

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 thish change?

- **/s/-retraction:** a process that turns */s/* into a more [ʃ]-like sound (e.g. [ʃ]tree)
- 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)

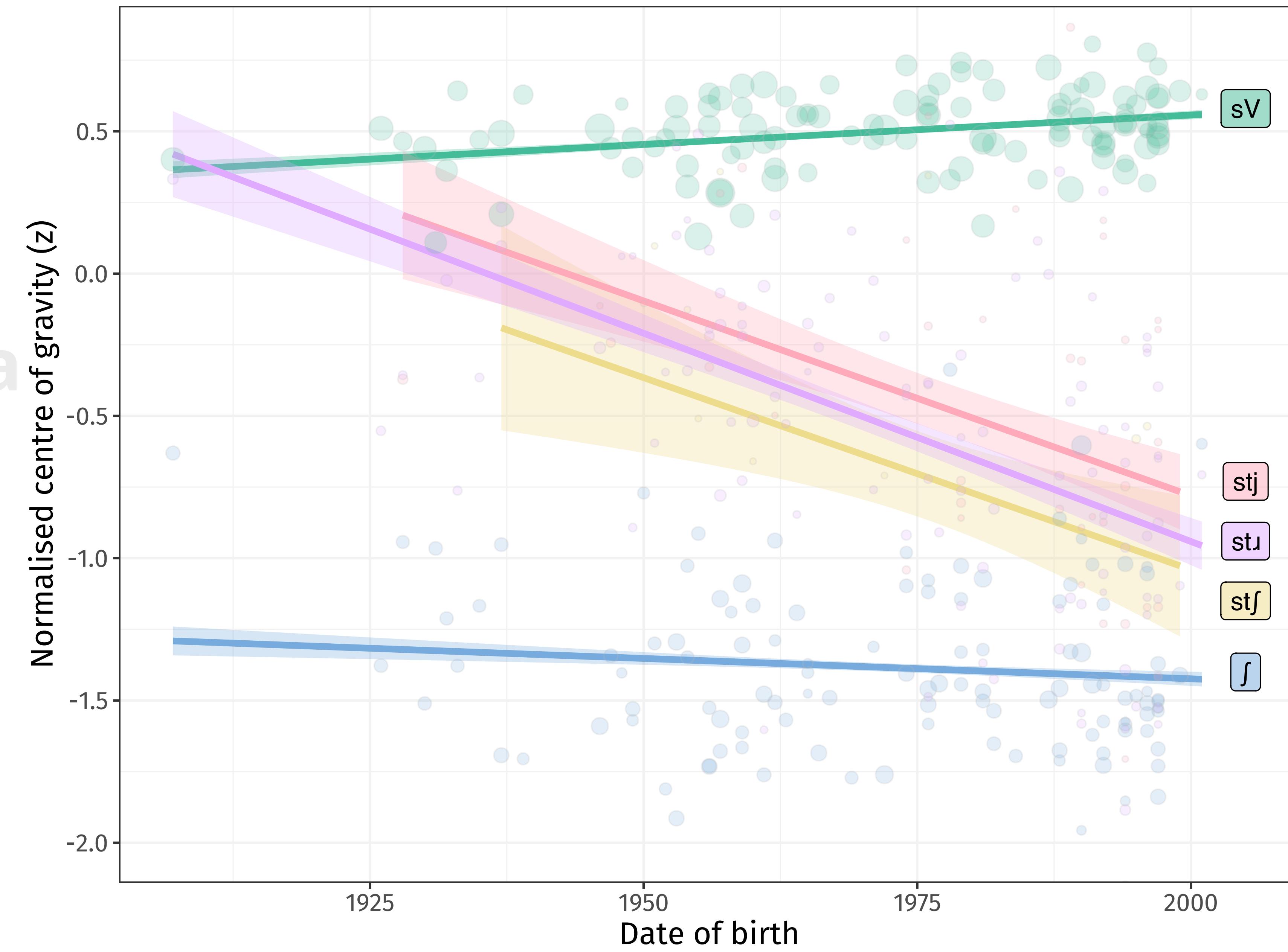
b. 1932

b. 1997



What is thish change?

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



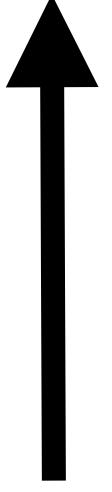
seat

s that
like sound
student
street
question
sheet

What is this change?

- **/s/-retraction:** a process that turns /s/ into a more [ʃ]-like sound (e.g. [ʃ]tree)
- 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]tree)
- 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

(#)stu

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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e.g. glass chunk

s#ɹ

e.g. this rock

s#j

e.g. press you

z#dʒ

e.g. wise job

z#dʒ

e.g. these dunes

z#dɹ

e.g. his drink

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e.g. glass chunk

s#ɹ

e.g. this rock

s#j

e.g. press you

z#dʒ

e.g. wise job

z#dʒ

e.g. these dunes

z#dɹ

e.g. his drink

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(#)stj
e.g. student

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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

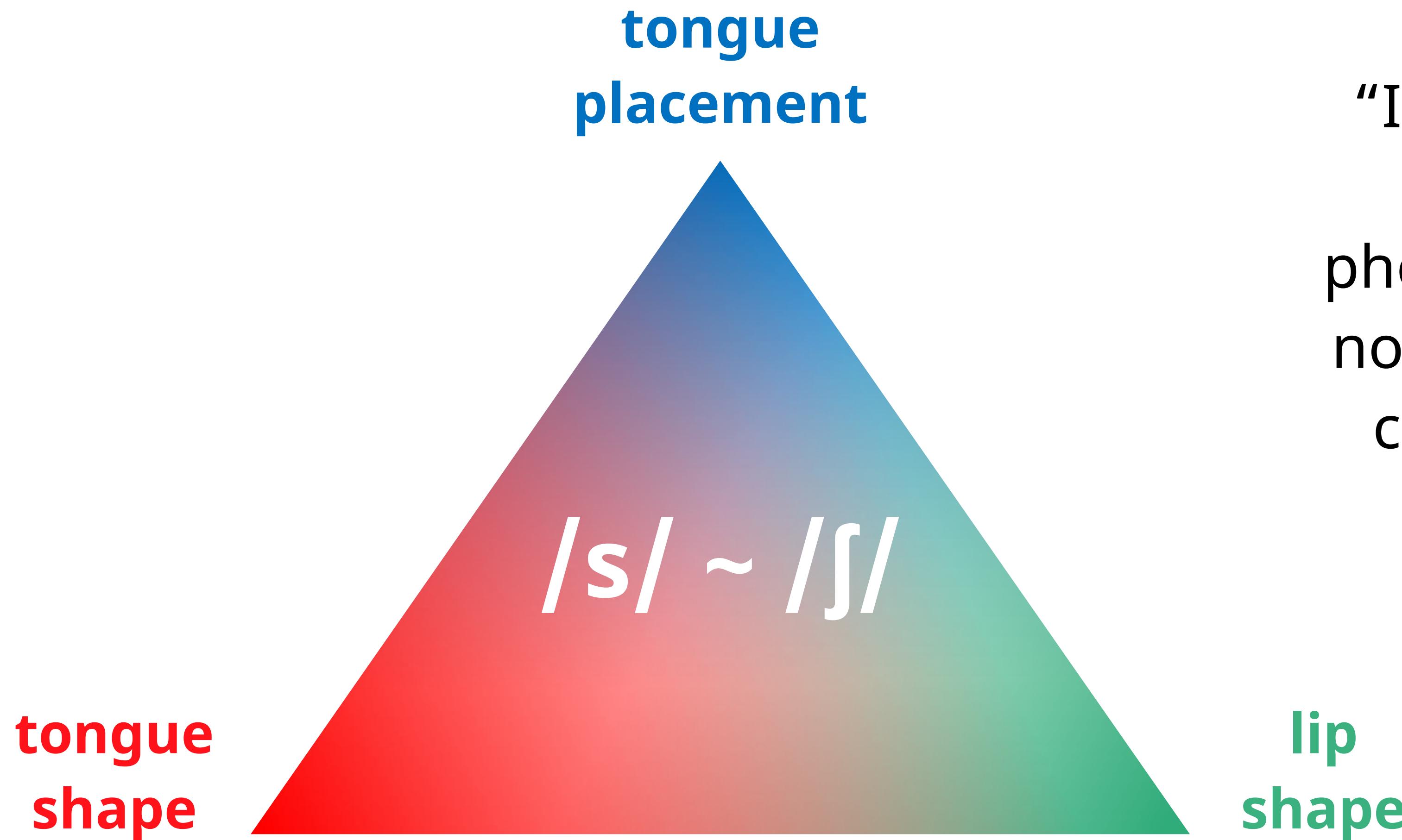
z#dj
e.g. these dunes

z#dɹ
e.g. his drink

(see Smith et al. 2019) ←

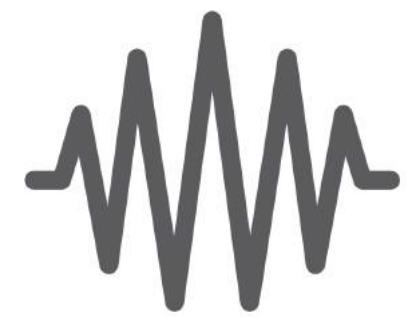
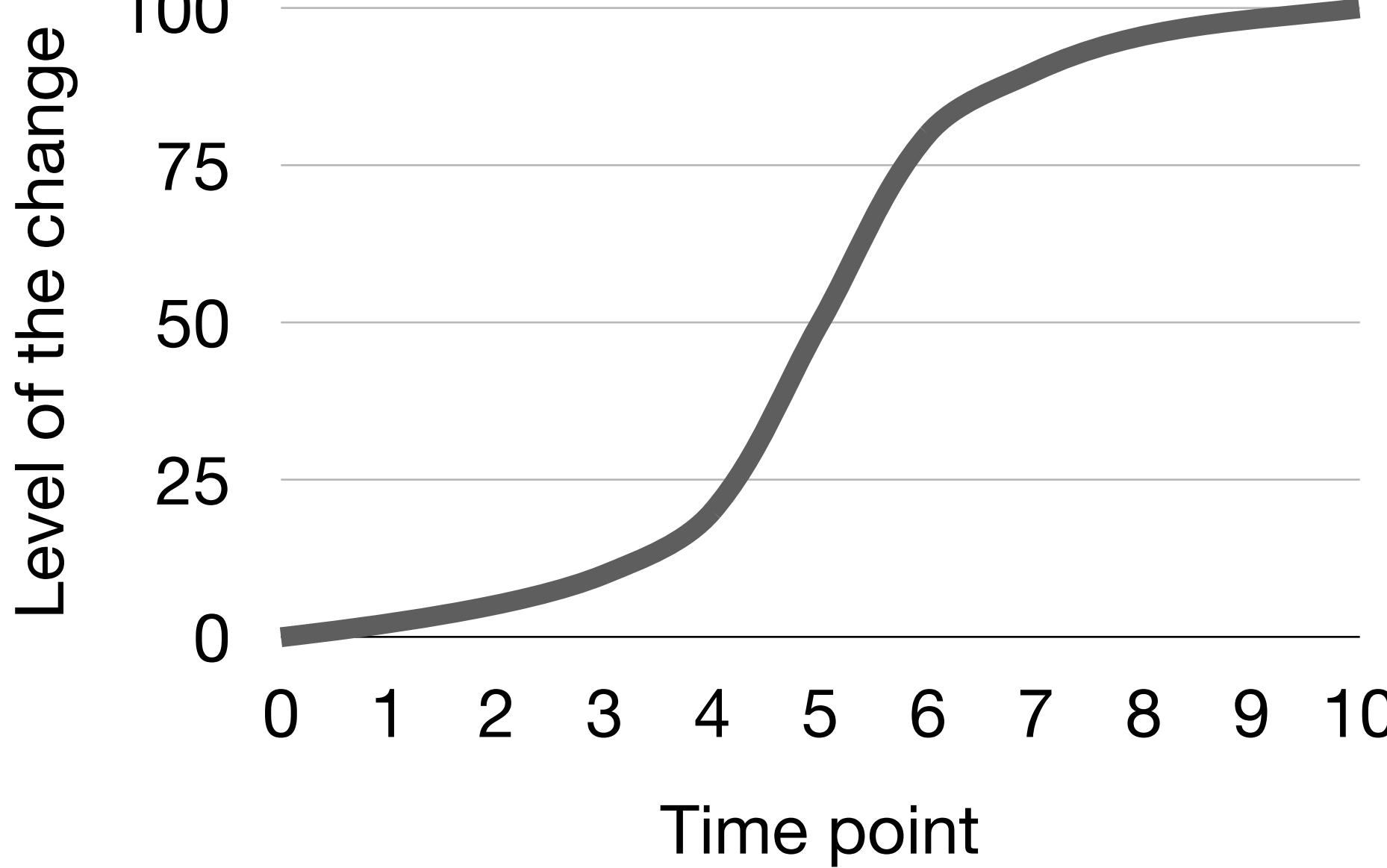
→ (see Zsiga 1995)

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**



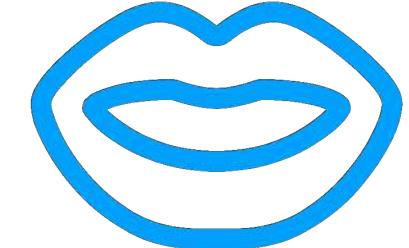
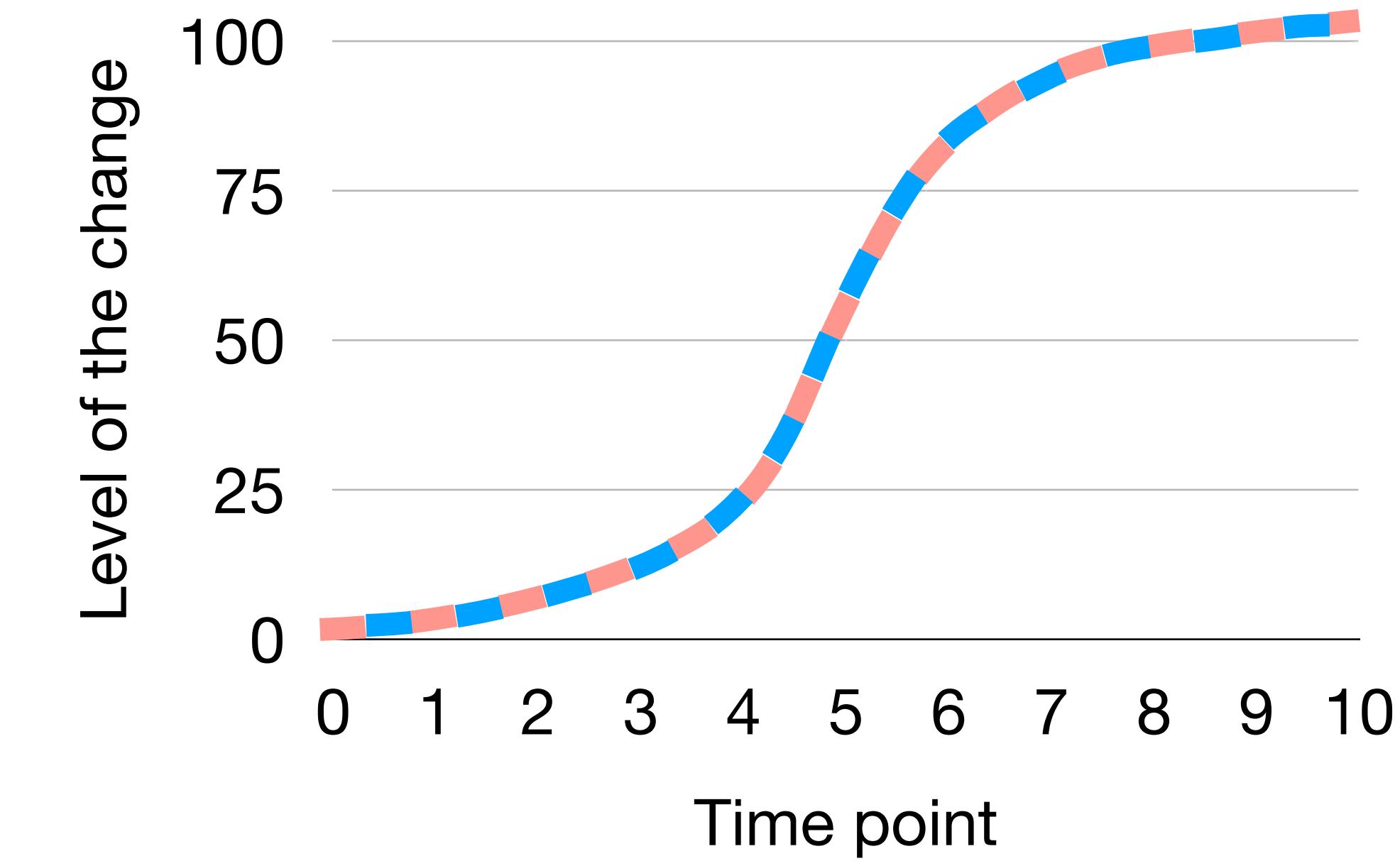
“It is also worth noting that changes in one of the phonetic parameters [...] may not necessarily co-occur with changes in the other two”

– Rutter 2011: 31

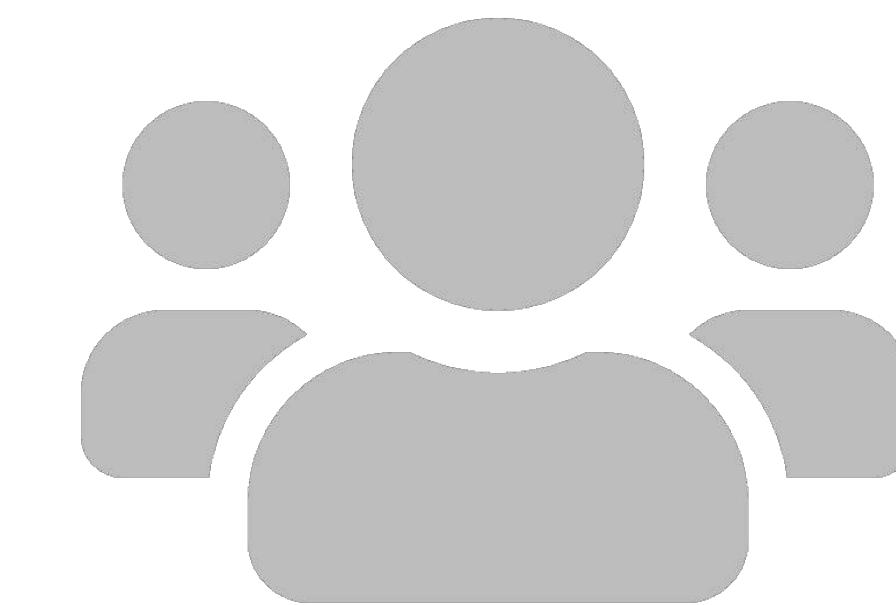
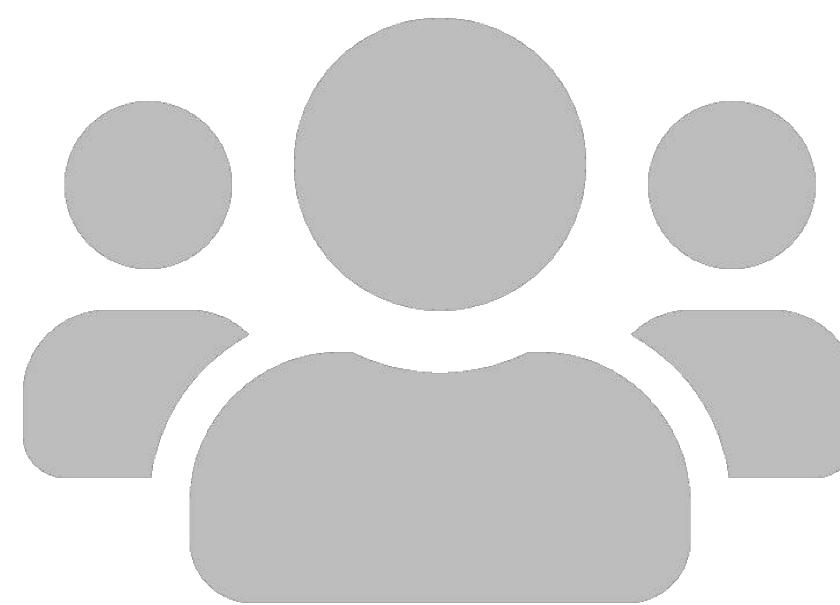
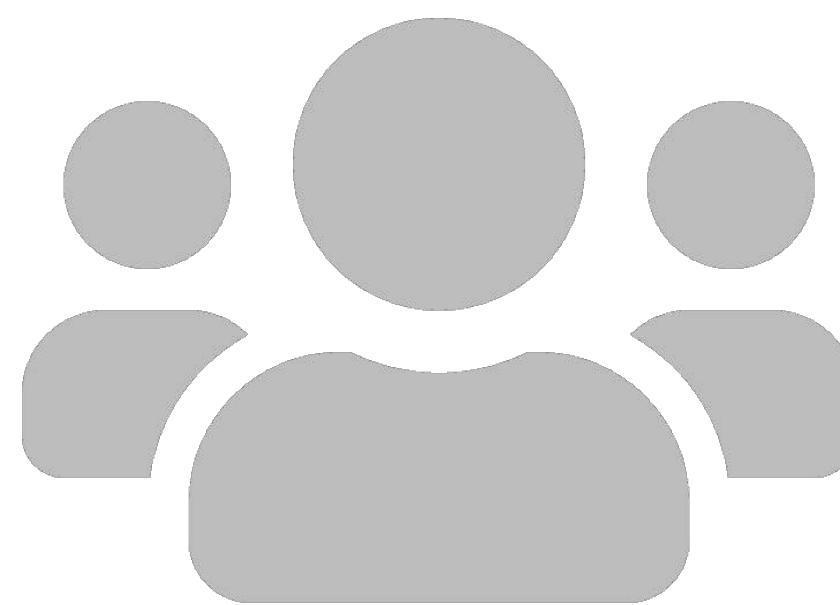
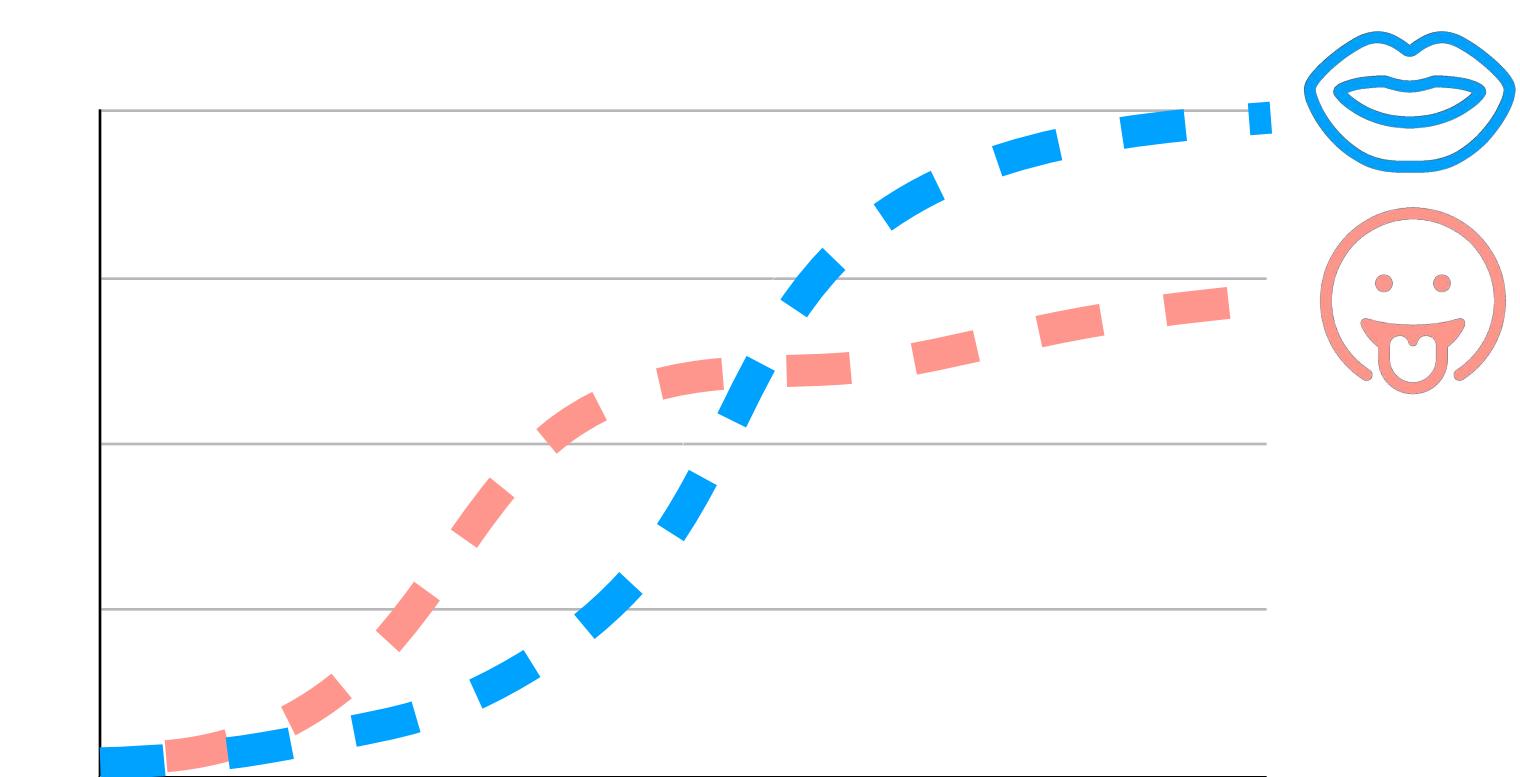
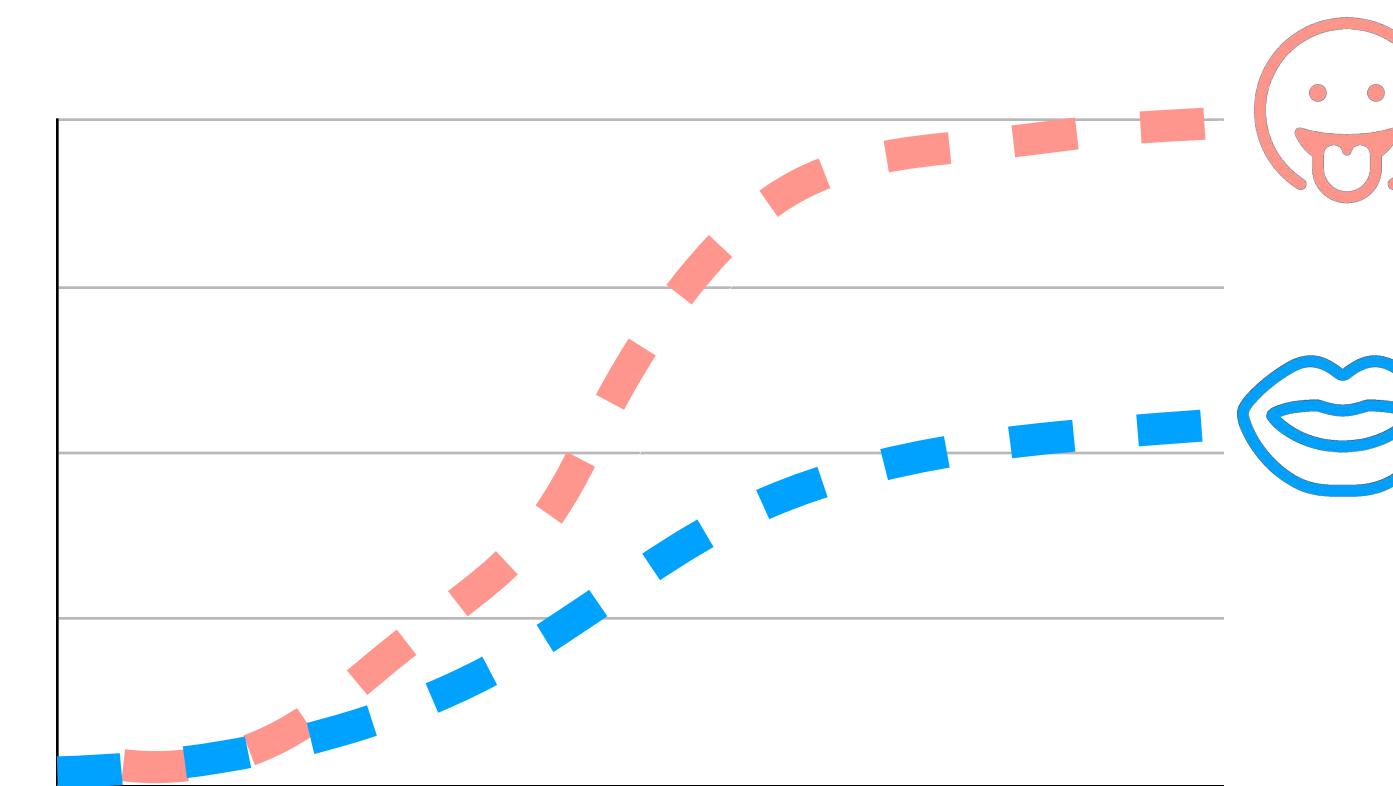
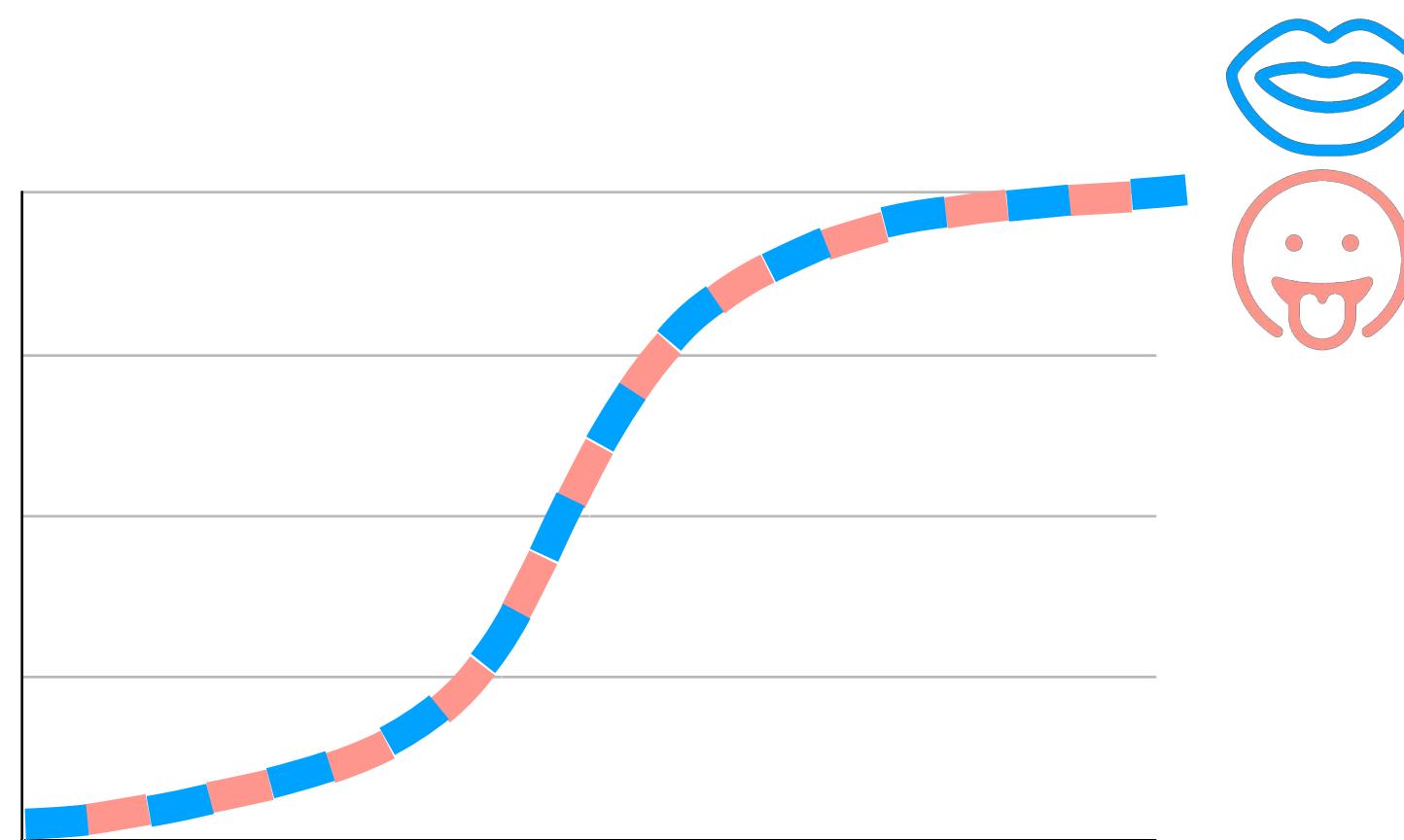


Tracking the acoustics of a sound change

Tracking the articulatory gestures involved in sound change



Articulatory variation, individuals, and the community



Methods

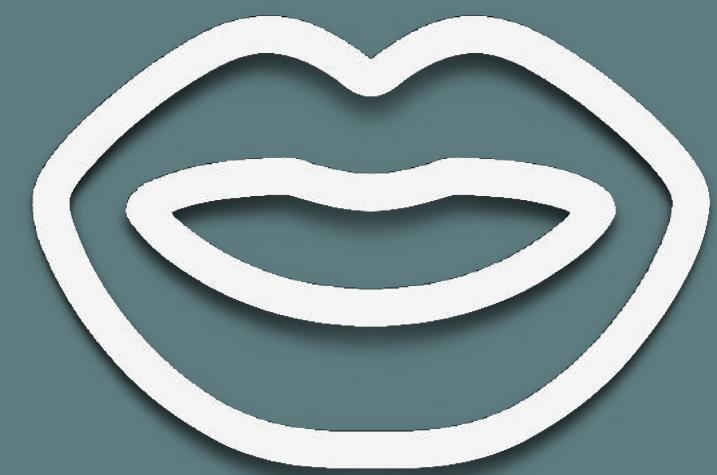
Data collection

- 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**

+

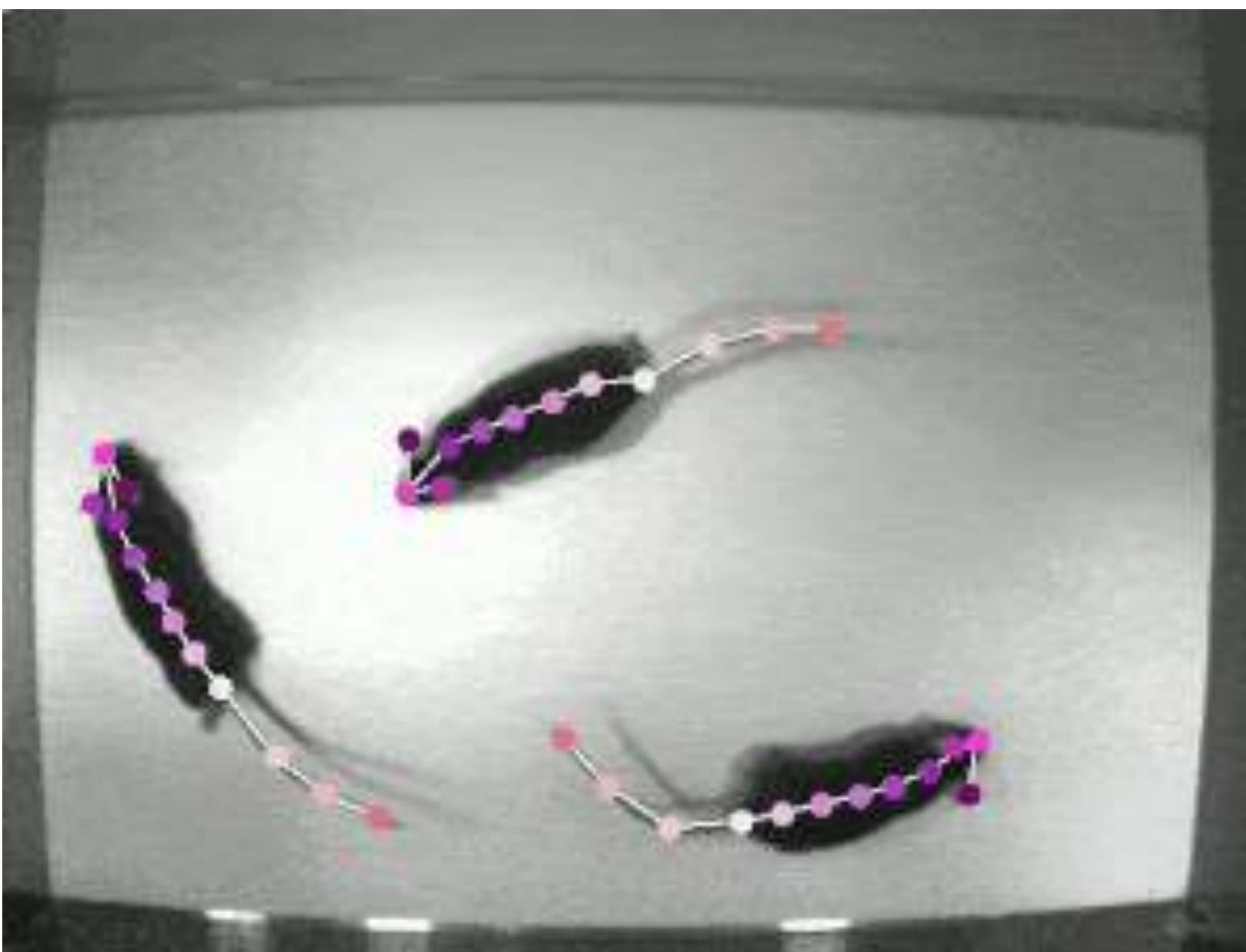
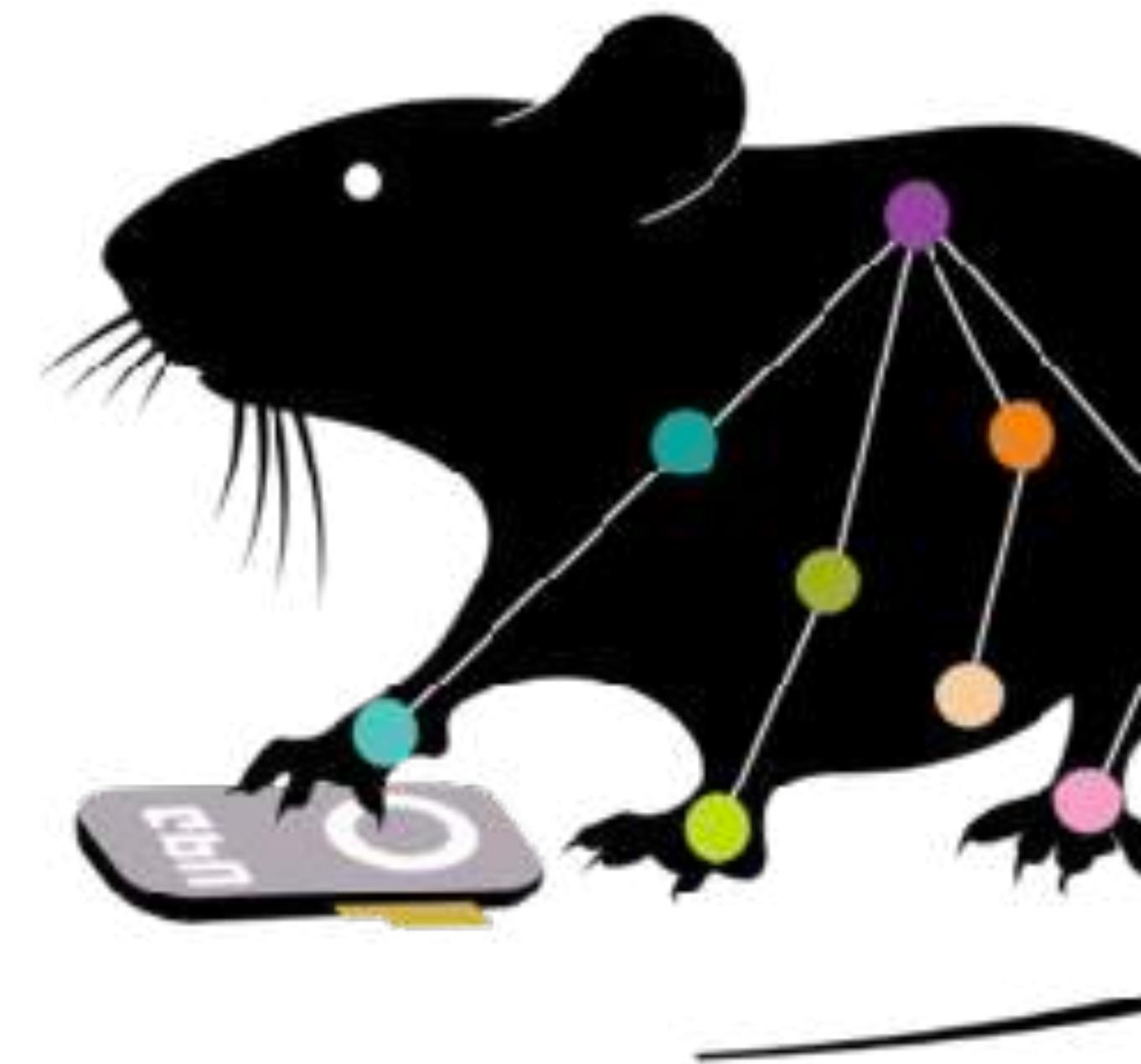


audio recording

Methods

Data processing

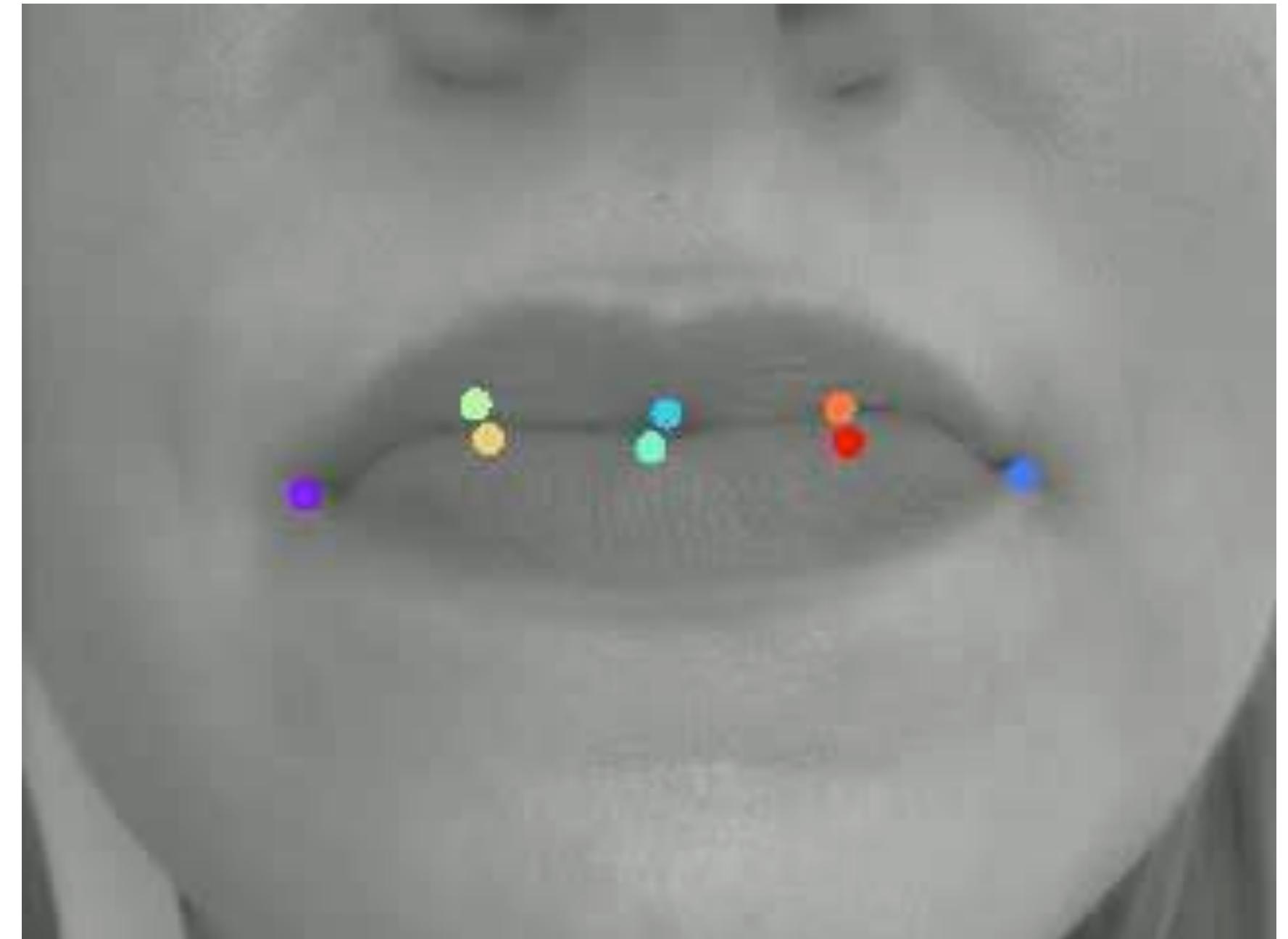
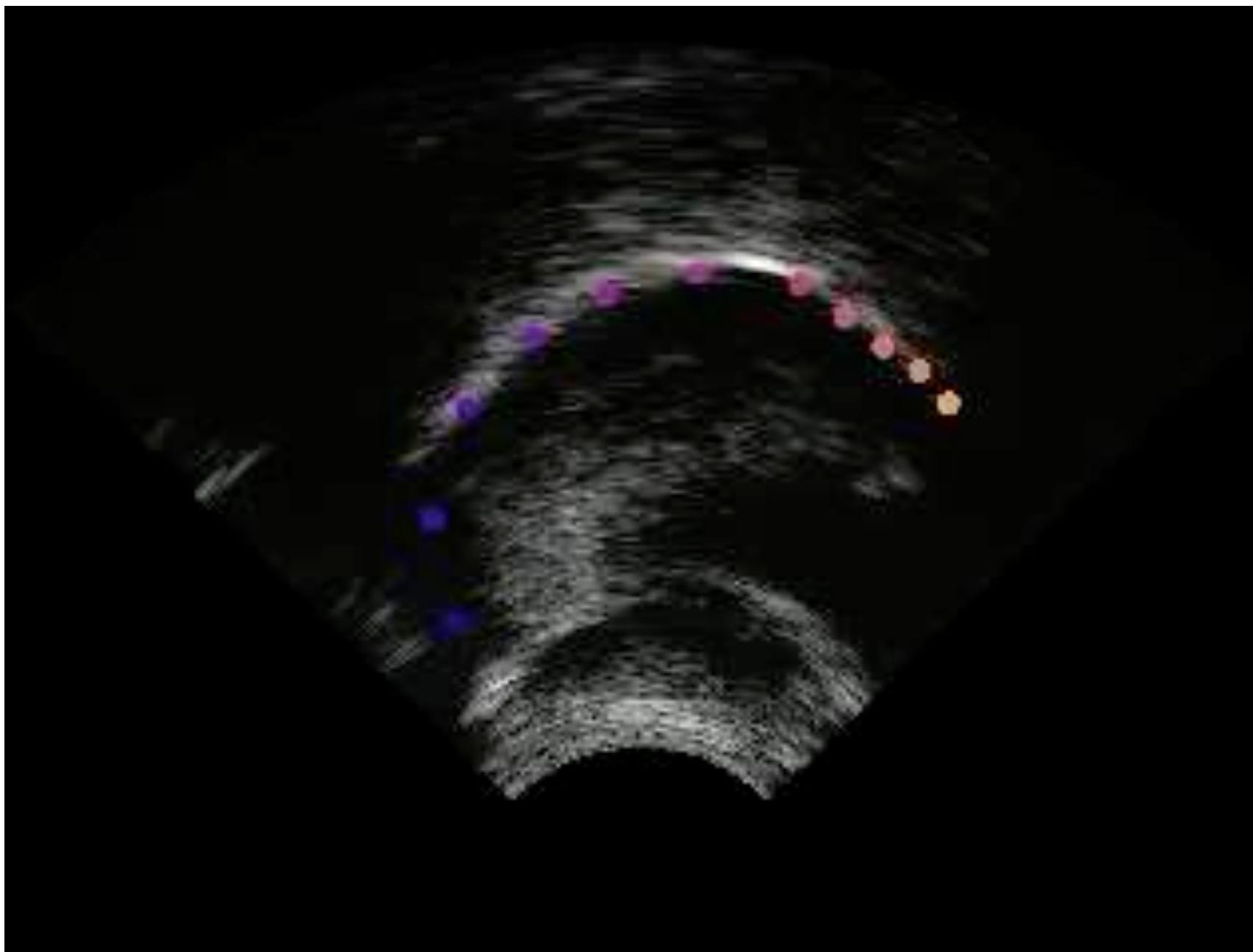
- **DeepLabCut** - new method of processing ultrasound recordings using machine learning and markerless pose estimation (Wrench & Balch-Tomé 2022)



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

		/ʃ, ʒ/	/tʃ, dʒ/	/tr, dr/	/tj, dj/	/r/	/j/
I said...	/u:/	shoe	chew toy	trooper	tube / tune	room	youth
	/i:/	sheep	cheese	tree	—	reed	yeast / year
	/ɒ/	shop	chopper	trolley	—	rock	yacht
the/z/e	/u:/	jus (PL)	jewels	druids	dunes / dukes		
	/i:/	gilets	jeeps	dreams	—		
	/ɒ/	genres	jobs	drops	—		

Methods

Stimuli design

word-initial retraction

I said...

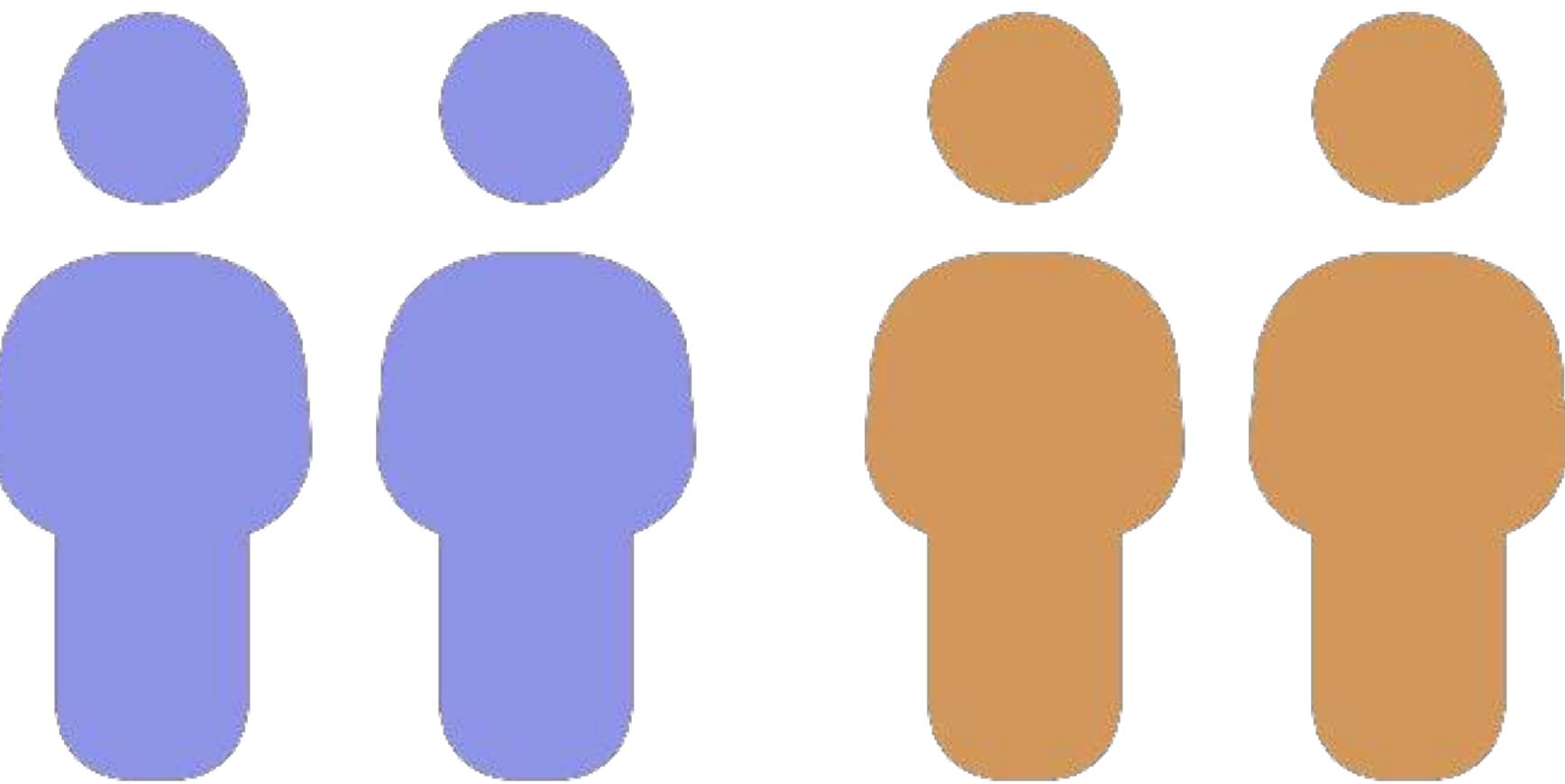
th/ə/

		/s/	/stu/	/stj/	/ʃ/
I said...	/u:/	soup	stroop test	student / stupid	chute
	/i:/	seat	street	—	sheet
	/ɒ/	sock	strop	—	shot
		/z/			/ʒ/
	/u:/	zoo			jus
	/i:/	zine			gilet
	/ɒ/	zombie			genre

Methods

Population sample

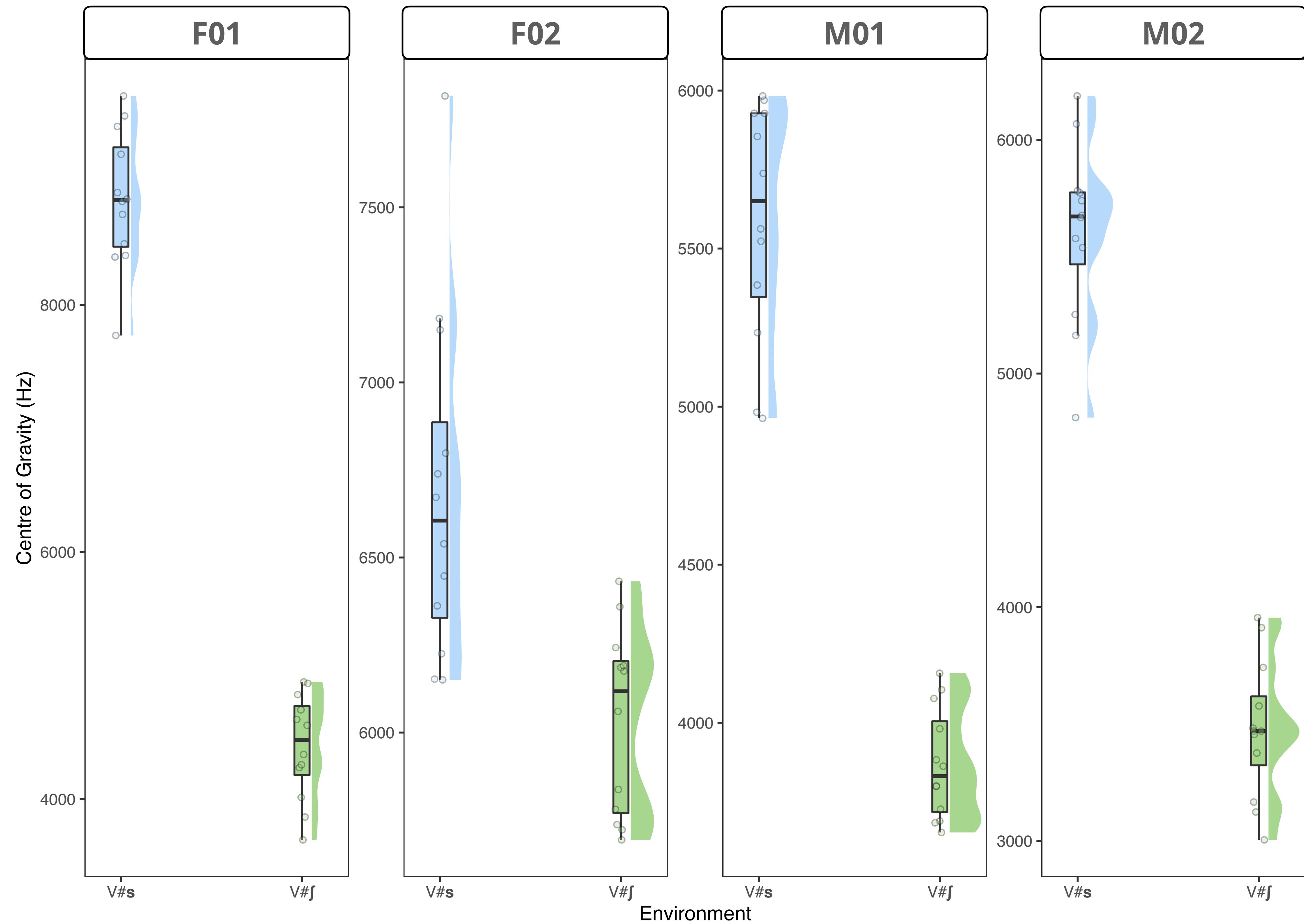
- 4 speakers recorded and analysed so far
 - 2x M from Manchester
 - 2x F from Blackburn
 - all aged 28–30
- Highly complex time-series dataset: roughly 1 million rows of observations *per speaker*



Acoustics

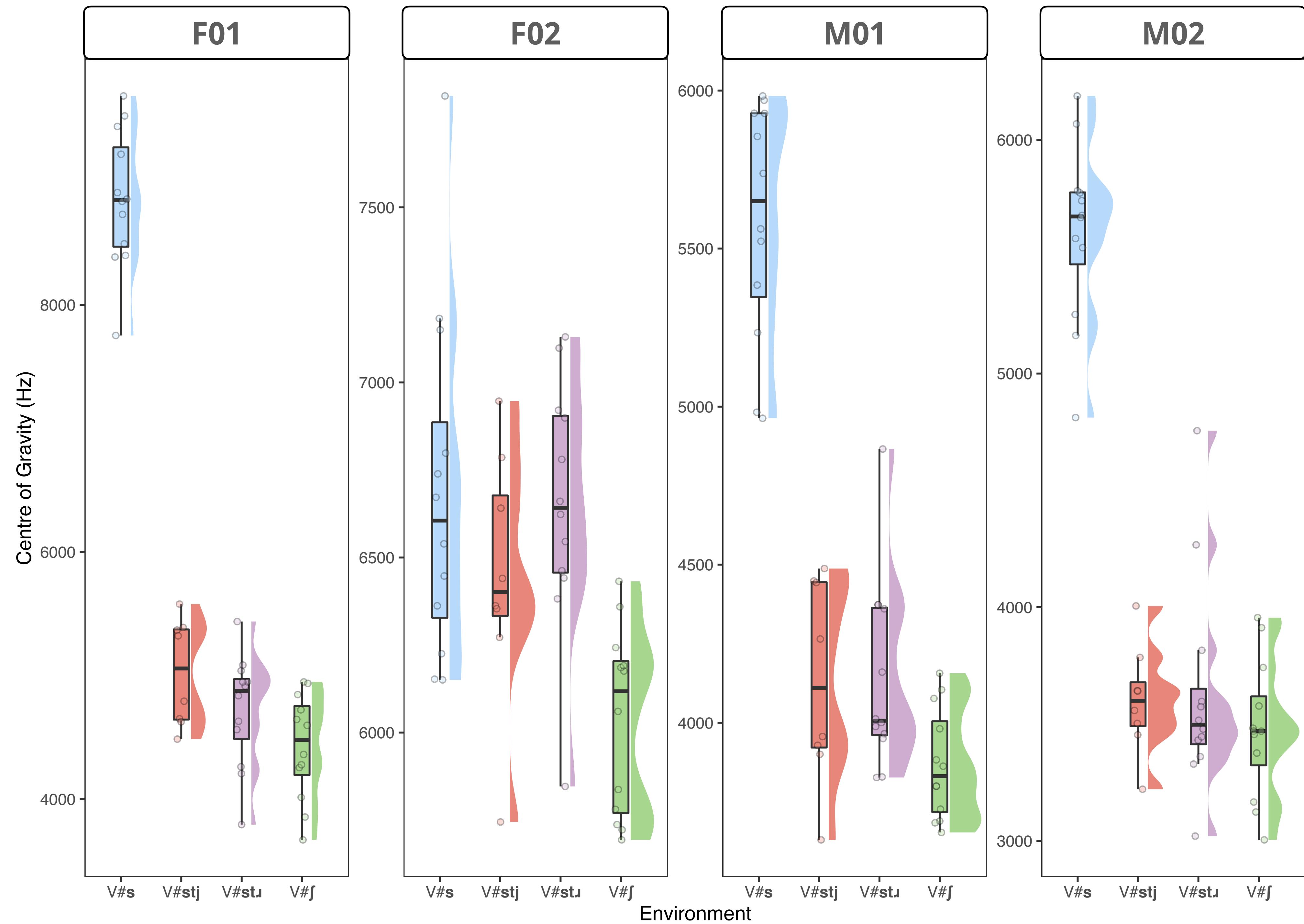
word-internal retraction





$\text{V}\#\text{s}$
e.g. *seat*

$\text{V}\#\text{ʃ}$
e.g. *sheet*

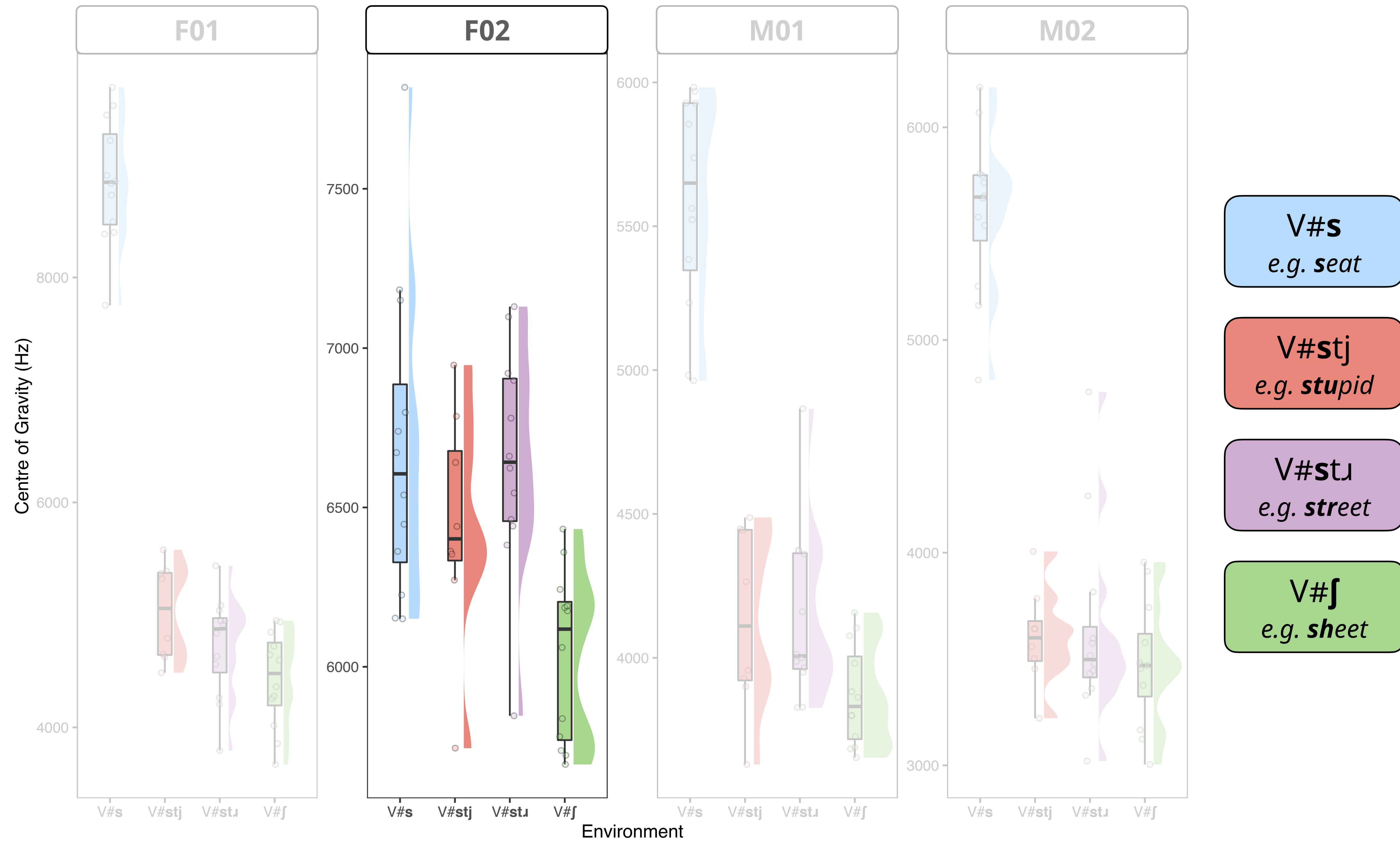


V#s
e.g. *seat*

V#stj
e.g. *stupid*

V#stu
e.g. *street*

V#ʃ
e.g. *sheet*



V#s
e.g. *seat*

V#stj
e.g. *stupid*

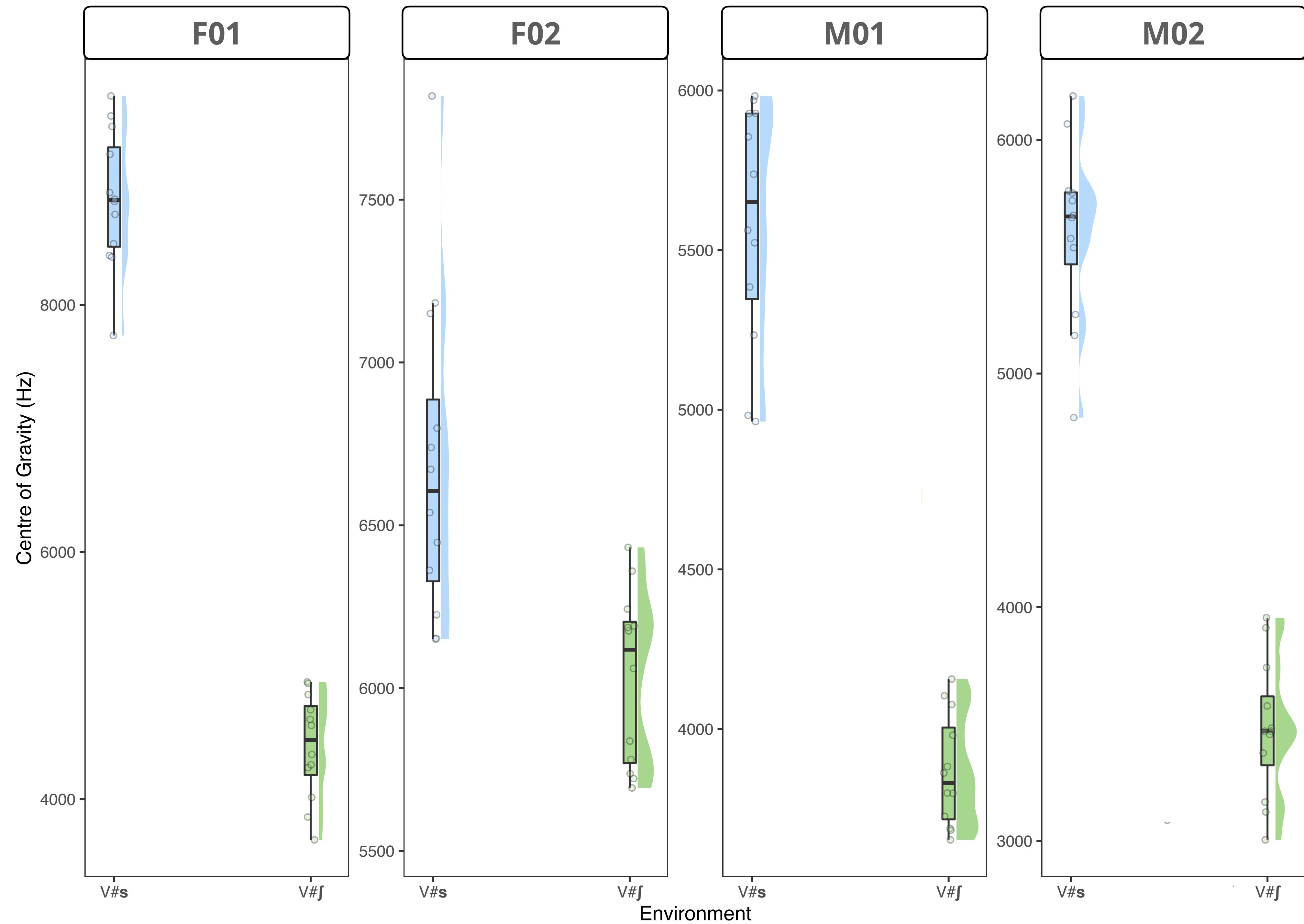
V#stu
e.g. *street*

V#ʃ
e.g. *sheet*

Acoustics

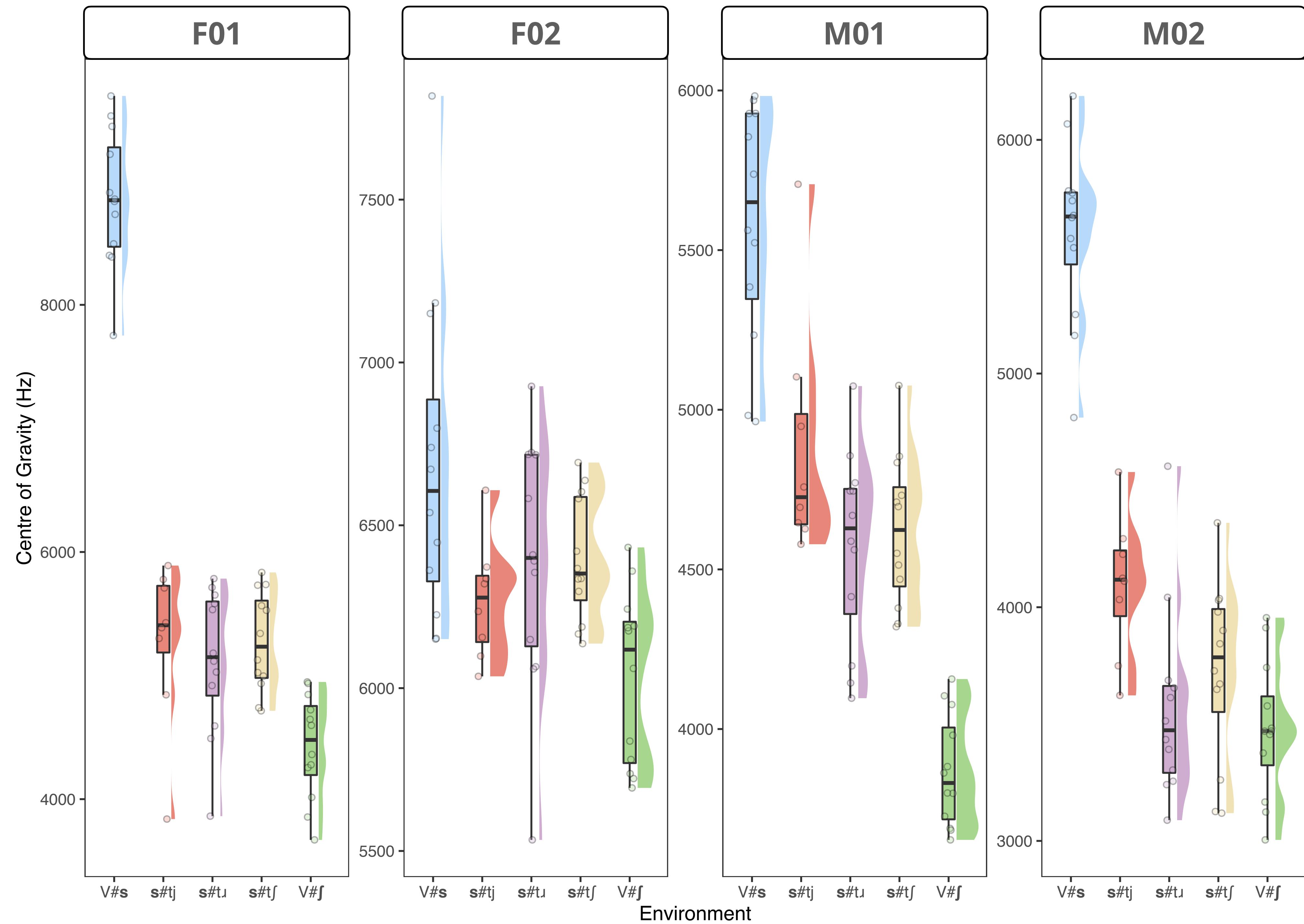
post-lexical retraction





V#s
e.g. seat

V#ʃ
e.g. sheet



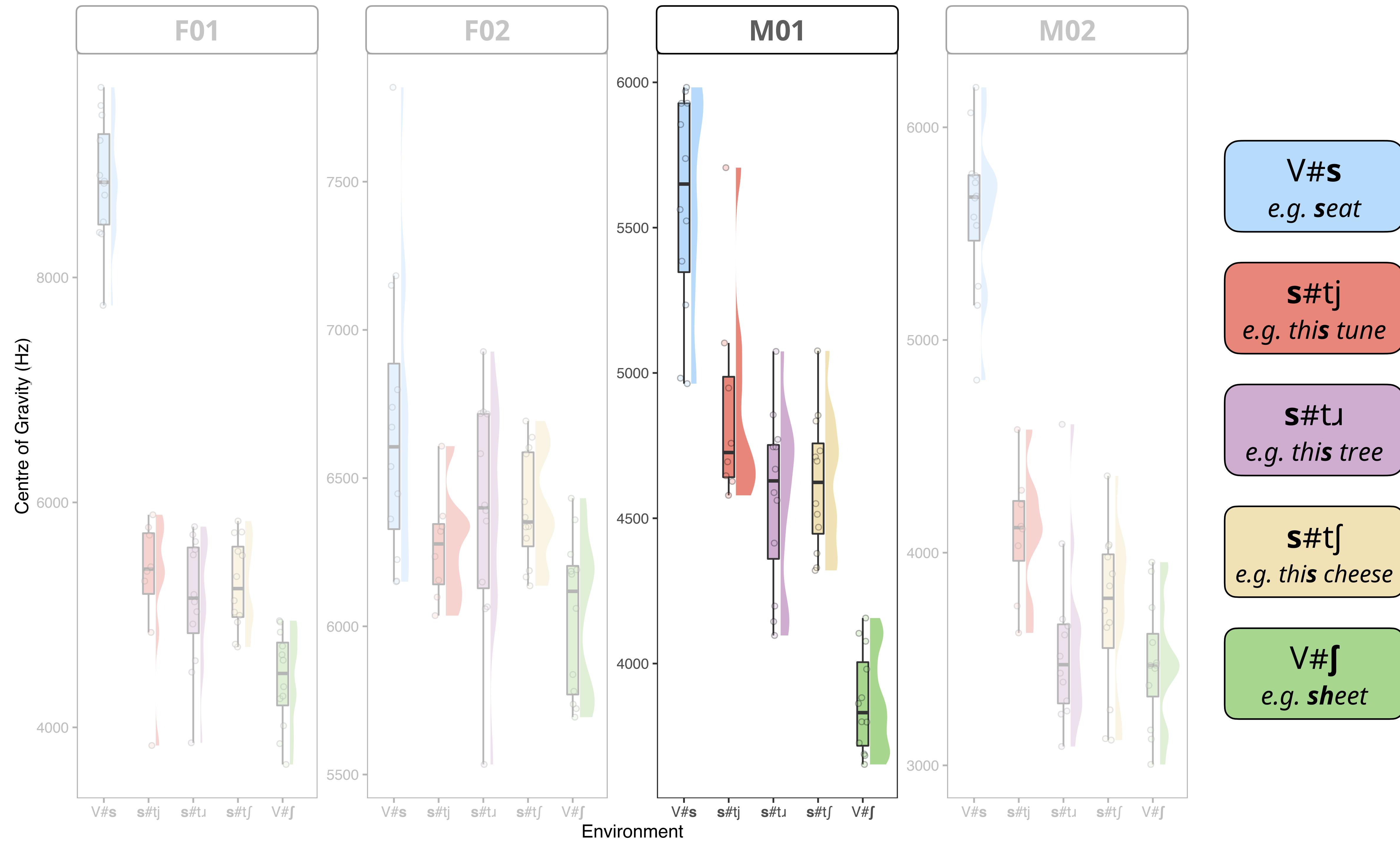
V#s
e.g. *seat*

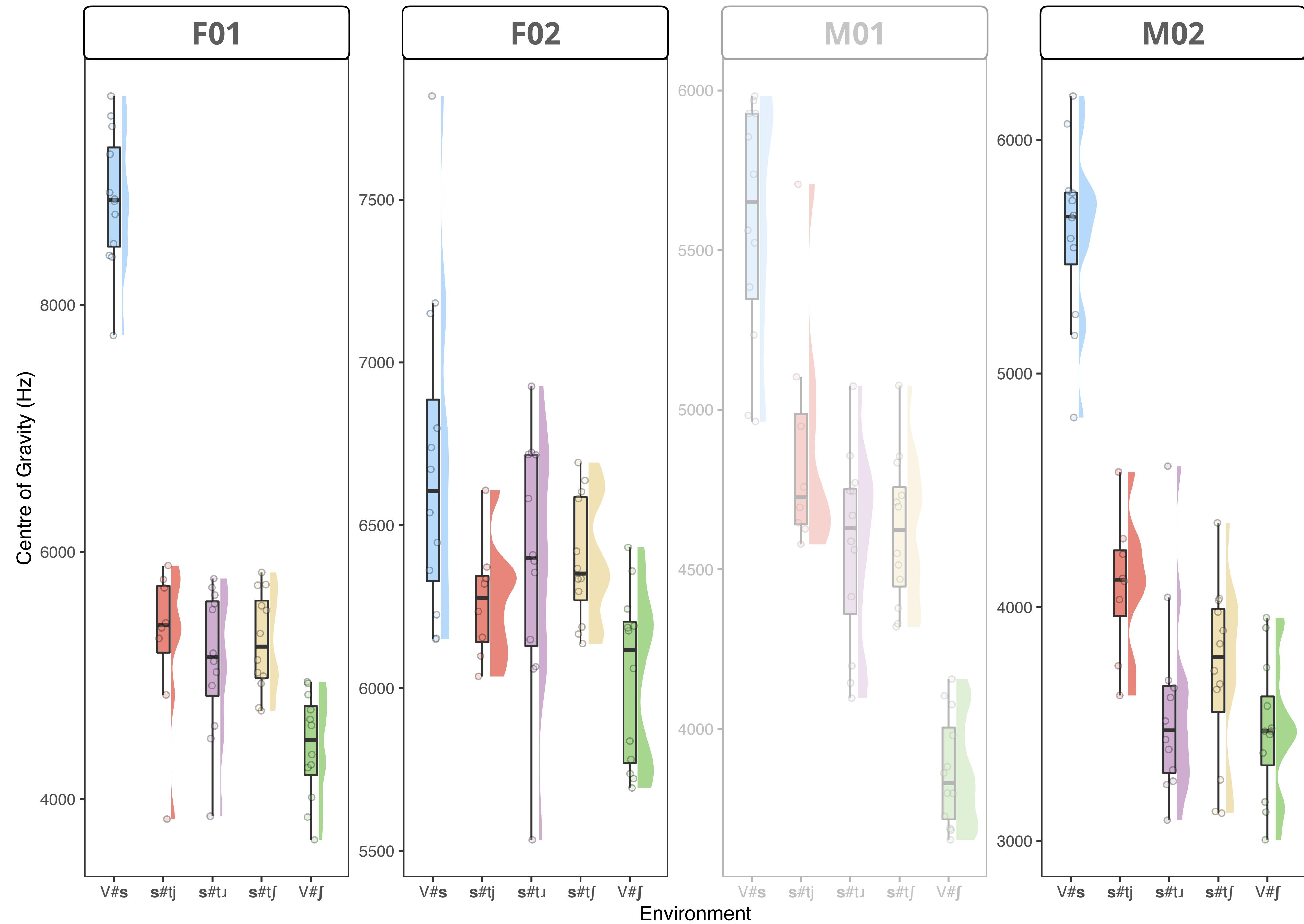
s#tj
e.g. *this tune*

s#tu
e.g. *this tree*

s#tʃ
e.g. *this cheese*

V#ʃ
e.g. *sheet*





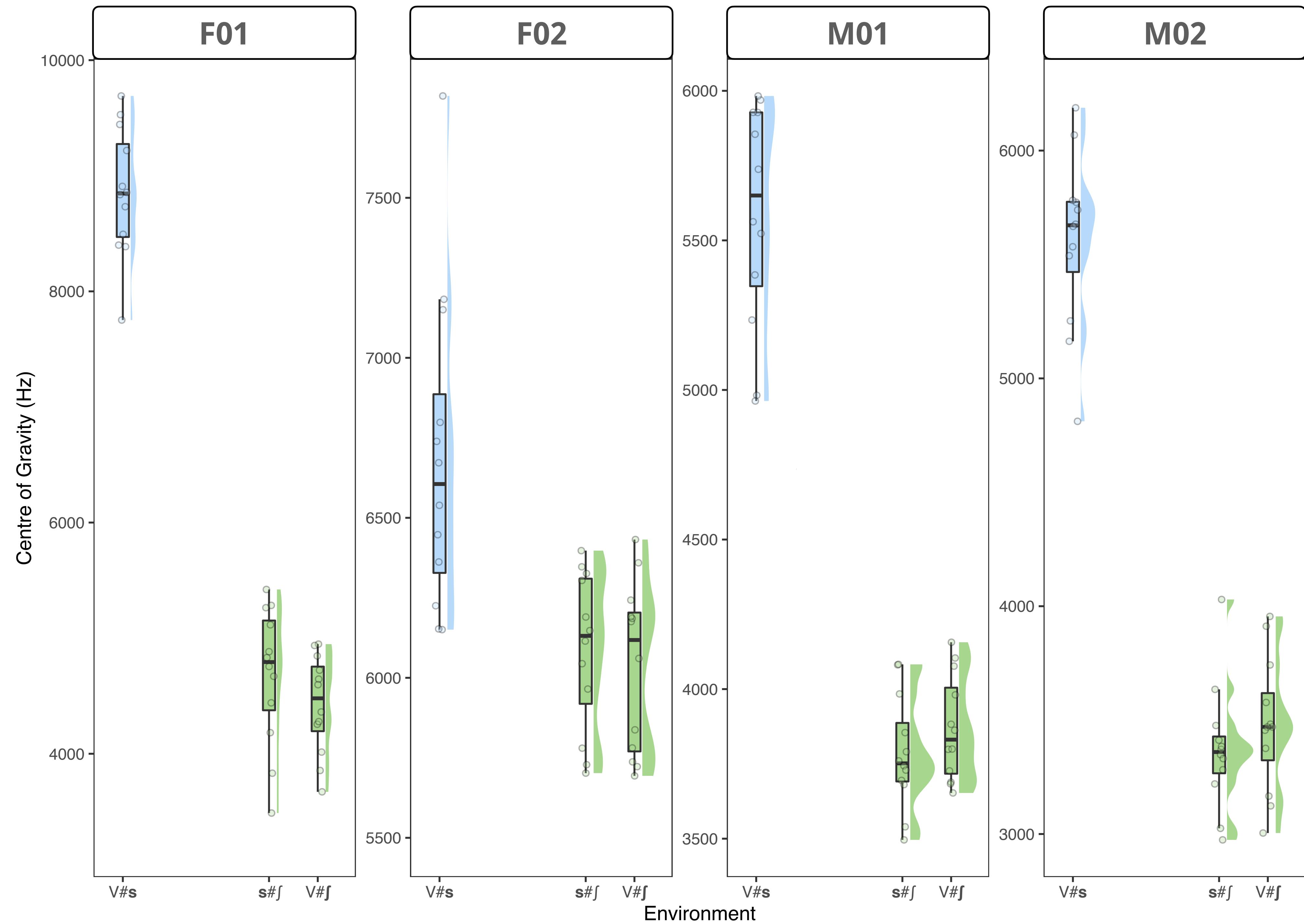
V#s
e.g. *seat*

s#tj
e.g. *this tune*

s#tu
e.g. *this tree*

s#tʃ
e.g. *this cheese*

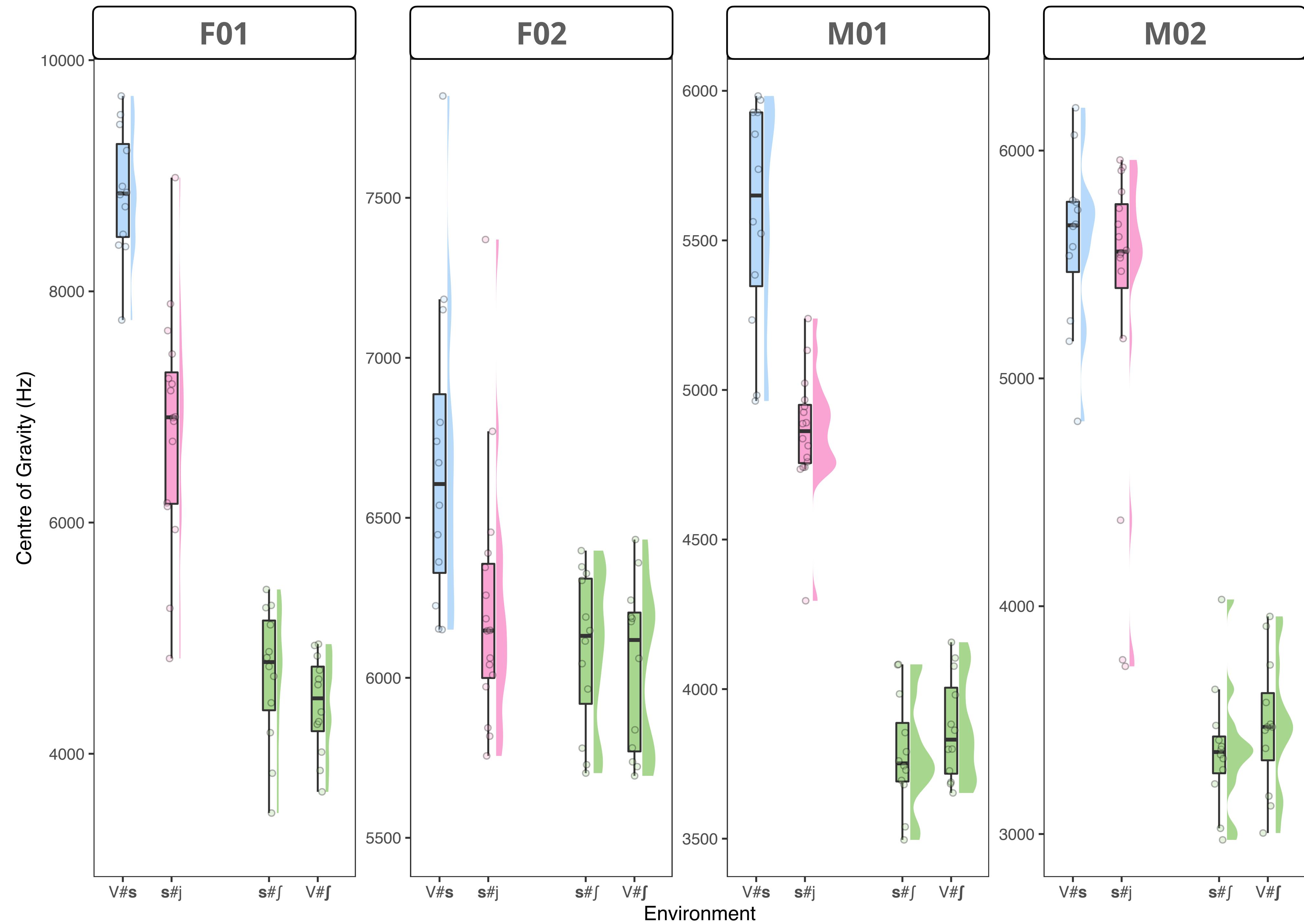
V#ʃ
e.g. *sheet*



V#s
e.g. *seat*

s#ʃ
e.g. *this sheep*

V#ʃ
e.g. *sheet*

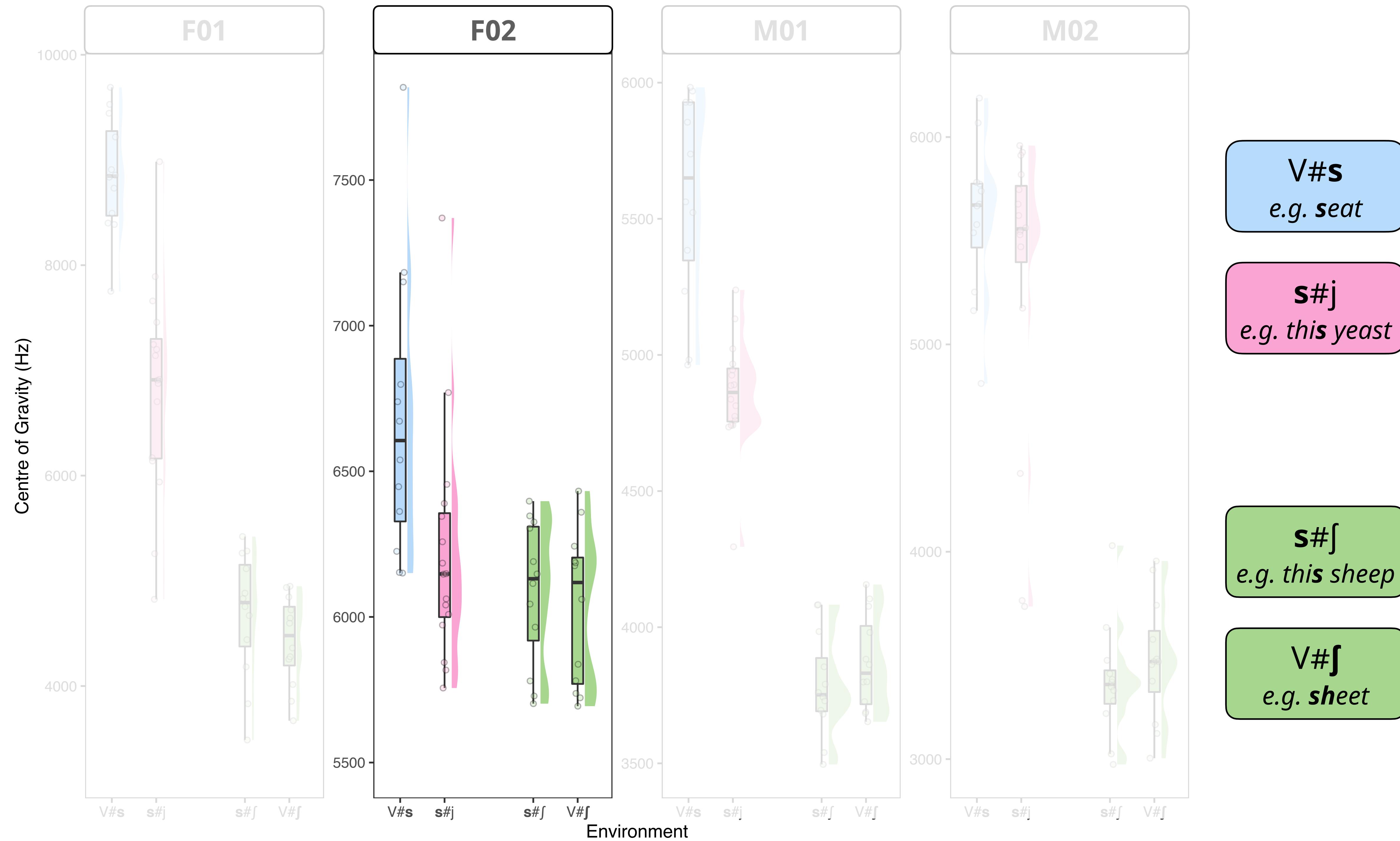


V#s
e.g. *seat*

s#j
e.g. *this yeast*

s#ʃ
e.g. *this sheep*

V#ʃ
e.g. *sheet*

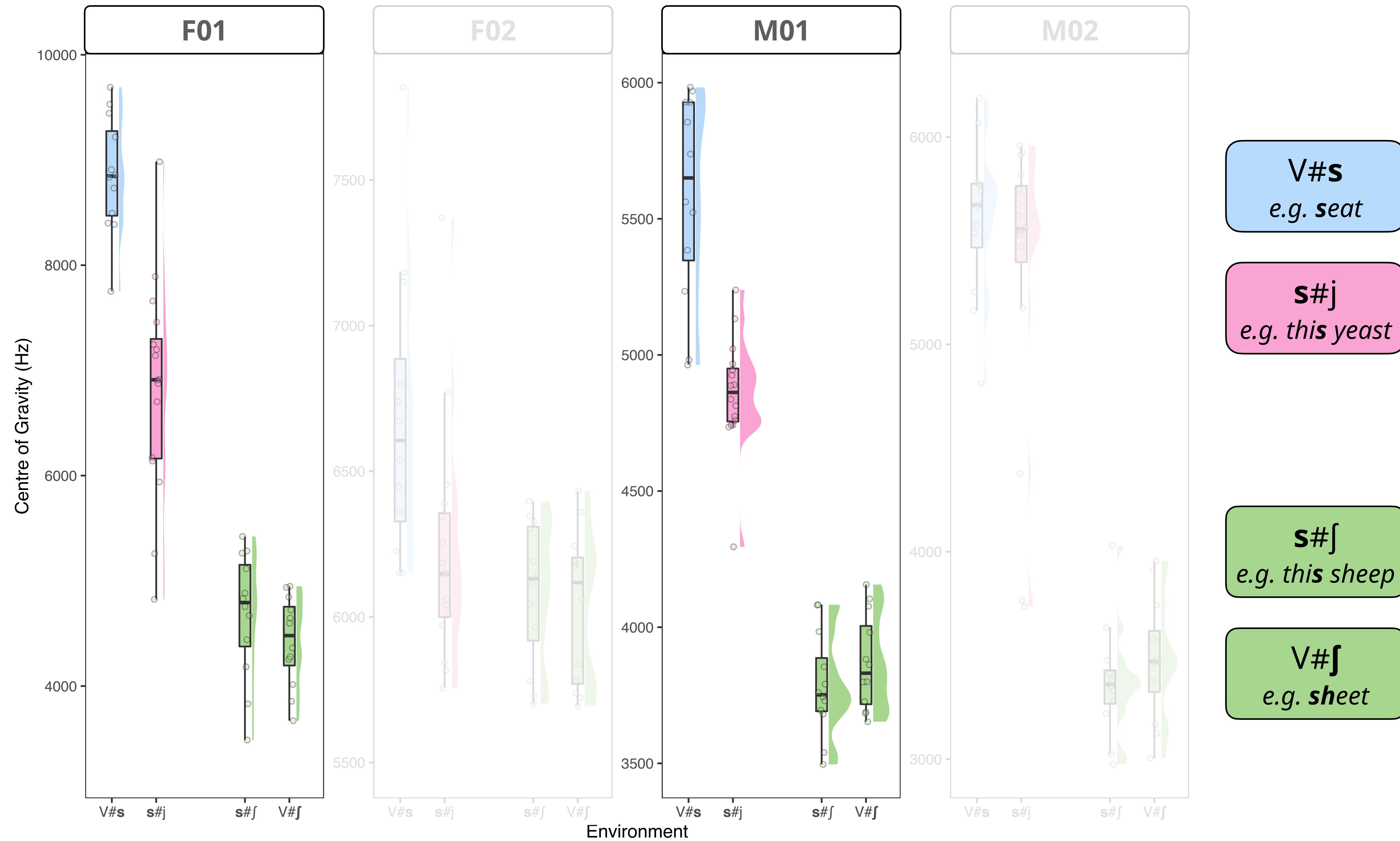


V#s
e.g. *seat*

s#j
e.g. *this yeast*

s#ʃ
e.g. *this sheep*

V#ʃ
e.g. *sheet*



Centre of Gravity (Hz)

F01

F02

M01

M02

V#s s#j

s#ʃ V#ʃ

V#s s#j

s#ʃ V#ʃ

V#s s#j

s#ʃ V#ʃ

V#s s#j

s#ʃ V#ʃ

Environment

F01

F02

M01

M02

V#s

e.g. seat

s#j

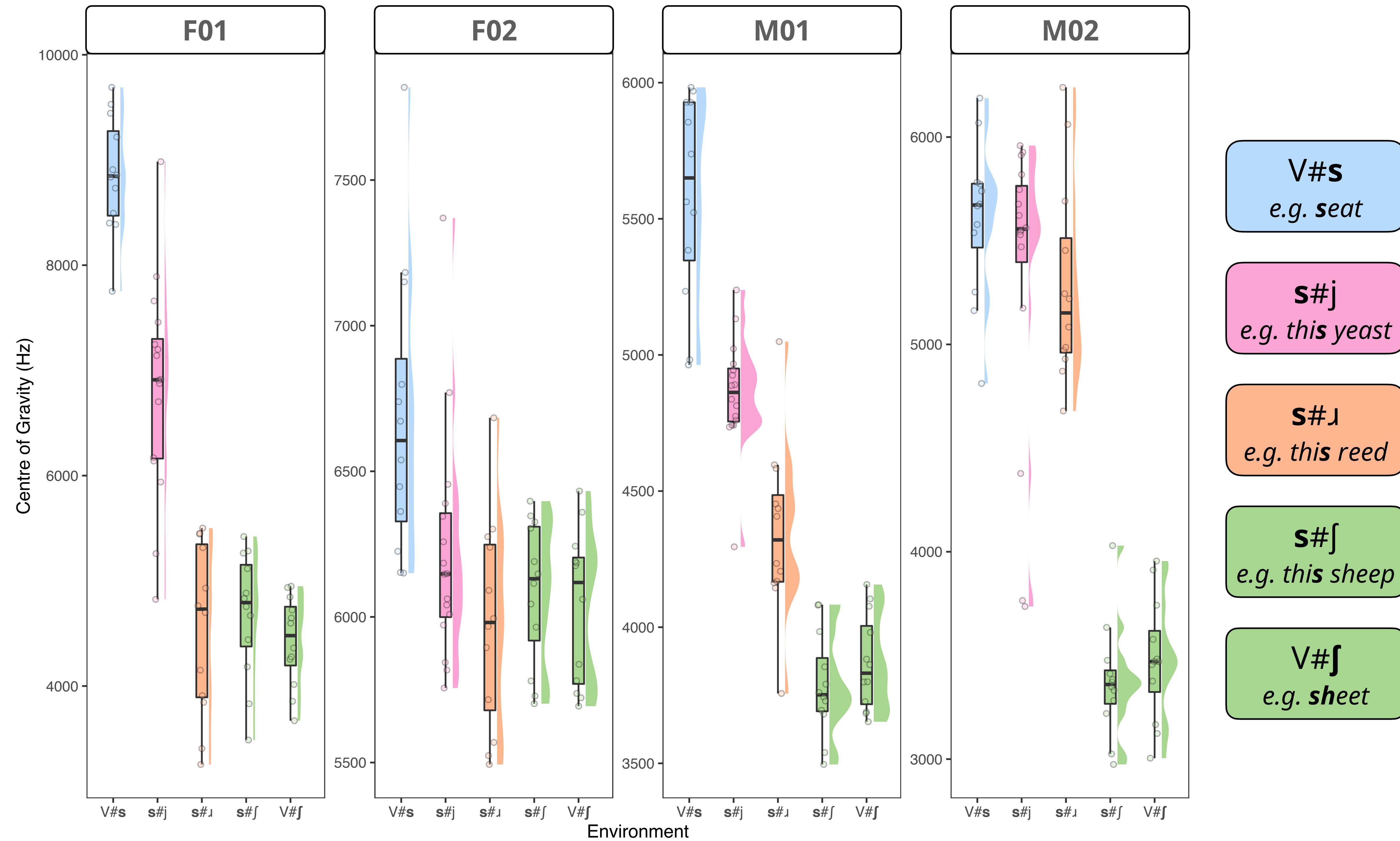
e.g. this yeast

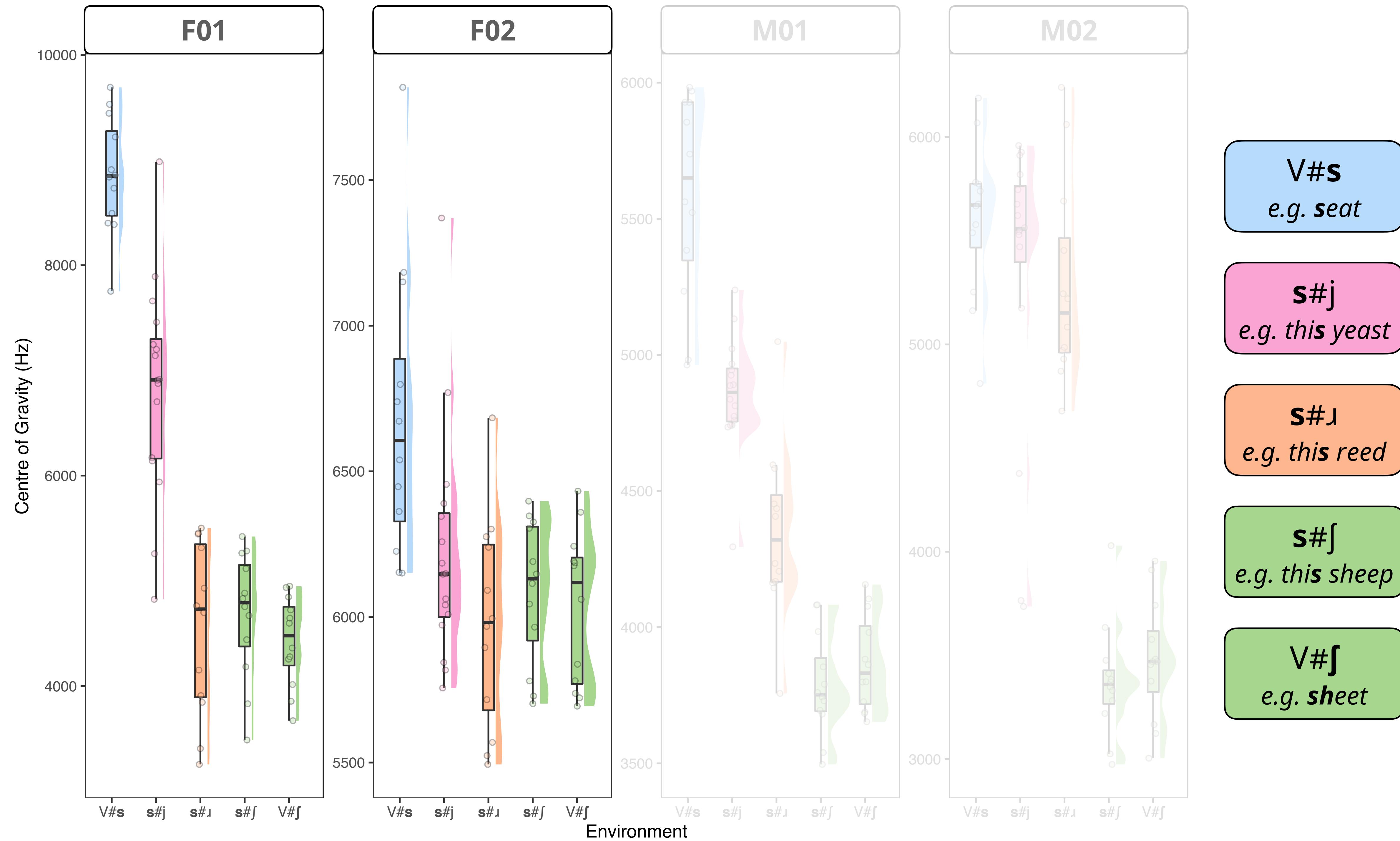
s#ʃ

e.g. this sheep

V#ʃ

e.g. sheet





V#s
e.g. *seat*

s#j
e.g. *this yeast*

s#r
e.g. *this reed*

s#ʃ
e.g. *this sheep*

V#ʃ
e.g. *sheet*

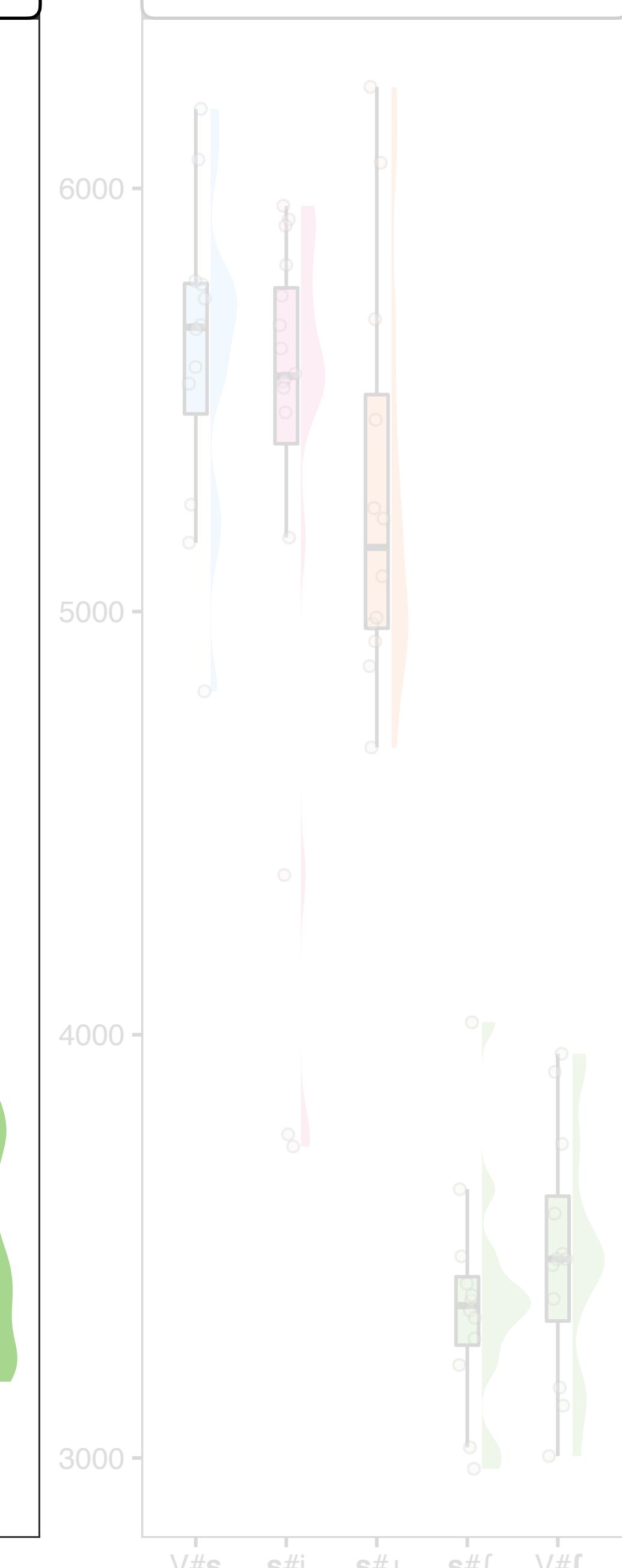
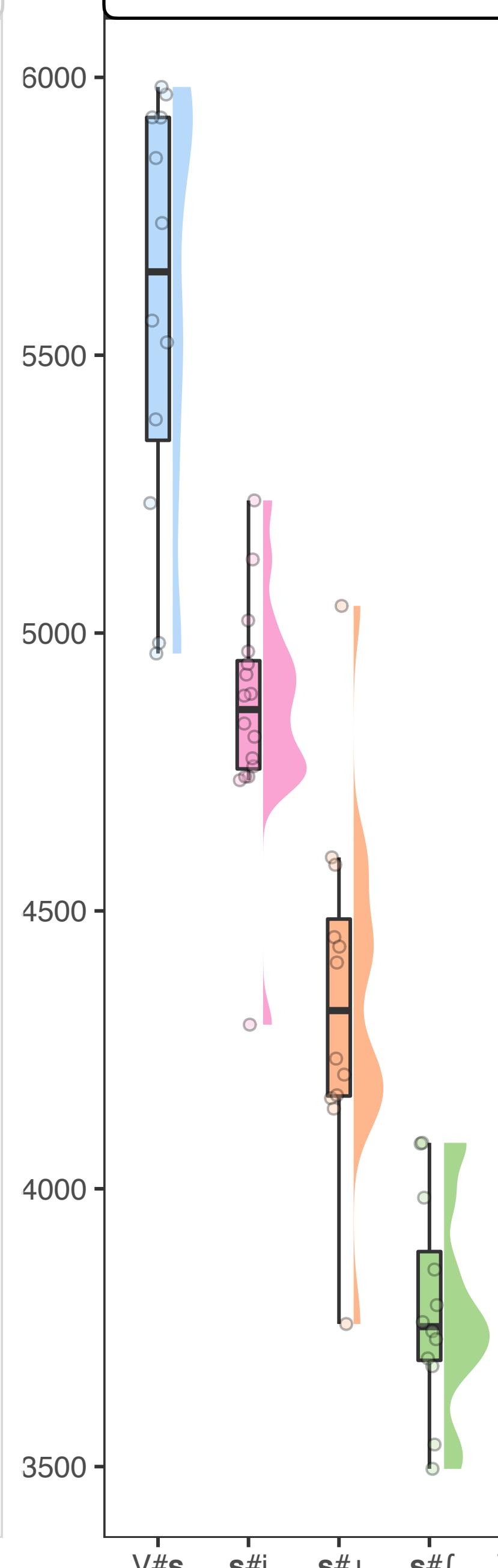
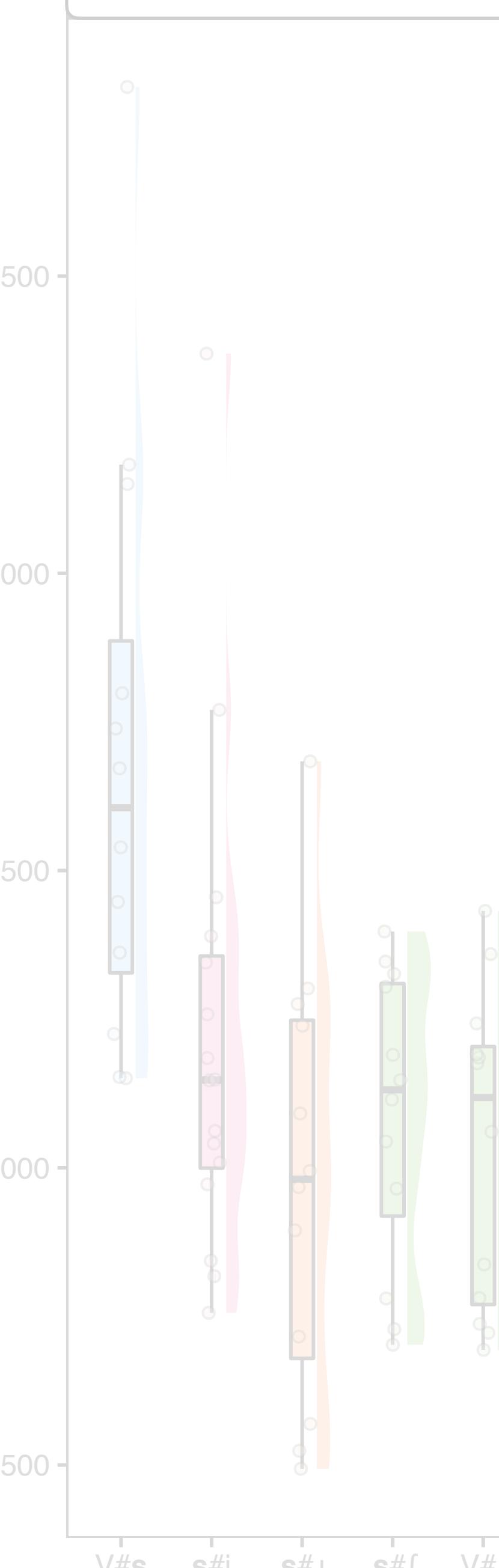
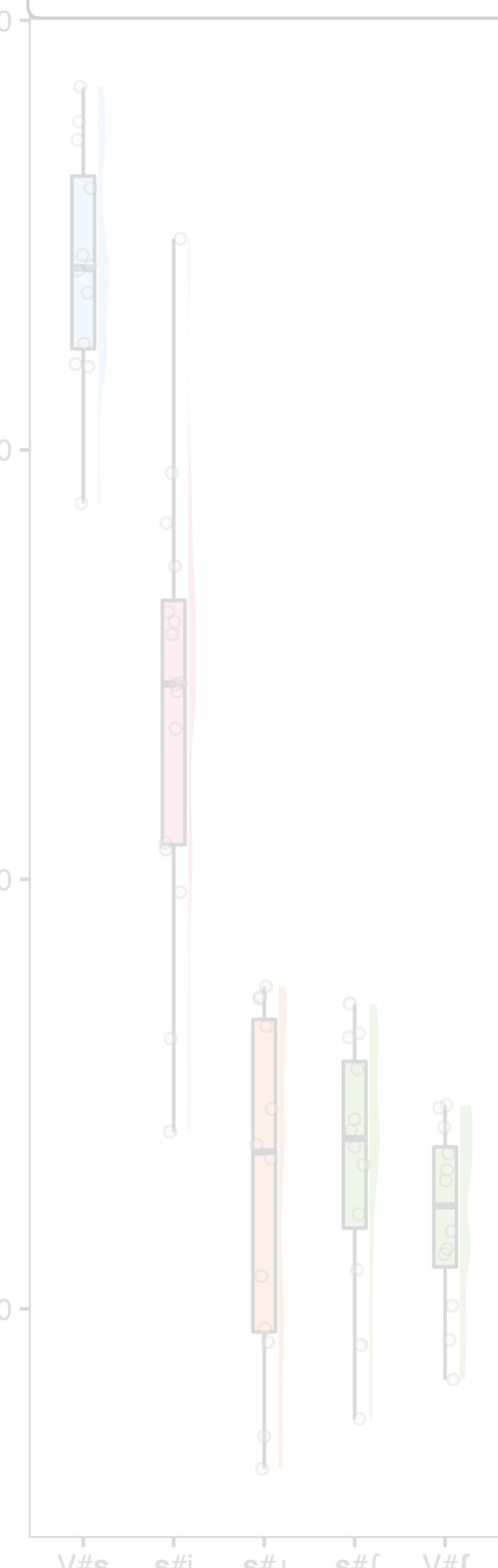
Centre of Gravity (Hz)

F01

F02

M01

M02



V#s
e.g. *seat*

s#j
e.g. *this yeast*

s#r
e.g. *this reed*

s#ʃ
e.g. *this sheep*

V#ʃ
e.g. *sheet*

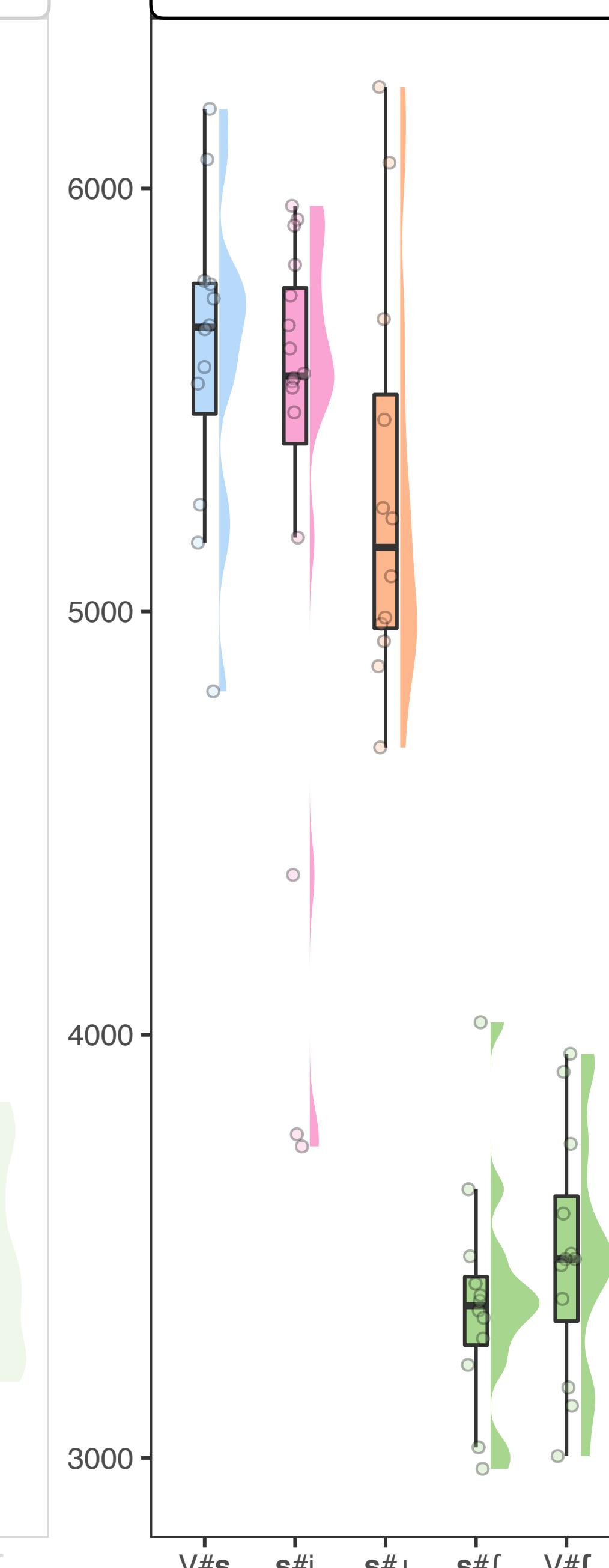
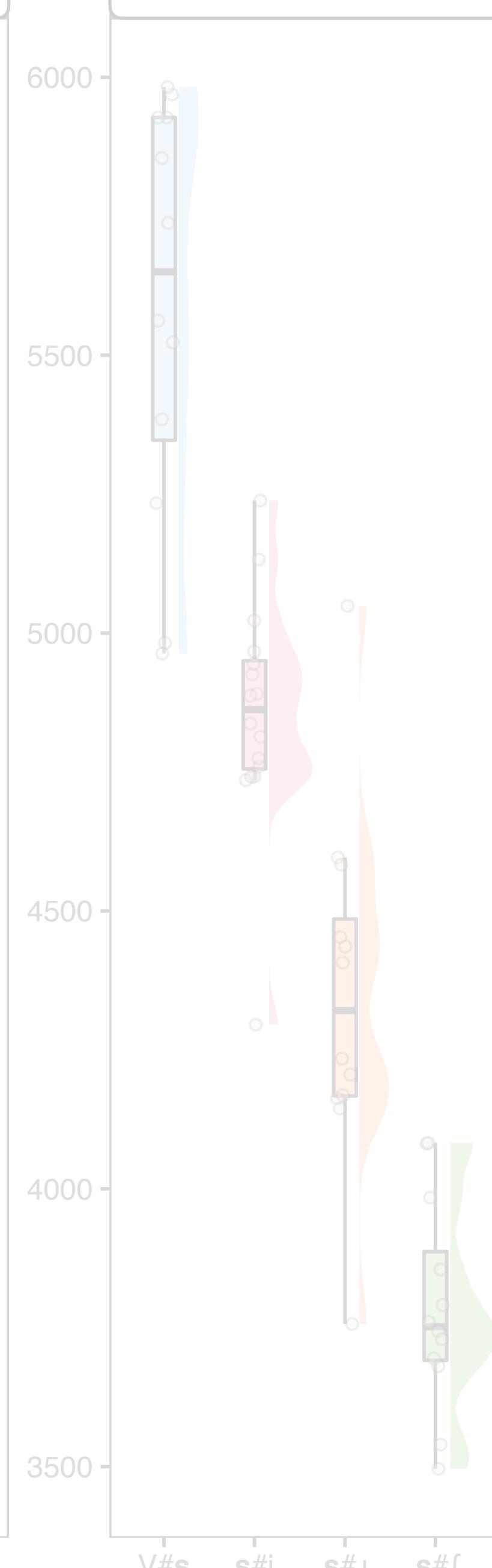
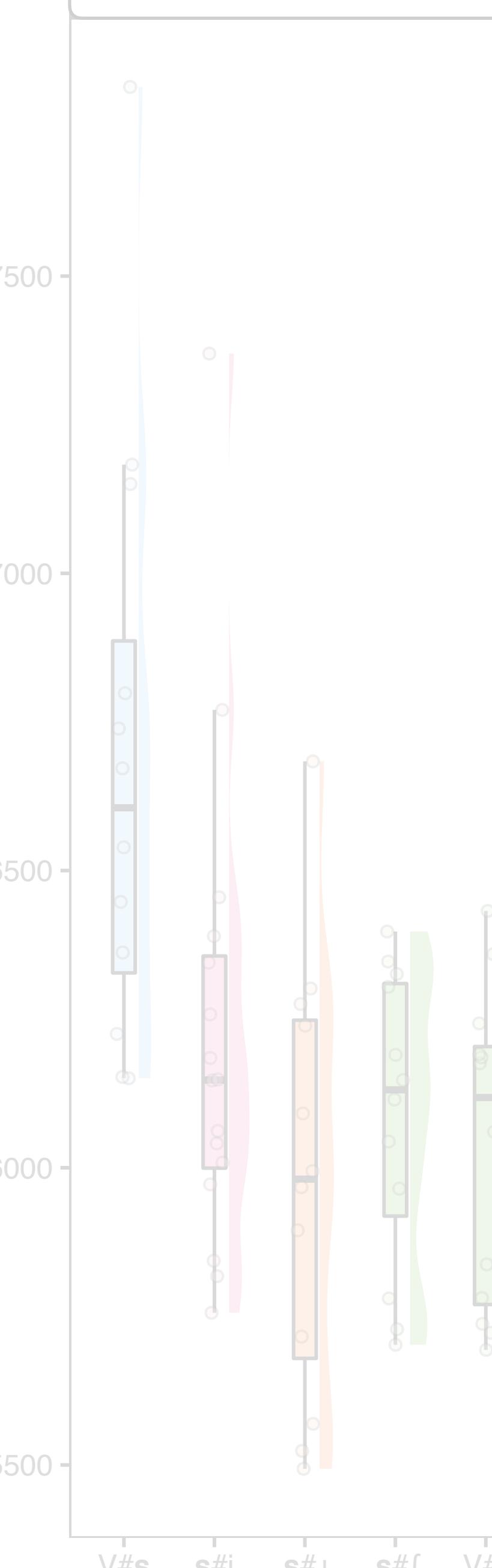
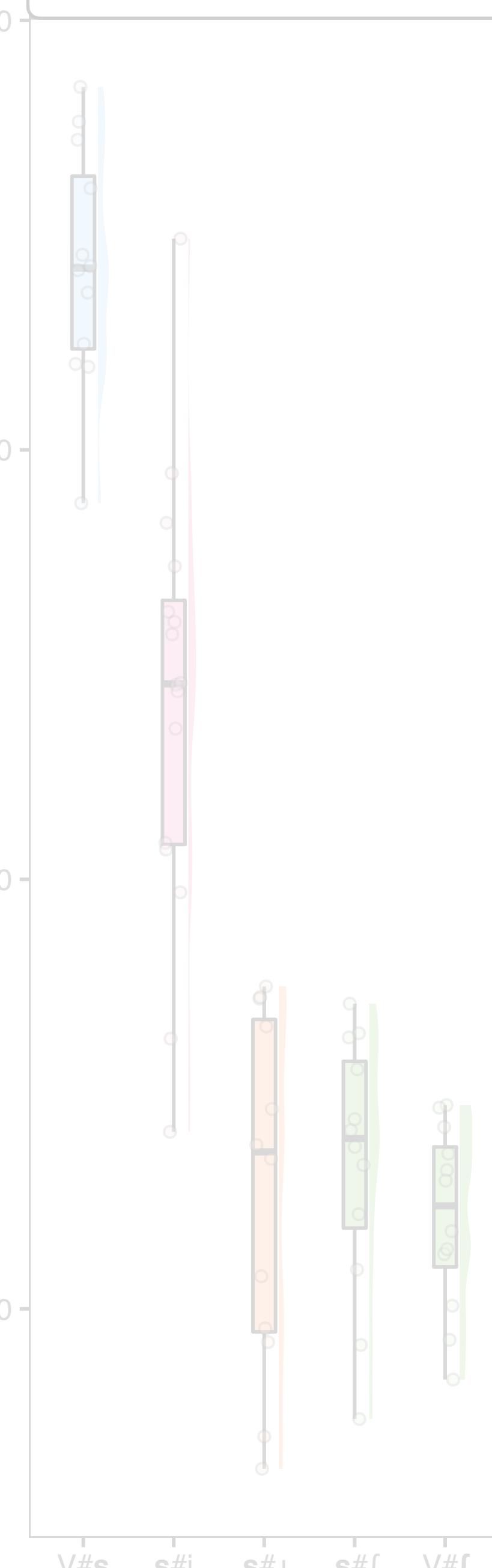
Centre of Gravity (Hz)

F01

F02

M01

M02



V#s
e.g. *seat*

s#j
e.g. *this yeast*

s#r
e.g. *this reed*

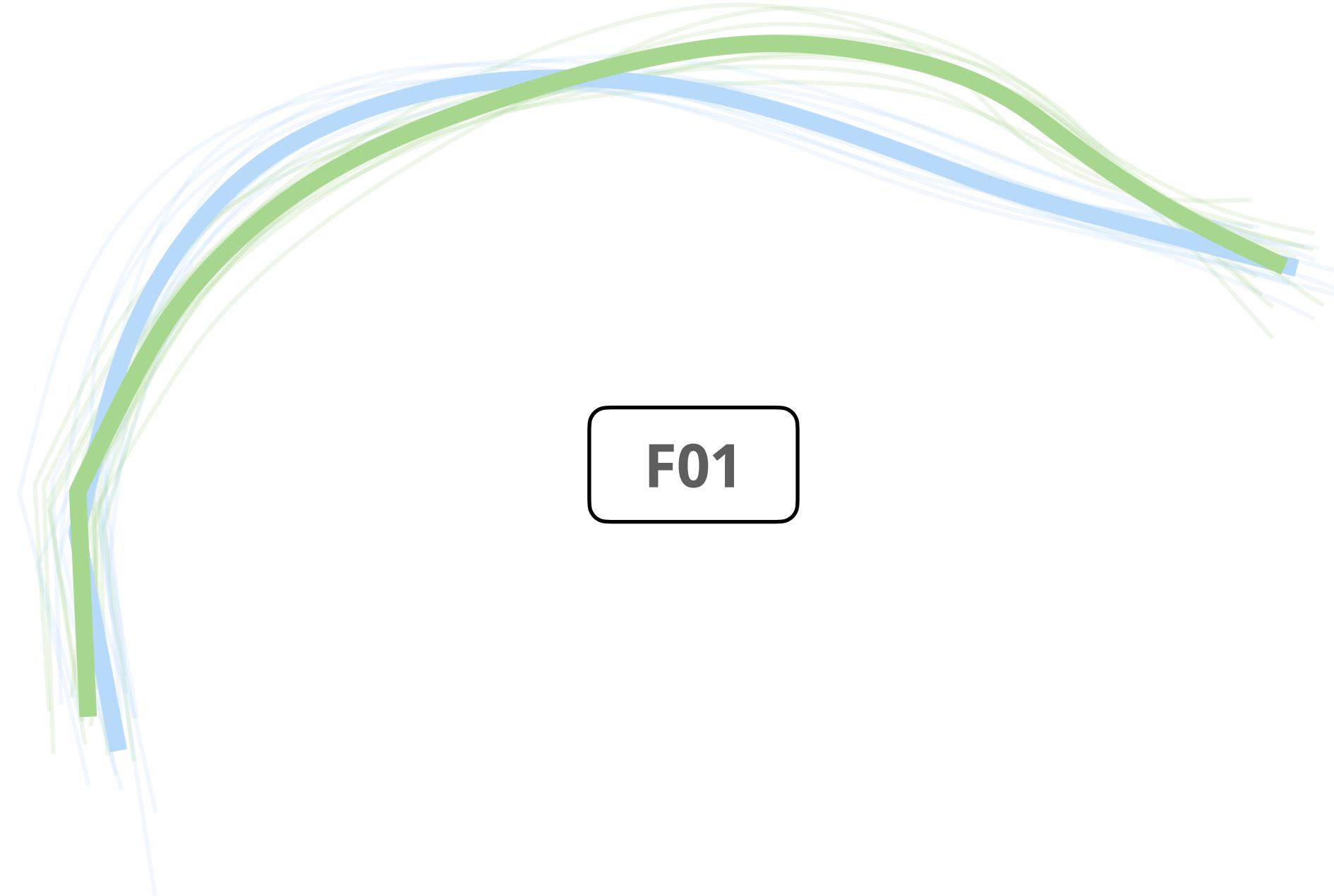
s#ʃ
e.g. *this sheep*

V#ʃ
e.g. *sheet*

Tongue

post-lexical retraction



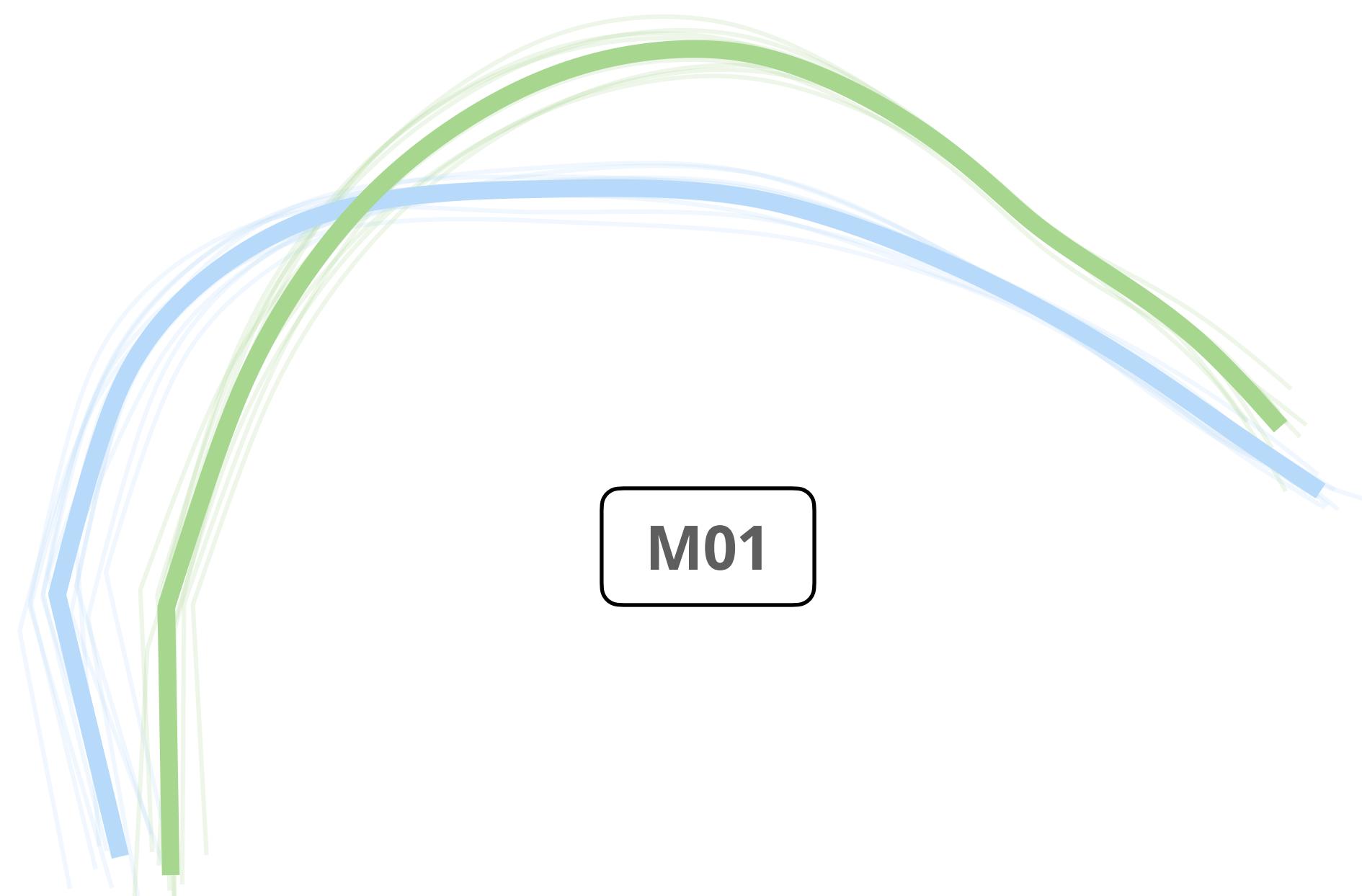


F01

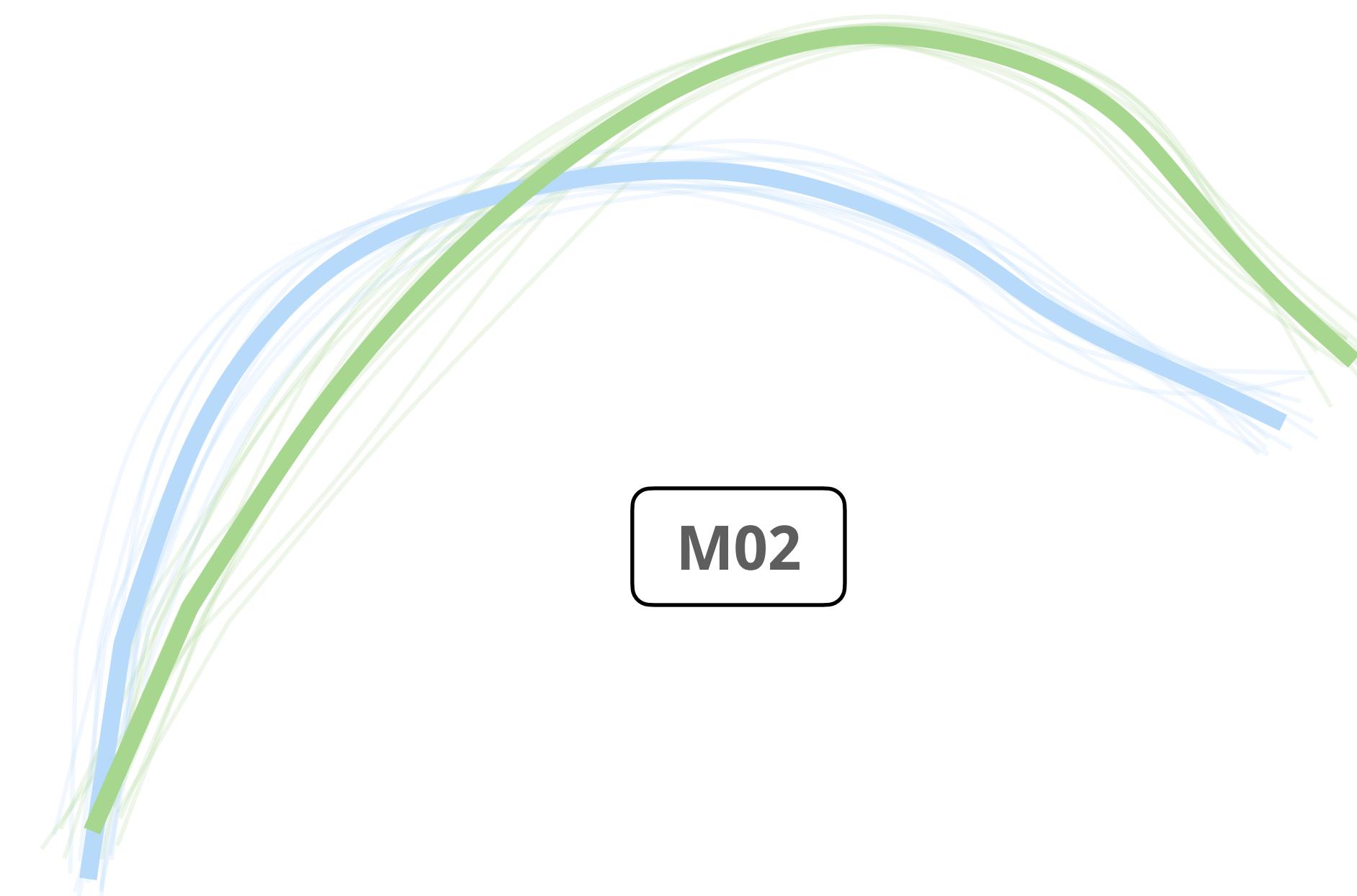


F02

V#s
e.g. the *seat*

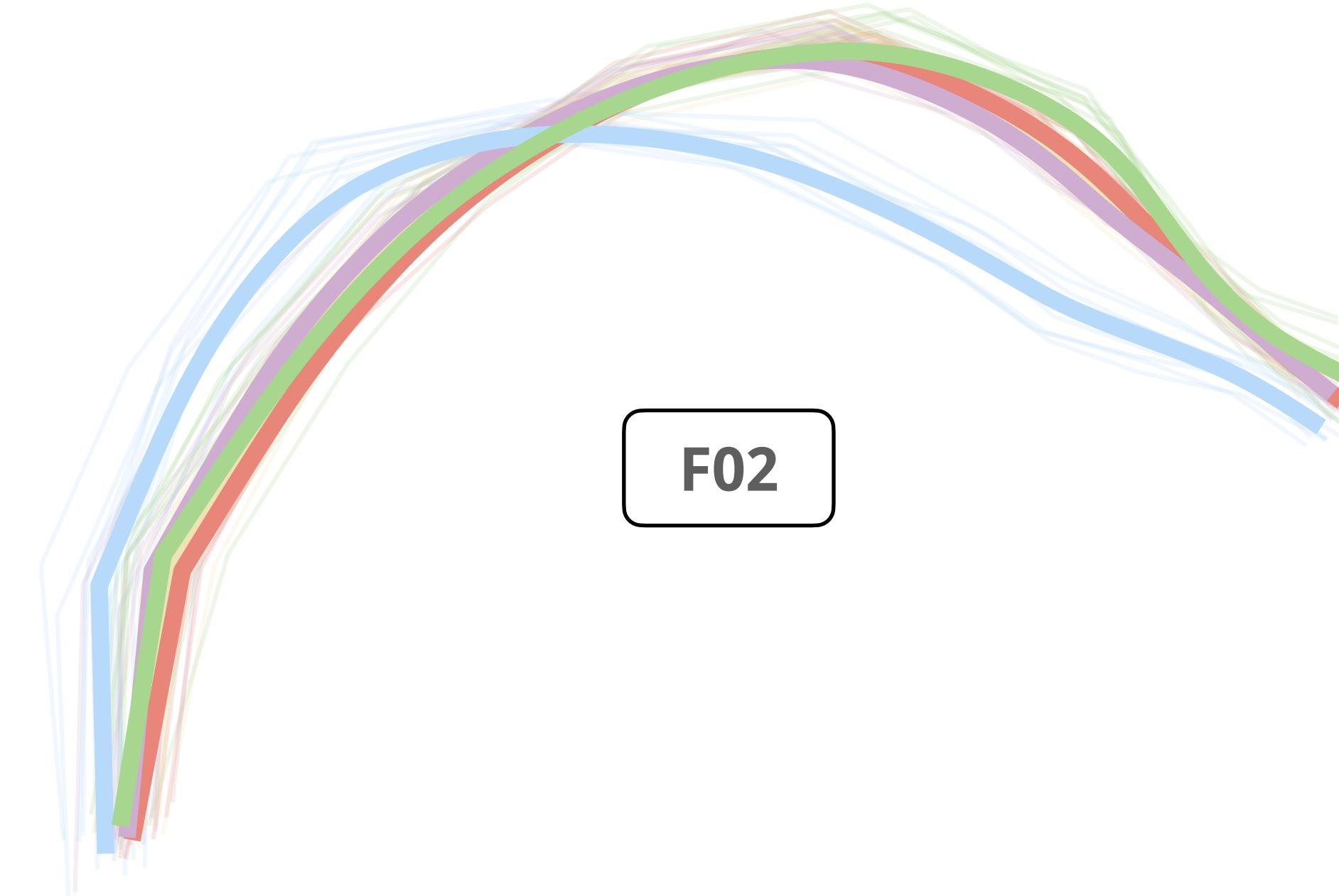


M01



M02

V#ʃ
e.g. the *sheet*

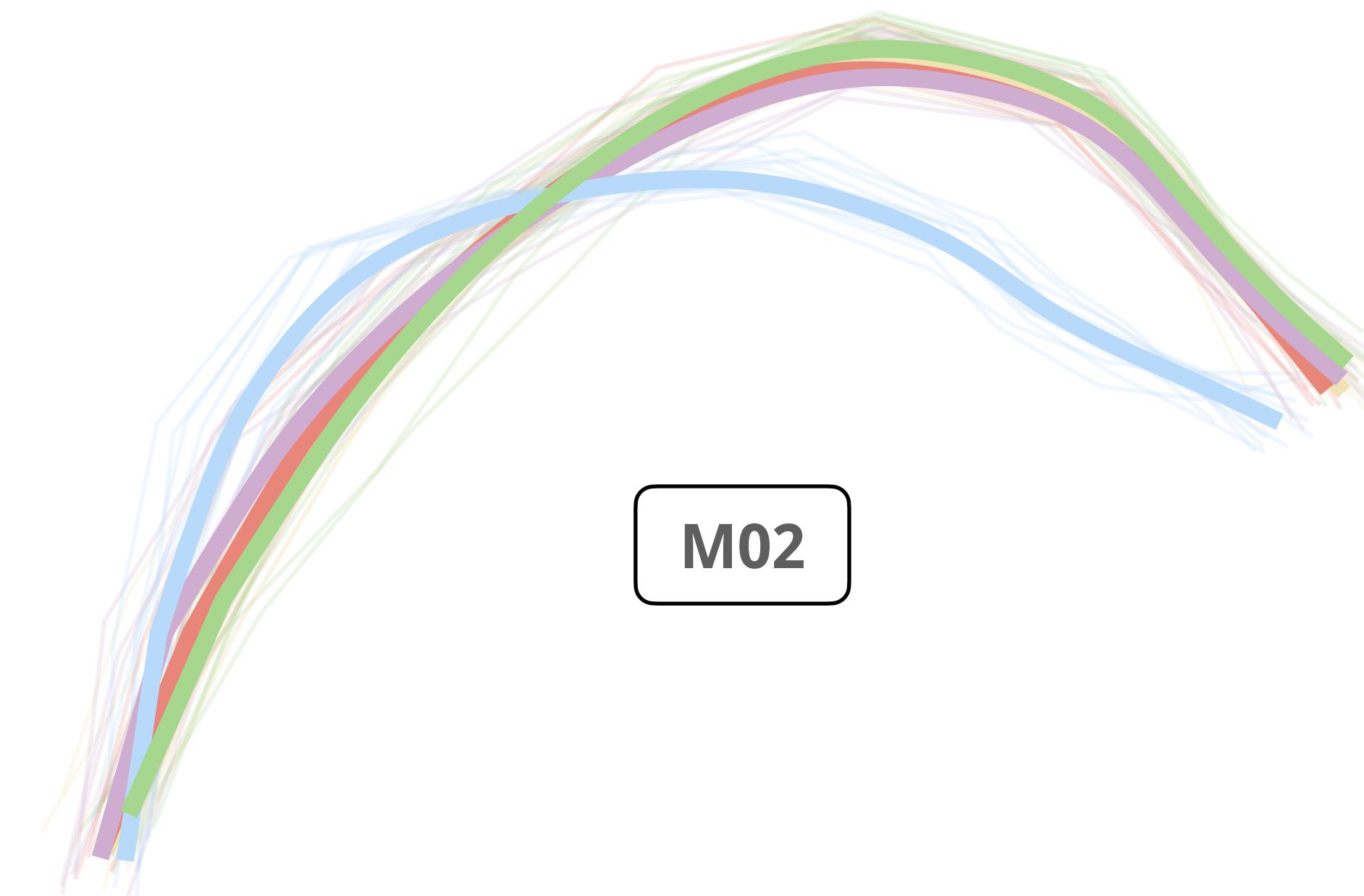
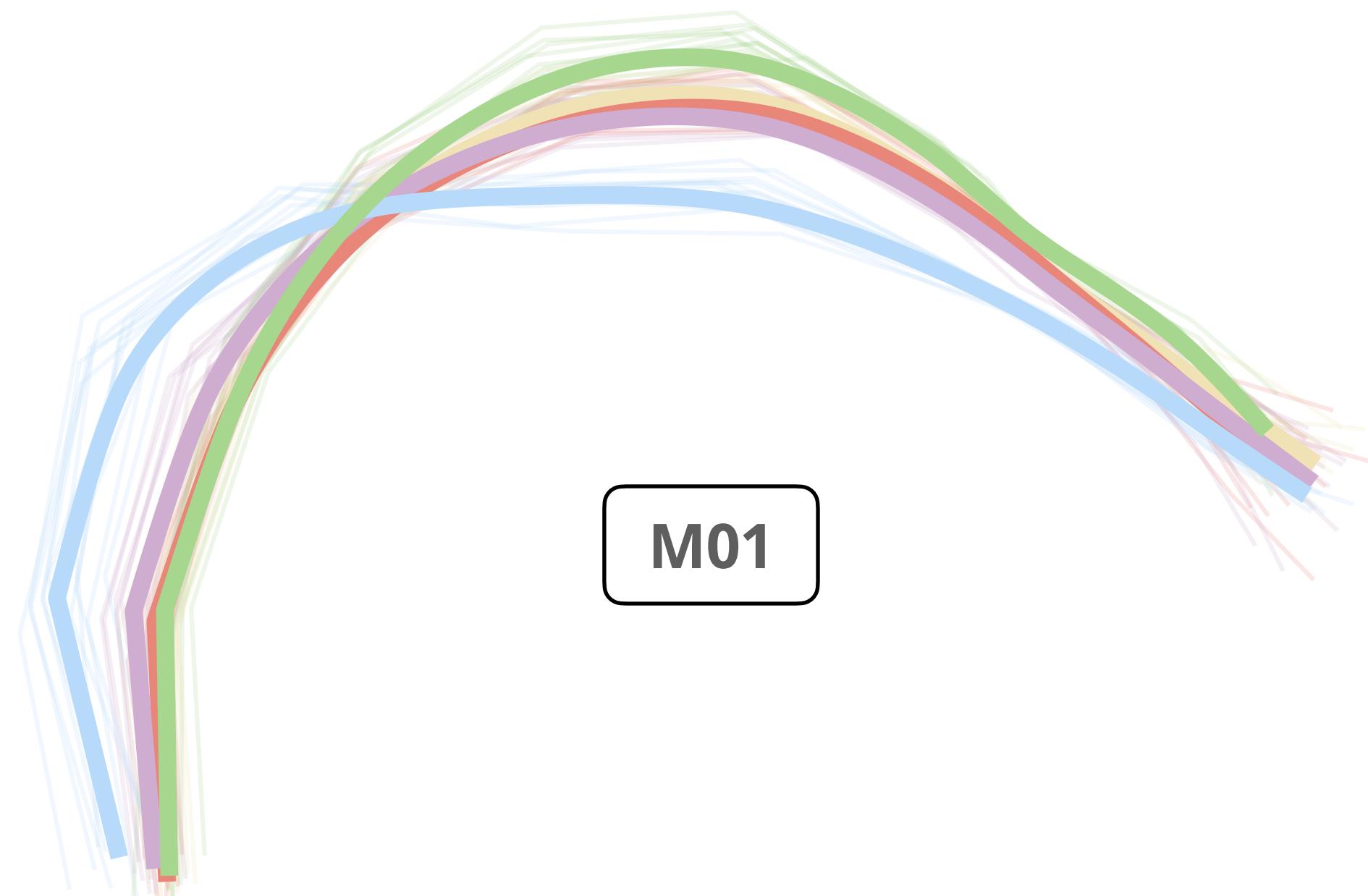


V#s
e.g. the *seat*

s#tj
e.g. *this tune*

s#tu
e.g. *this tree*

s#tʃ
e.g. *this cheese*



V#ʃ
e.g. the *sheet*



F01



F02

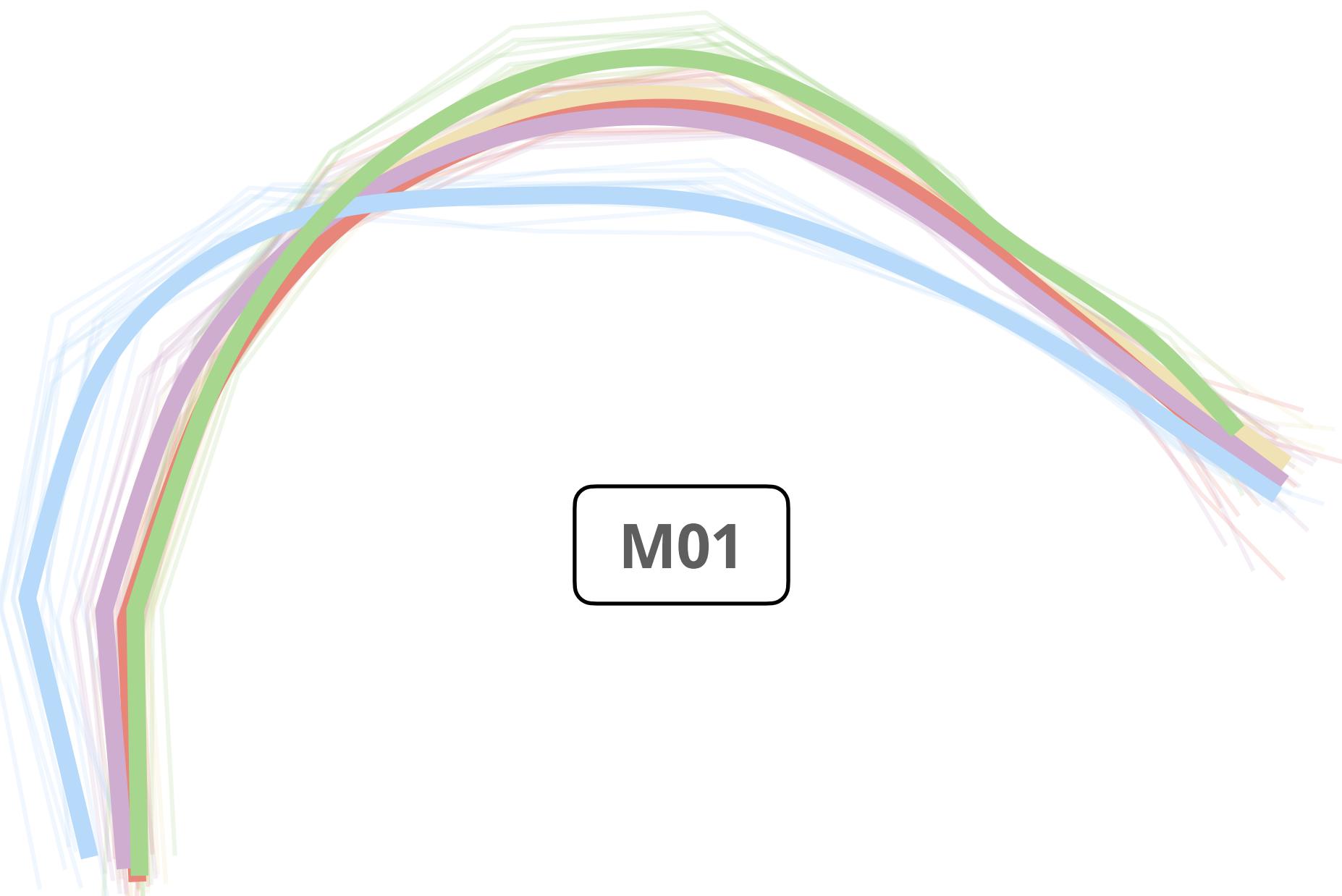
V#s
e.g. the *seat*

s#tj
e.g. *this tune*

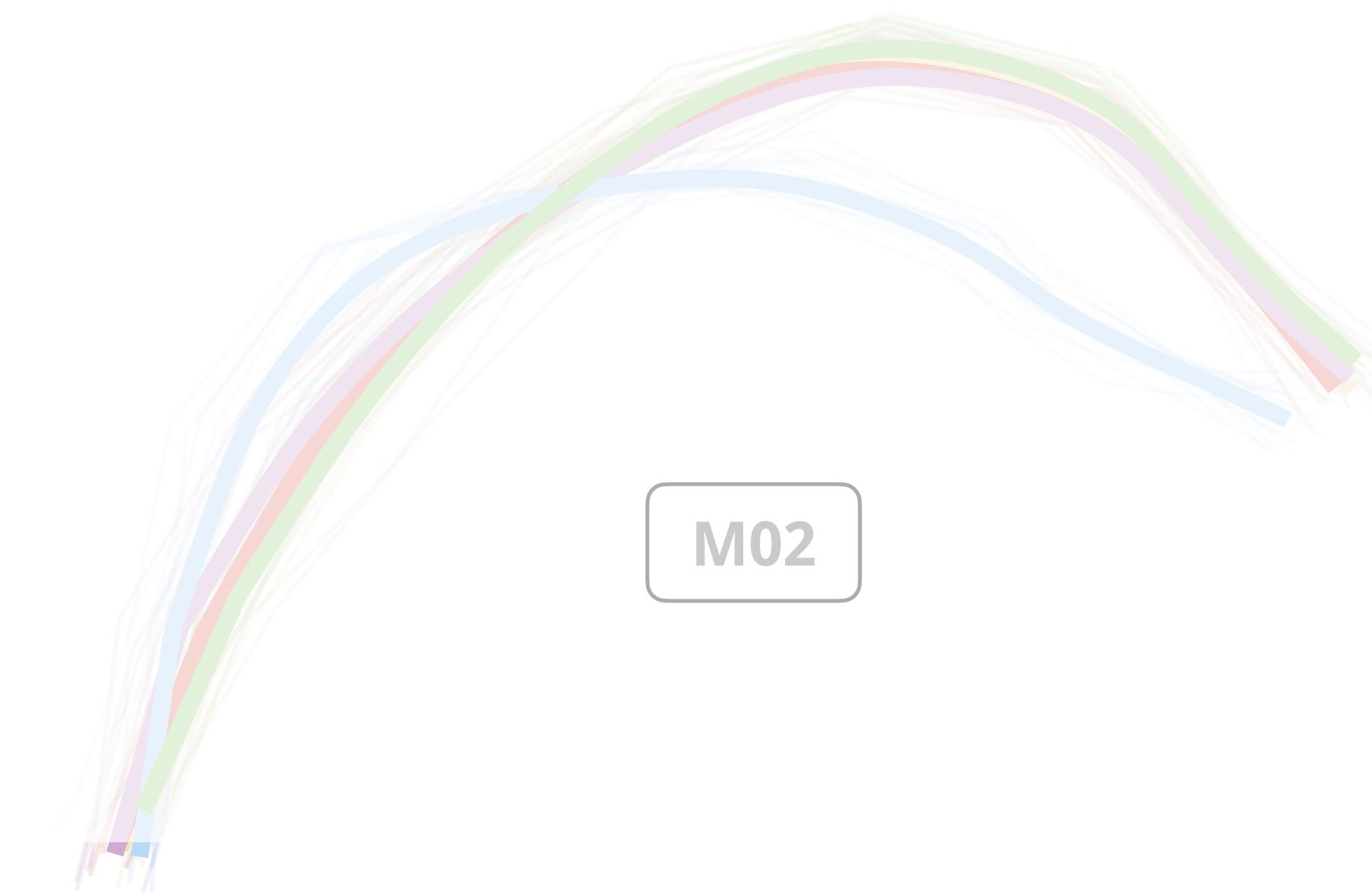
s#tu
e.g. *this tree*

s#tʃ
e.g. *this cheese*

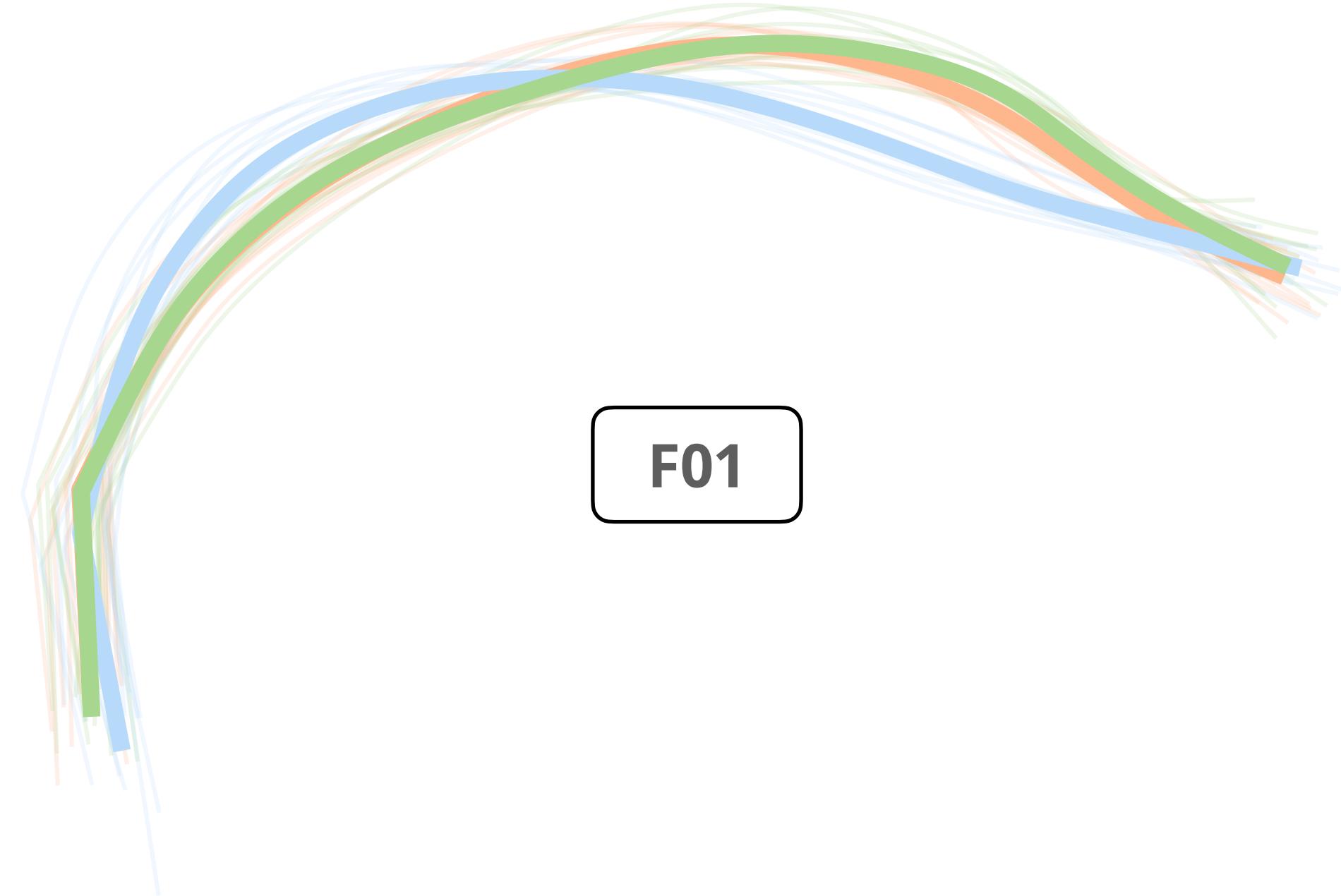
V#ʃ
e.g. the *sheet*



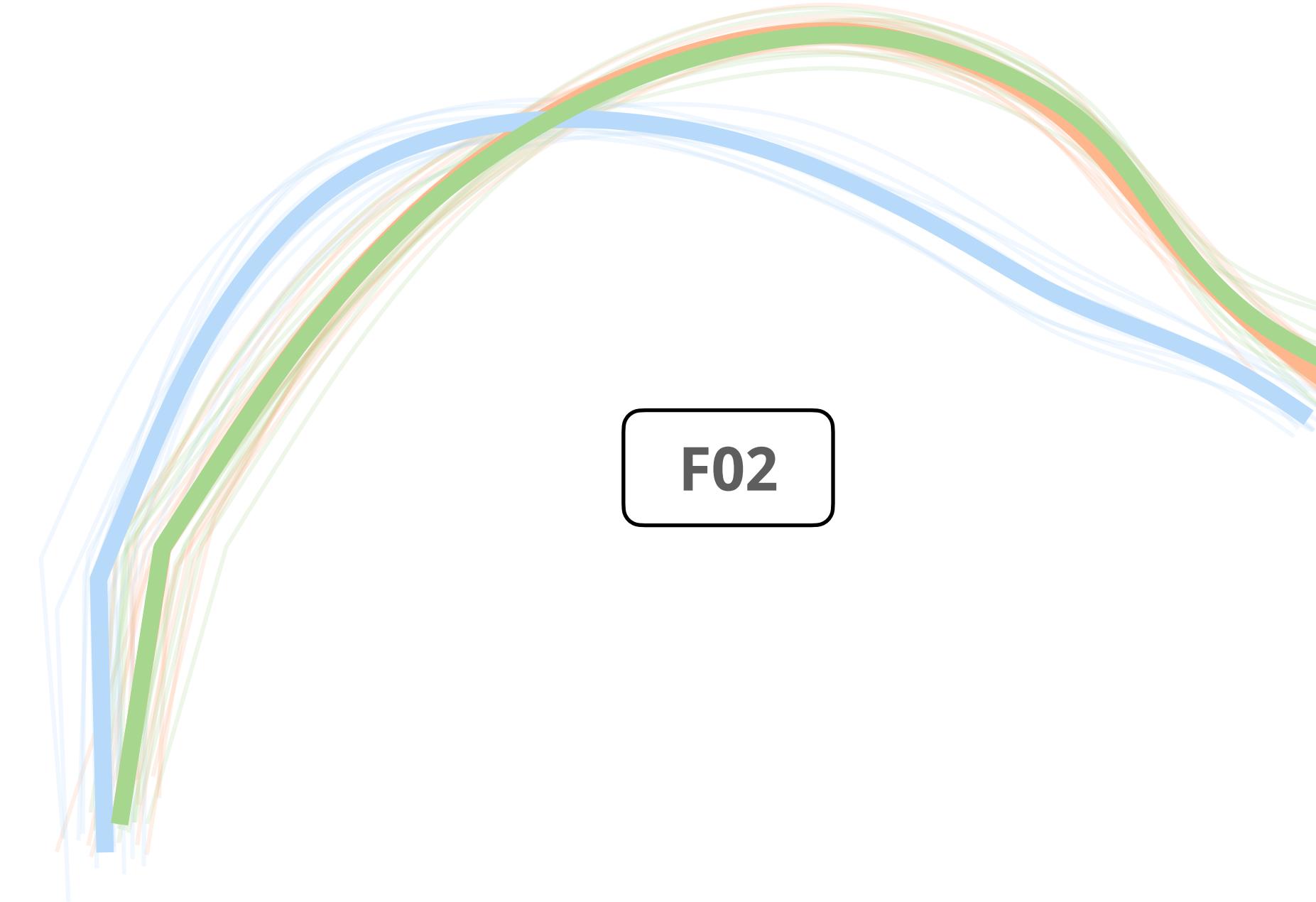
M01



M02

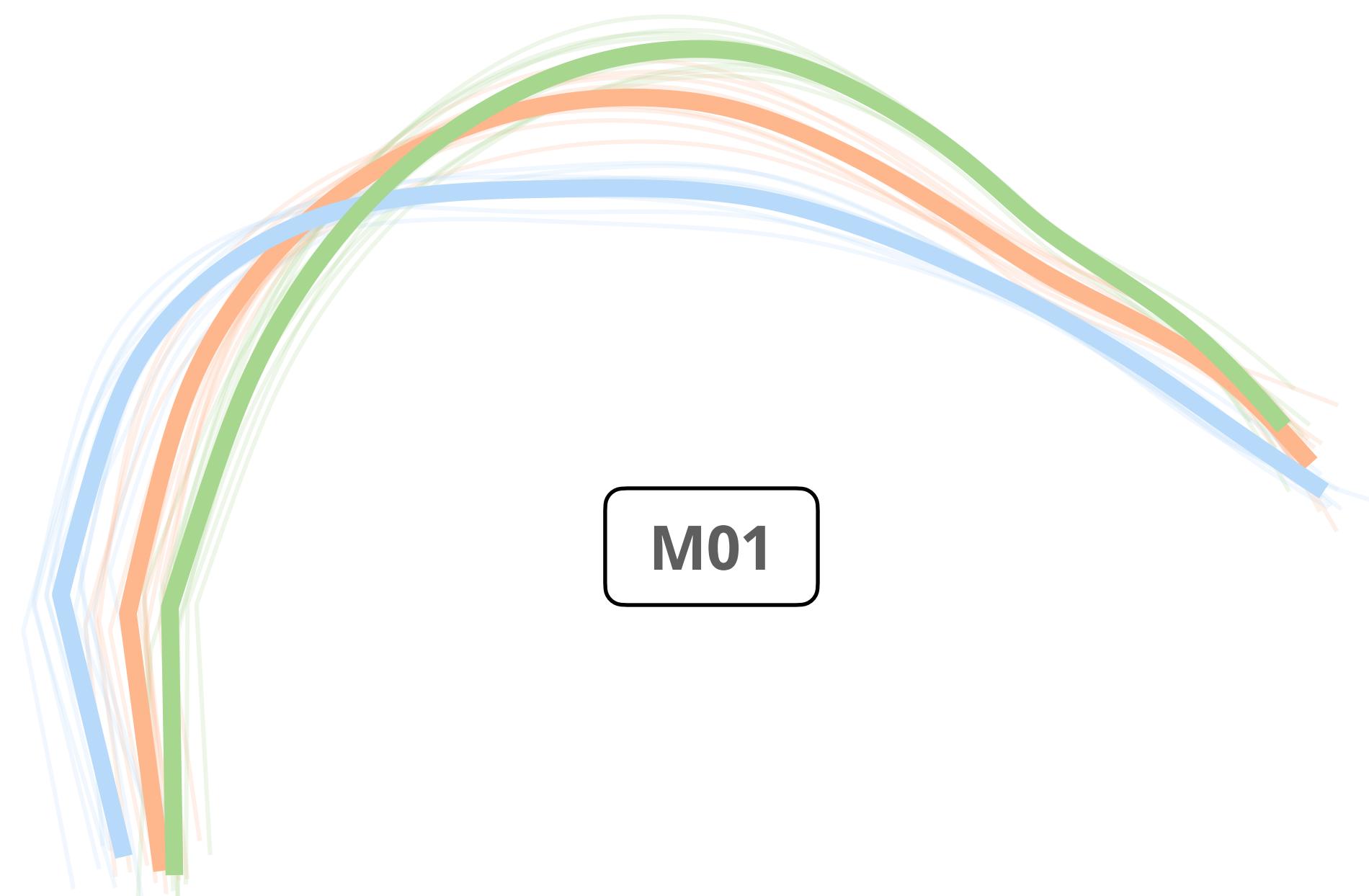


F01

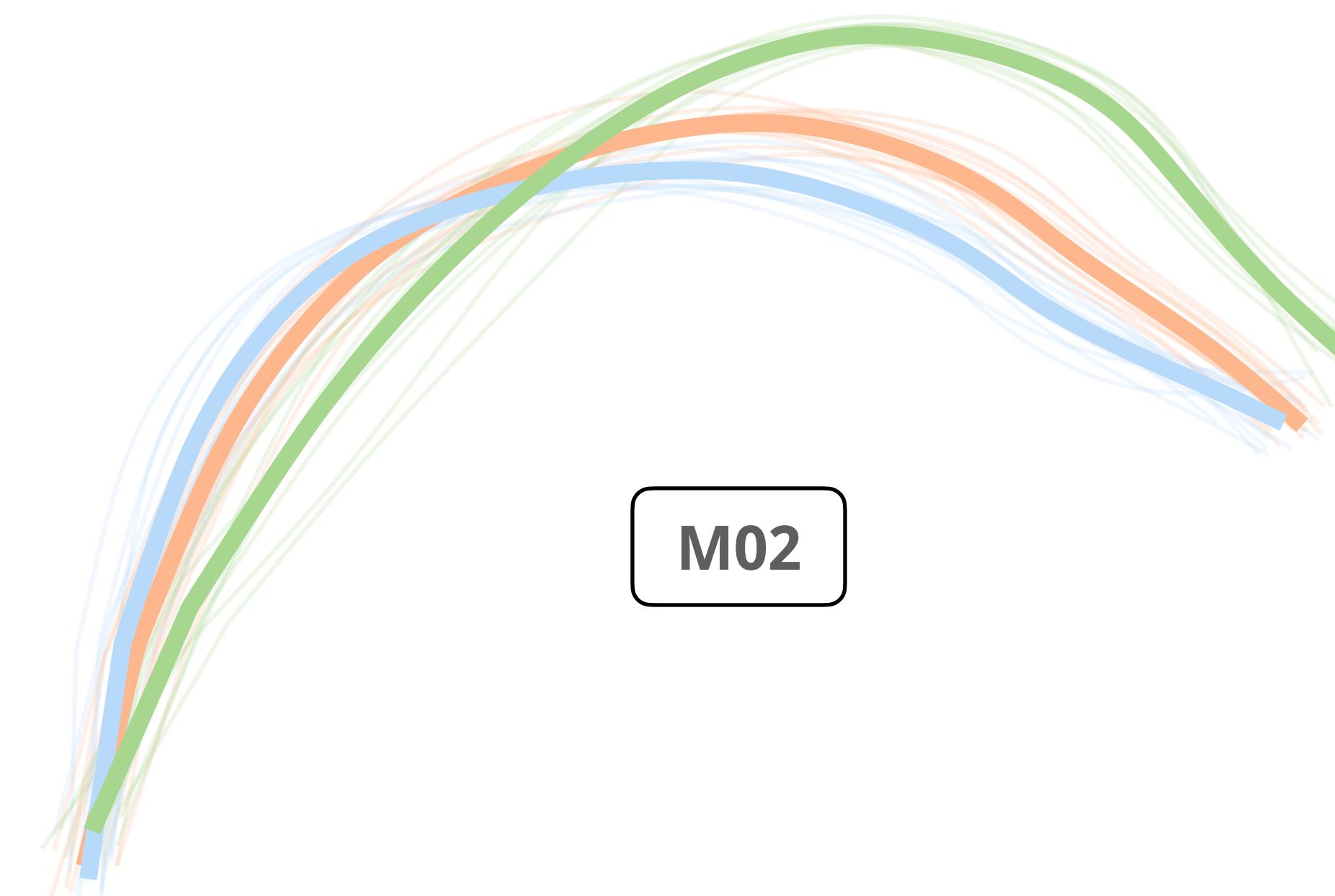


F02

V#s
e.g. the *seat*



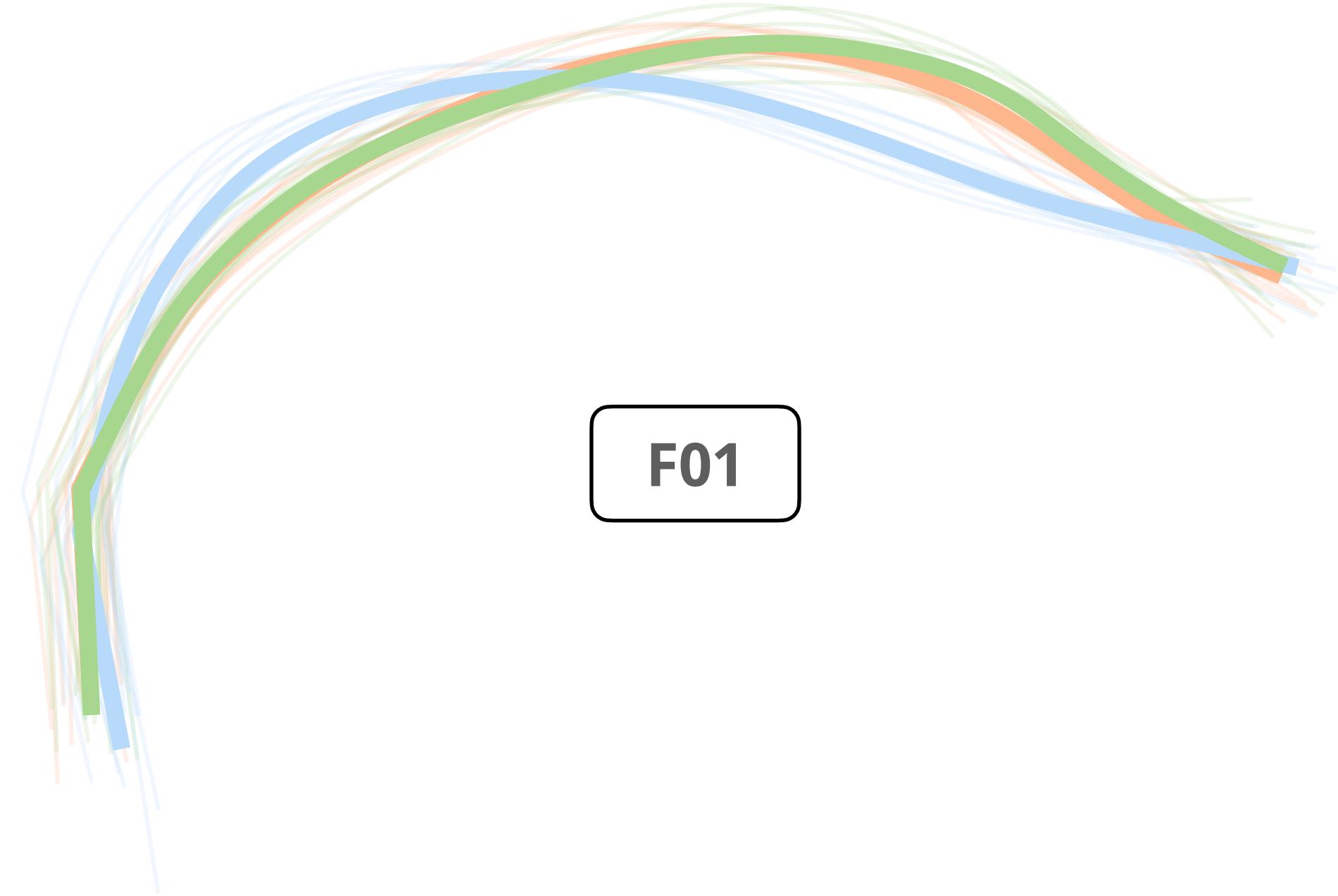
M01



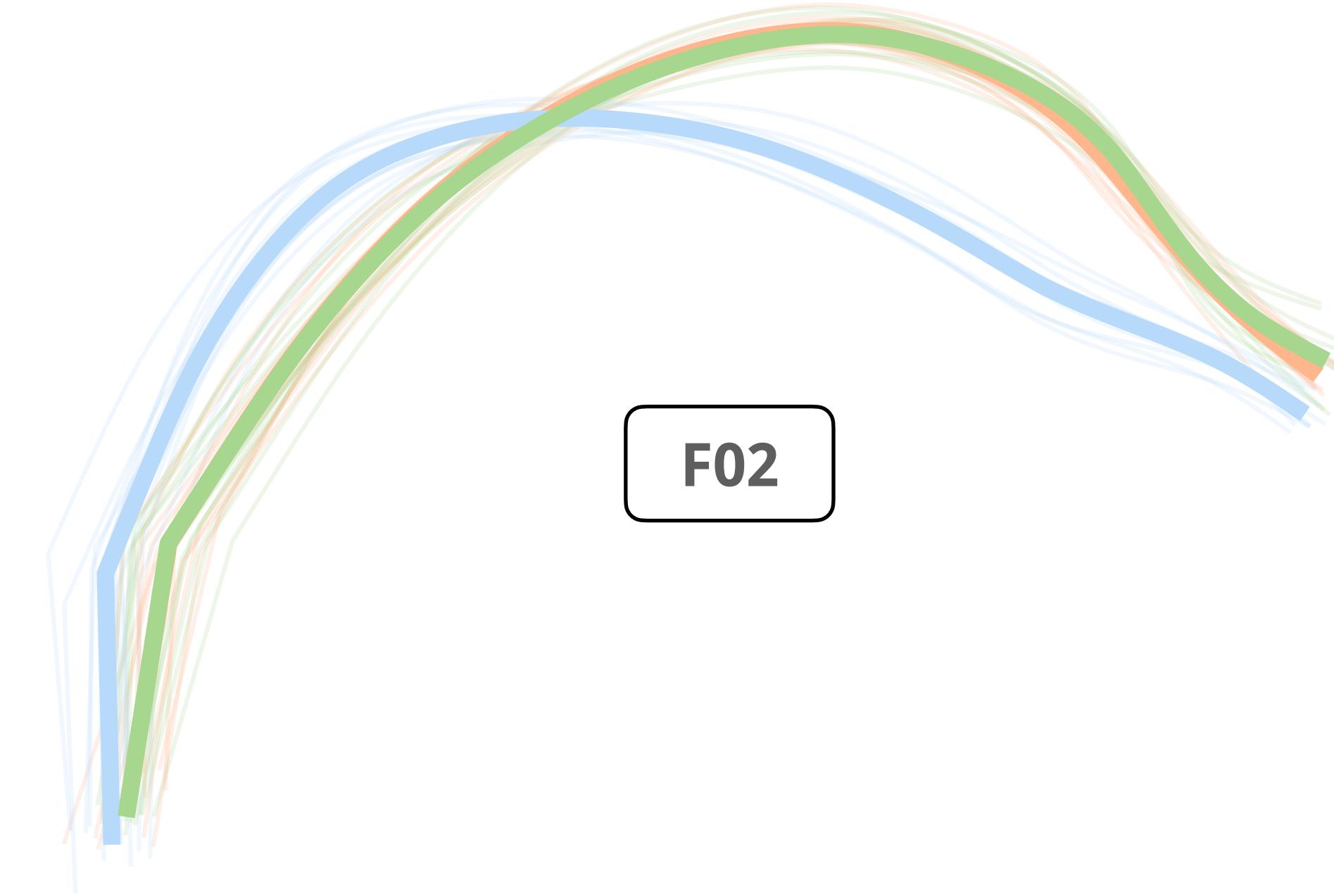
M02

V#ʃ
e.g. the *sheet*

s#ɹ
e.g. *this reed*

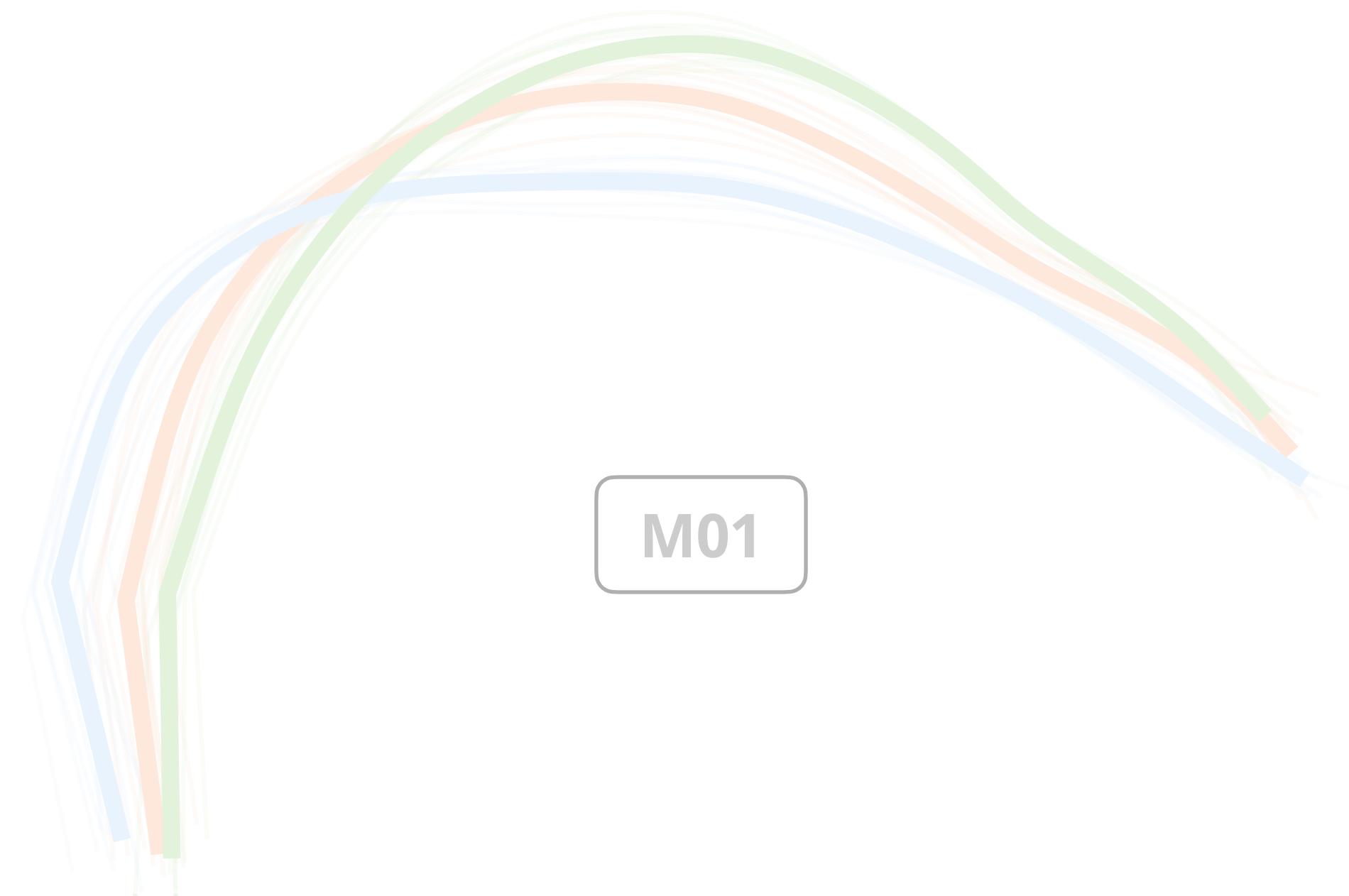


F01

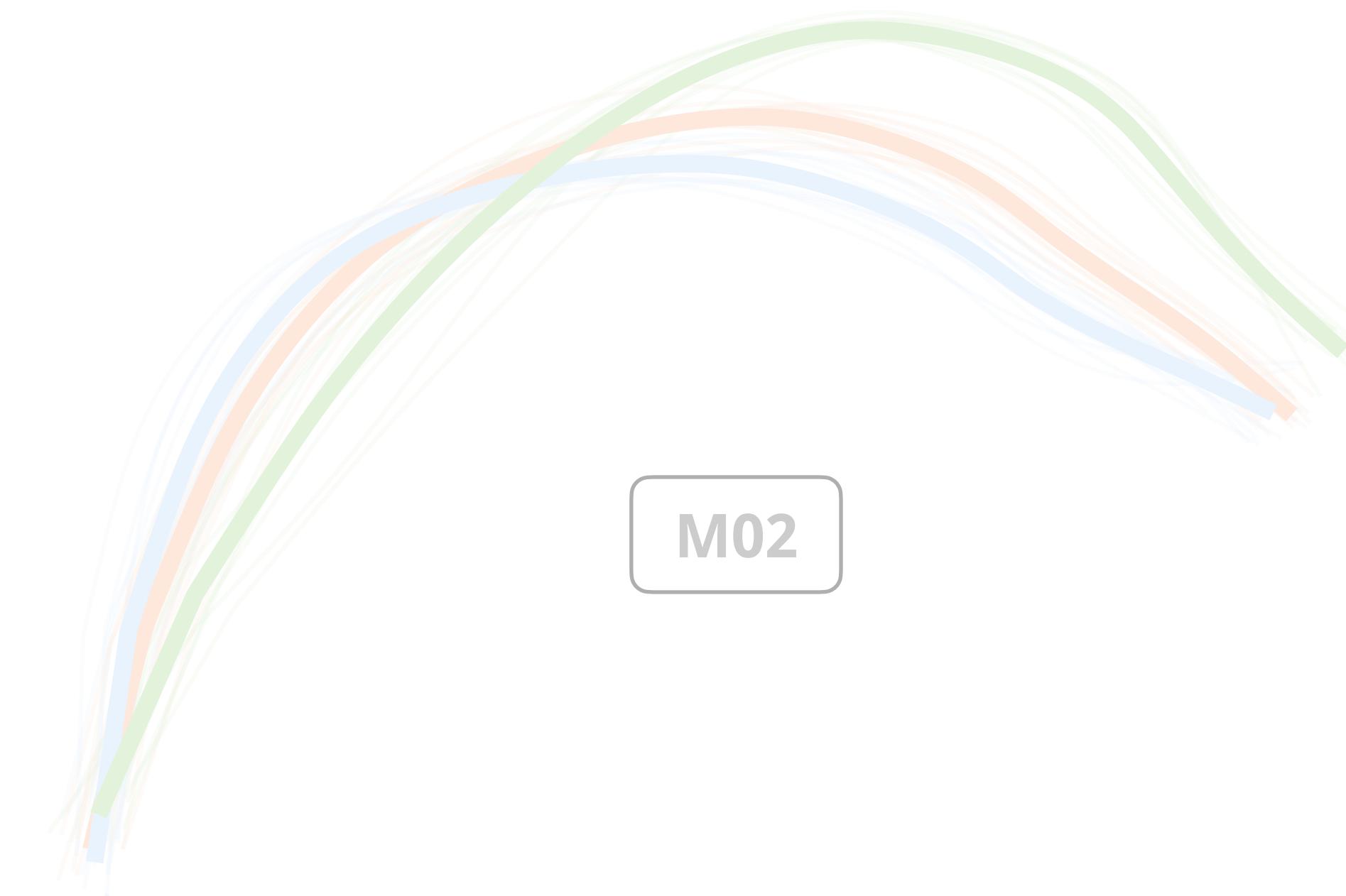


F02

V#s
e.g. the *seat*



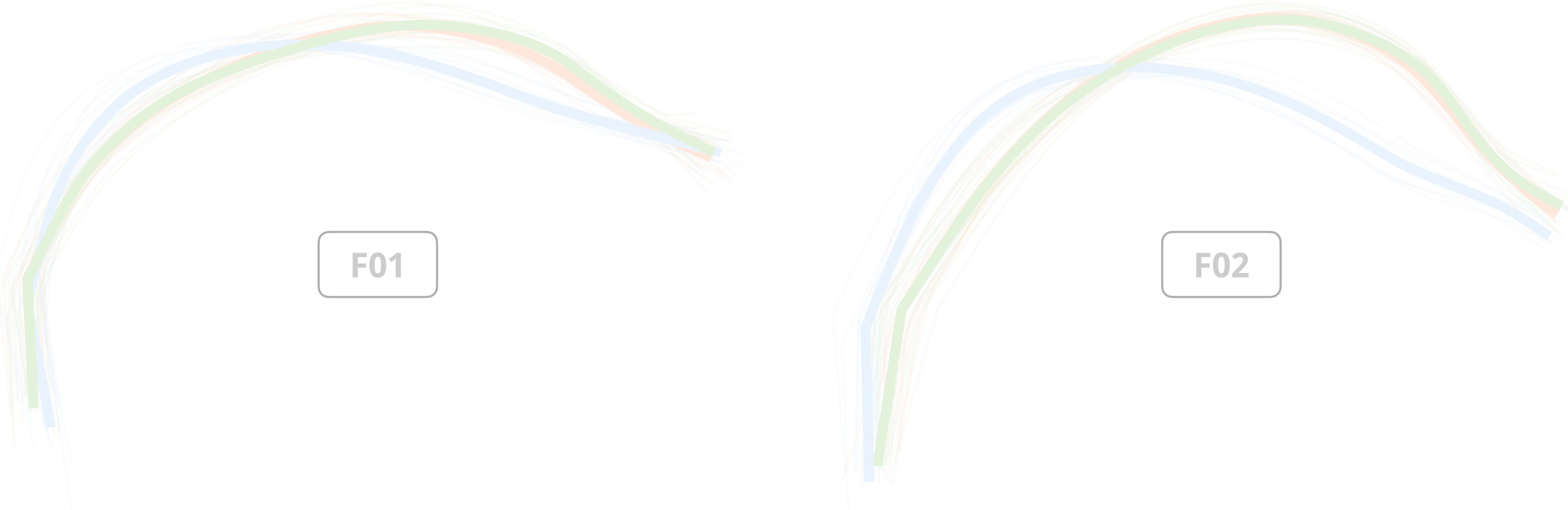
M01



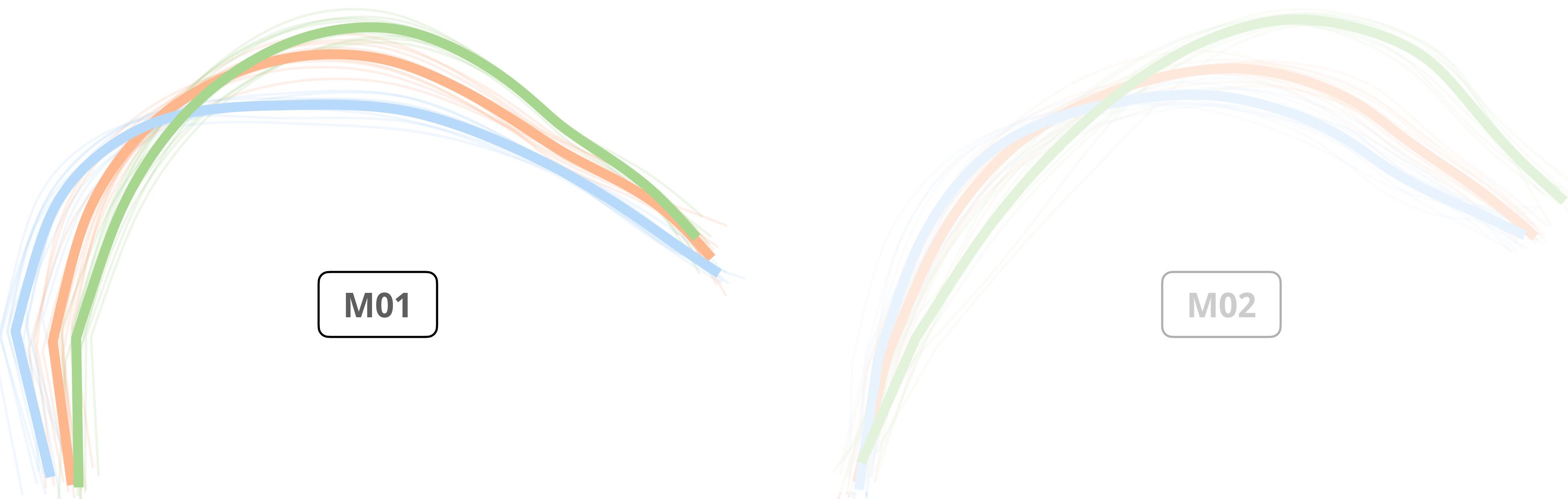
M02

V#ʃ
e.g. the *sheet*

s#ɹ
e.g. *this reed*

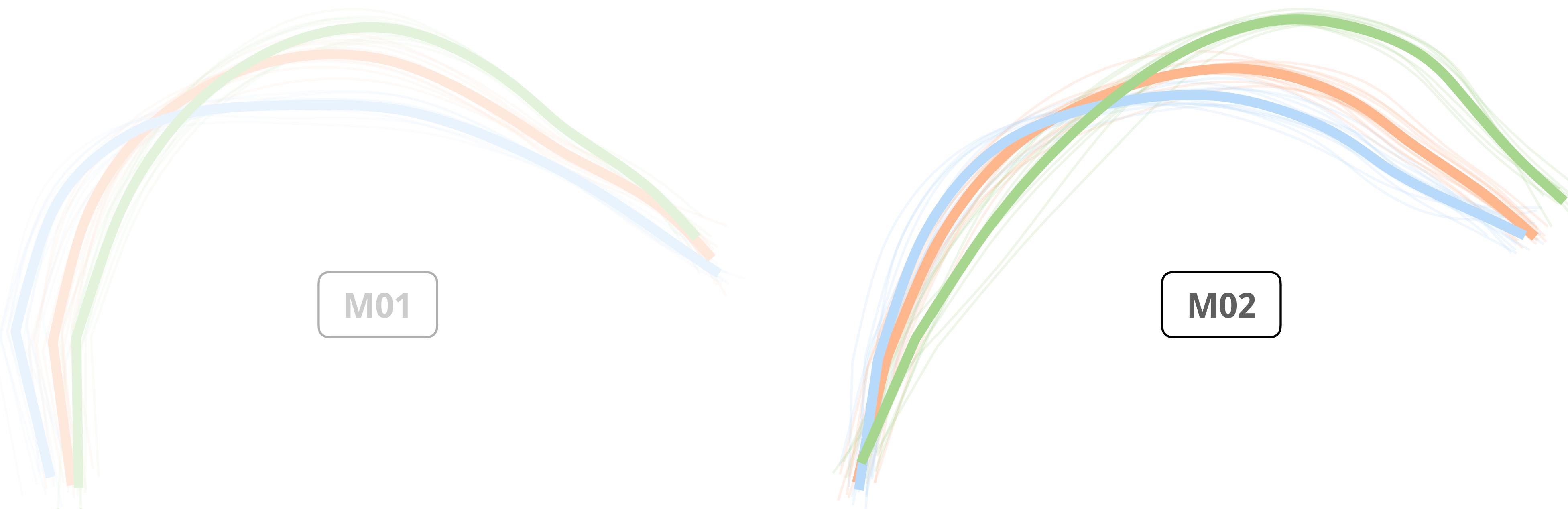
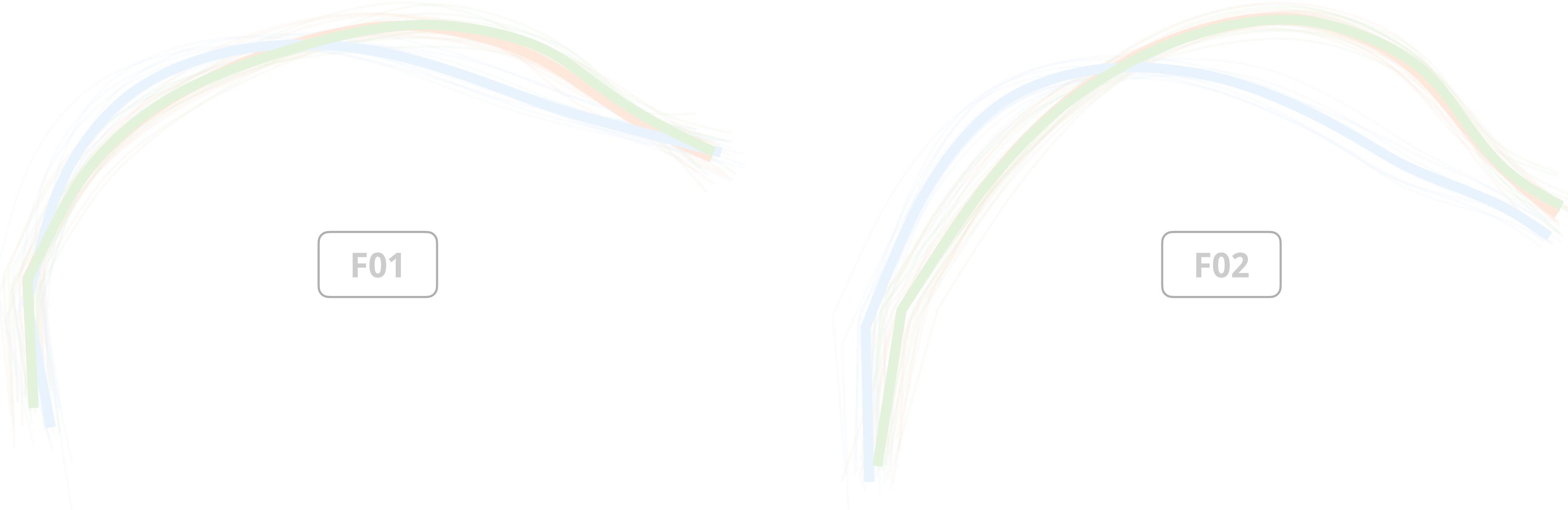


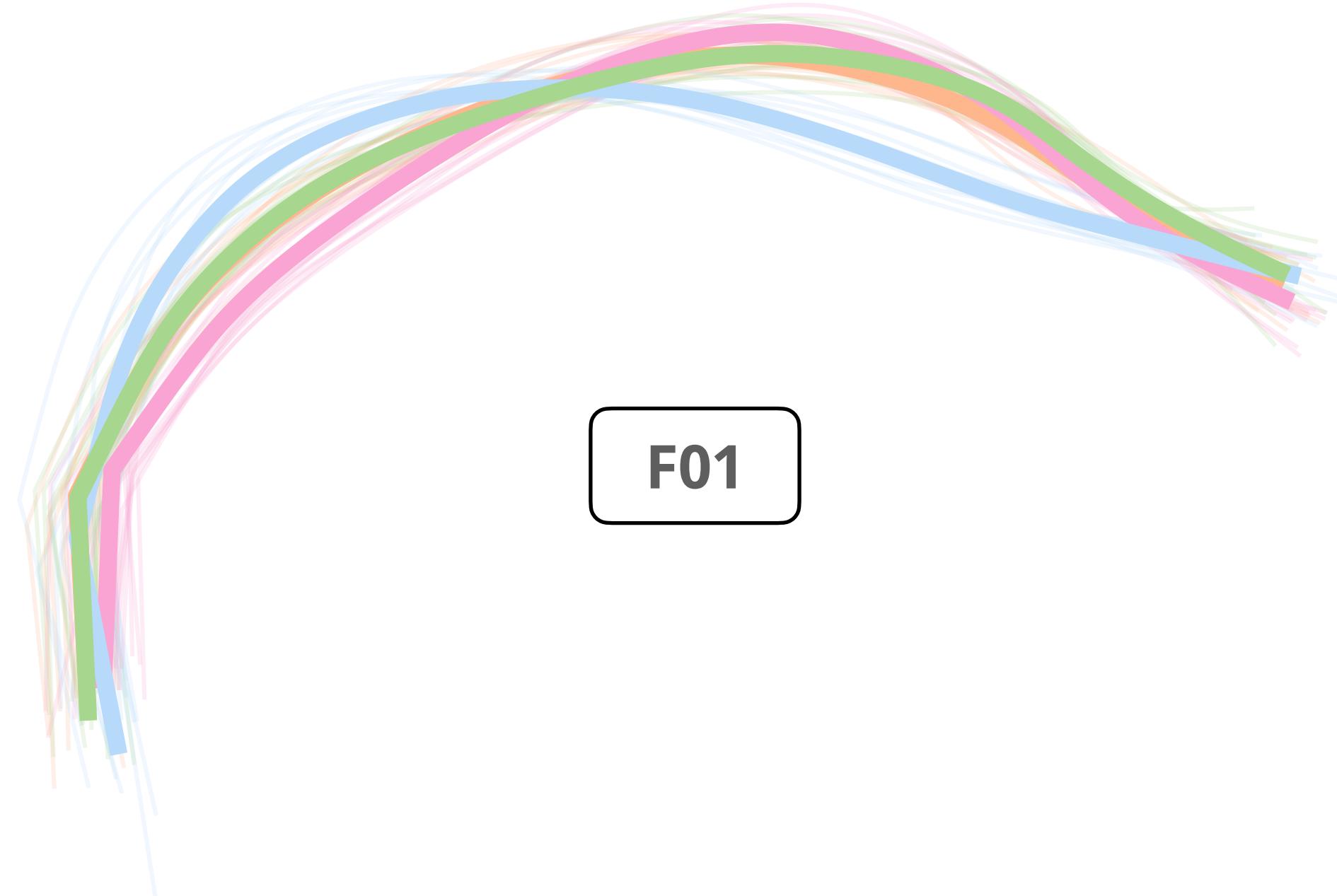
V#s
e.g. *the seat*



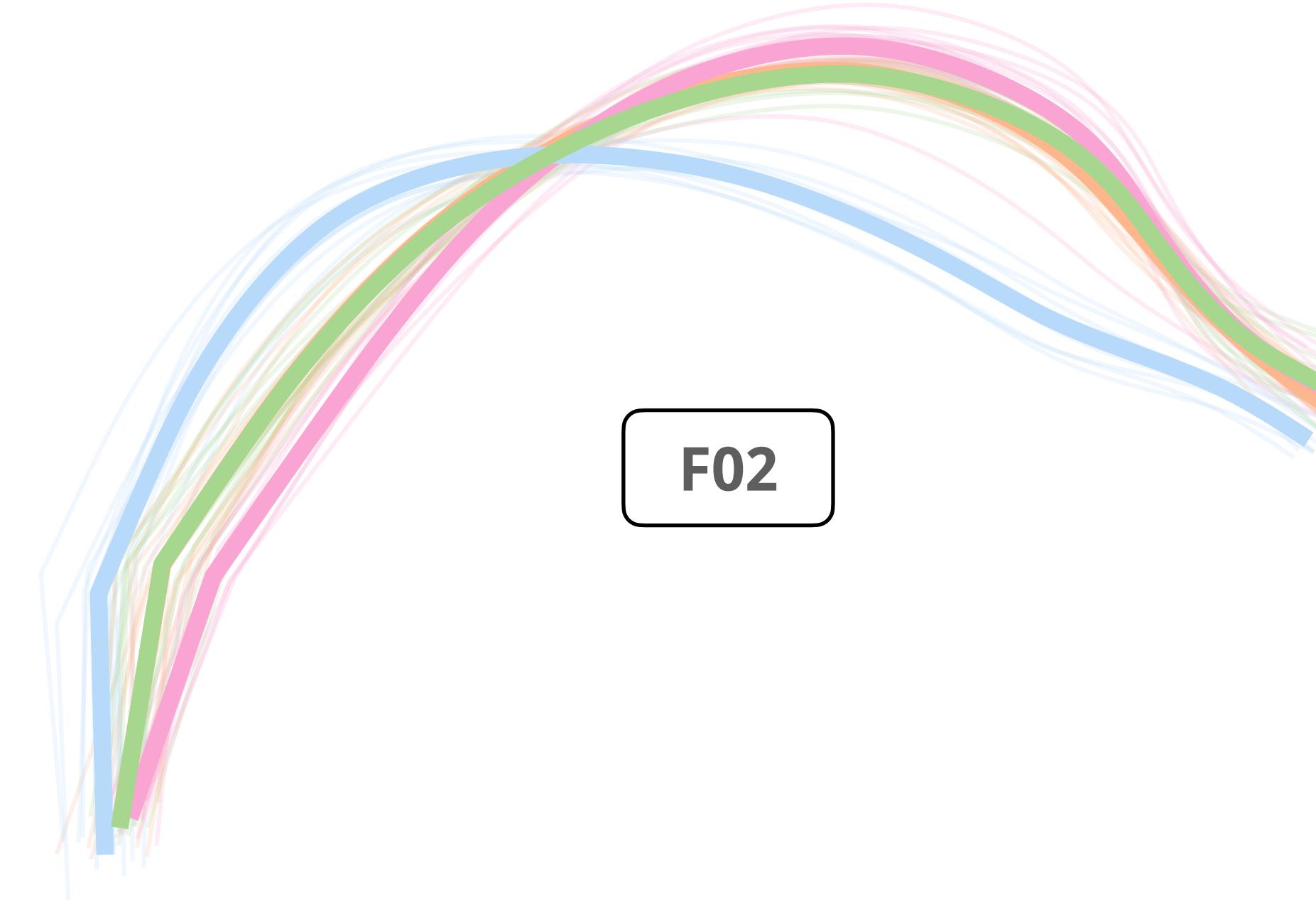
S#r
e.g. *this reed*

V#ʃ
e.g. *the sheet*



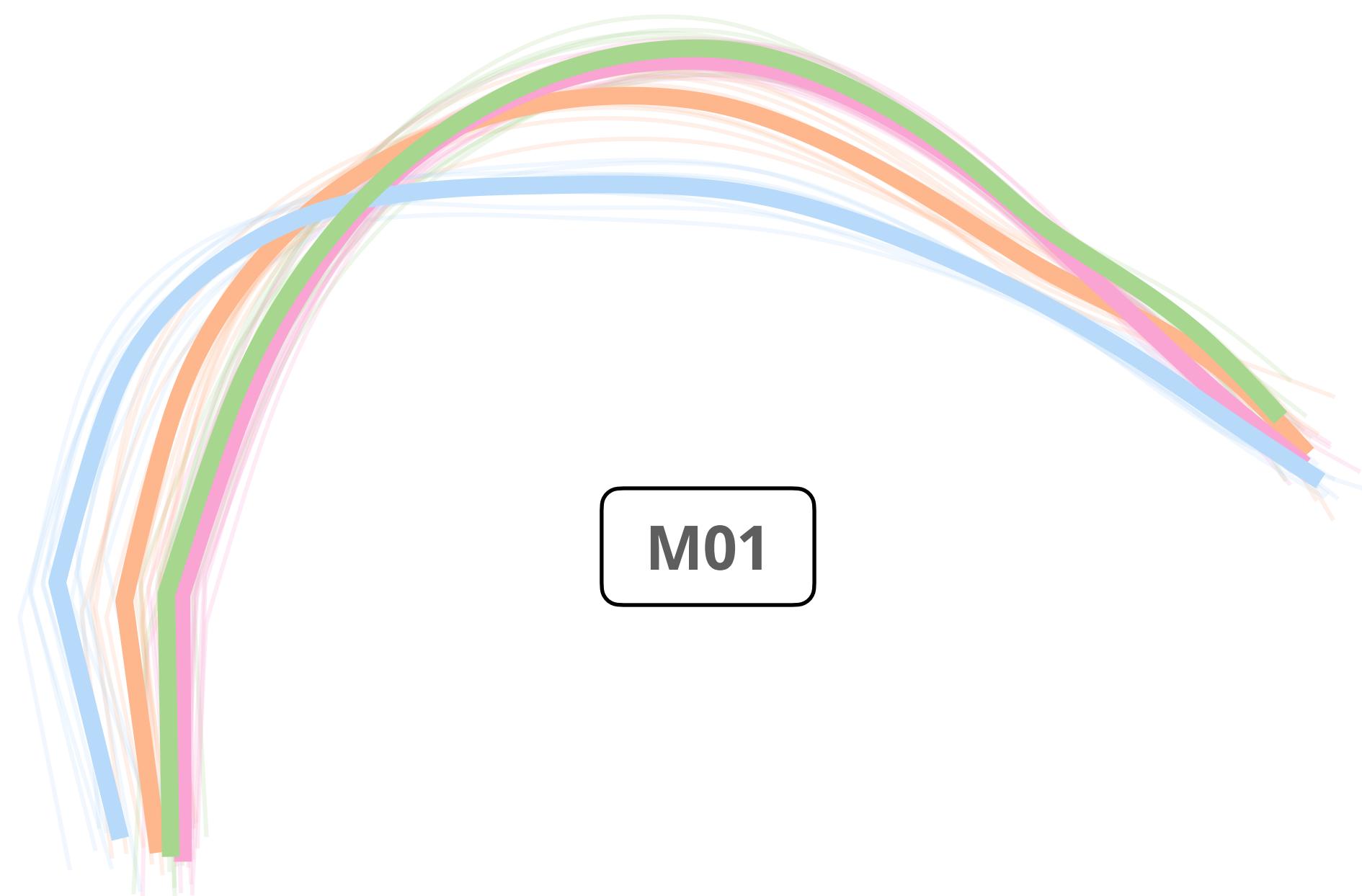


F01

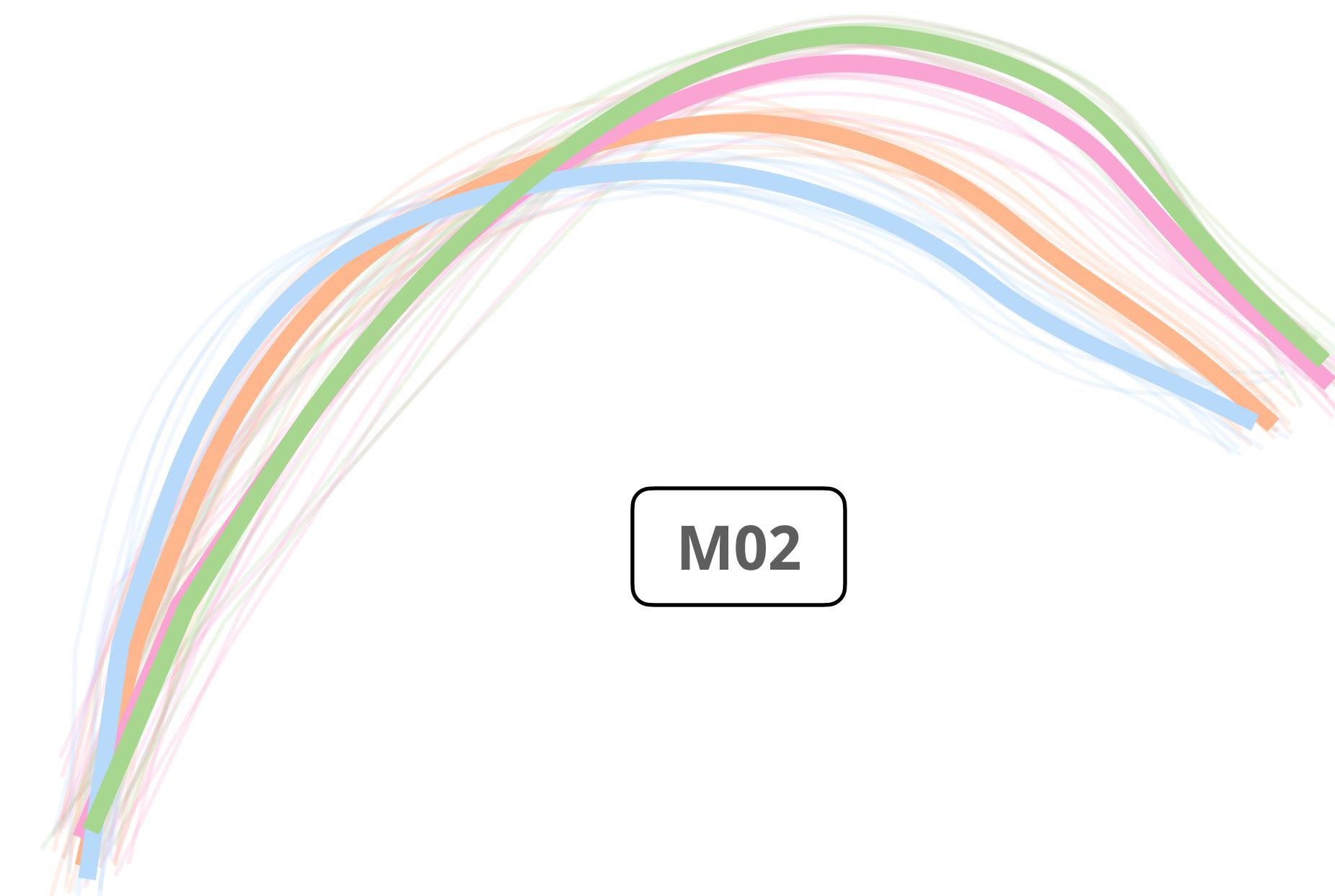


F02

V#s
e.g. the *seat*



M01

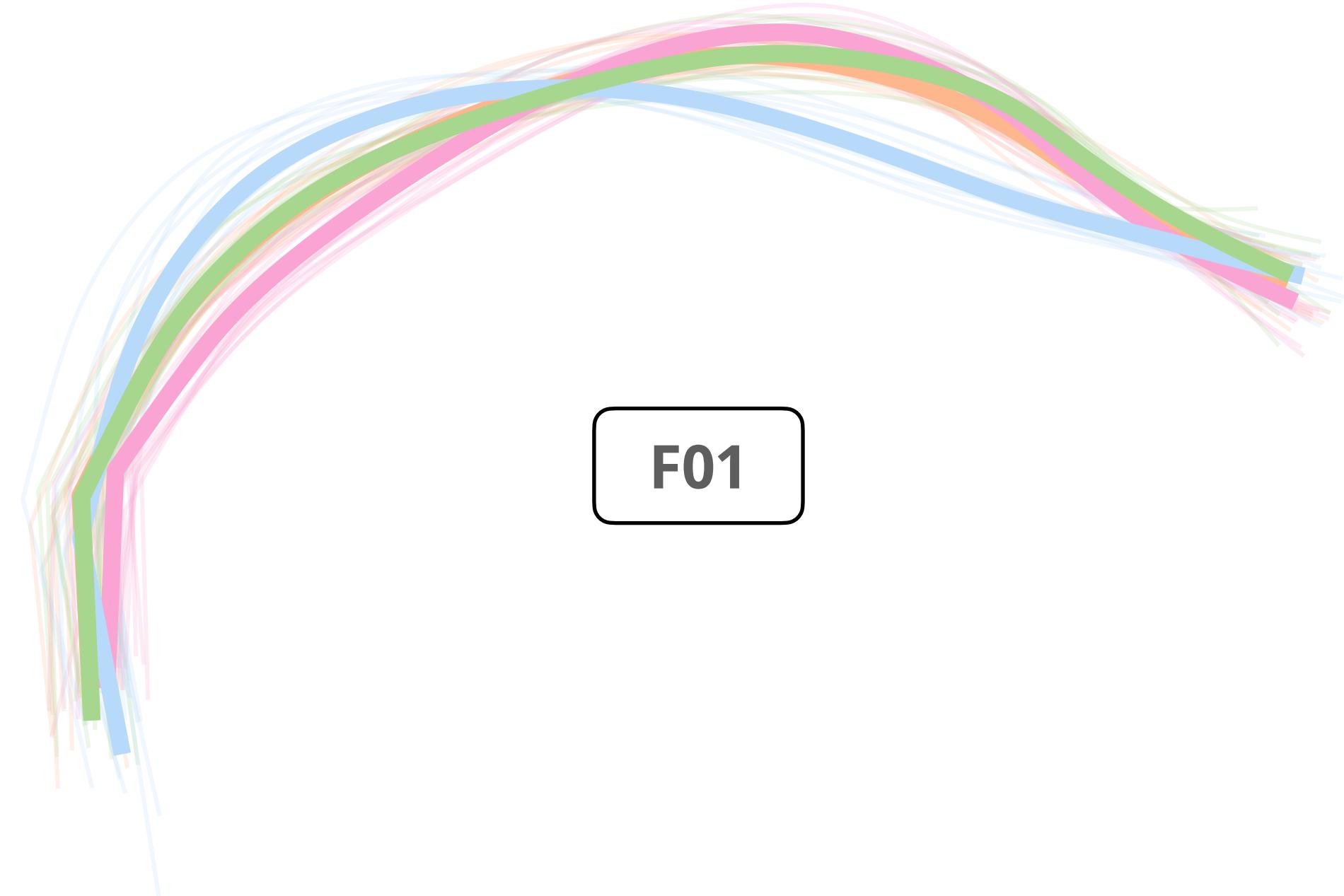


M02

s#ɹ
e.g. *this reed*

s#j
e.g. *this yeast*

V#ʃ
e.g. *the sheet*

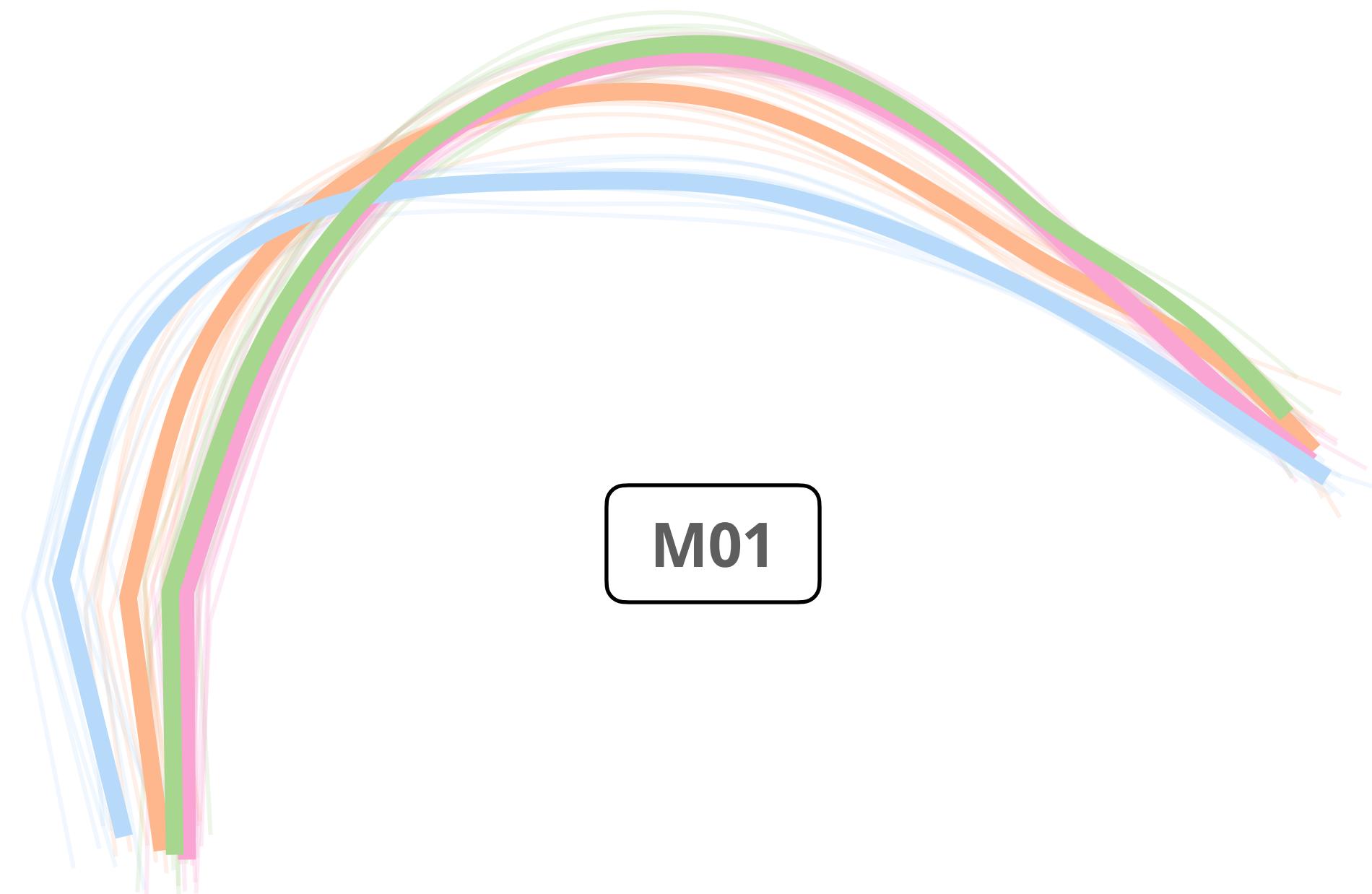


F01

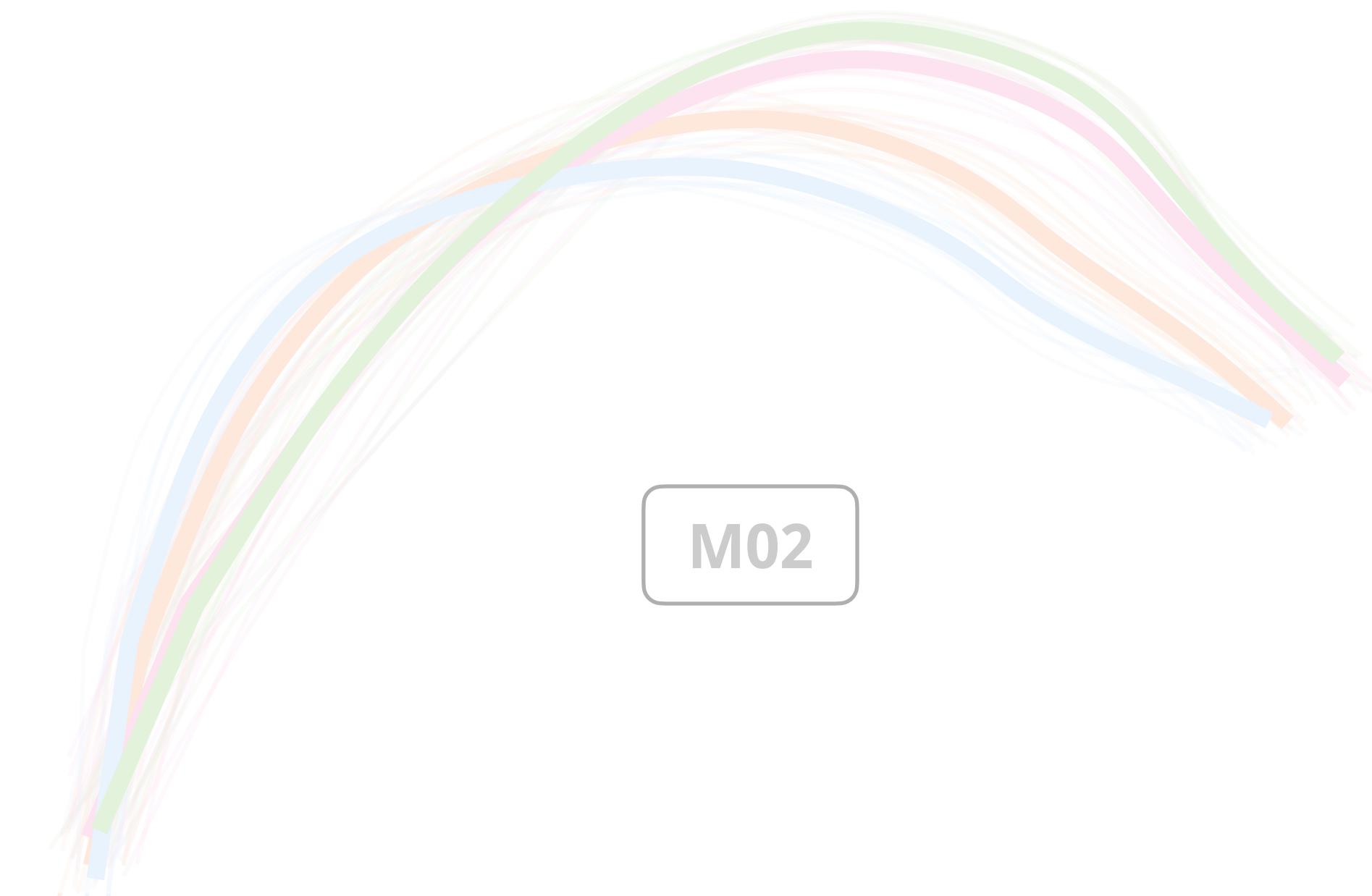


F02

V#s
e.g. the *seat*



M01



M02

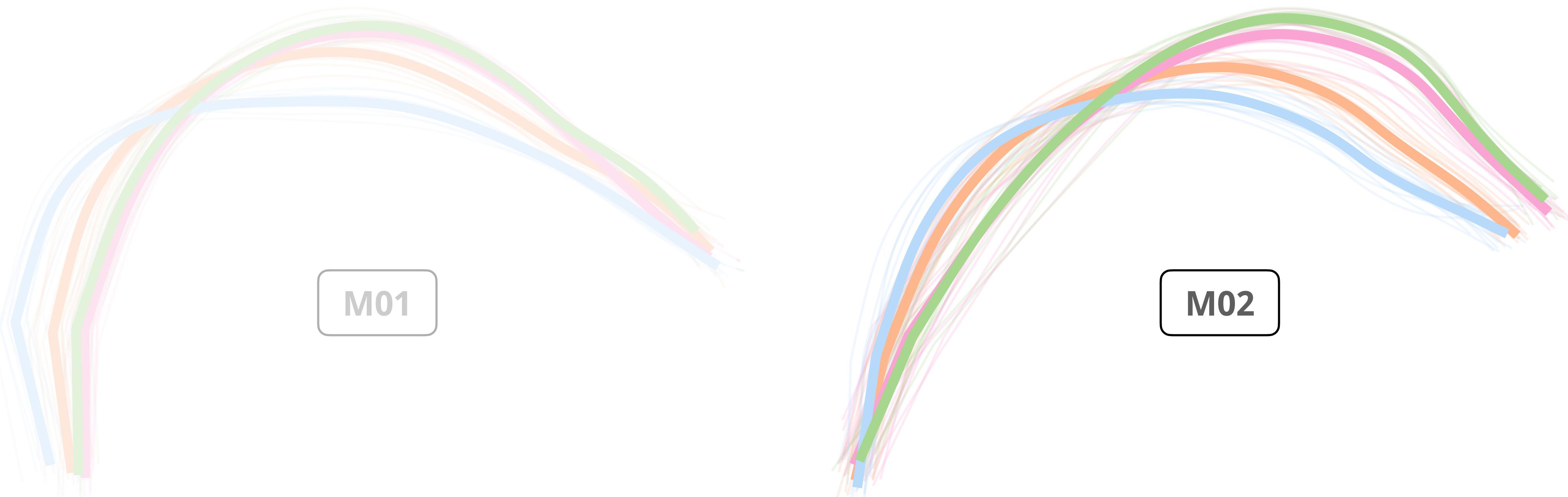
s#ɹ
e.g. *this reed*

s#j
e.g. *this yeast*

V#ʃ
e.g. the *sheet*



V#s
e.g. *the seat*



s#j
e.g. *this yeast*



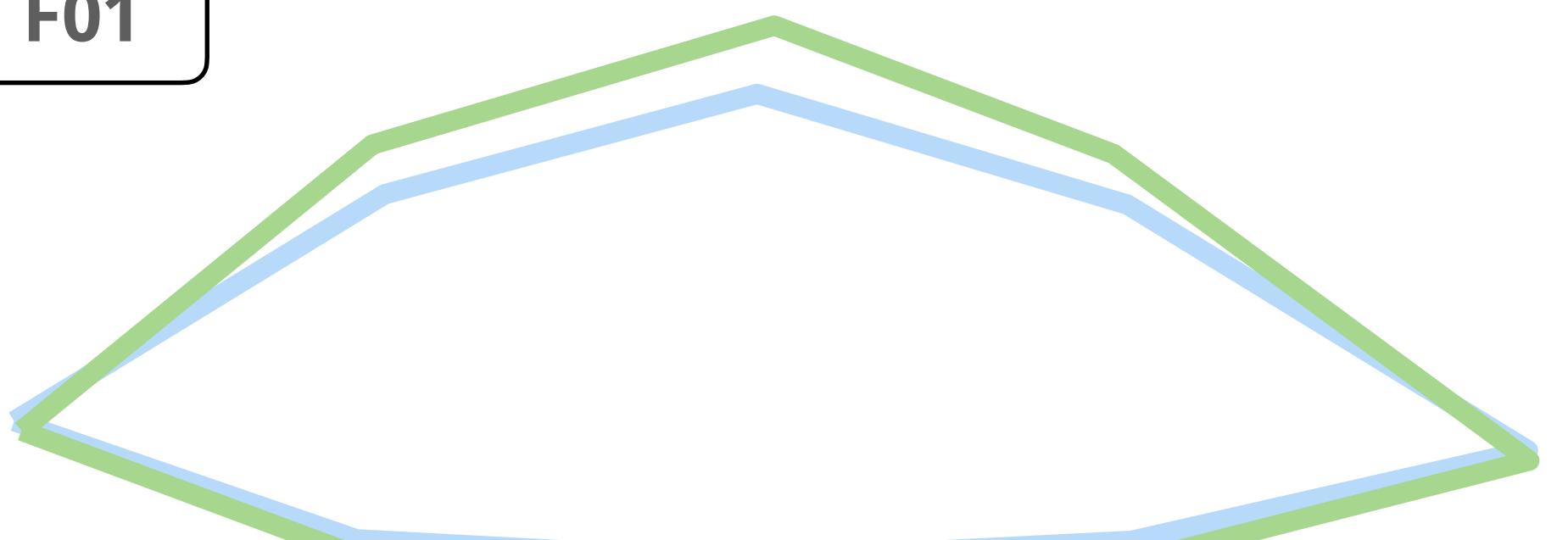
v#ʃ
e.g. *the sheet*

Lips

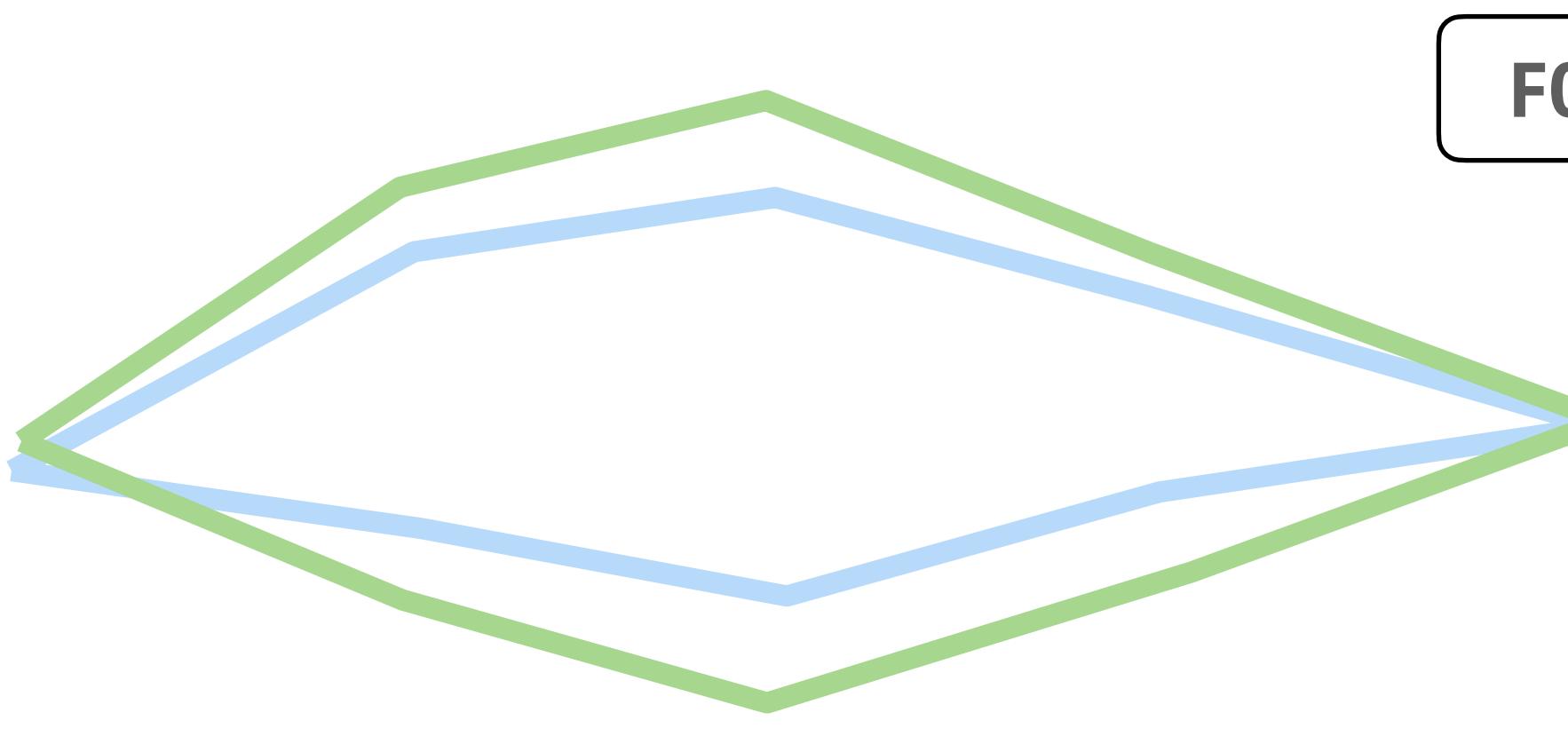
post-lexical retraction



F01



F02



V#s
e.g. seat

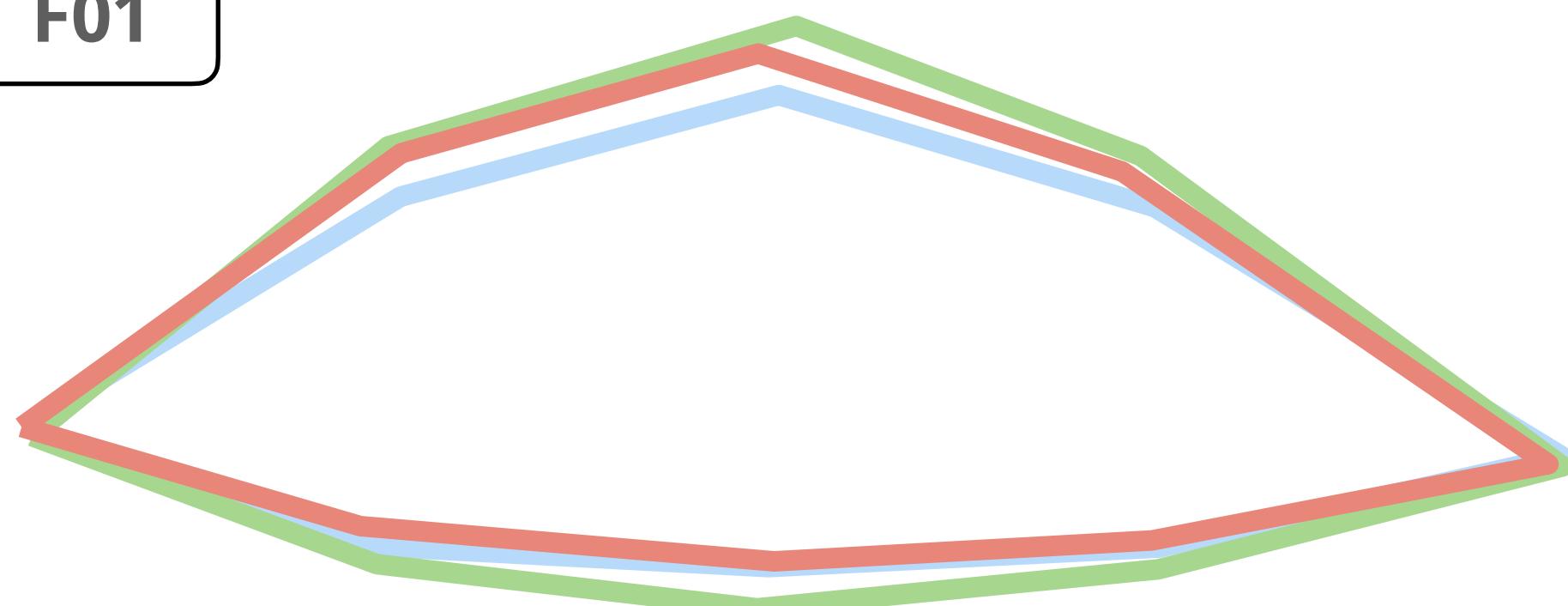
M01



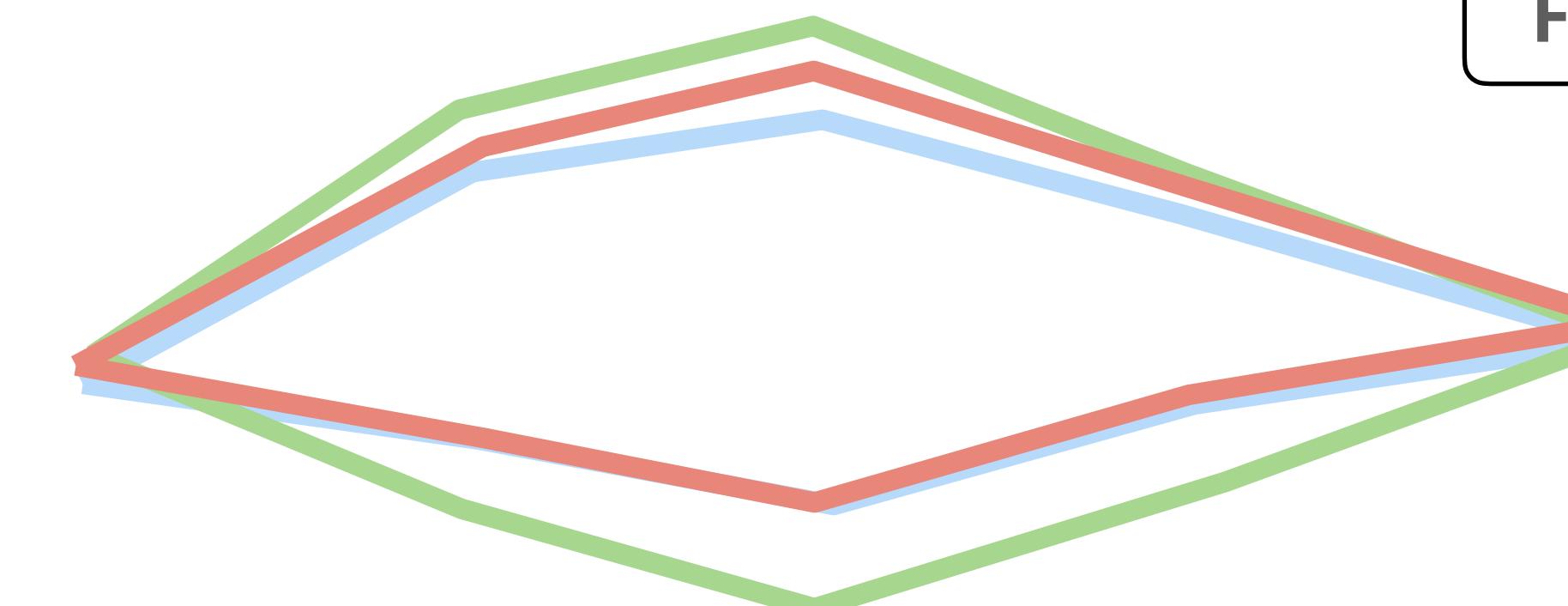
M02

V#ʃ
e.g. sheet

F01



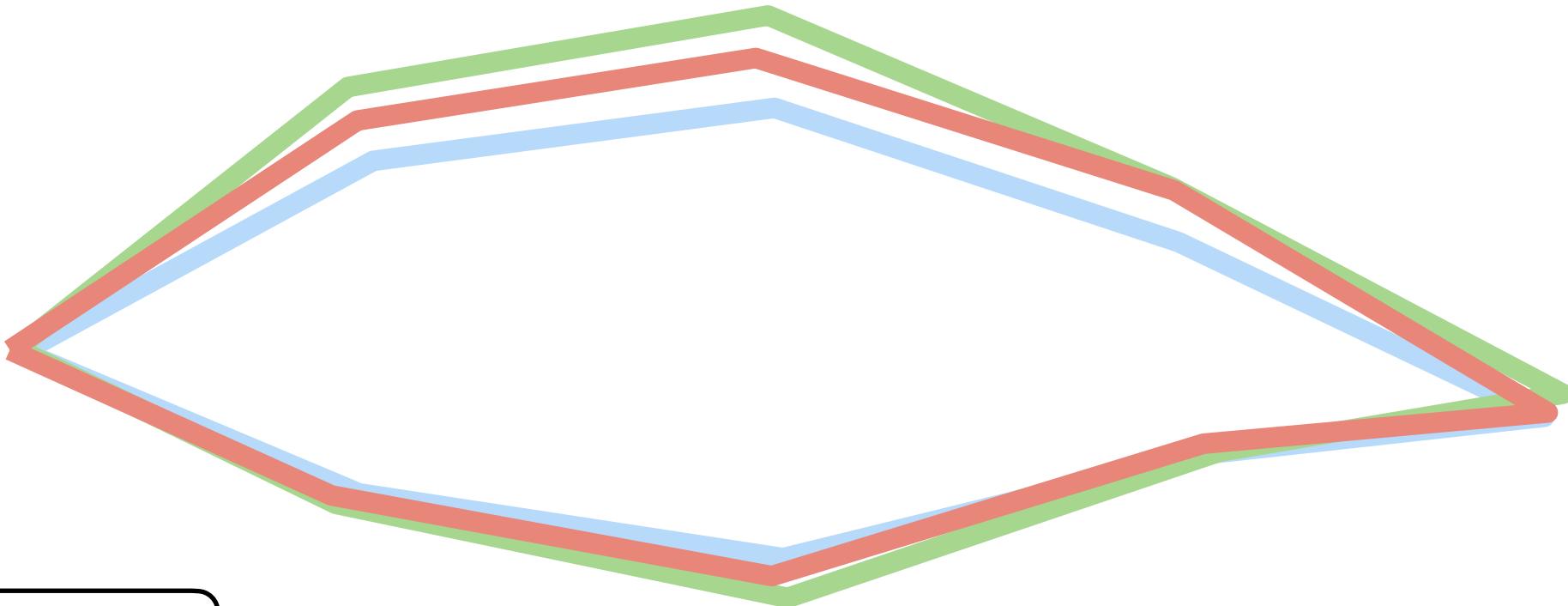
F02



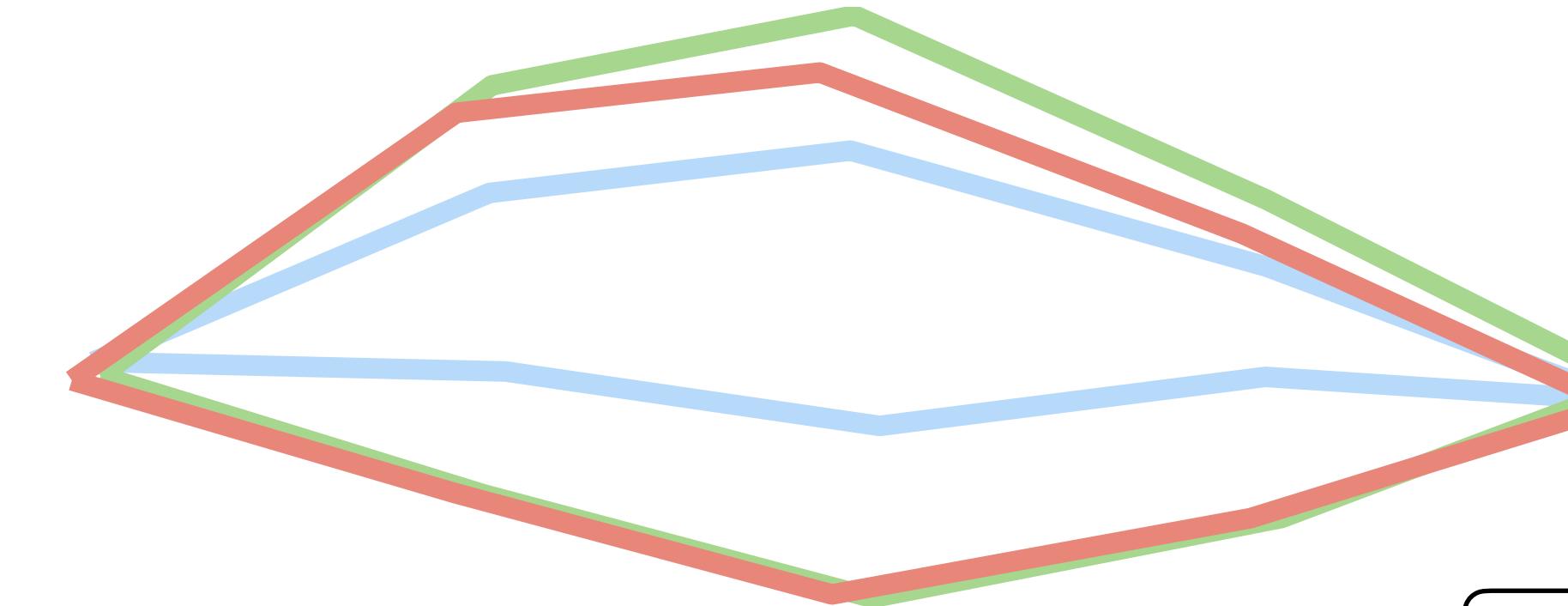
V#s
e.g. *seat*

s#tj
e.g. *this tune*

M01

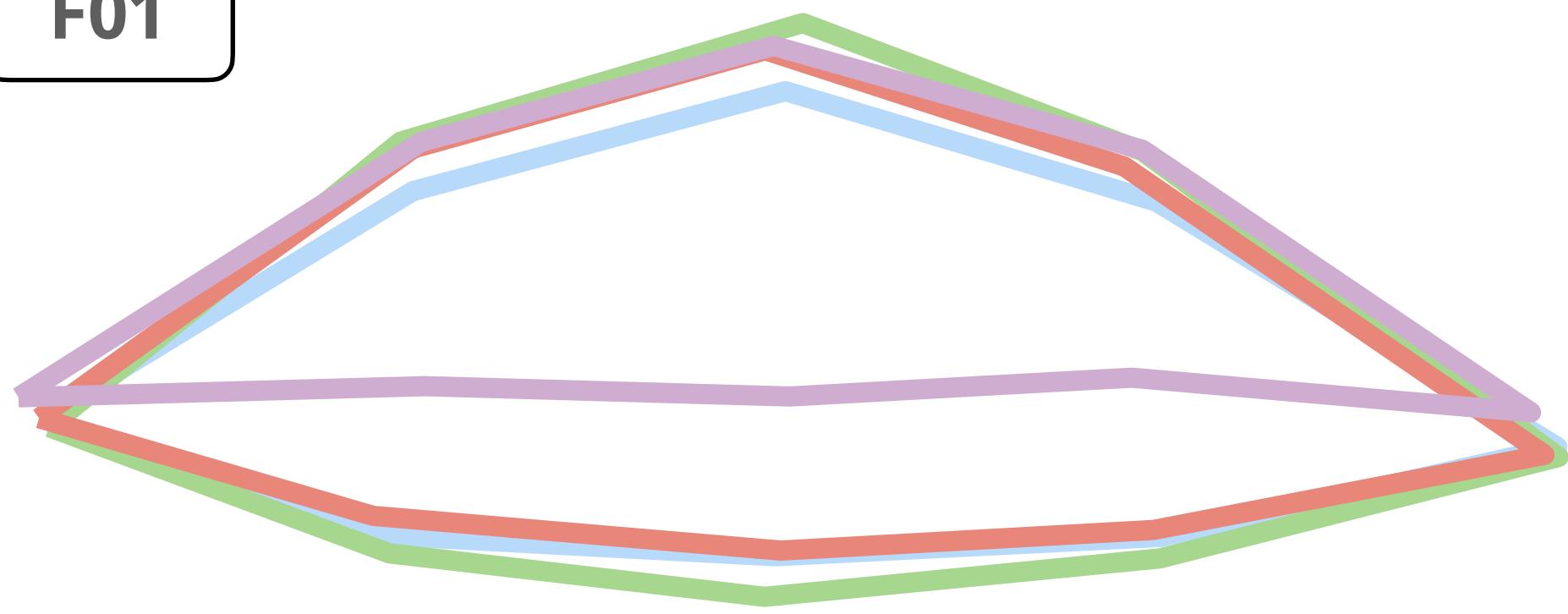


M02

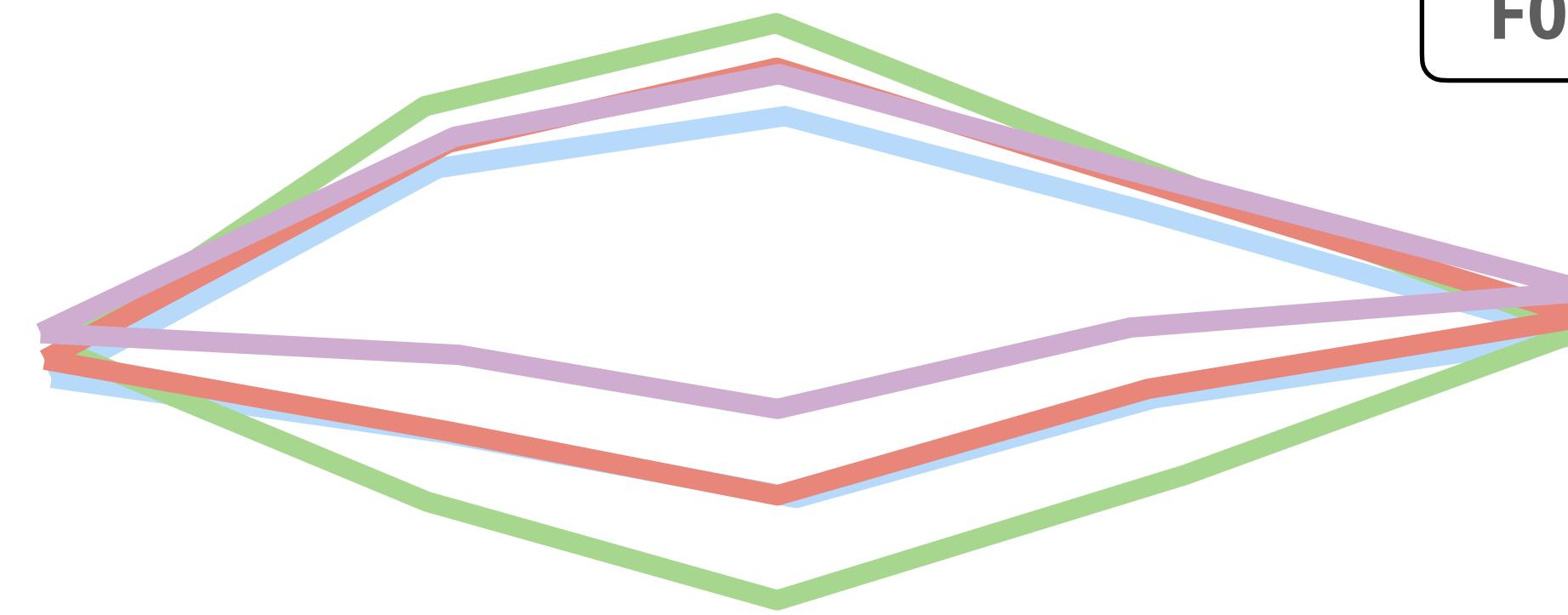


V#ʃ
e.g. *sheet*

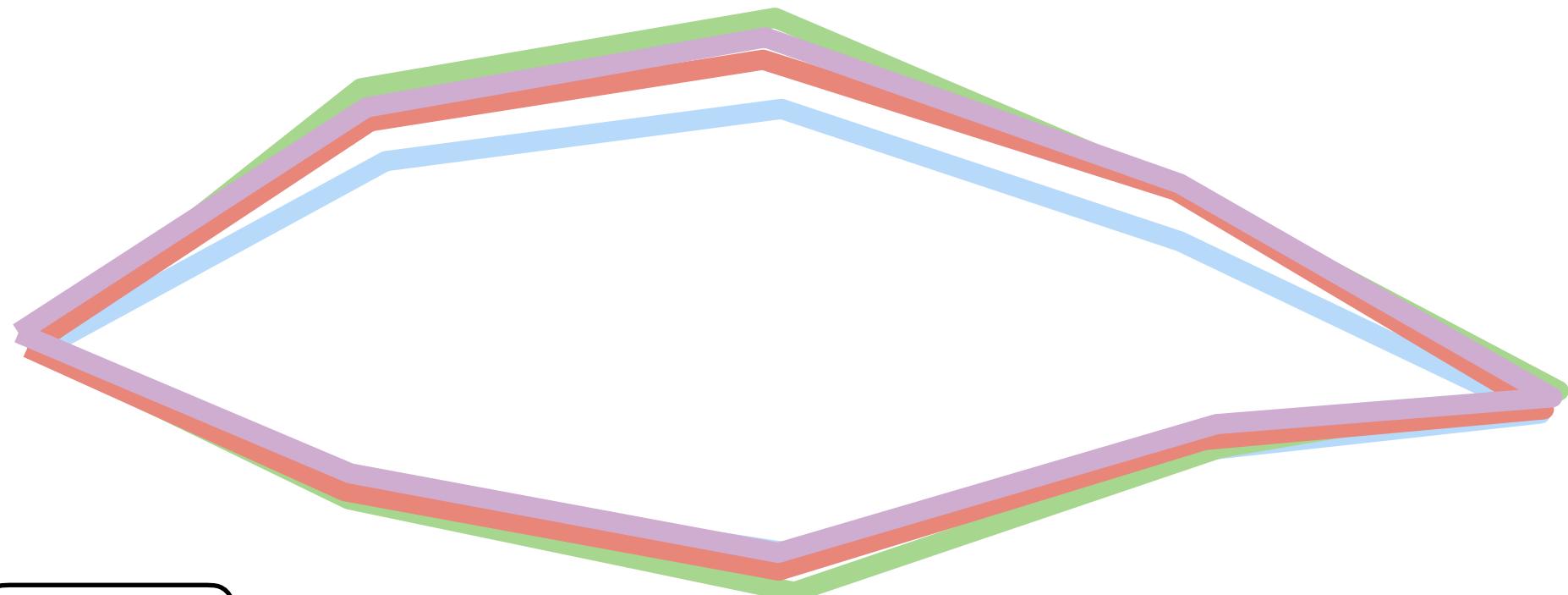
F01



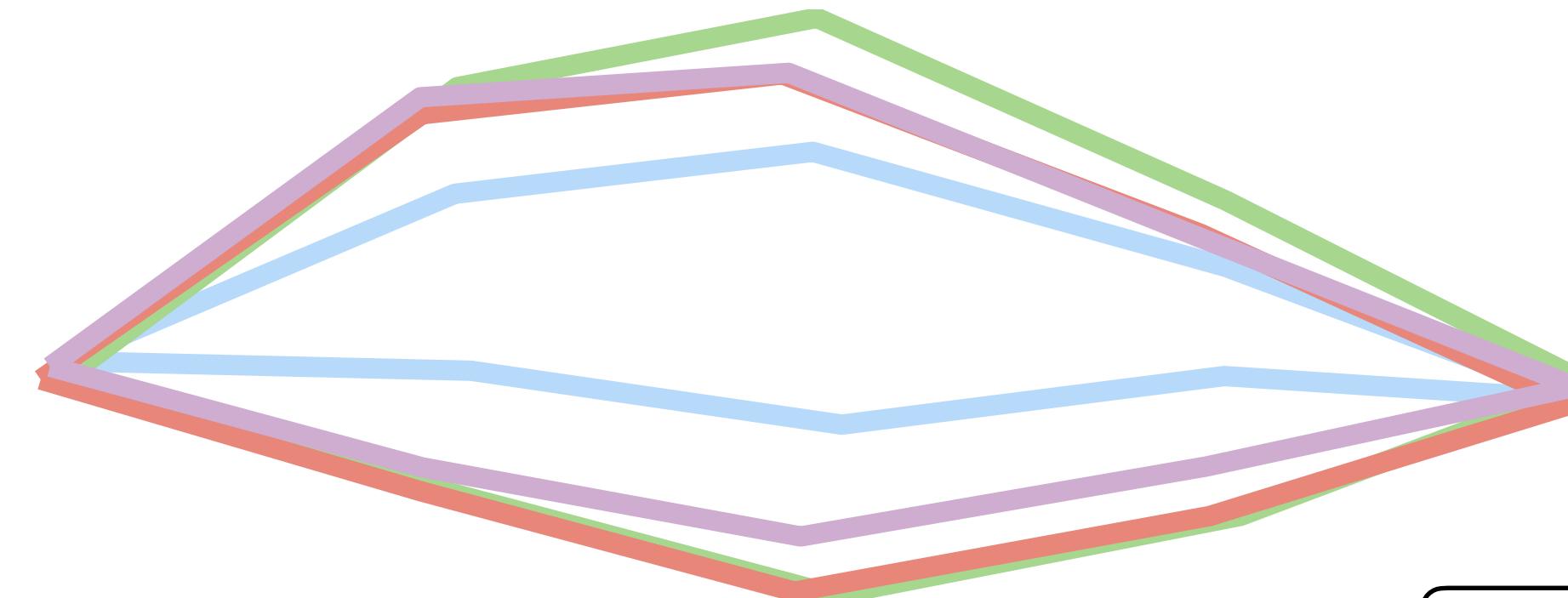
F02



M01



M02



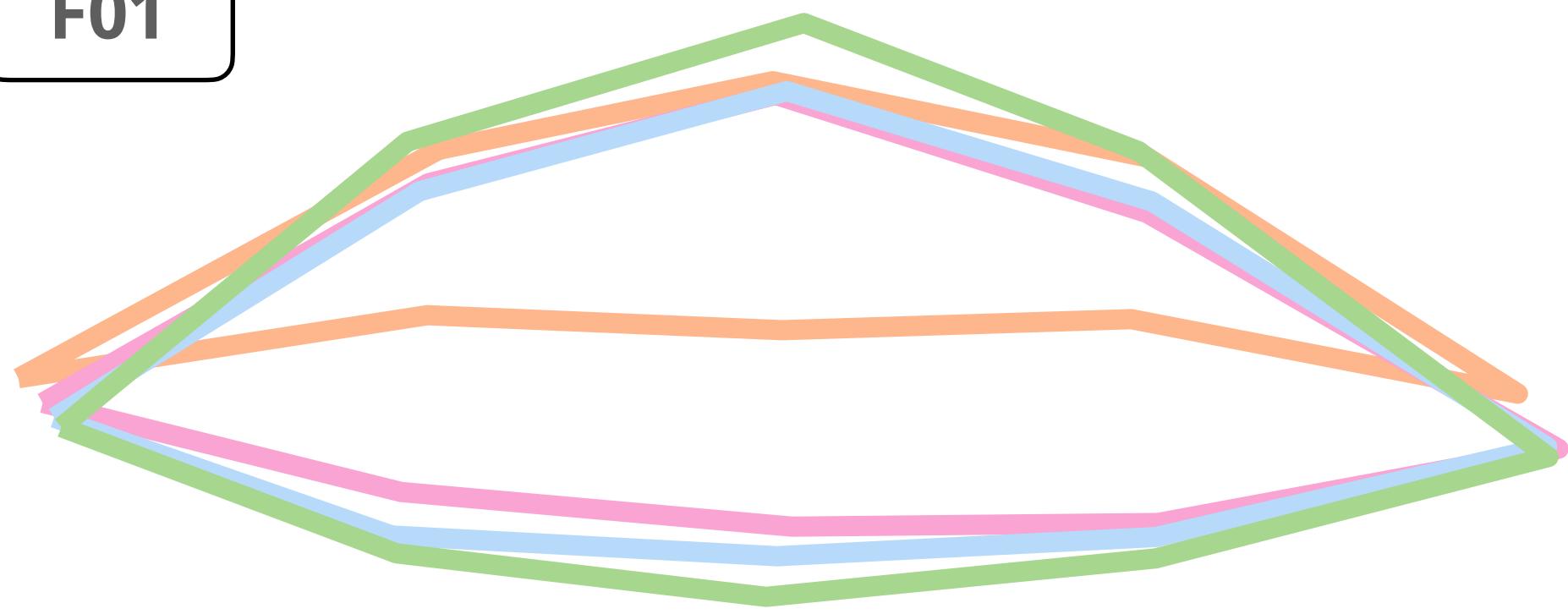
V#s
e.g. *seat*

s#tj
e.g. *this tune*

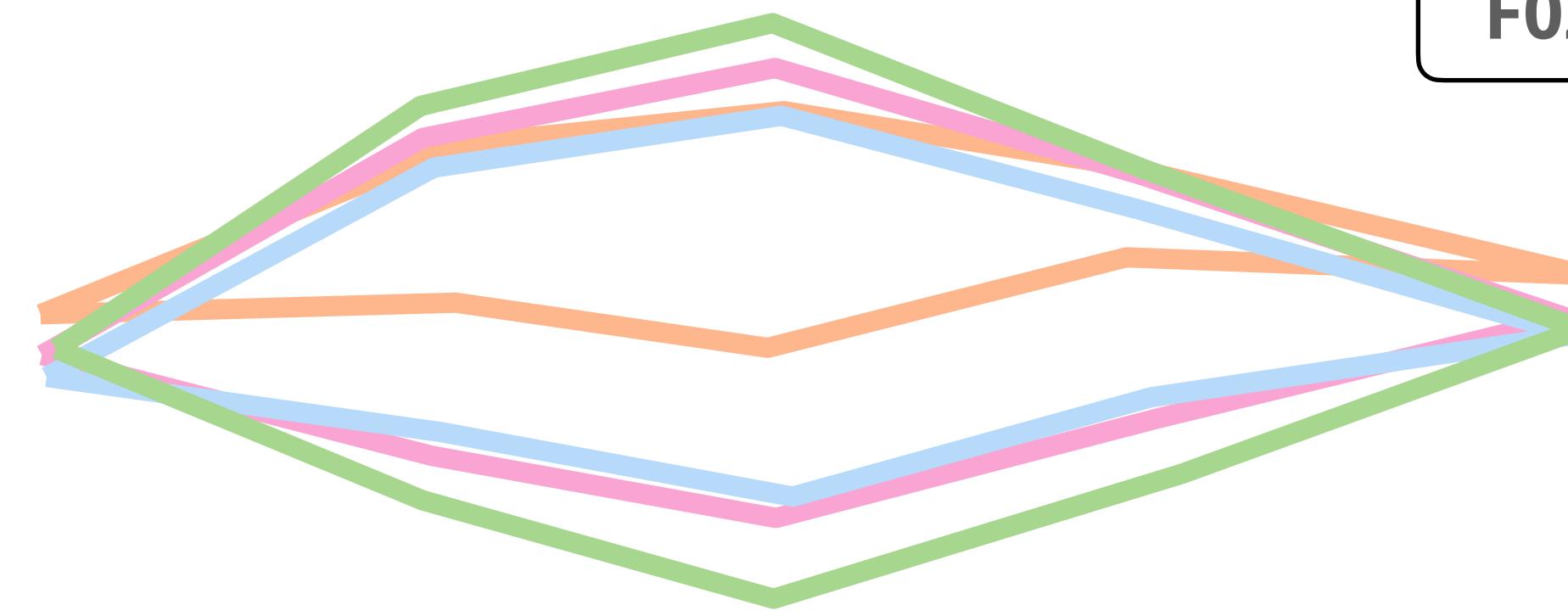
s#tu
e.g. *this tree*

V#ʃ
e.g. *sheet*

F01



F02



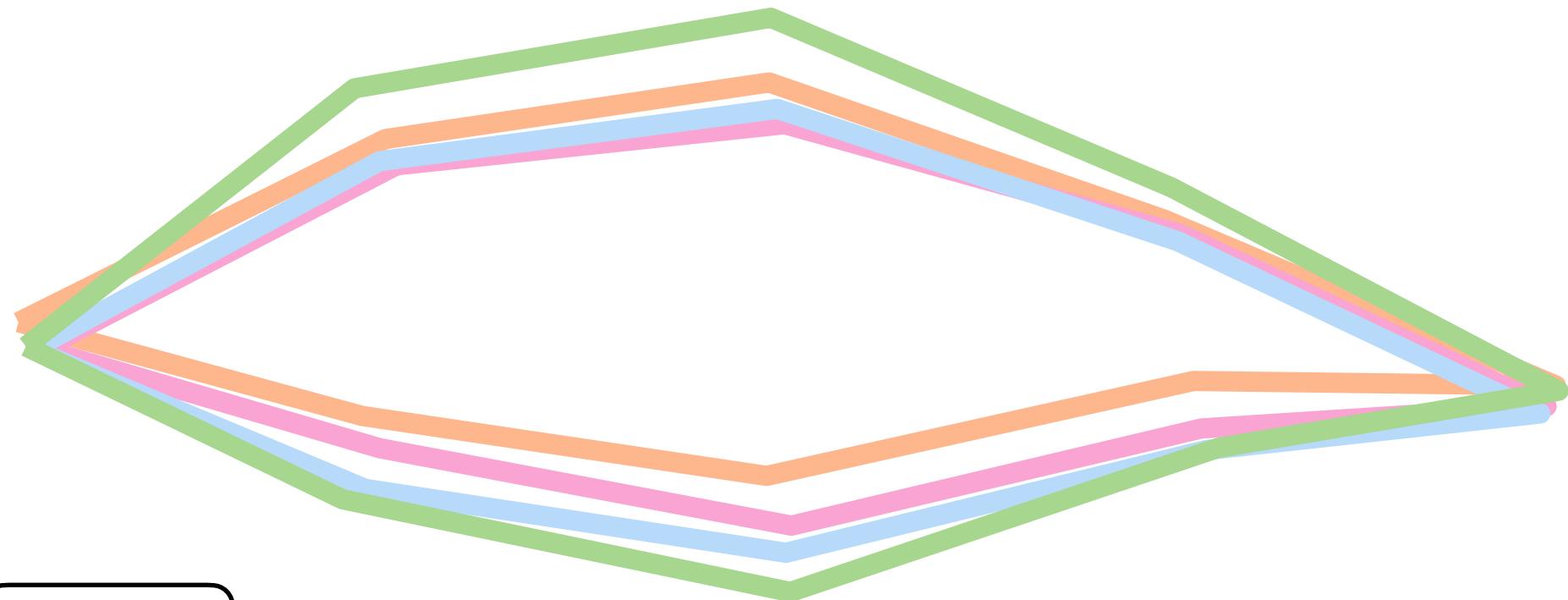
V#s
e.g. *seat*

s#r
e.g. *this reed*

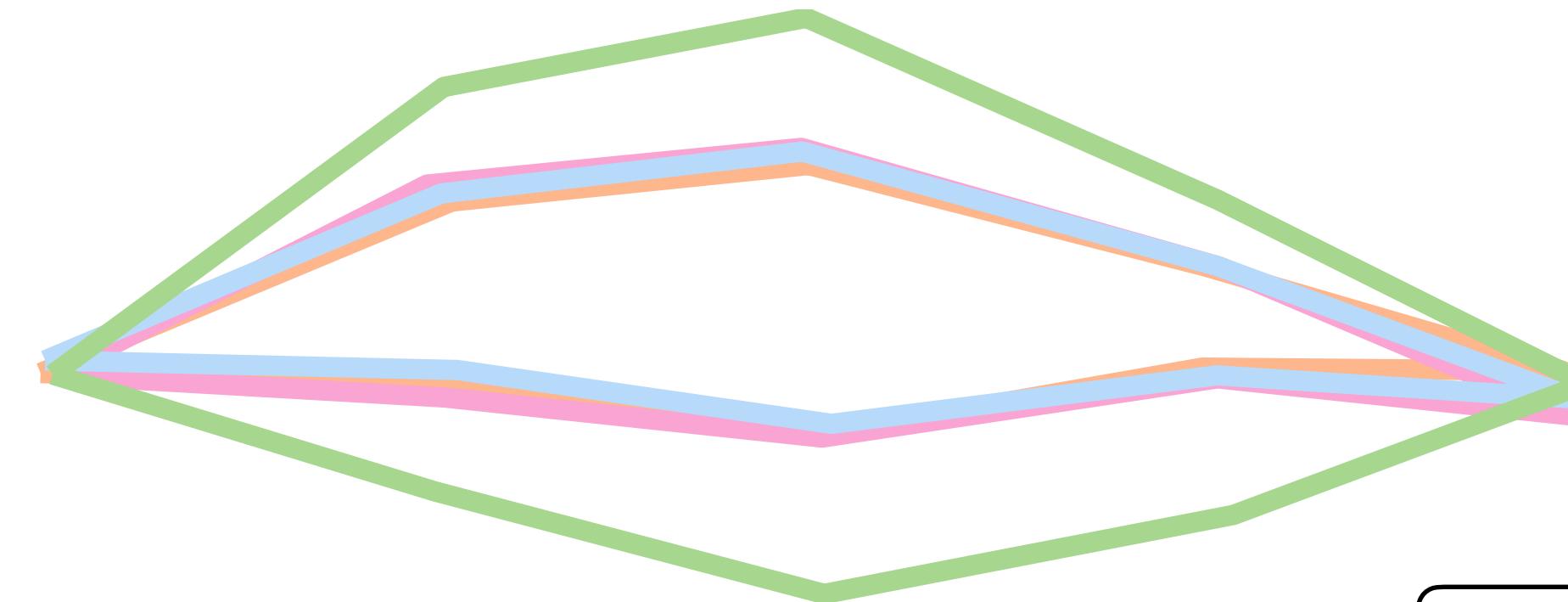
s#j
e.g. *this yeast*

V#ʃ
e.g. *sheet*

M01



M02



F01

V#s

V#ʃ

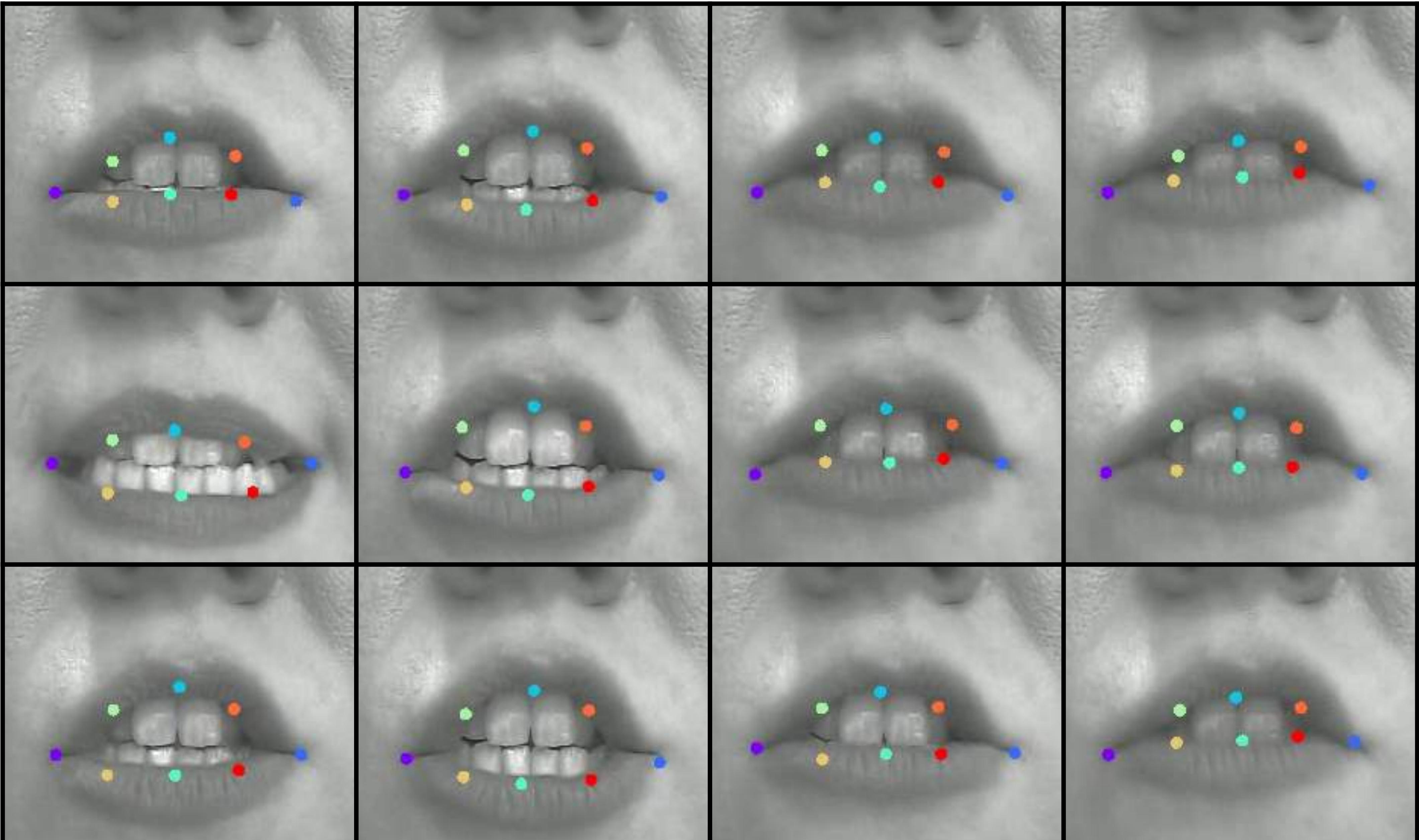
s#tʃ

s#ɹ

/p/

/i/

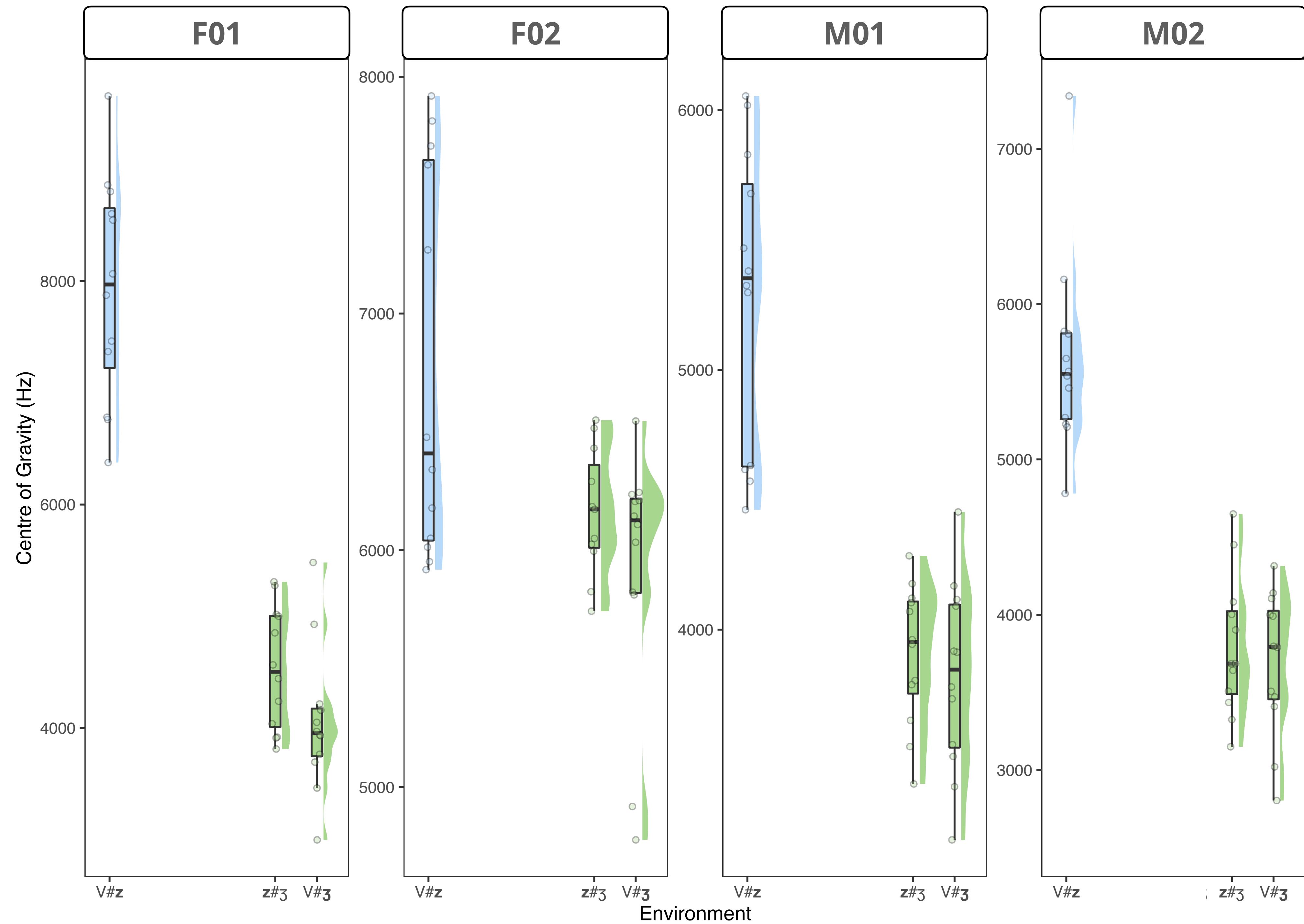
/u/



Acoustics

/z/-retraction

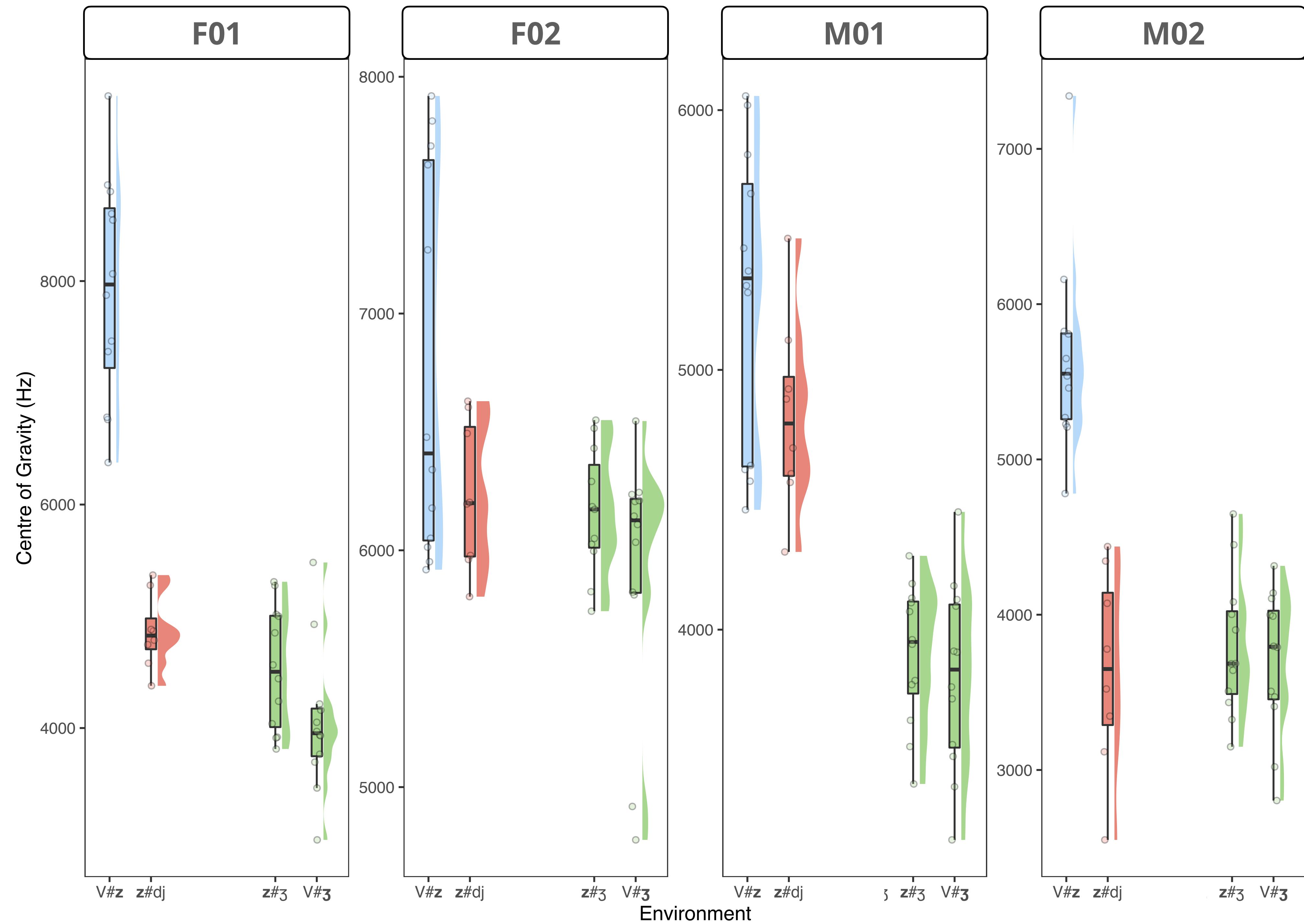




V#z
e.g. *the zombie*

z#3
e.g. *these genres*

V#3
e.g. *the genre*

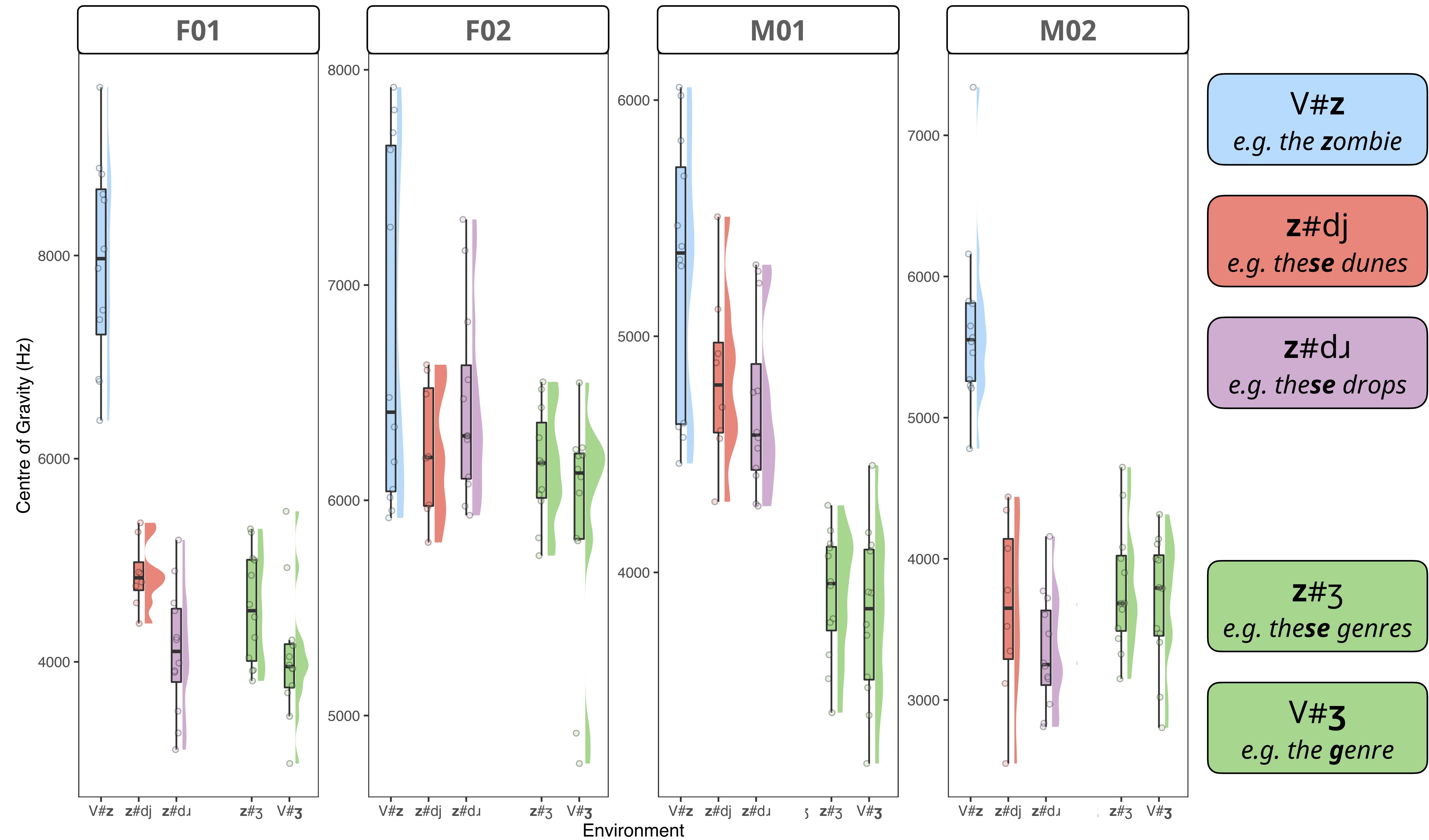


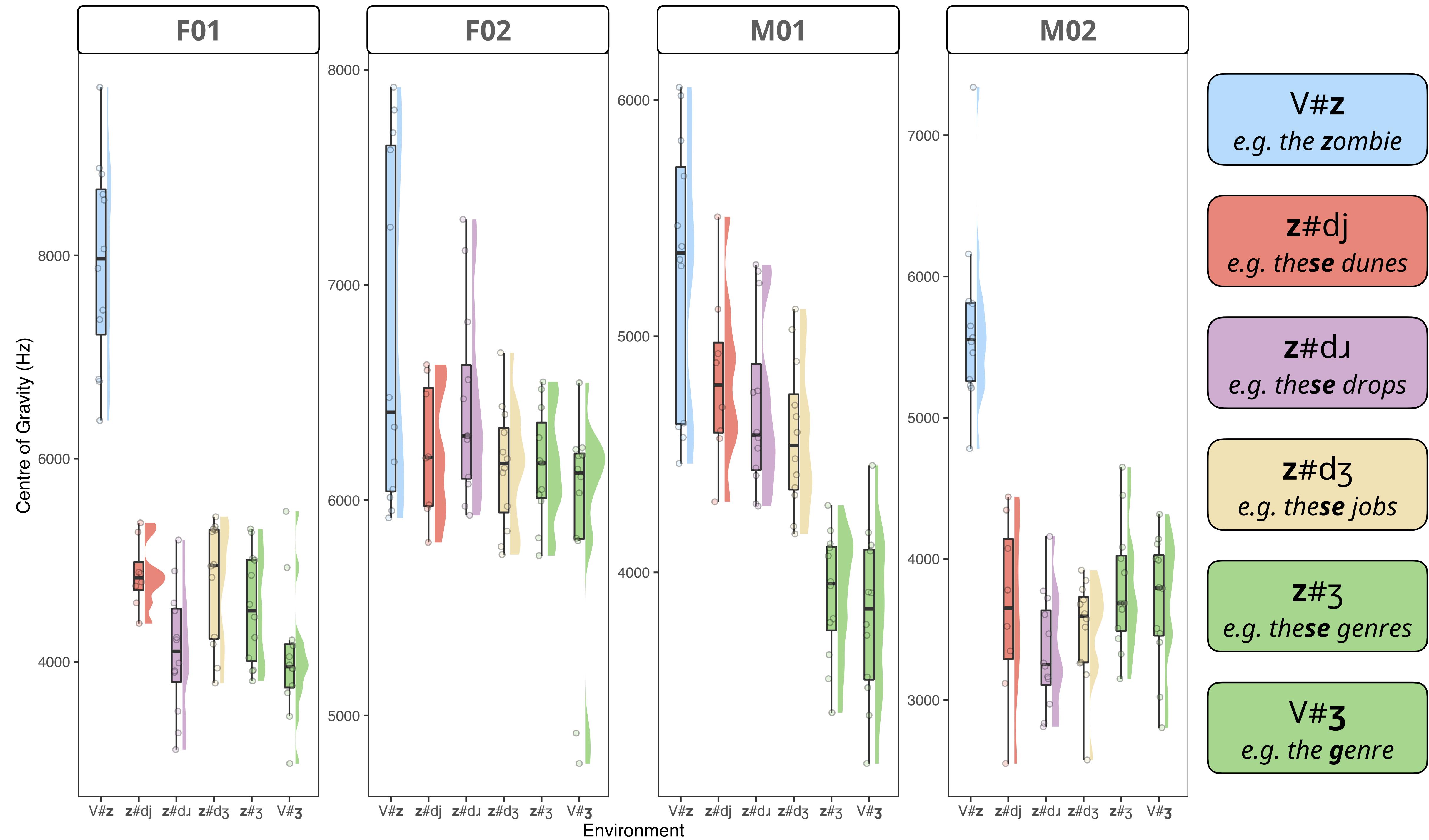
V#z
e.g. *the zombie*

z#dj
e.g. *these dunes*

z#3
e.g. *these genres*

V#3
e.g. *the genre*





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, tʂ/ 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

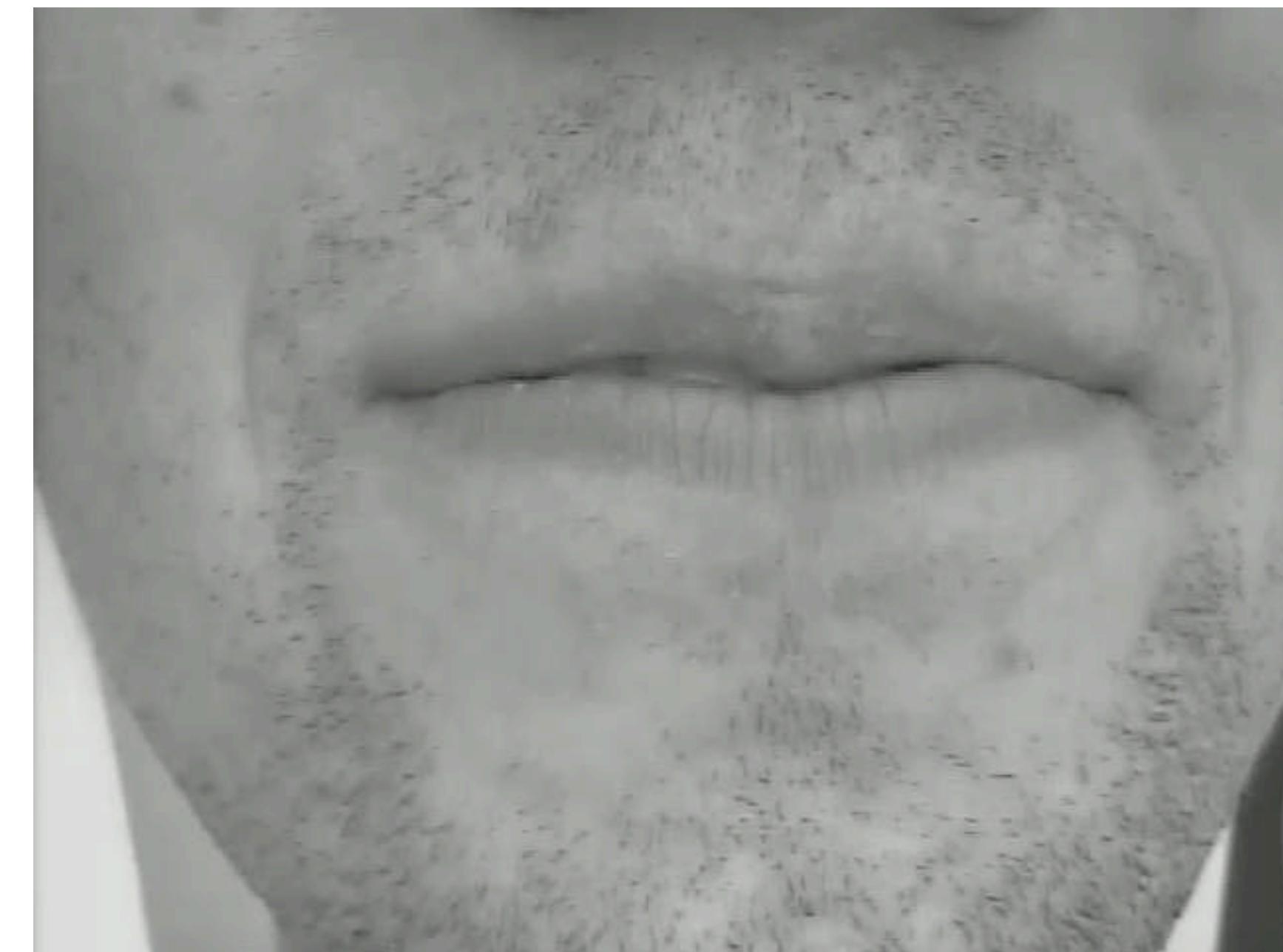
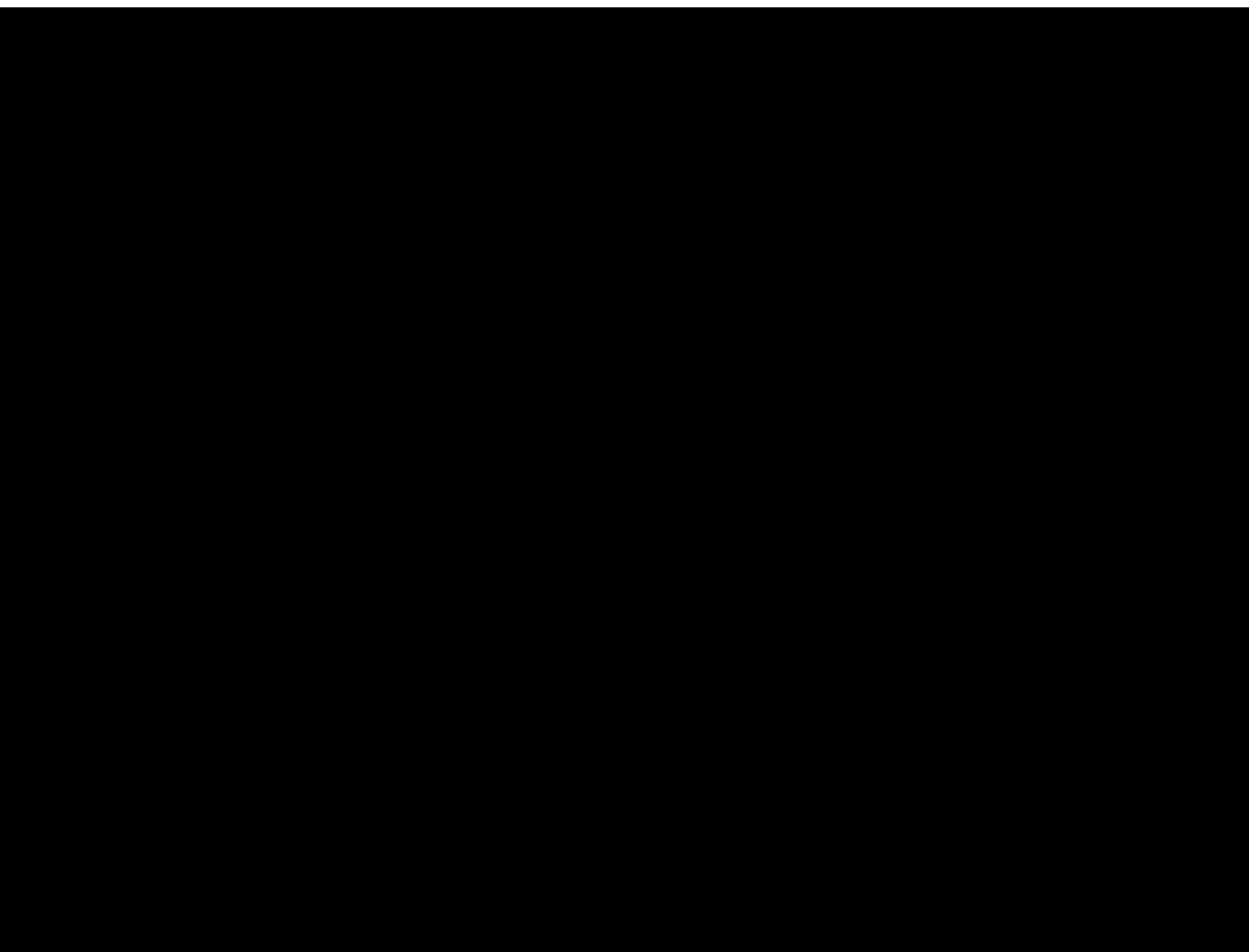
/s/-retraction is an extremely *complex* process

- 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

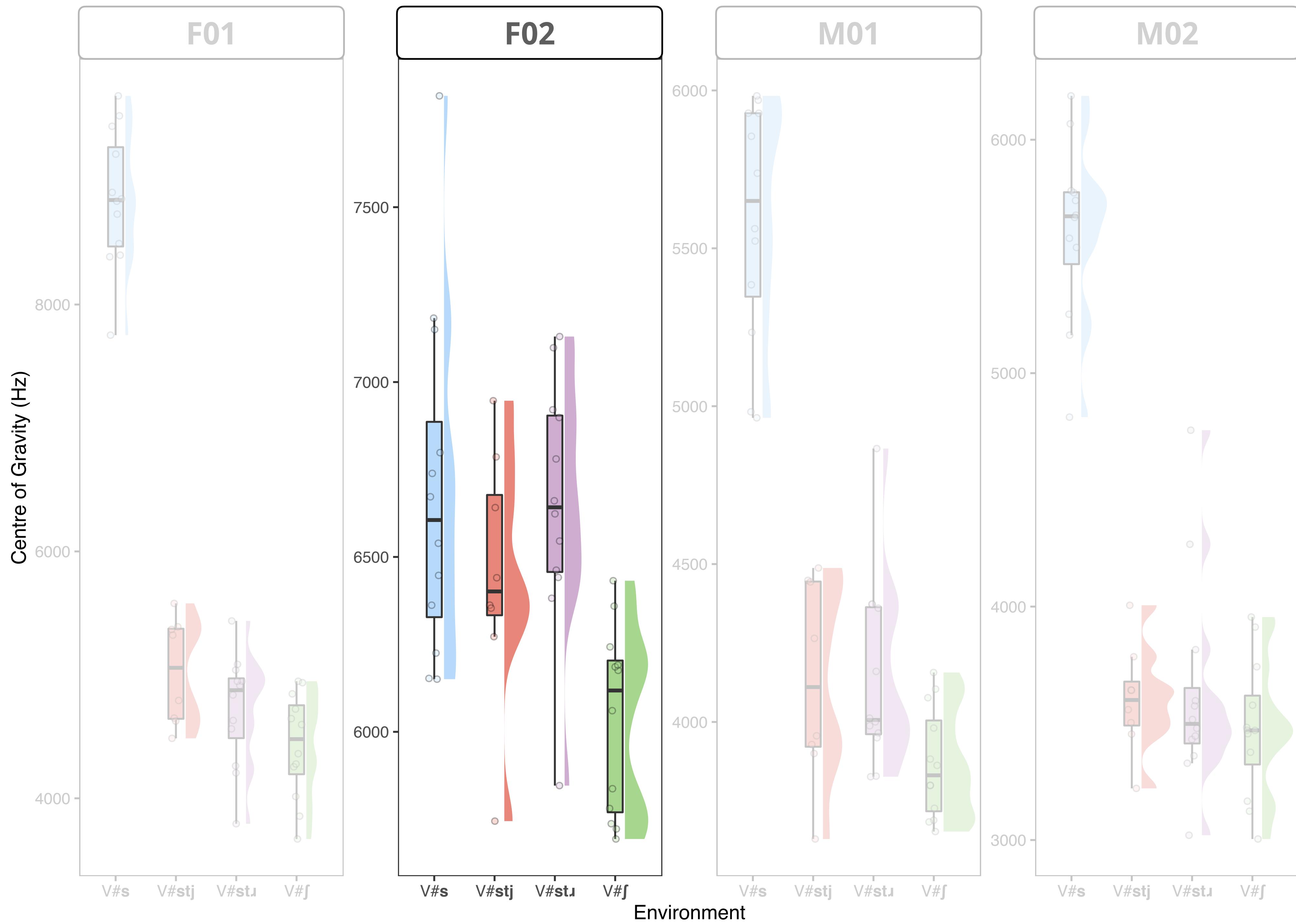
What /r/ /ɹ/ future plans?

- 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

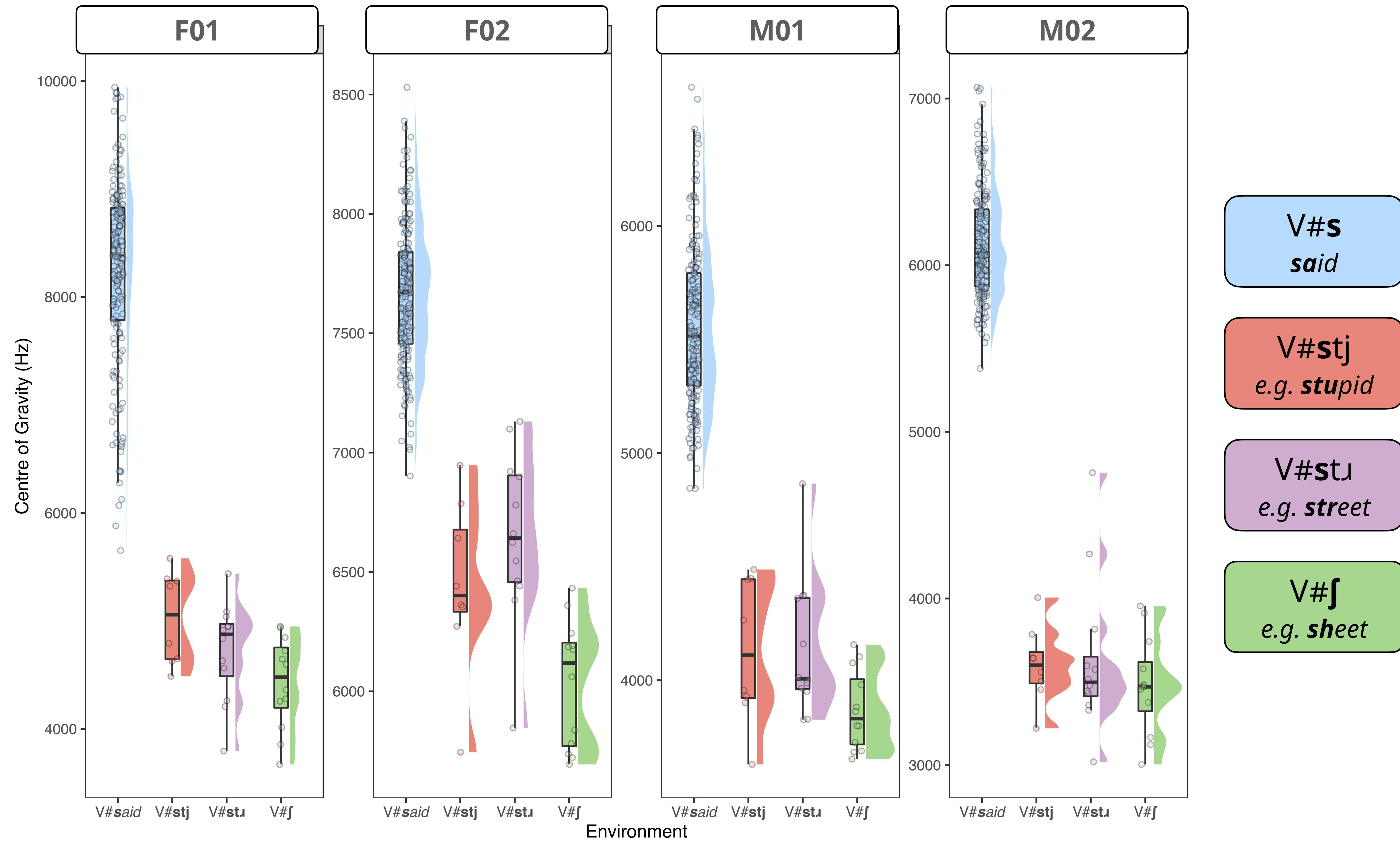


V#s
e.g. seat

V#stj
e.g. *stupid*

V#stu
e.g. *street*

V#ʃ
e.g. *sheet*



V#s
said

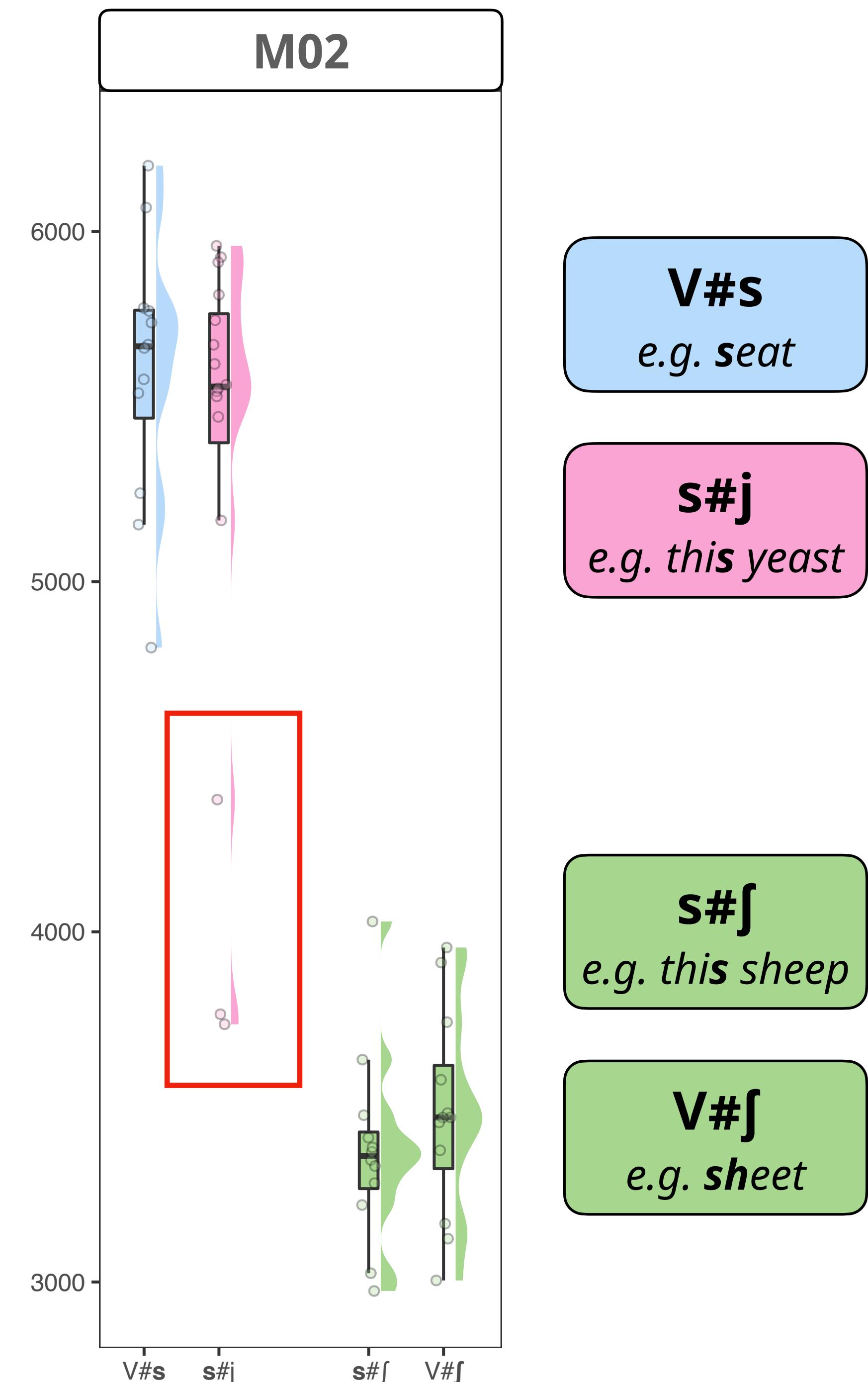
V#stj
e.g. *stupid*

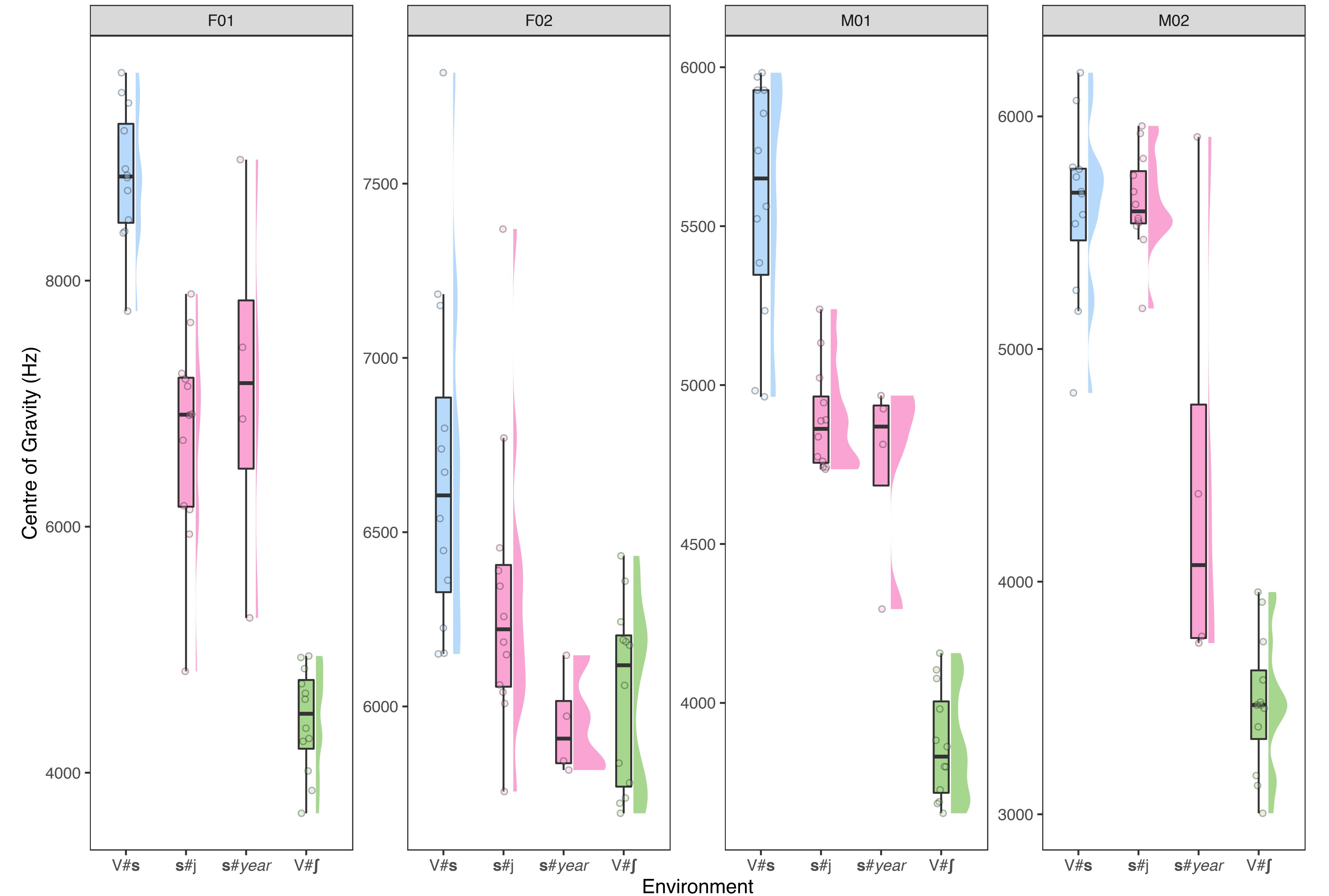
V#stu
e.g. *street*

V#ʃ
e.g. *sheet*

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*





V#s
e.g. *seat*

s#j
e.g. *this yeast*

s#year

s#ʃ
e.g. *this sheep*

V#ʃ
e.g. *sheet*

Tongue

word-internal retraction



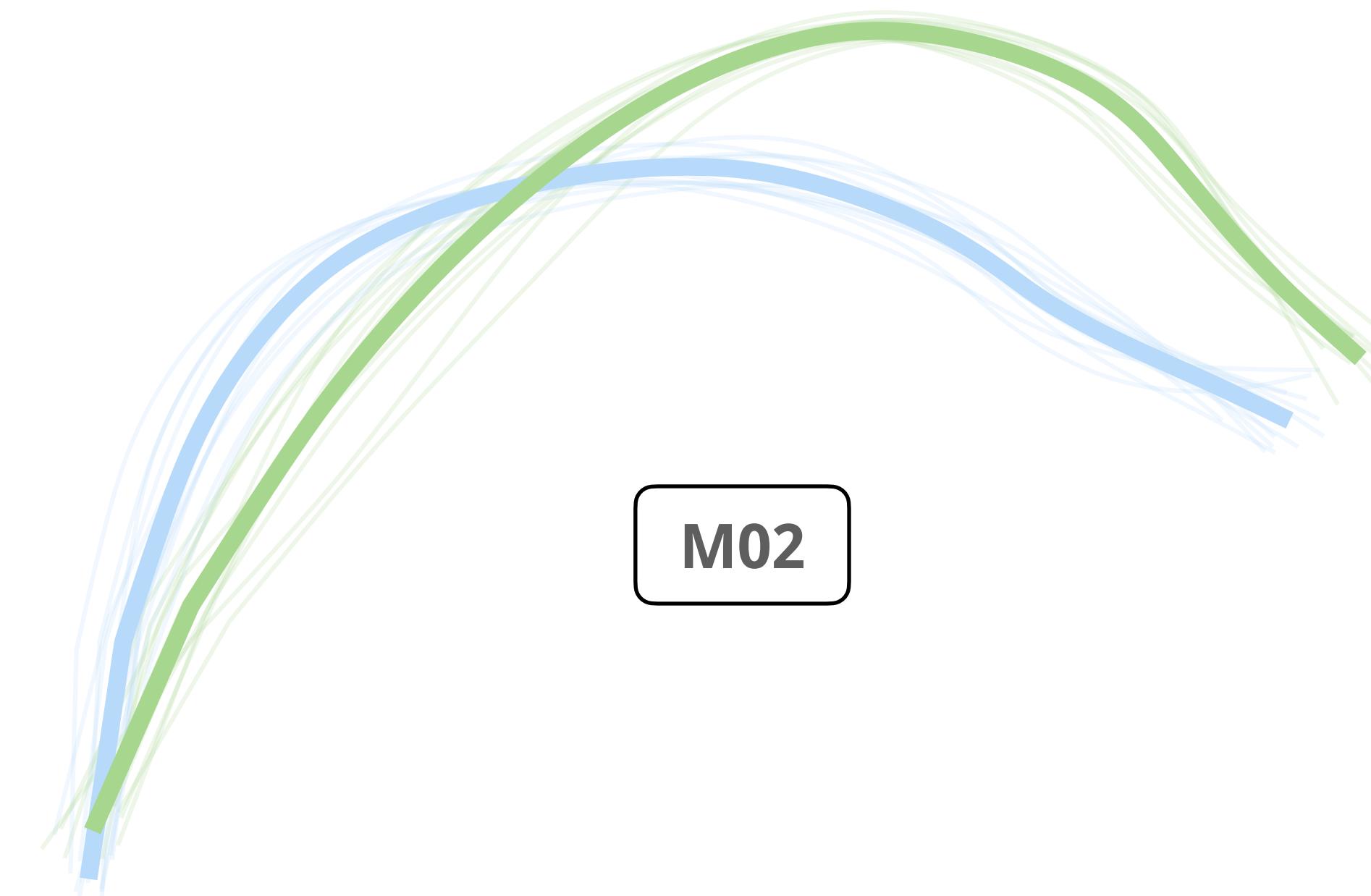
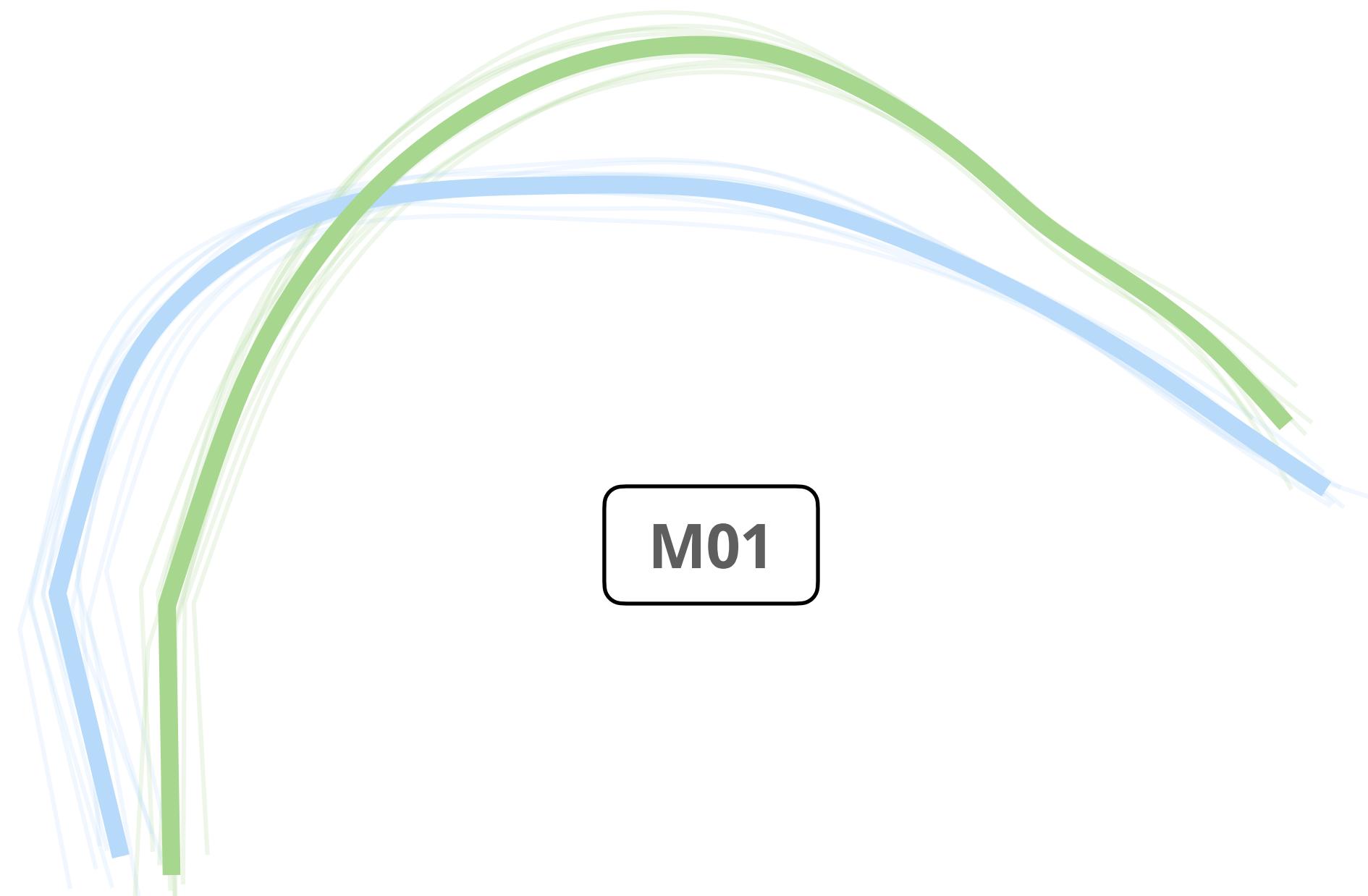


V#s
e.g. *seat*

V#stj
e.g. *stupid*

V#str
e.g. *street*

V#ʃ
e.g. *sheet*





F01



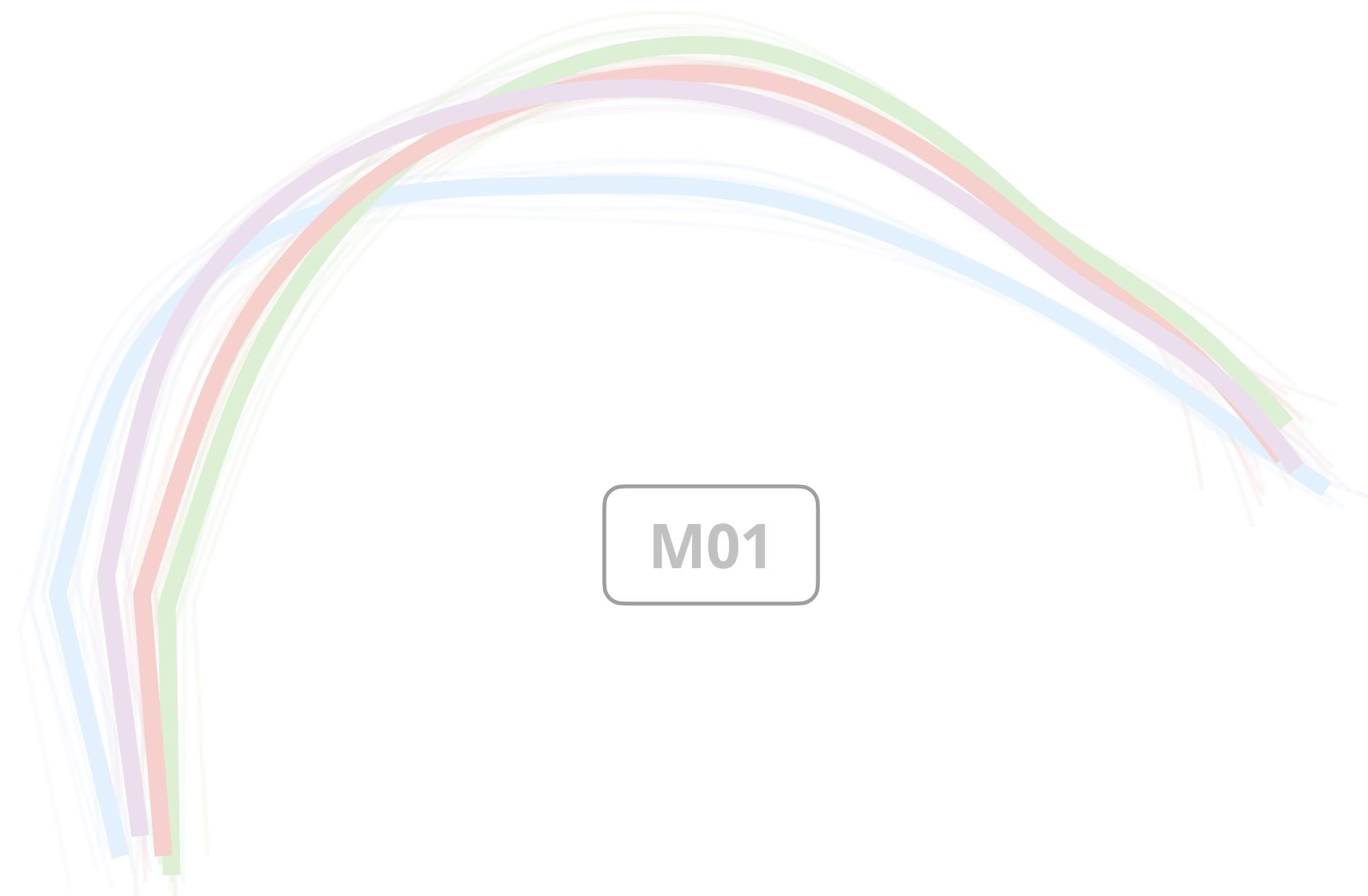
F02

V#s
e.g. *seat*

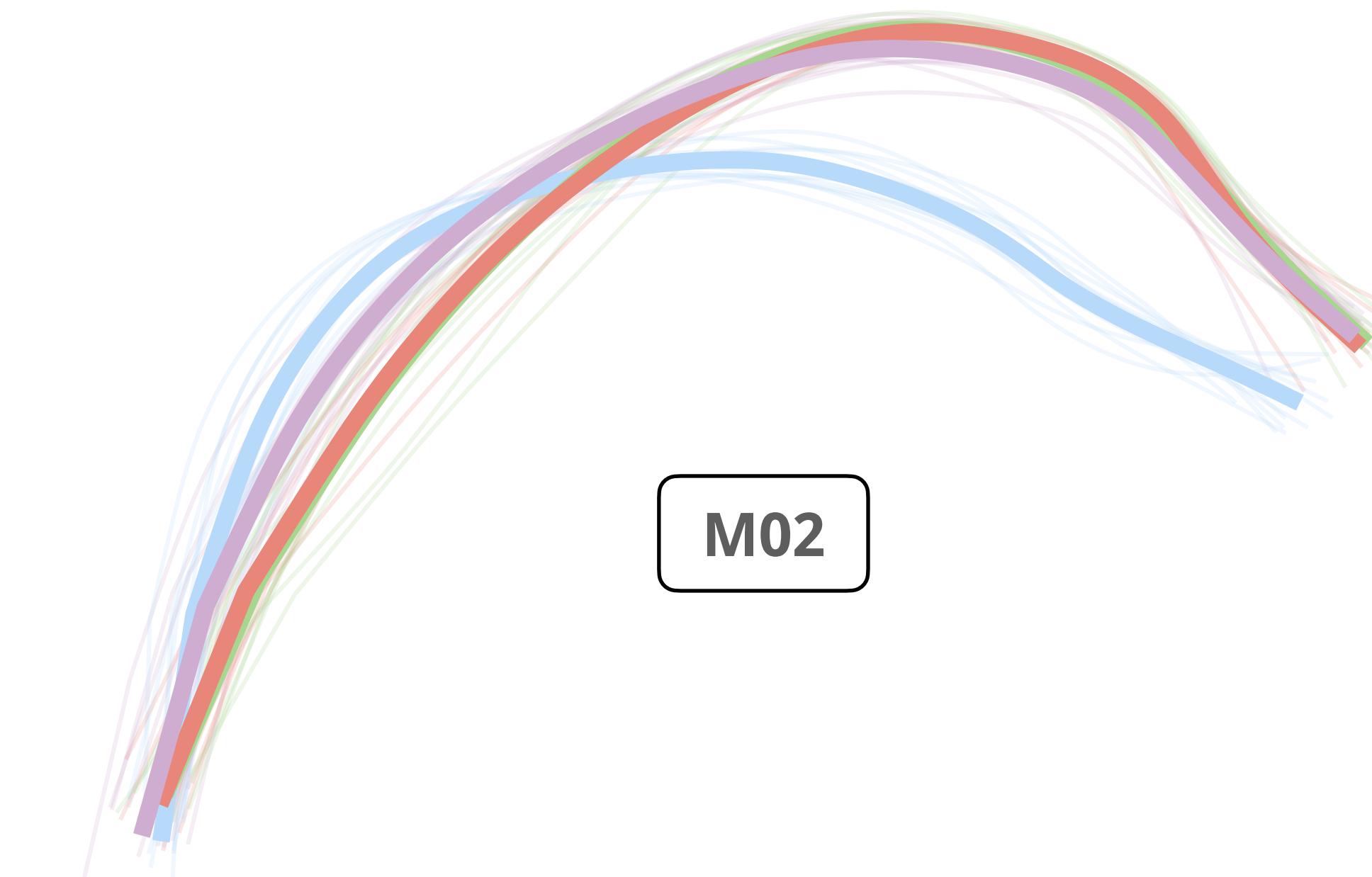
V#stj
e.g. *stupid*

V#str
e.g. *street*

V#ʃ
e.g. *sheet*



M01



M02

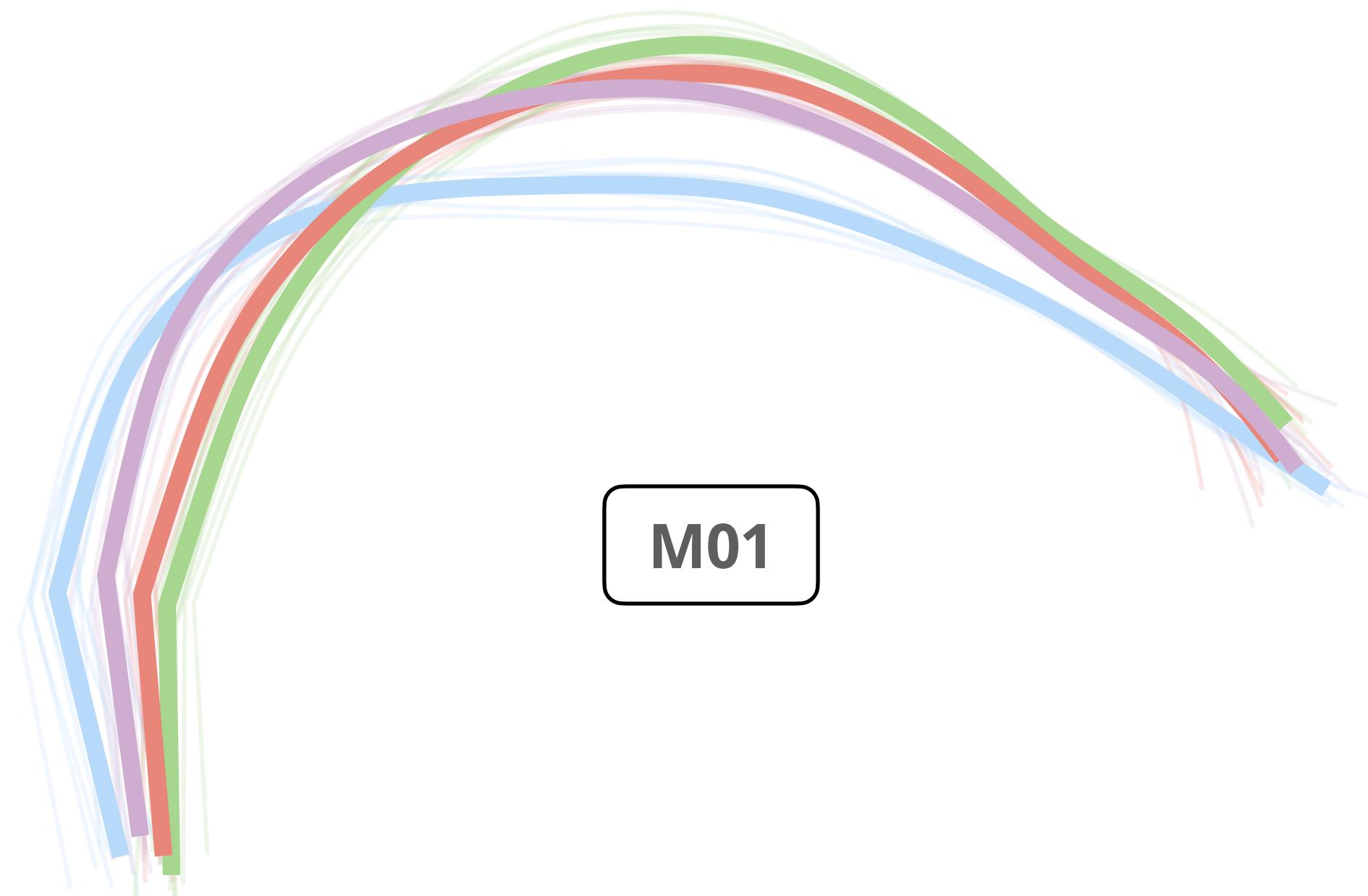


V#s
e.g. *seat*

V#stj
e.g. *stupid*

V#str
e.g. *street*

V#ʃ
e.g. *sheet*

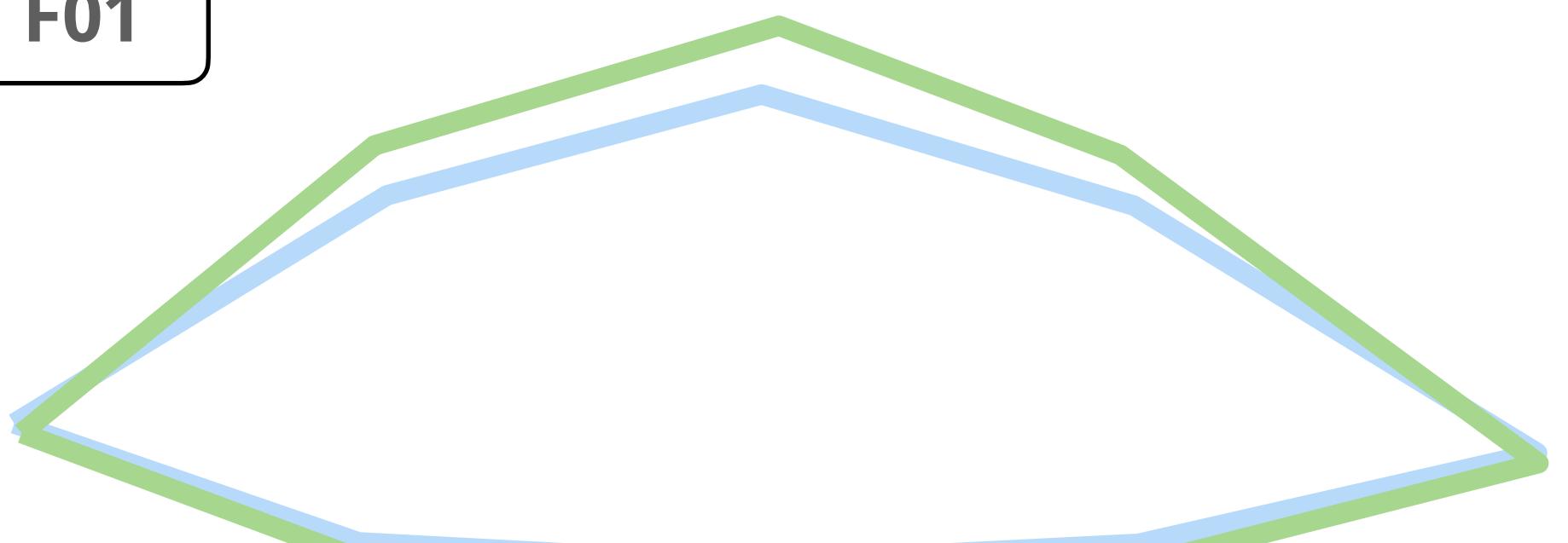


Lips

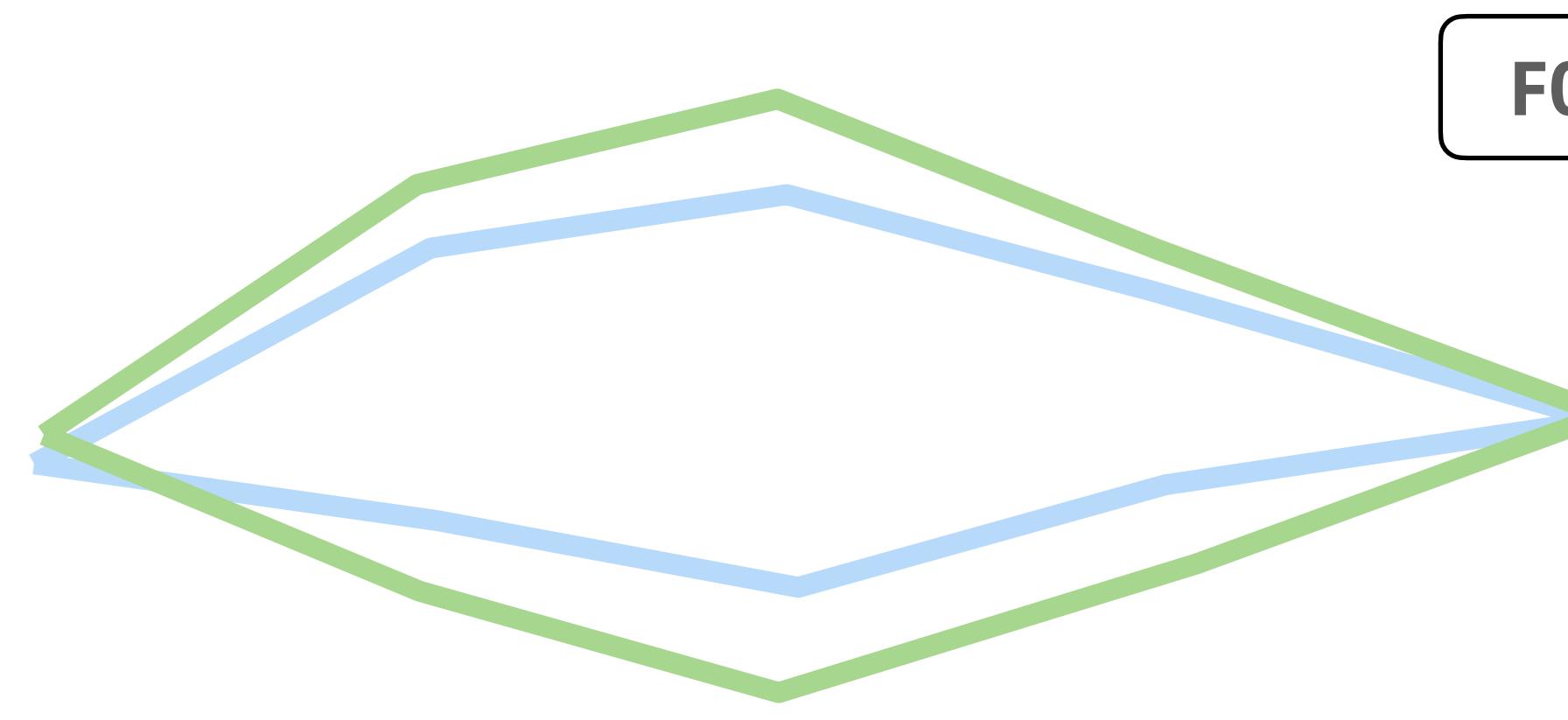
word-internal retraction



F01

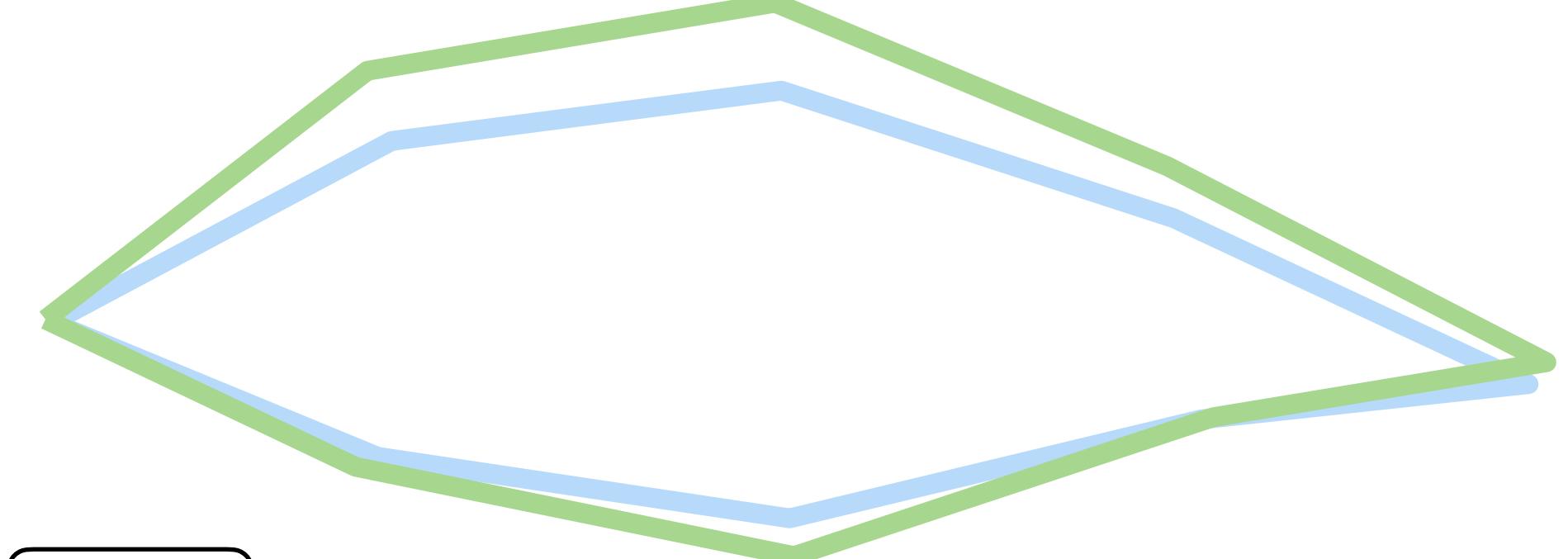


F02

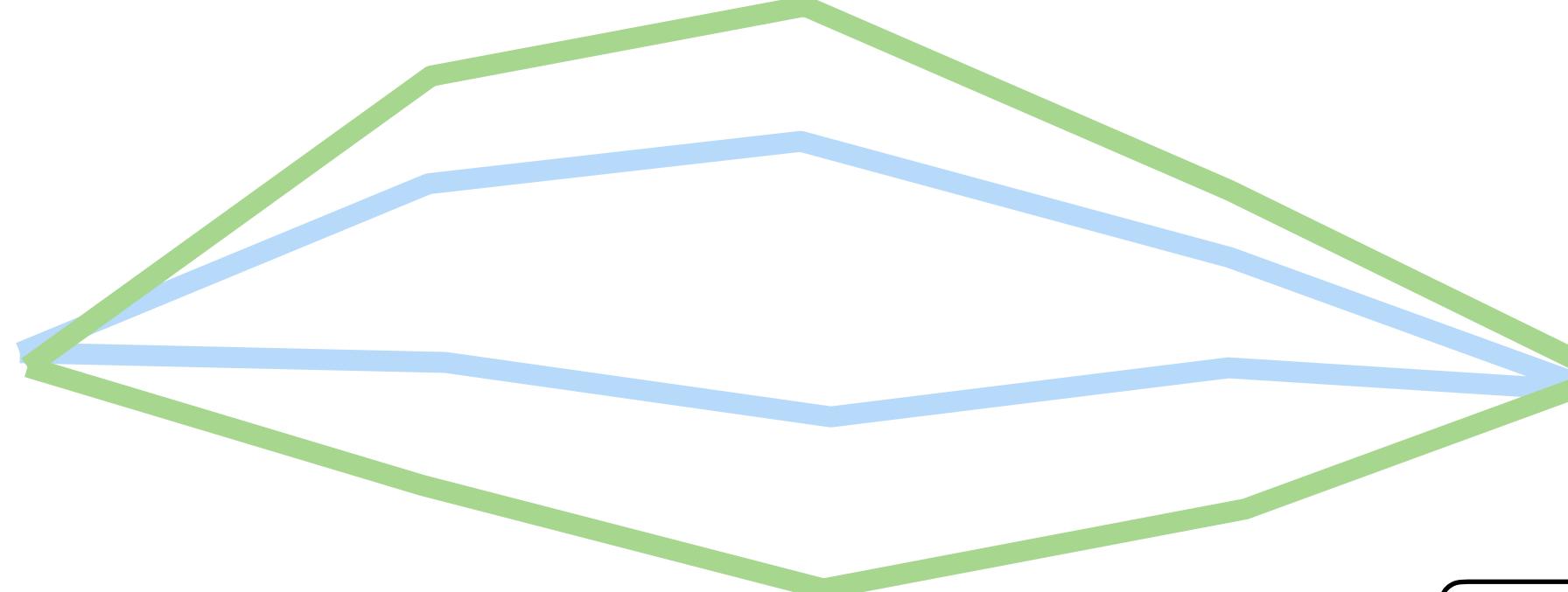


V#s
e.g. seat

M01

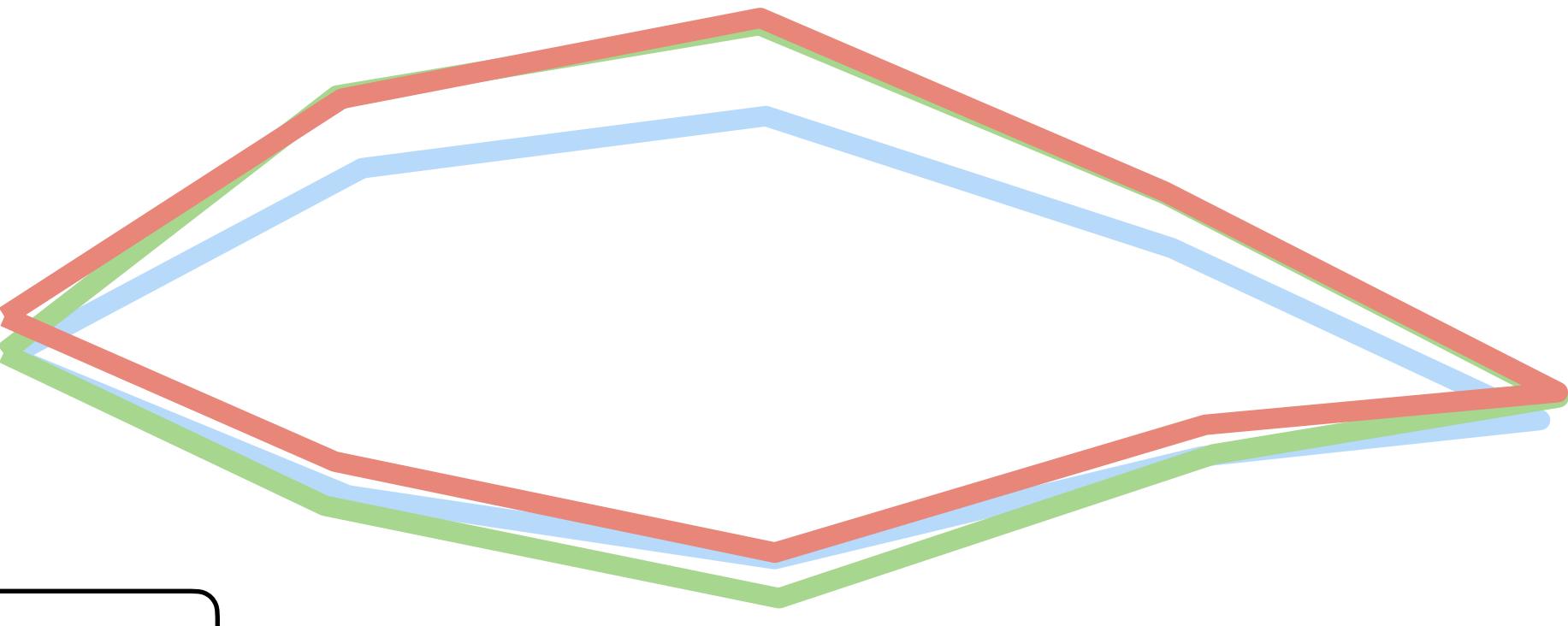


M02

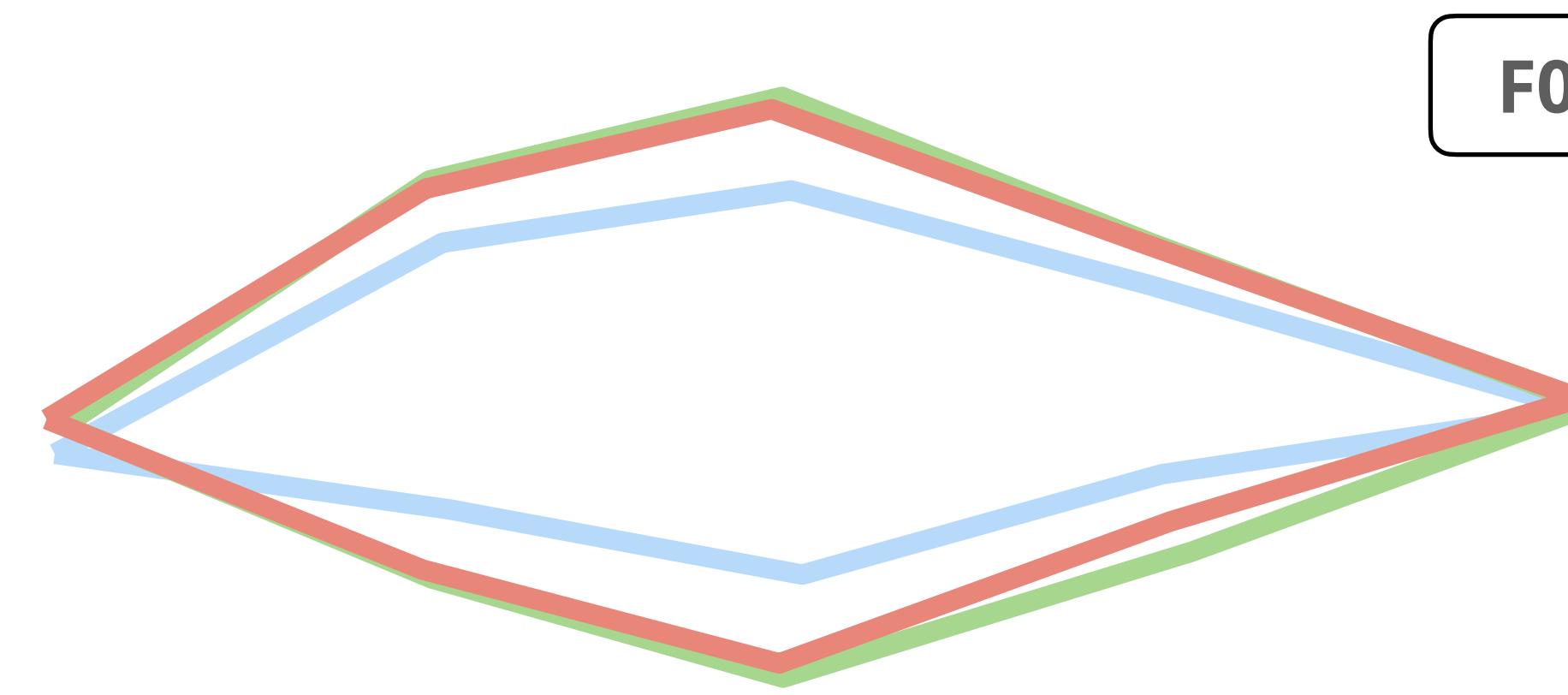


V#ʃ
e.g. sheet

F01



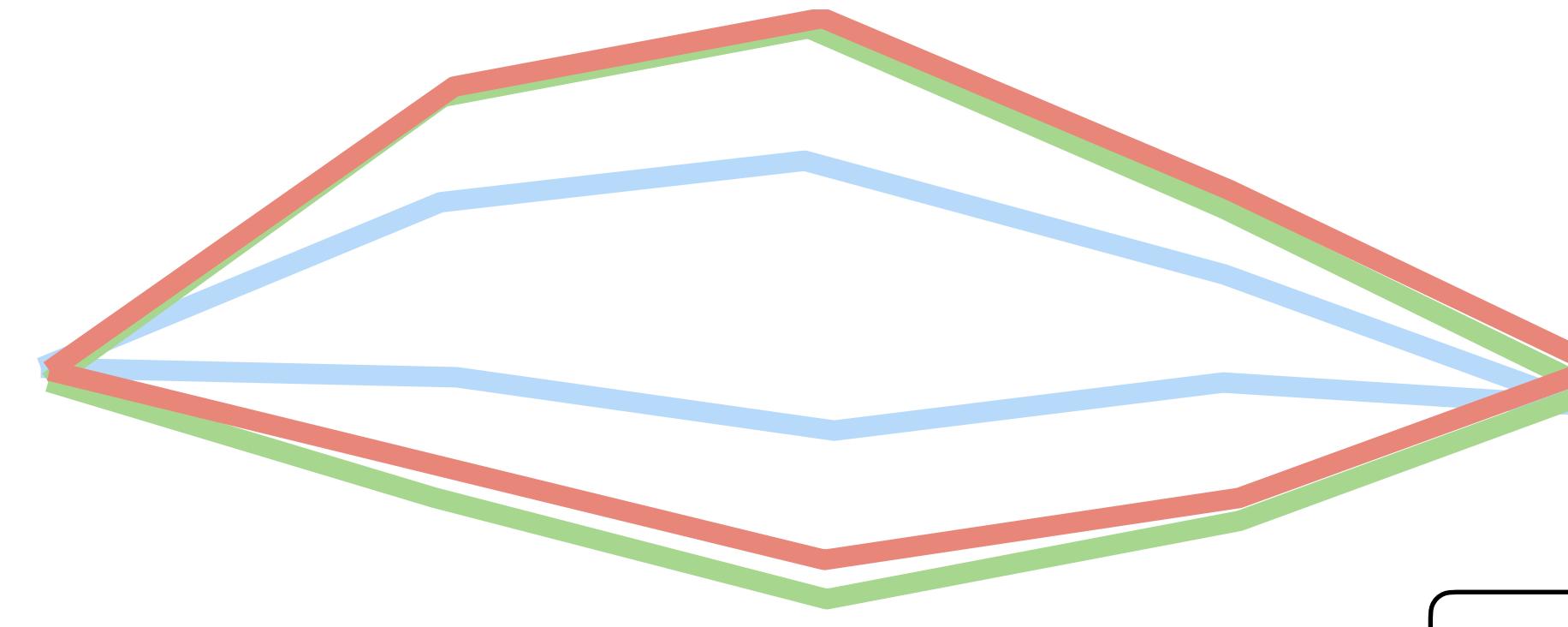
F02



V#s
e.g. *seat*

V#stj
e.g. *stupid*

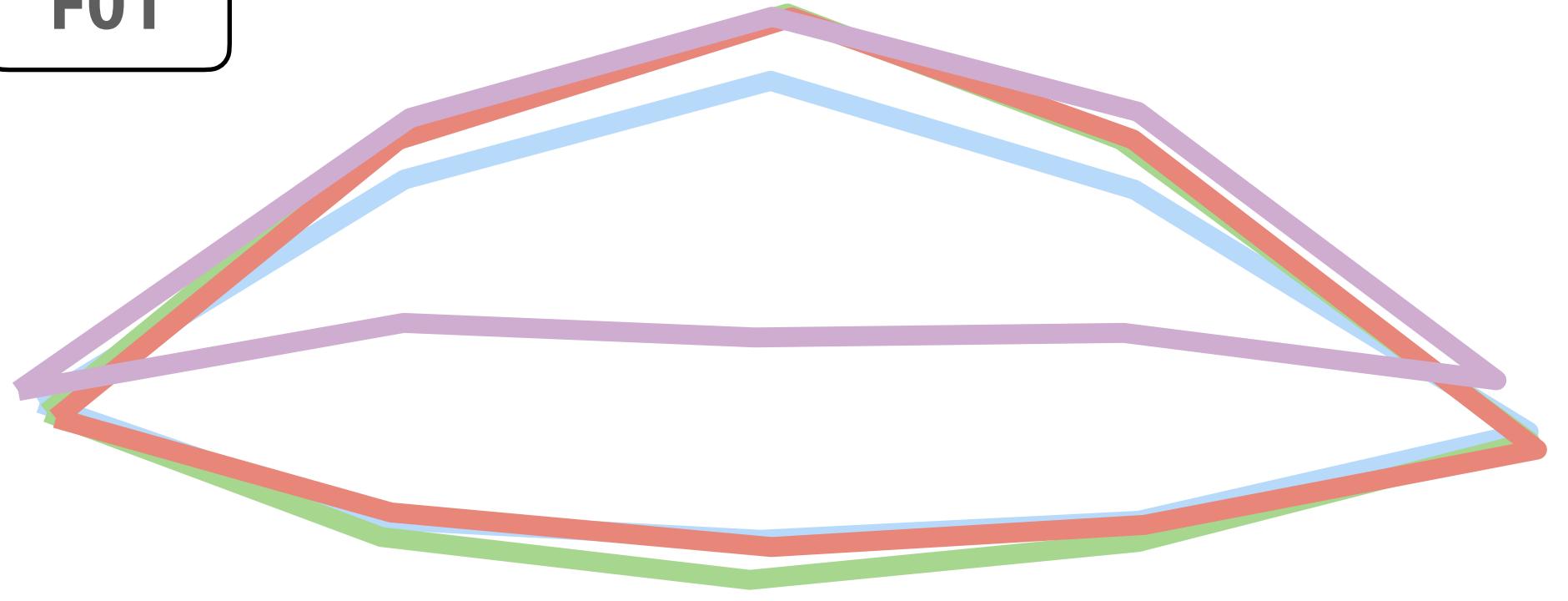
M01



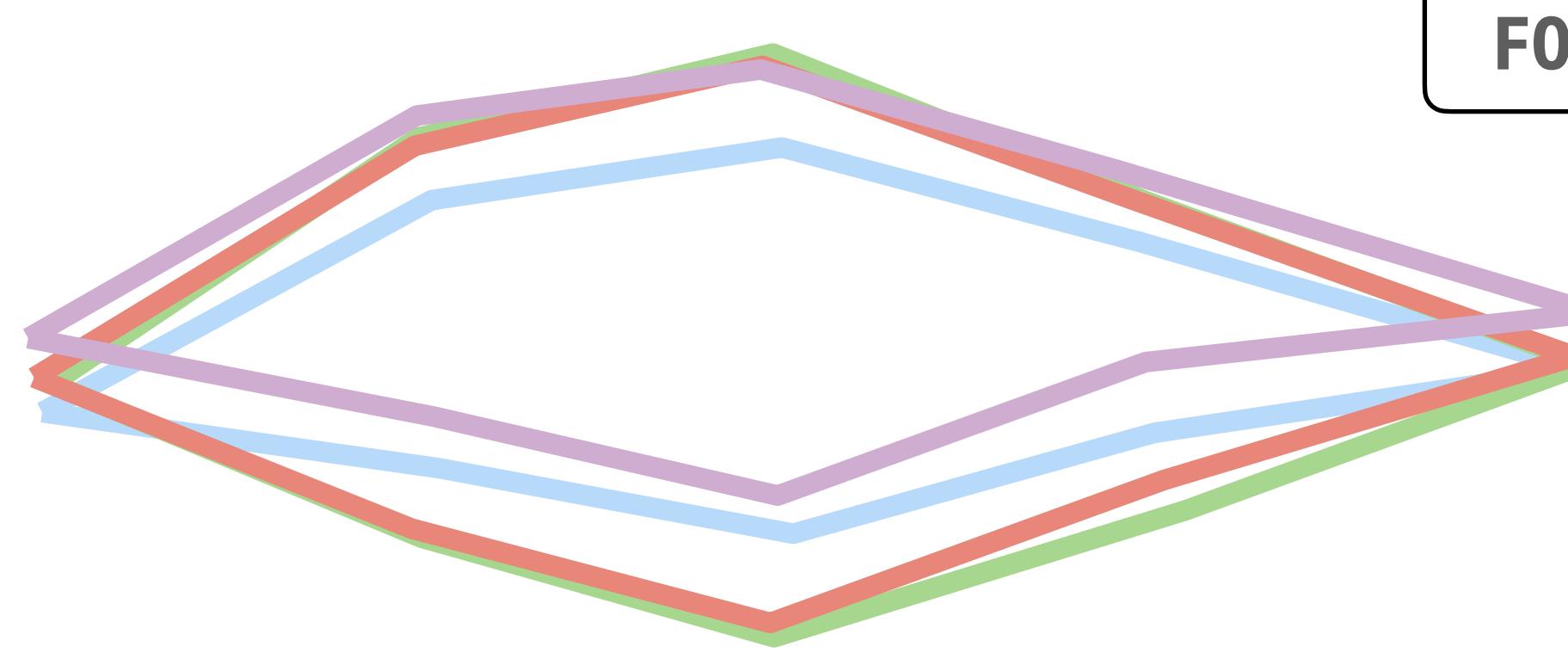
M02

V#ʃ
e.g. *sheet*

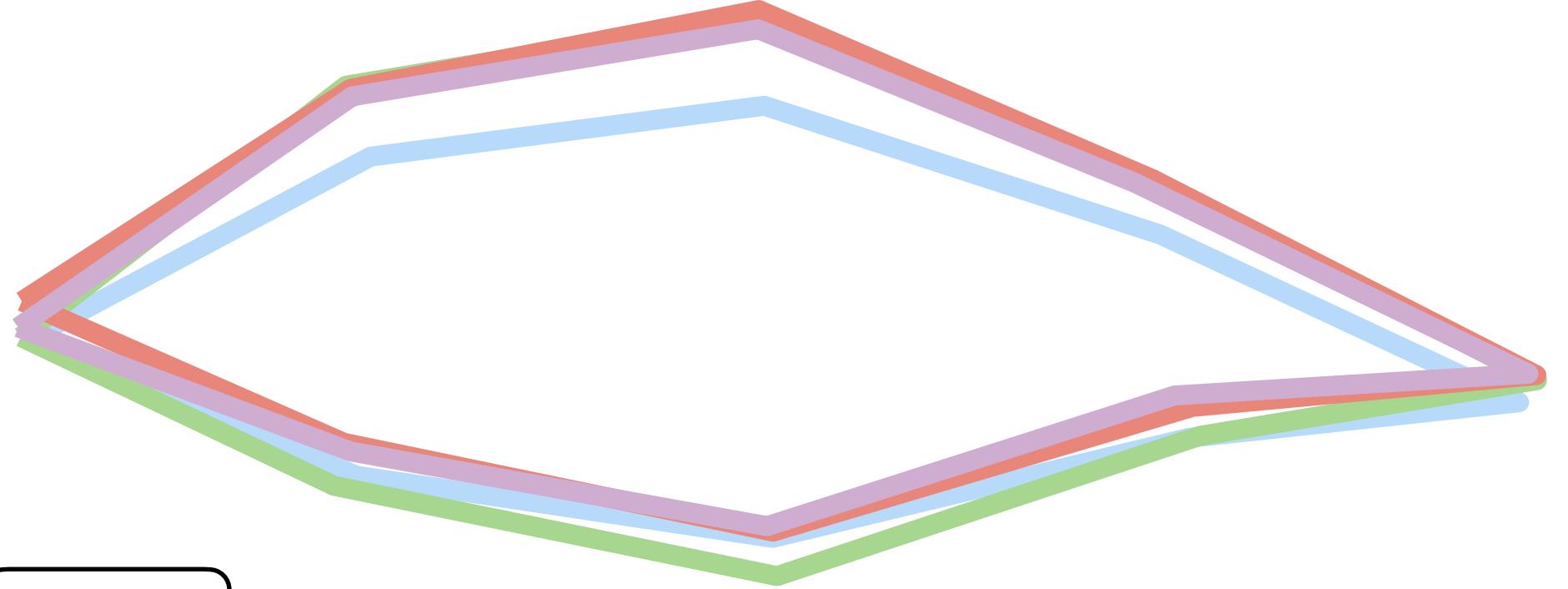
F01



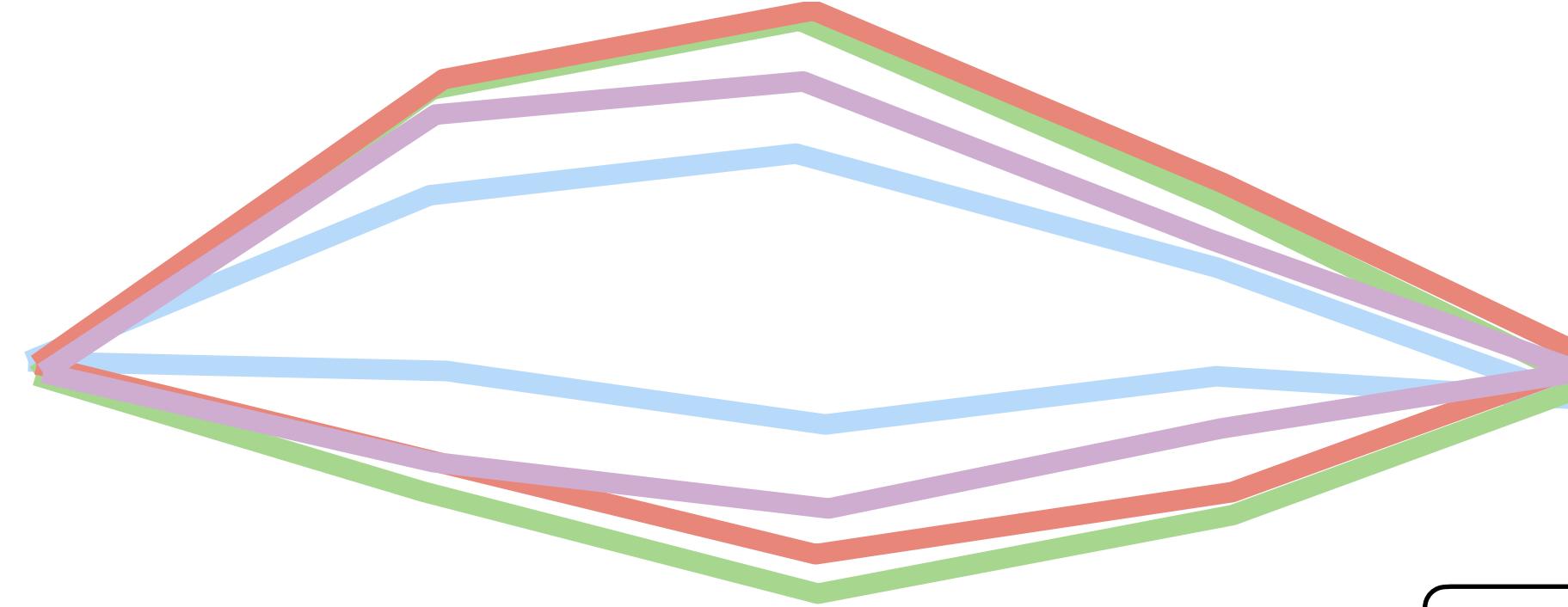
F02



M01



M02



V#s

e.g. *seat*

V#stj

e.g. *stupid*

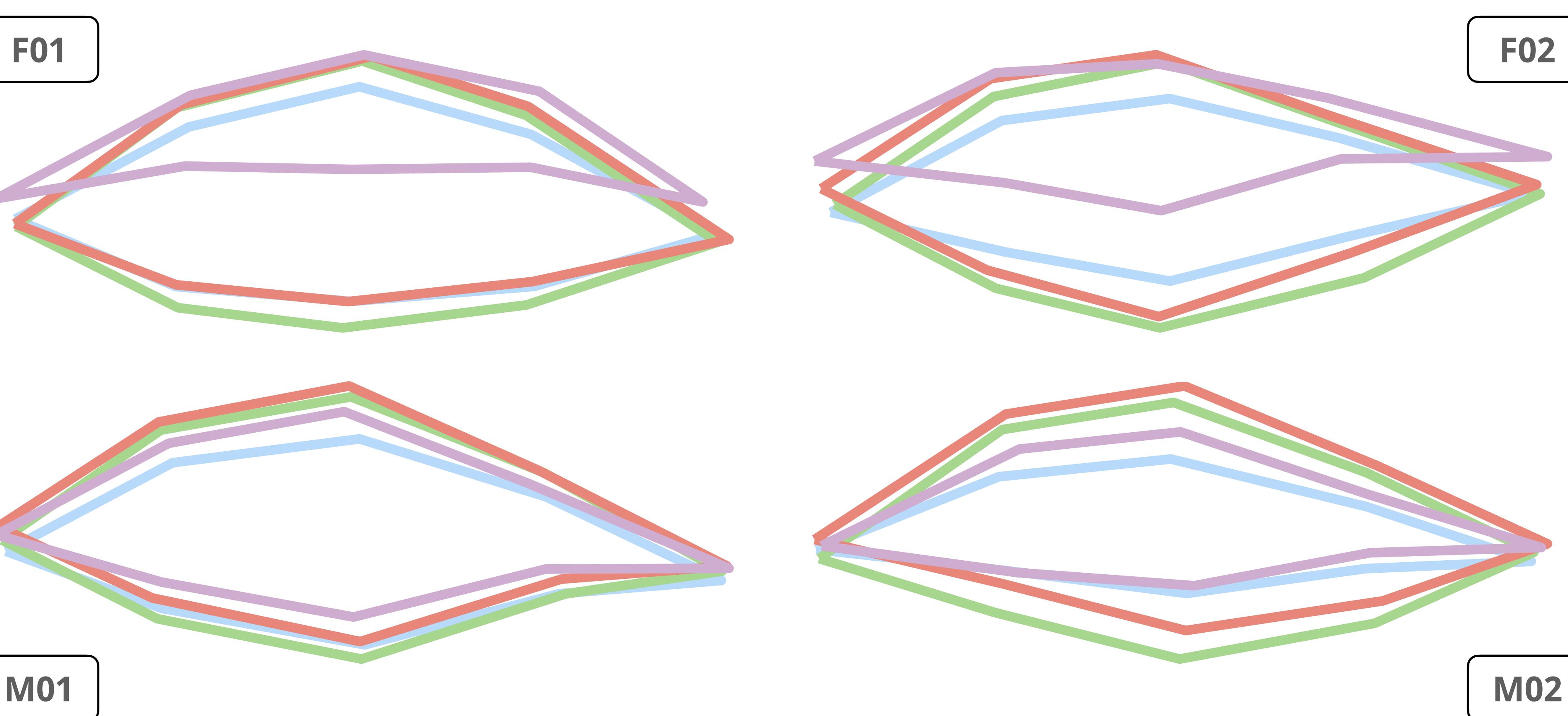
V#str

e.g. *street*

V#ʃ

e.g. *sheet*

segment offset



V#s
e.g. *seat*

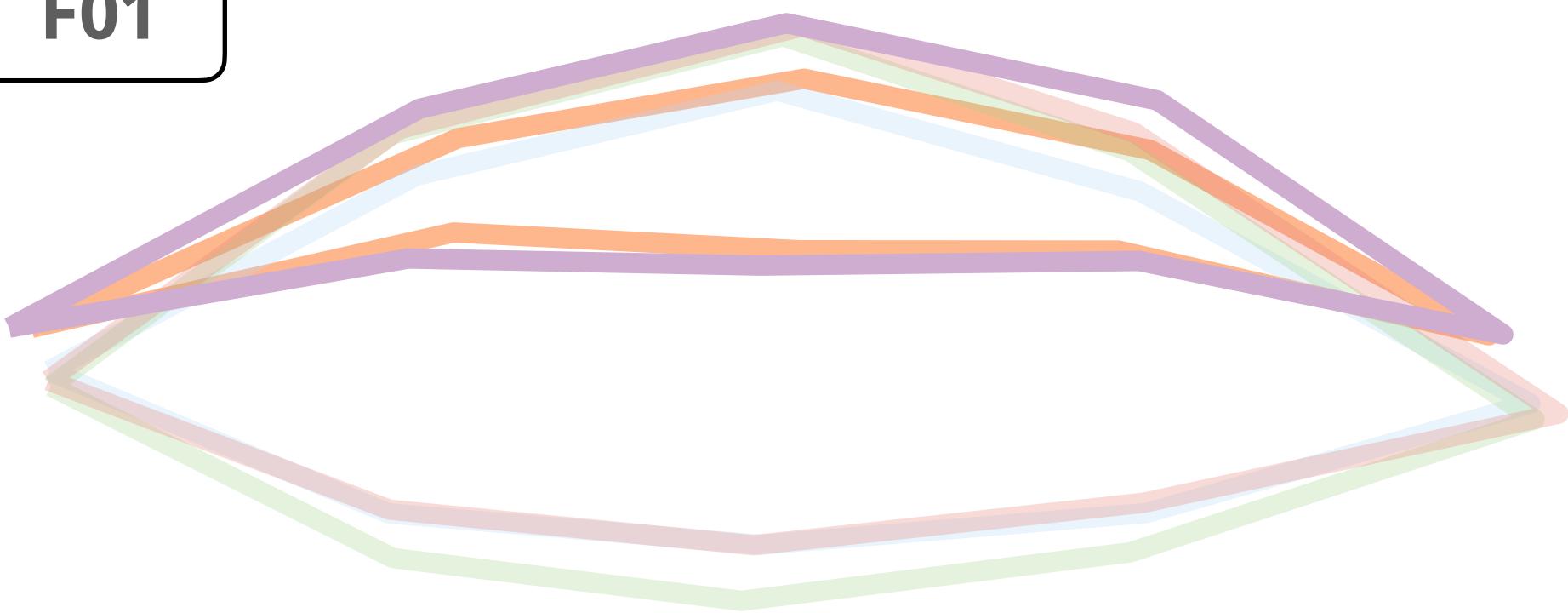
V#stj
e.g. *stupid*

V#str
e.g. *street*

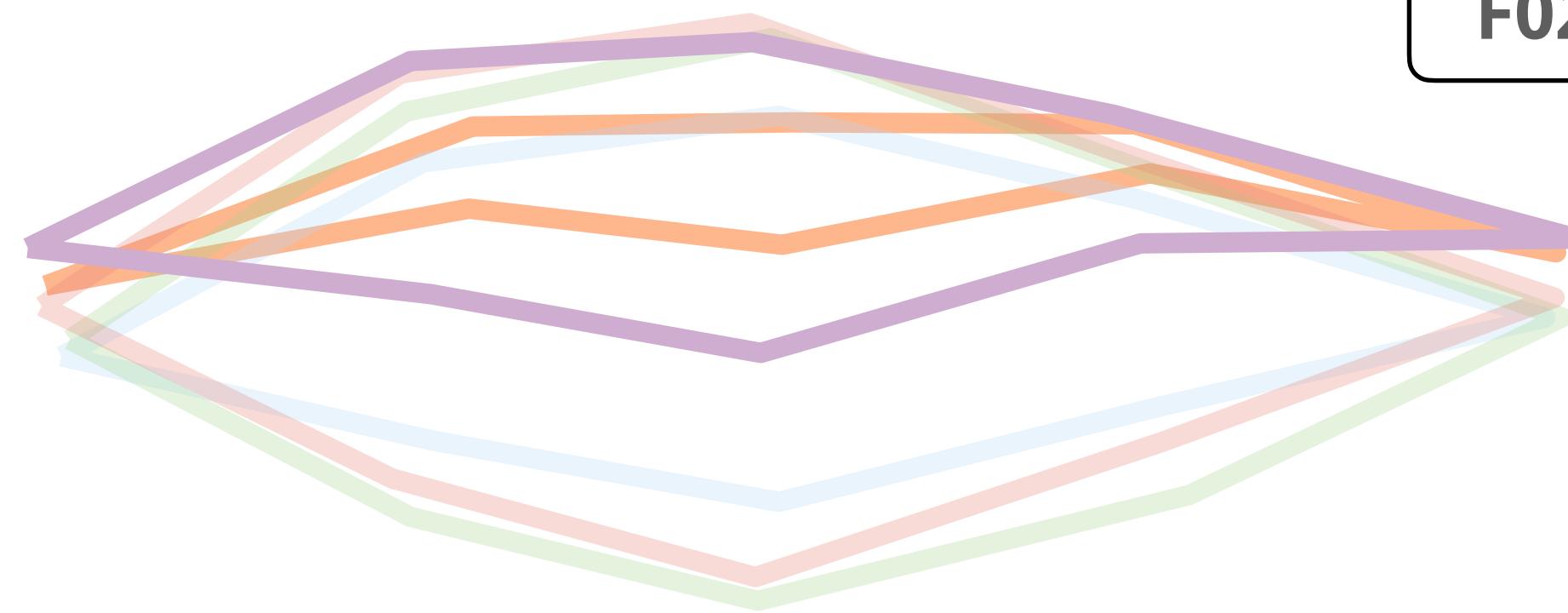
V#ʃ
e.g. *sheet*

segment offset (with / overlaid)

F01



F02



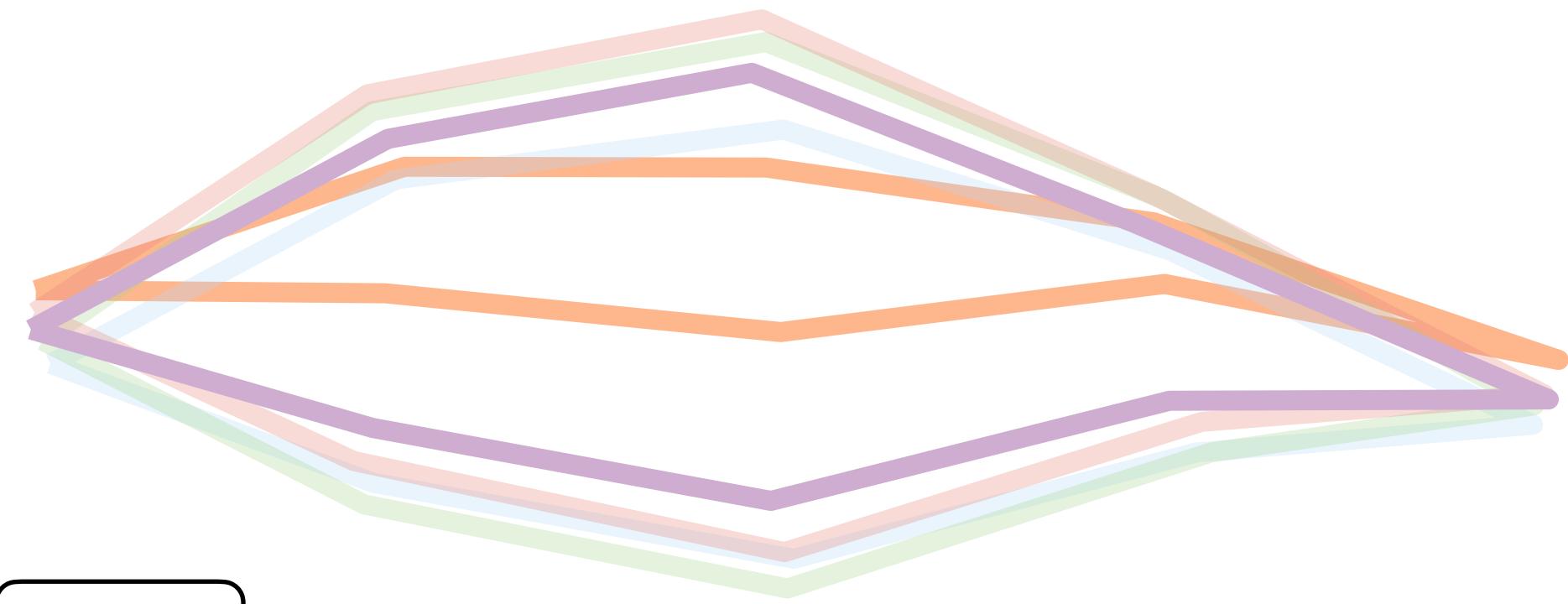
V#s
e.g. *seat*

V#stj
e.g. *stupid*

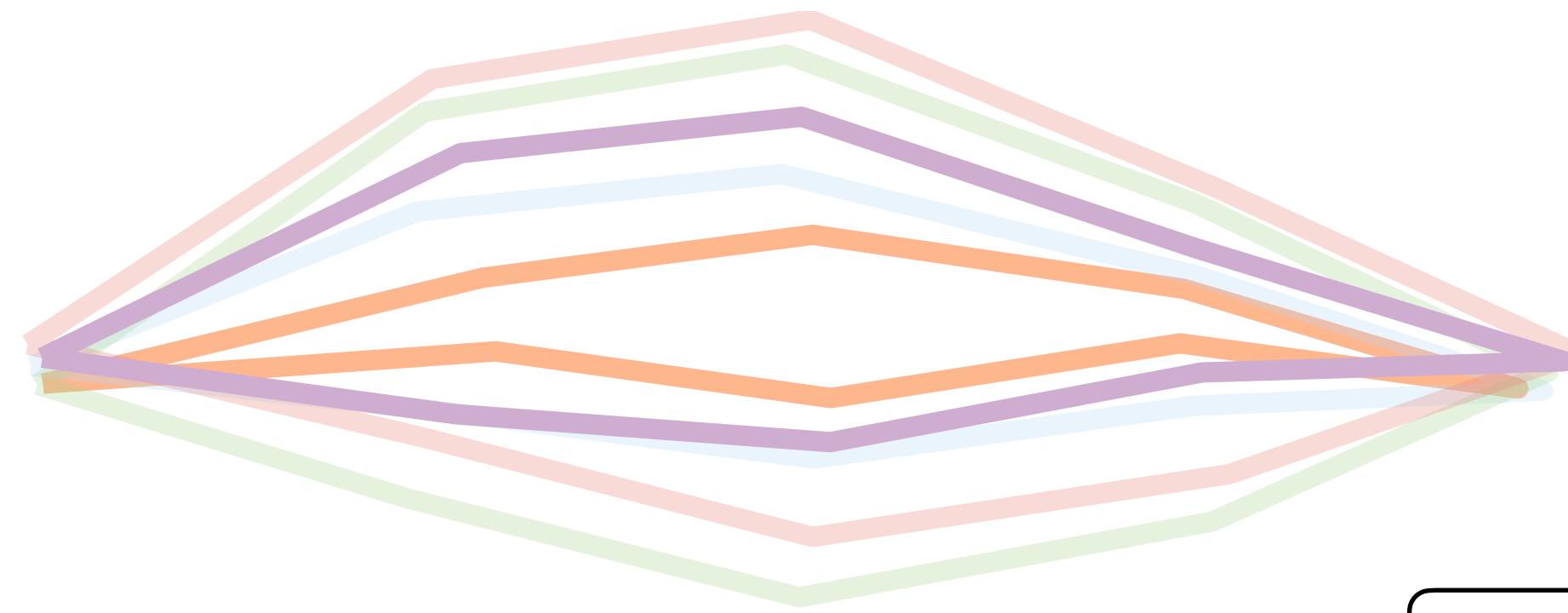
V#str
e.g. *street*

V#ʃ
e.g. *sheet*

M01



M02



V#r
e.g. *reed*

V#s

V#ʃ

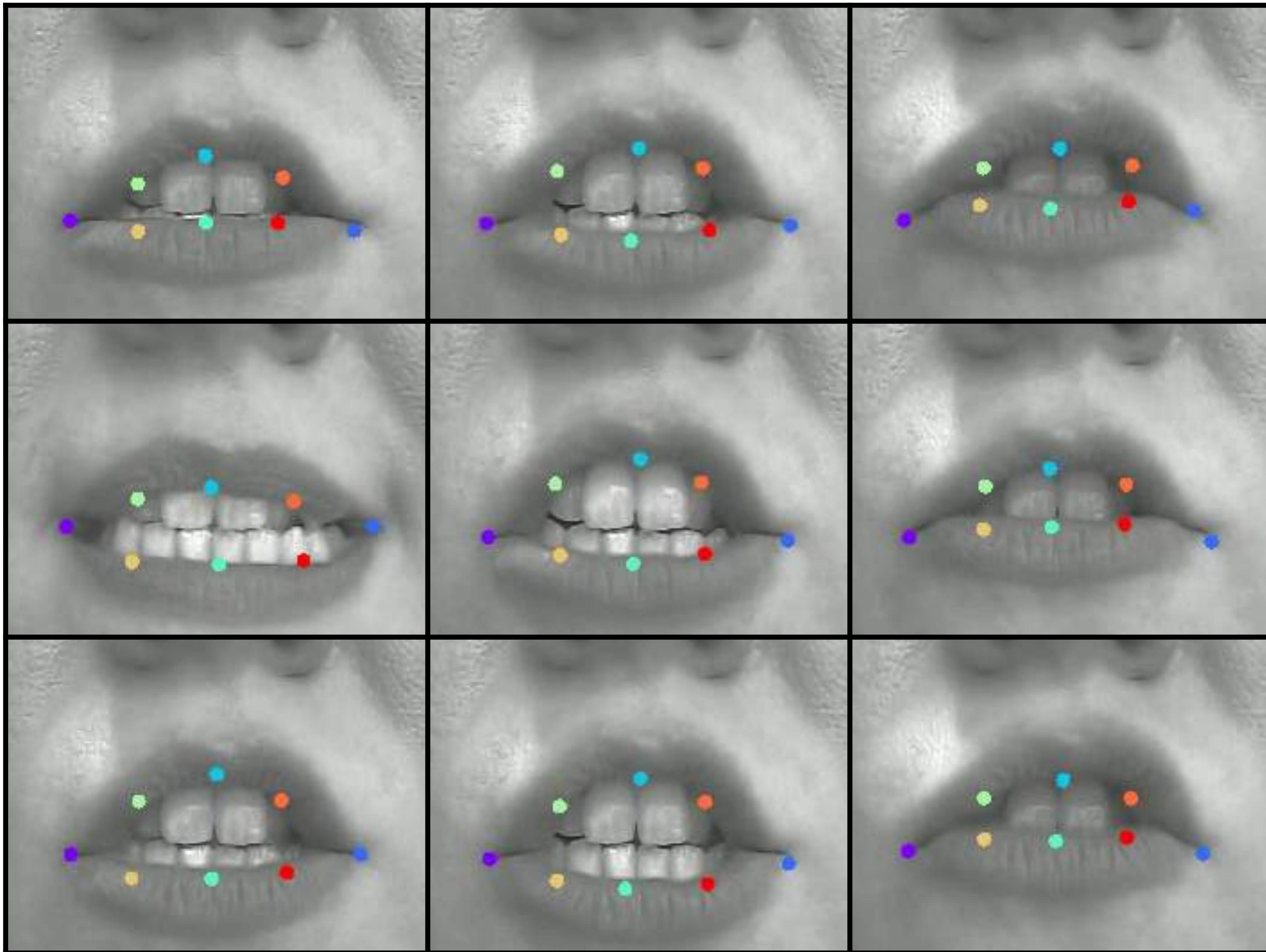
V#stʃ

/p/

/i/

/u/

F01



V#s

V#ʃ

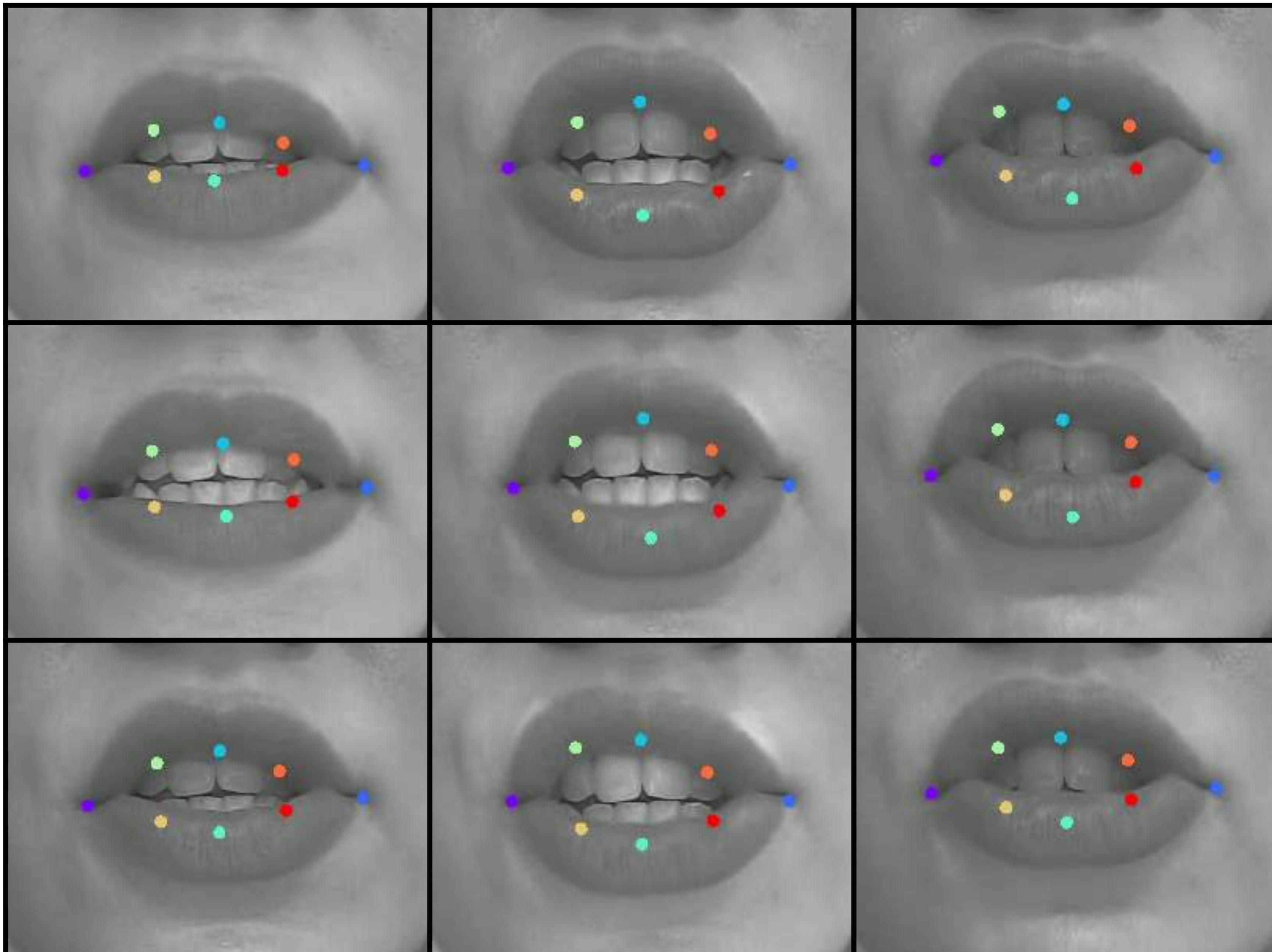
V#stɹ

/p/

/i/

/u/

F02

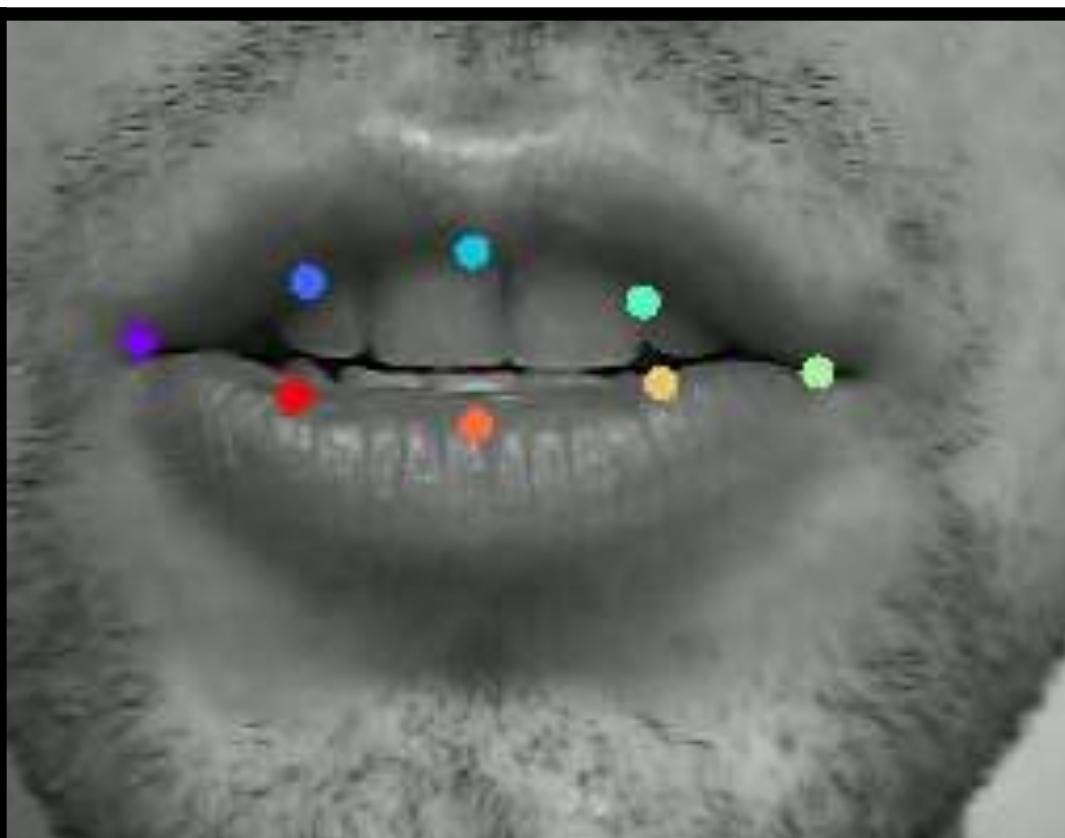


V#s

V#ʃ

V#stʃ

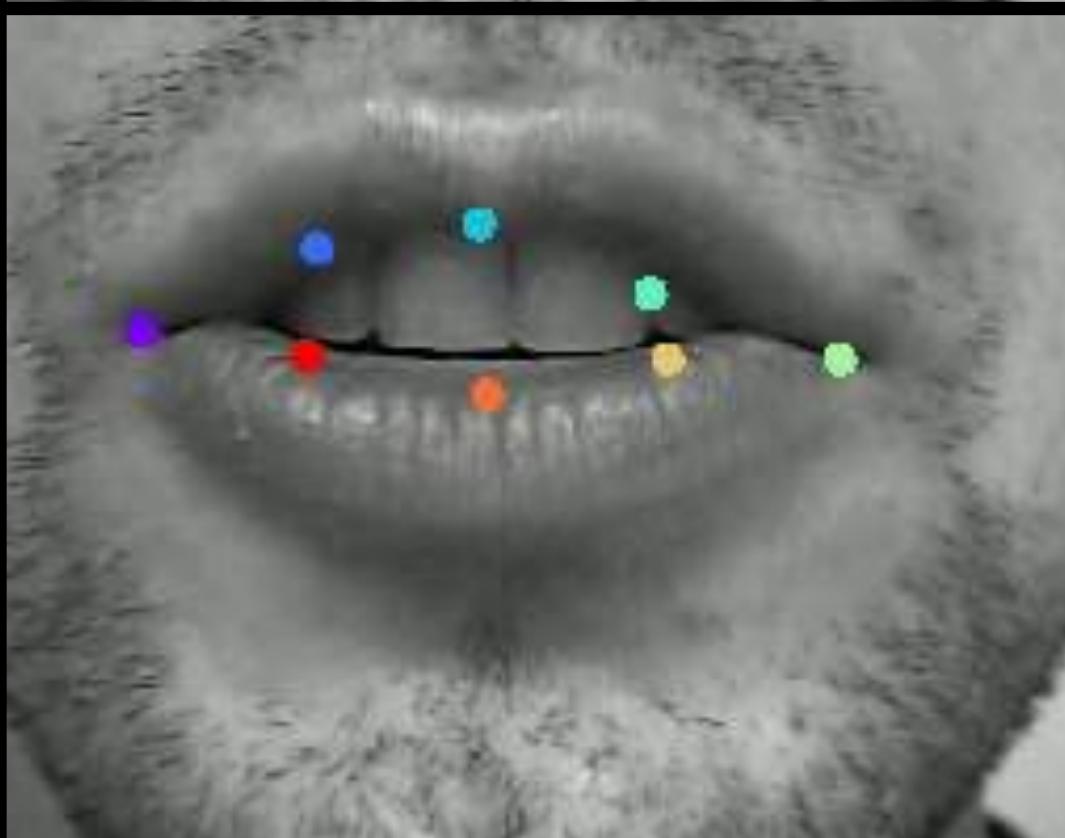
/p/



/i/



/u/



M01

Tongue

/z/-retraction



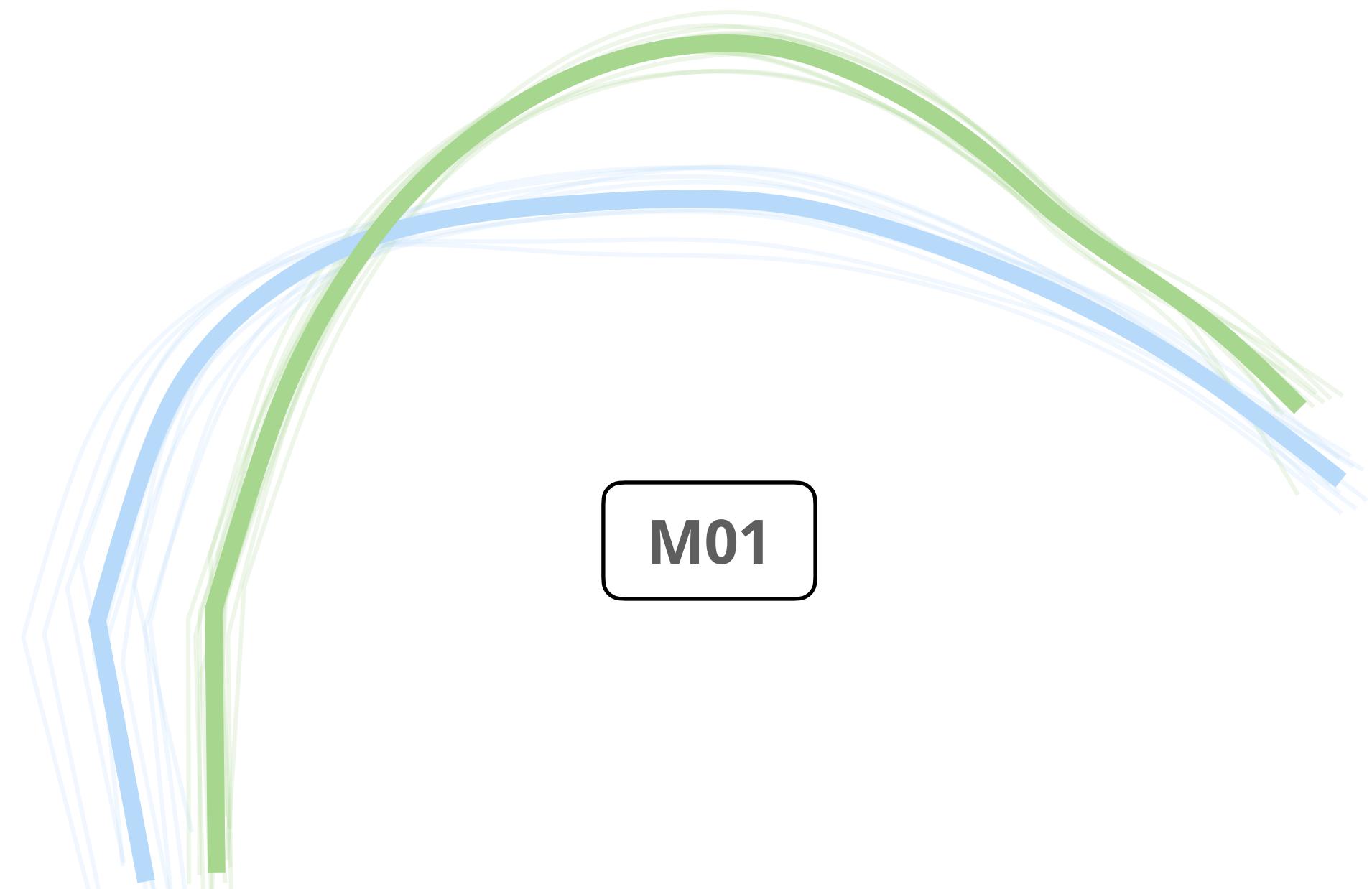


F01

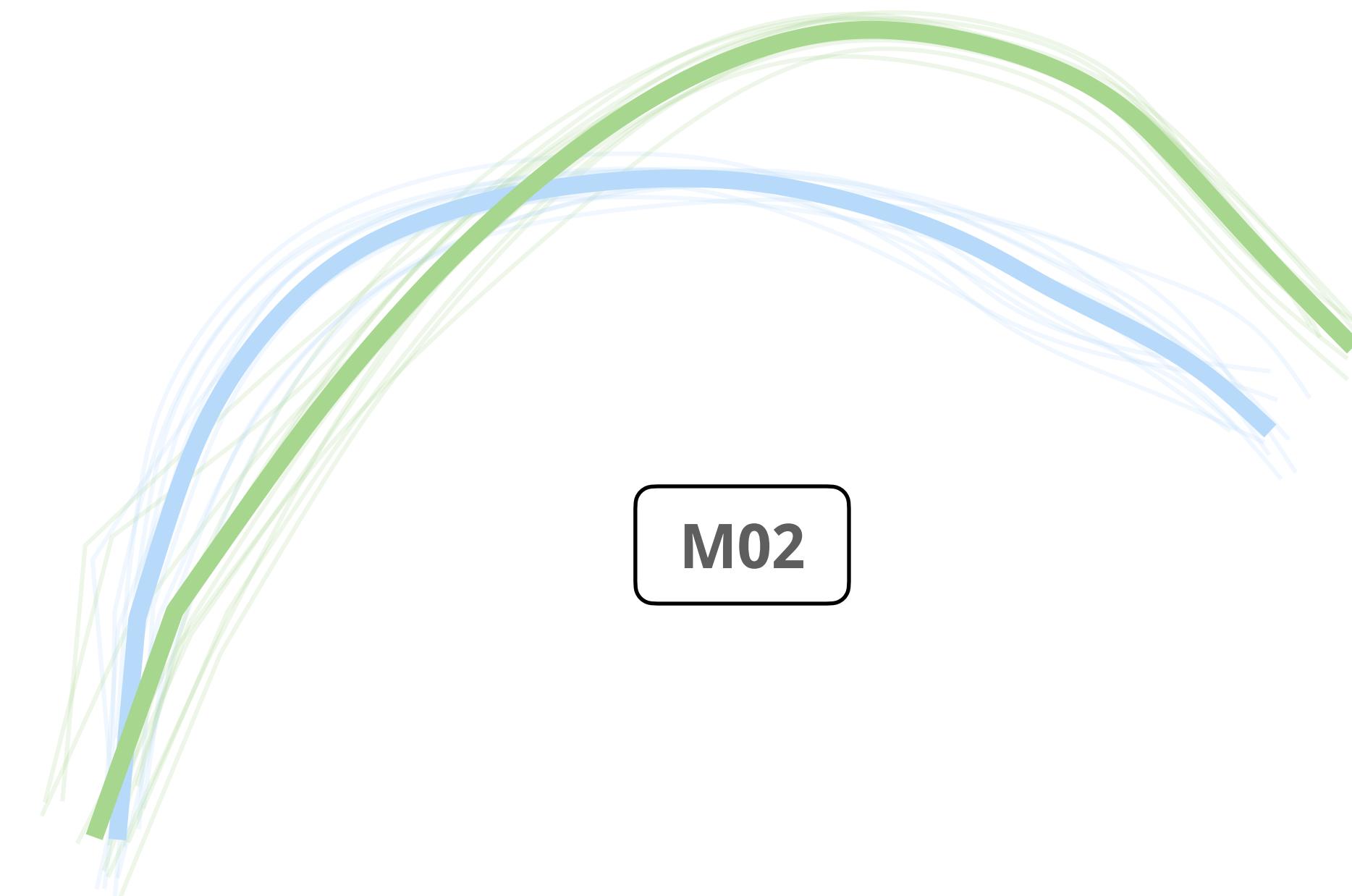


F02

V#z
e.g. *the zombie*

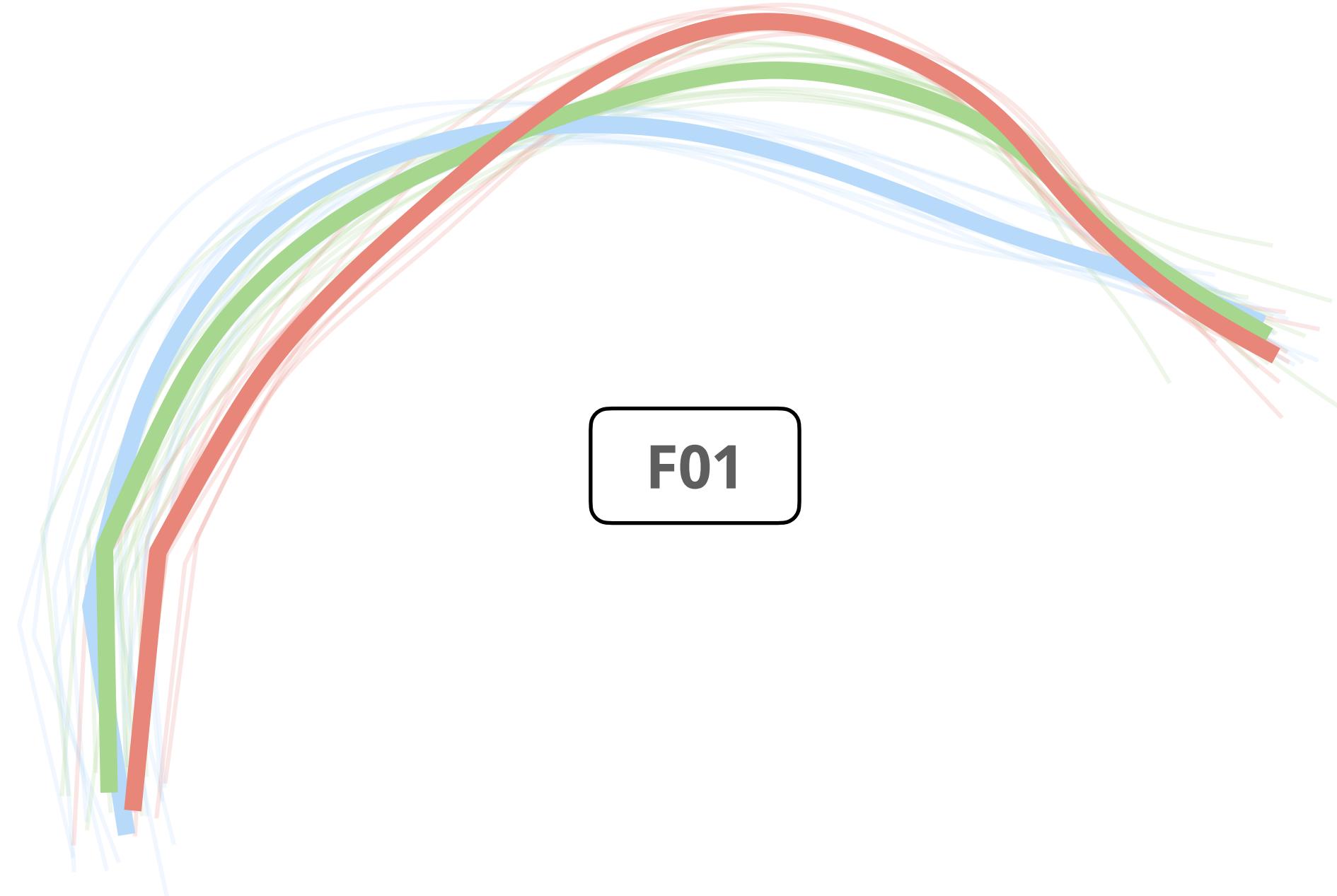


M01



M02

V#3
e.g. *the genre*

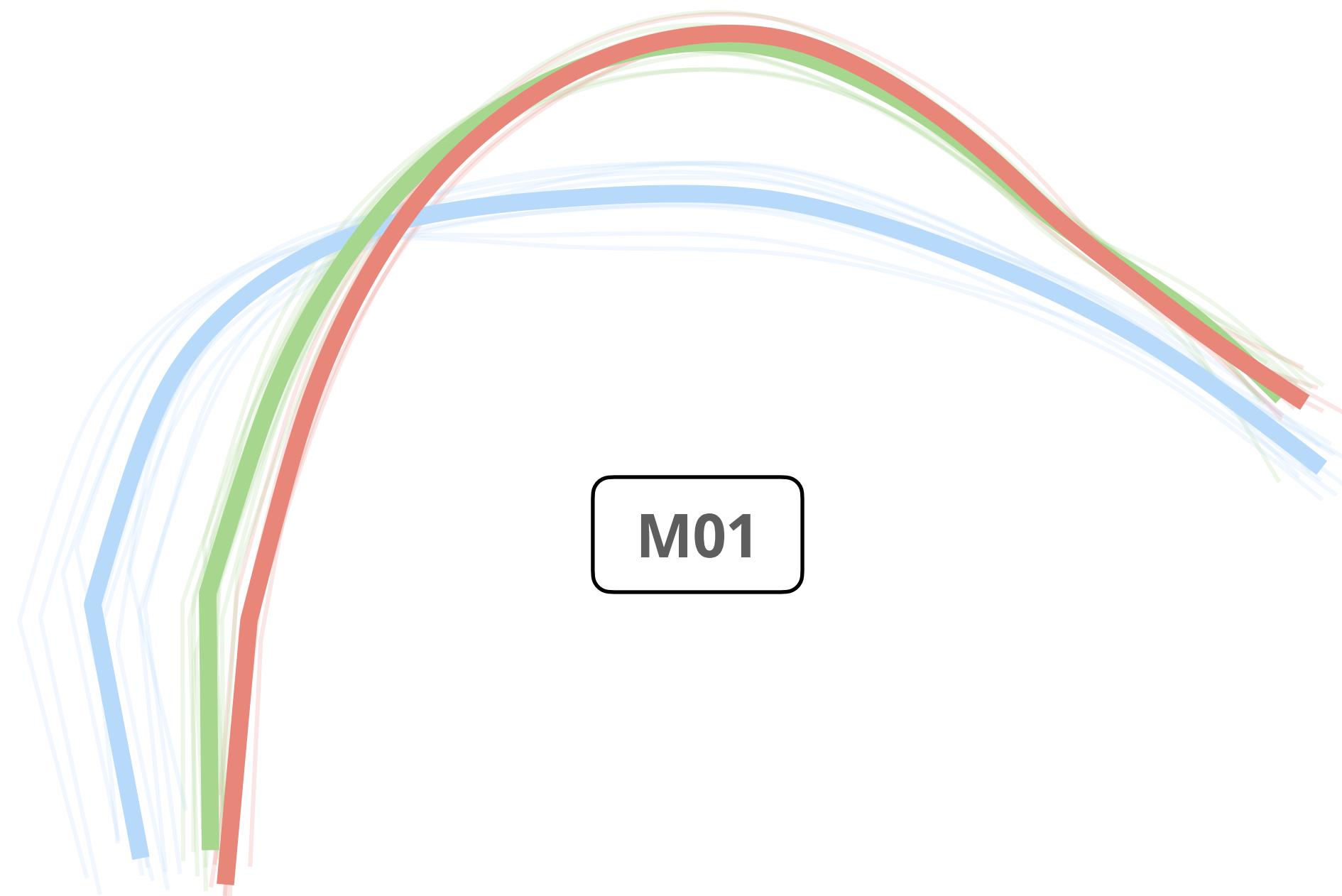


F01

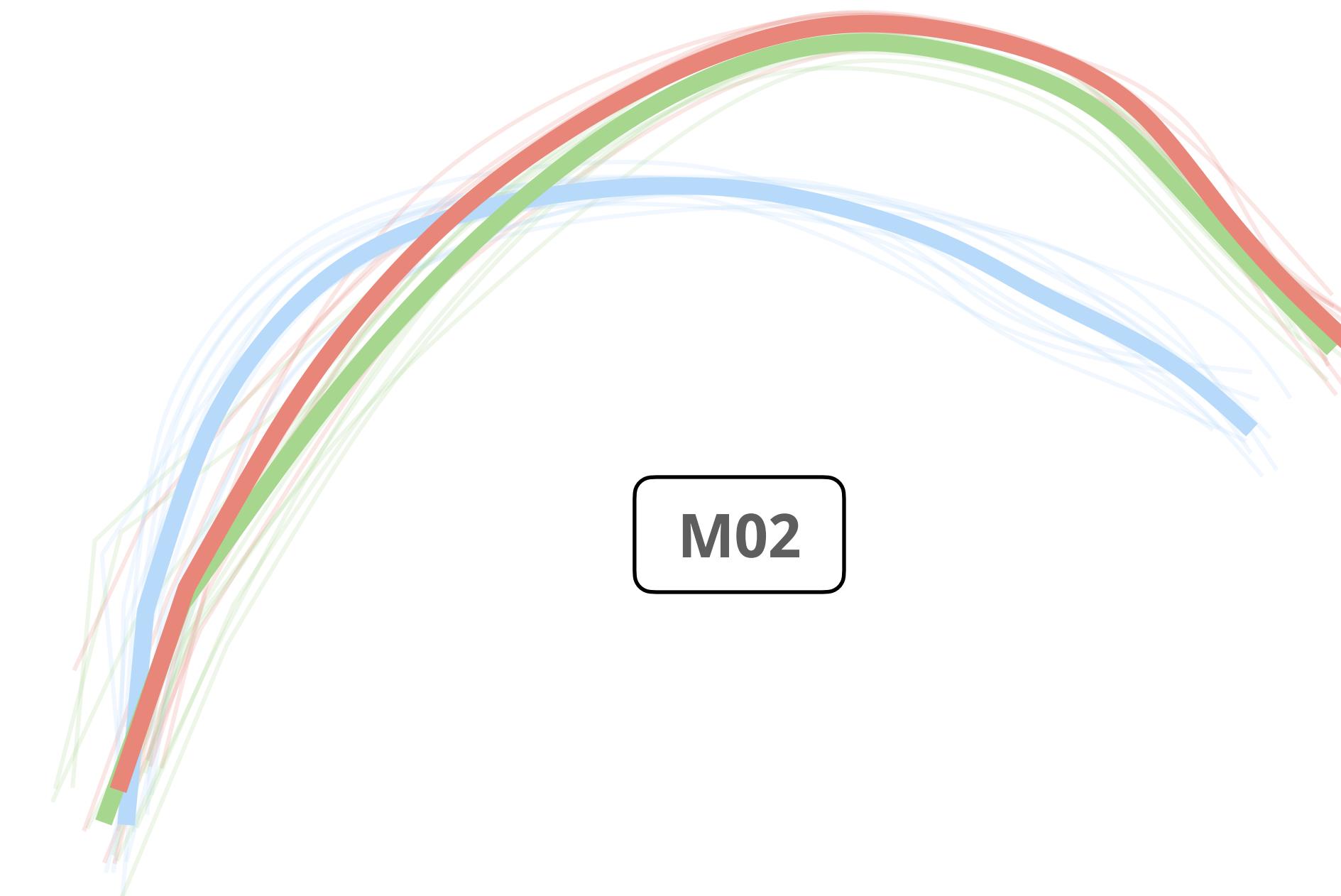


F02

V#z
e.g. *the zombie*

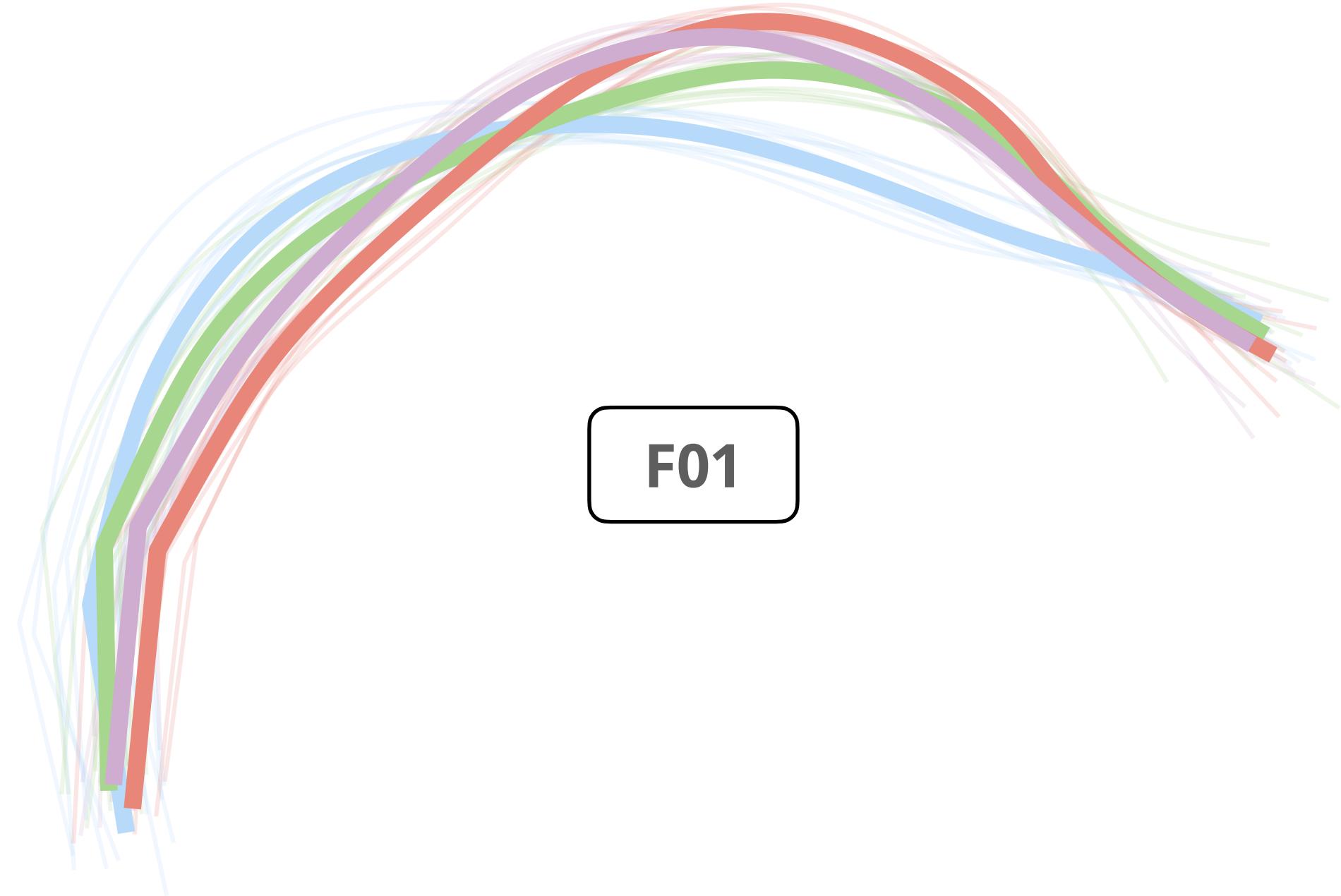


M01



M02

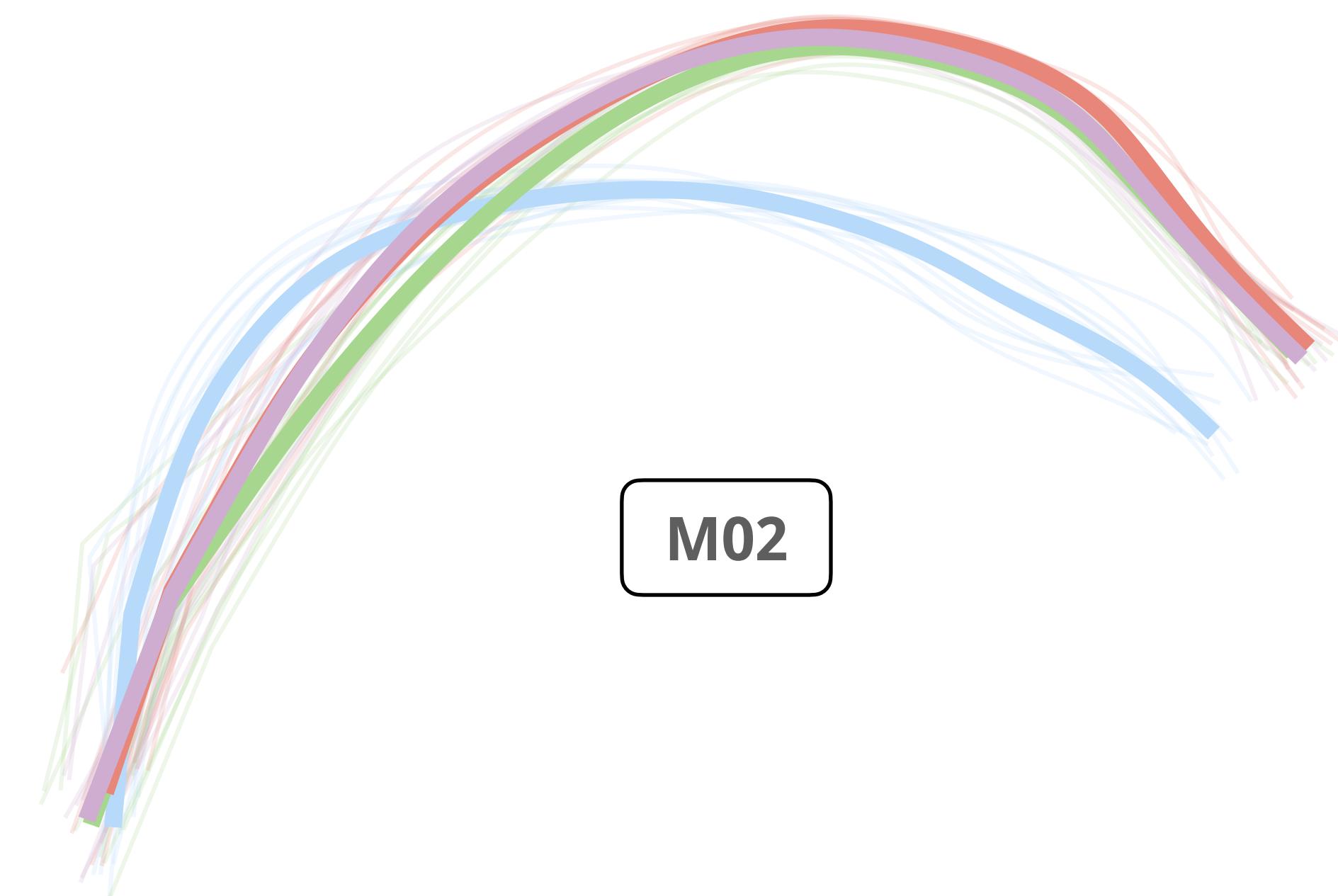
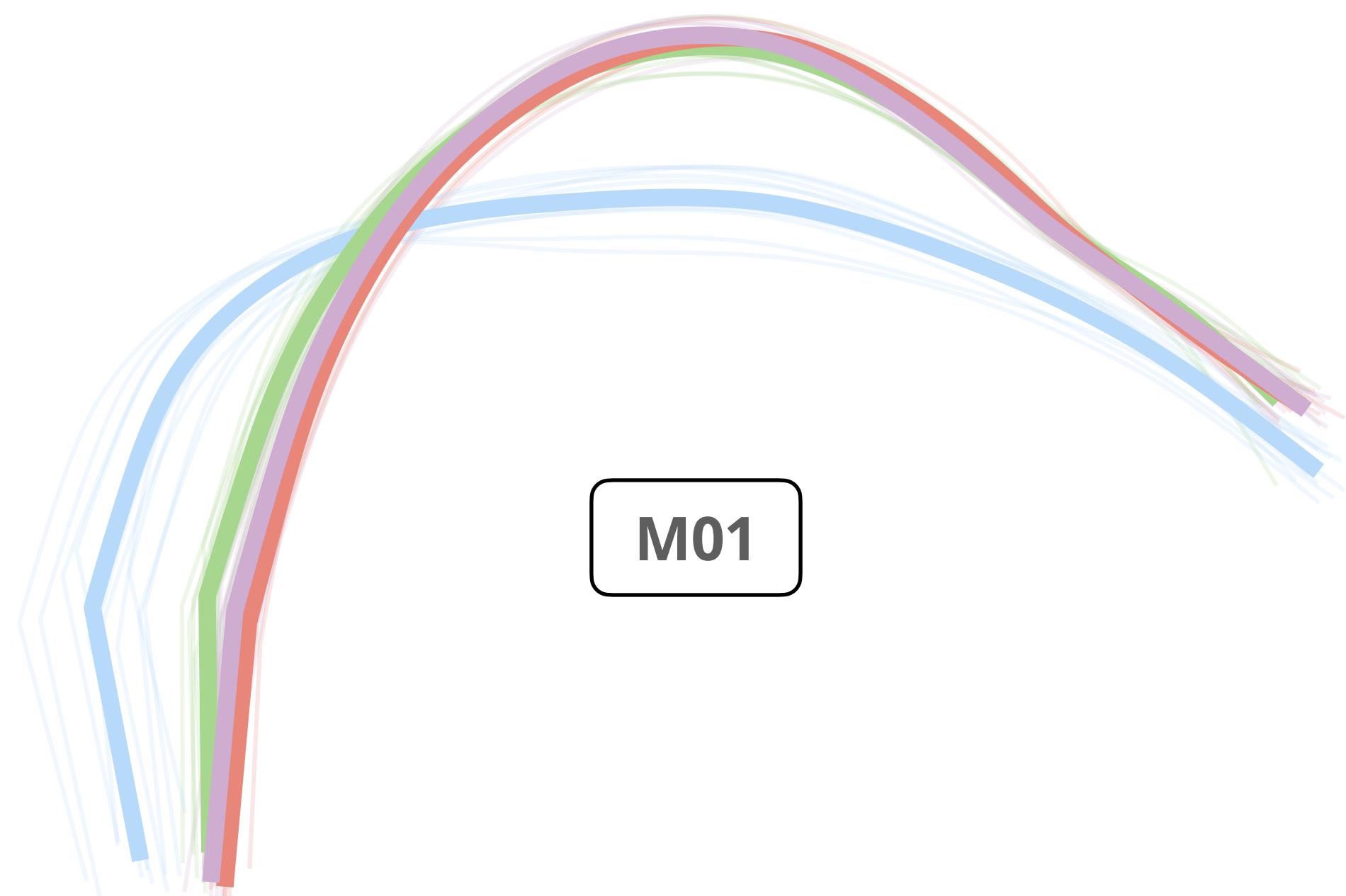
V#3
e.g. *the genre*



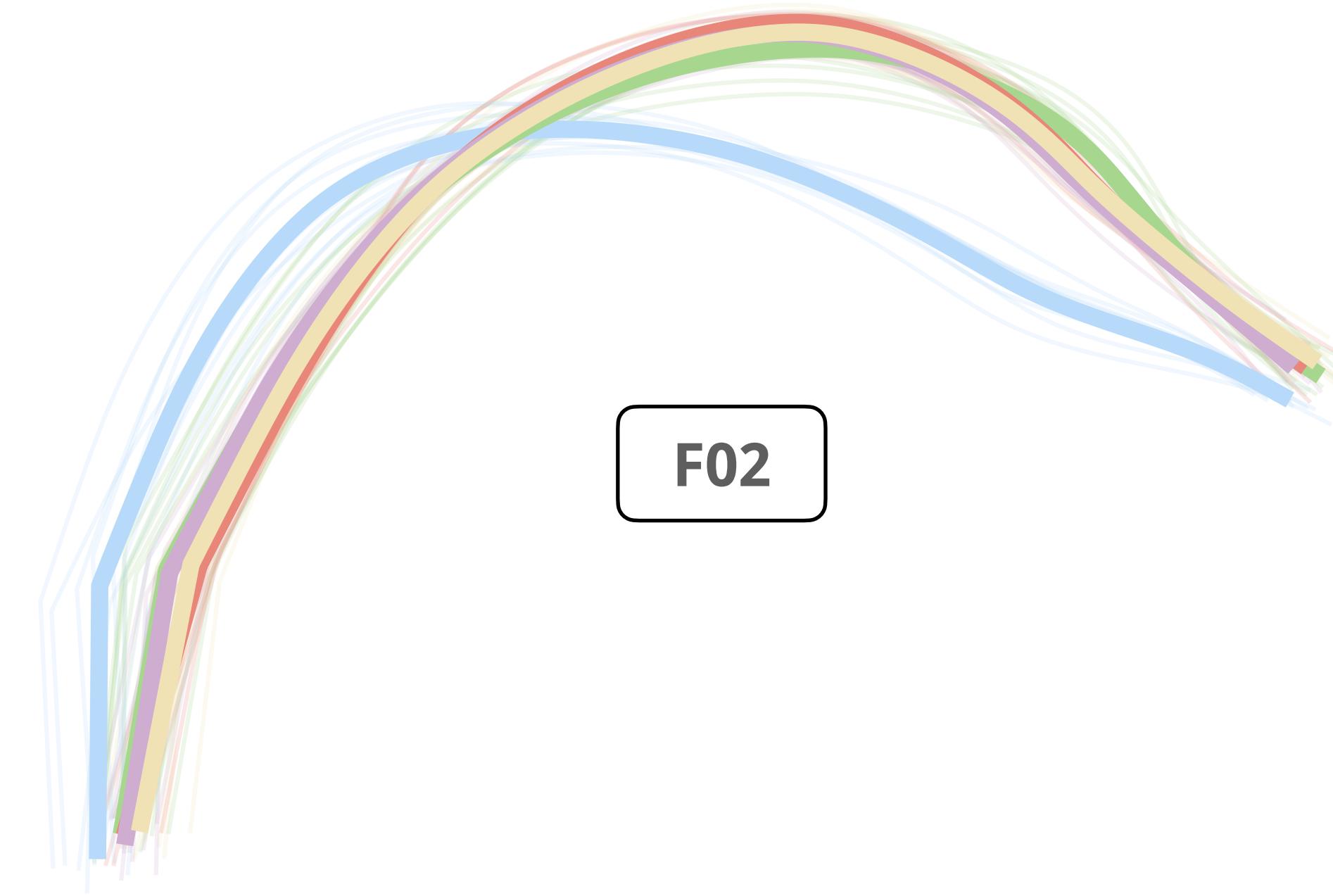
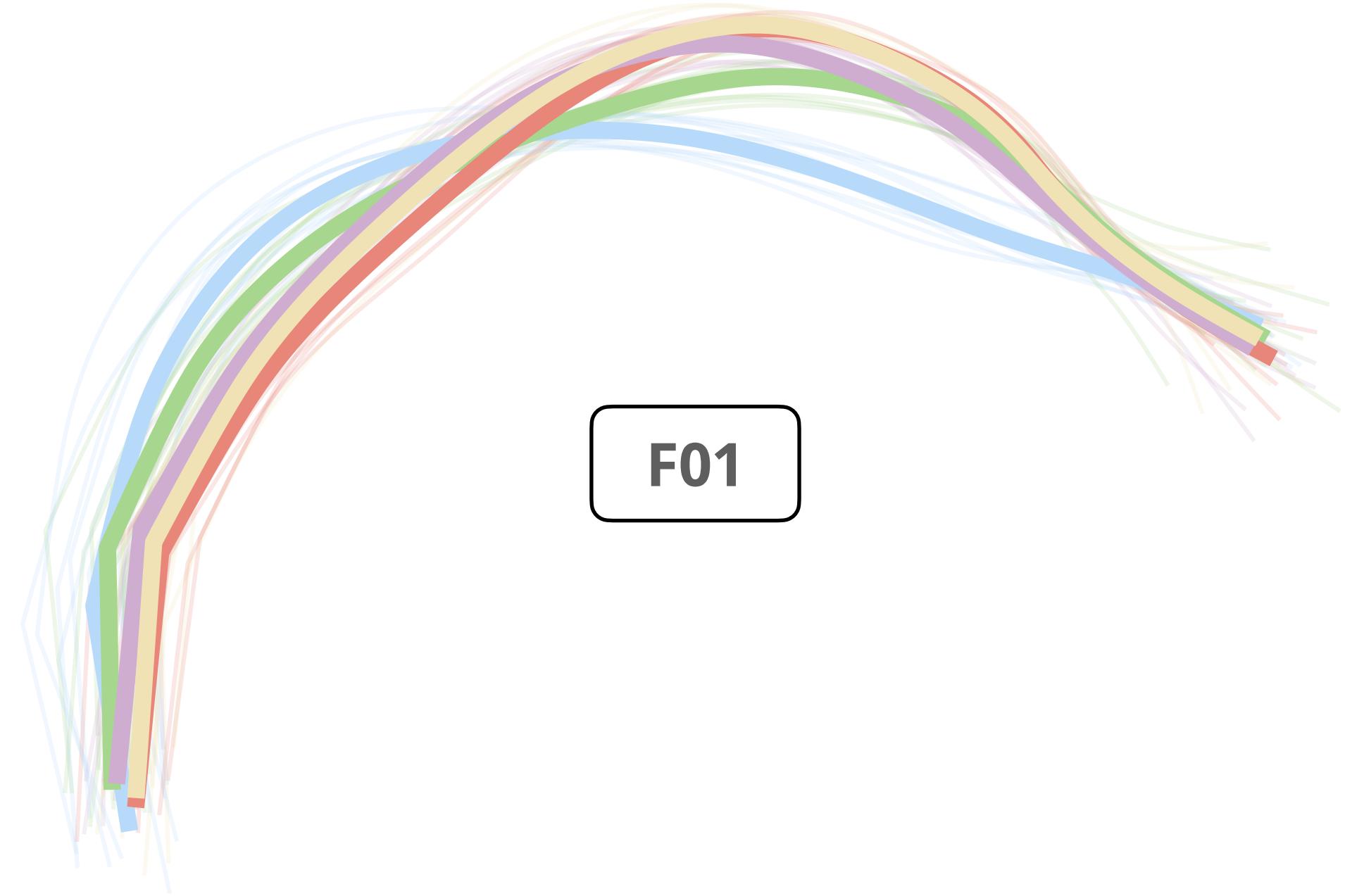
V#z
e.g. *the zombie*

z#dj
e.g. *these dunes*

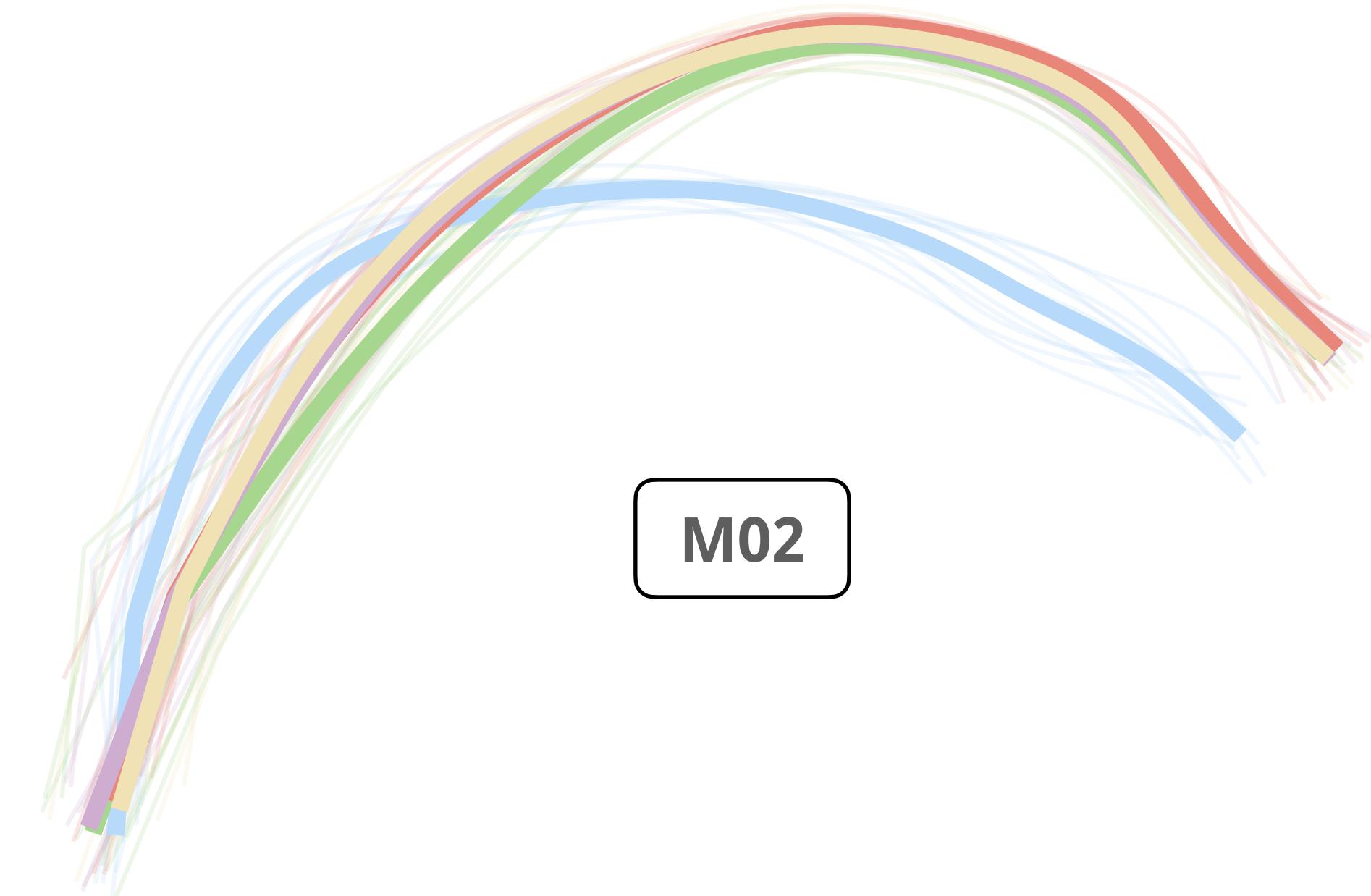
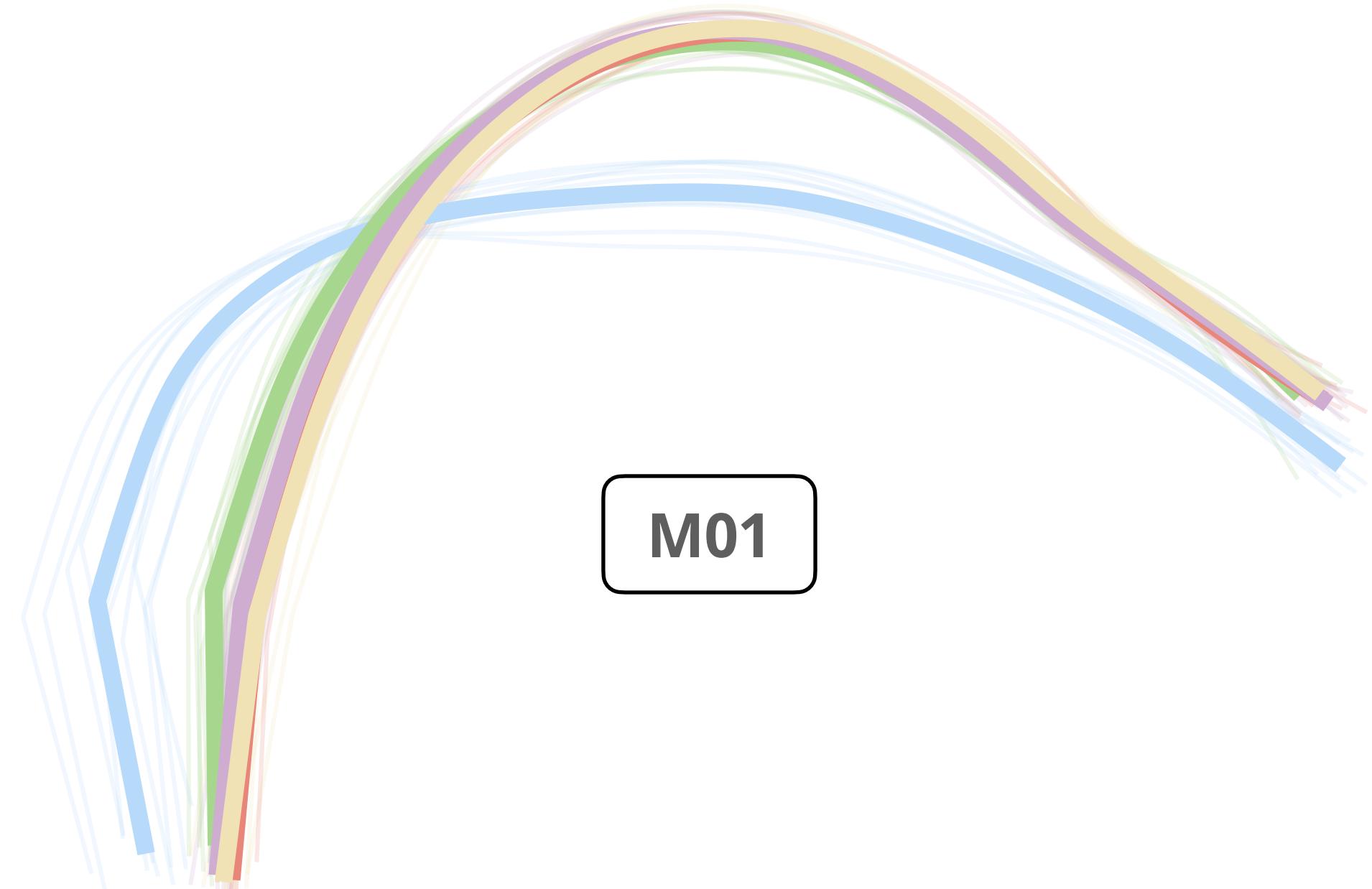
z#dr
e.g. *these drops*



V#3
e.g. *the genre*



V#z
e.g. *the zombie*



z#dʒ
e.g. *these dunes*

z#dɹ
e.g. *these drops*

z#dʒ
e.g. *these jobs*

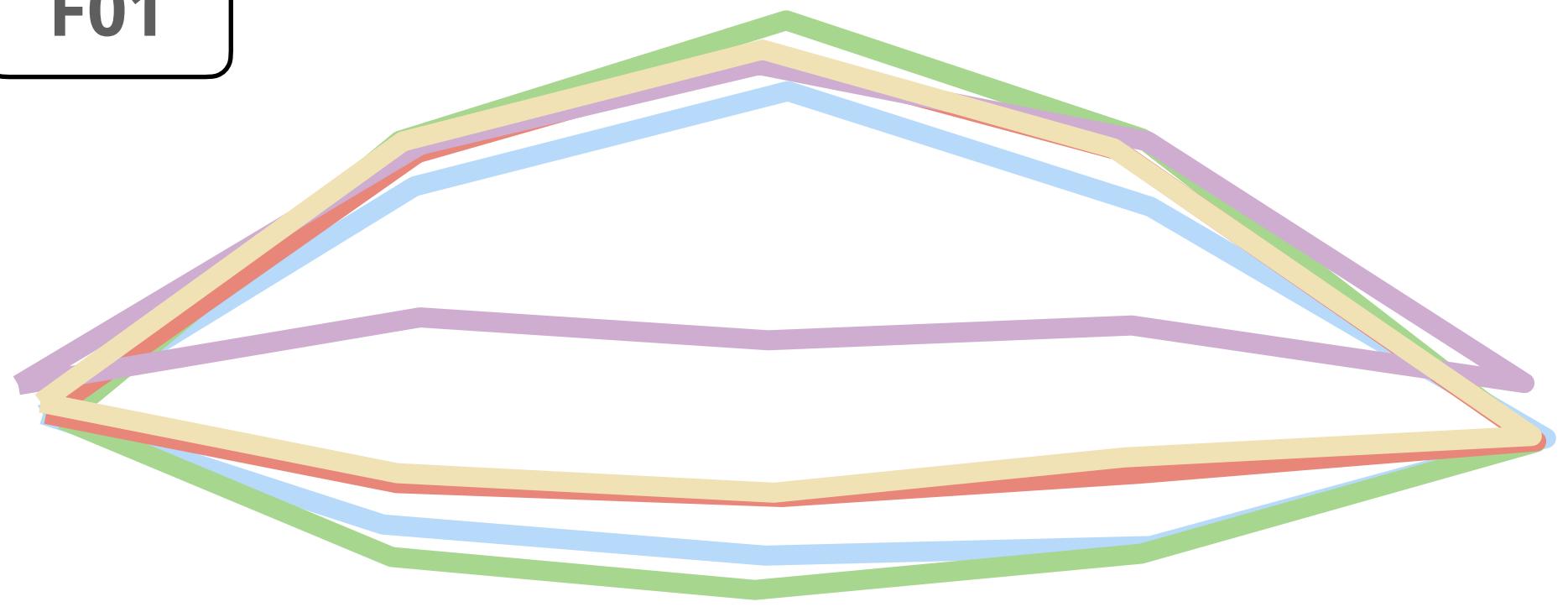
V#ʒ
e.g. *the genre*

Lips

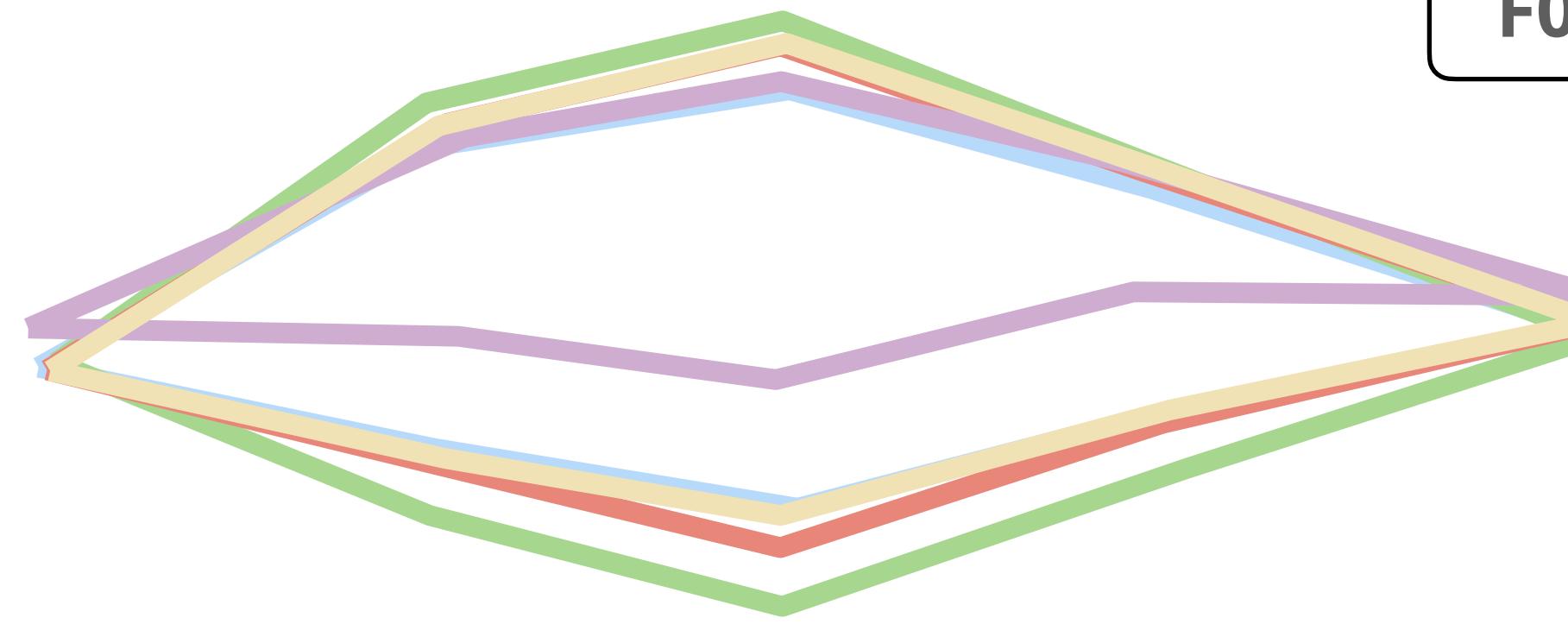
/z/-retraction



F01



F02



V#z

e.g. *the zombie*

z#dʒ

e.g. *these dunes*

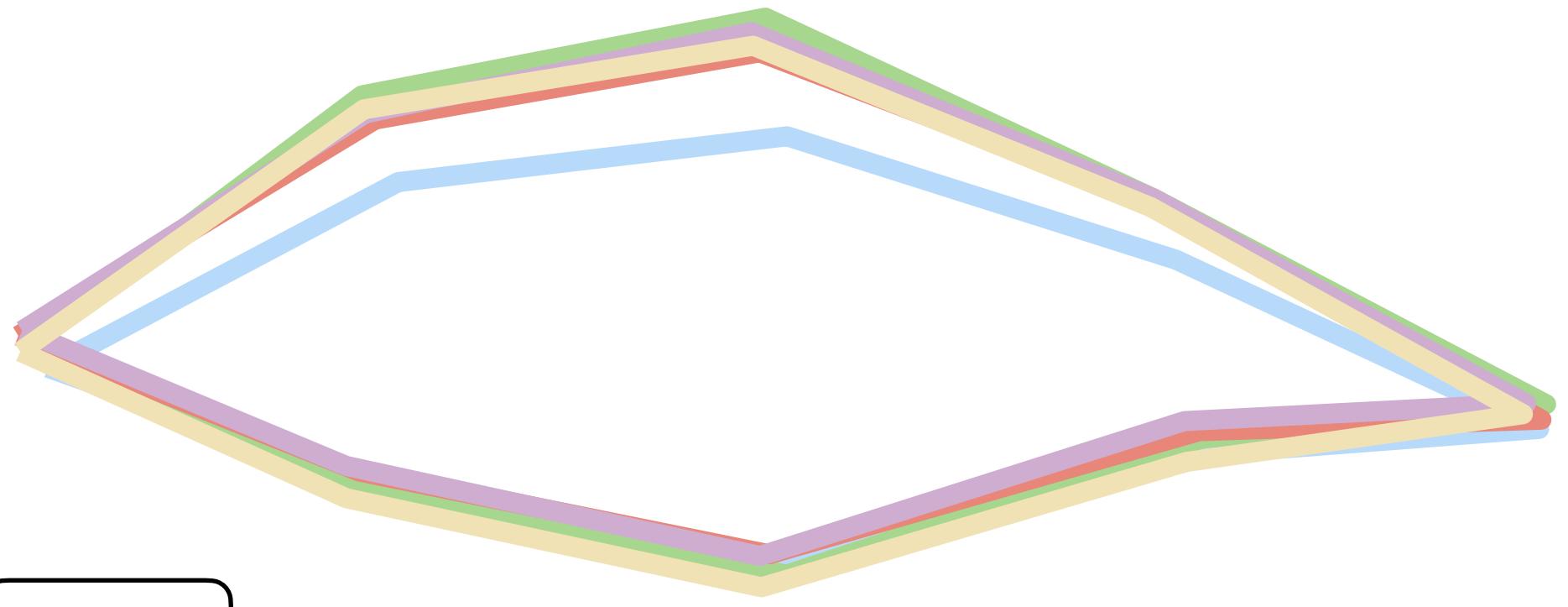
z#dɹ

e.g. *these drops*

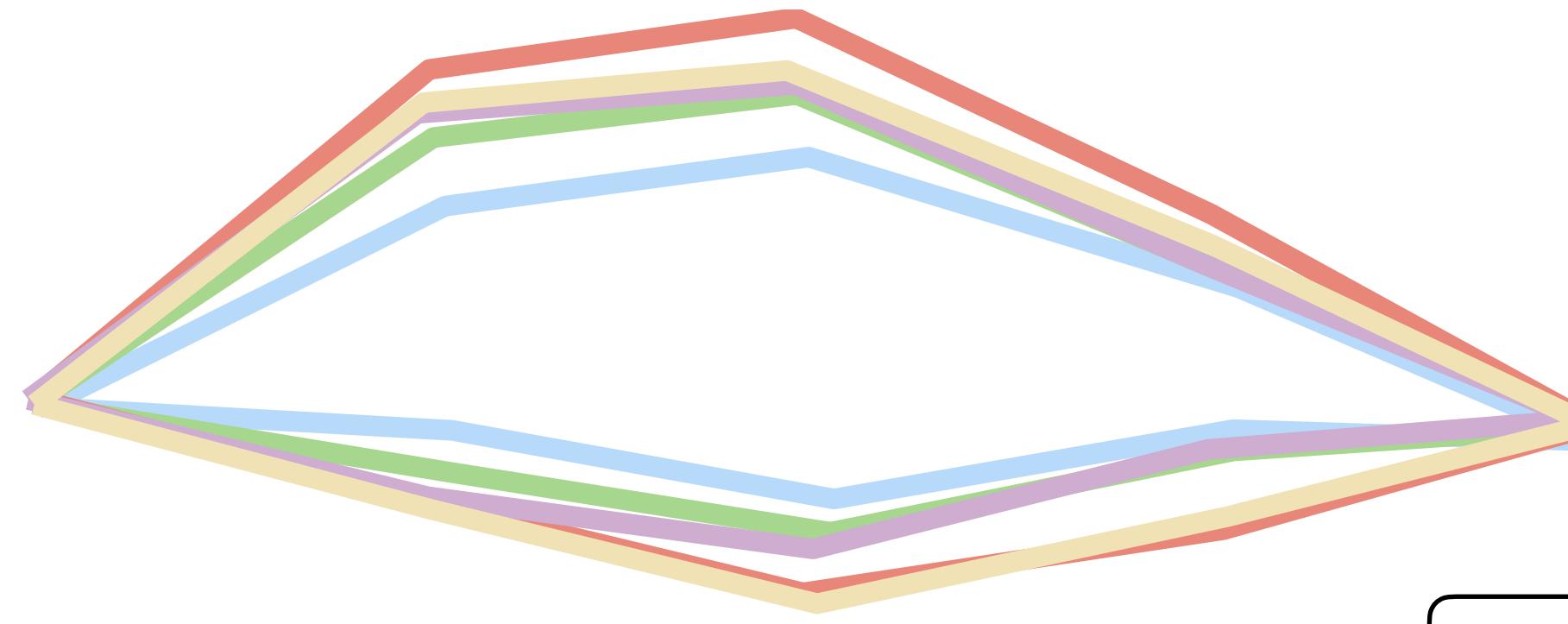
z#dʒ

e.g. *these jobs*

M01



M02



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 /ʃ/? (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