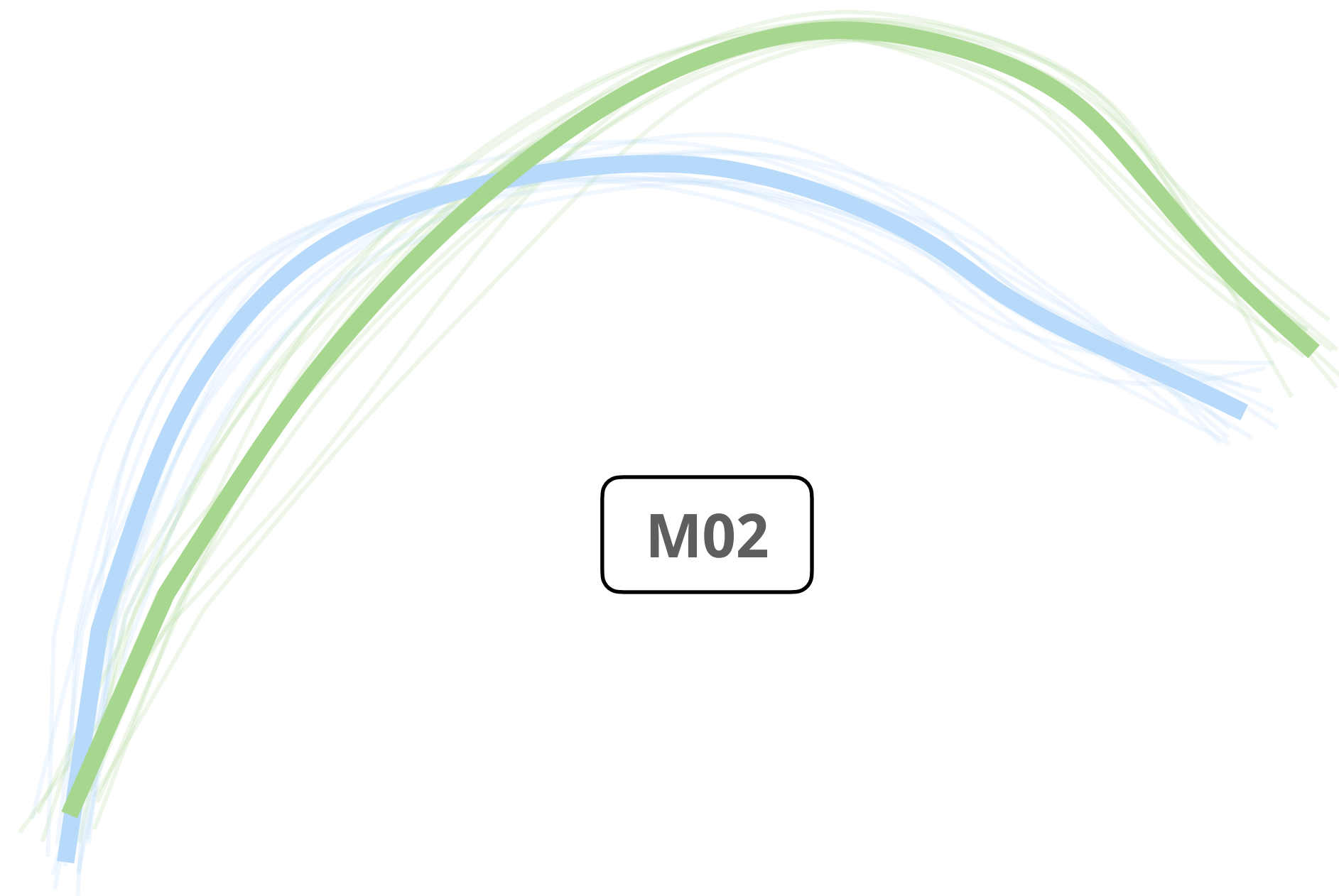
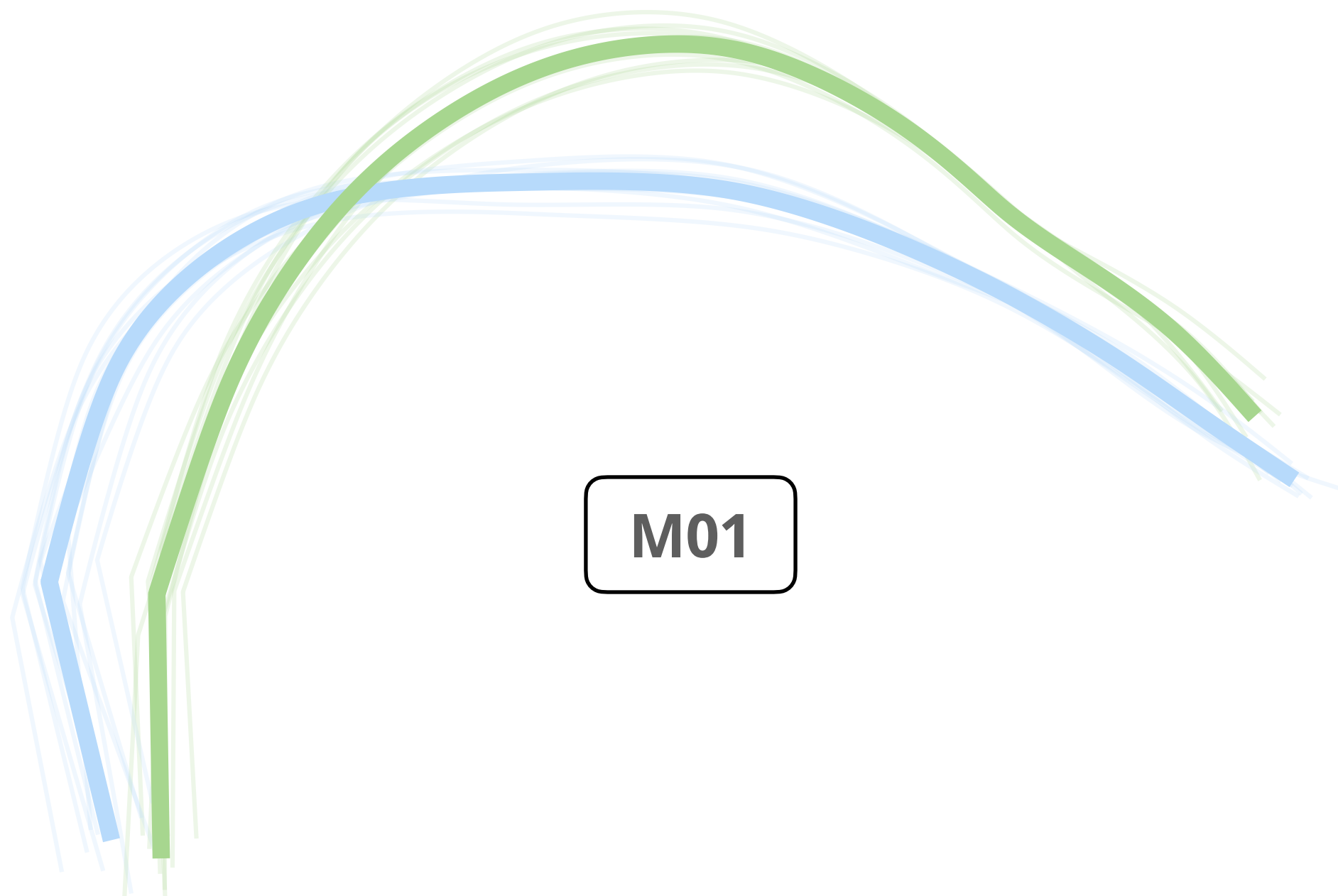
Tongue

post-lexical retraction

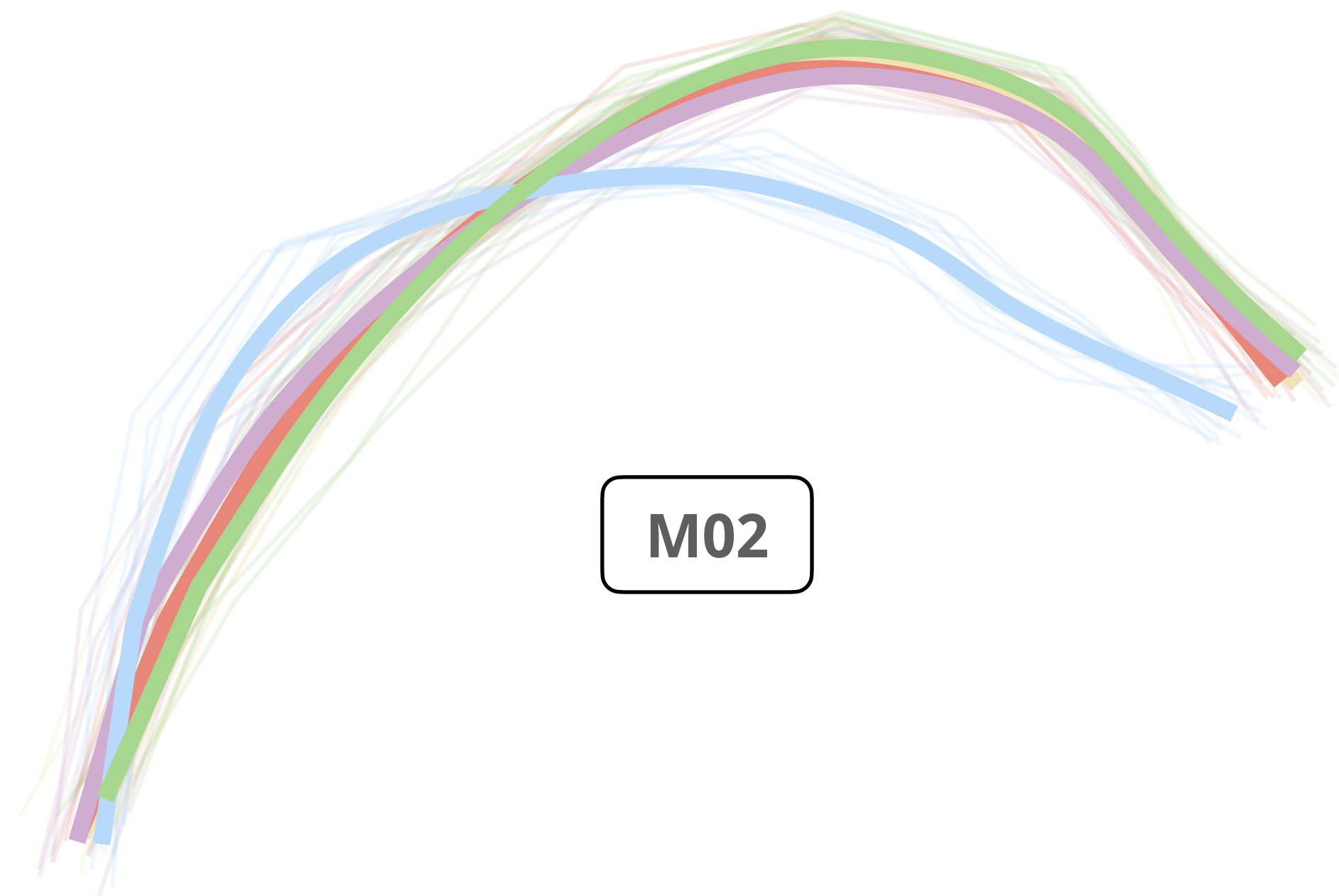
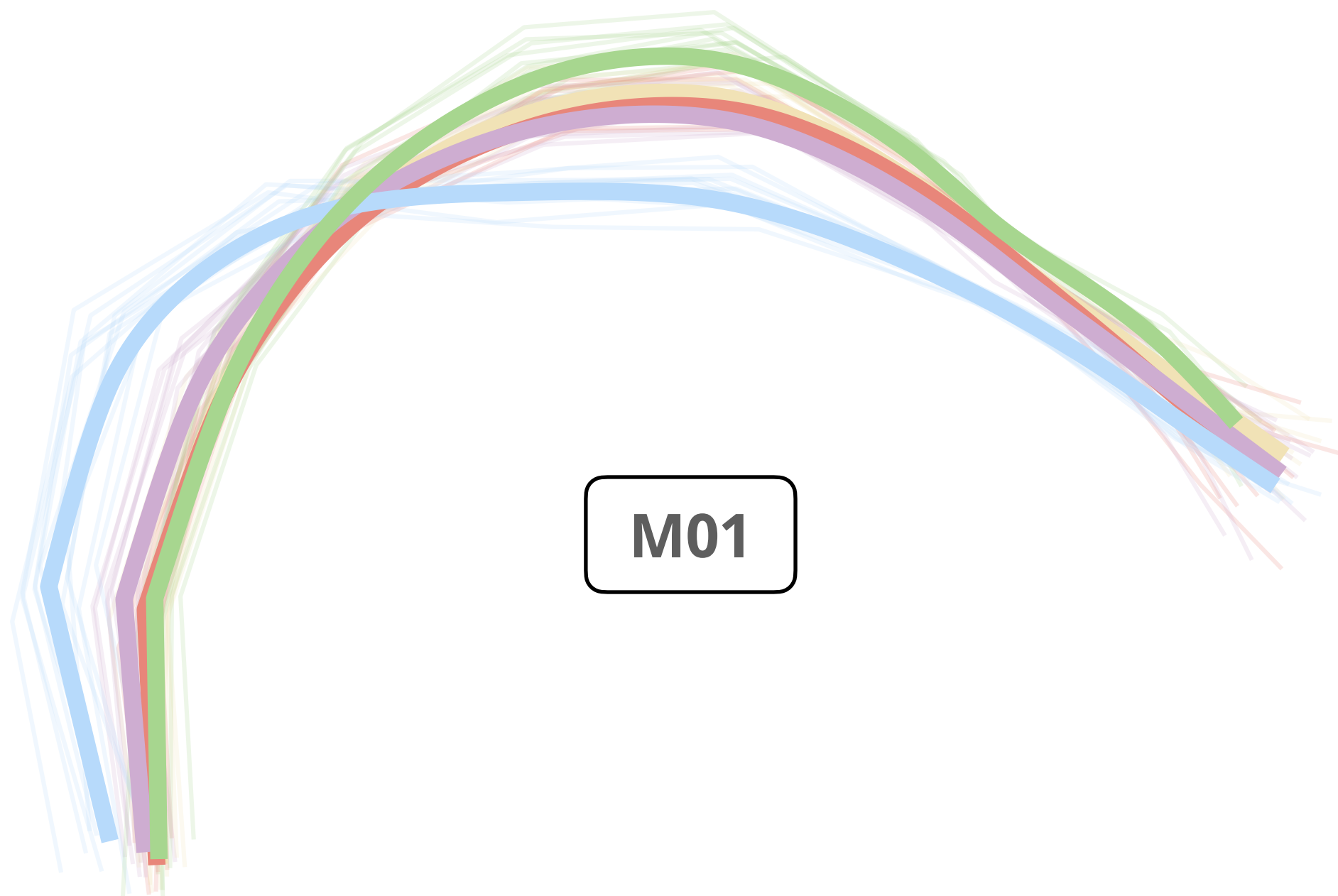
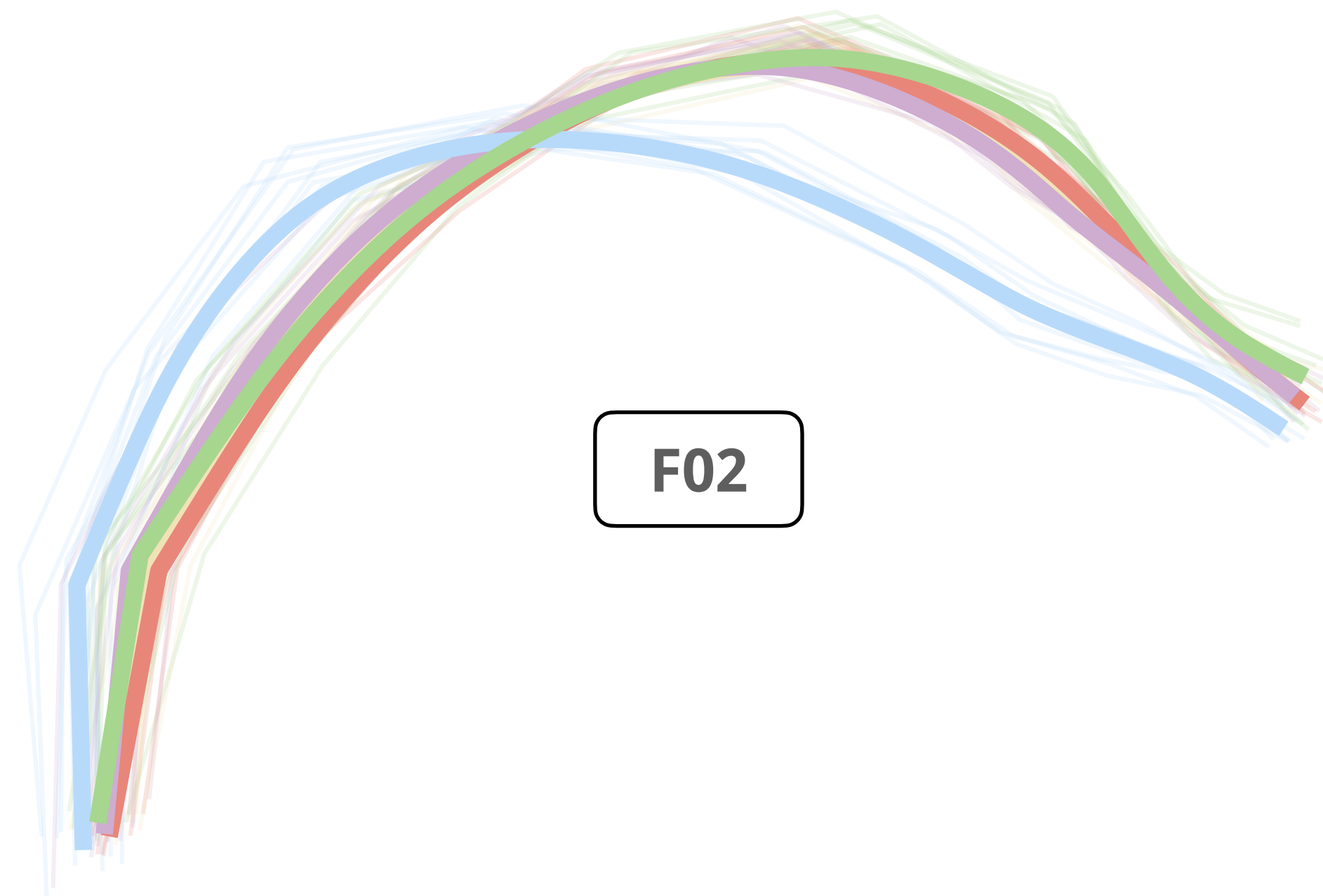
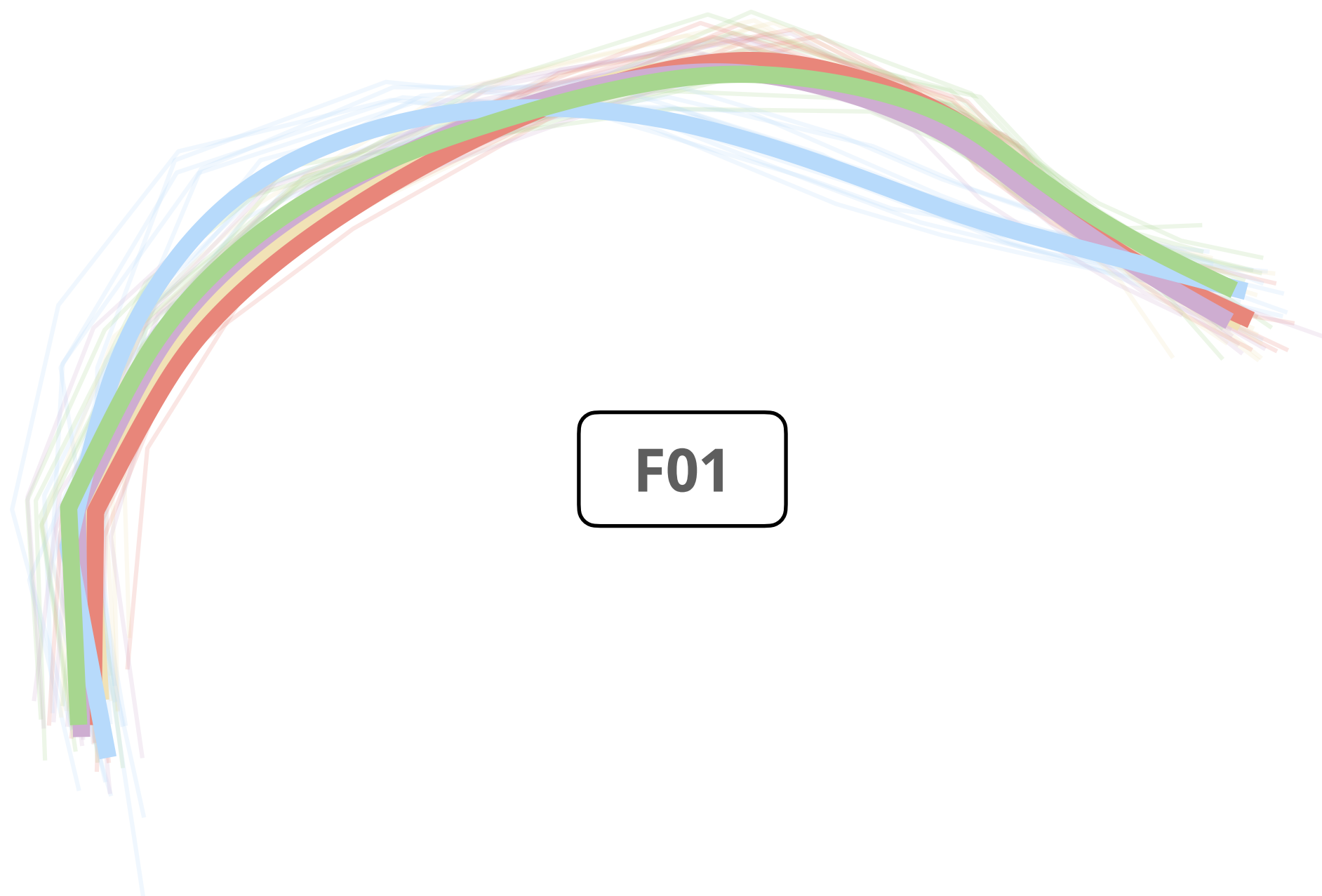




V#s
e.g. the seat



V#j
e.g. the sheet



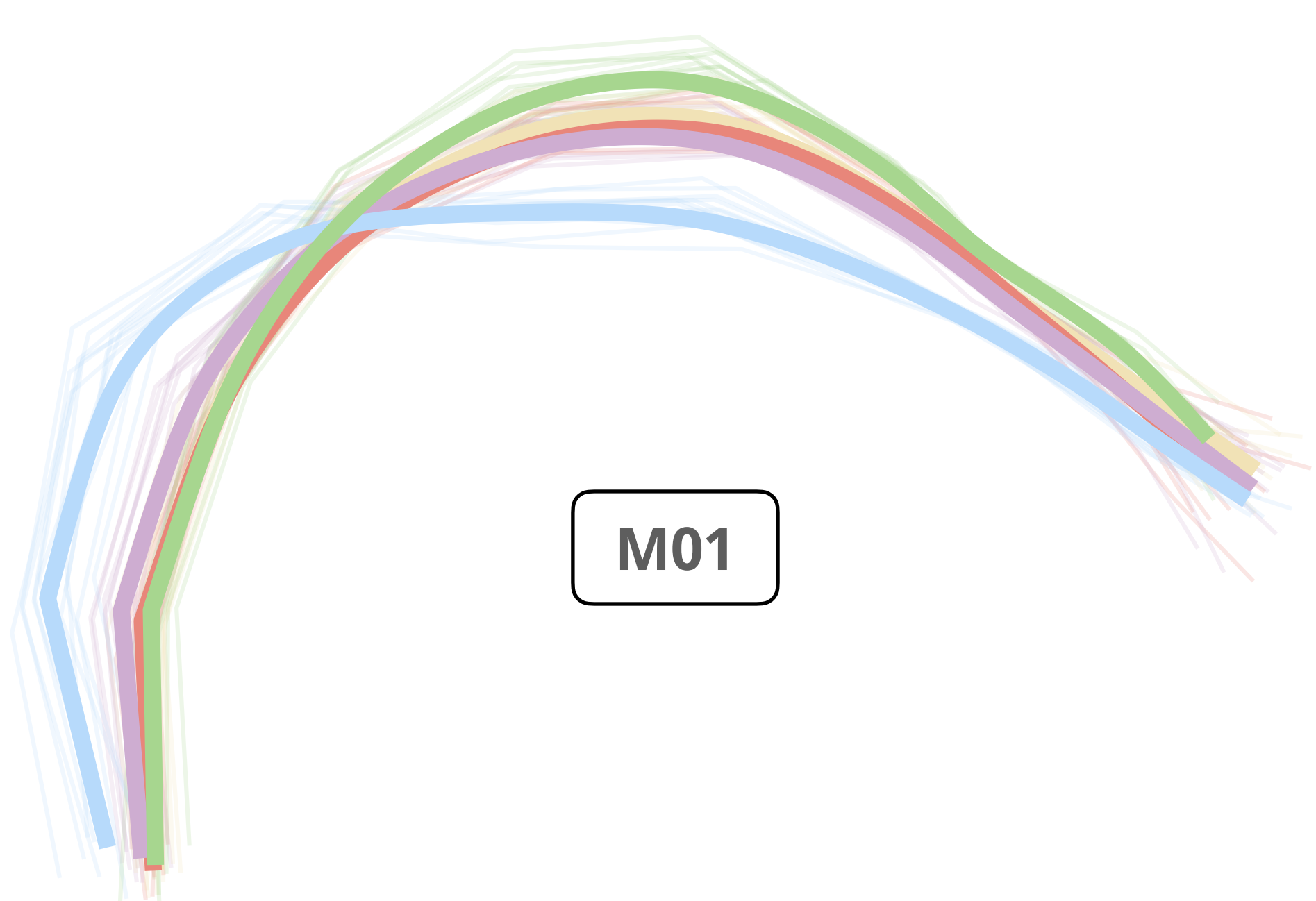
V#s
e.g. *the seat*

s#tj
e.g. *this tune*

s#tɹ
e.g. *this tree*

s#tʃ
e.g. *this cheese*

V#ʃ
e.g. *the sheet*



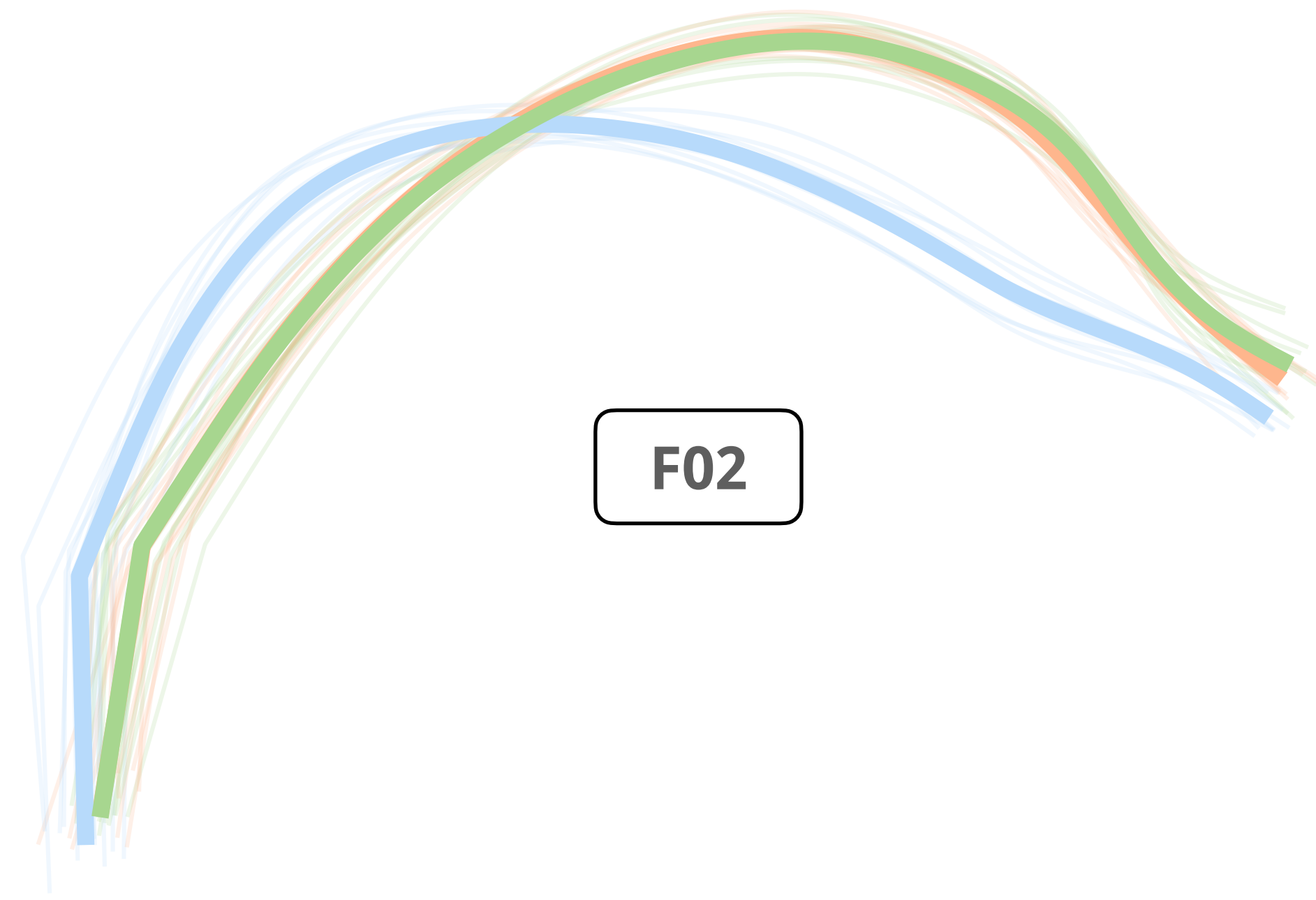
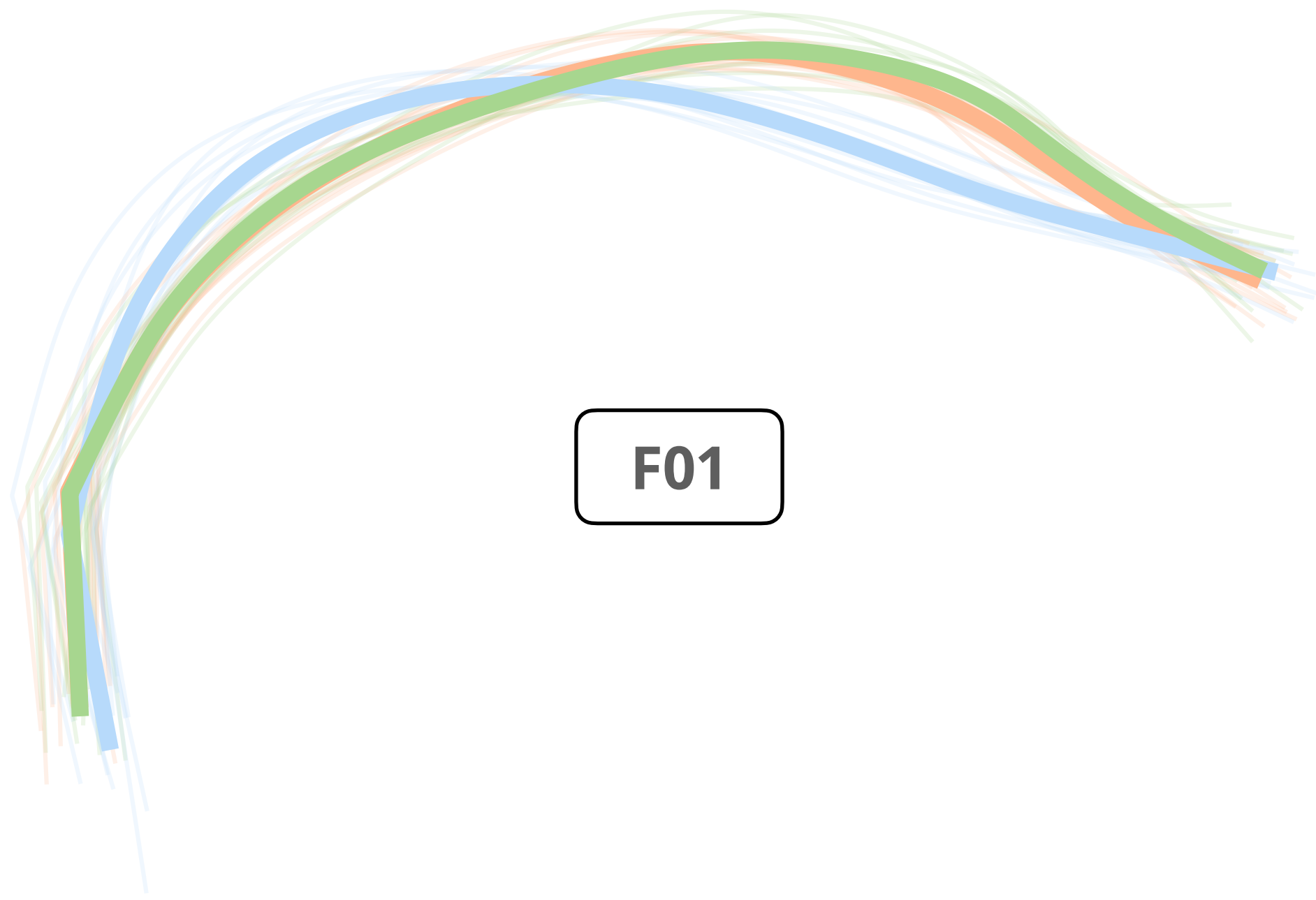
V#s
e.g. *the seat*

s#tj
e.g. *this tune*

s#tɹ
e.g. *this tree*

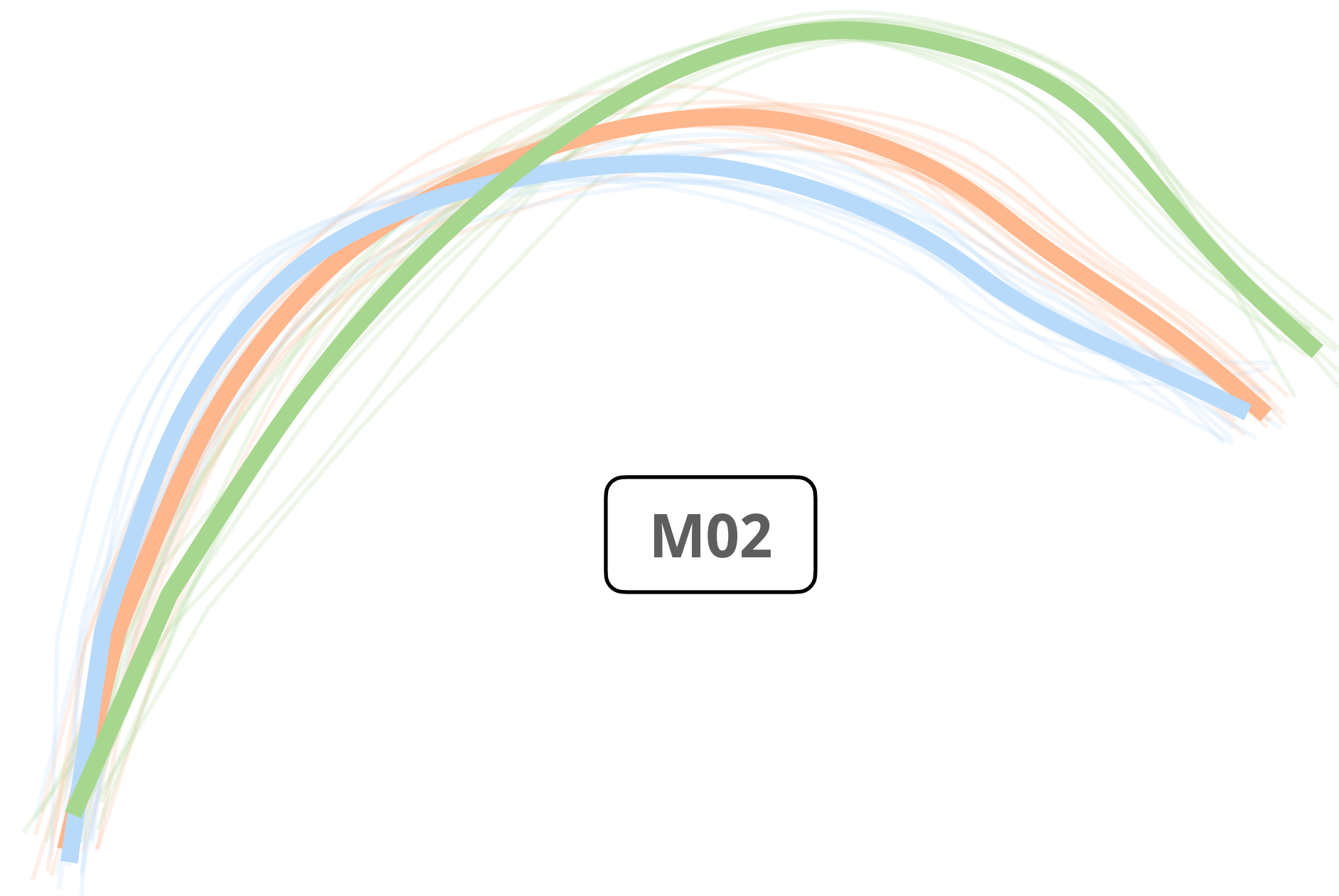
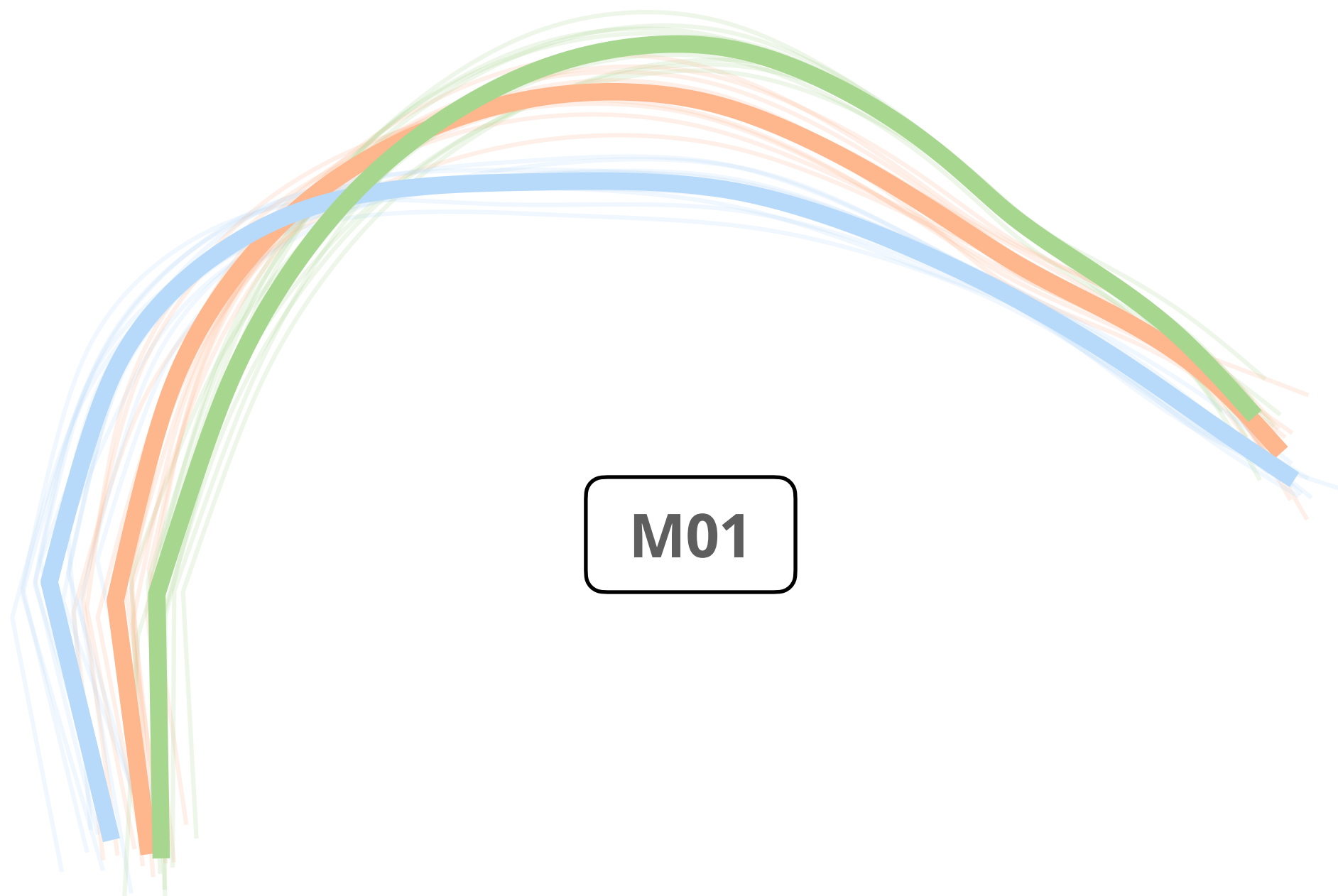
s#tʃ
e.g. *this cheese*

V#ʃ
e.g. *the sheet*

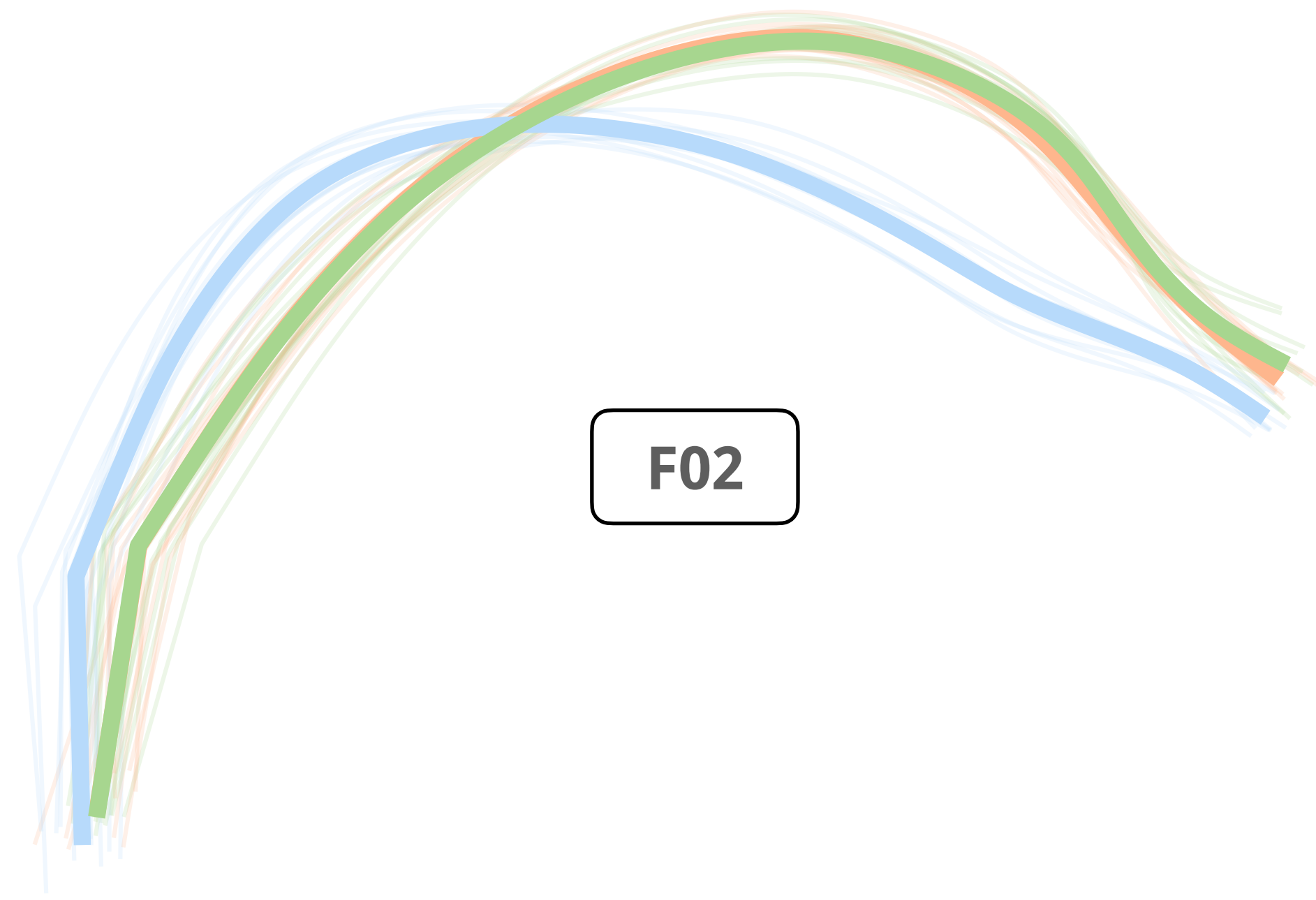
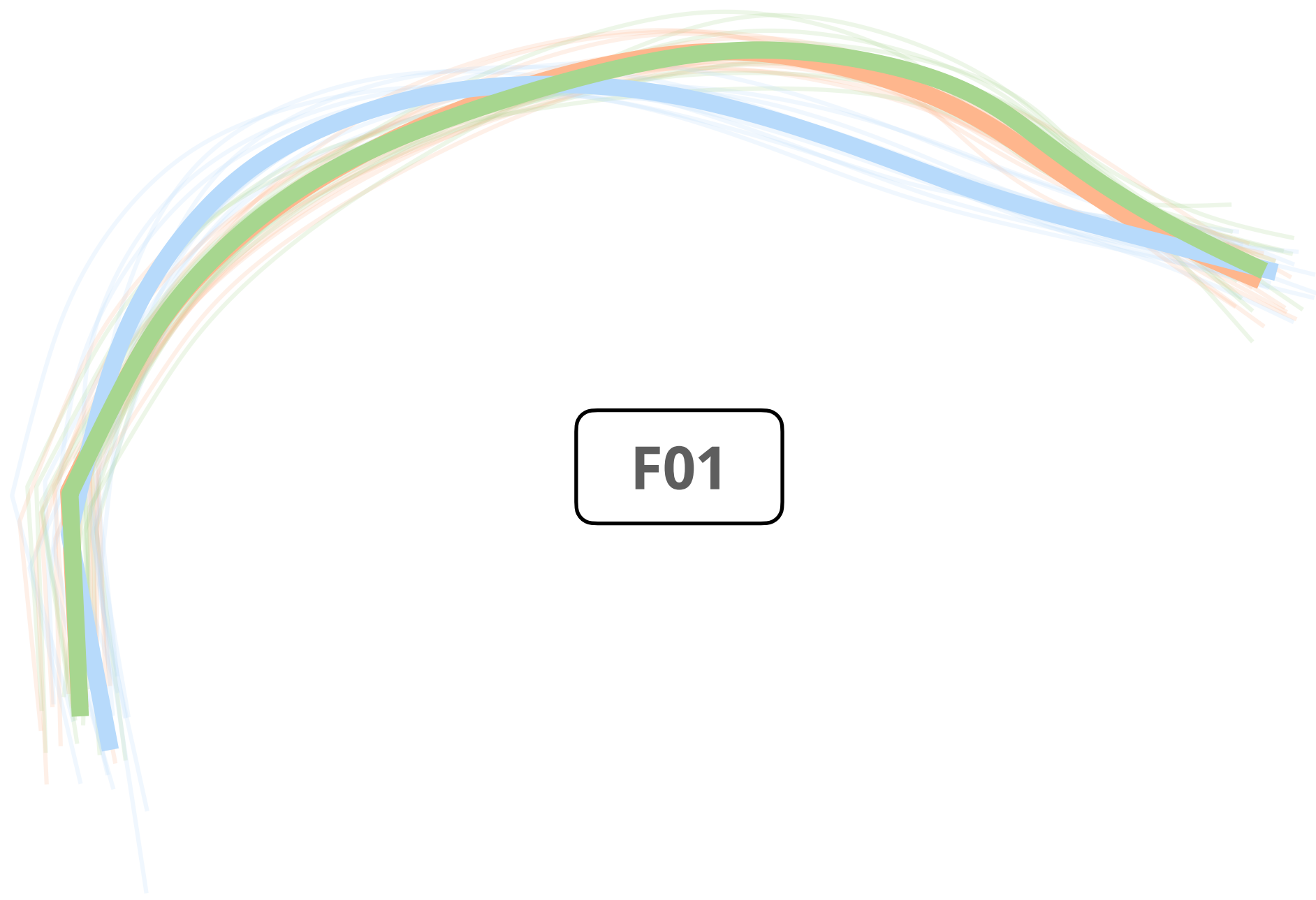


V#s
e.g. the seat

S#J
e.g. this reed

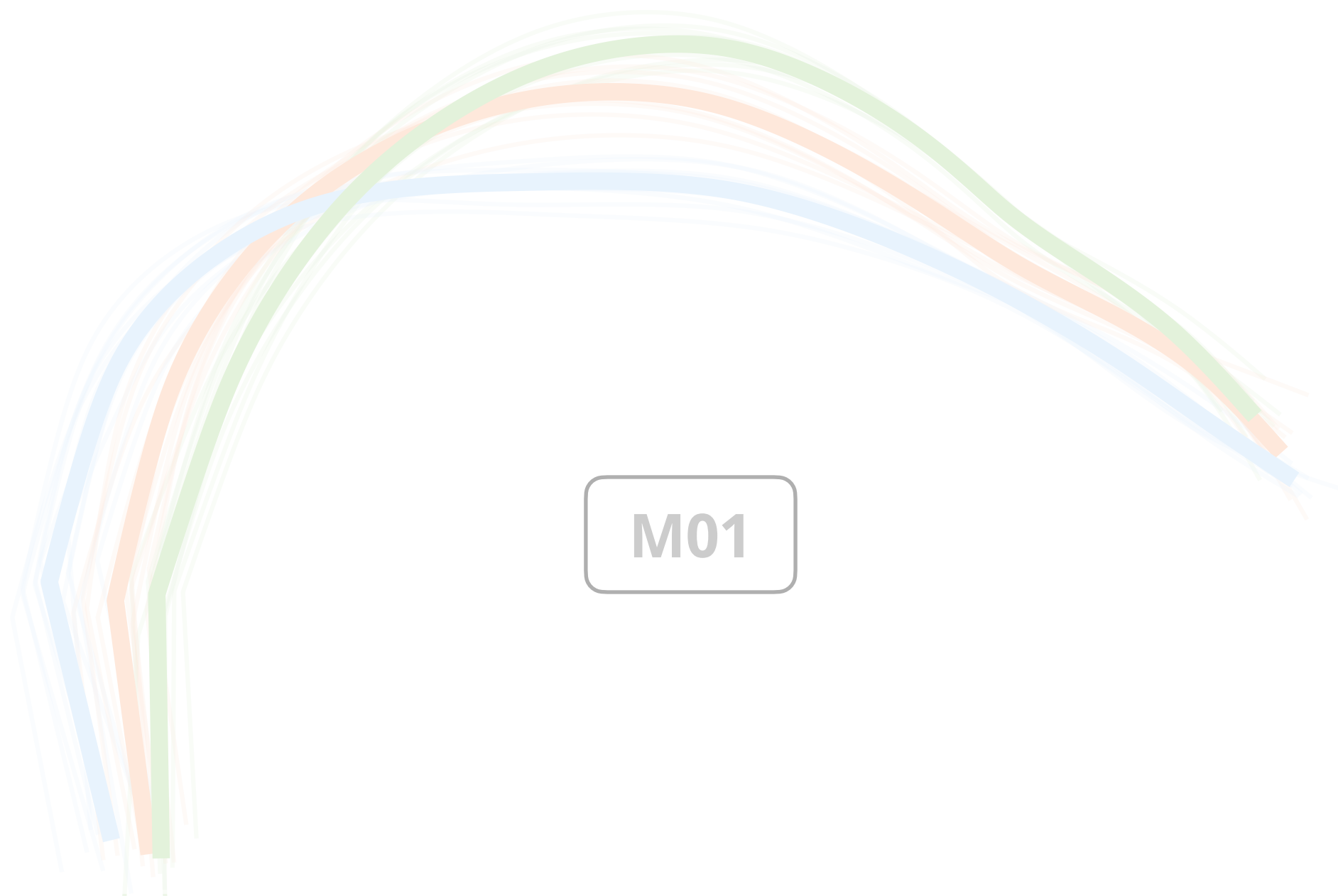


V#j
e.g. the sheet



V#s
e.g. the seat

S#J
e.g. this reed

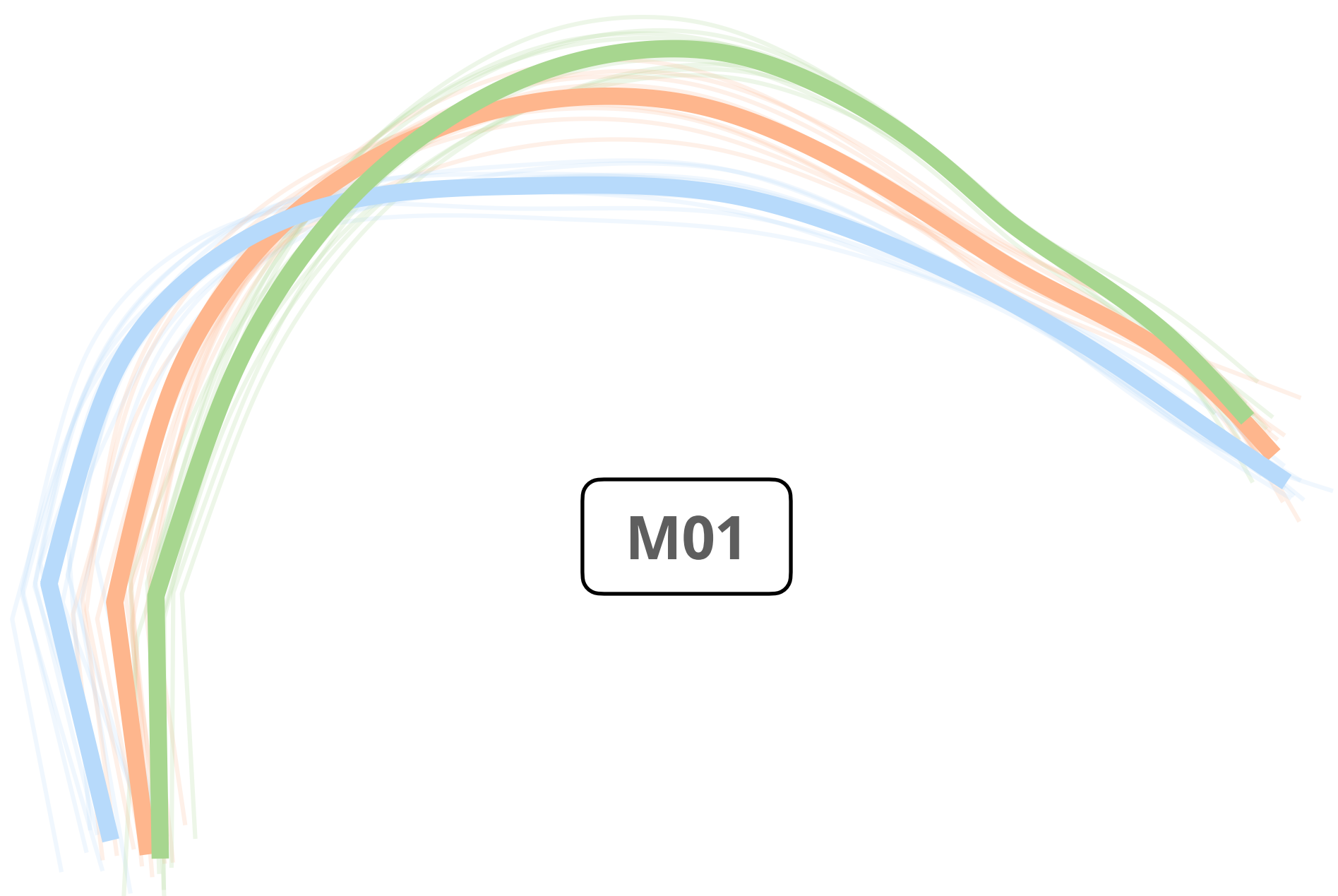


V#j
*e.g. the **sheet***



V#s
e.g. the *seat*

S#J
e.g. this *reed*

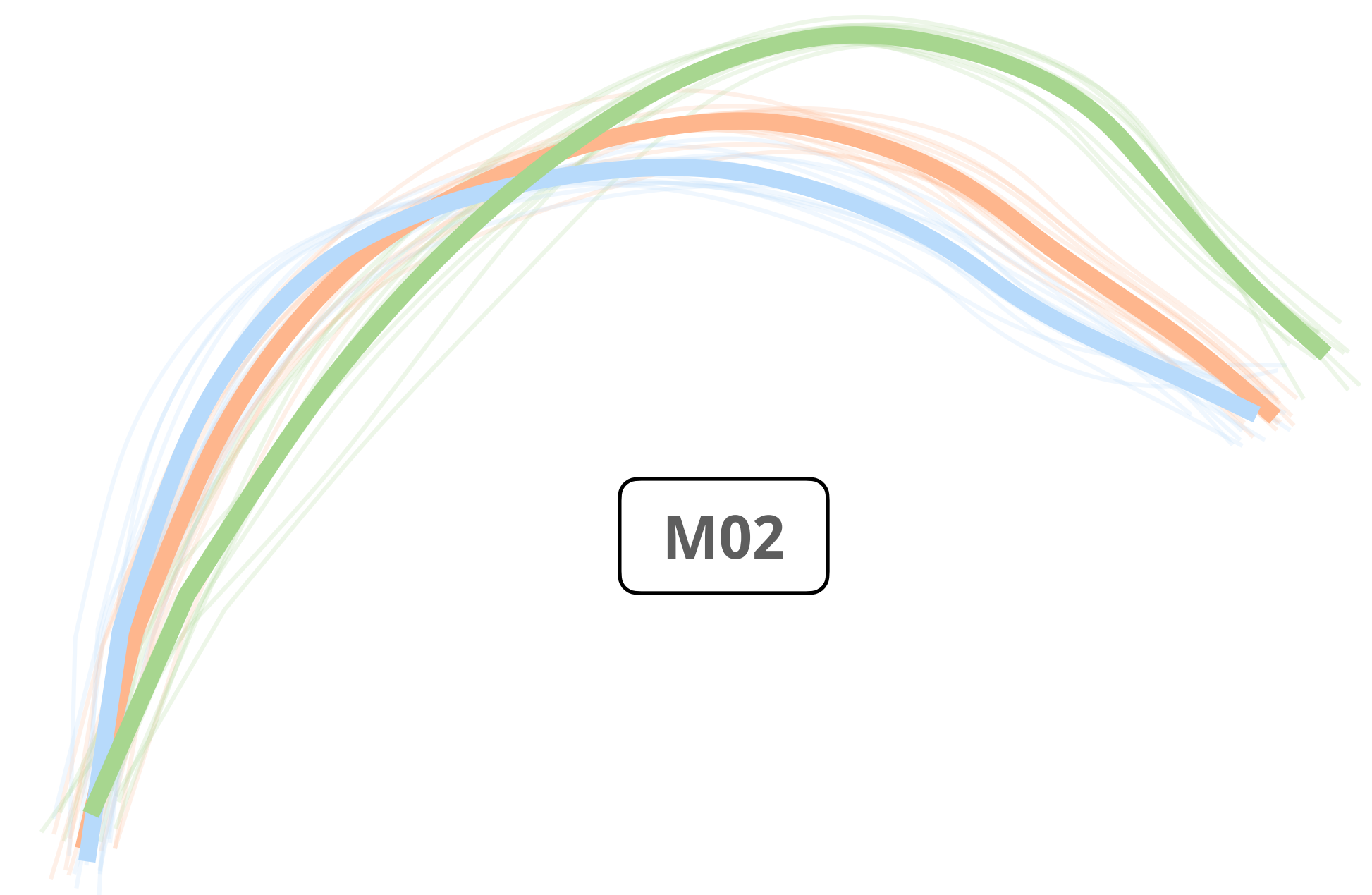
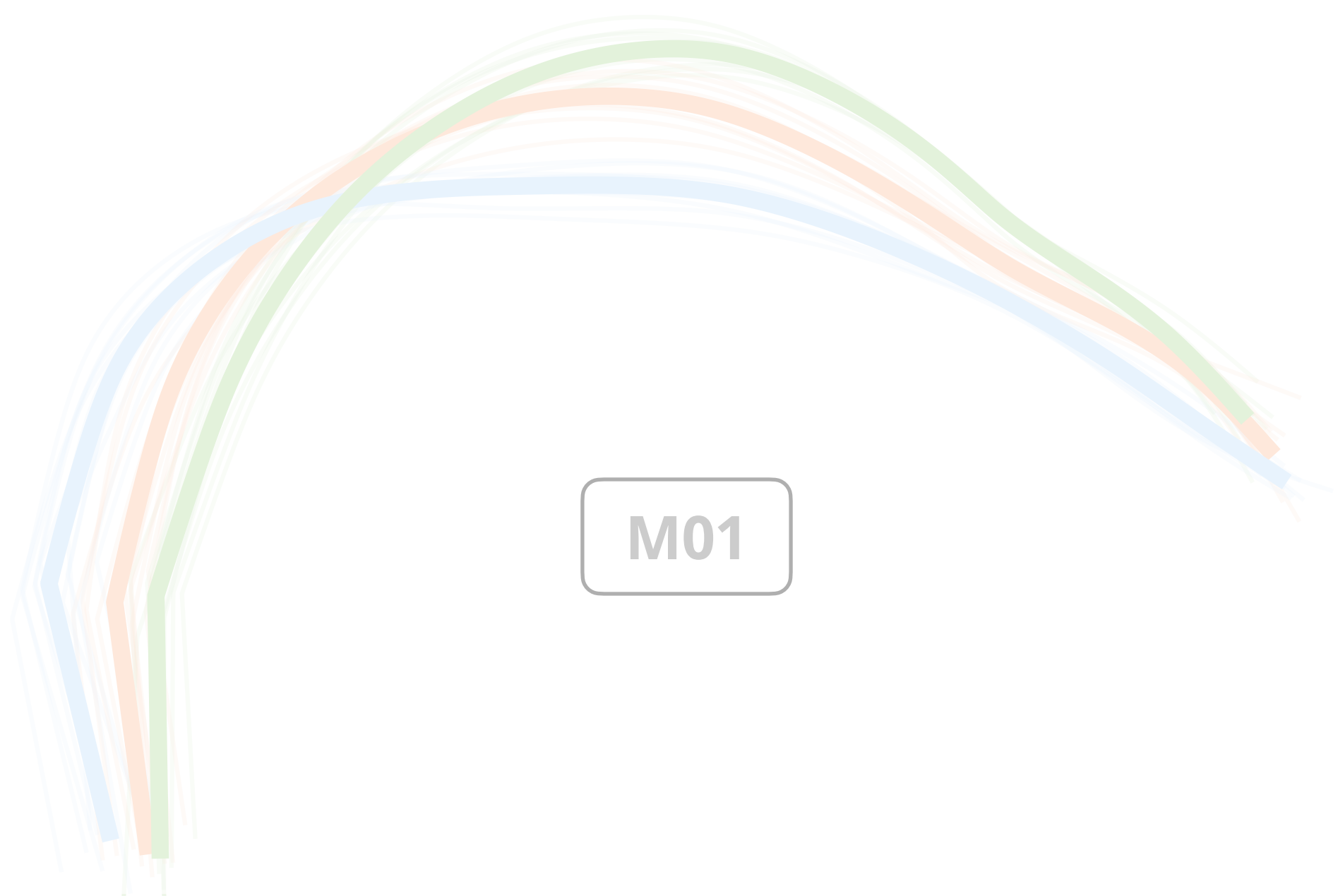


V#j
e.g. the *sheet*

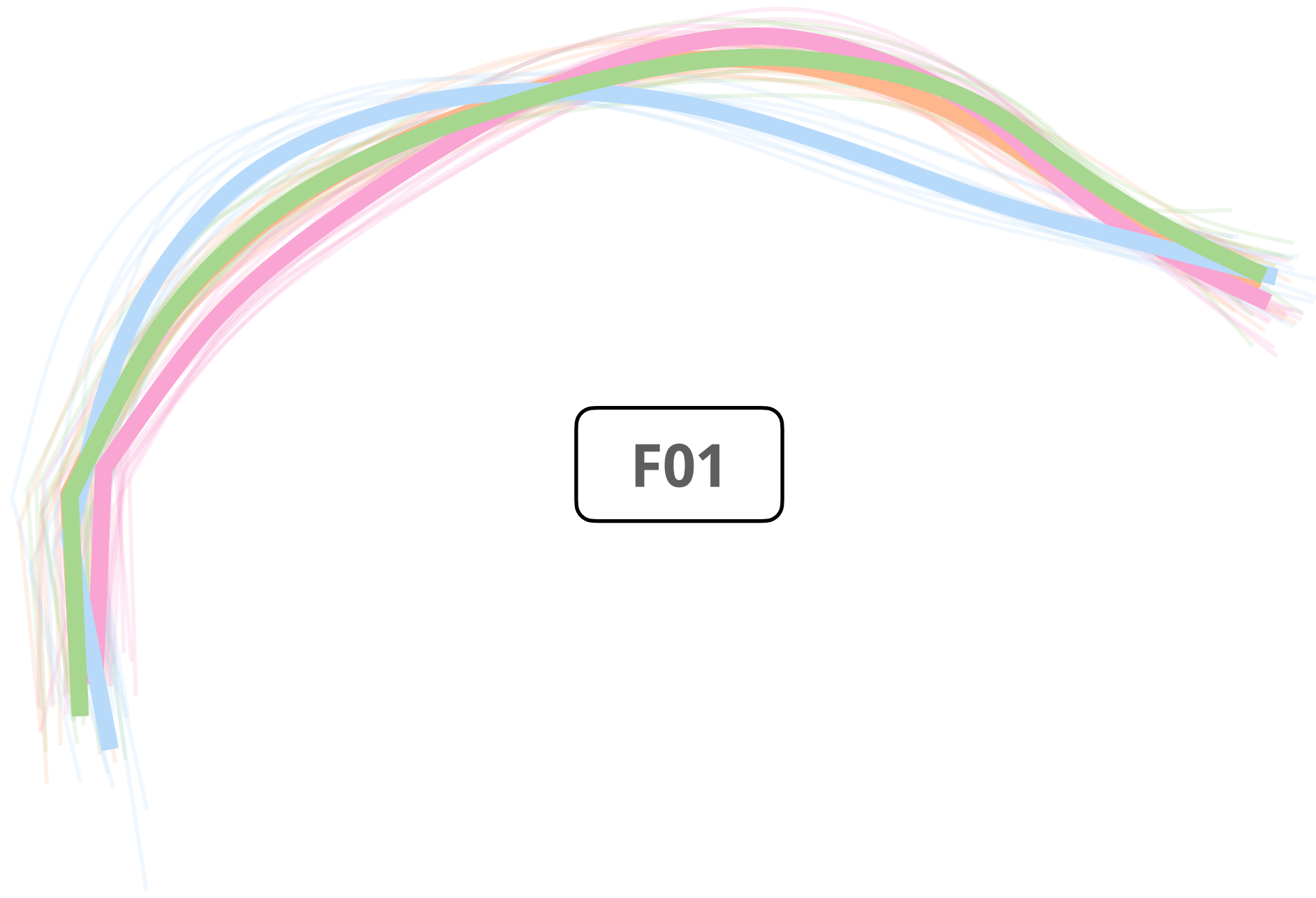


V#s
e.g. *the seat*

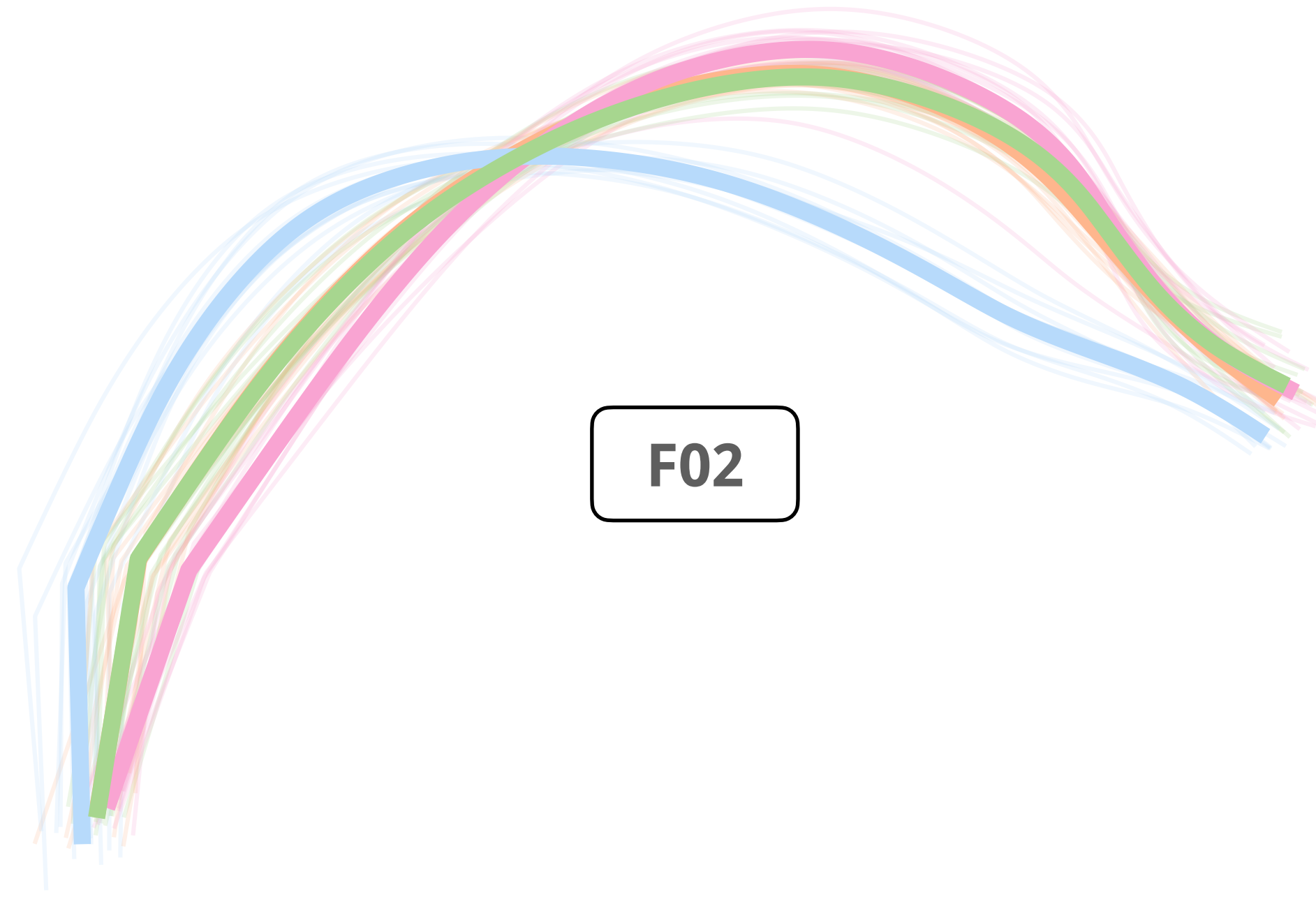
S#j
e.g. *this reed*



V#j
e.g. *the sheet*



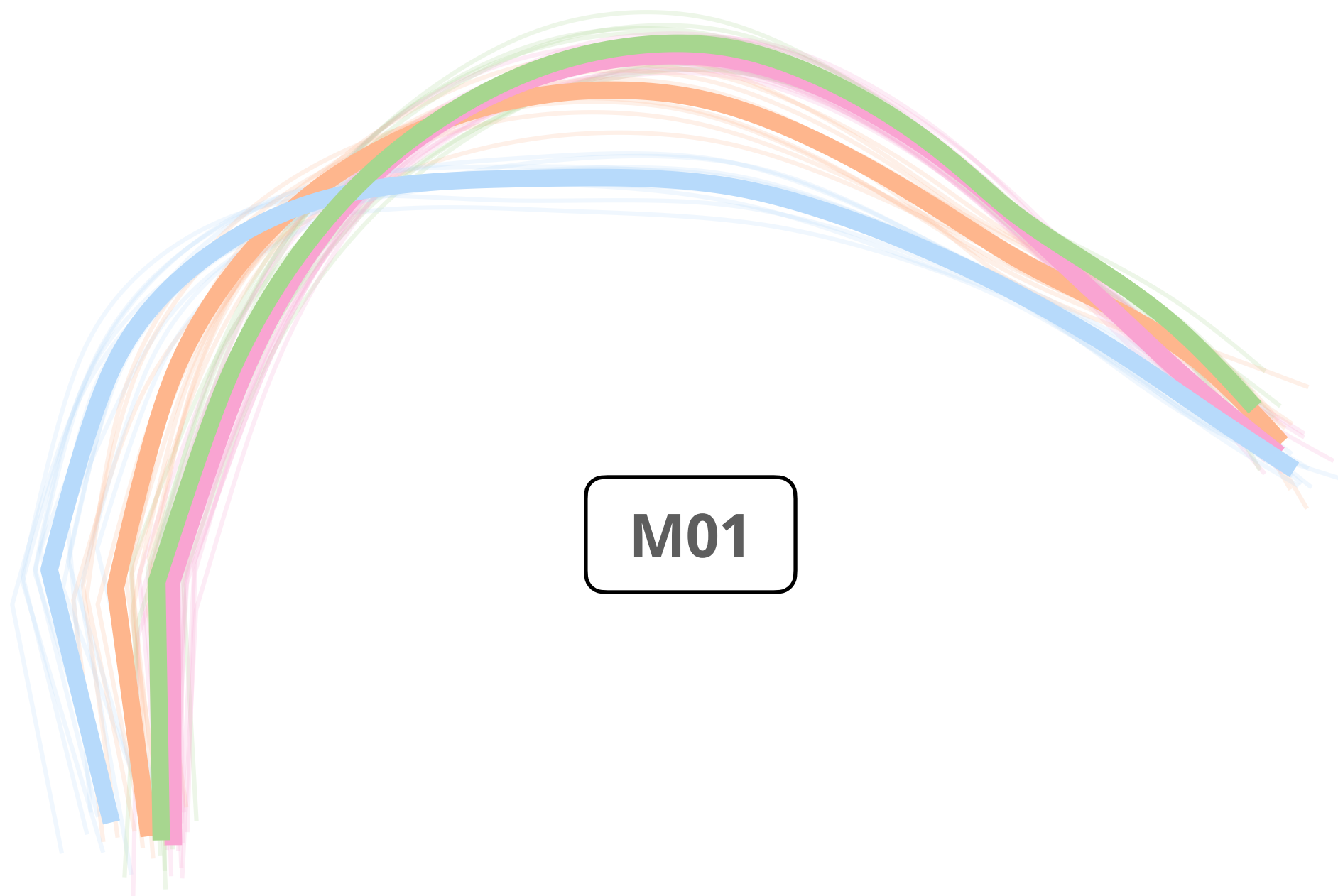
F01



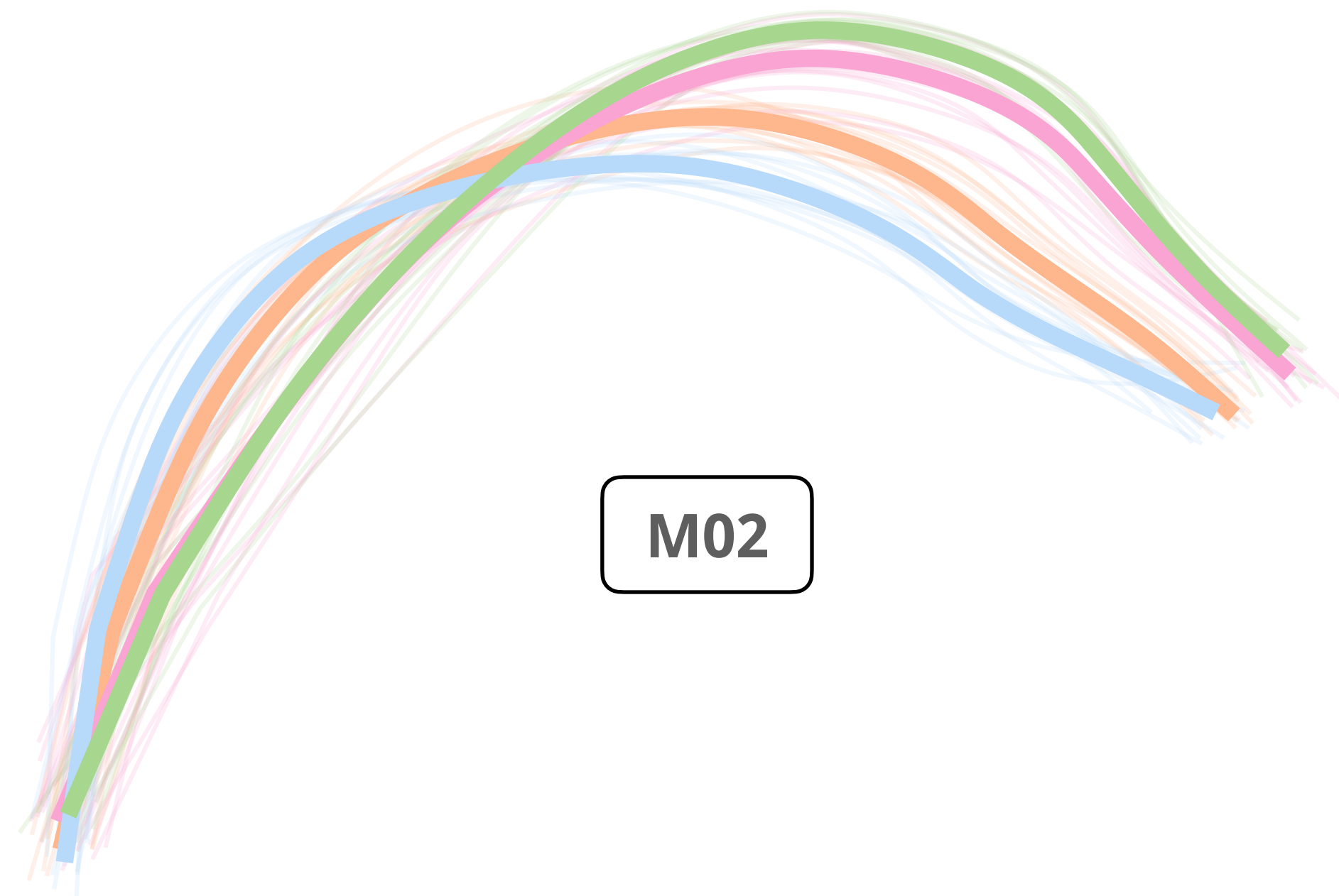
F02

V#s
e.g. *the seat*

S#j
e.g. *this reed*



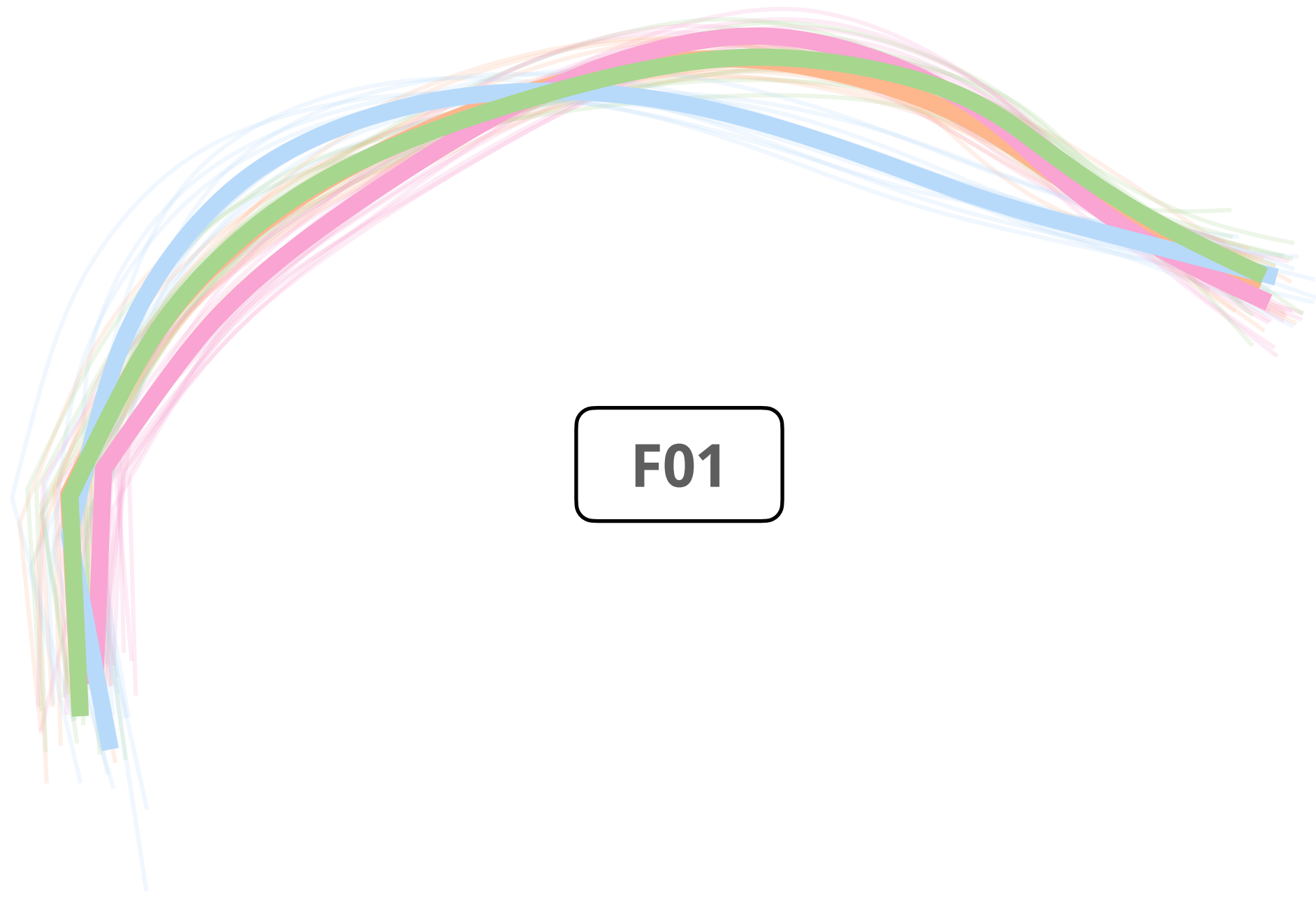
M01



M02

s#j
e.g. *this yeast*

V#j
e.g. *the sheet*



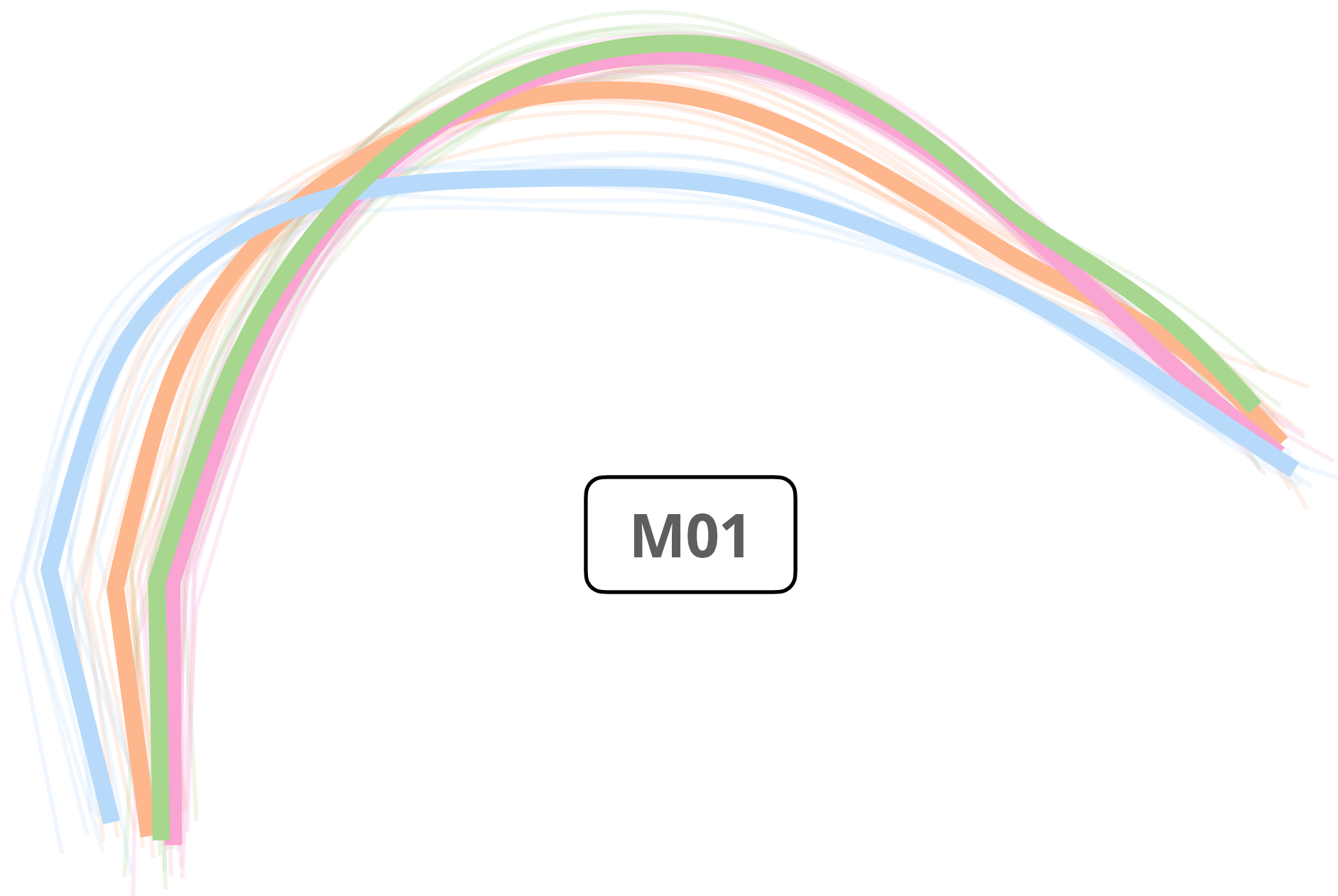
F01



F02

V#s
e.g. *the seat*

s#j
e.g. *this reed*



M01



M02

s#j
e.g. *this yeast*

V#j
e.g. *the sheet*



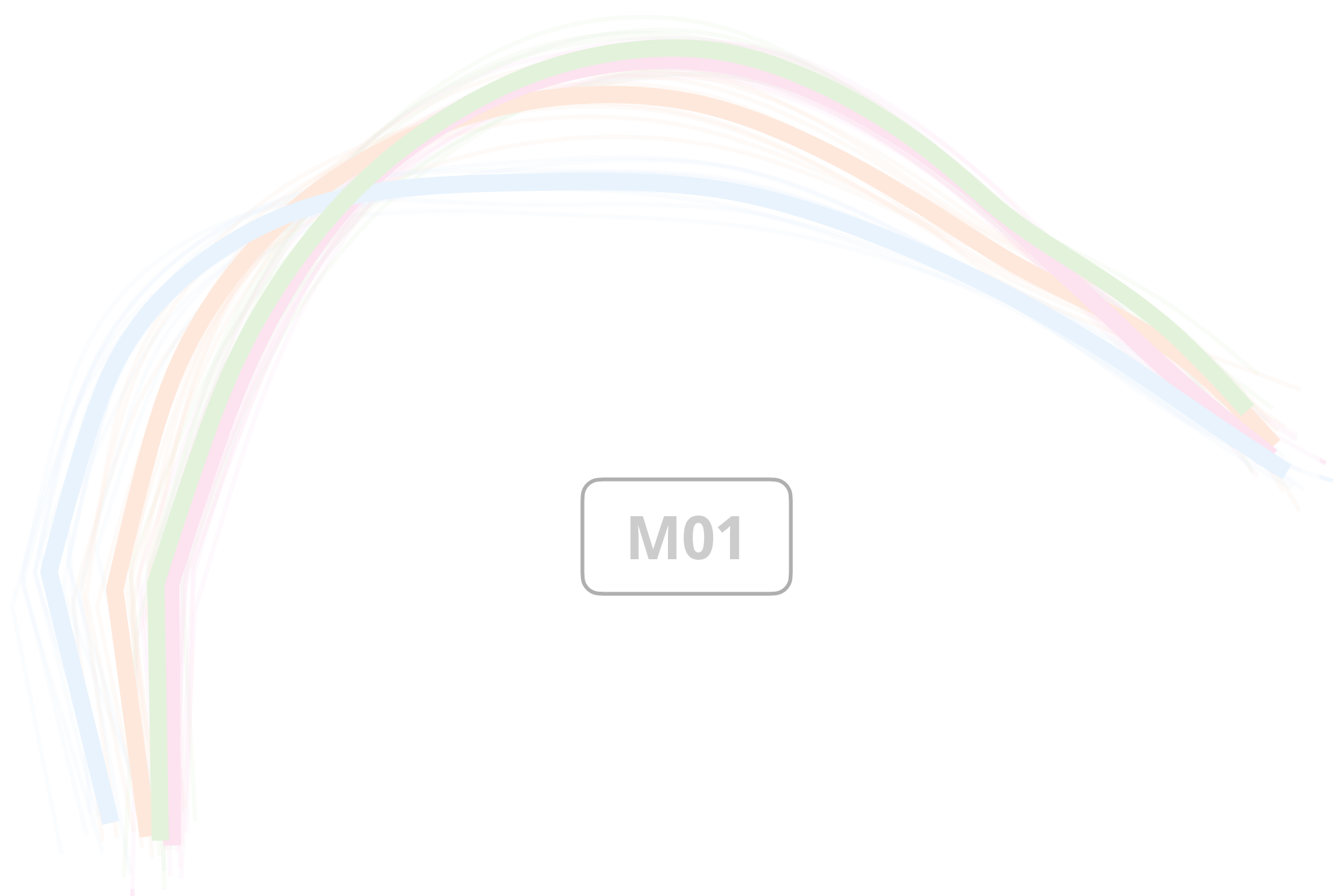
F01



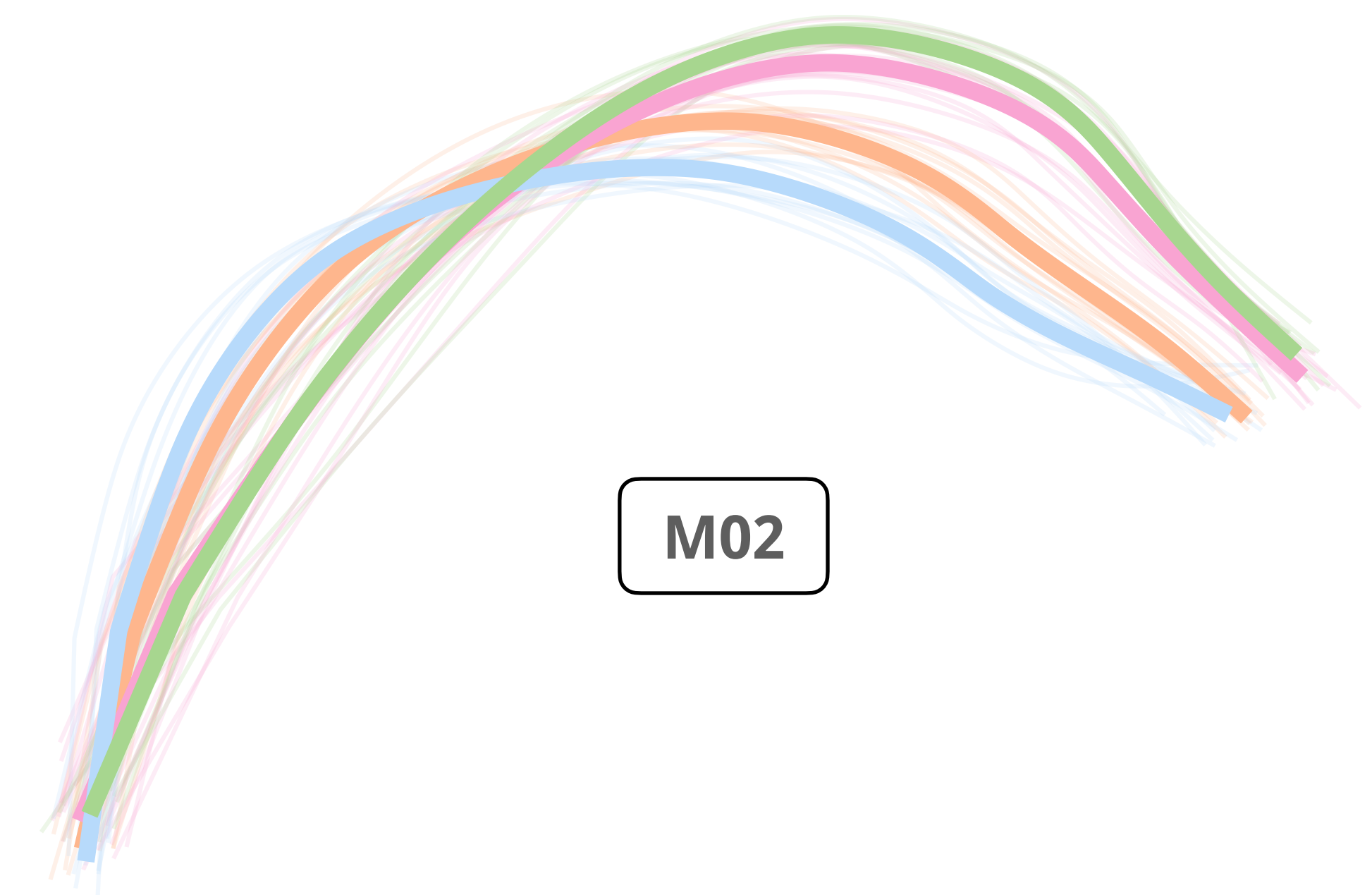
F02

V#s
e.g. *the seat*

s#j
e.g. *this reed*



M01



M02

s#j
e.g. *this yeast*

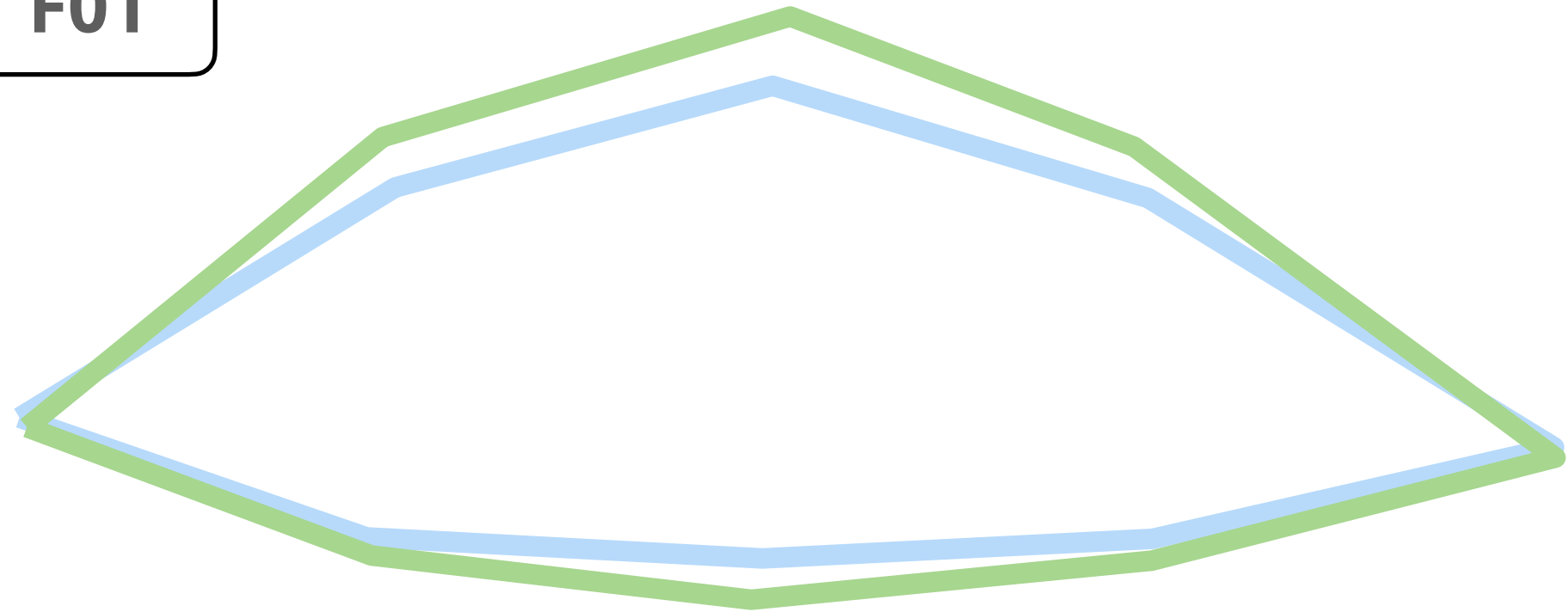
V#j
e.g. *the sheet*

Lips

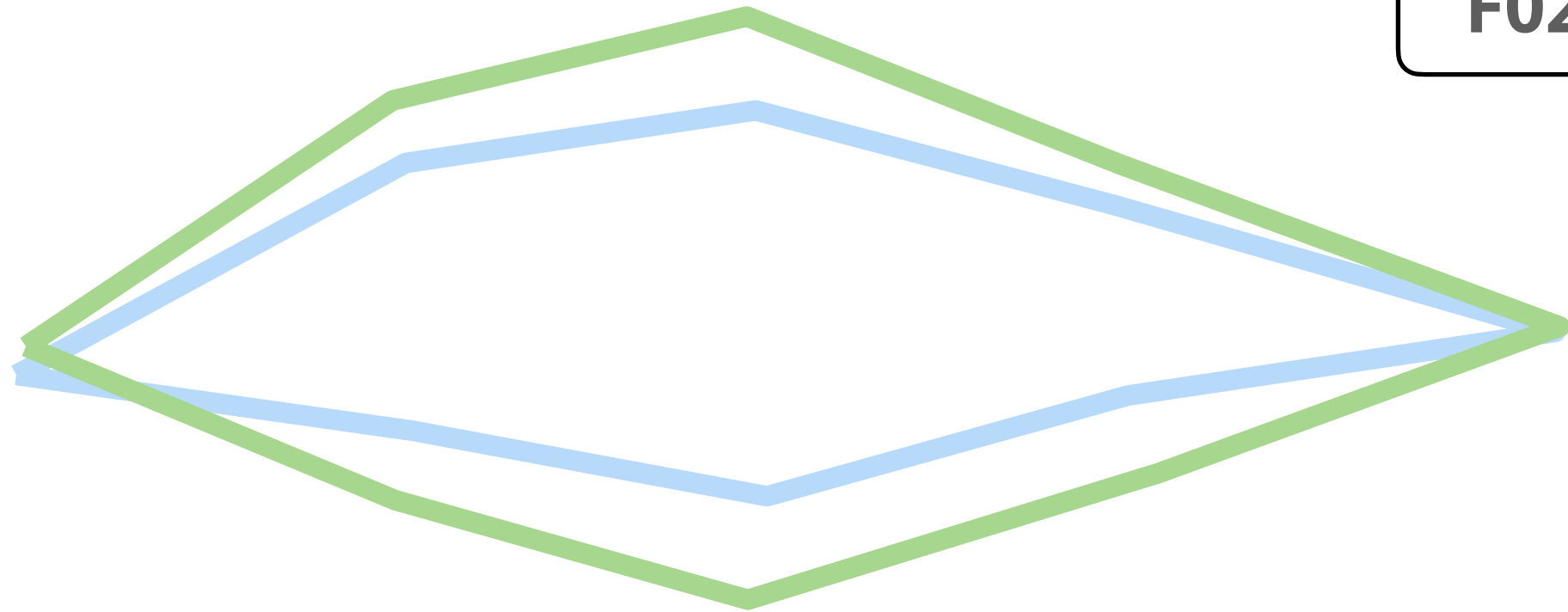
post-lexical retraction



F01

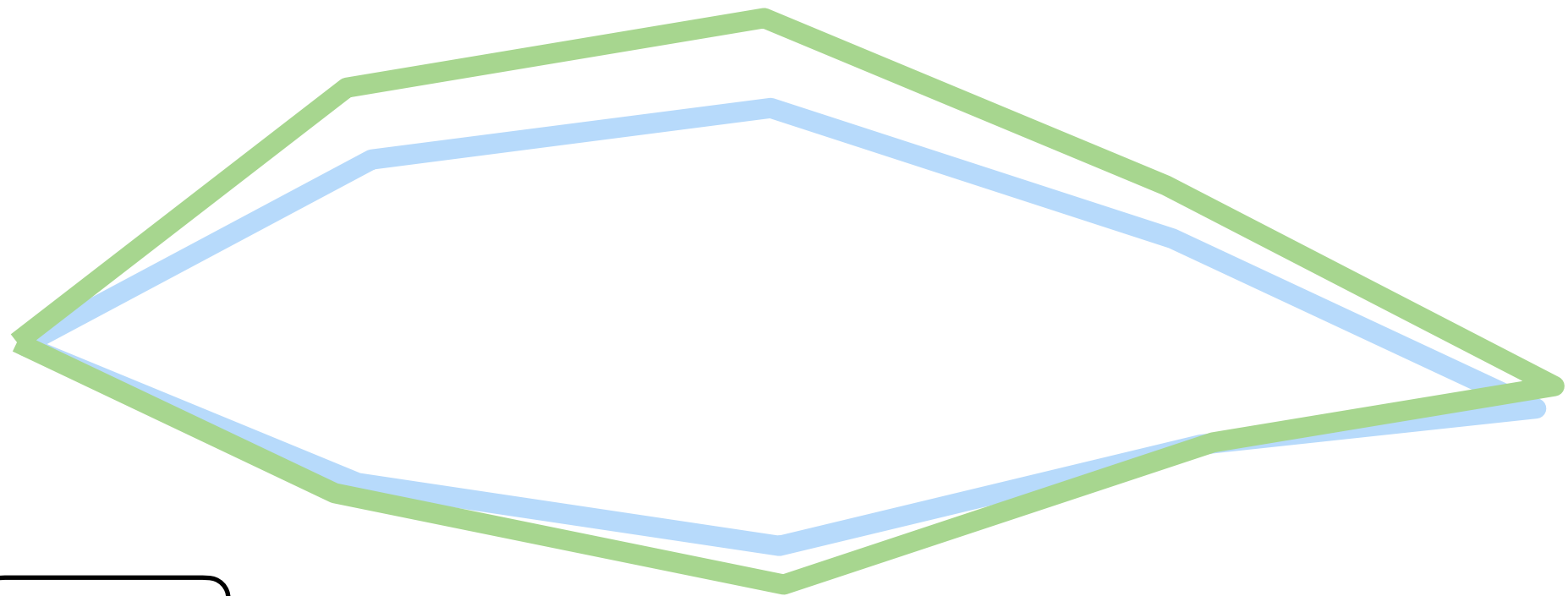


F02

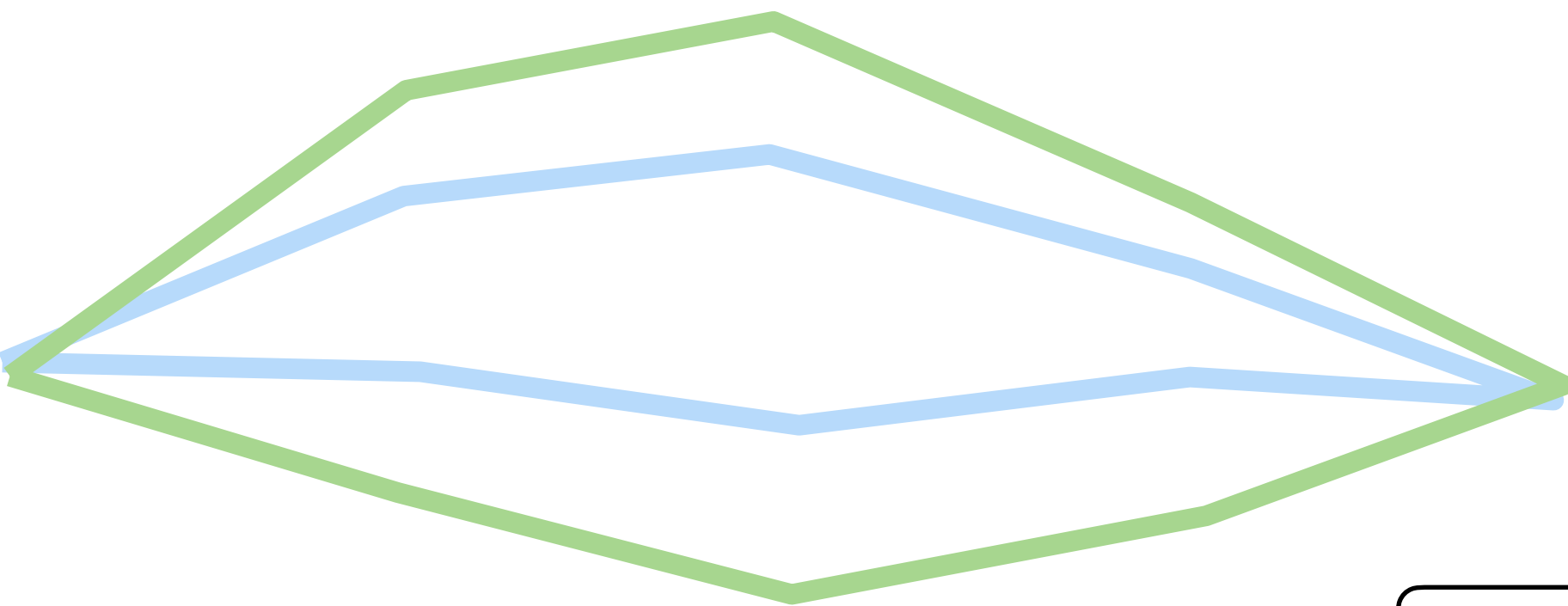


V#s
e.g. *seat*

M01

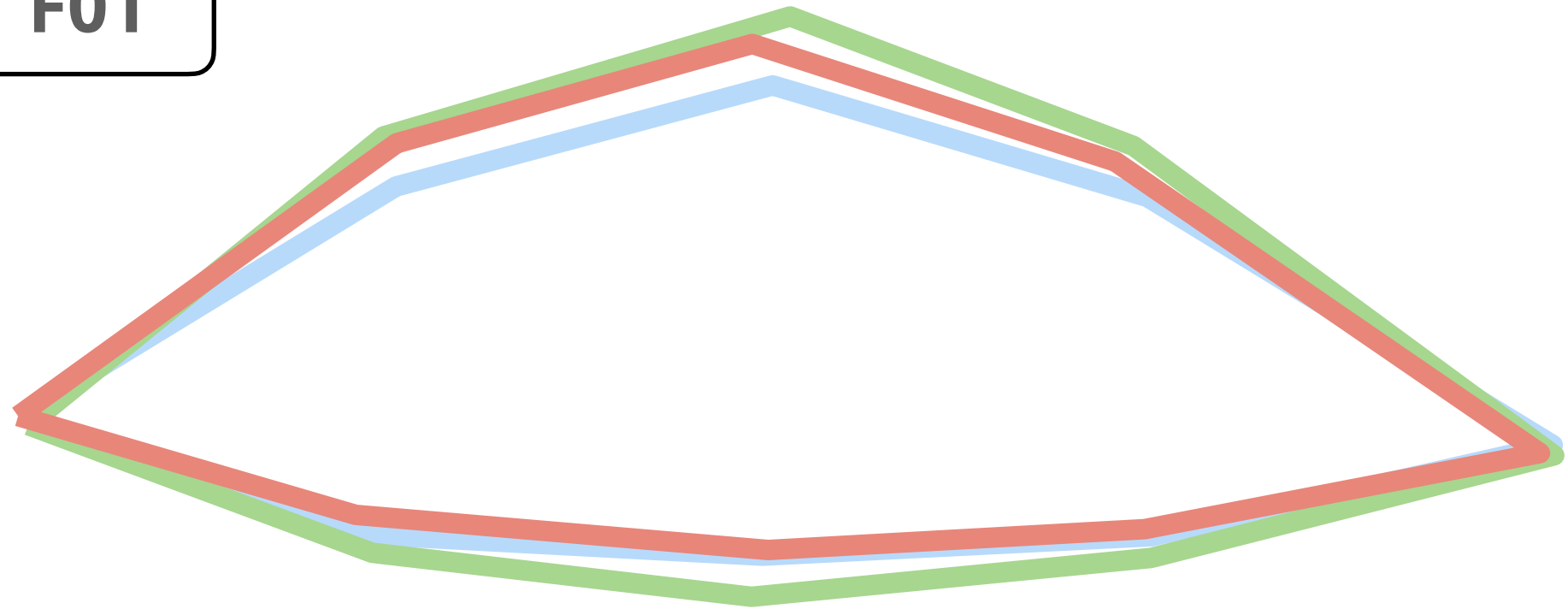


M02

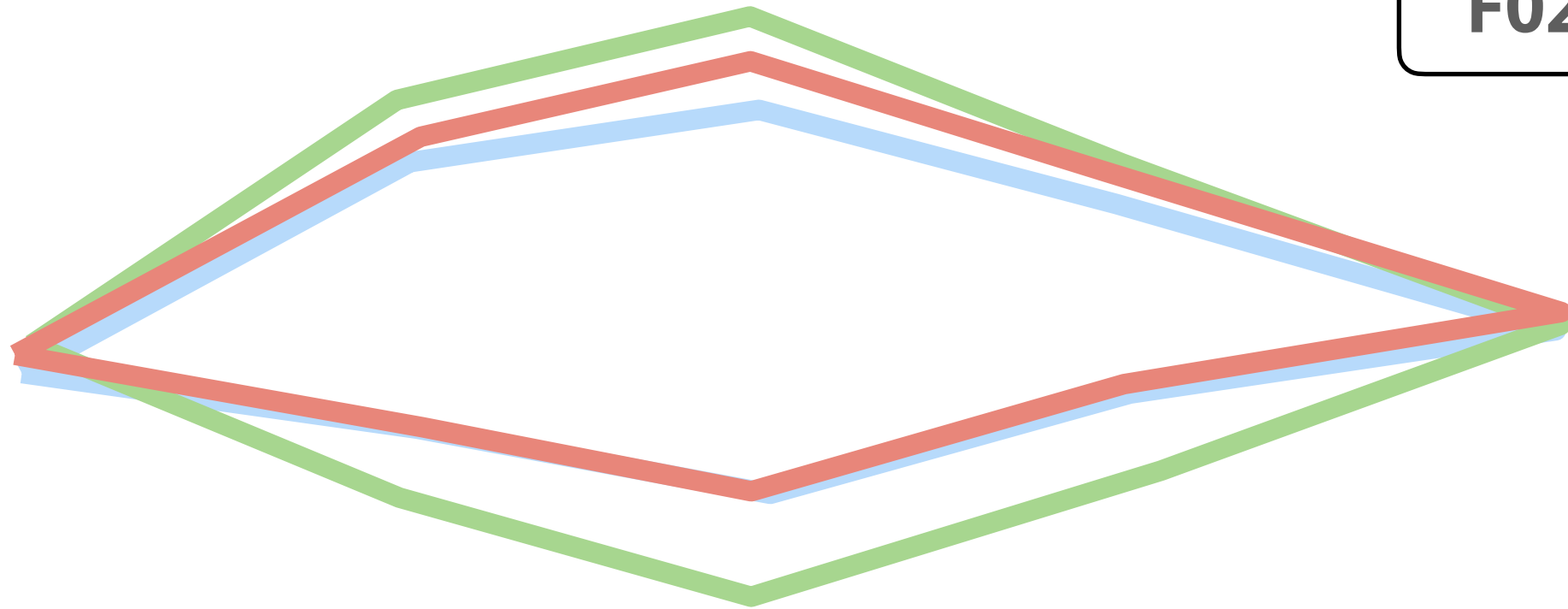


V#j
e.g. *sheet*

F01



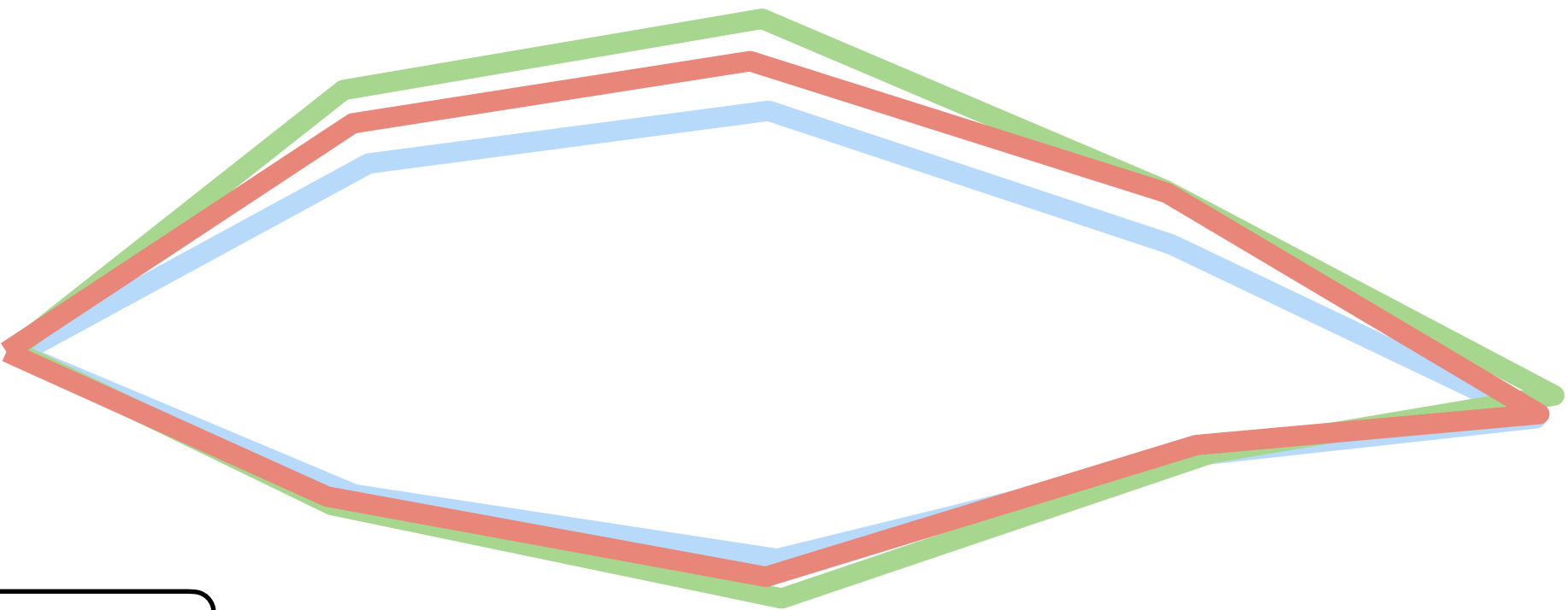
F02



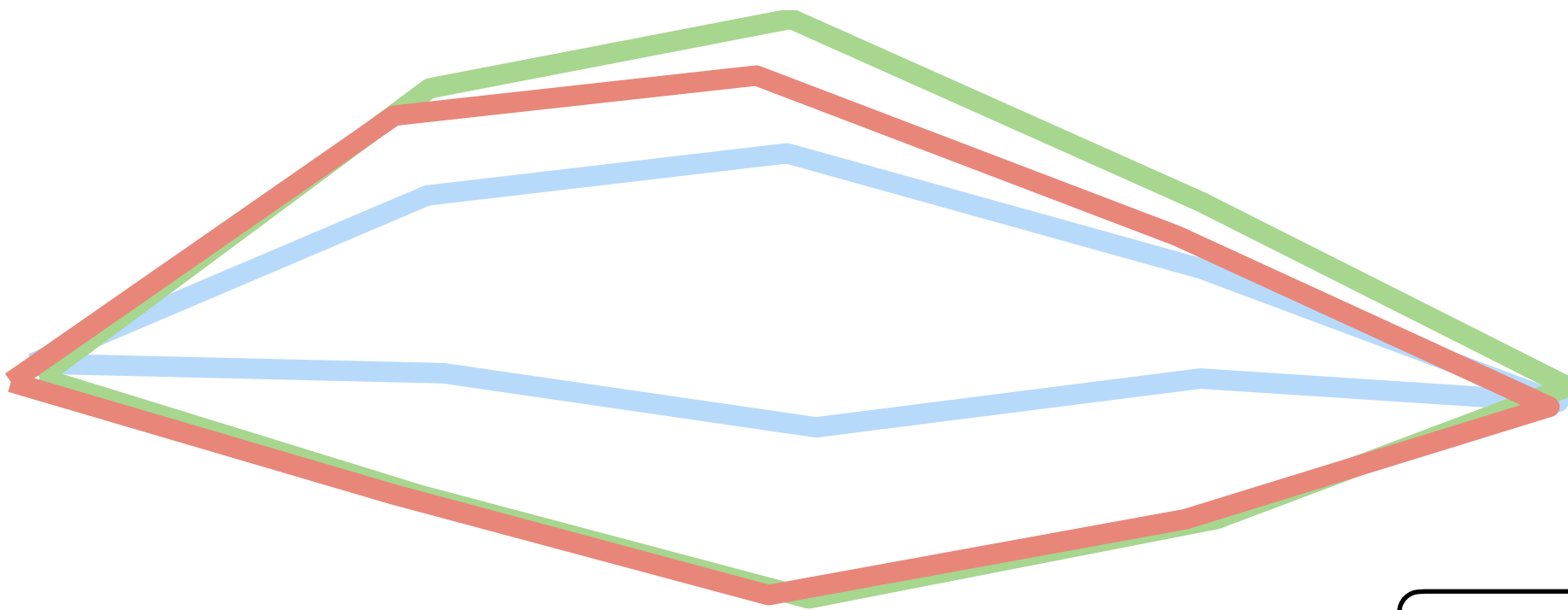
V#s
e.g. *seat*

s#tj
e.g. *this tune*

M01

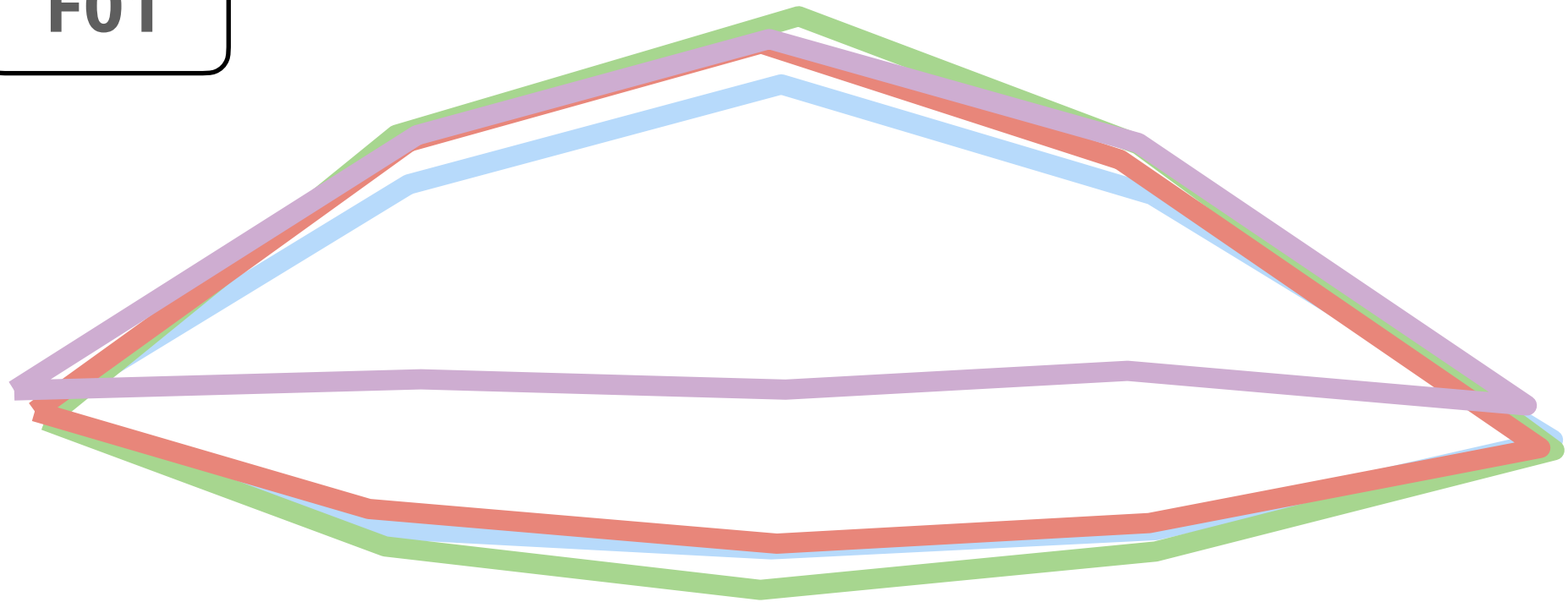


M02

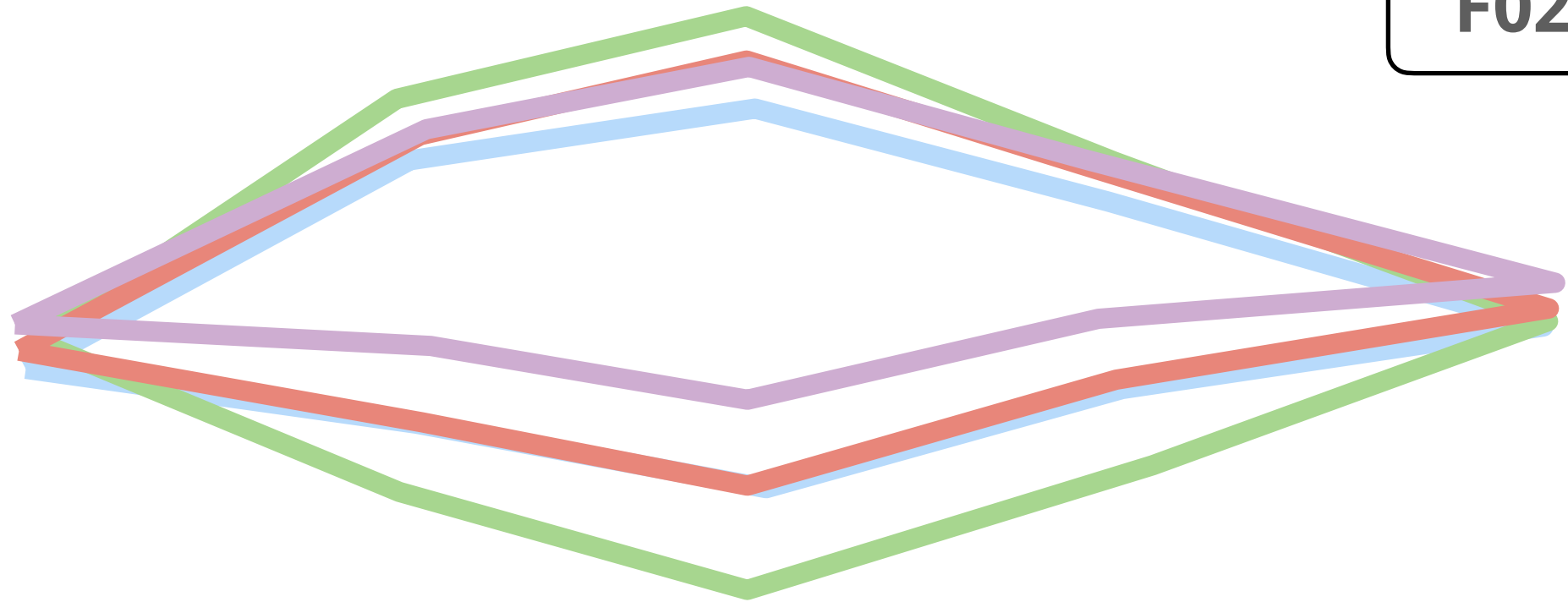


V#j
e.g. *sheet*

F01



F02



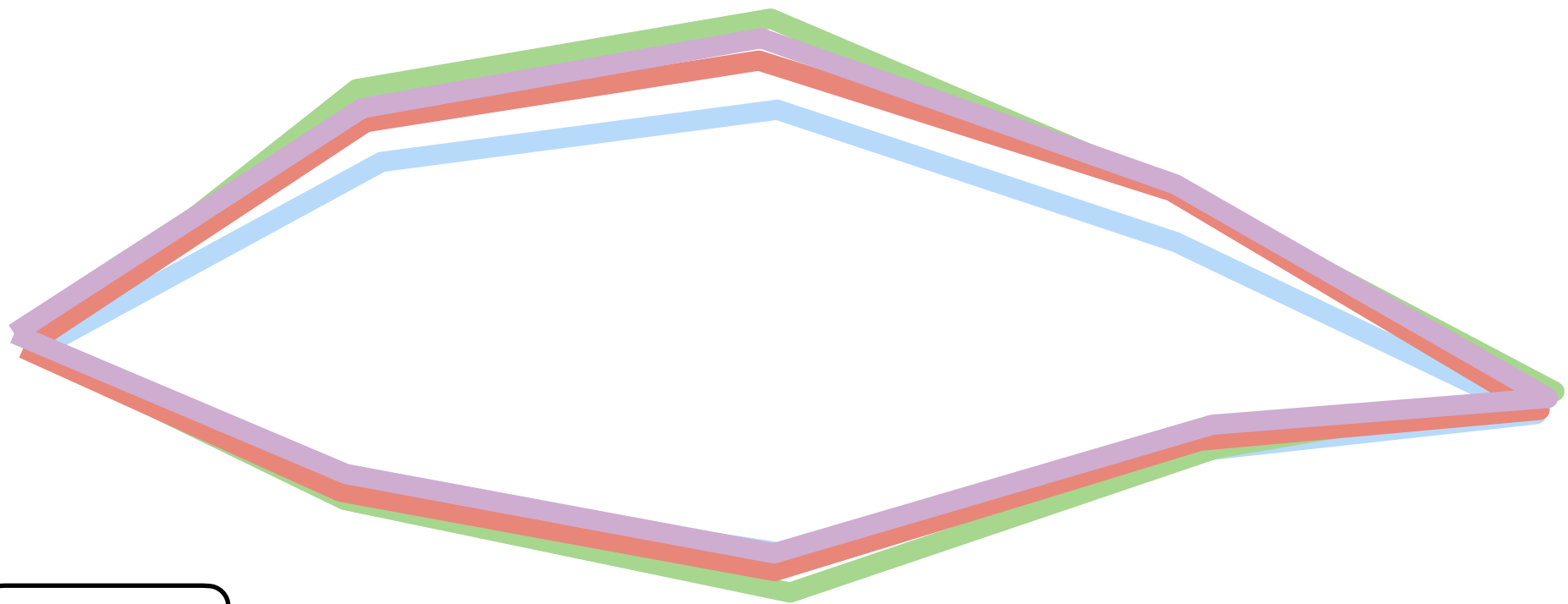
V#s
e.g. *seat*

s#tj
e.g. *this tune*

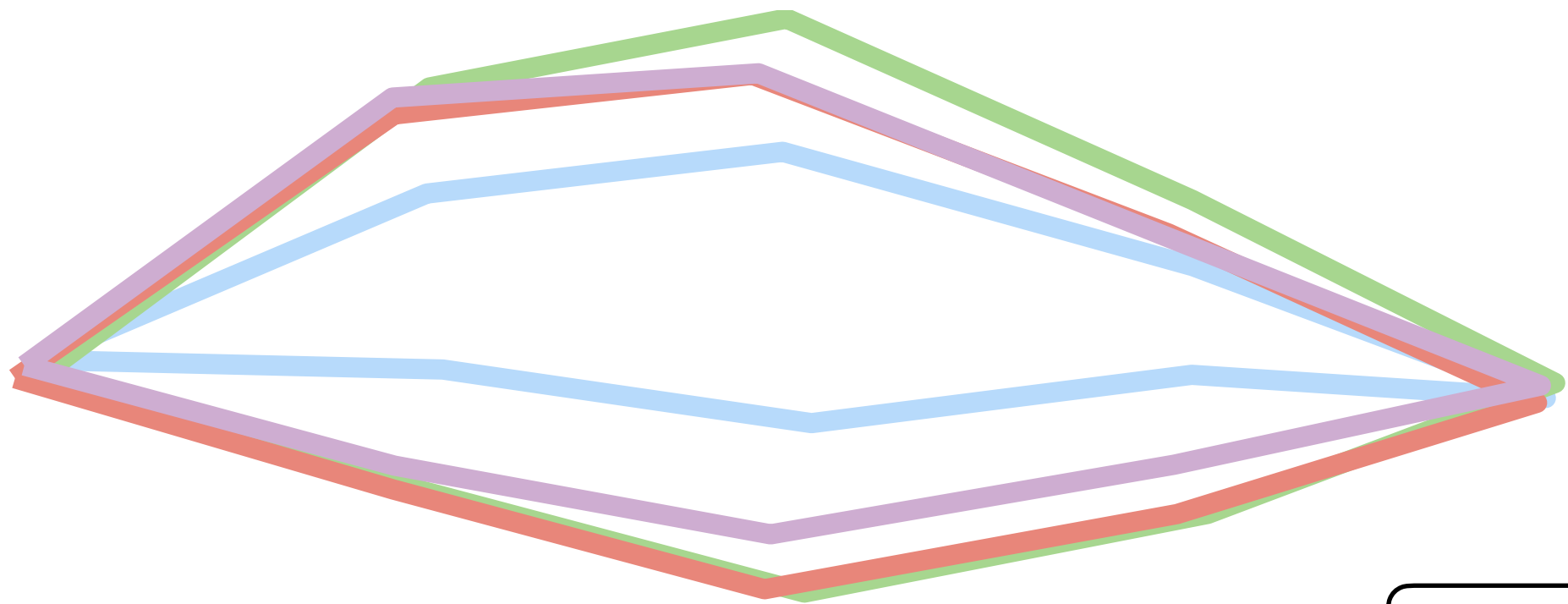
s#tɹ
e.g. *this tree*

V#ʃ
e.g. *sheet*

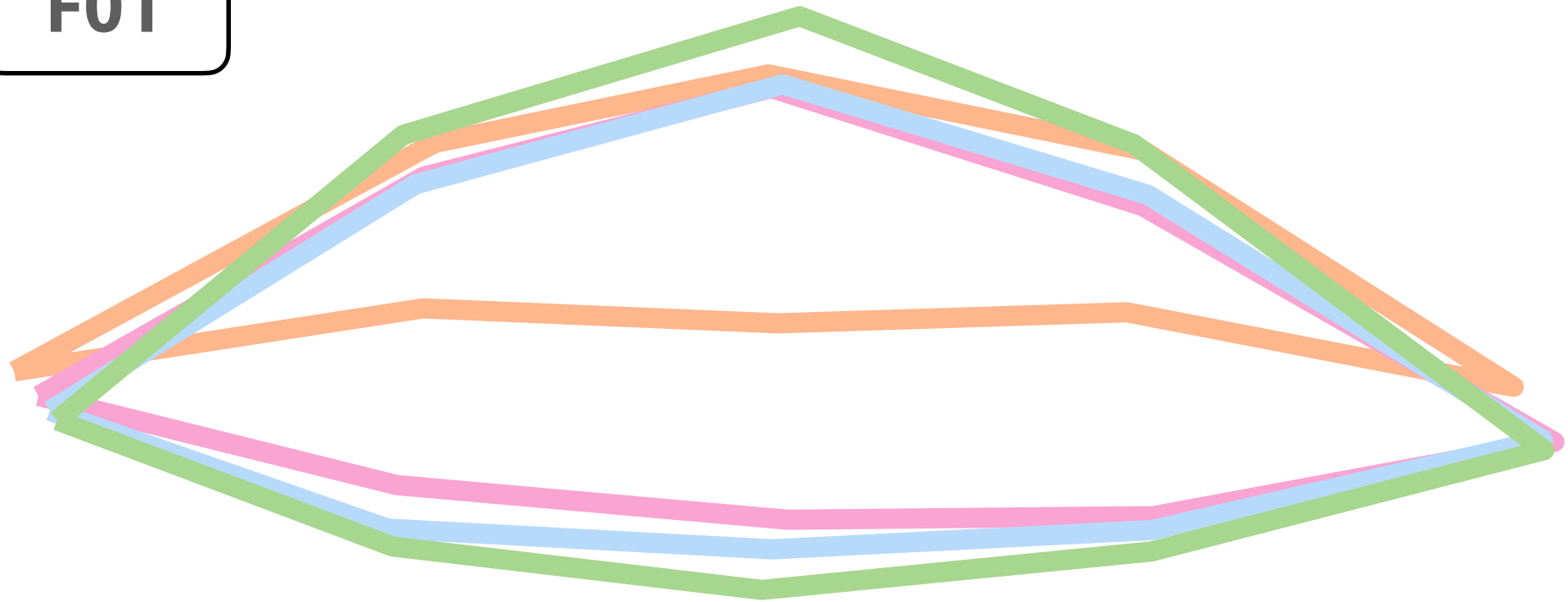
M01



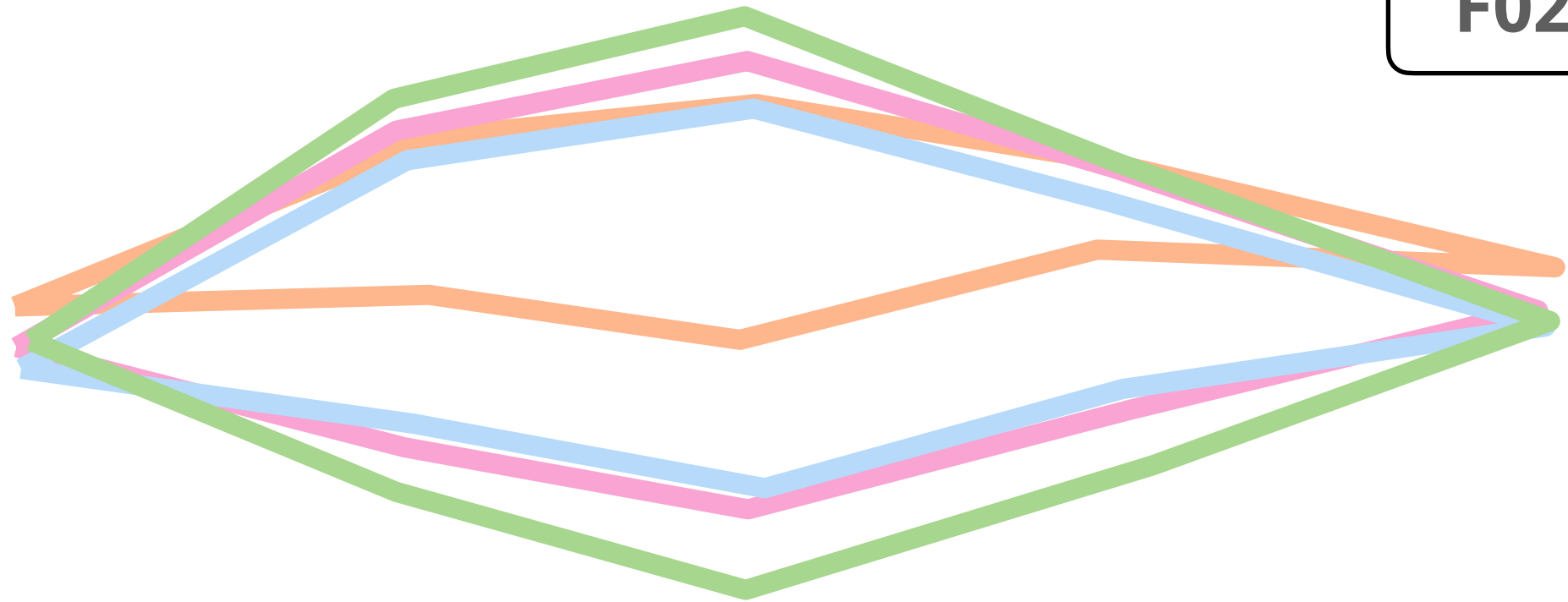
M02



F01



F02



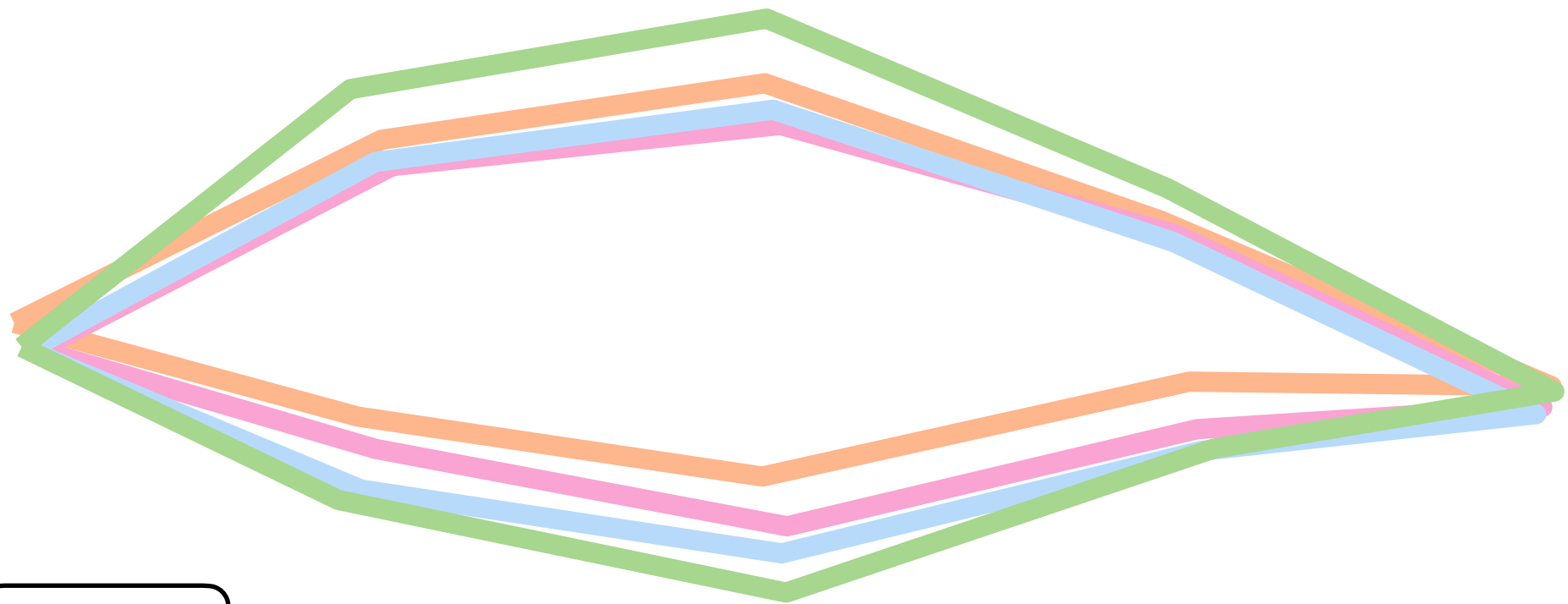
V#s
e.g. *seat*

s#j
e.g. *this reed*

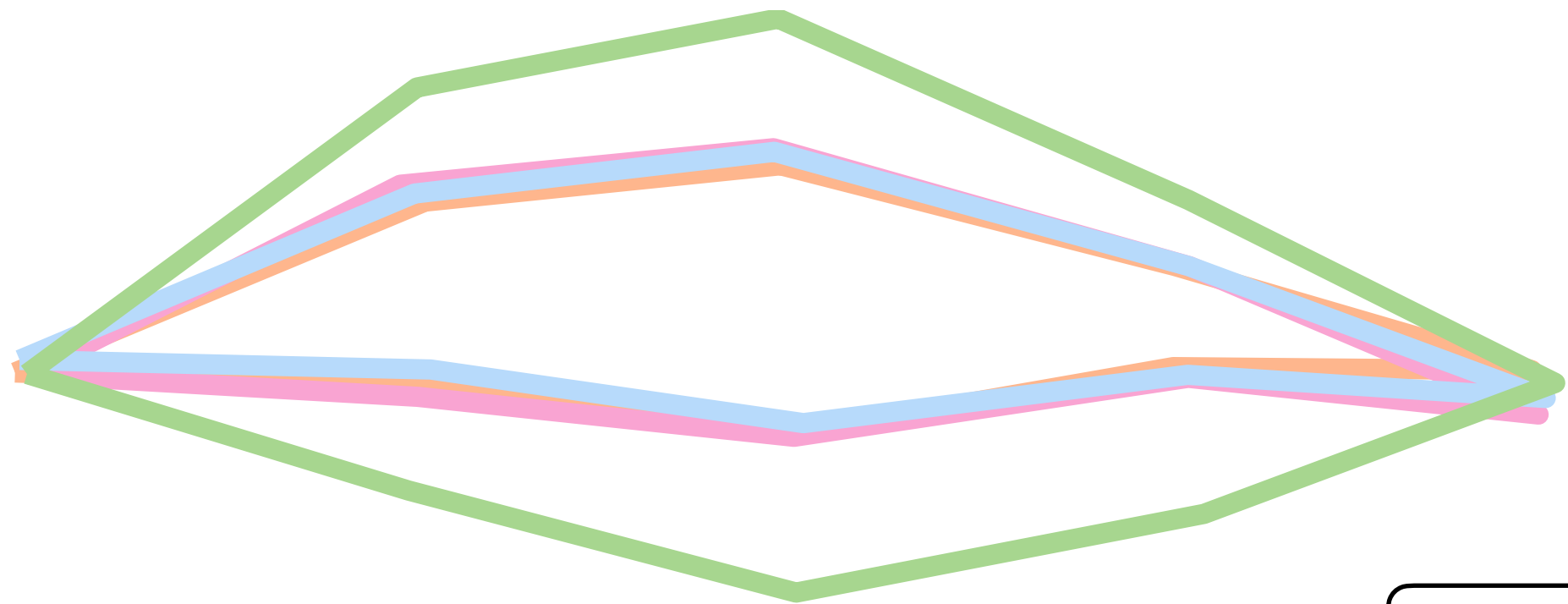
s#j
e.g. *this yeast*

V#j
e.g. *sheet*

M01



M02



F01

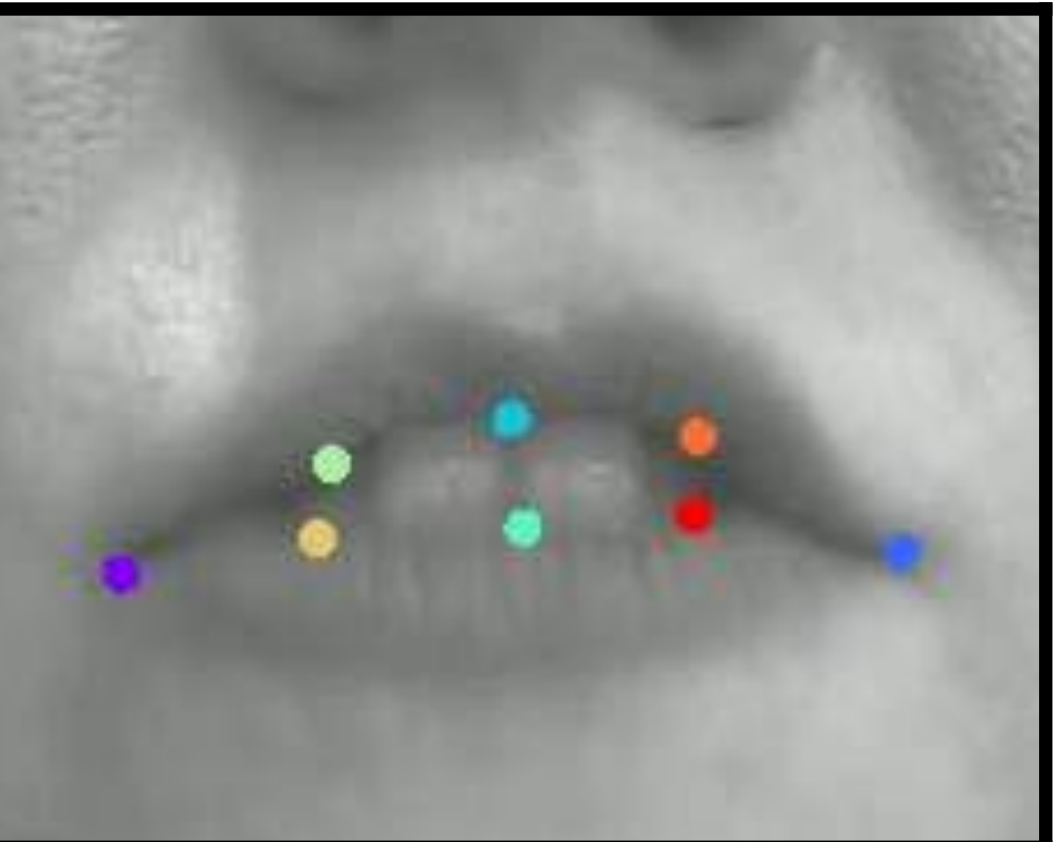
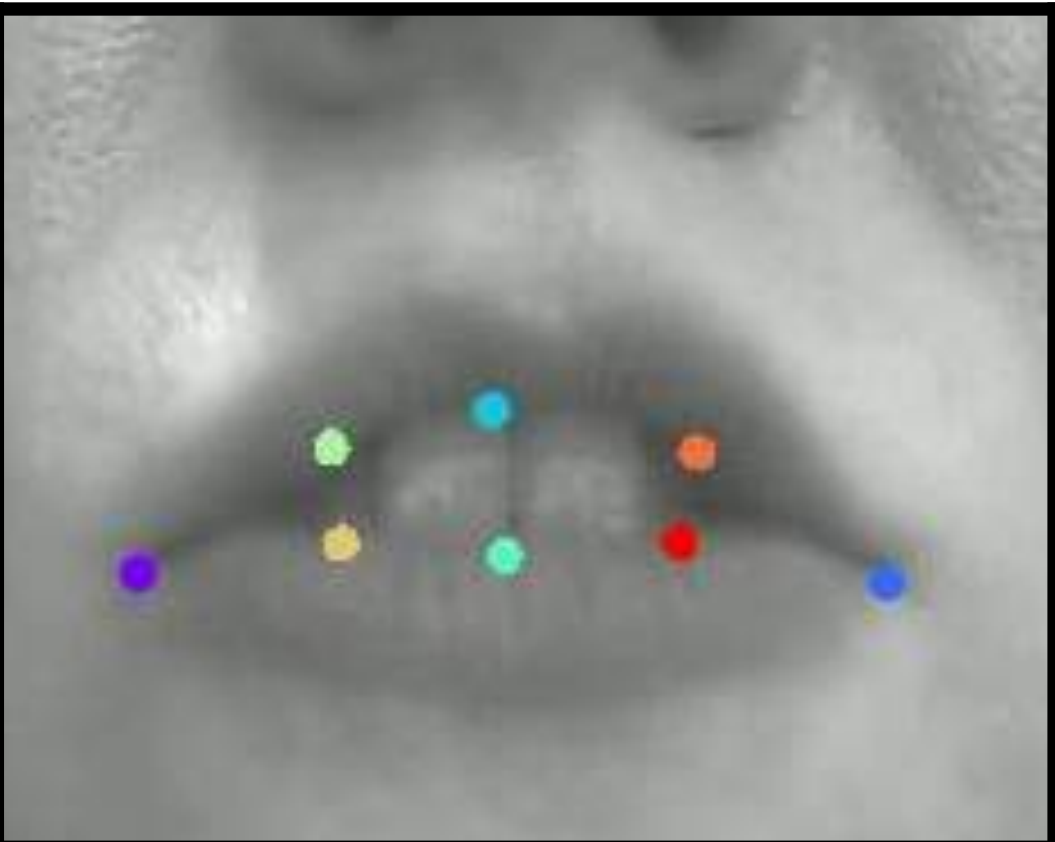
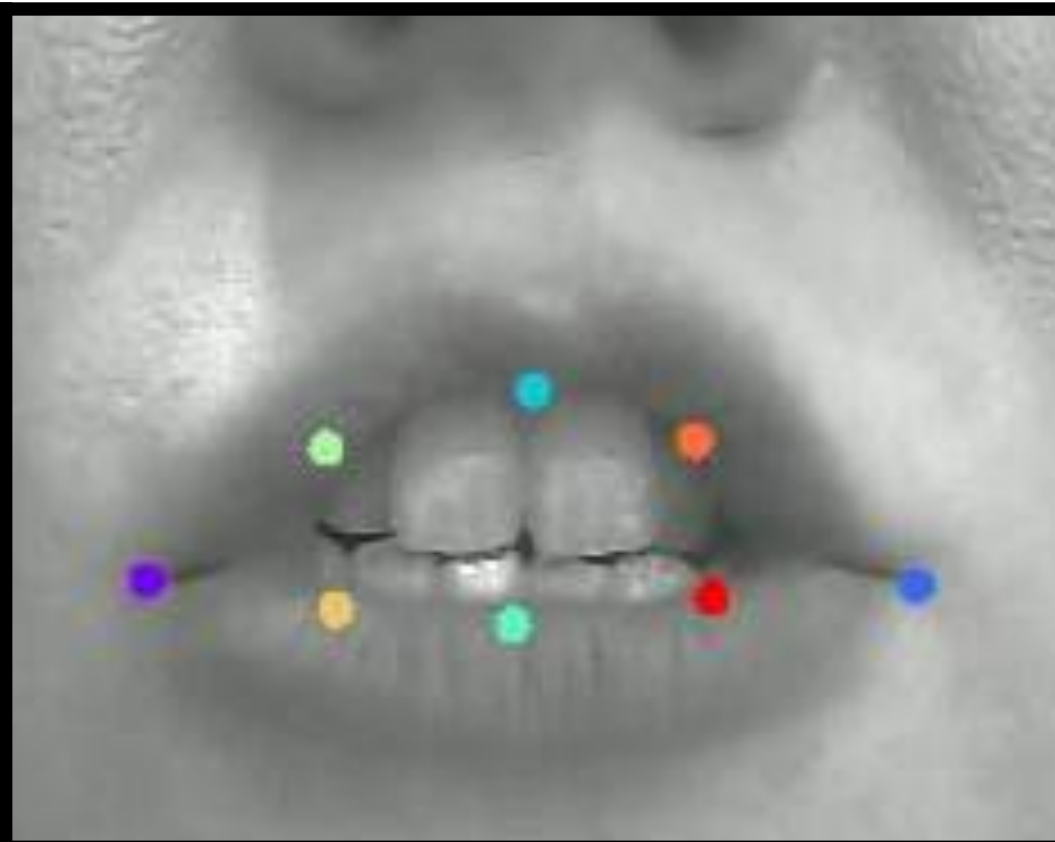
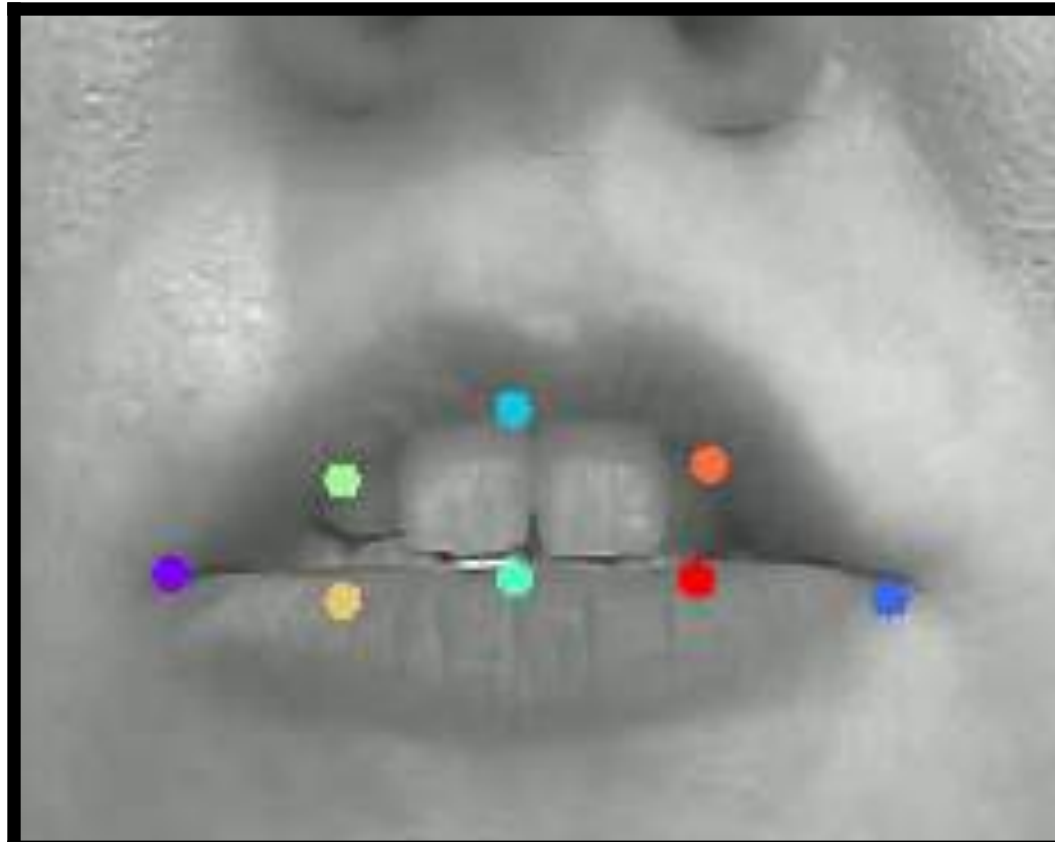
V#s

V#ʃ

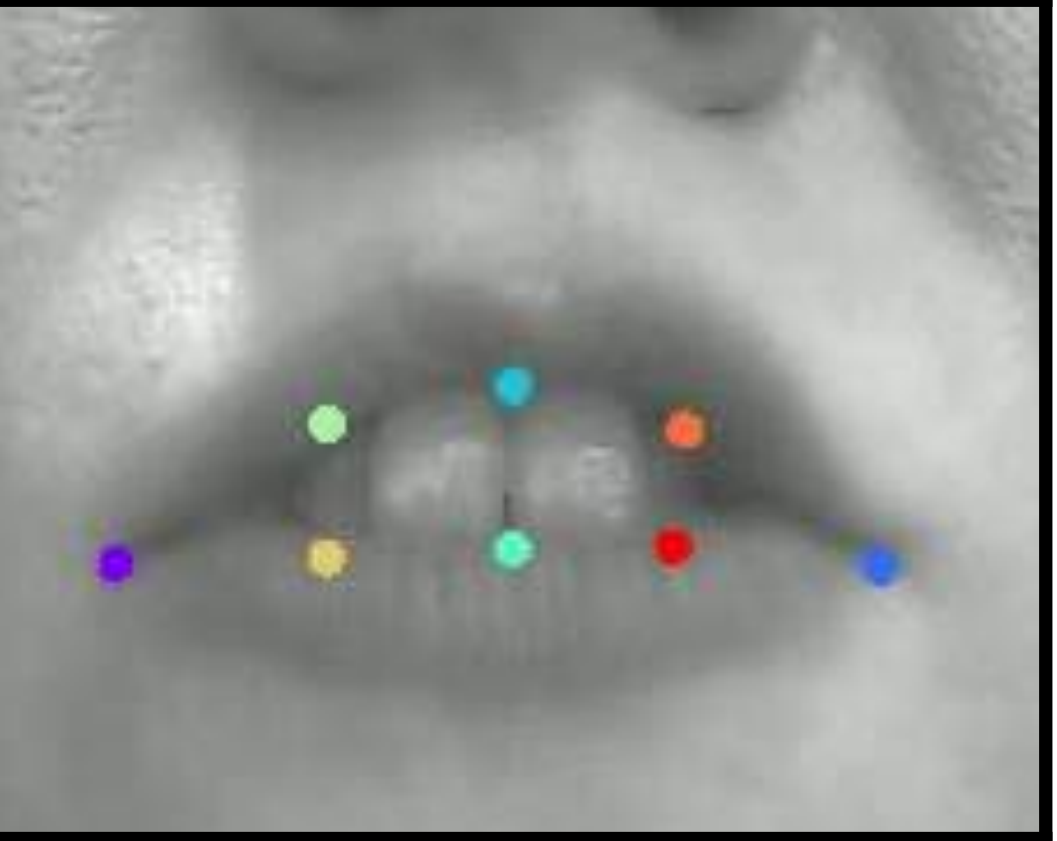
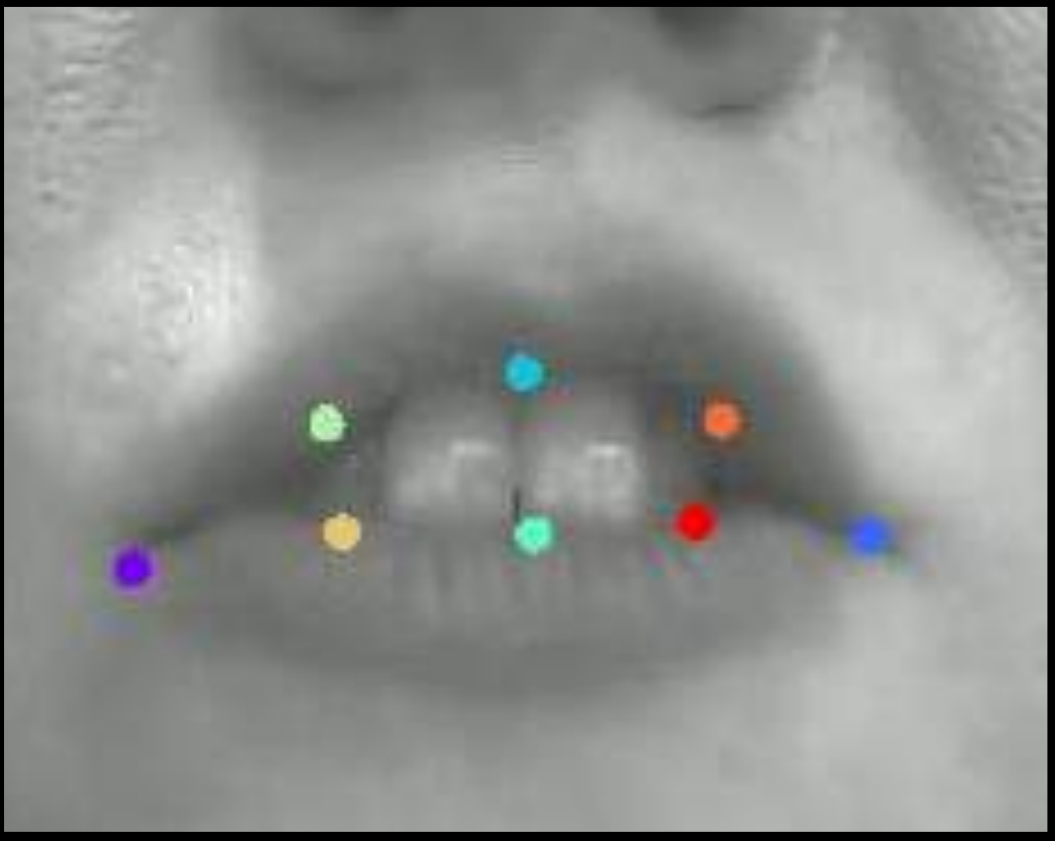
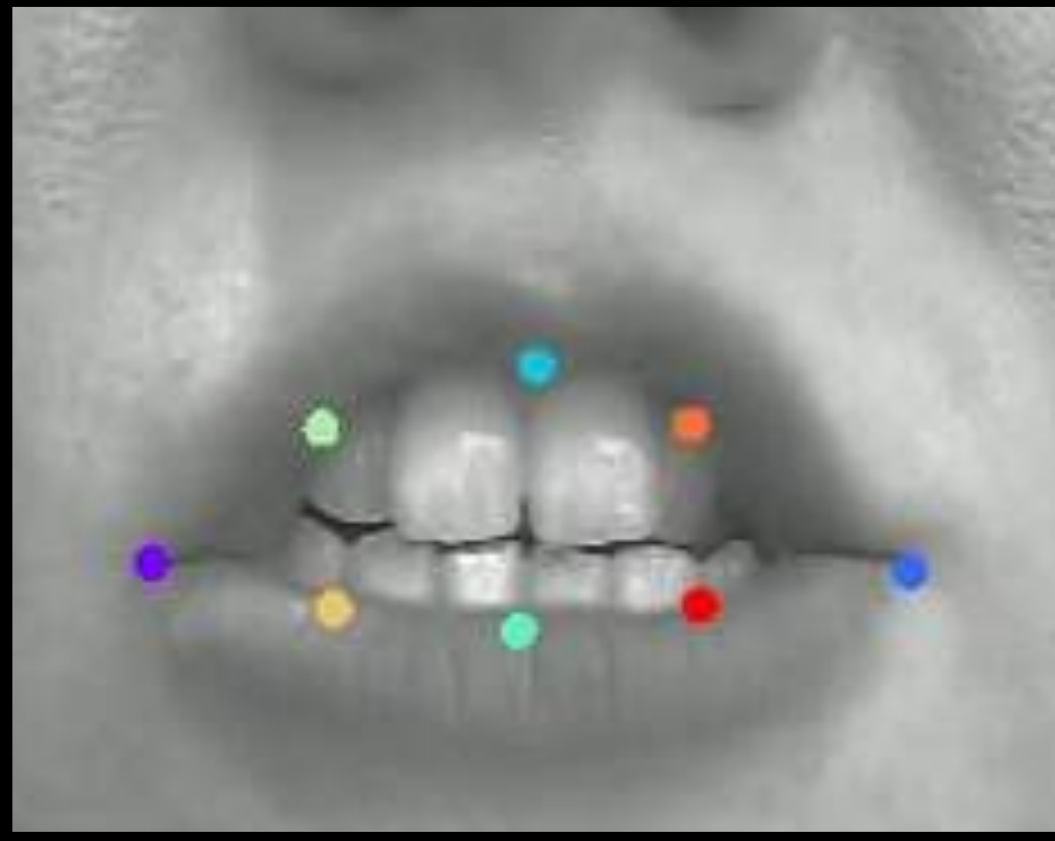
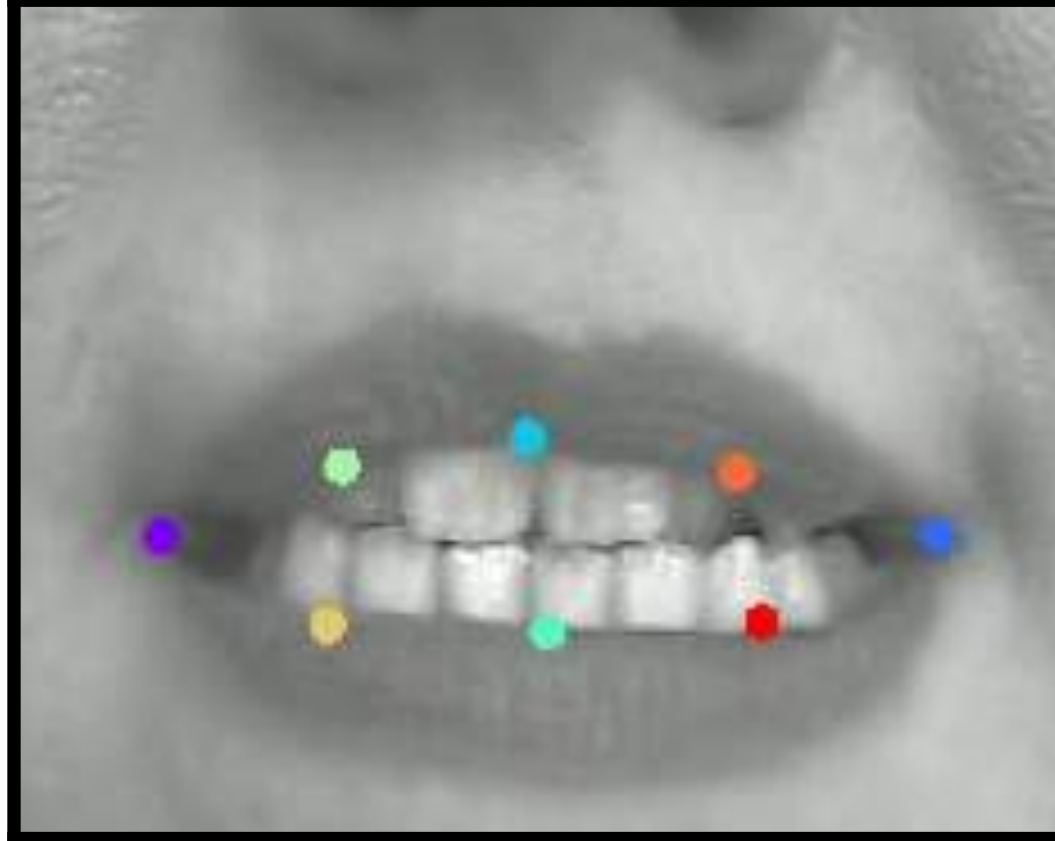
s#tʌ

s#ʌ

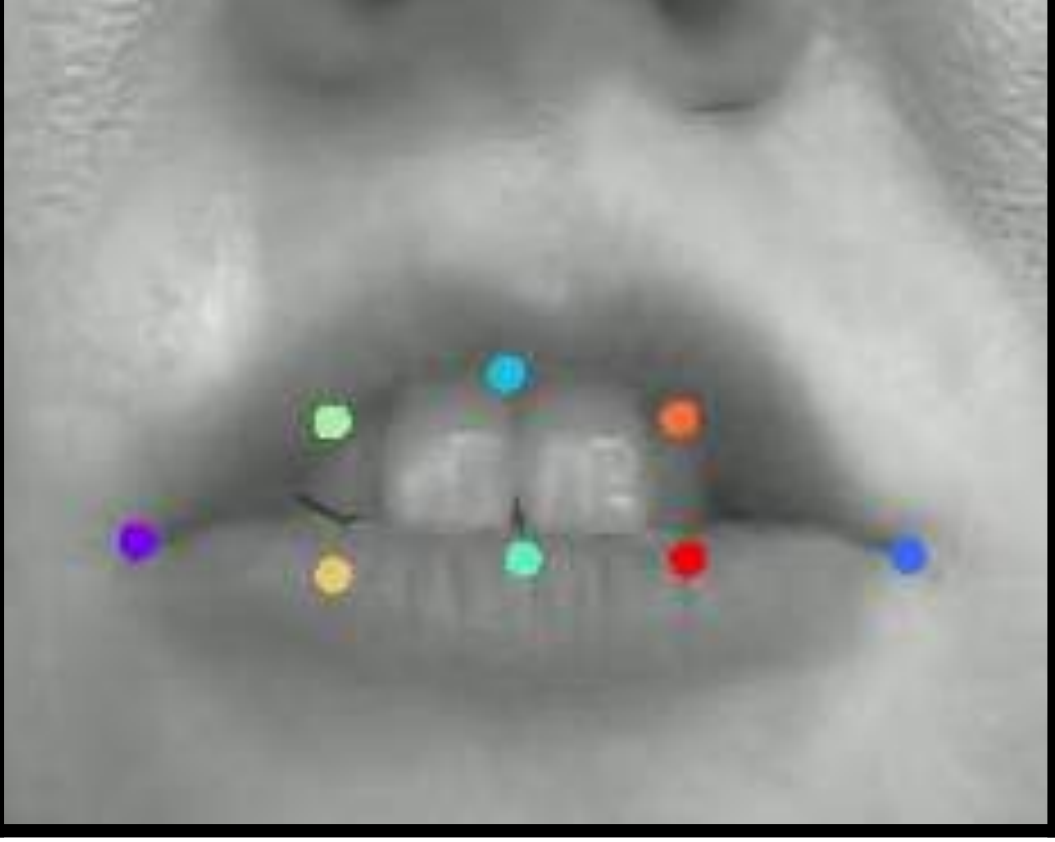
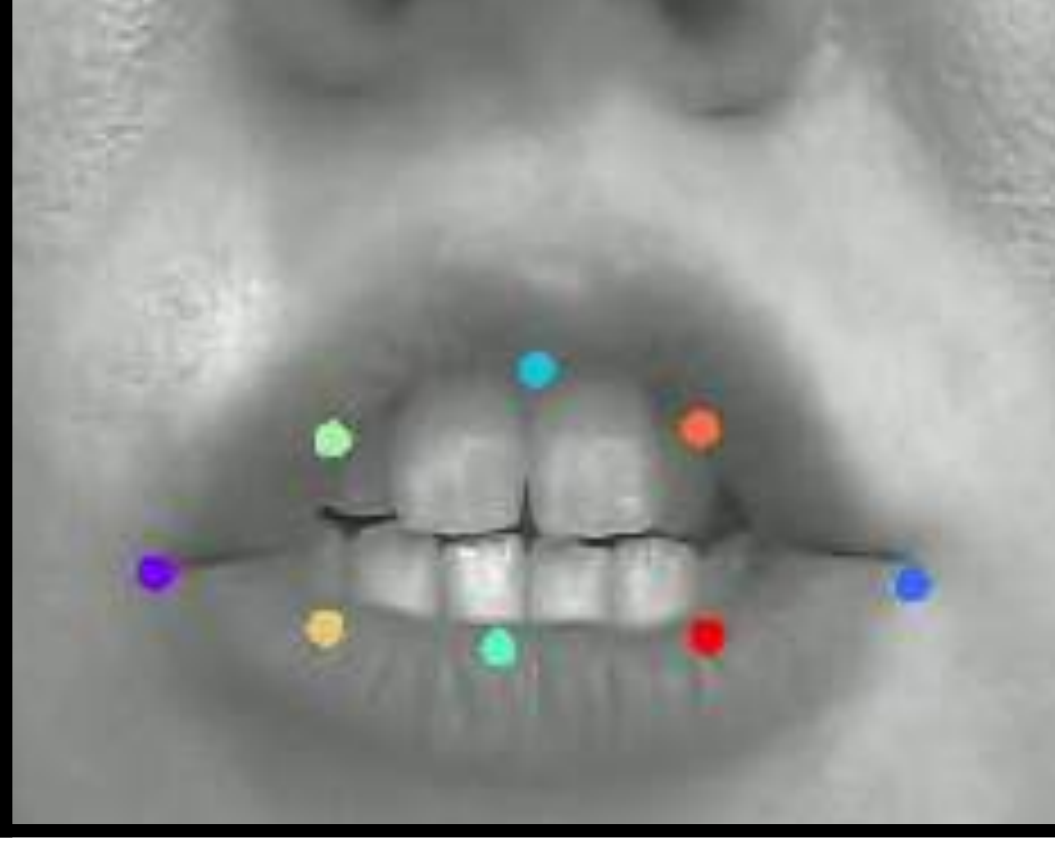
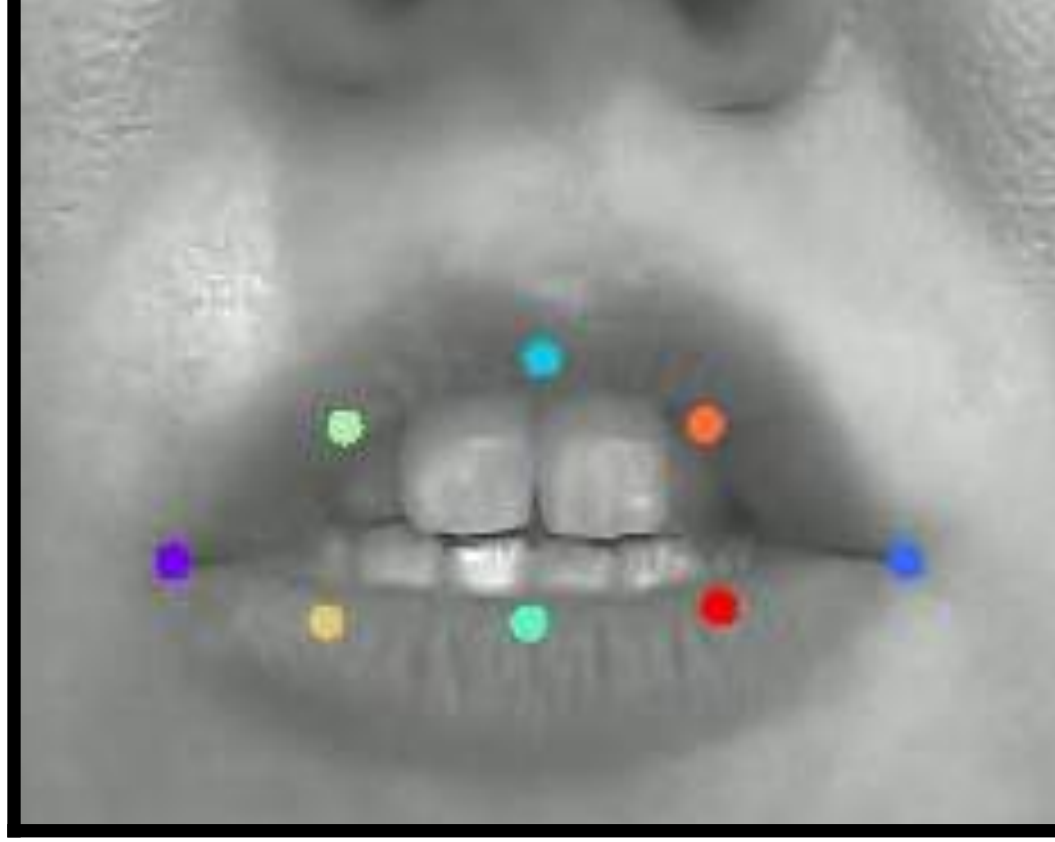
/ɒ/



/i/



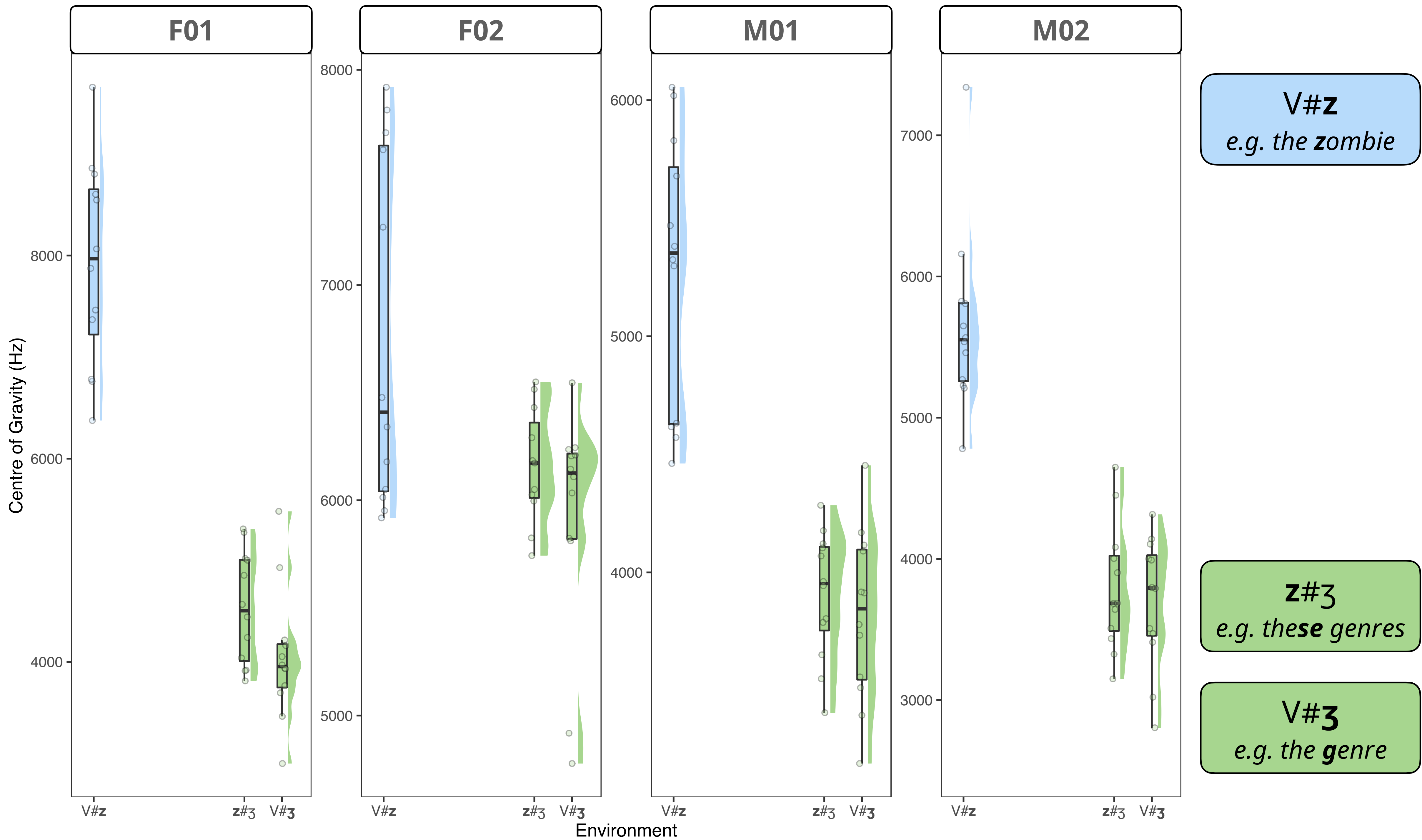
/ʊ/

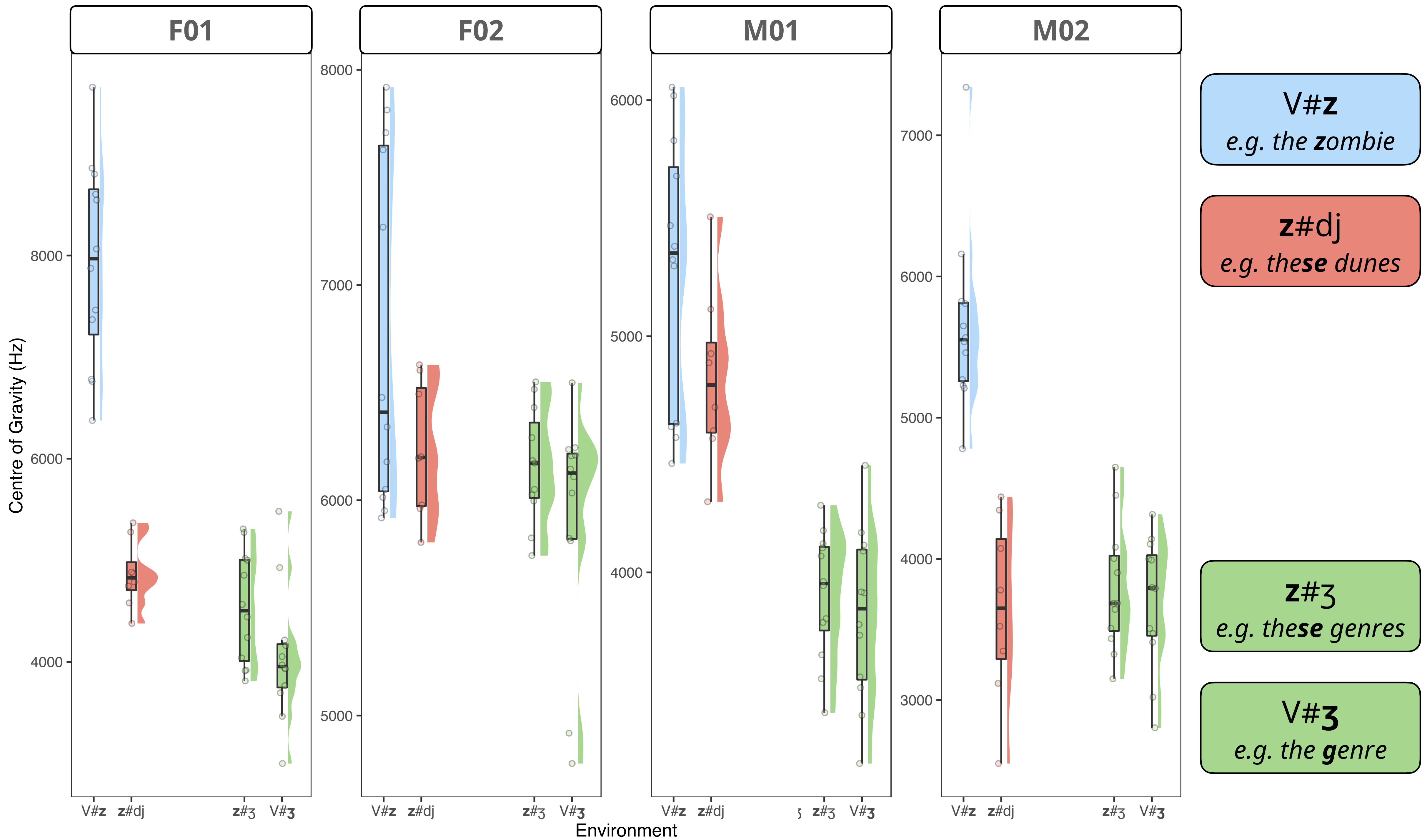


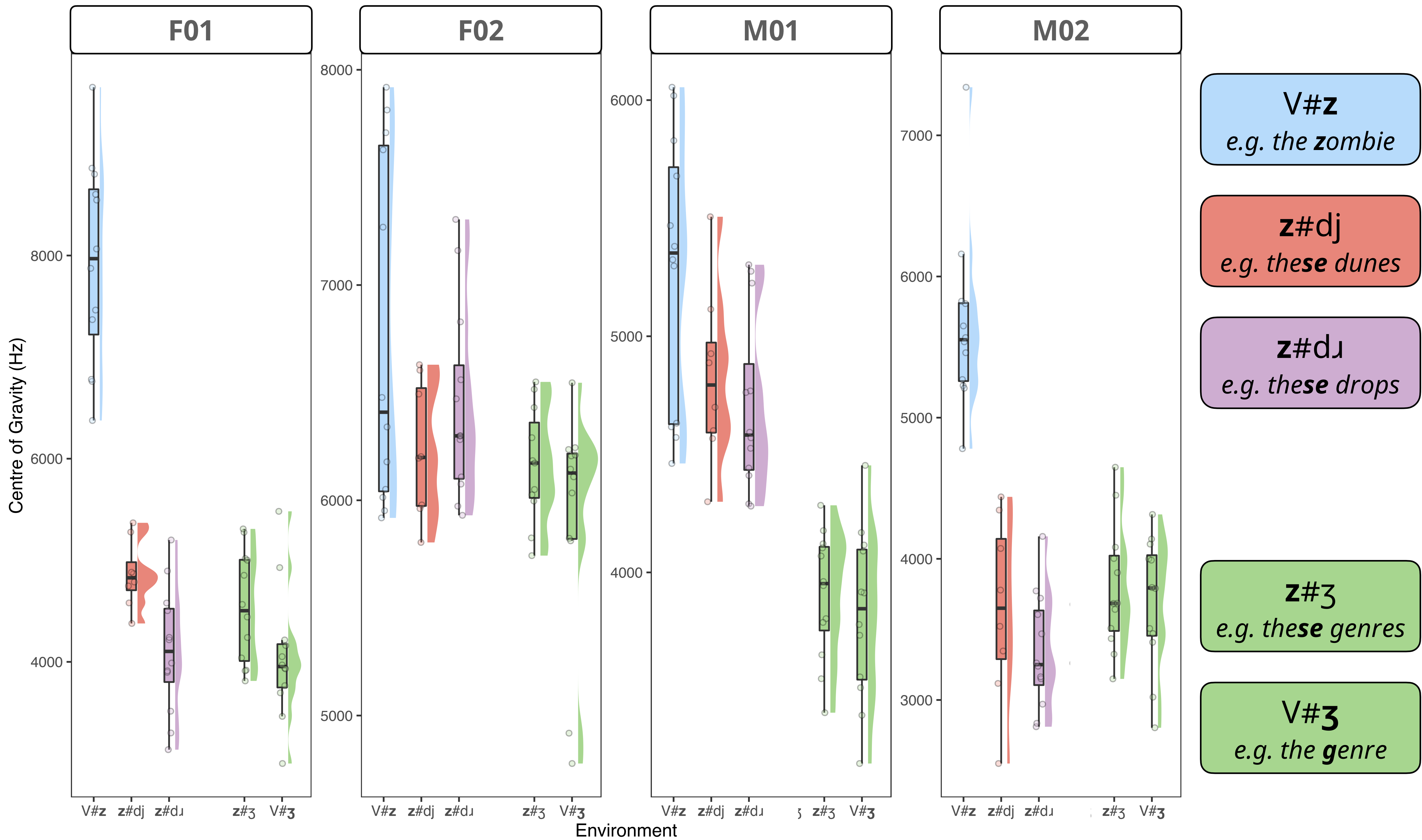
Acoustics

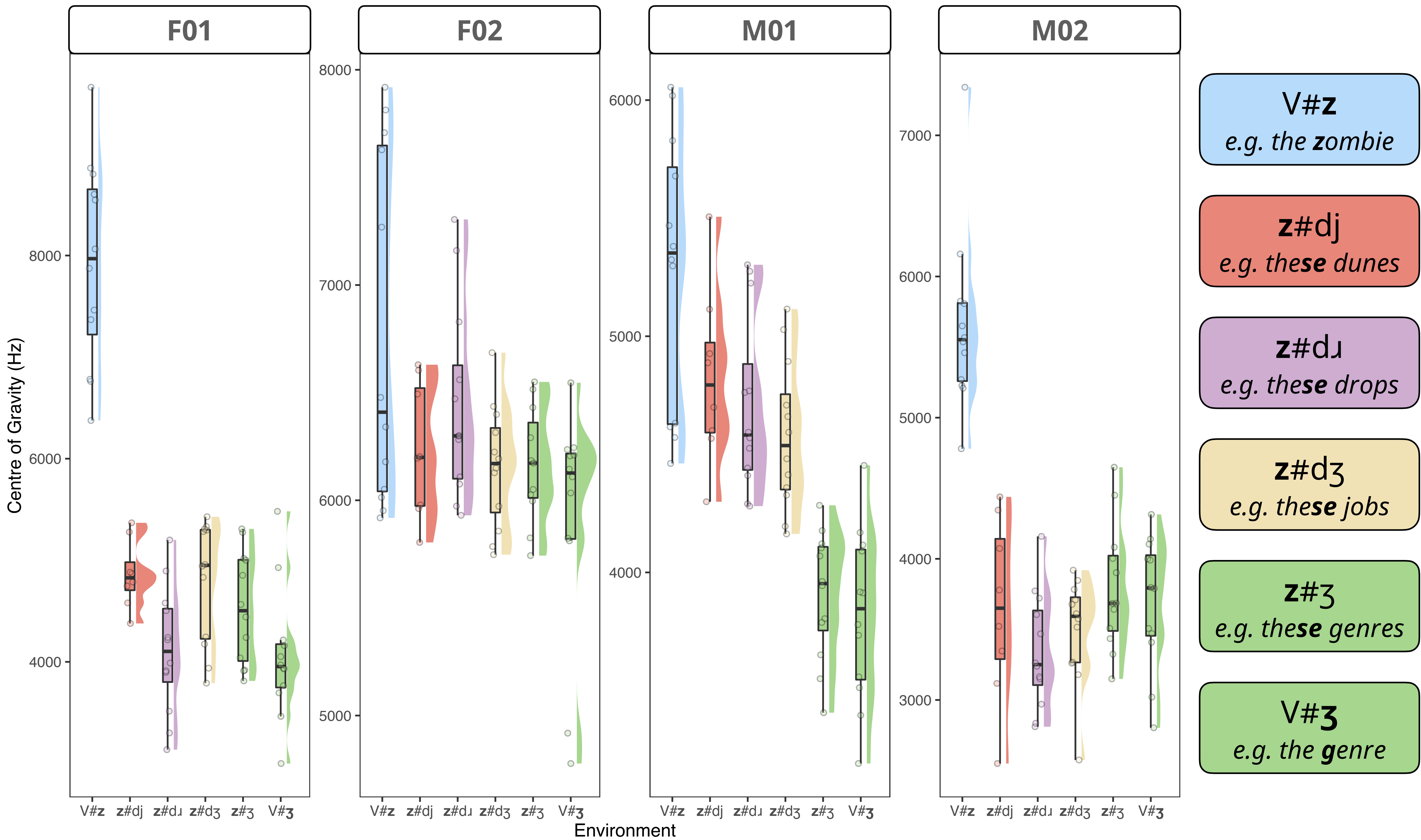
/z/-retraction











Making sense of it all

/s/-retraction is an extremely widespread process

- very advanced even across word boundaries, and in voiced /z/!
- phonetic uniformity of the pre-affricate(d) /tɹ, tʃ, tʃ/ contexts
- retraction *does* happen before /ɹ, j/ in the absence of affrication (cf. Baker et al. 2011; Bailey et al. 2022)
 - **but** the magnitude varies between speakers in a way that the other pre-affricate(d) contexts don't, suggesting multiple sources/processes of retraction

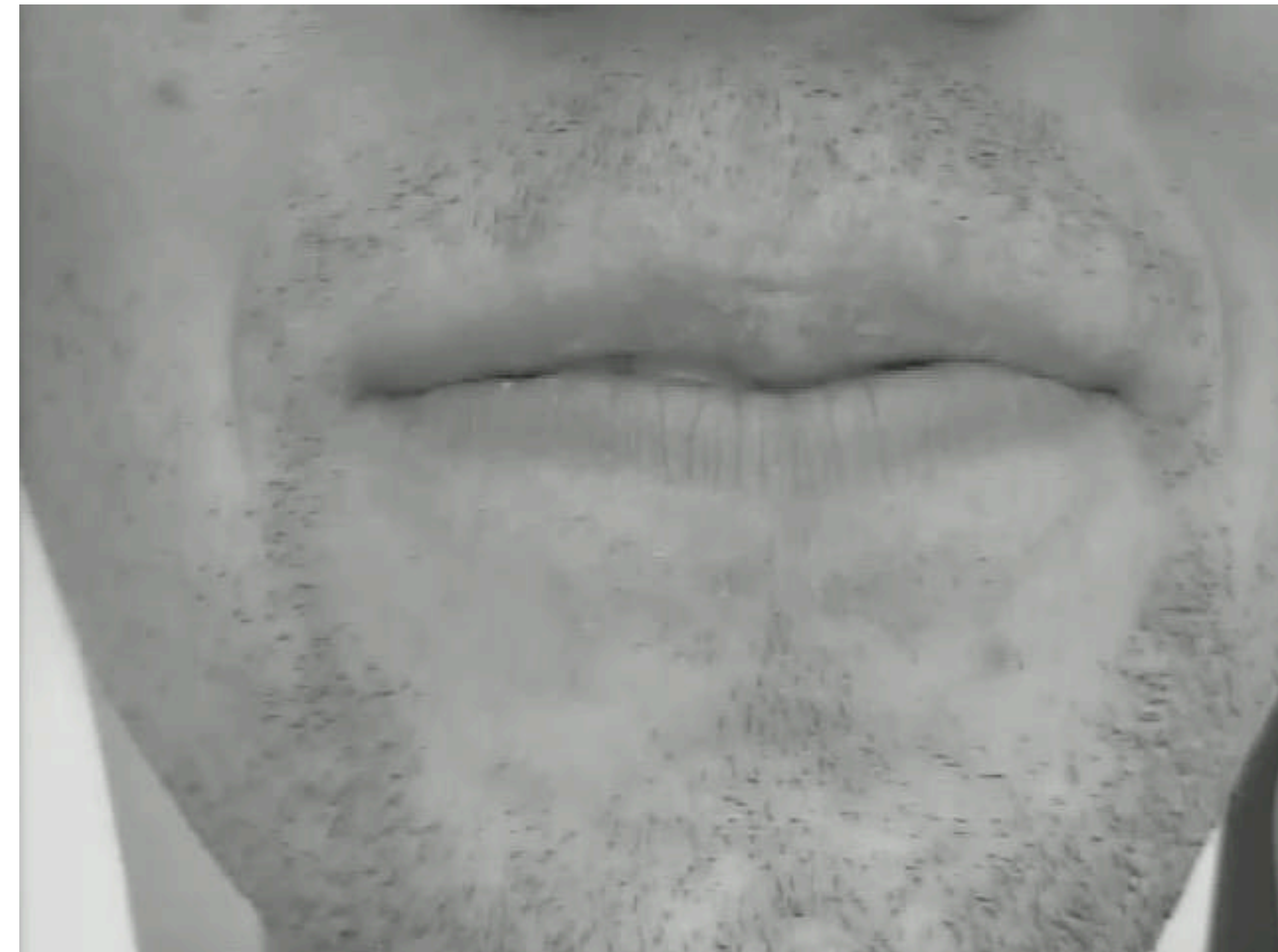
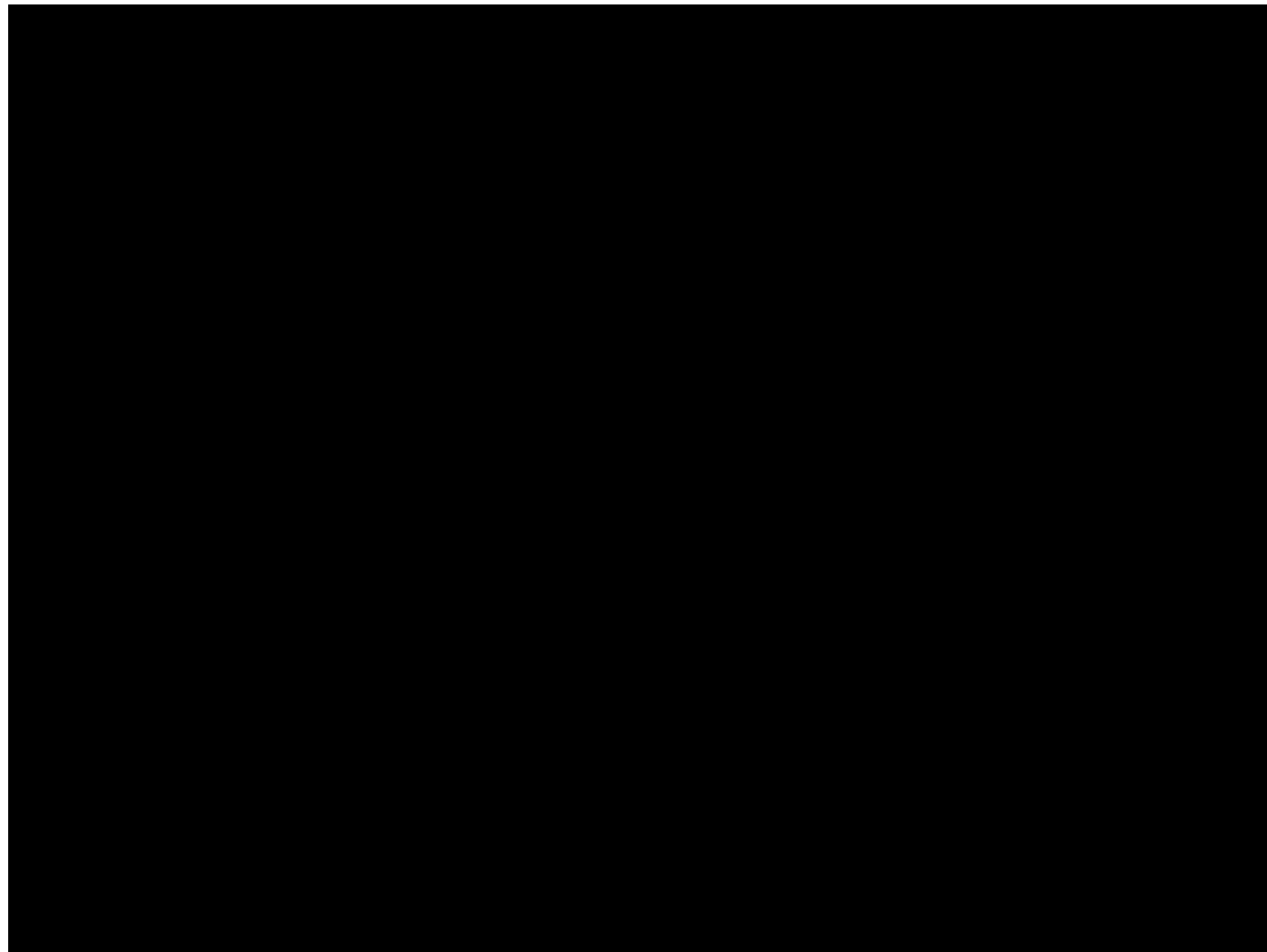
/s/-retraction is an extremely complex process

- phonetic uniformity on the surface masks a lot of individual-level variation in articulatory mechanisms:
 - ▶ some contexts show a direct correlation between lingual gesture and acoustic signal
 - ▶ but the labial gesture varies between contexts in speaker-specific ways (cf. Thielking 2022)
- /ʃ/ and /ɹ/ are ‘rounded’ but in different ways (see also Smith et al. 2019), and retracted /s/ can display both types depending on the trigger

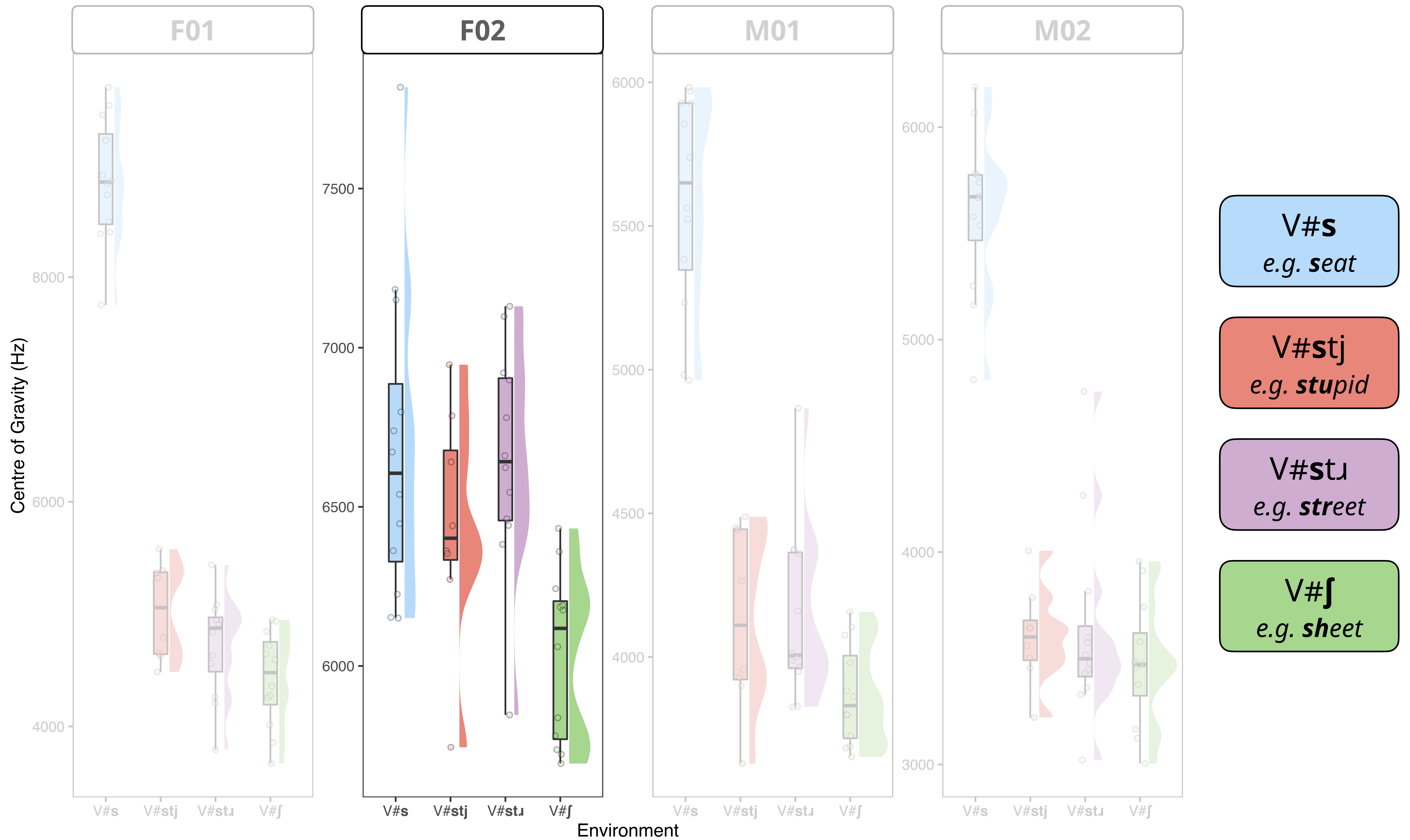
What /r/ /r/ future plans?

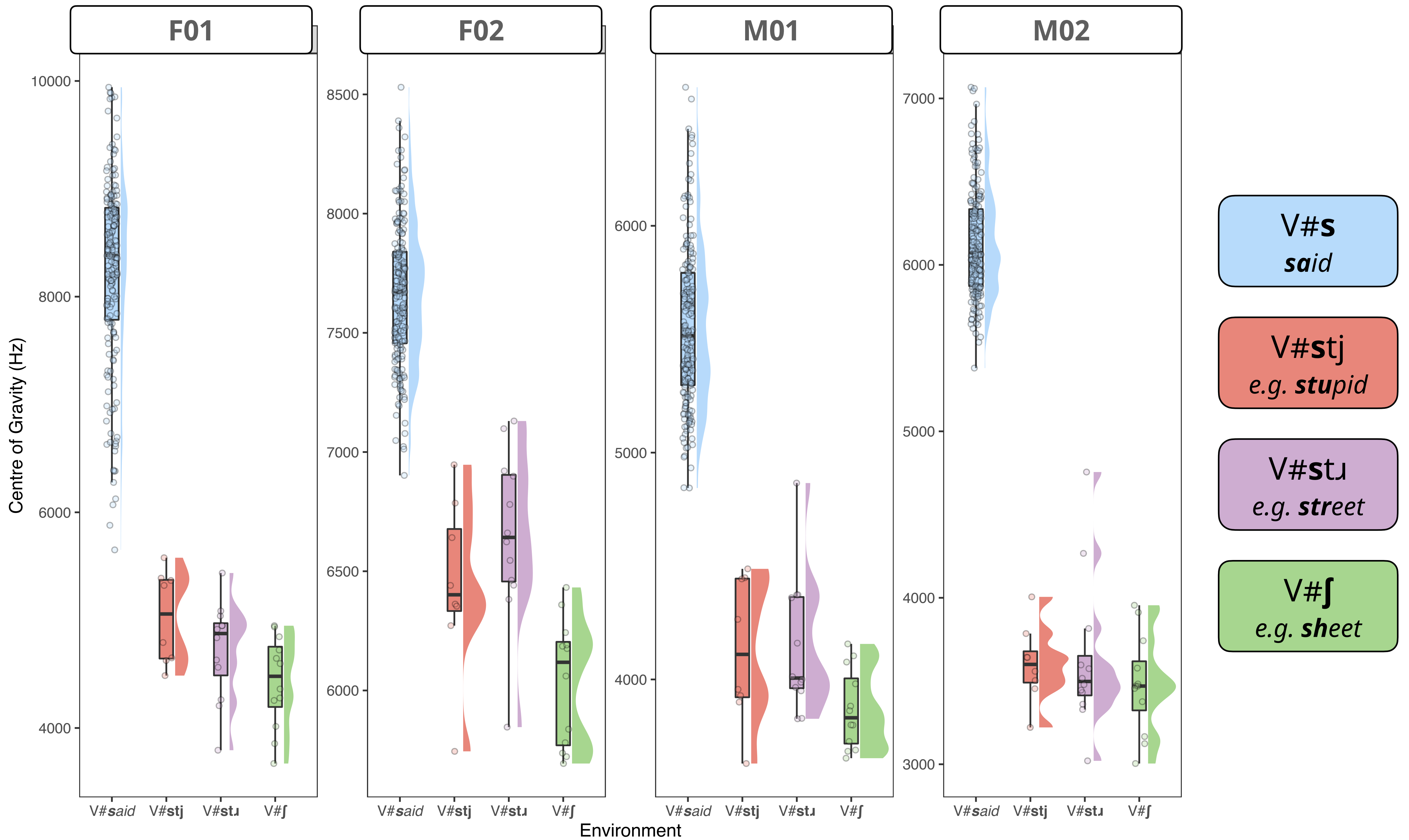
- Recording more speakers who represent the full conservative–innovative continuum of the change
- With a focus on /ɹ/, this study feeds into bigger questions about:
 - covert variability in the lingual gesture of /ɹ/ (**bunched** vs **retroflex**) (Delattre & Freeman 1968; Baker et al. 2011)
 - variation in the labial gesture of /ɹ/ (**protrusion/out-rounding** vs **compression/in-rounding**) (Smith et al. 2019)
 - the link between those gestures (**bunched** favours **protrusion**; **retroflex** favours **compression**) (King & Ferragne 2020)
 - how those gestures influence the degree and manner of /s/-retraction

Thanks for listening!



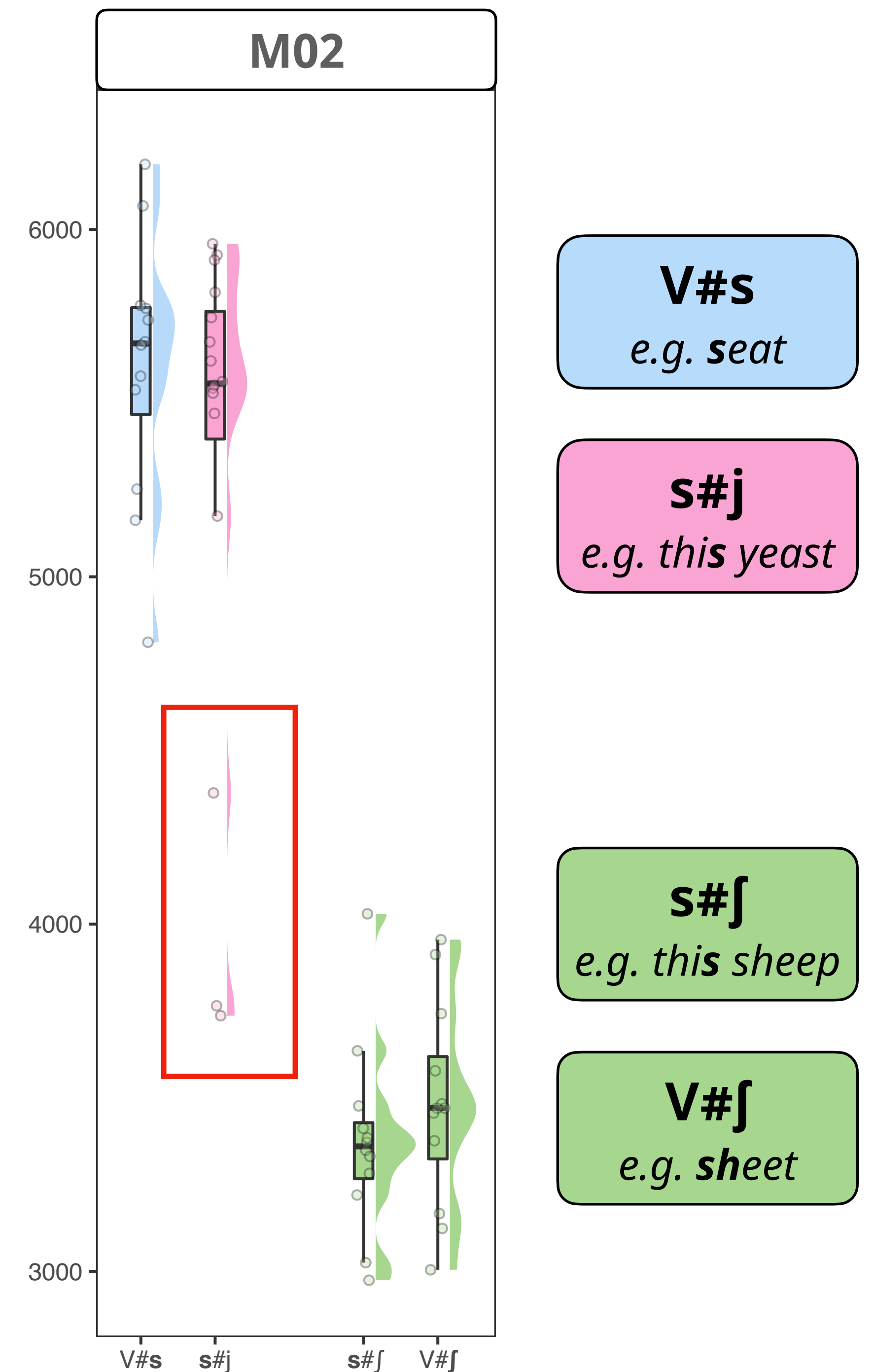
Bonus slides / encore

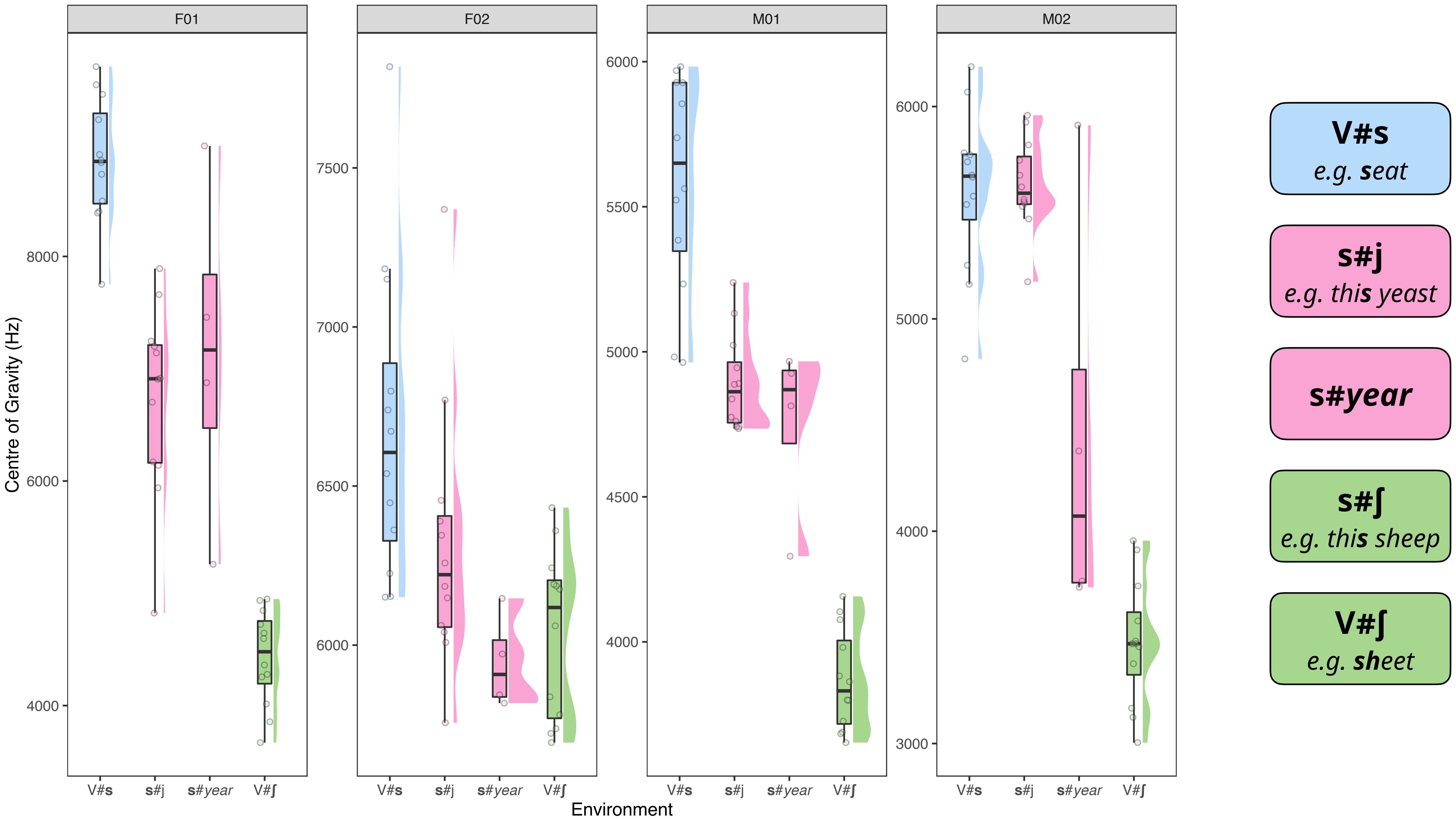




M02 and the retraction of s#j

- M02 largely doesn't retract in s#j, but there are 2–3 exceptional tokens with particularly low CoG
 - this is lexically-specific behaviour!
 - univerbification of the high-frequency collocation *this year*

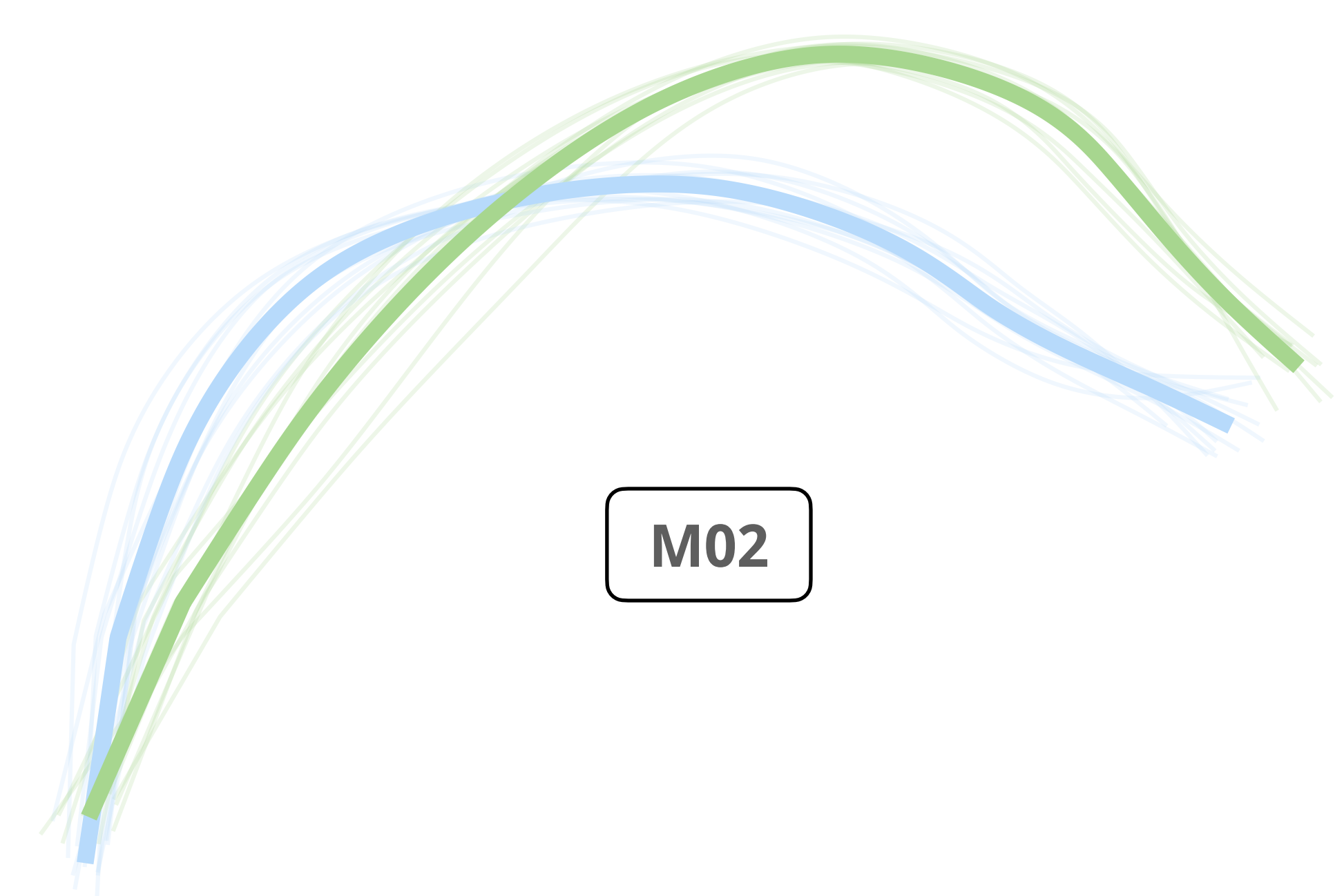
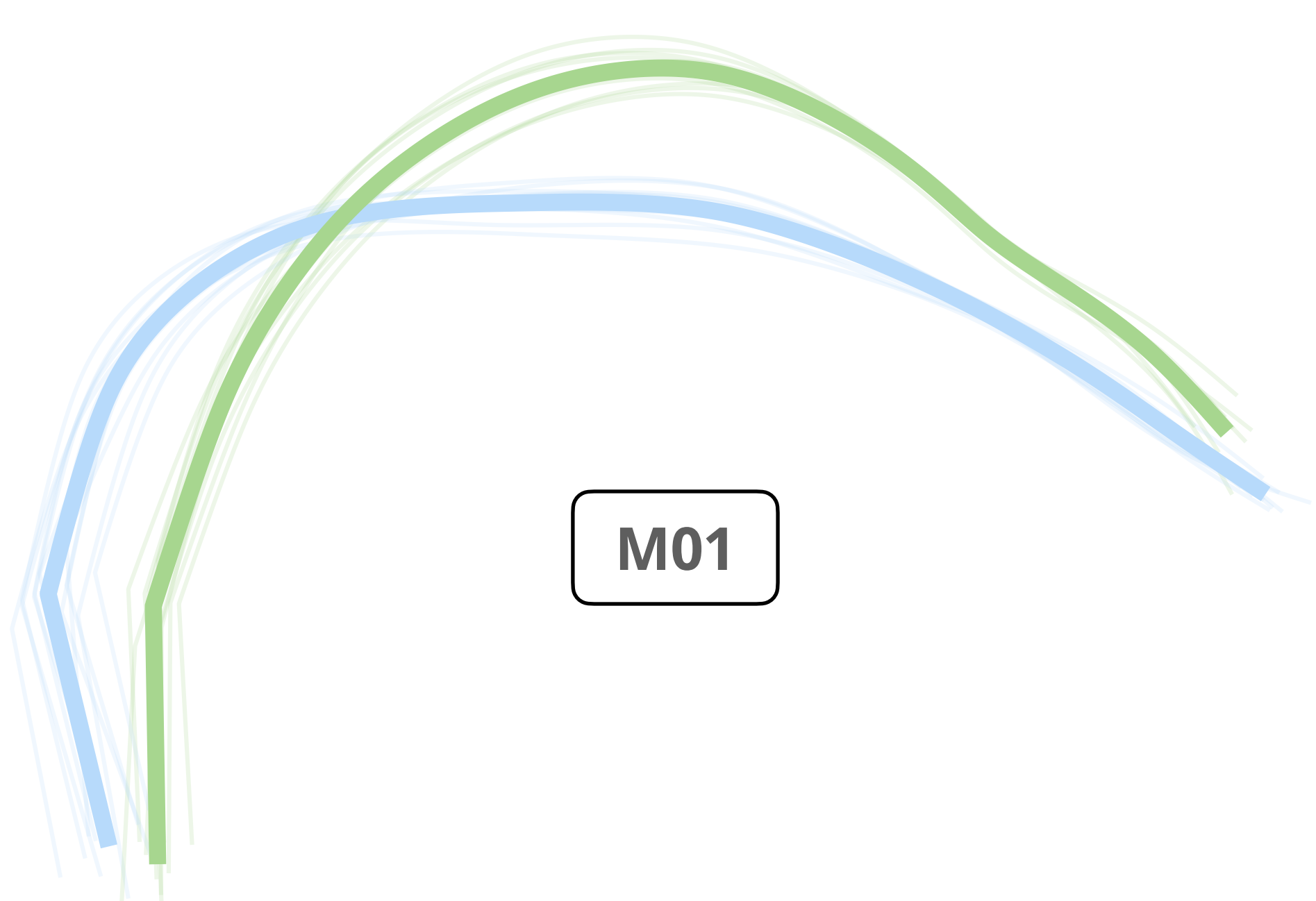




Tongue

word-internal retraction



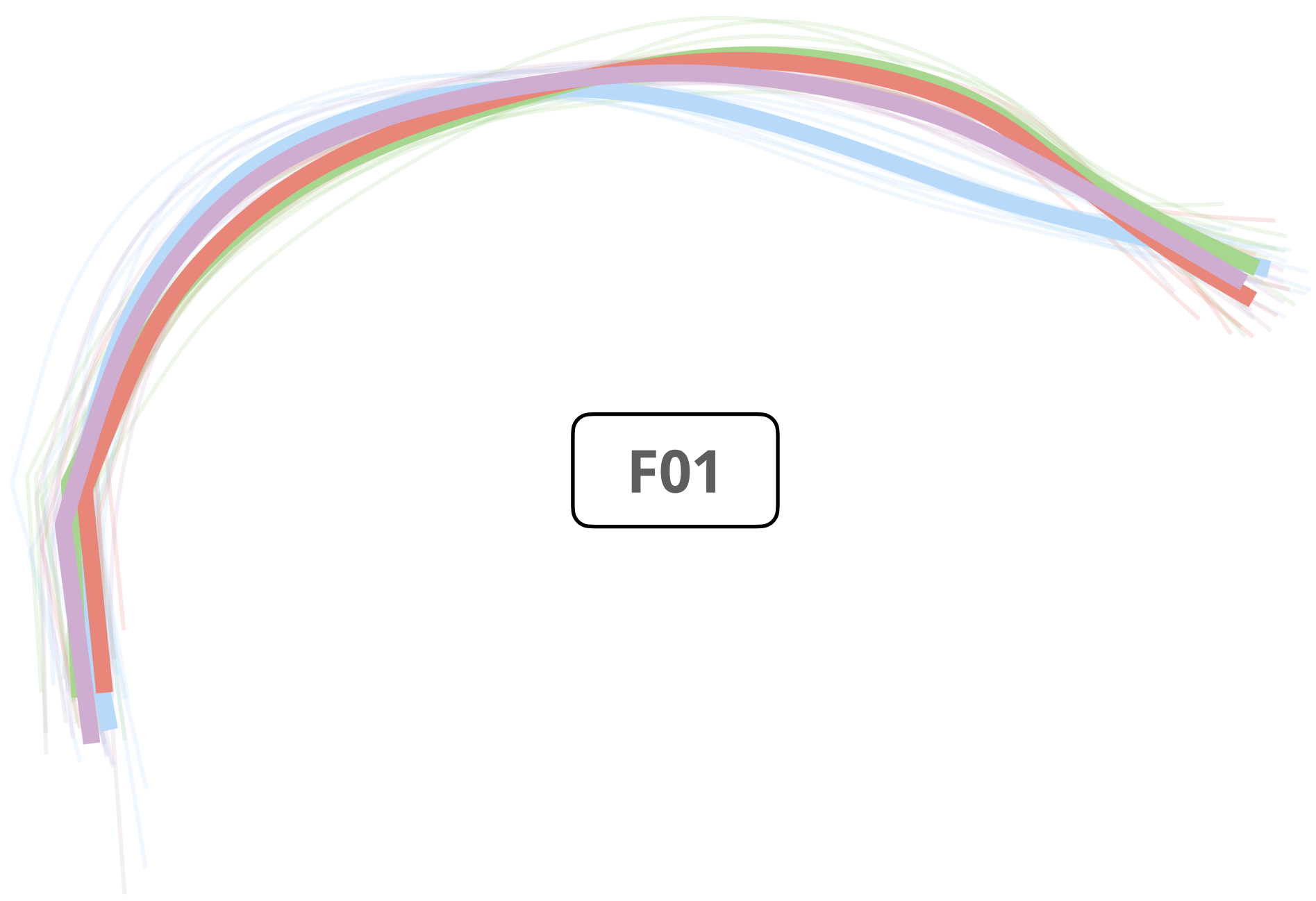


V#s
e.g. *seat*

V#stj
e.g. *stupid*

V#stɹ
e.g. *street*

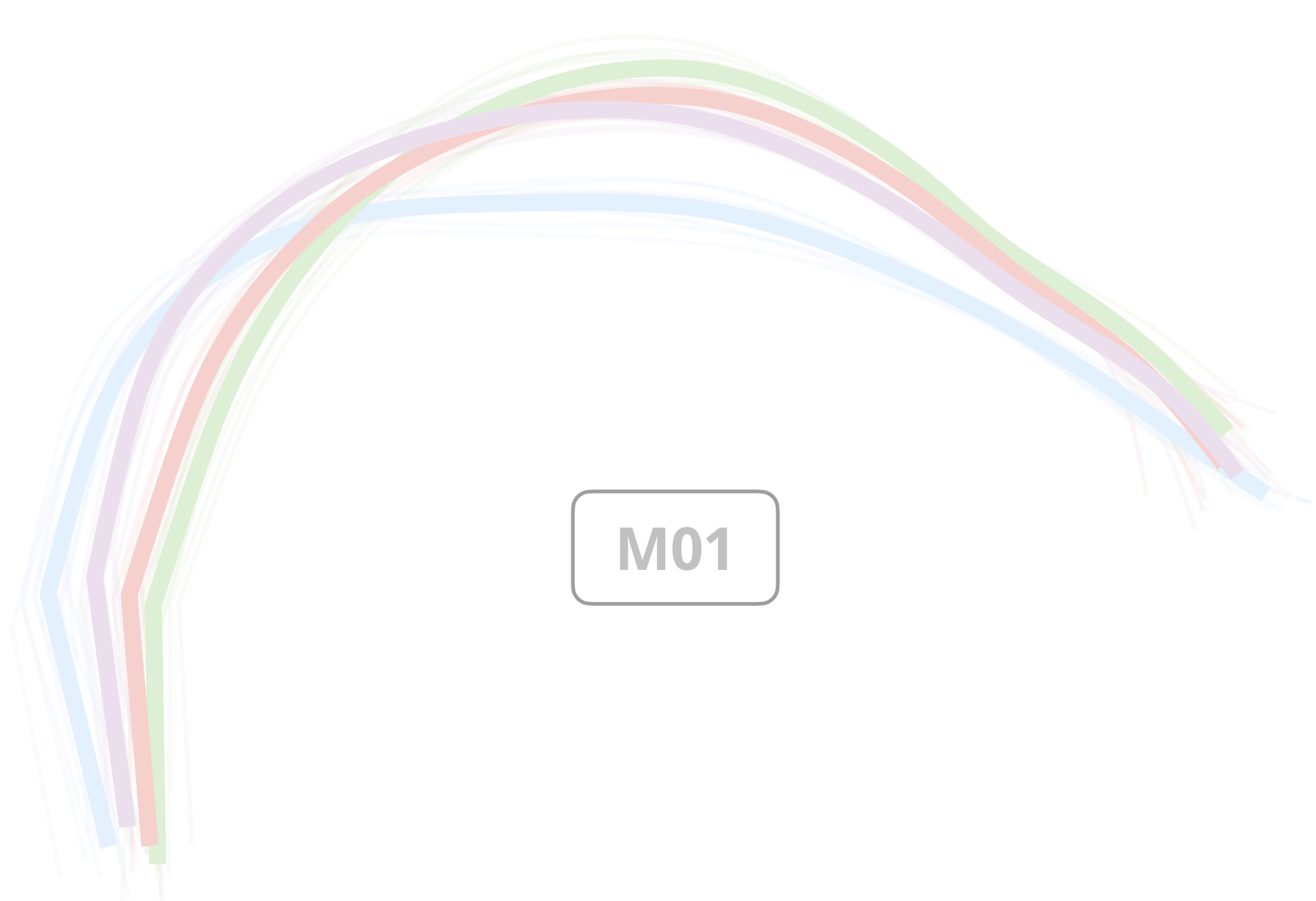
V#ʃ
e.g. *sheet*



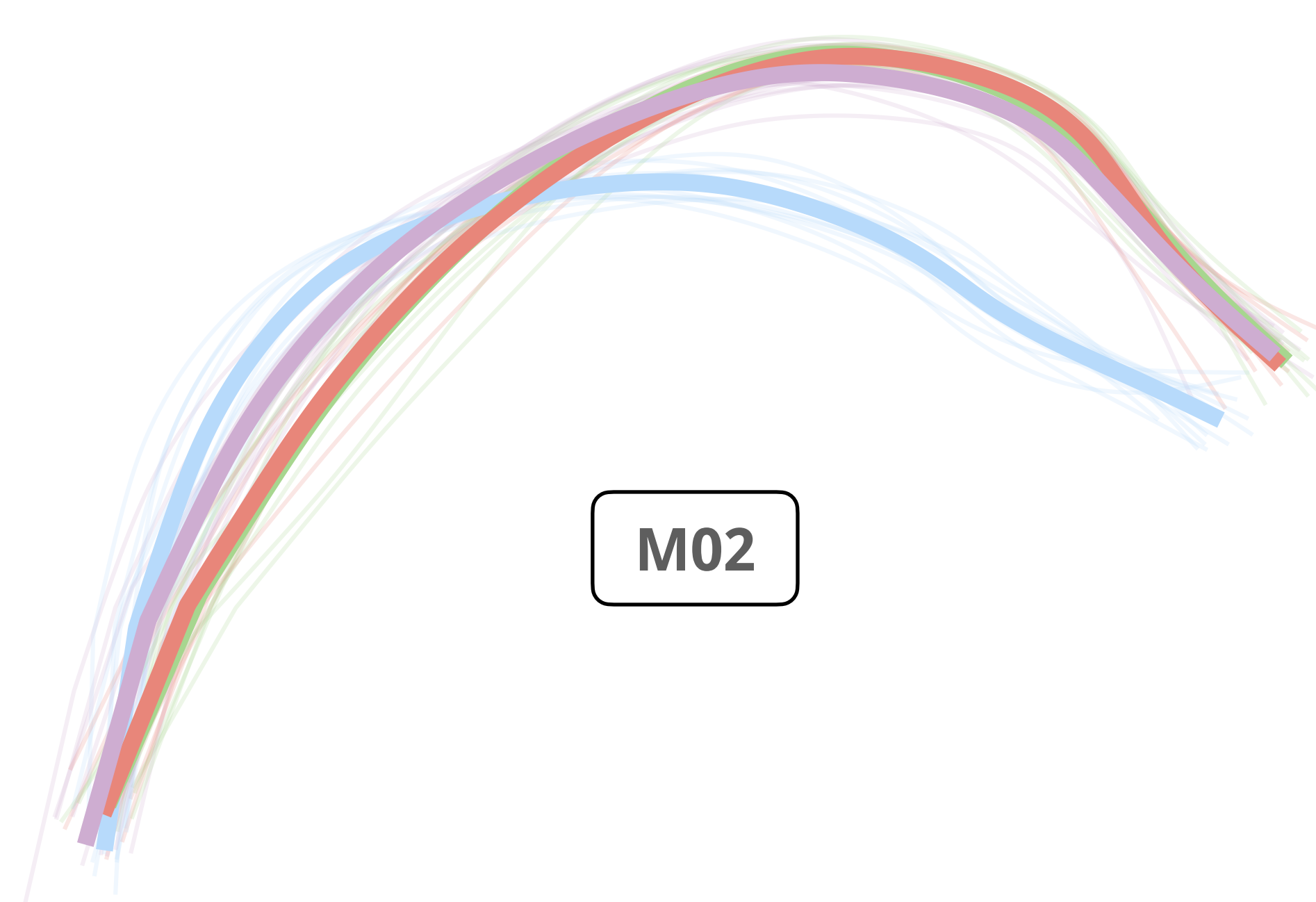
F01



F02



M01



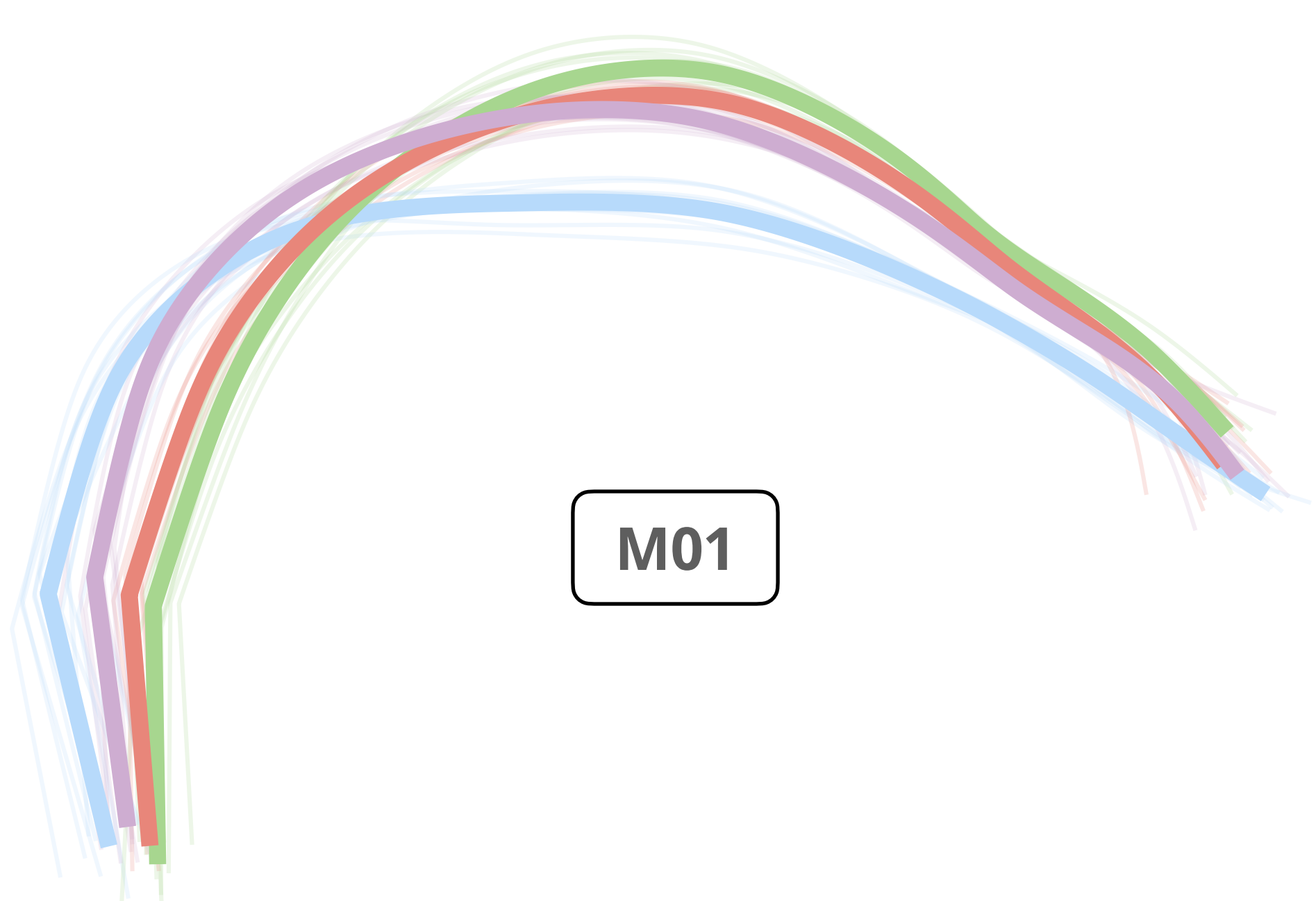
M02

V#s
e.g. *seat*

V#stj
e.g. *stupid*

V#stɹ
e.g. *street*

V#ʃ
e.g. *sheet*



V#s
e.g. *seat*

V#stj
e.g. *stupid*

V#stɹ
e.g. *street*

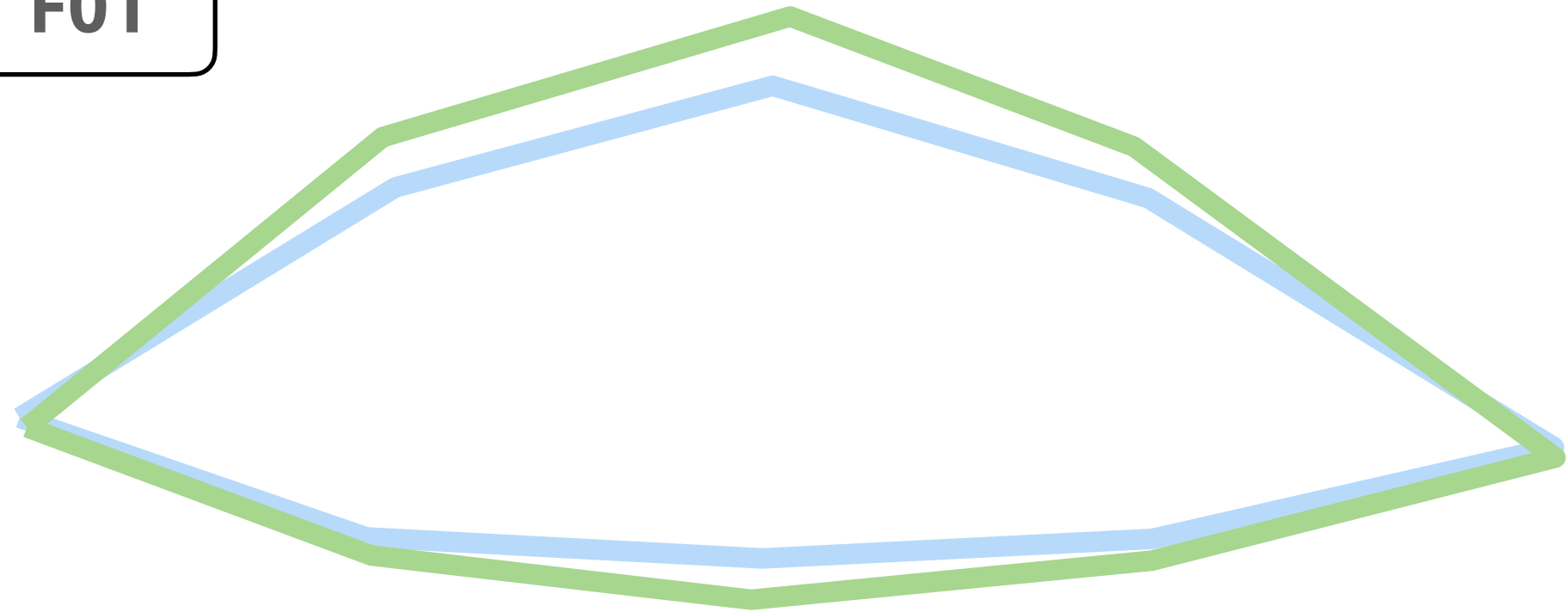
V#ʃ
e.g. *sheet*

Lips

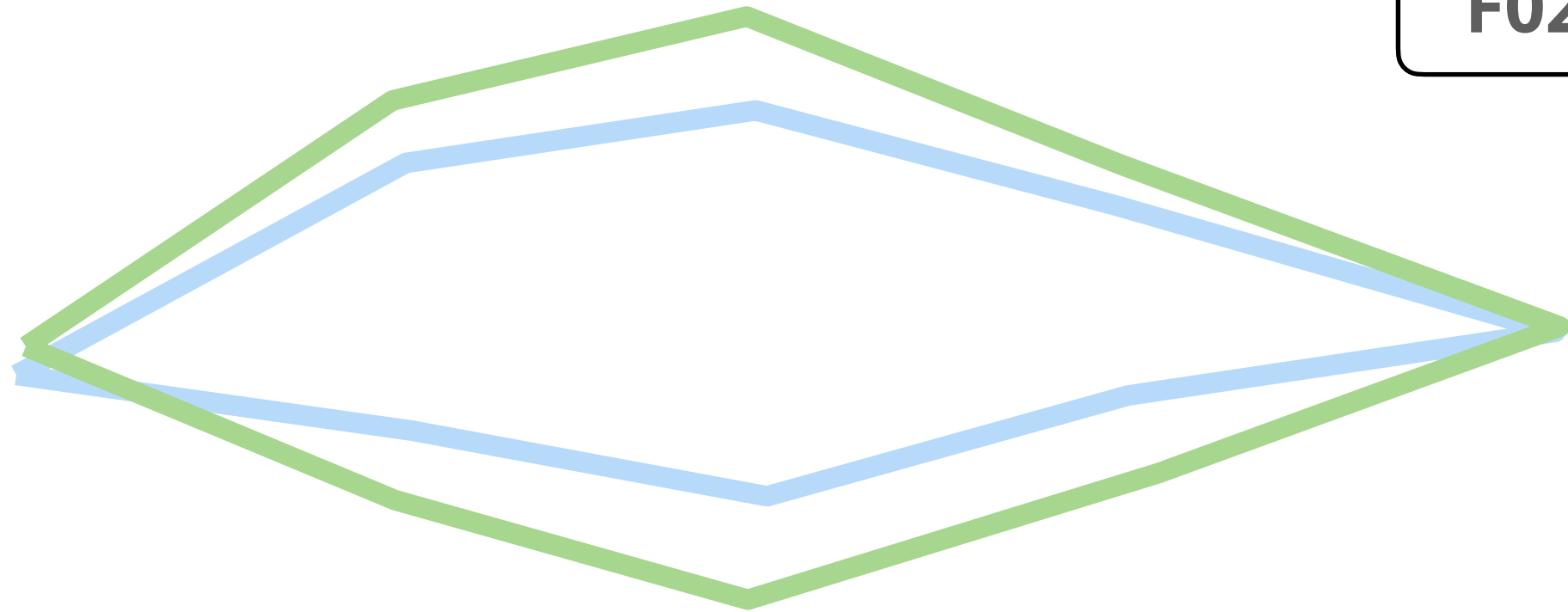
word-internal retraction



F01

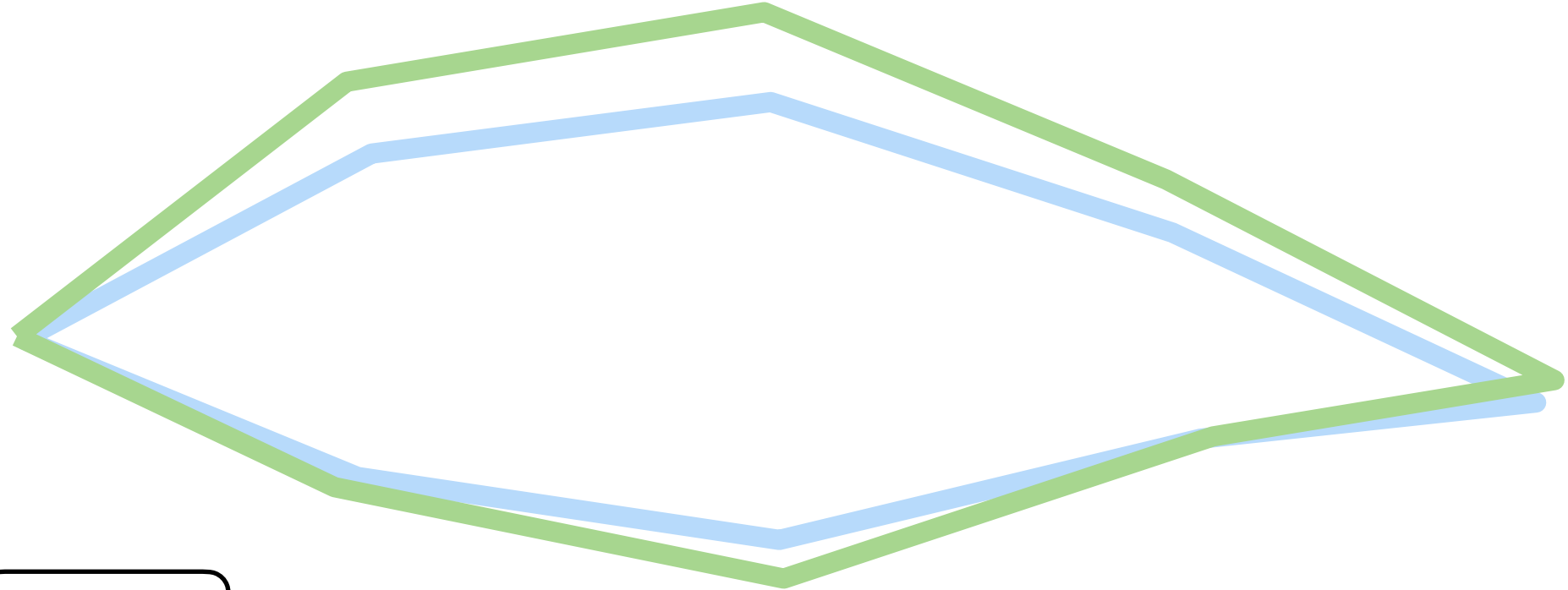


F02

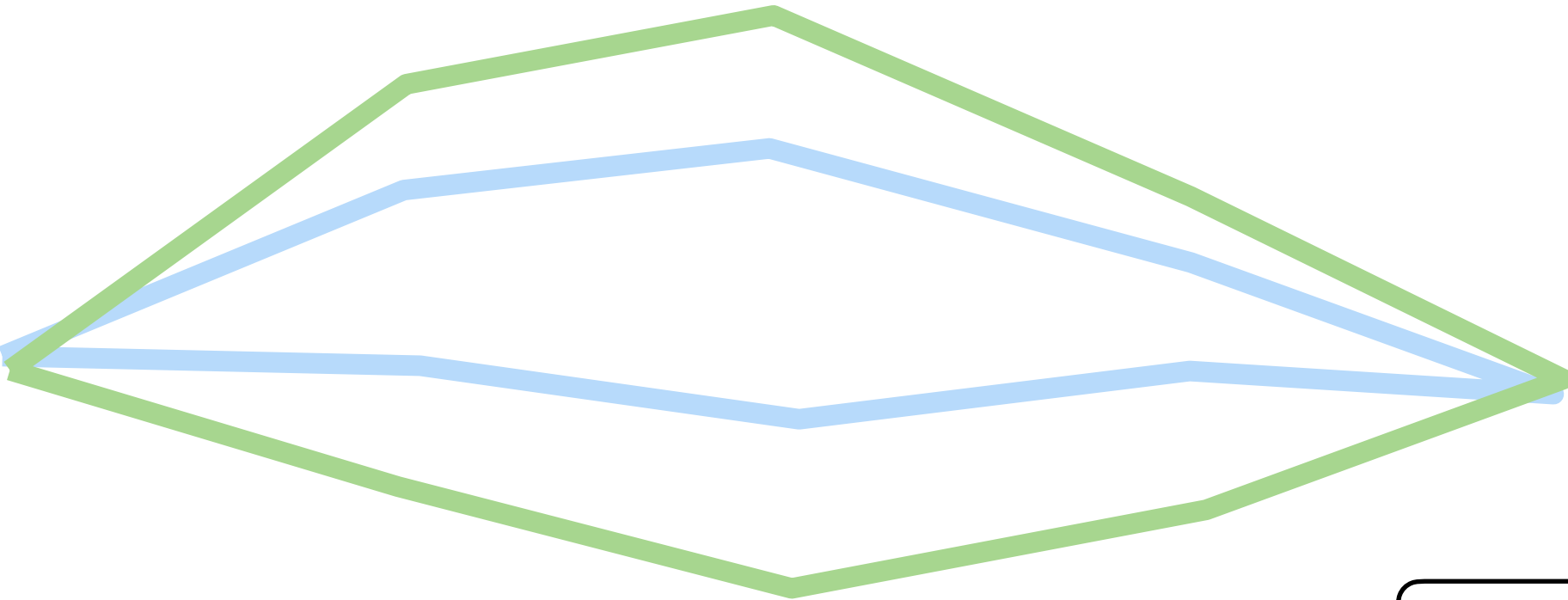


V#s
e.g. seat

M01

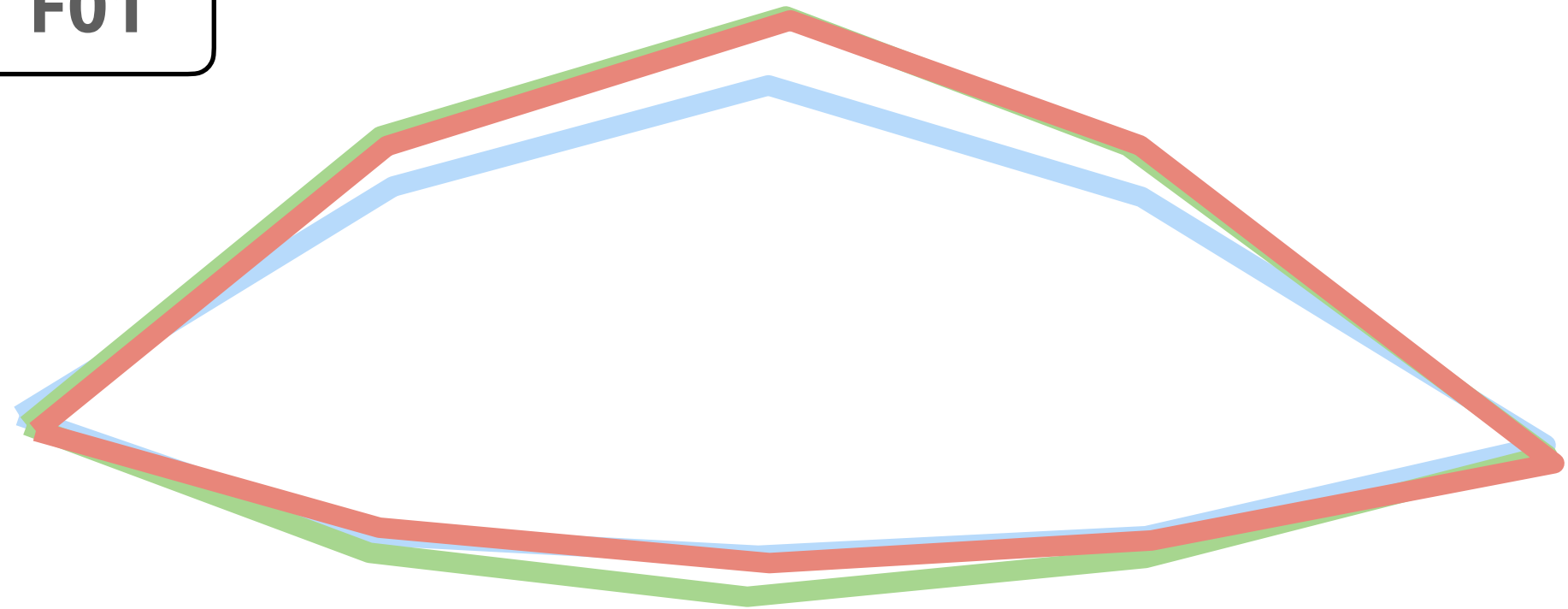


M02

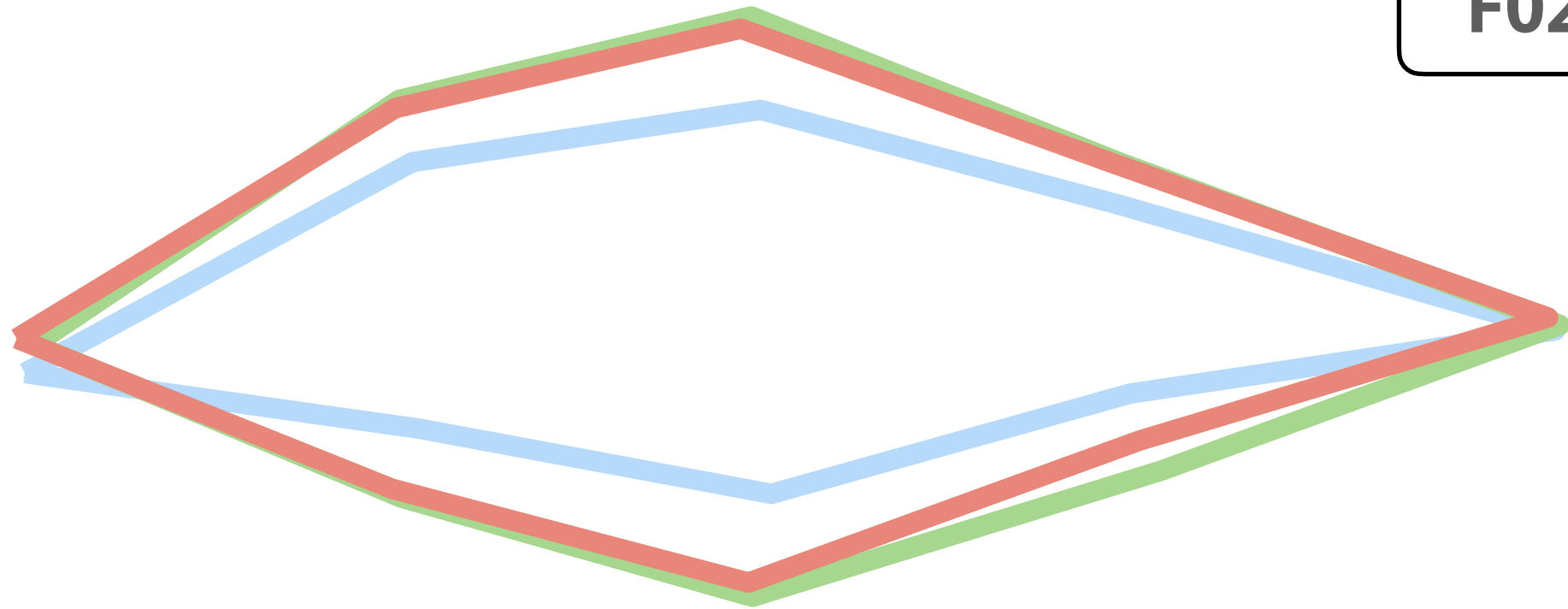


V#j
e.g. sheet

F01



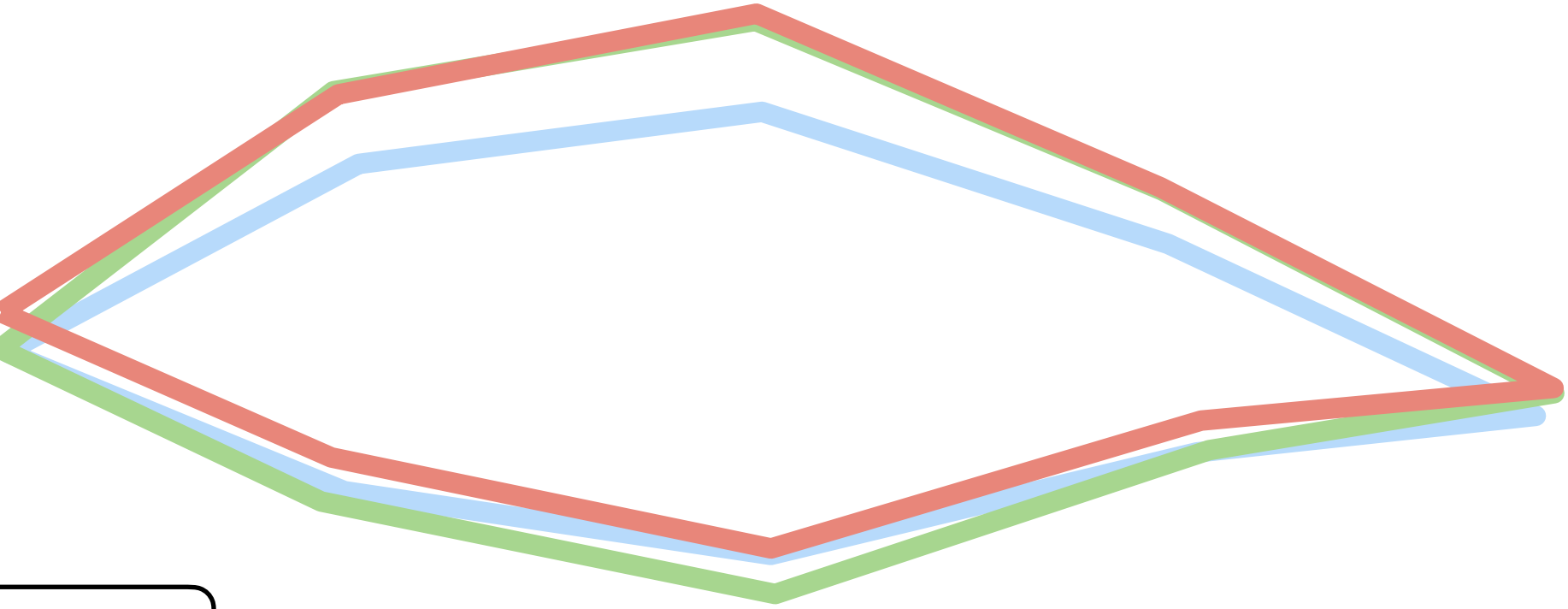
F02



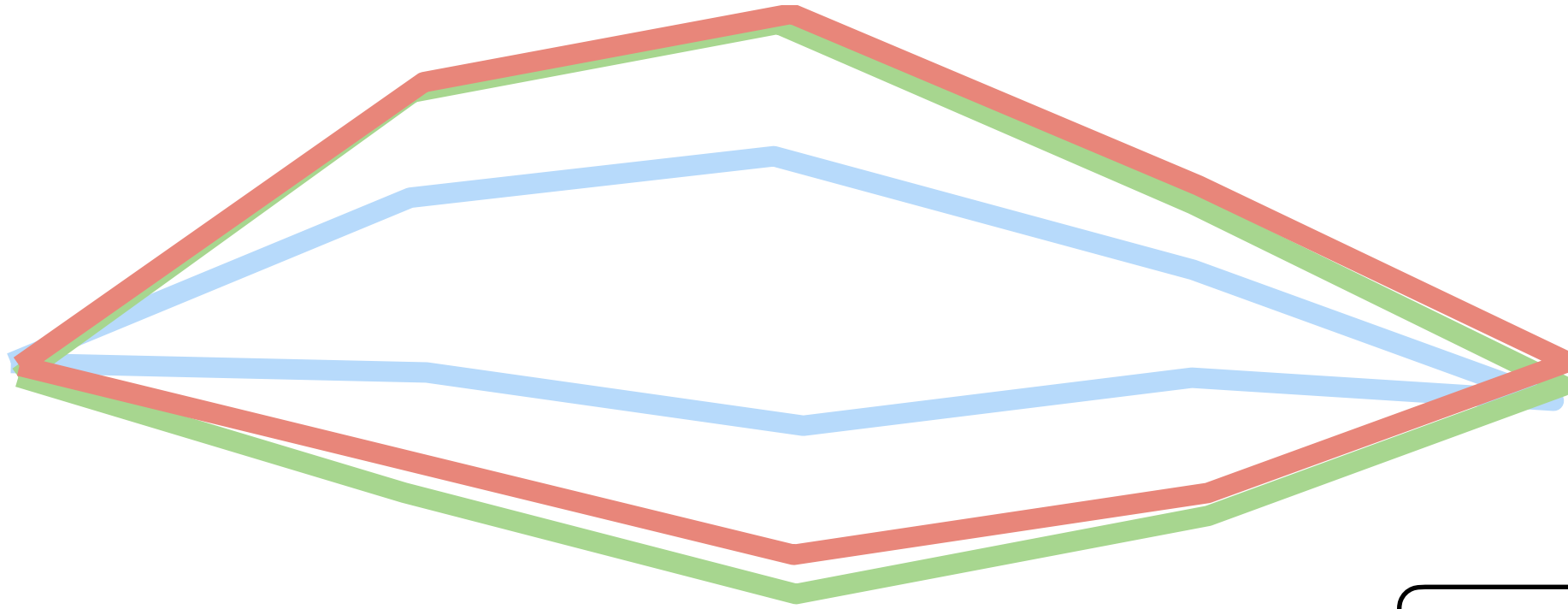
V#s
e.g. seat

V#stj
e.g. stupid

M01

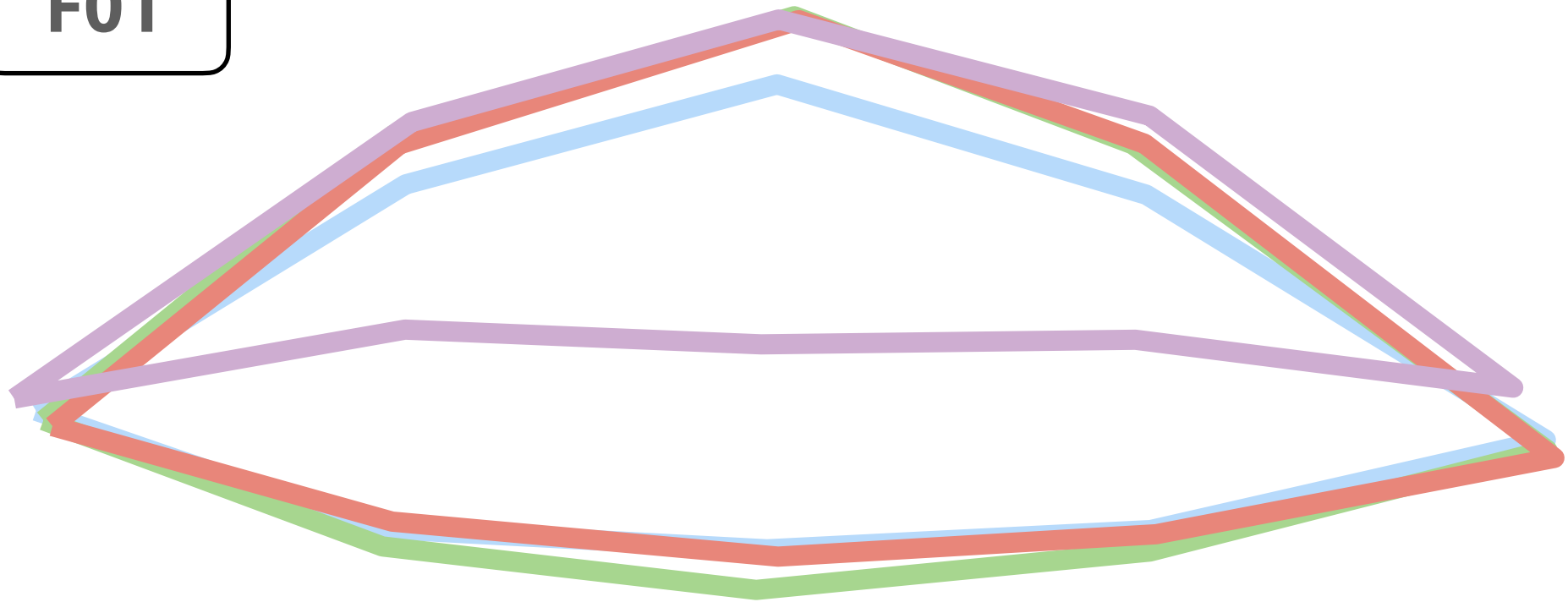


M02

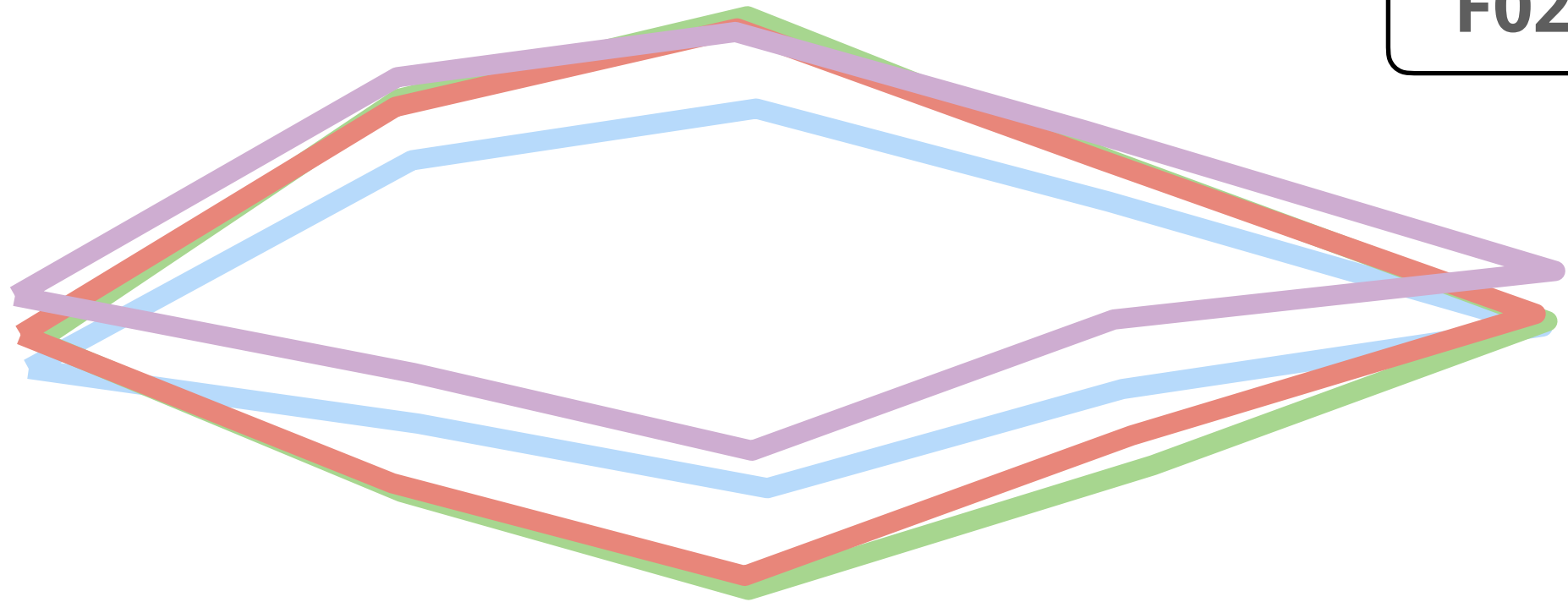


V#j
e.g. sheet

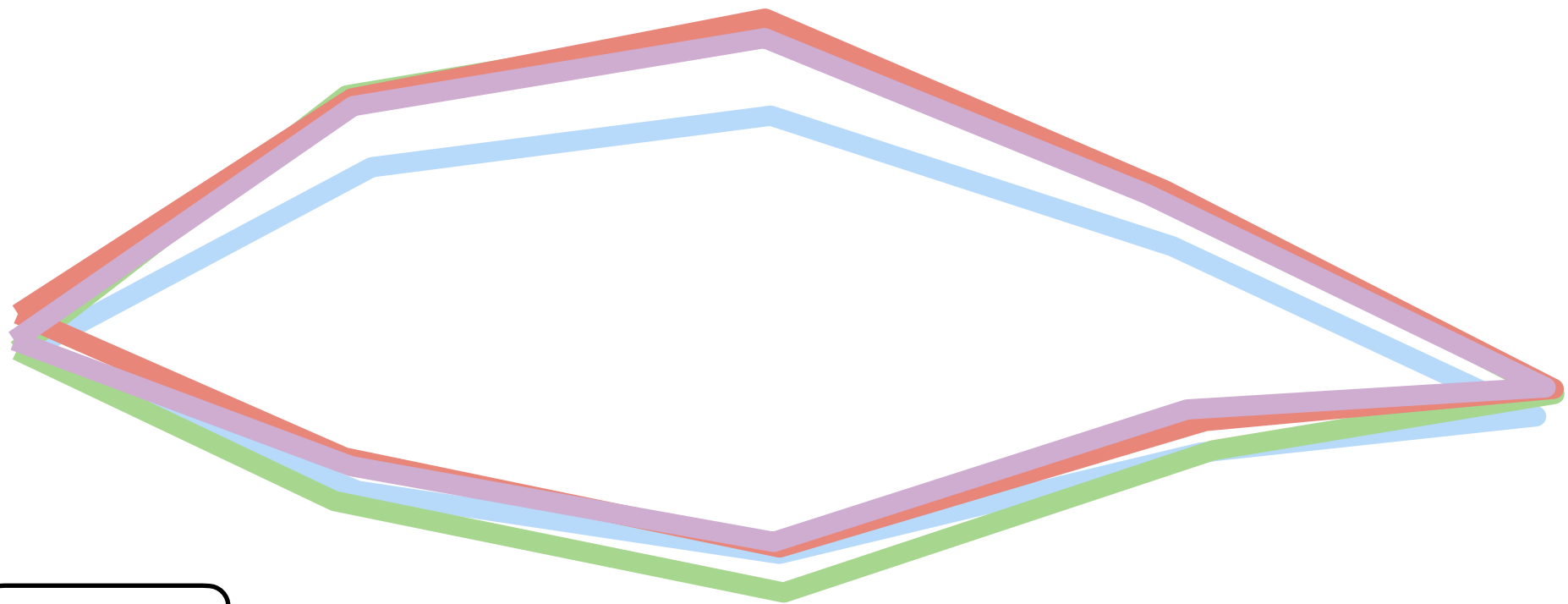
F01



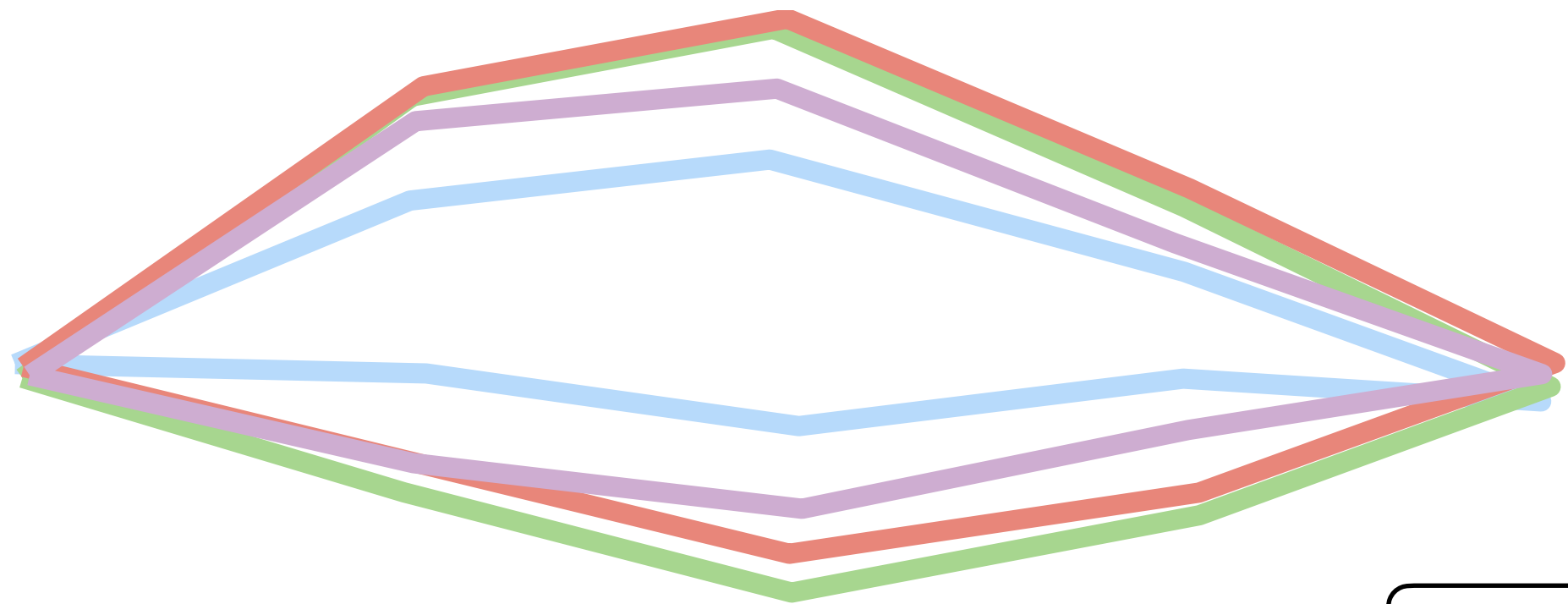
F02



M01



M02



V#s
e.g. *seat*

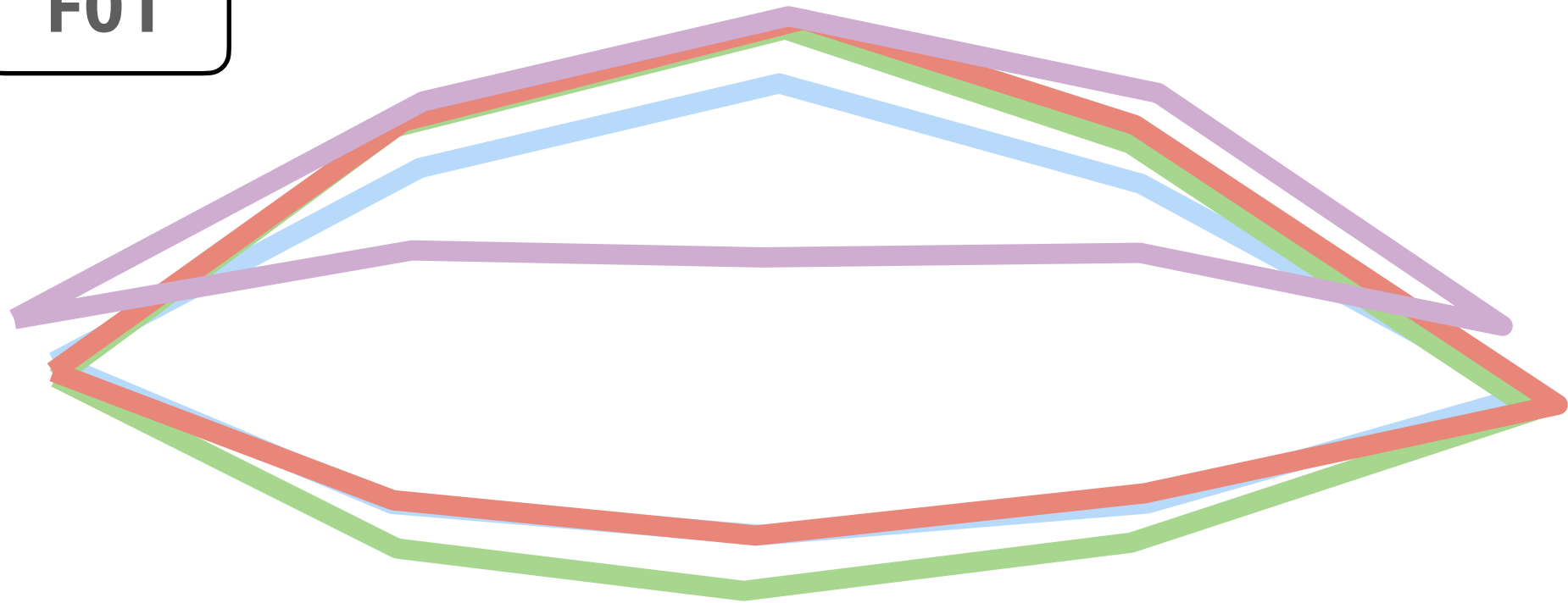
V#stj
e.g. *stupid*

V#stɹ
e.g. *street*

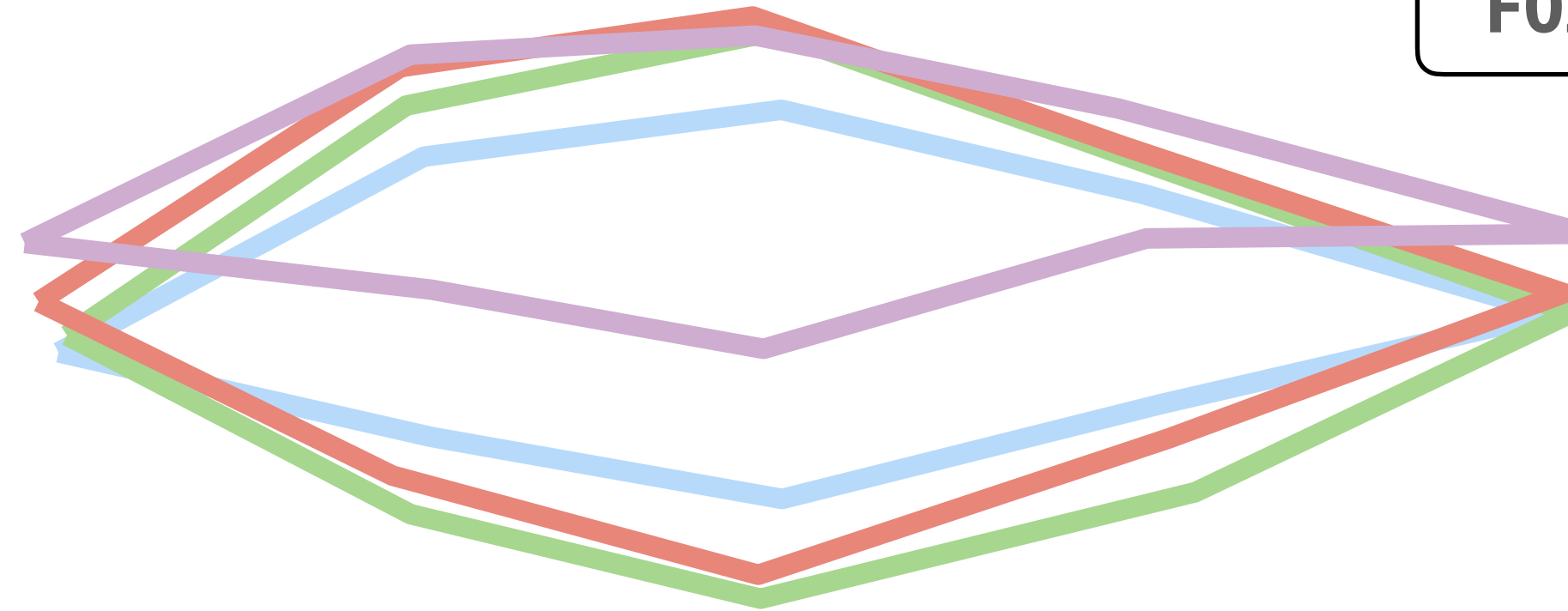
V#ʃ
e.g. *sheet*

segment offset

F01



F02



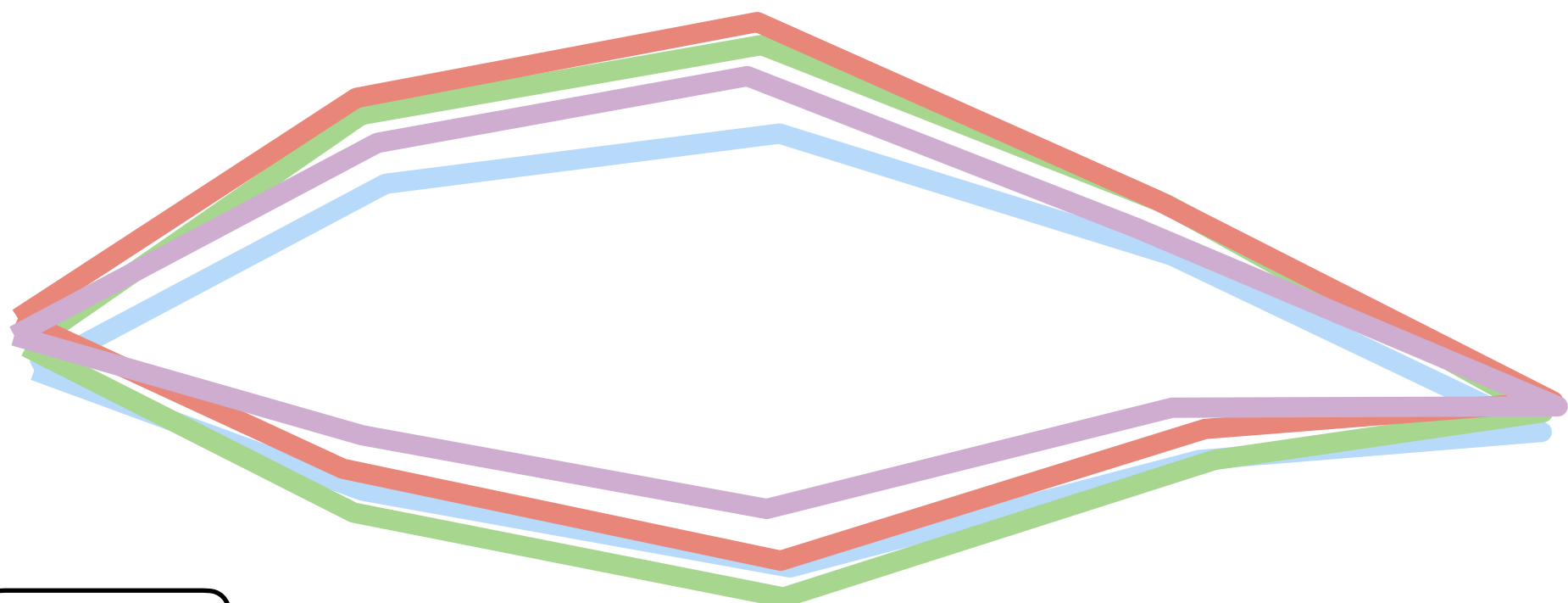
V#s
e.g. seat

V#stj
e.g. stupid

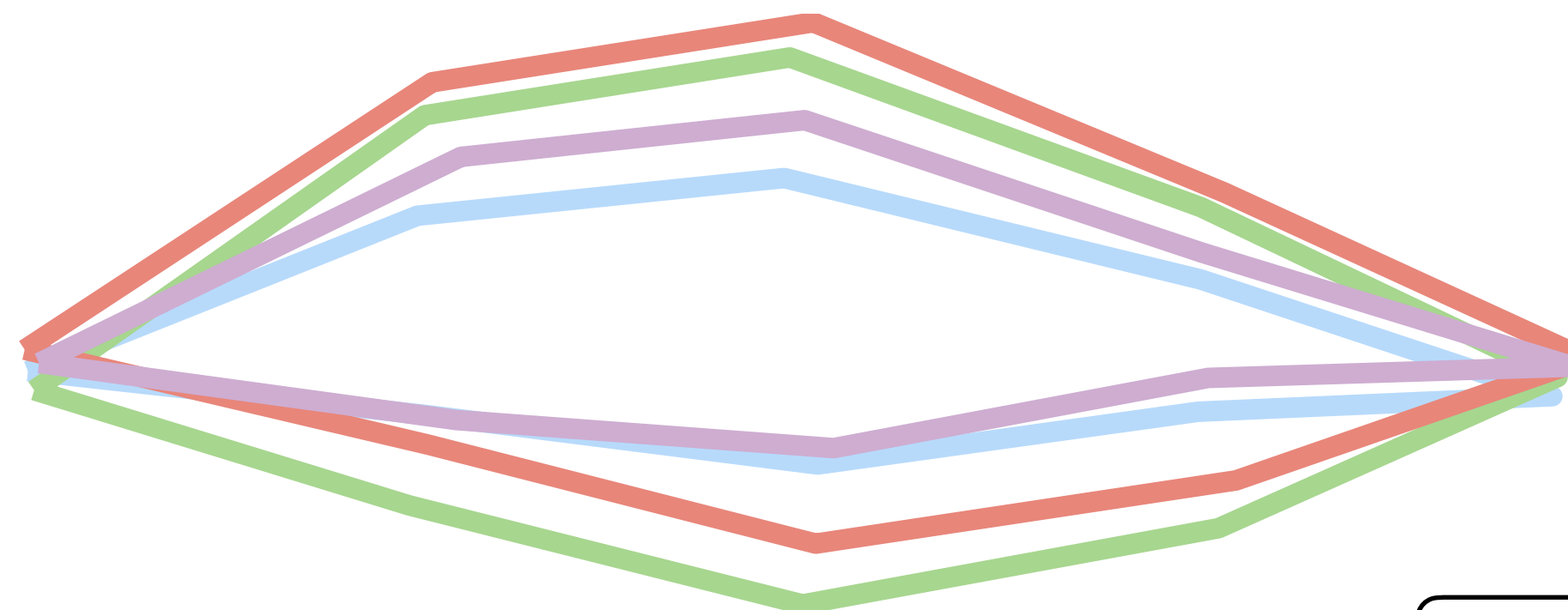
V#stɹ
e.g. street

V#ʃ
e.g. sheet

M01

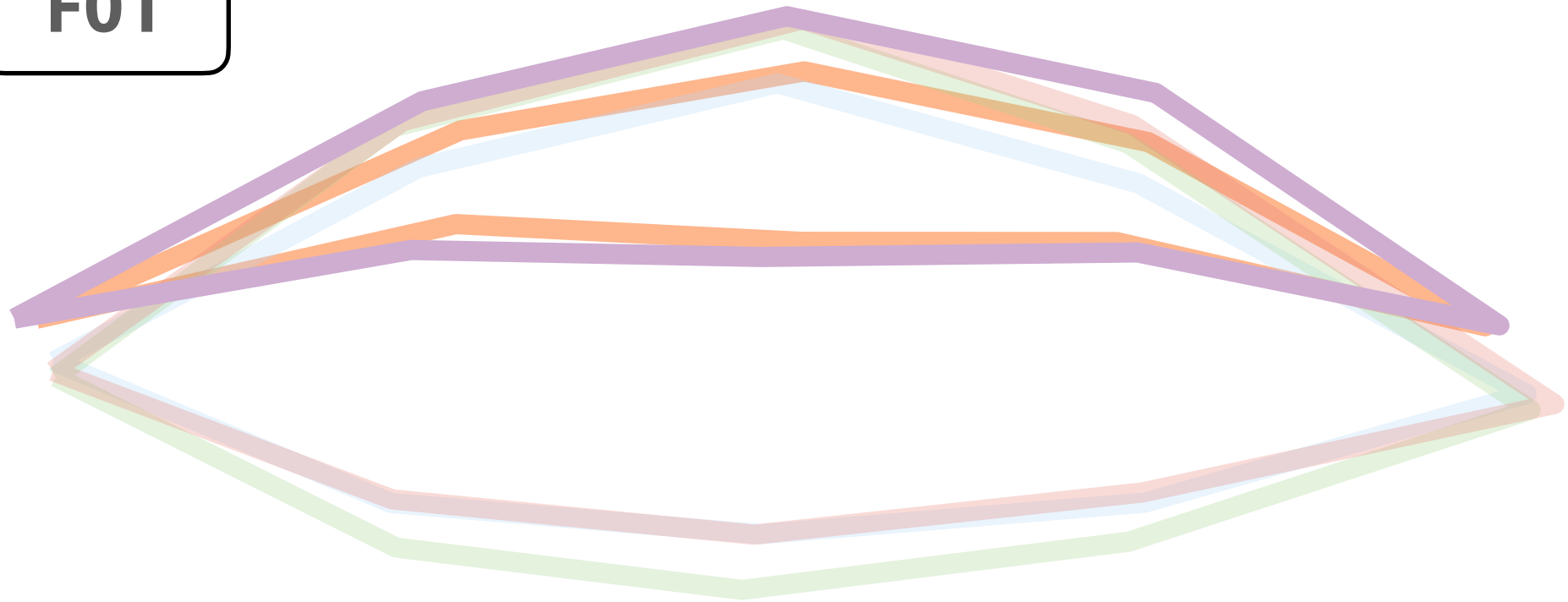


M02

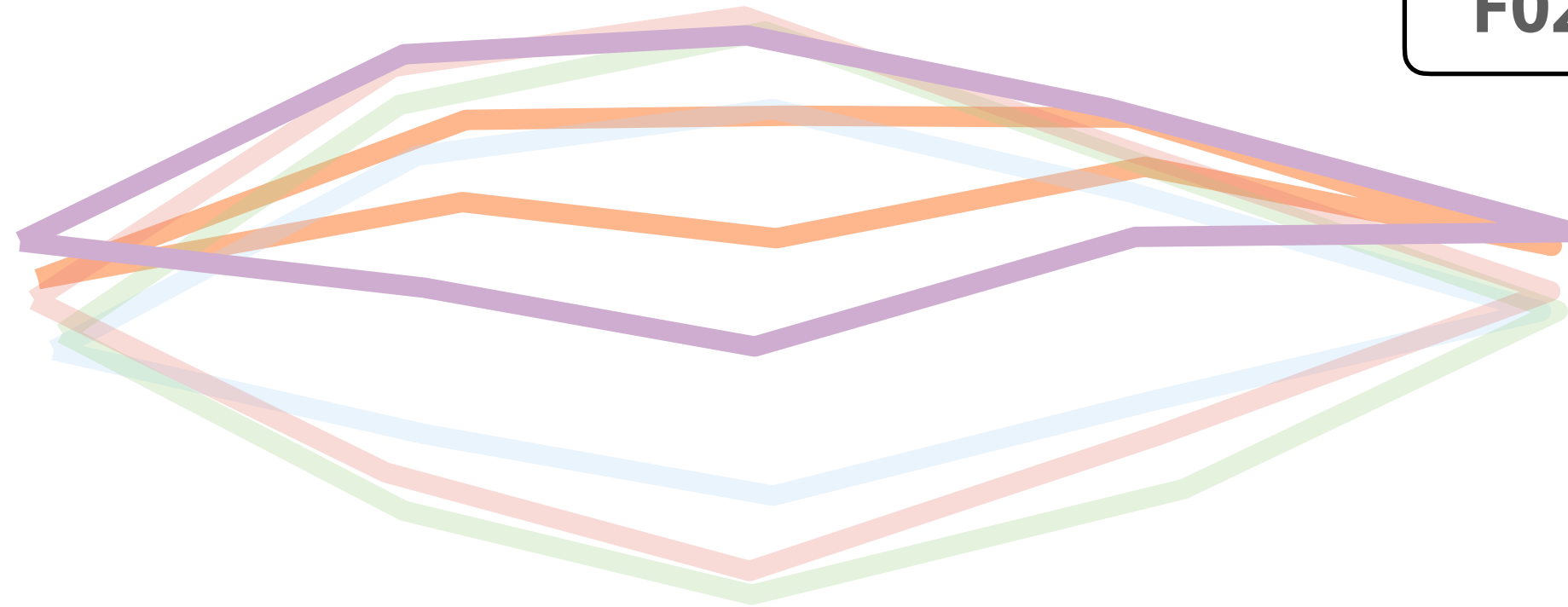


segment offset
(with /ɹ/ overlaid)

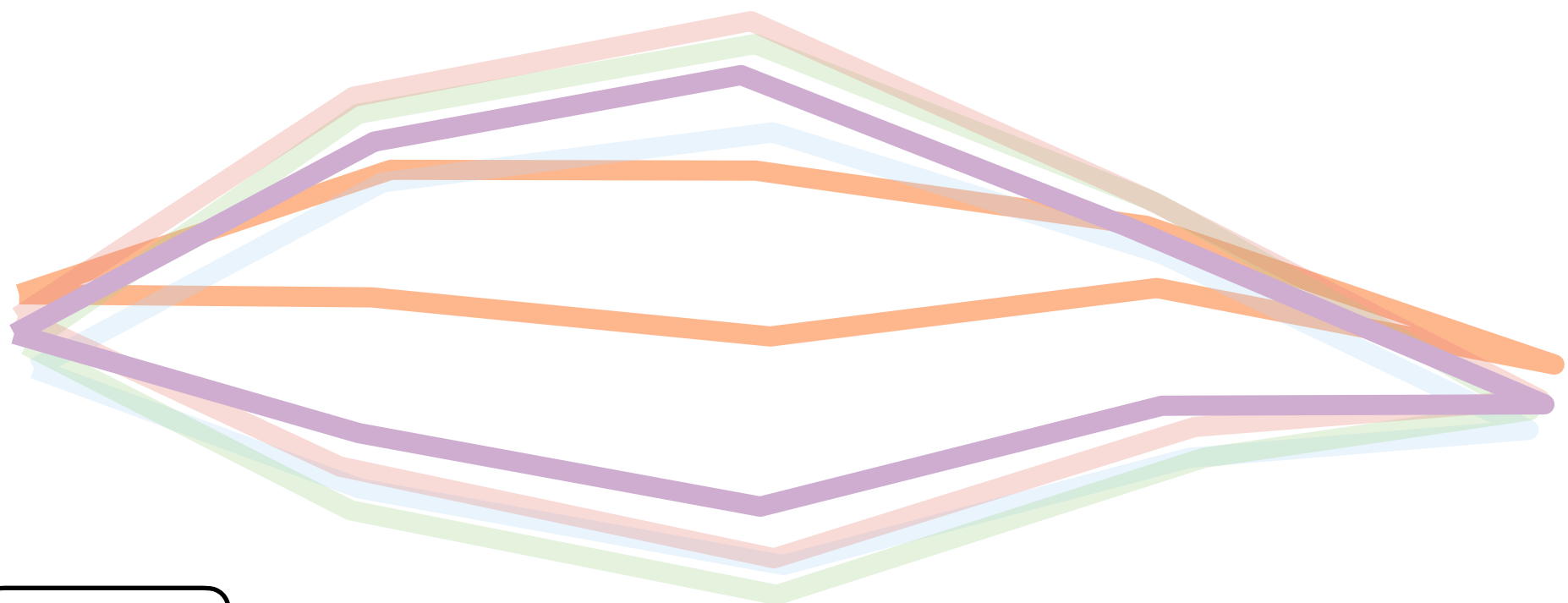
F01



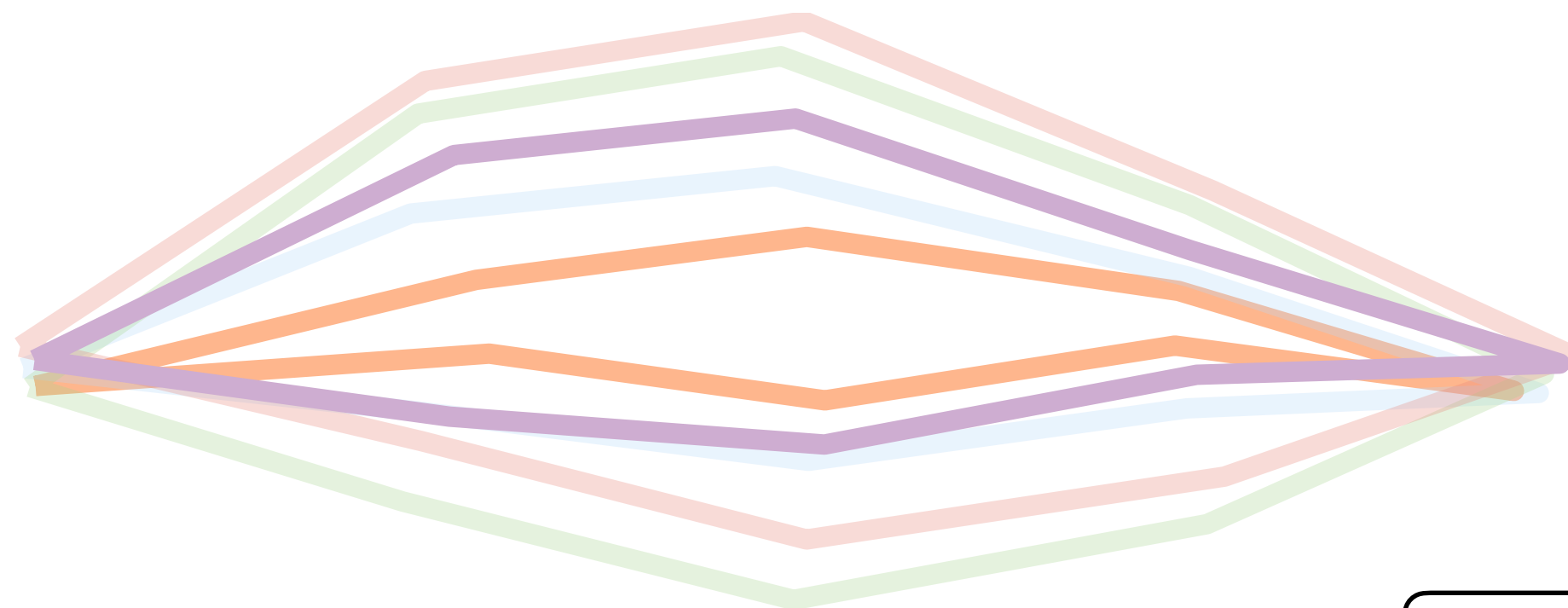
F02



M01



M02



V#s
e.g. seat

V#stj
e.g. stupid

V#stɹ
e.g. street

V#ʃ
e.g. sheet

V#ɹ
e.g. reed

V#s

V#ʃ

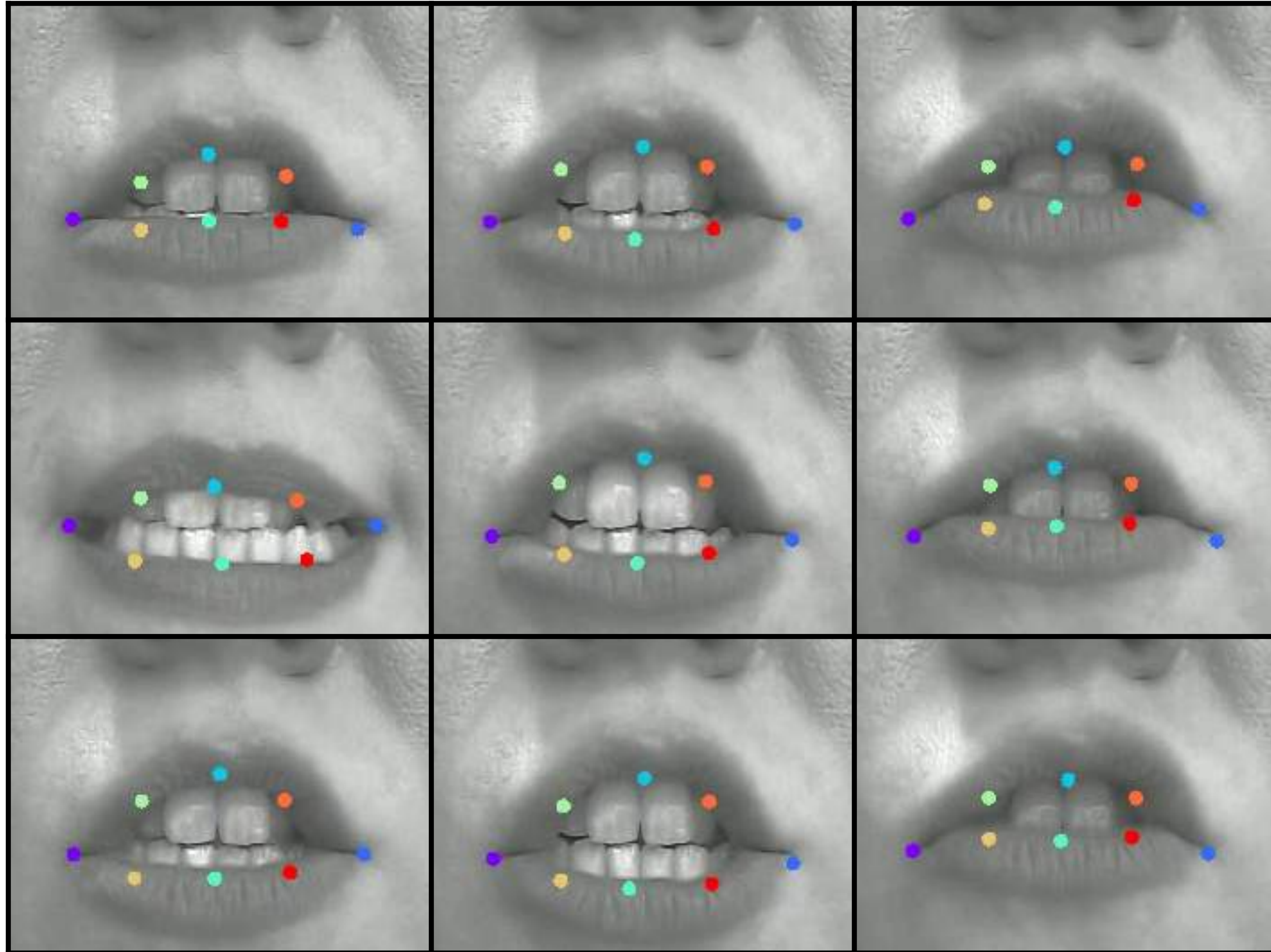
V#stɹ

/ɒ/

/i/

/u/

F01



V#s

V#j

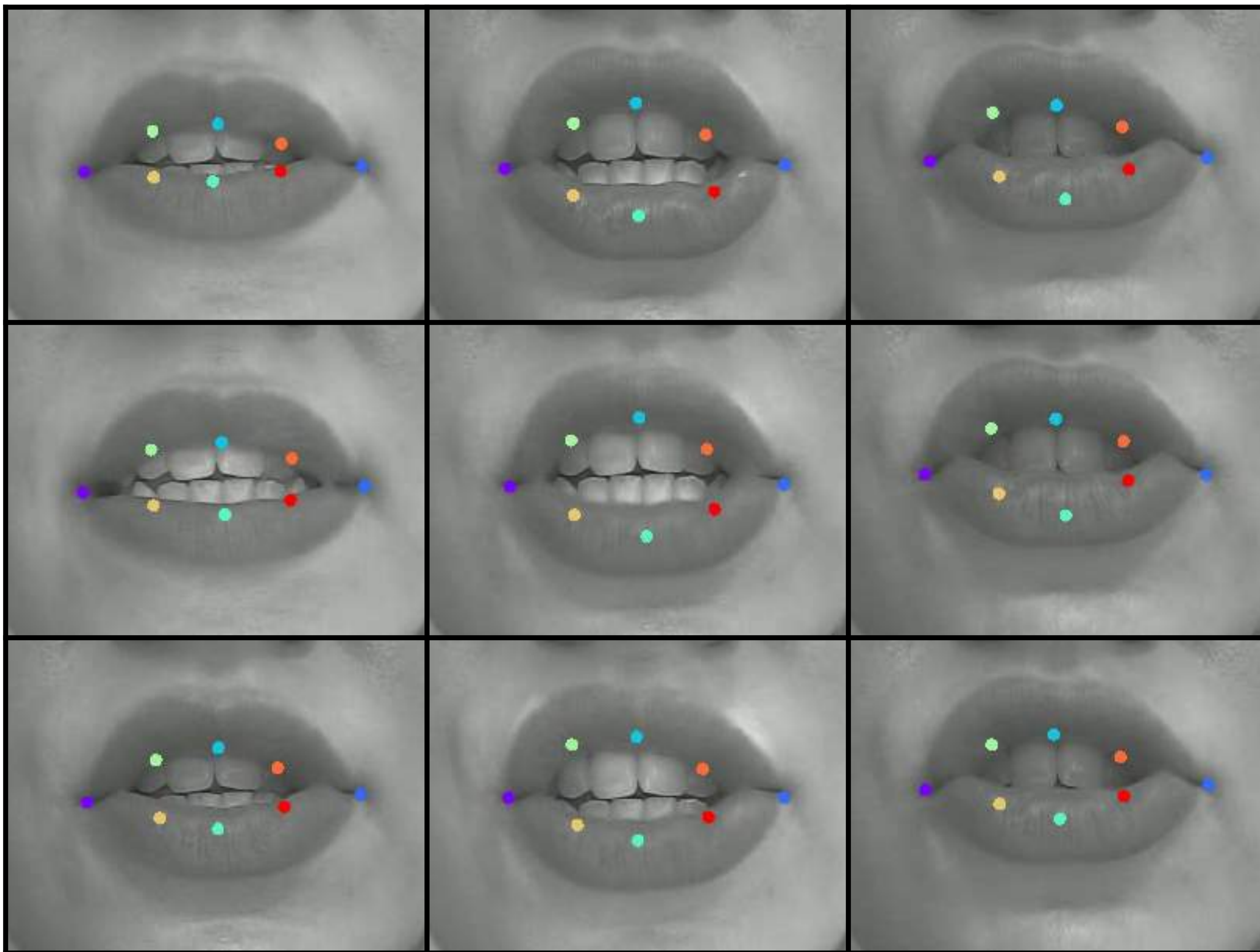
V#stɹ

/ɒ/

/i/

/u/

F02

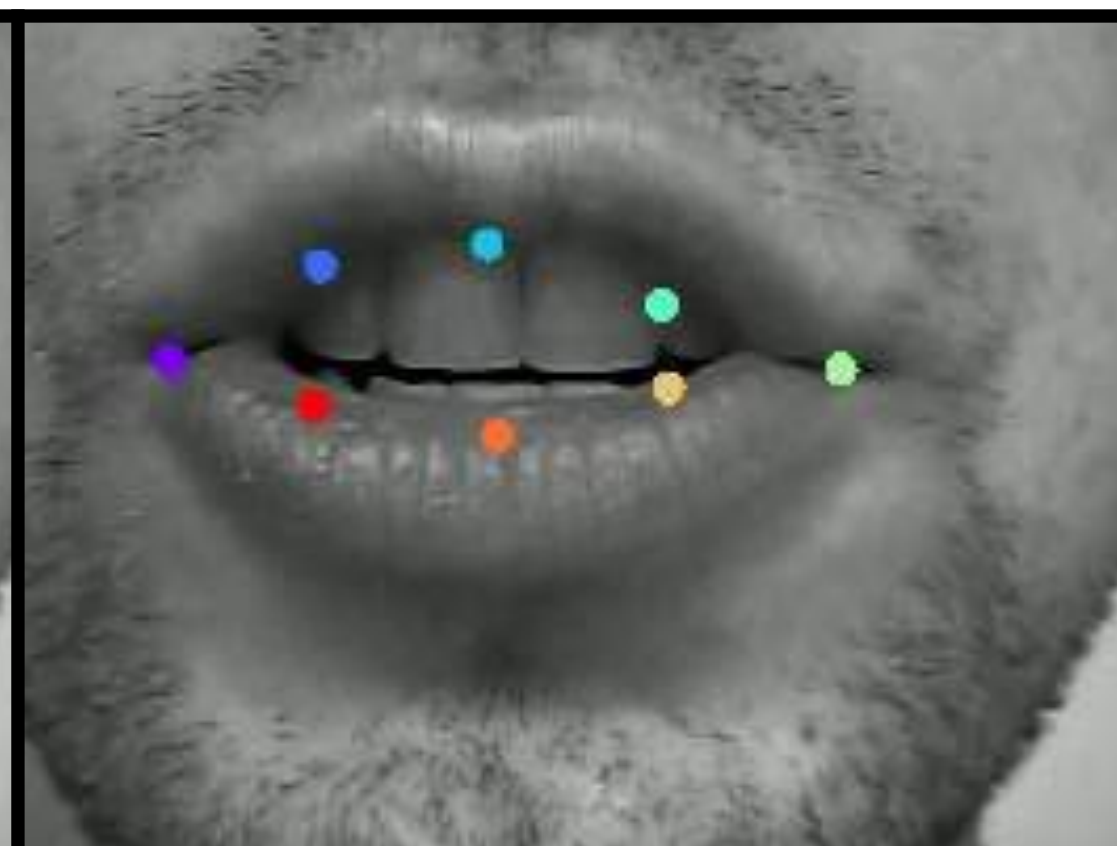
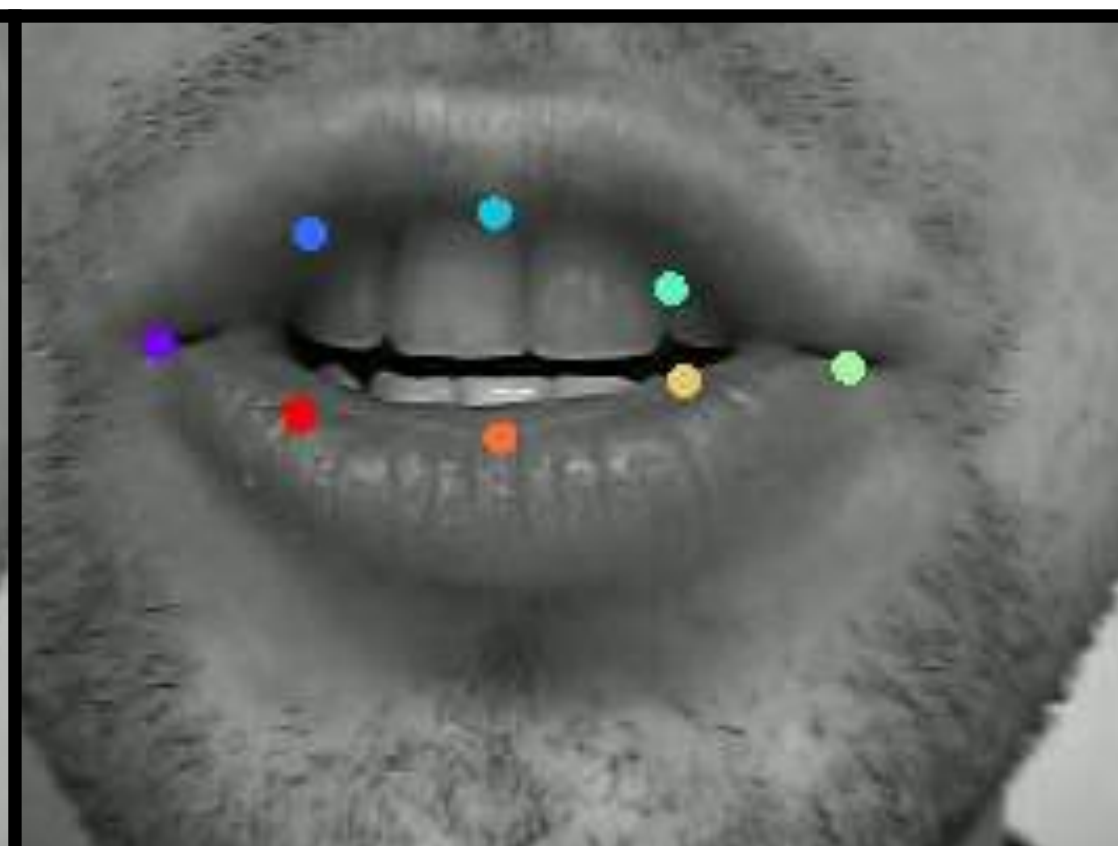
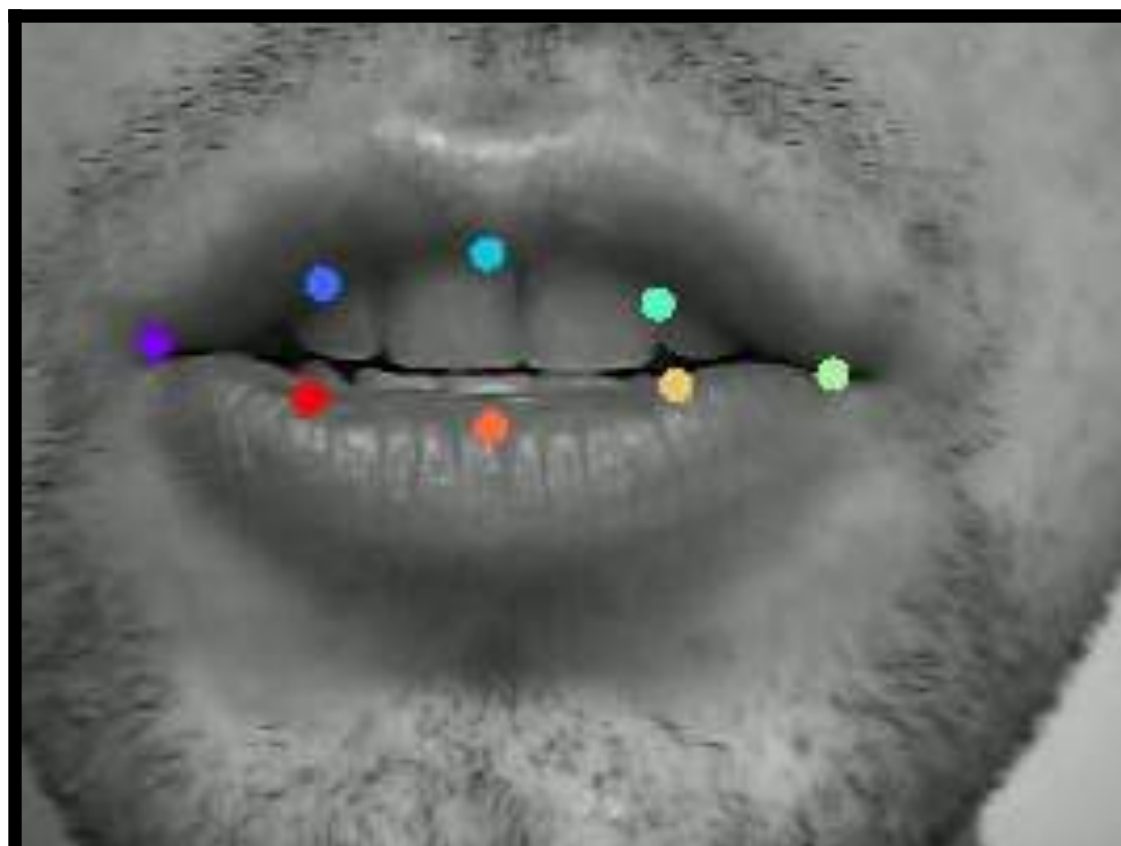


V#s

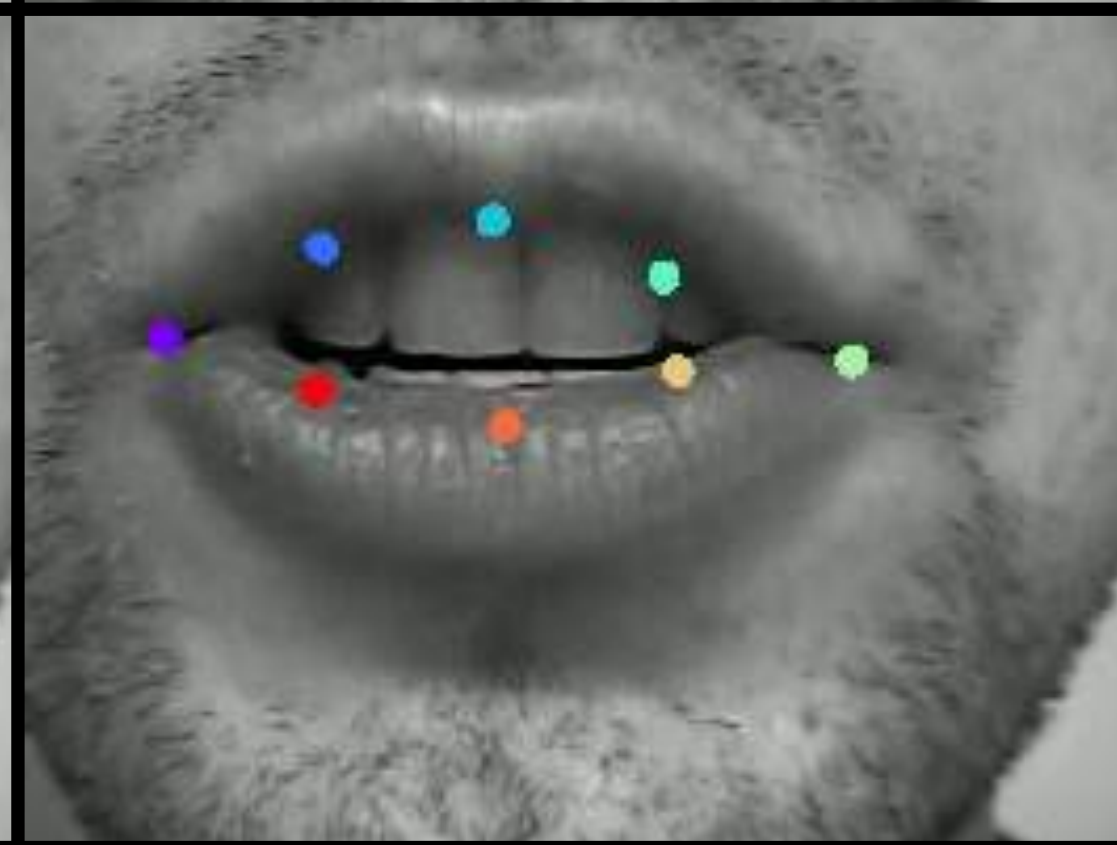
V#ʃ

V#stɹ

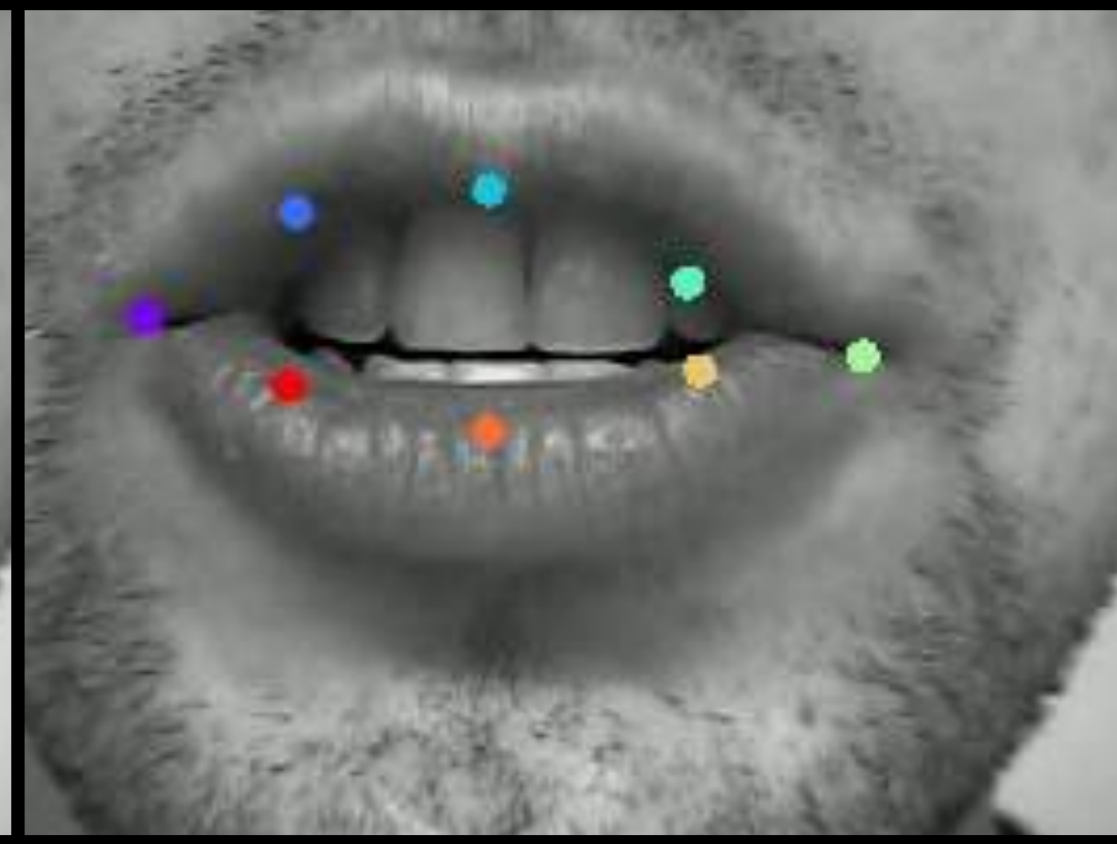
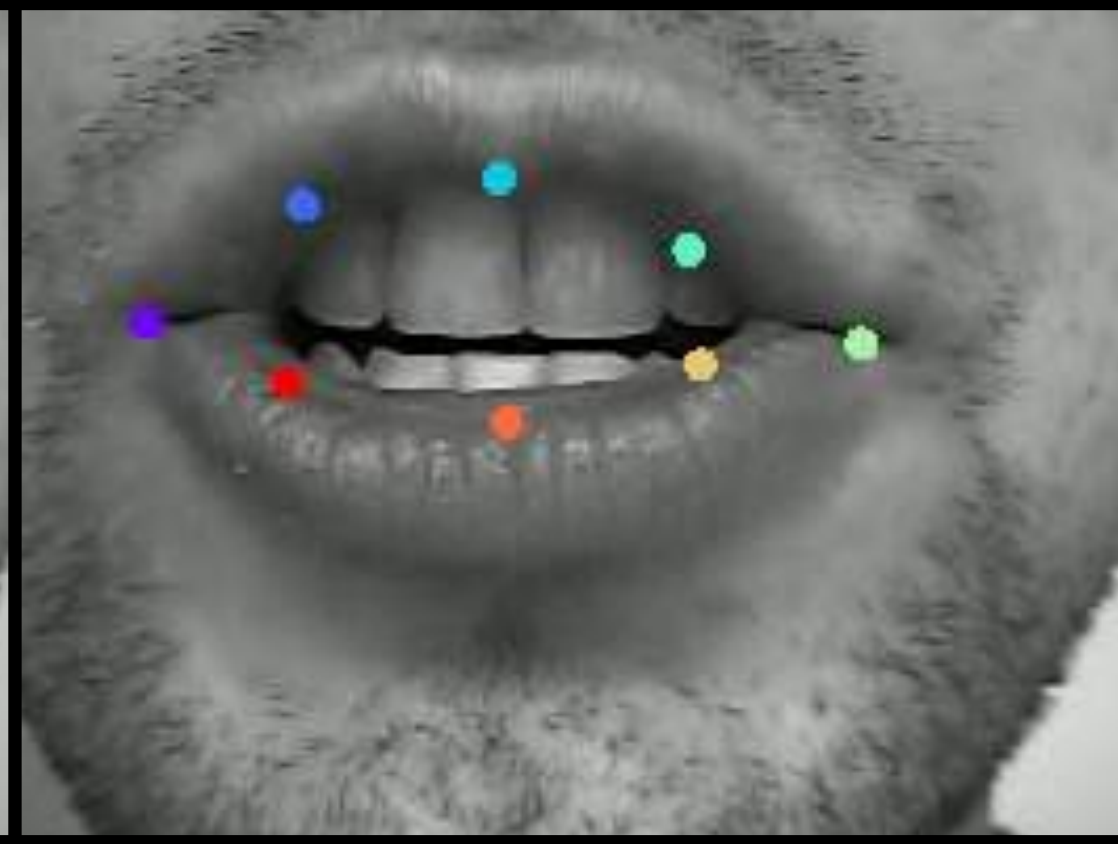
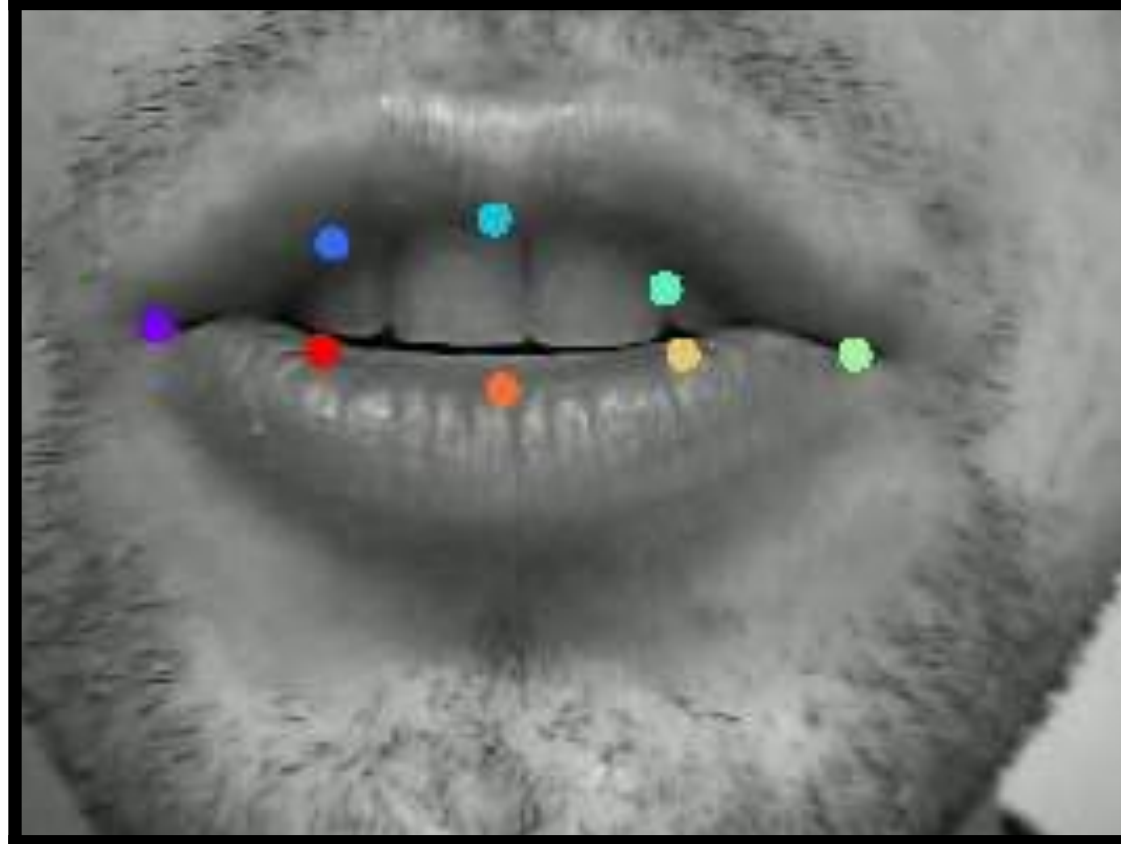
/ɒ/



/i/



/u/



M01

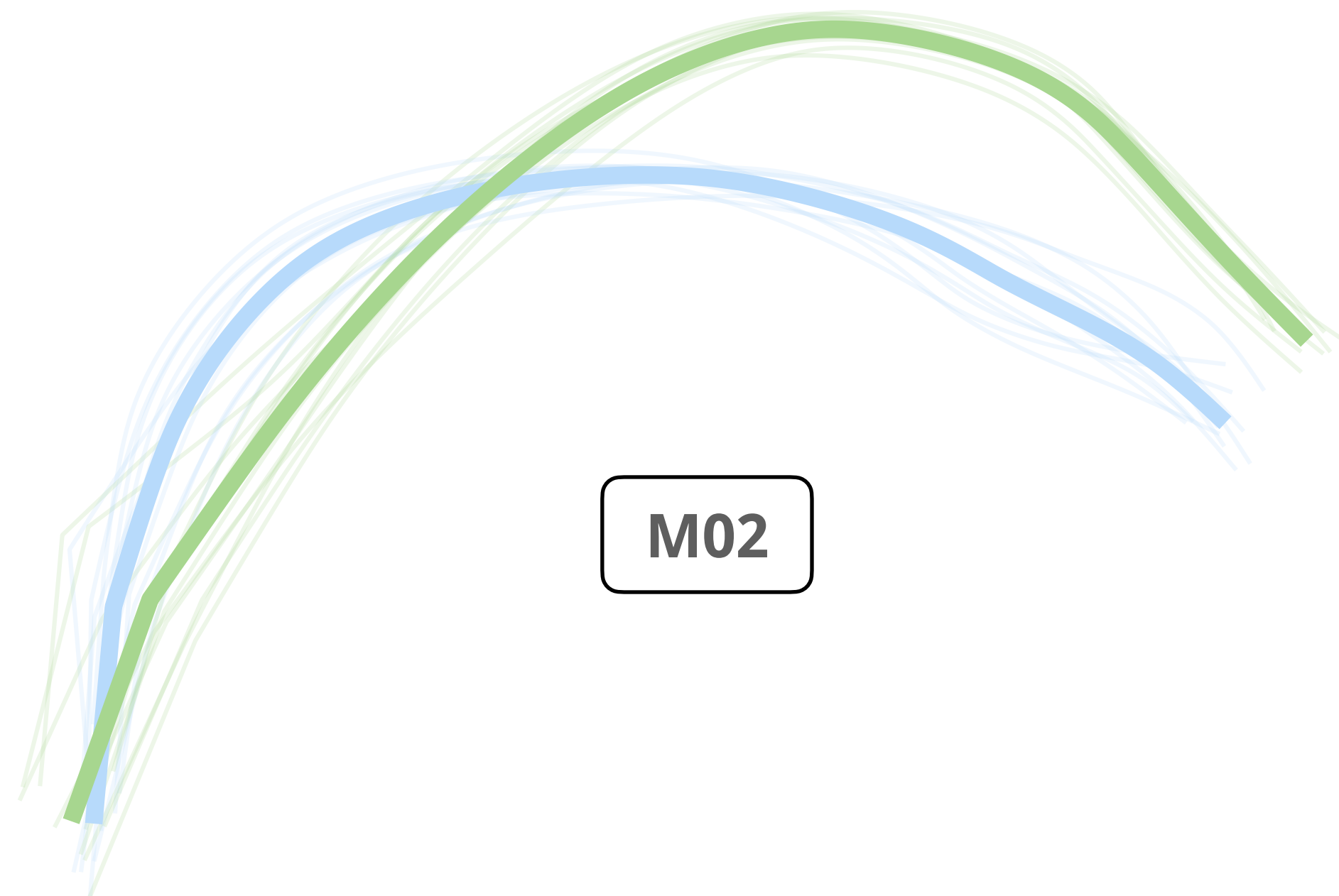
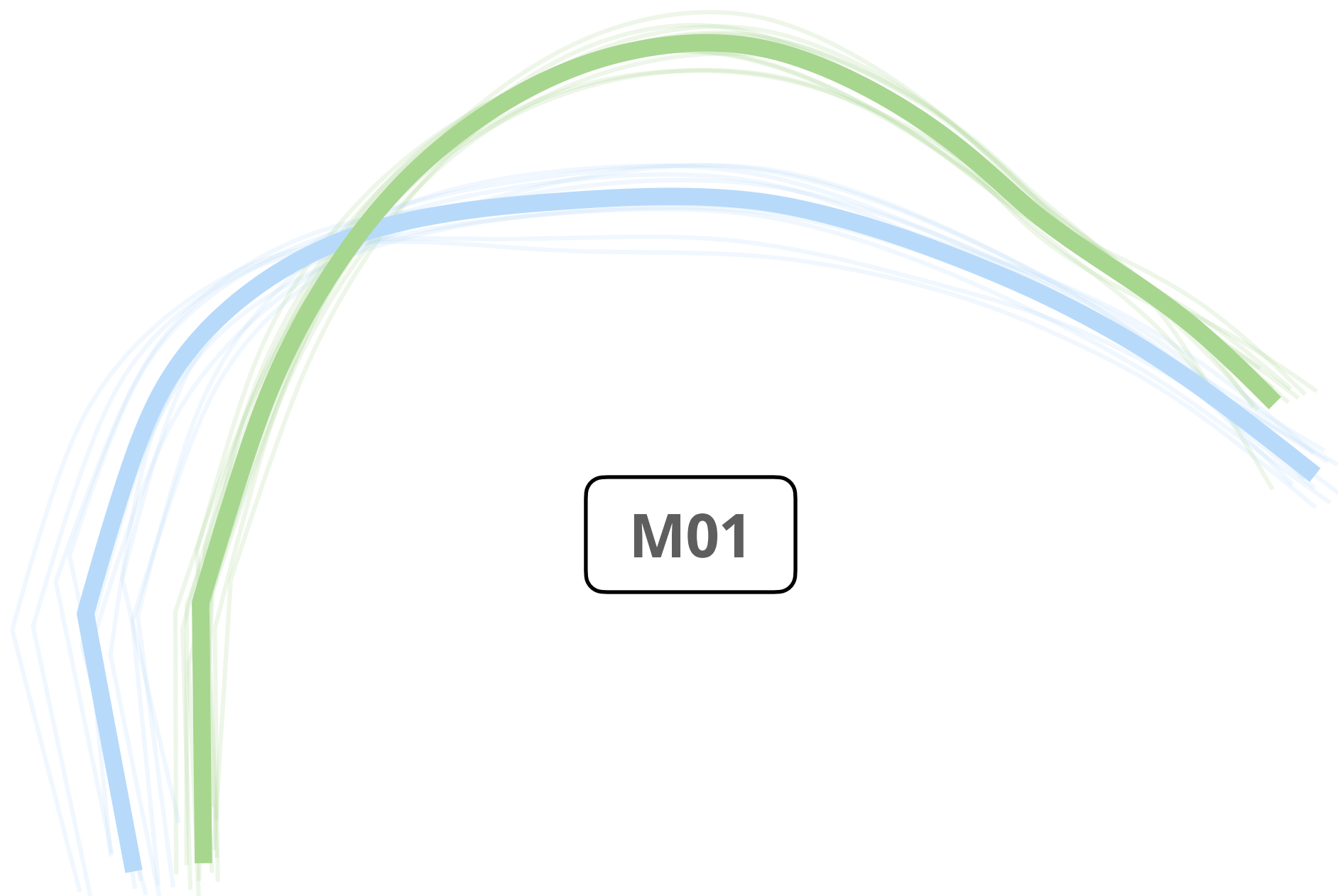
Tongue

/z/-retraction

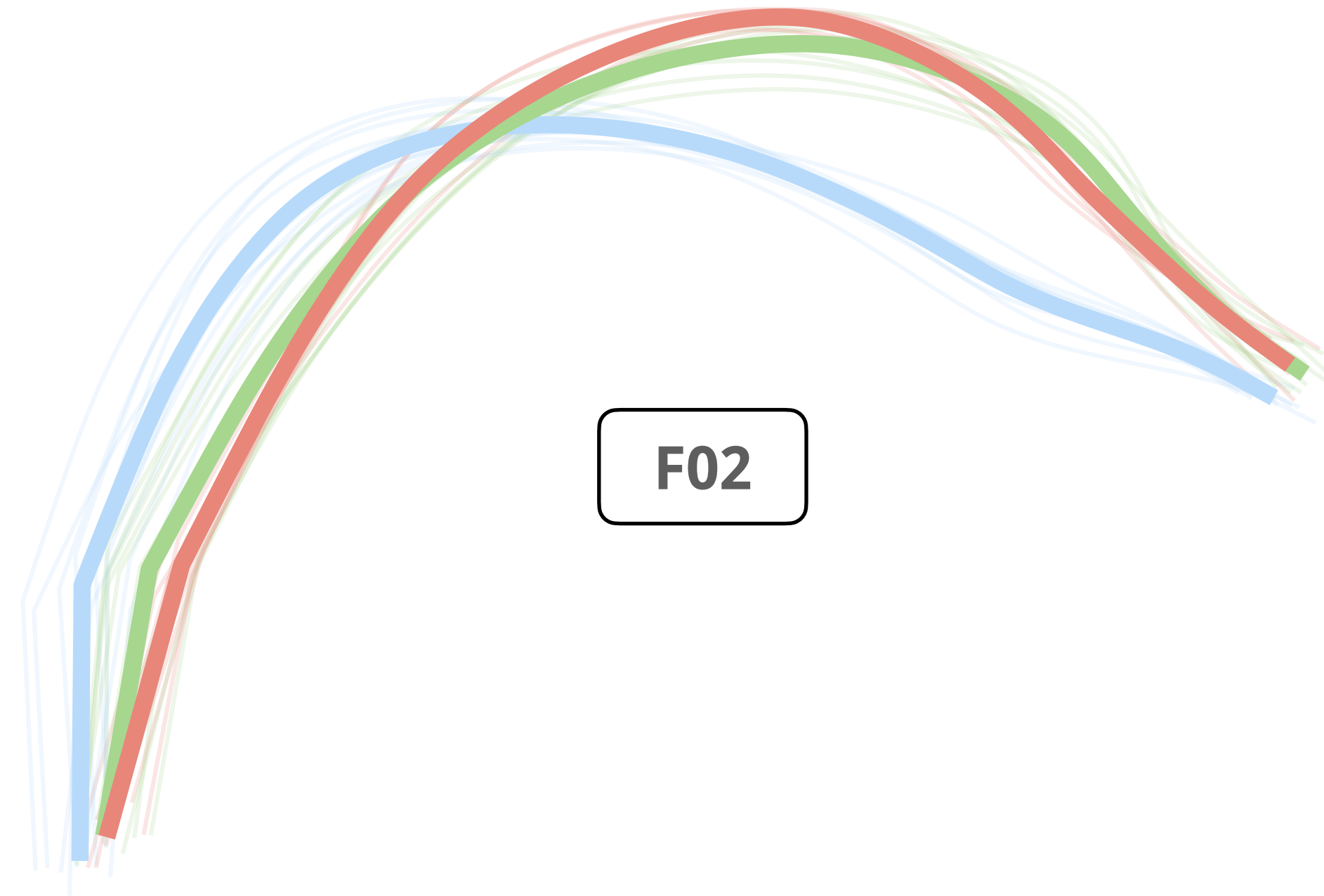
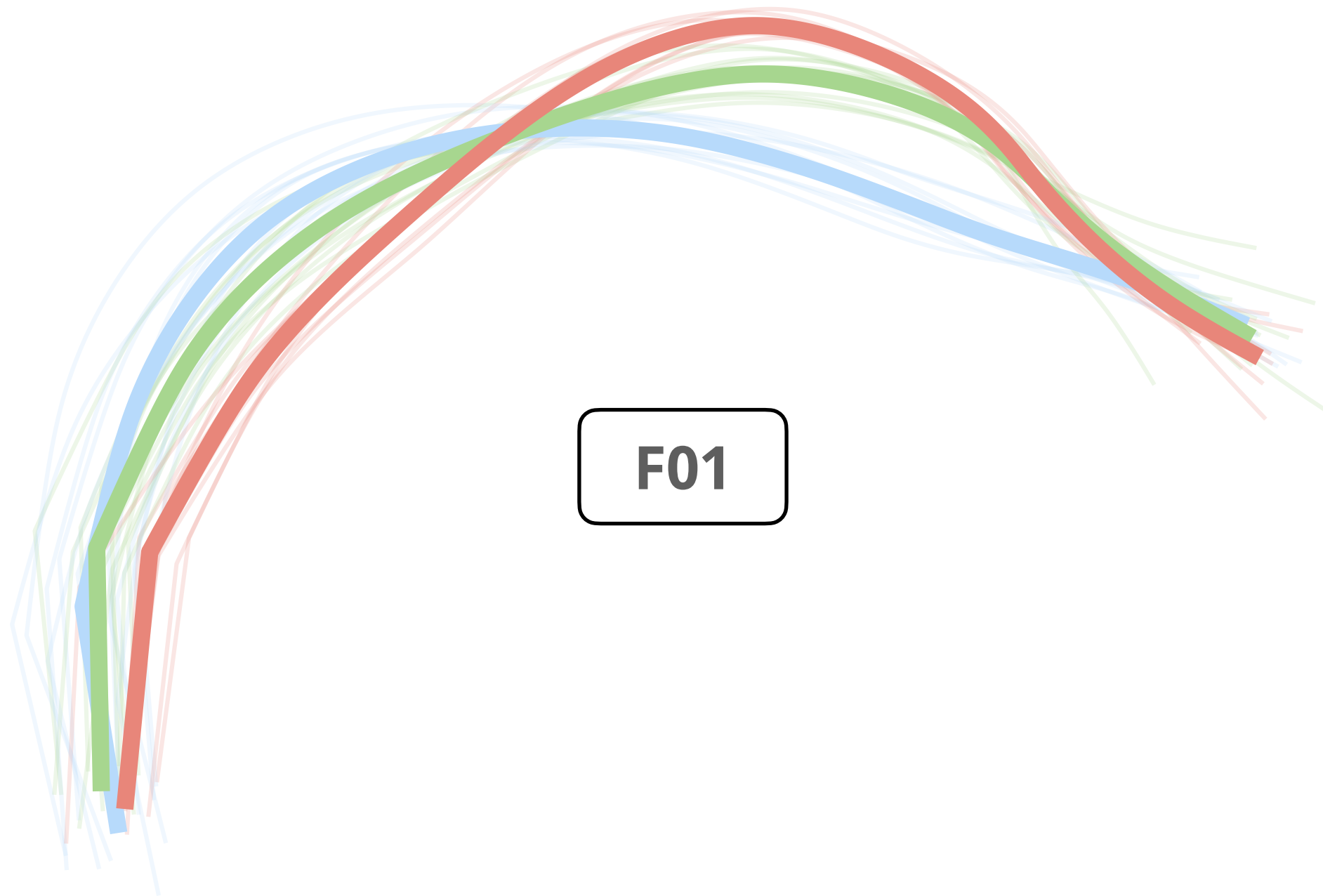




V#z
e.g. the zombie

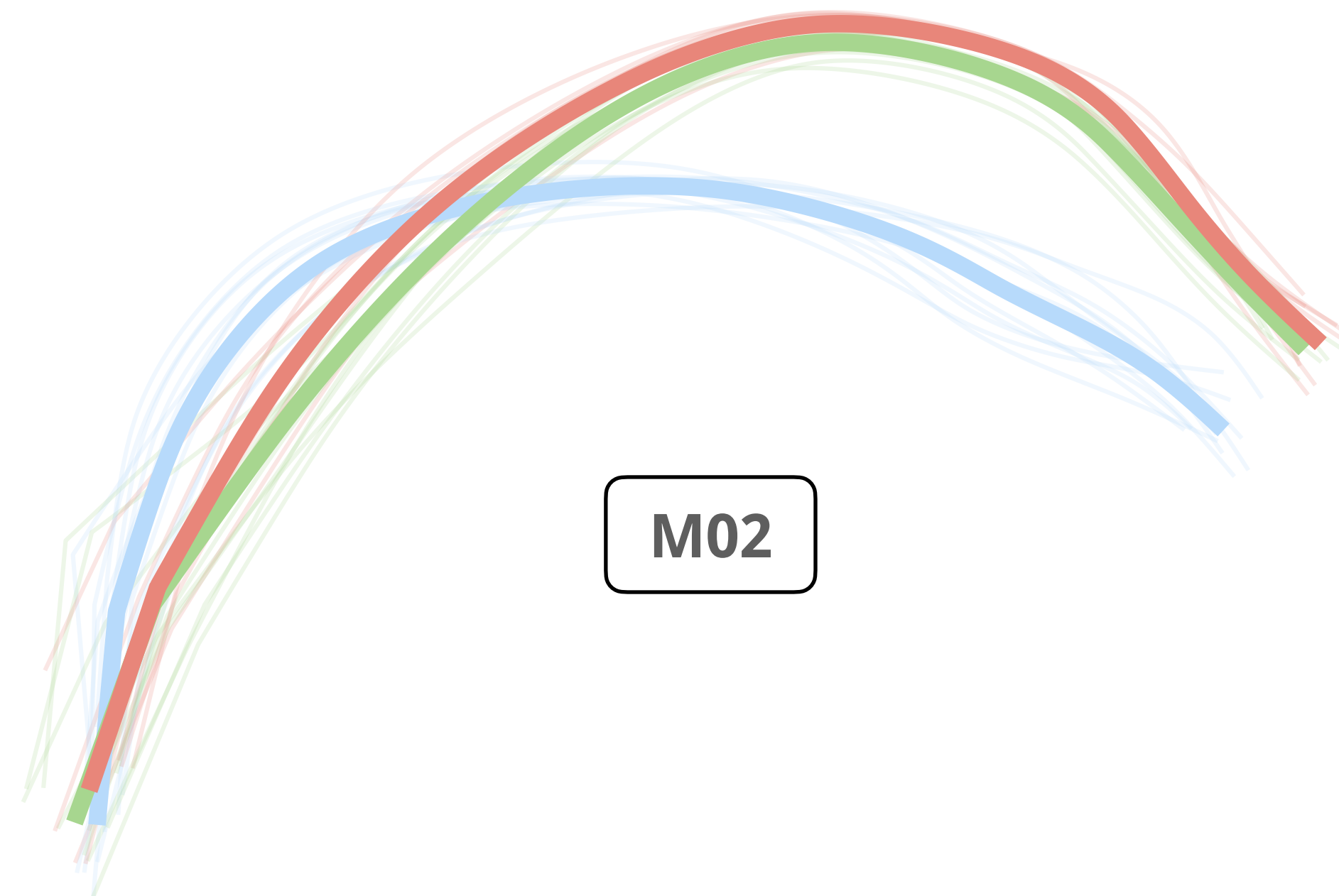
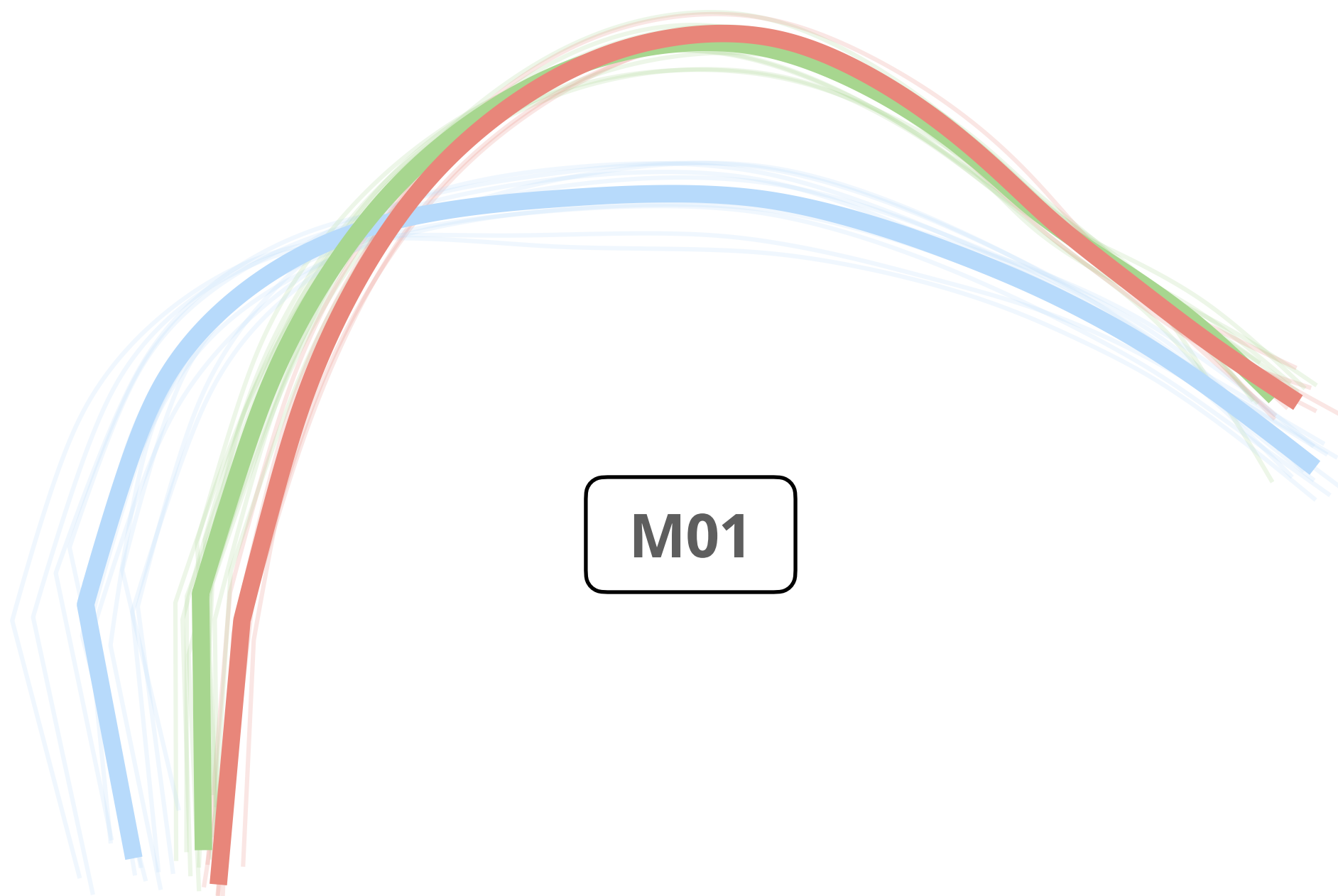


V#3
e.g. the genre

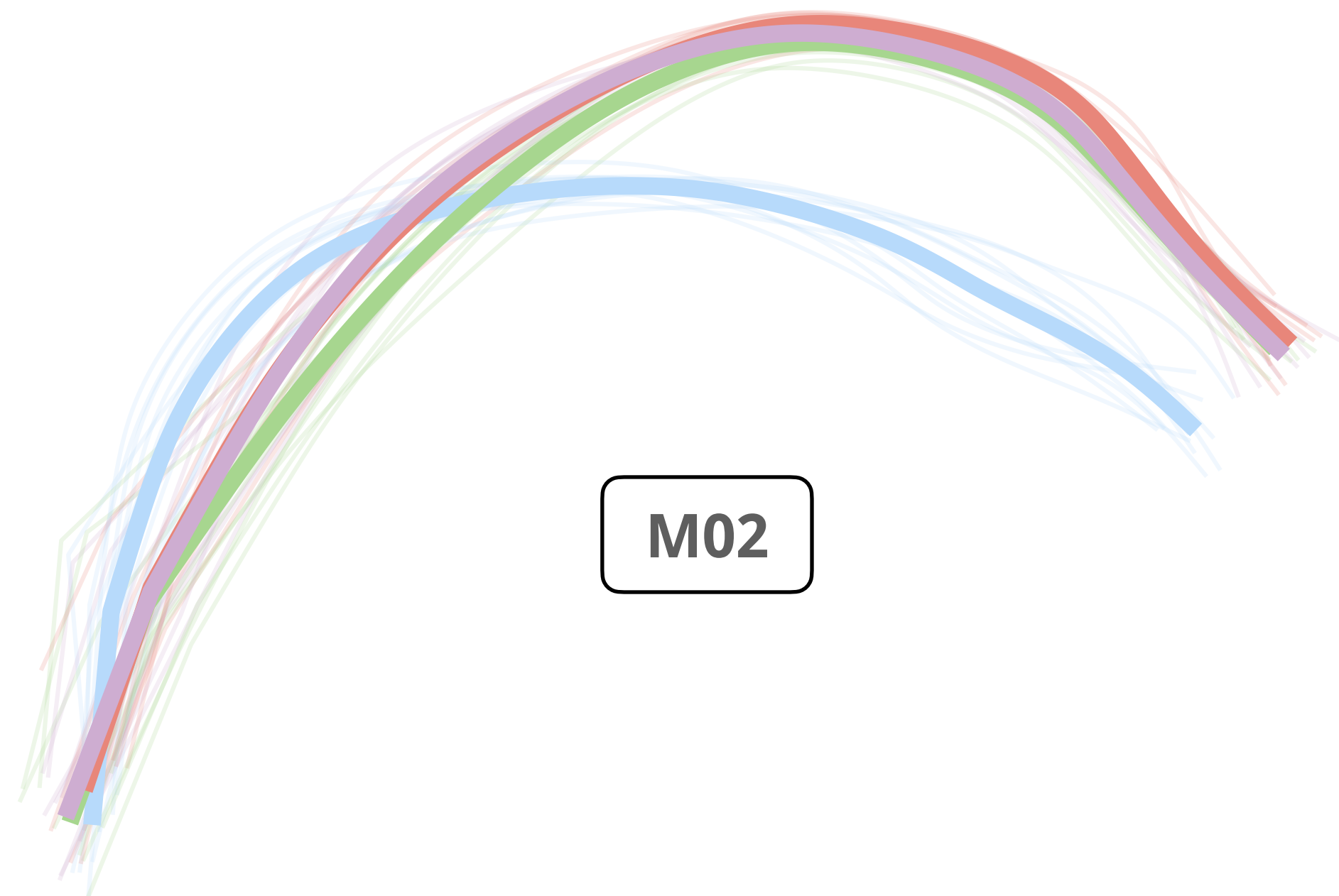
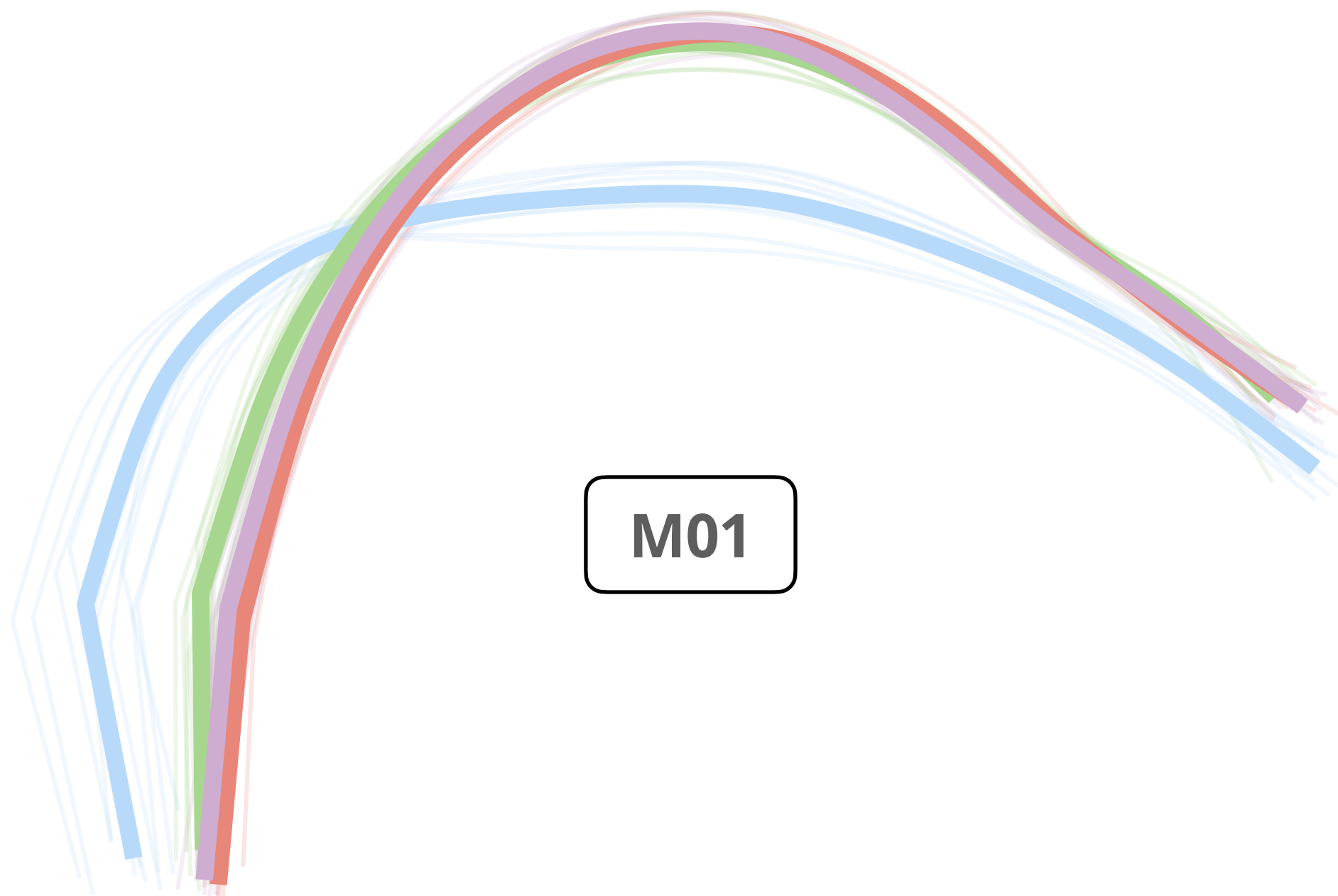
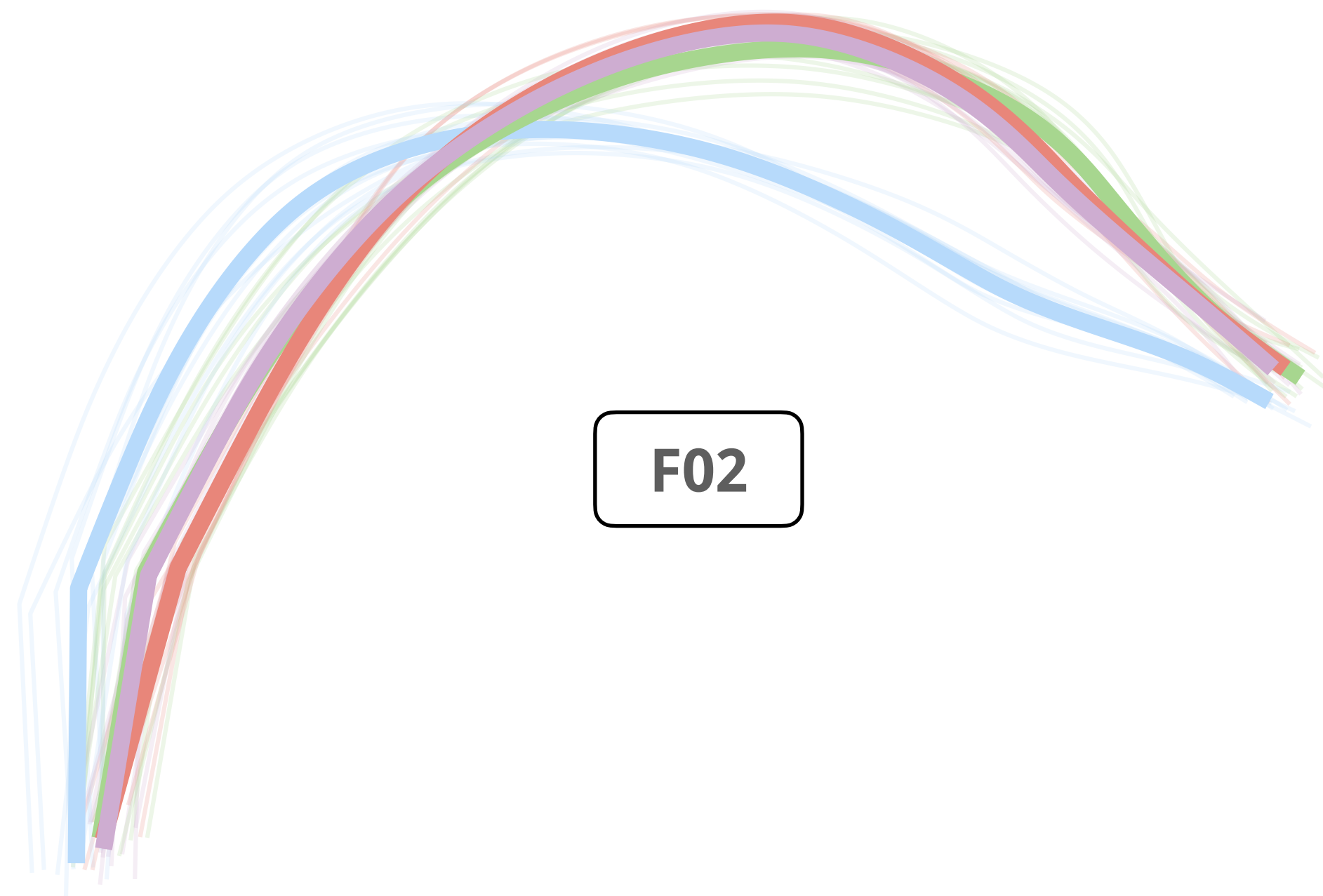
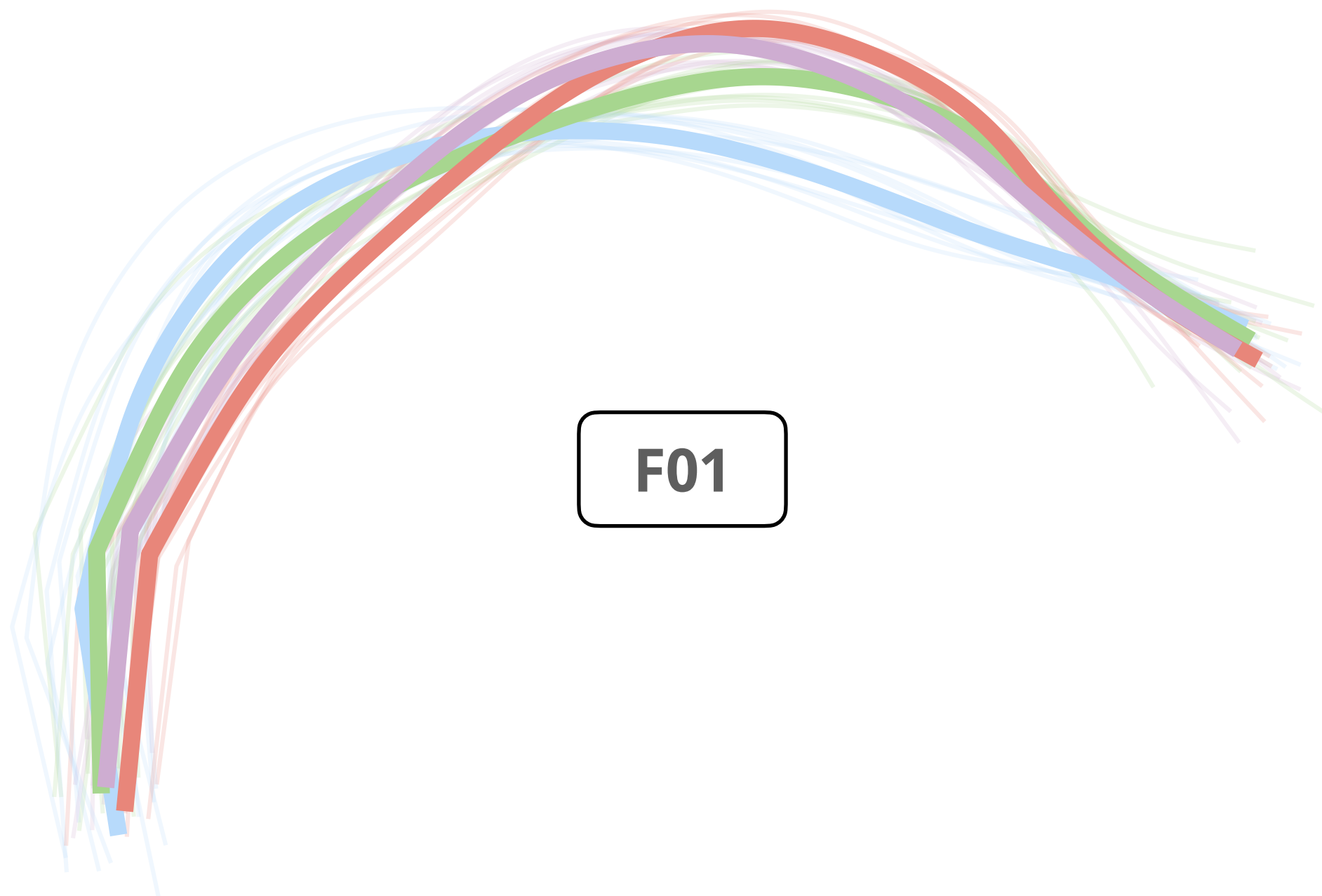


V#z
e.g. the zombie

z#dj
e.g. these dunes



V#3
e.g. the genre

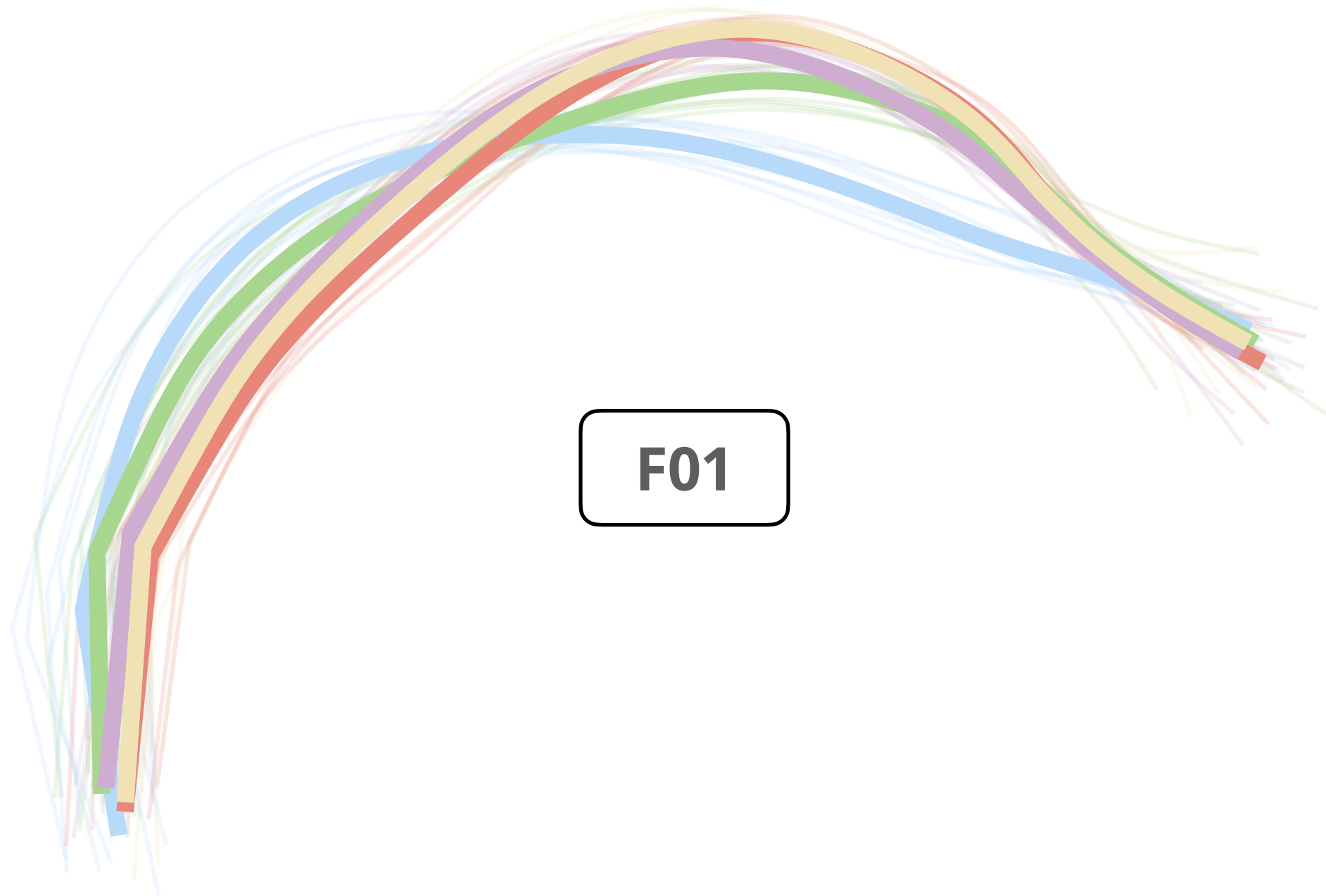


V#z
e.g. *the zombie*

z#dj
e.g. *these dunes*

z#dɹ
e.g. *these drops*

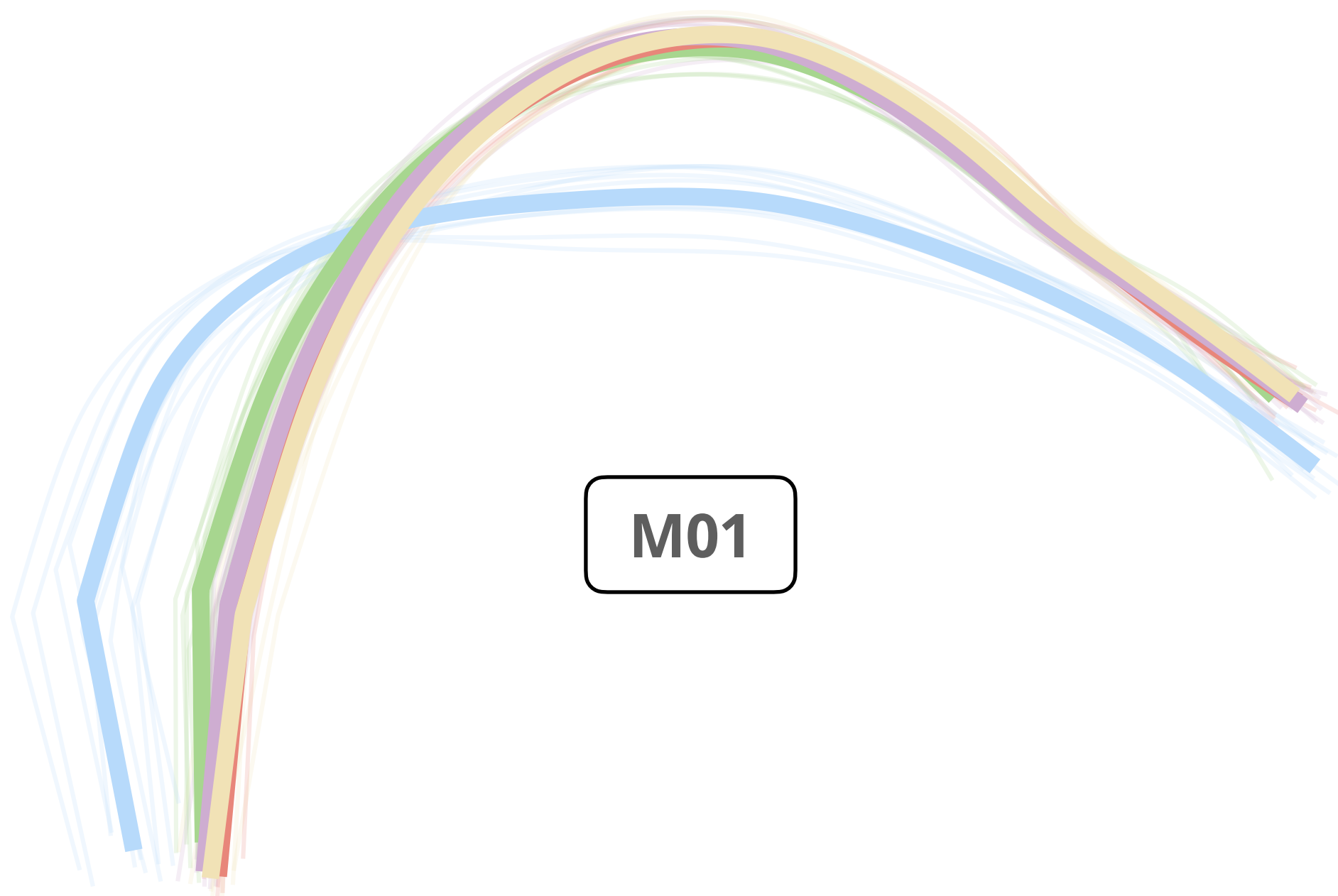
V#ɜ
e.g. *the genre*



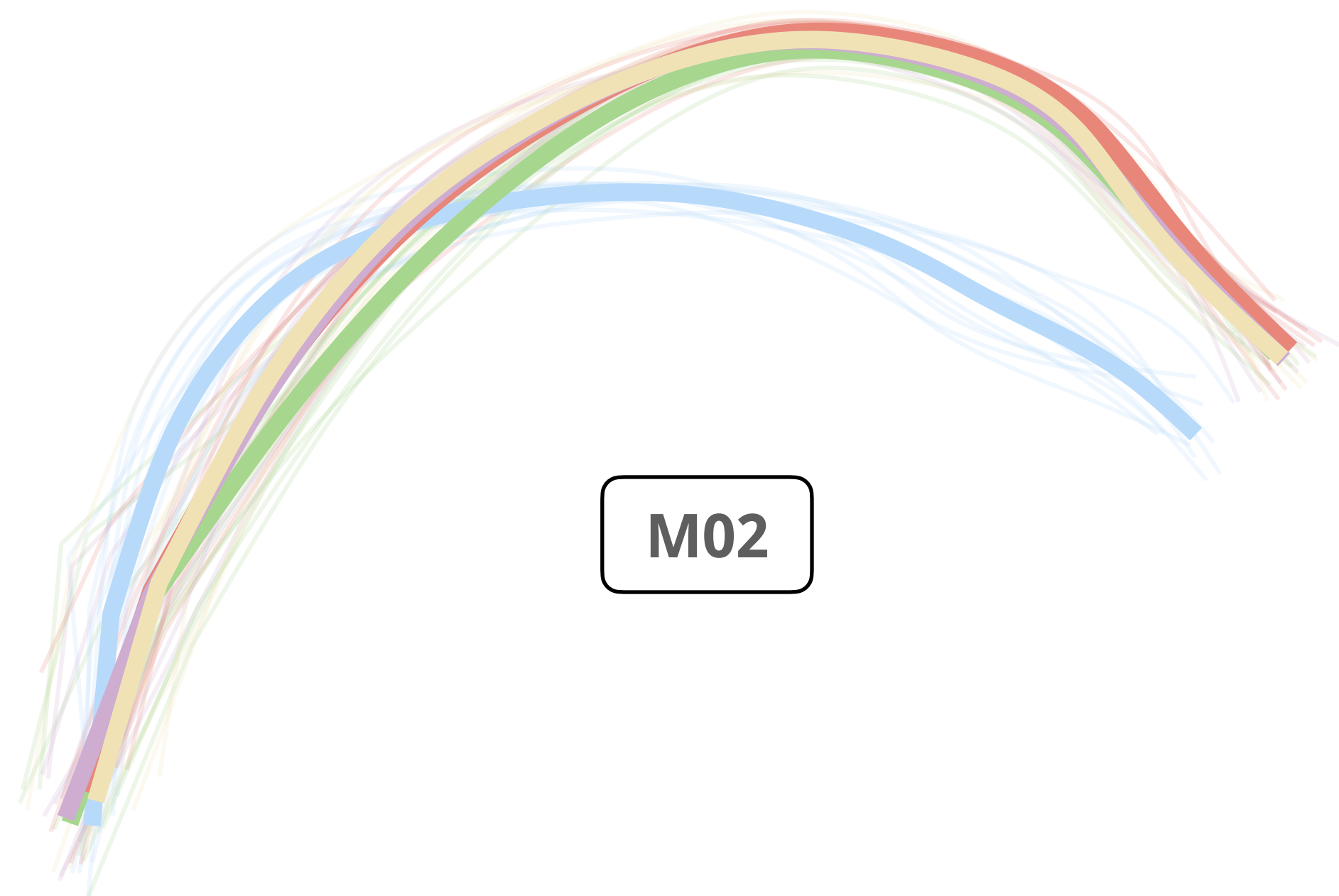
F01



F02



M01



M02

V#z
e.g. *the zombie*

z#dj
e.g. *these dunes*

z#dɹ
e.g. *these drops*

z#dʒ
e.g. *these jobs*

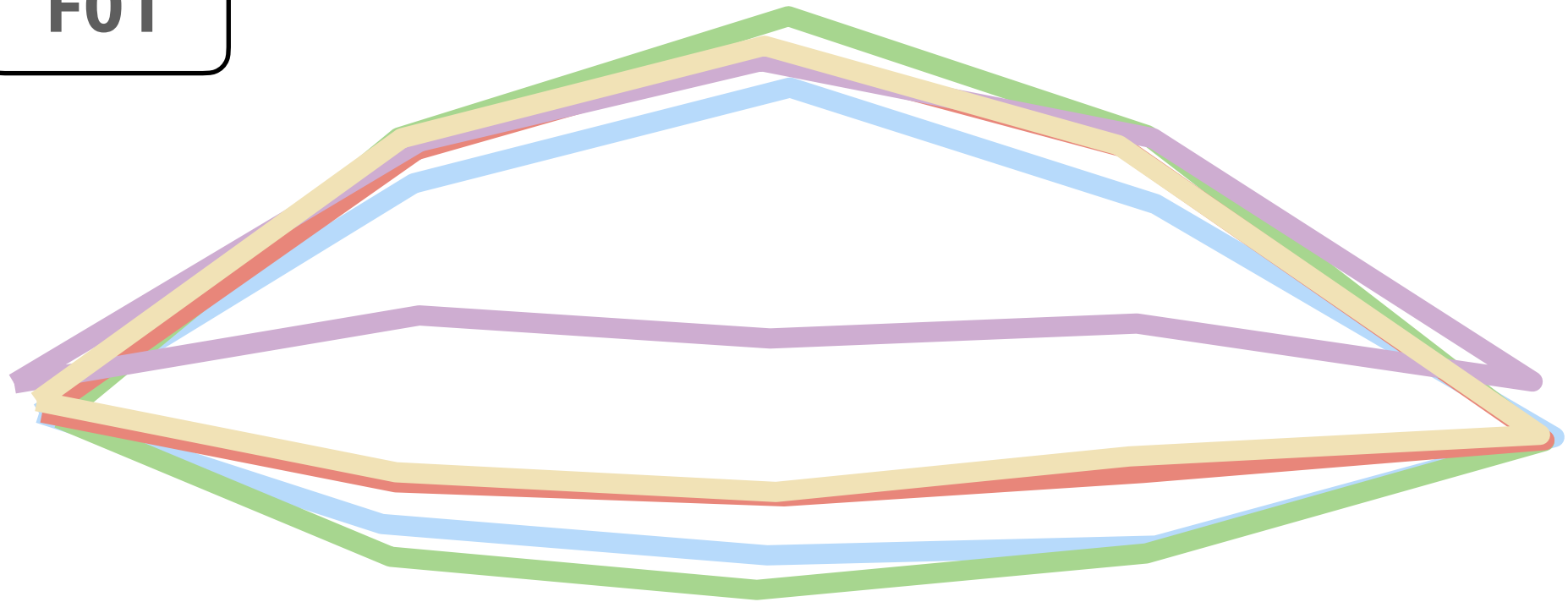
V#ʒ
e.g. *the genre*

Lips

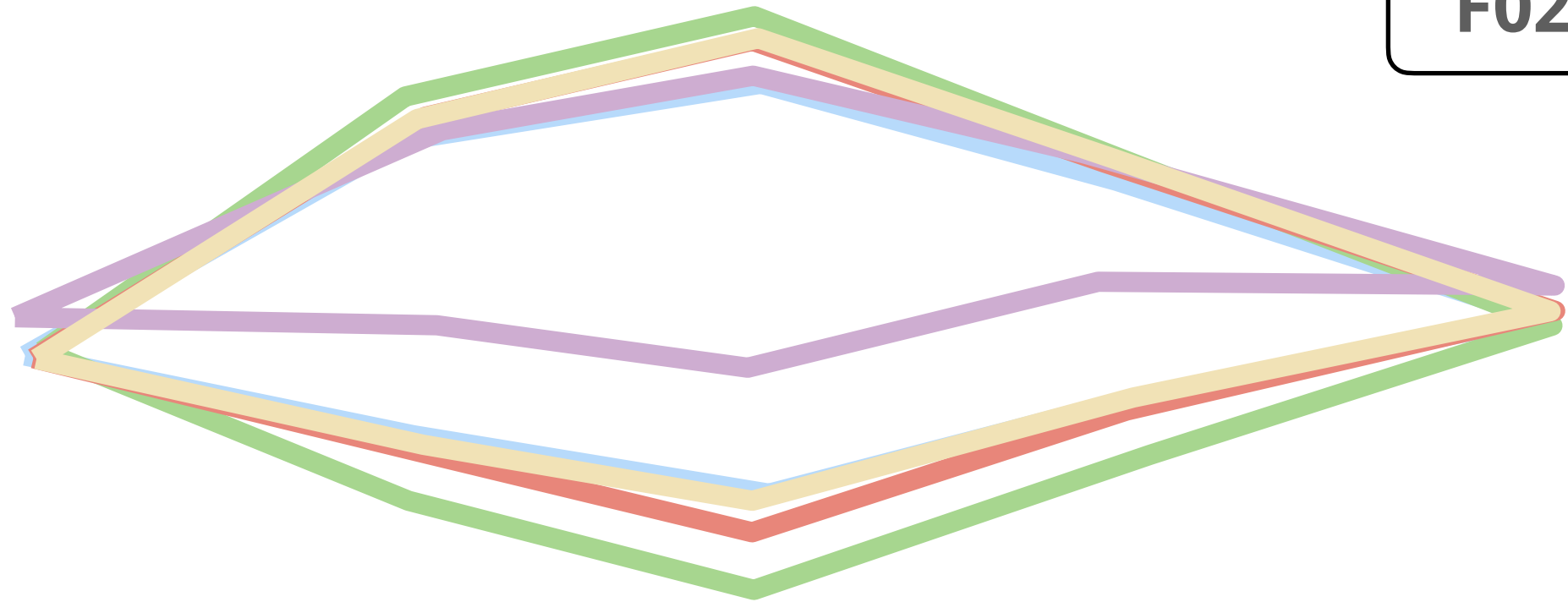
/z/-retraction



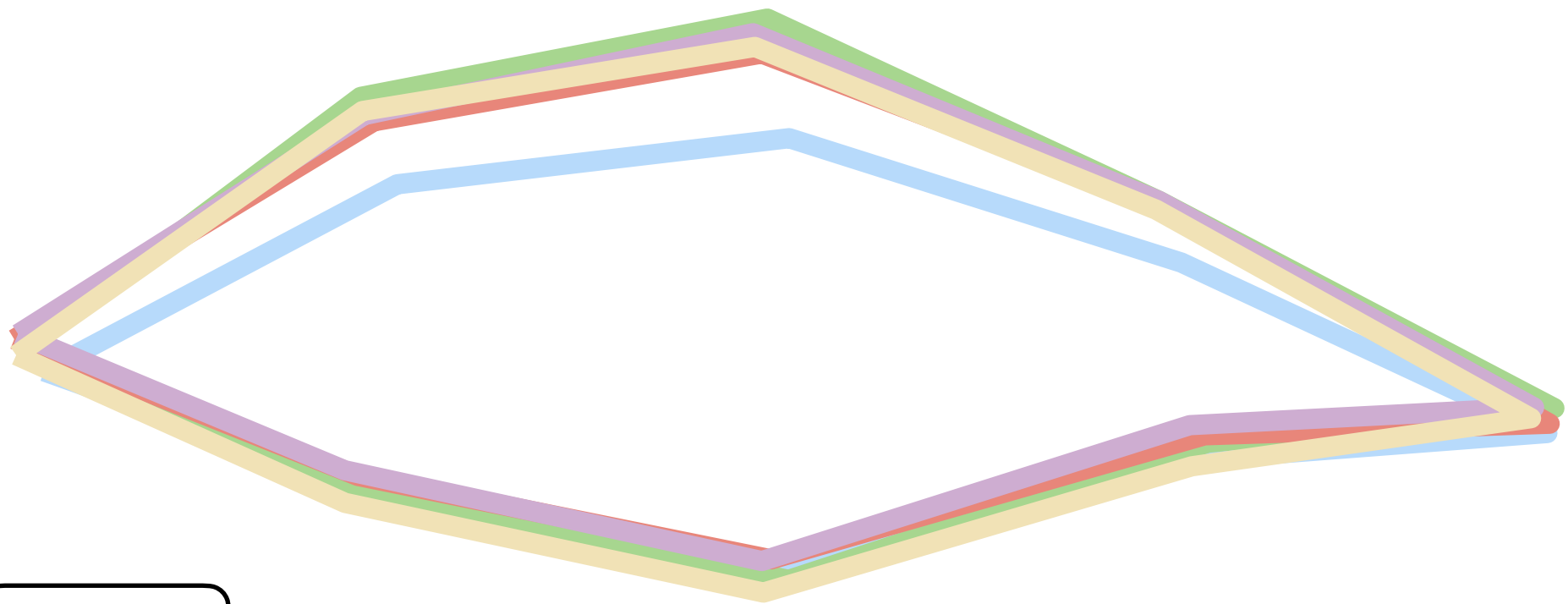
F01



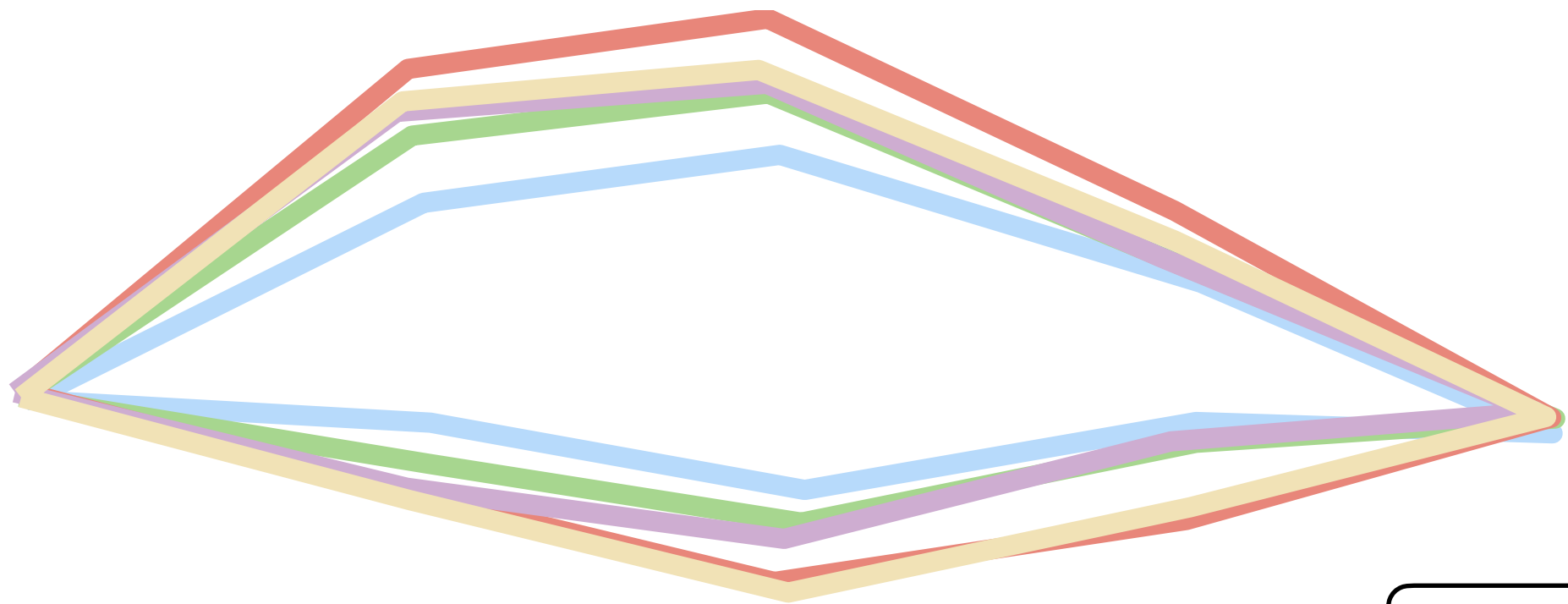
F02



M01



M02



V#z
e.g. *the zombie*

z#dj
e.g. *these dunes*

z#dɹ
e.g. *these drops*

z#dʒ
e.g. *these jobs*

V#ʒ
e.g. *the genre*

Theoretical significance

Contributing to our understanding of:

- post-lexical vs word-level behaviour in **pathways of sound change** (e.g. Bermúdez-Otero 2015 on the LIFE CYCLE OF PHONOLOGICAL PROCESSES)
 - see Zsiga (1995) on categorical retraction in word-internal *pressure* but gradient in *press you*
- competing accounts over the **triggering mechanisms** behind /s/-retraction
 - non-local assimilation to /ɹ/? (Shapiro 1995; Baker et al. 2011)
 - local assimilation to following /t/-affrication? (Lawrence 2000; Bailey et al. 2022)
- the role of **generalisation** in the spread of a sound change and its targeted environments
 - comparing retraction of /s/ and /z/, which have different positional distributions
 - see also Chodroff & Wilson (2022) on phonetic uniformity in sibilant production

Making sense of it all

1

What's going on **across word boundaries**?

2

What's going on in these **additional segmental contexts**?

3

What's going on with **/z/**?

4

What's going on with the **lips** and **tongue**?

Making sense of it all

1

What's going on across word boundaries?

- post-lexical retraction is most definitely 'a thing'
 - cf. previous work with narrower scope on e.g. /s#j/ (Zsiga 1995) , /s#ɹ/ (Smith et al. 2019), /s#ʃ/ (Nolan et al. 1996; Pouplier et al. 2011)
- it works in essentially the same way as word-internal retraction with uniformity of the /tɹ, tʃ, tʃ/ contexts, but is generally *less* advanced

2

What's going on in these additional segmental contexts?

- retraction *does* happen before /ɹ, j/ in the absence of affrication (cf. Baker et al. 2011; Bailey et al. 2022)
- **but** the magnitude varies between speakers in a way that the other pre-affricate(d) contexts don't, suggesting multiple sources/processes of retraction

Making sense of it all

3

What's going on with /z/?

- voiced /z/-retraction is acoustically very similar to /s/-retraction
- speakers who are more advanced in /s/-retraction tend to be more advanced in /z/-retraction too

4

What's going on with the lips and tongue?

- phonetic uniformity on the surface masks a lot of individual-level variation in articulatory mechanisms:
 - ▶ some contexts show a direct correlation between lingual gesture and acoustic signal
 - ▶ but the labial gesture varies between contexts in speaker-specific ways (cf. Thielking 2022)
- /ʃ/ and /ɹ/ are 'rounded' but in different ways (see also Smith et al. 2019), and retracted /s/ can display both types depending on the trigger

Making sense of it all

4 What's going on with the lips and tongue? (cont.)

- already suggestive evidence of how articulatory gestures might vary according to the life cycle of the change
- in AmEng, Smith et al. (2019) report gradient phonetic retraction in the acoustics of /s#ɹ/, with anticipatory lip rounding but still an /s/-like tongue shape
- here, speakers whose acoustics display a *phonological* implementation of retraction in /s#ɹ/ combine an /ʃ/-like tongue shape **and** /ɹ/-like labialisation in their articulation