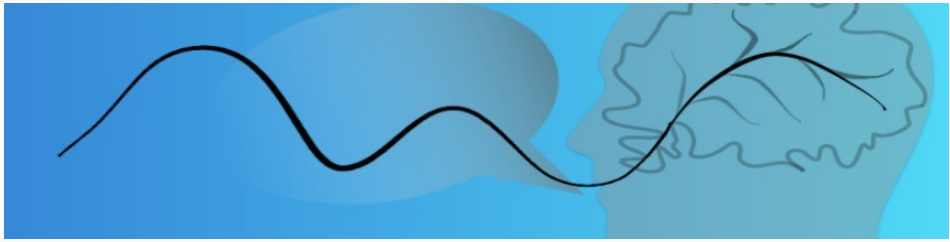

Information Theoretic Constant Rate Effects

Joel C. Wallenberg[1], Rachael Bailes[2], Anton K. Ingason[3] and Christine Cuskley[2]

[1] University of York, UK
[2] Newcastle University, UK
[3] University of Iceland, Iceland

Constant Rate Effects

- When a change is in progress for a given linguistic variable, some contexts favour one of its variants over another **without affecting the change** (Kroch, 1989).

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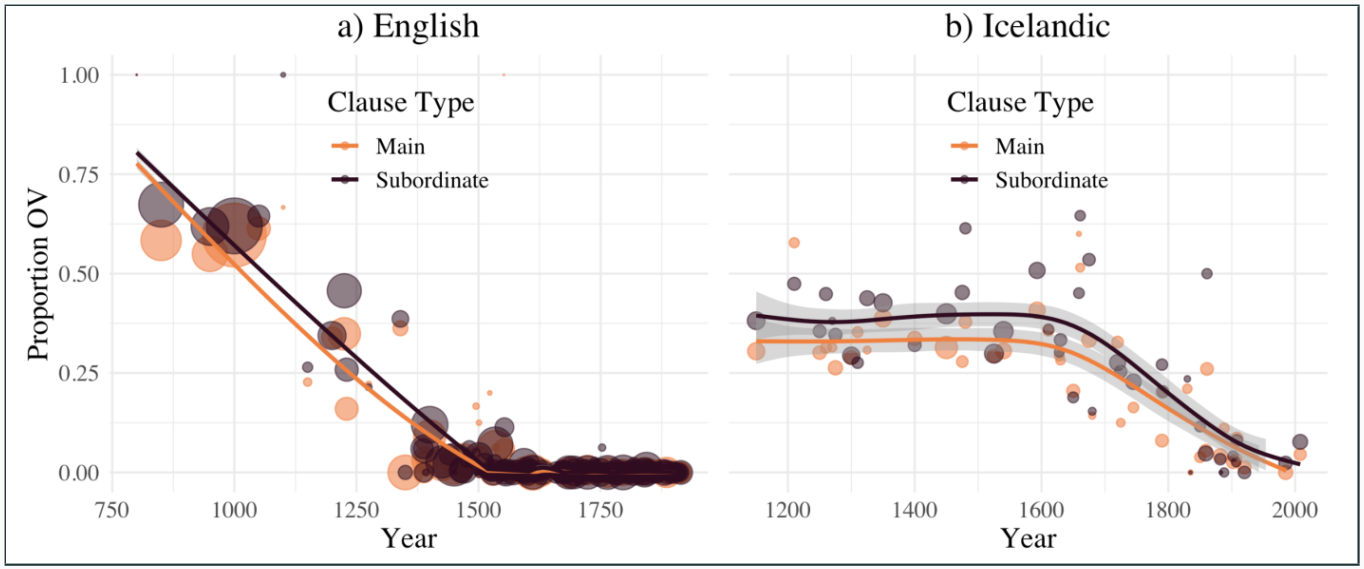


e.g. In the change from OV to VO in English & Icelandic, OV is consistently favoured in subordinate clauses throughout the steady decrease in its overall proportion (see also Pintzuk & Taylor 2006).

Information Theoretic Constant Rate Effects

Today's talk:

- summarises CRE of subject/object type in OV to VO
  - predicted and explained by our information theoretic account of language use
- expands on earlier findings on Icelandic, adding fronting under V2
- explains an apparent exception to the CRE
- discusses some theoretical implications for syntax and the CRE.

Information Uniformity and Language (a crash course)

Study 1: Information theoretic CRE in OV to VO

Study 2: Adding V2

Discussion

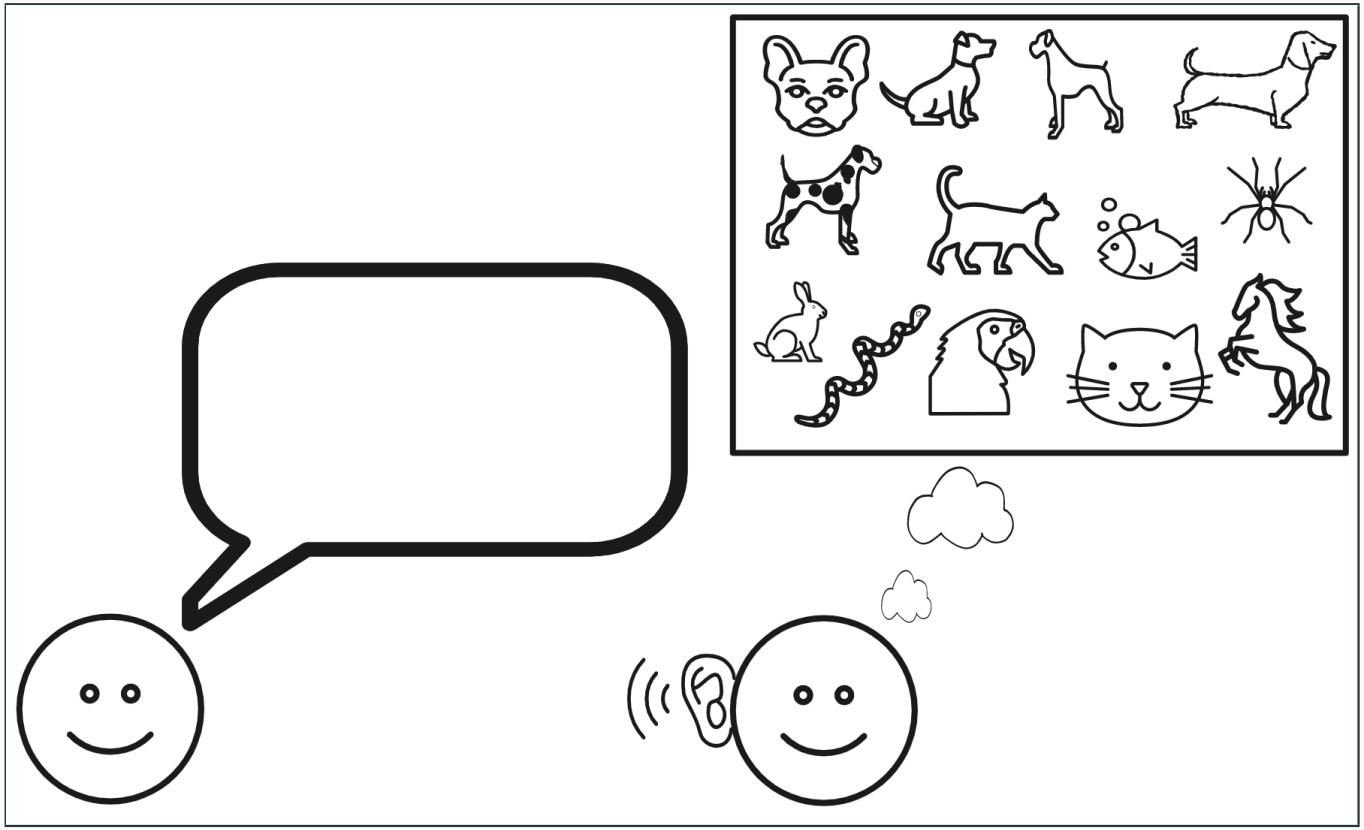
Information content of words

Information Theory quantifies information and describes how communication systems work (Shannon, 1948).

Key point for today:

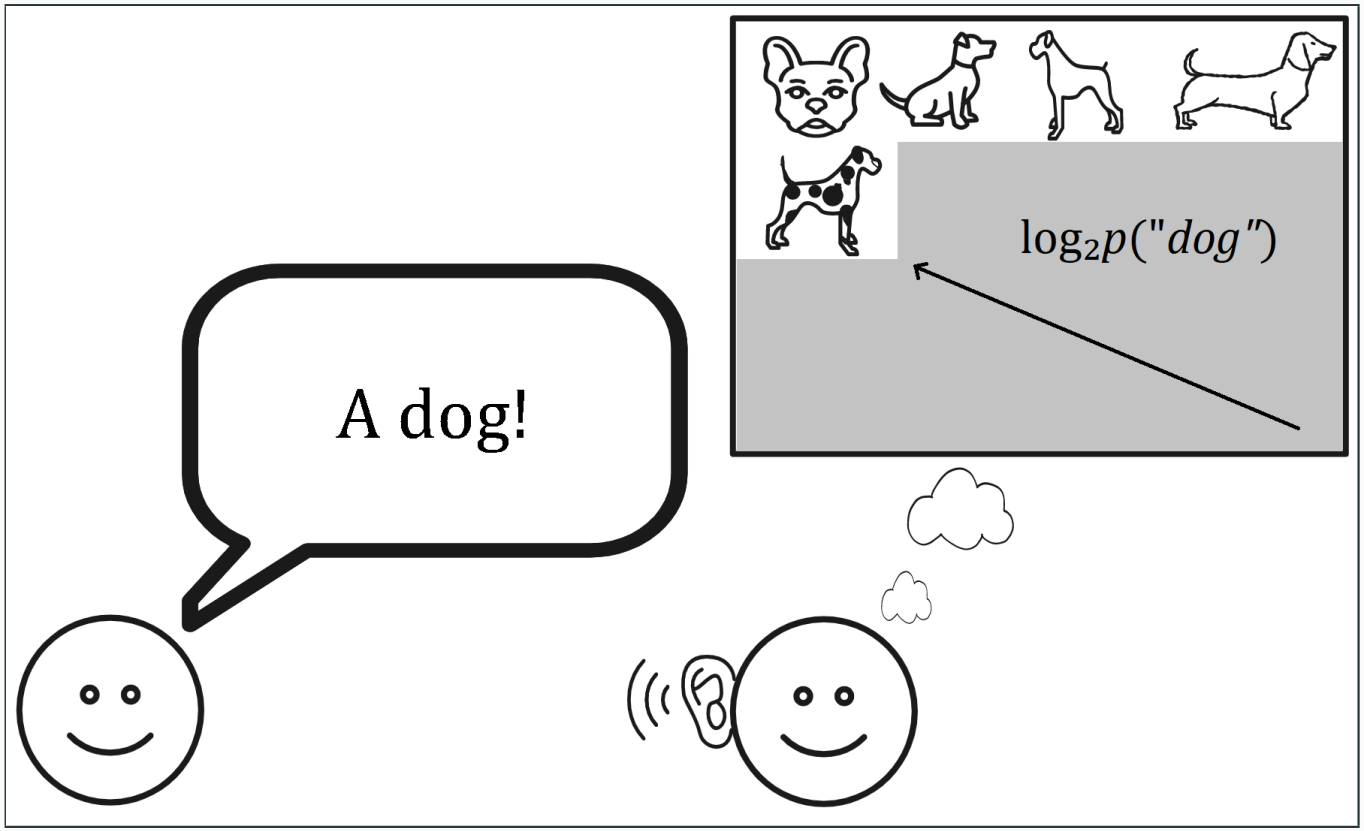
$\Rightarrow$ Low frequency words are high information,
high frequency words are low information.

Information content of words



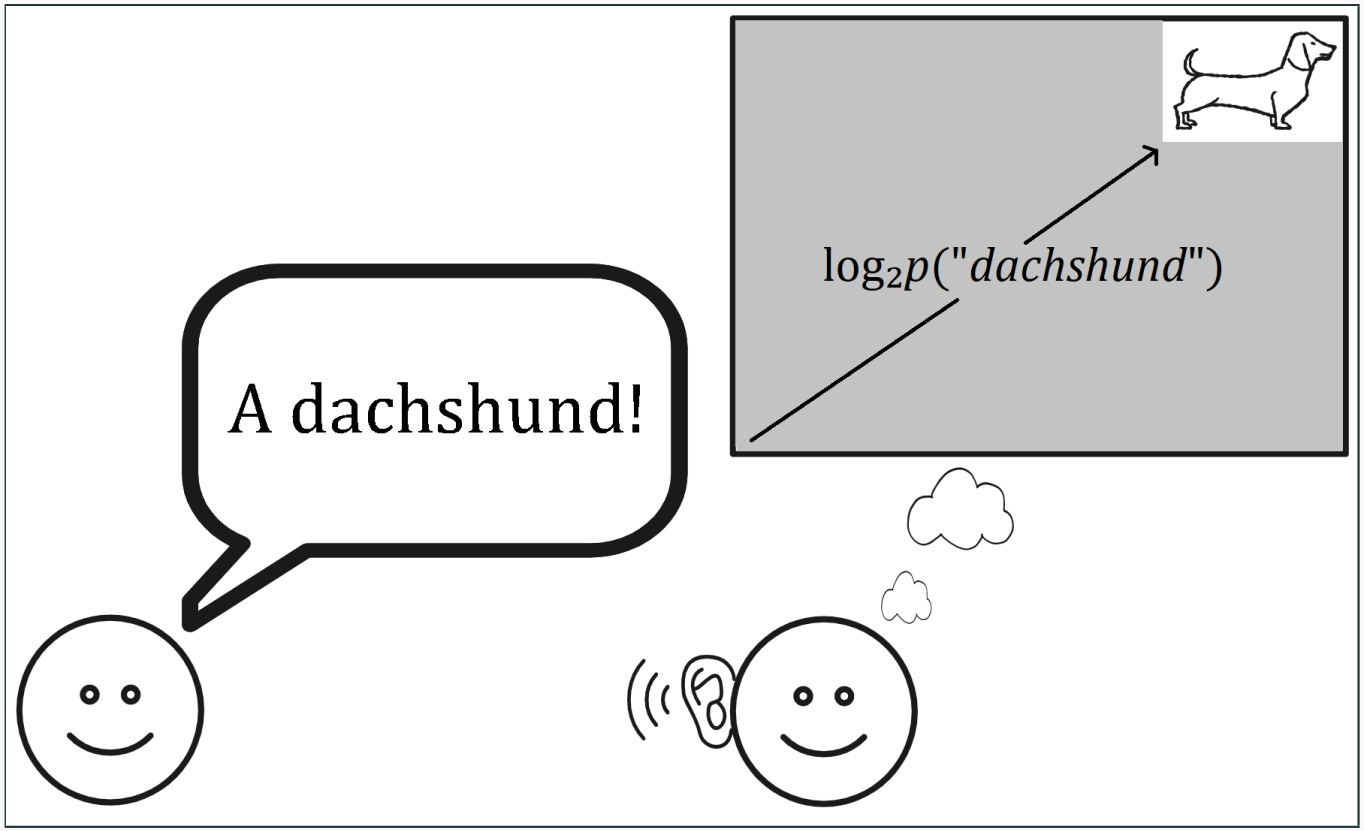
Receiver begins with a **set of expected outcomes** that could result from the message they receive. This set of expected outcomes is the amount of **uncertainty** they have about the message.

Information content of words



Sender uses a word that **reduces the receiver's uncertainty** by some amount proportional to the word's frequency. Here, the word is relatively frequent.

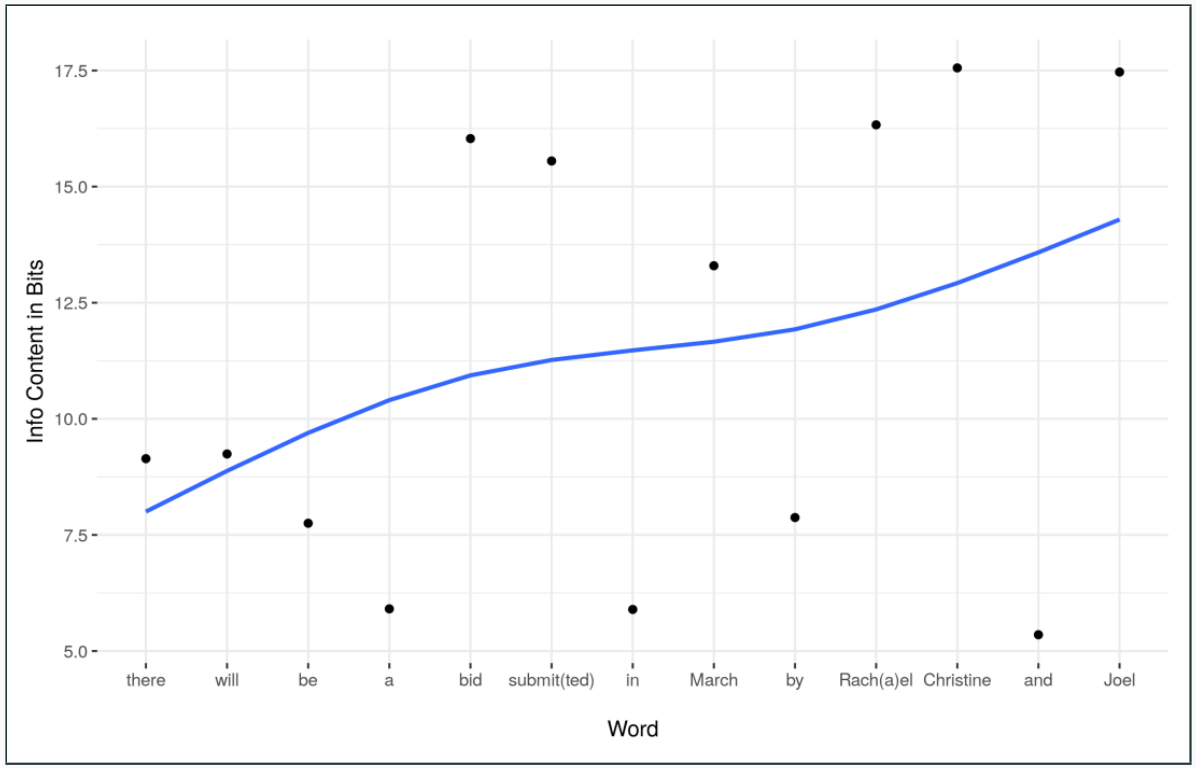
Information content of words



The more infrequent the word, the more uncertainty is reduced. This is the same thing as saying **the more infrequent the word, the more information it has**.

Information distributions of sentences

Deriving the information content of each word means we can derive a **distribution of information content values** for a given sentence.



Uniformity of information distributions

These distributions can vary in terms of how the information is spread or clustered. The **order of elements** in a sentence derives **more uniform** or **more asymmetric** distributions of information (Cuskley, Bailes, & Wallenberg, 2021).

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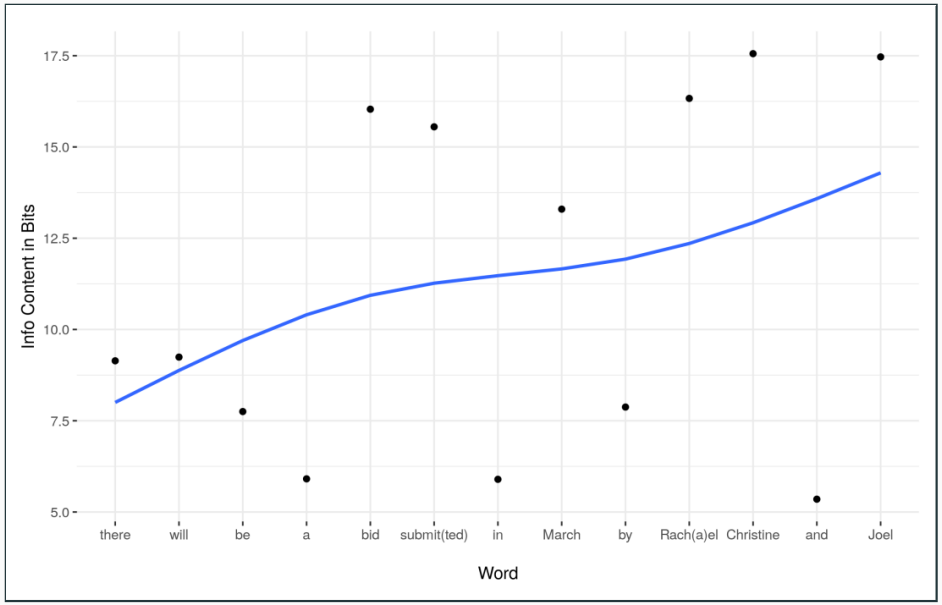

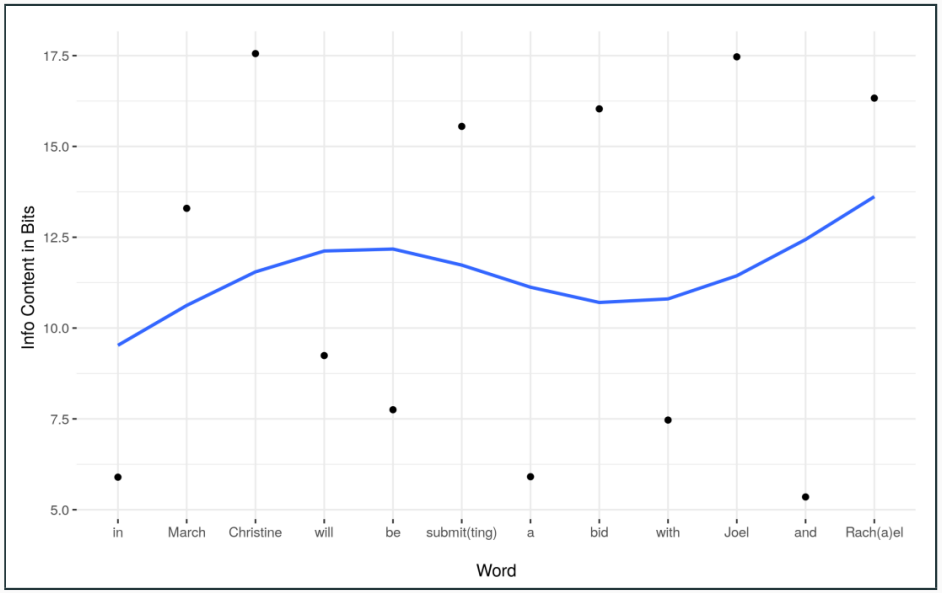

We can measure how uniform an information distribution is (Cuskley et al., 2021) - details available in the Q&A upon request!

Information Uniformity and Language (a crash course)

Study 1: Information theoretic CRE in OV to VO

Study 2: Adding V2

Discussion

CRE in English and Icelandic OV to VO

languages

MDPI

Article

Smooth Signals and Syntactic Change

Joel C. Wallenberg [1,*], Rachael Bailes [1], Christine Cuskley [1] and Anton Karl Ingason [2,*]

- Based on this account of information uniformity, (Wallenberg, Bailes, Cuskley, & Ingason, 2021) predicted a previously undetected CRE in the English and Icelandic OV to VO changes

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Smooth Signals and Syntactic Change

Joel C. Wallenberg [1,*], Rachael Bailes [1], Christine Cuskley [1] and Anton Karl Ingason [2,*]

- Based on this account of information uniformity, (Wallenberg et al., 2021) predicted a previously undetected CRE in the English and Icelandic OV to VO changes
- During the change, speakers had access to both constituent orders, making this an ideal case for testing whether language users choose more informationally uniform constructions

OV-to-VO in English

Middle English:

(1) Mi feader & Mi moder for-þi þt ich nule þe
My father and my mother because that I not+would you
forsaken; habbe forsake me.
forsake have forsaken me
"Because I would not forsake you, my father and mother have forsaken me"

(*St. Juliana*, northern Herefordshire/southern Shropshire, date: c1225; ID CMJULIA-M1,106.172 from the *Penn Parsed Corpus of Middle English 2* PPCME2, 2000)

OV-to-VO in Icelandic

Historical Icelandic:

(2) a. . . . og sannleikurinn mun yður frelsa
and the truth will you free
". . . and the truth will free you."

(*Oddur Gottskálksson's New Testament*, date: 1540; ID 1540.NTJOHN.REL-BIB, 204.662 from *Icelandic Parsed Historical Corpus (IcePaHC, 2009)*)

b. . . . en eg skal sjá yður aftur.
but I shall see you-pl again
". . . but I shall see you again"

(*Oddur Gottskálksson's New Testament*, date: 1540; ID 1540.NTJOHN.REL-BIB, 223.1305 from IcePaHC)

CRE in English and Icelandic OV to VO

- Syntactic constituents (and their lexical content) occur at different frequencies, which means they have different information content values.

CRE in English and Icelandic OV to VO

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Constituent Type	**Average Information Content** (PPCMBE; Kroch et al., 2016)
Pronominal DP	low ($\approx$ 11.7 bits)
Nominal DP	high ($>$ 13.7 bits)
Lexical Verb	mid ($\approx$ 13.5 bits)

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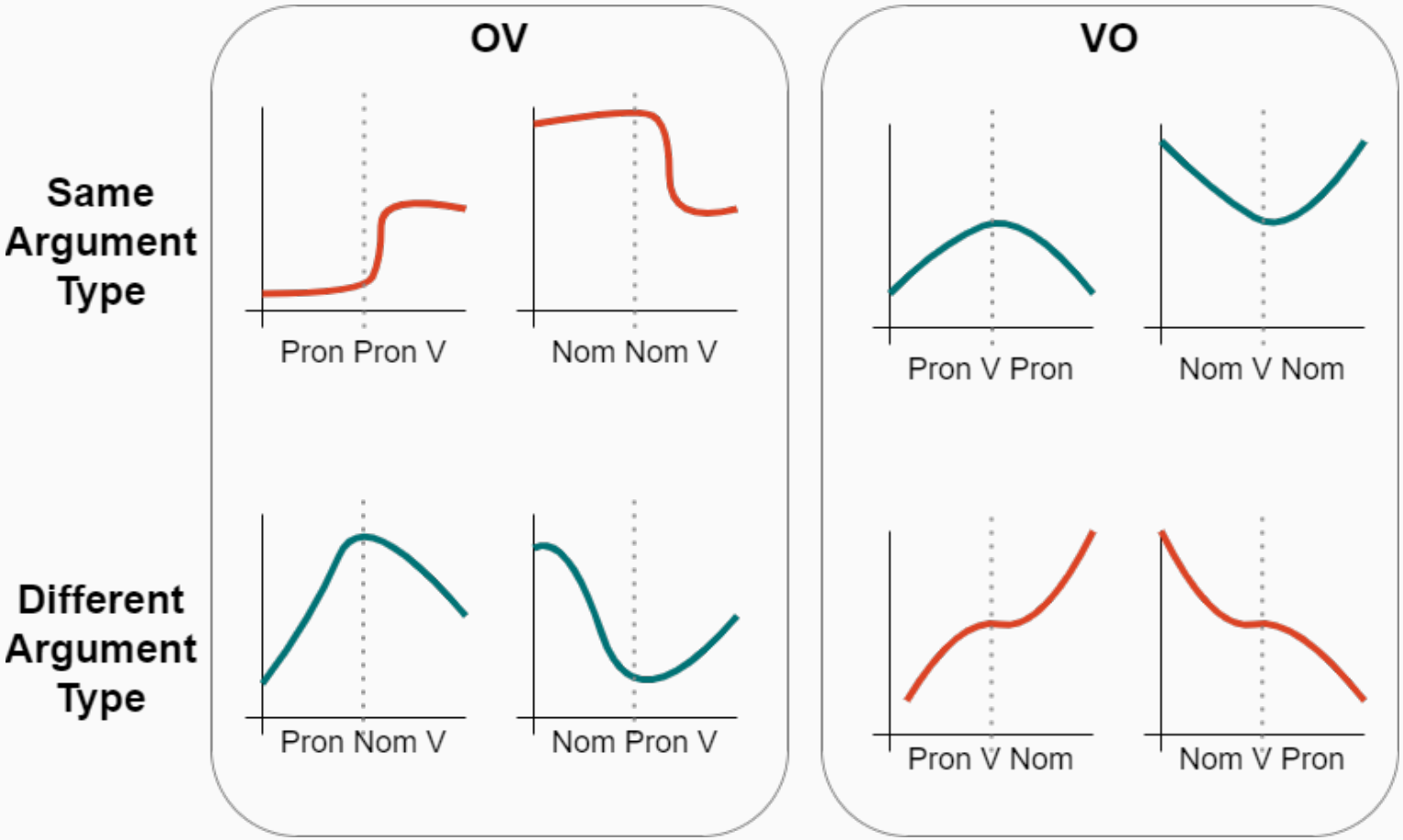
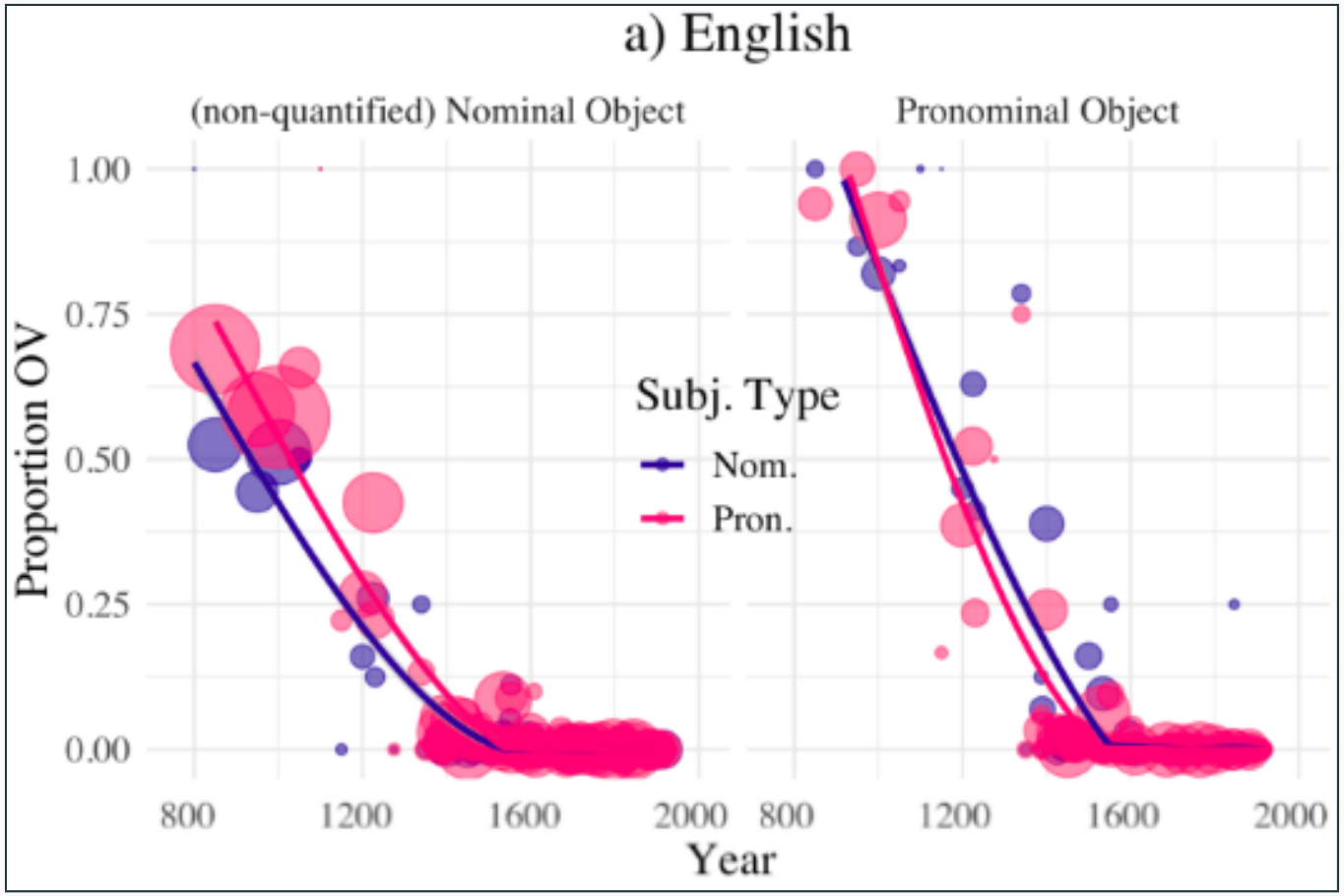
- We can therefore make predictions about the ordering of elements that speakers will prefer, when they have a choice - i.e., constituent orders that yield more uniform information distributions.

Study 1 Predictions



- **OV is disfavoured** when Sbj and Obj are the **same type**
- **OV is favoured** when Sbj and Obj are **different types**

Study 1 Results:
OV is favoured when Subject and Object are different types



YCOE and Penn Parsed Corpora of Historical English (Taylor, Warner, Pintzuk, & Beths, 2003; Kroch & Taylor, 2000; Kroch, Santorini, & Delfs, 2004; Kroch et al., 2016)

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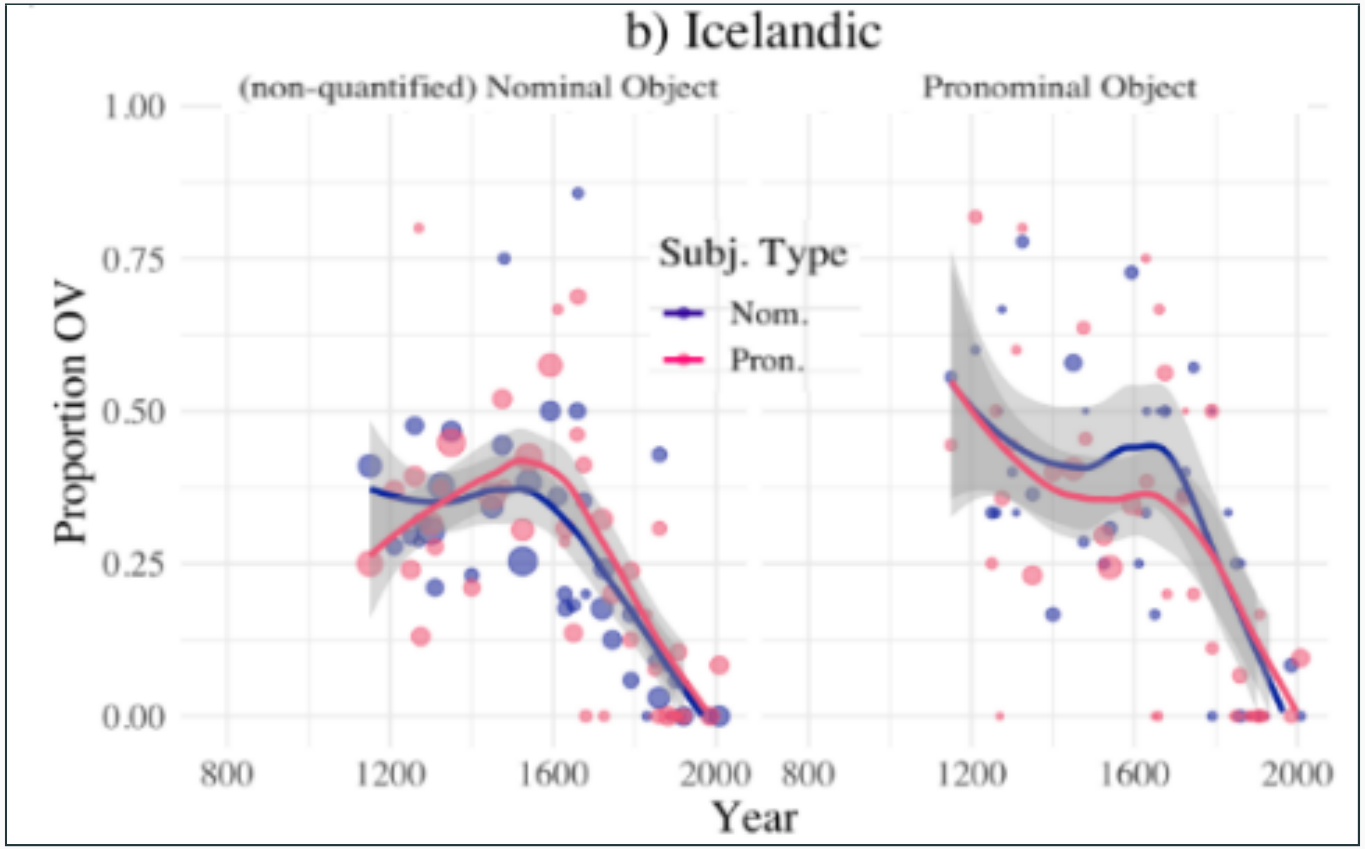


IcePaHC (Wallenberg, Ingason, Sigurðsson, & Rögnvaldsson, 2011)

Information Uniformity and Language (a crash course)

Study 1: Information theoretic CRE in OV to VO

Study 2: Adding V2

Discussion

Study 2: Adding V2

- Wallenberg et al. (2021) showed that a pressure for information uniformity creates contextual effects in the OV-to-VO change.
- OV-to-VO progresses across the argument-type contexts at the same rate (CRE).
- But we did not account for how Subject-Aux inversion under V2 interacts informationally with OV/VO.
- We now consider Icelandic main clauses with adjunct XPs...

Examples: adjunct fronting under V2

VO – no fronting

(3) Jón hefur keypt bók
Jón has bought a.book
í dag.
in today
'Jón has bought a book today.'

OV – no fronting

(4) Þessi sami riddari vildi
This same knight wanted
eigi gaum gefa
not attention give
'This same knight didn't want to pay attention [to...].'
(1475.AEVINTYRI.NAR-REL,.933)

VO – adjunct fronting

(5) Í dag hefur Jón
in today has Jón
keypt bók.
bought a.book
'Today, Jón has bought a book.'

OV – adjunct fronting

(6) Aldrei hafði kóngsson
never has a prince
slíkan grip séð.
such a.thing seen
'Never has a prince seen such a thing'
(1450.VILHJALMUR.NAR-SAG,21.327)

Study 2: Adding V2

- From Study 1, constituent order affects distribution uniformity.

Study 2: Adding V2

- From Study 1, constituent order affects distribution uniformity.
- Remember: syntactic constituents occur at different frequencies, which means they have different information content values.

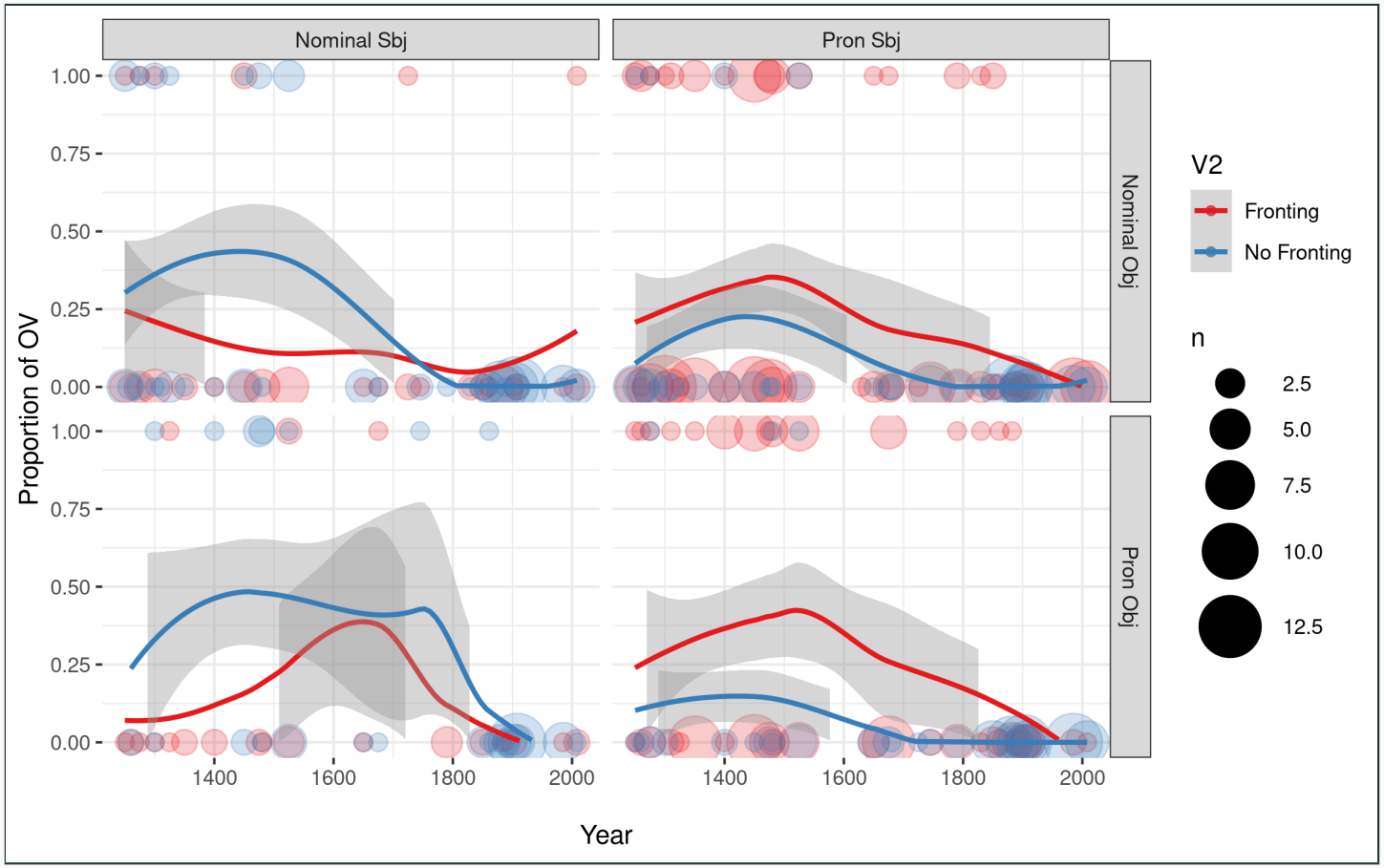
Constituent Type	**Average Information Content** (PPCMBE; Kroch et al., 2016)
Pronominal DP	low ($\approx$ 11.7 bits)
Aux	low-ish ($\approx$ 12.4 bits)
Lexical Verb	mid ($\approx$ 13.5 bits)
Nominal DP	high ($>$ 13.7 bits)

Finally, Adjunct XPs are comparable to (not least because in many cases they include) Nominal DPs, and are therefore treated here as high

Study 2: Adding V2

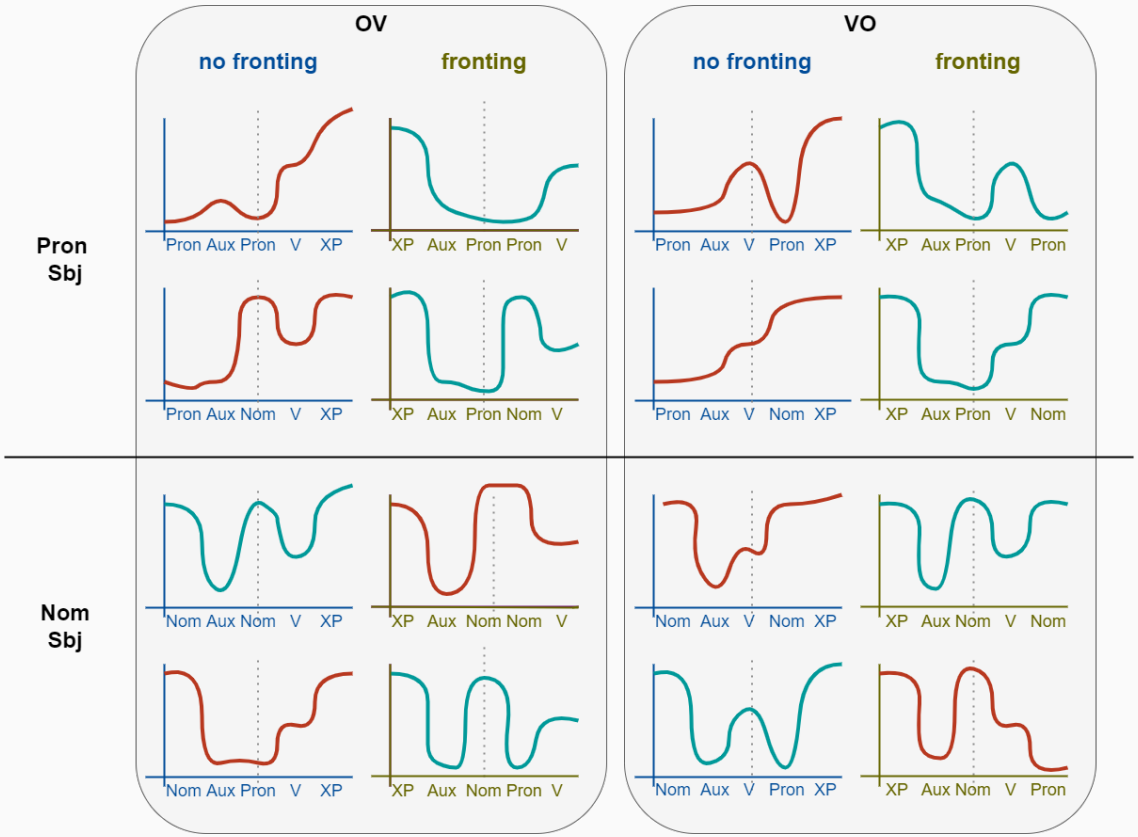
- We might also expect that V2 will also give rise to an information theoretic CRE in OV/VO, as argument type did in Study 1.
- So that's what we looked for...

Preliminary:
Is V2 a "context" for OV/VO (in the CRE sense)?



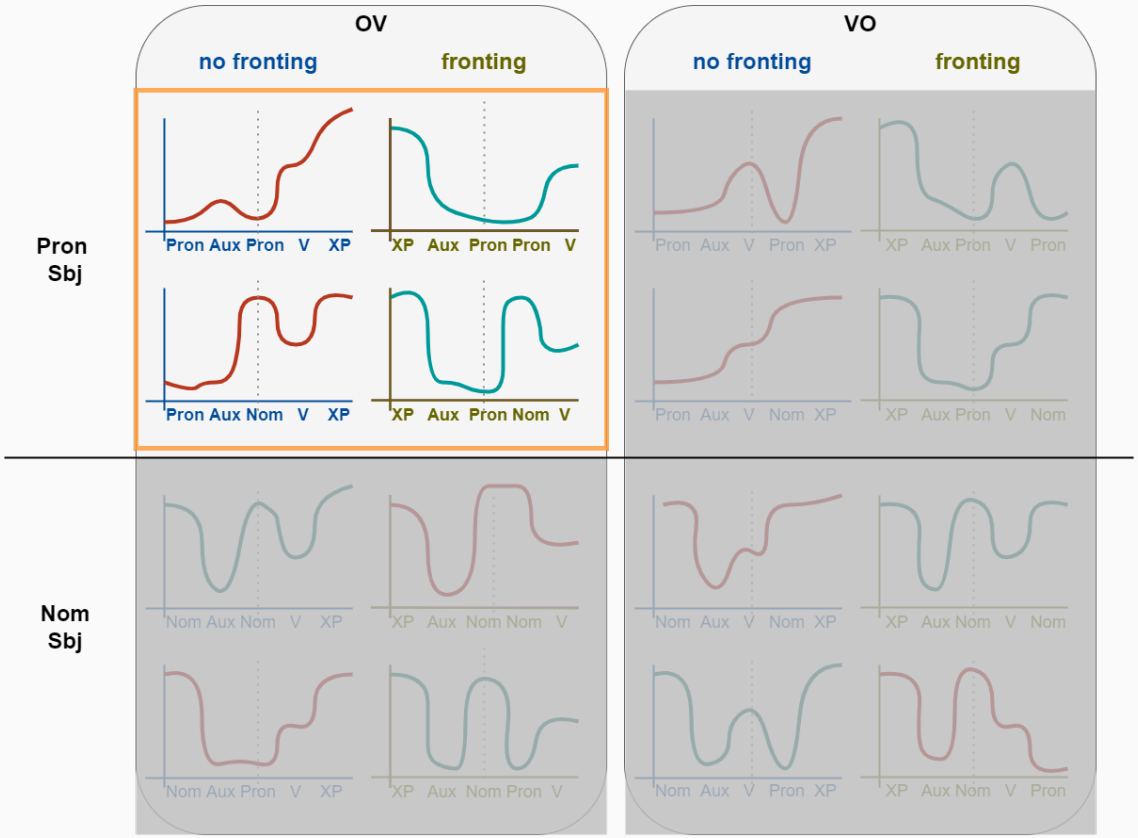
- If V2 were a conditioning context for OV/VO, we'd expect CRE.
- This *may* apply to Pron Sbj + Nom Obj, but not in other cases.
- Predictions not borne out if V2-fronting conditions choice of OV/VO.

Study 2 Predictions
Speakers deploy fronting when it yields more uniformity



If speakers *deployed* adjunct-fronting to maximise information uniformity (given other parameters), they would conform to this pattern

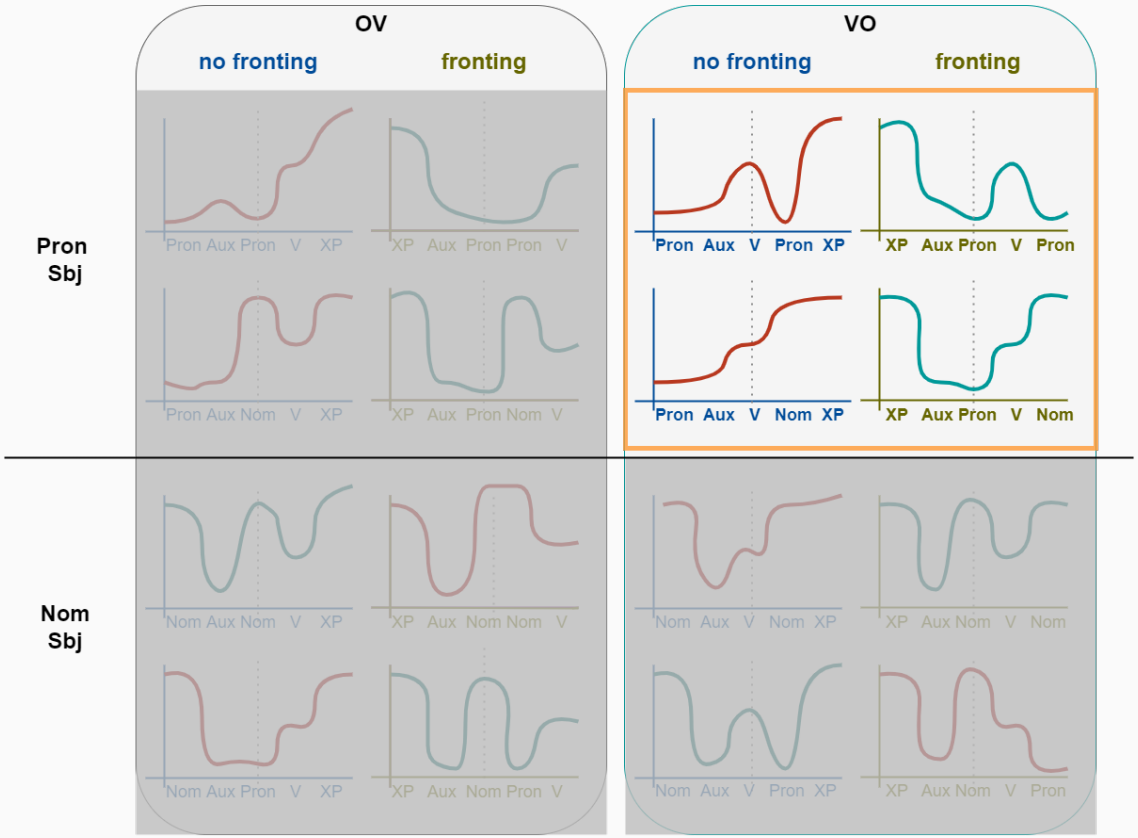
Study 2 Predictions
Given OV and Pron Sbj:



+ Pron Obj:
  - Fronting helps balance out the unavoidable 3-unit informational troughs (Pron-Aux-Pron & Aux-Pron-Pron)

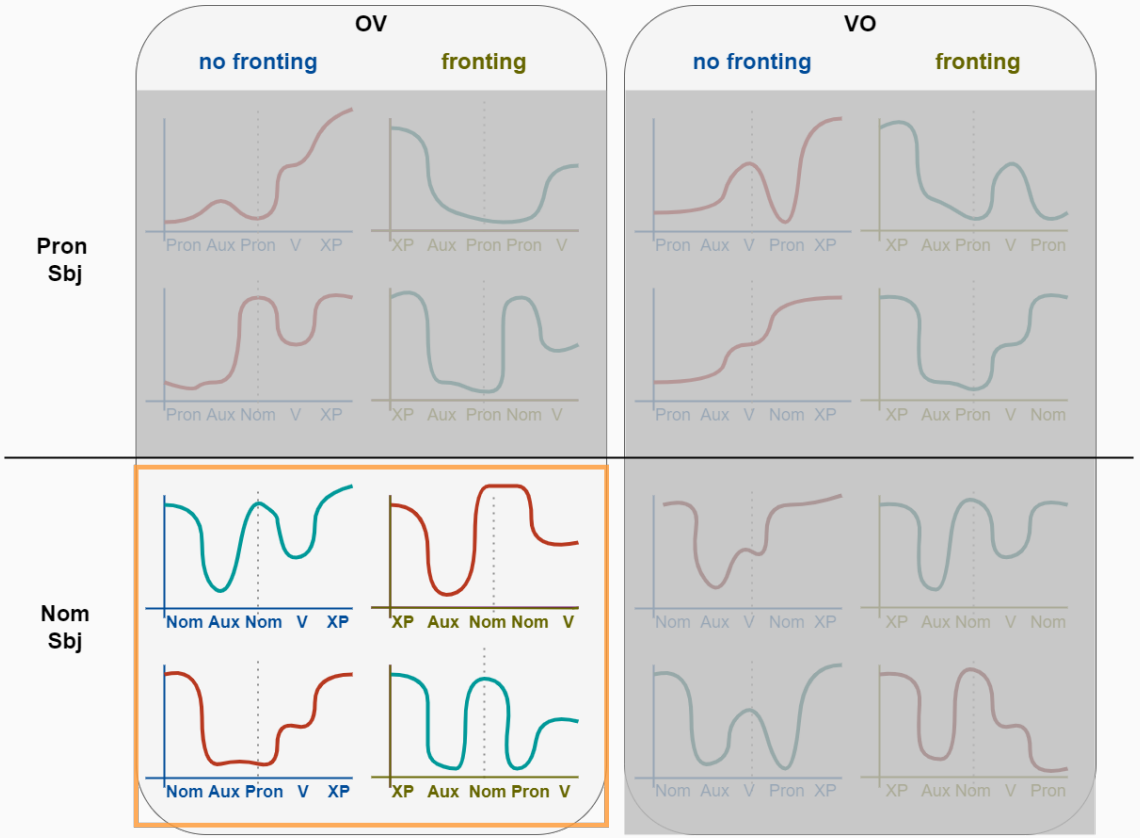
+ Nom Obj:
  - Fronting means avoidance of clustered information peak (Nom-V-XP)

Study 2 Predictions
Given VO and Pron Sbj:



+ Pron Obj:
  - Fronting may yield a bit more uniformity
+ Nom Obj
  - Pressure from 2-unit informational troughs and peaks (Pron-Aux & Nom-XP)
  - Maximally asymmetric distribution can be avoided by fronting

Study 2 Predictions
Given OV and Nom Sbj:

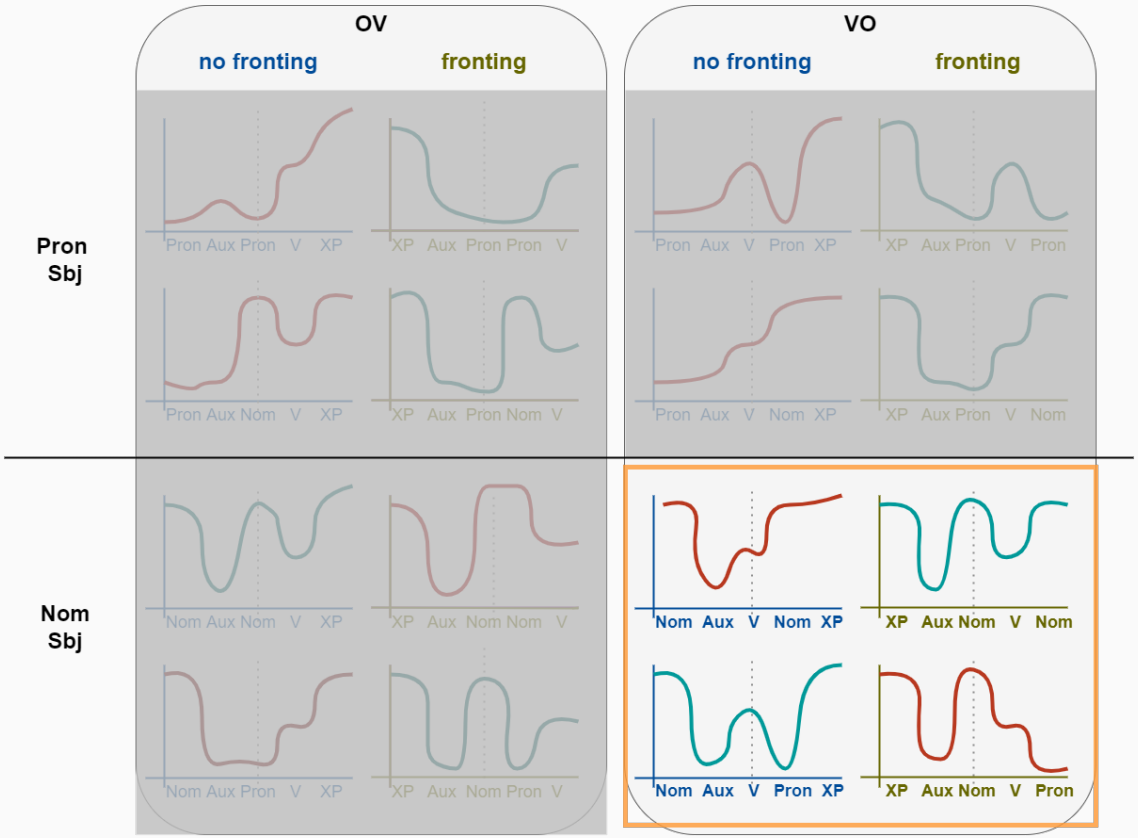


Distribution symmetries aren't so obviously different, so pressures probably aren't strong. But:

+ Nom Obj:
  - Fronting yields 2-unit informational peak (Nom-Nom), so *may* be disfavoured

+ Pron Obj:
  - Fronting *might* be more uniform (if not more symmetrical)

Study 2 Predictions
Given VO and Nom Sbj:



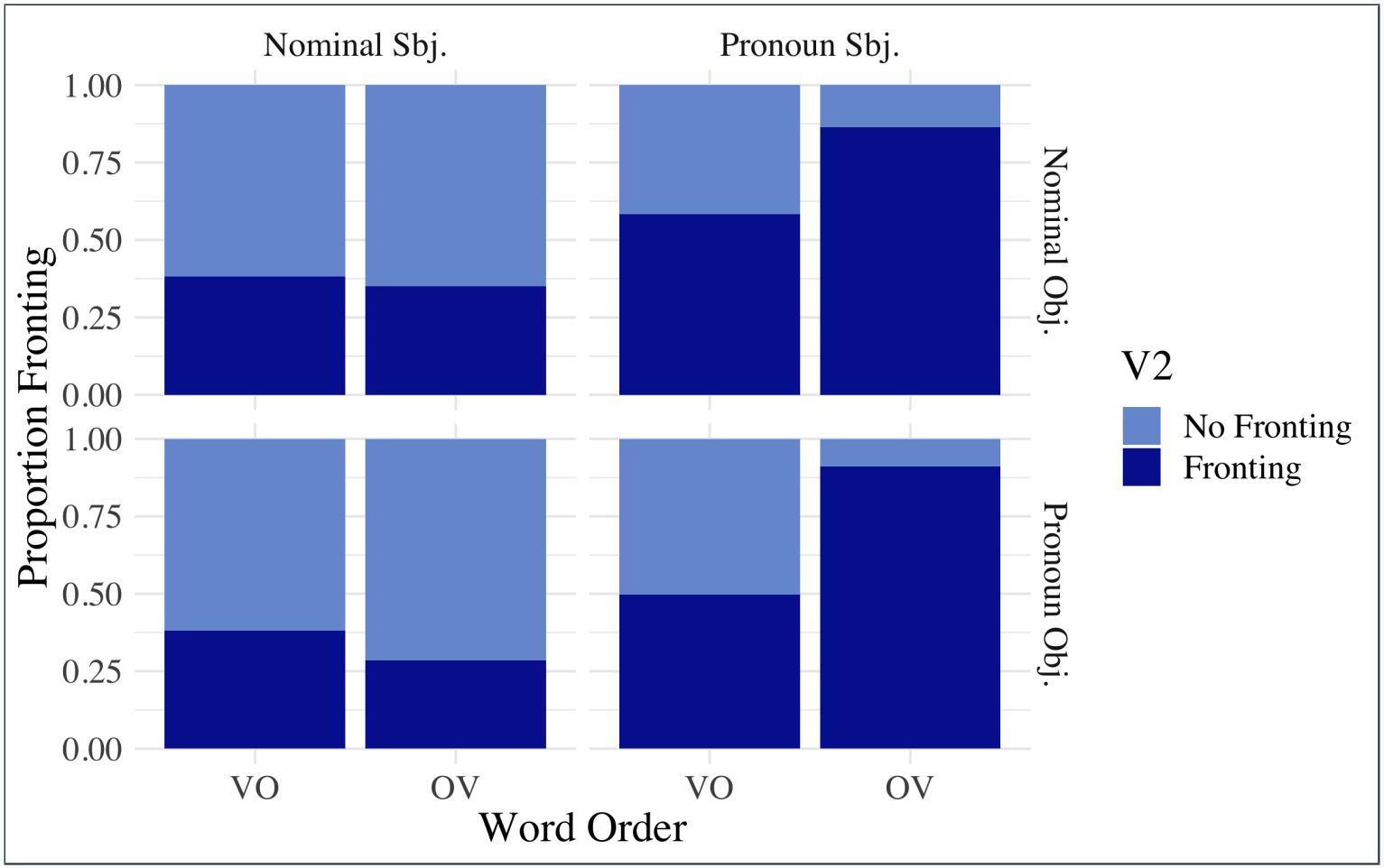
Distribution symmetries not obviously different, so pressures probably aren't strong. But:

+ Nom Obj:
  - Fronting *may* yield slightly more uniform distribution (by avoiding clustered peak of Nom+XP)

+ Pron Obj:
  - Non-fronting might be more symmetrical

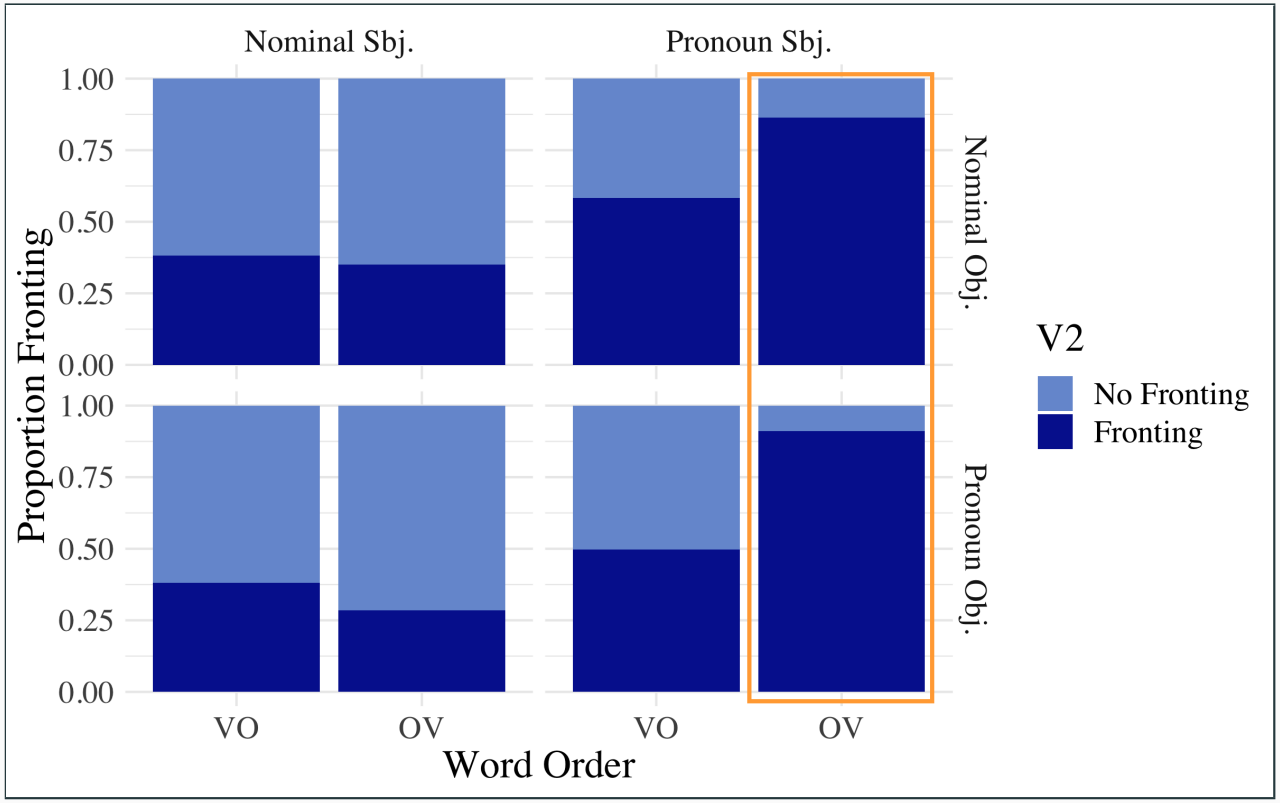
Study 2 Predictions
Speakers deploy fronting when it yields more uniformity

Study 2 Results



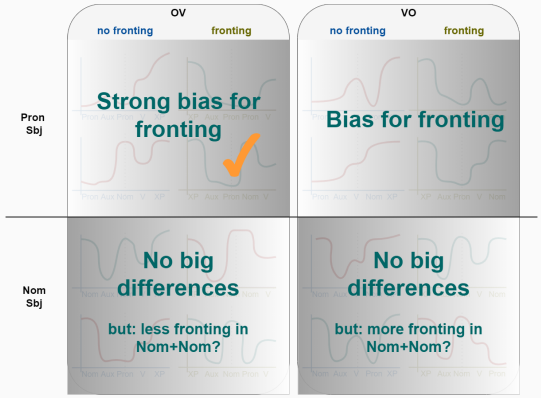
- Overall, fronting appears where we'd expect if speakers are trying to maximise the uniformity of information distributions with the order of constituents.

Study 2 Results: Given OV and Pron Sbj

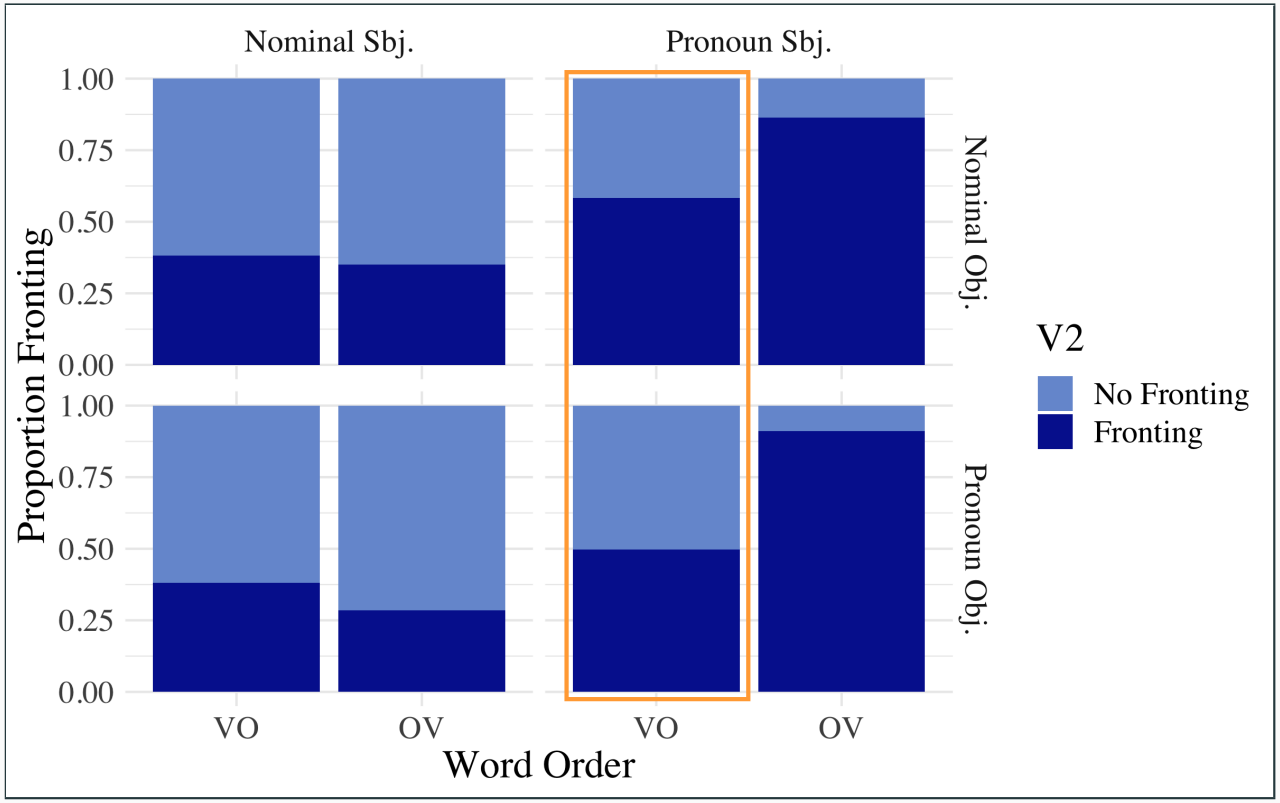


Two pressures for fronting

- Pron Sbj + Nom Obj: Avoid long peak (Nom-V-XP)
- Pron Sbj + Pron Obj: Avoid maximal asymmetry

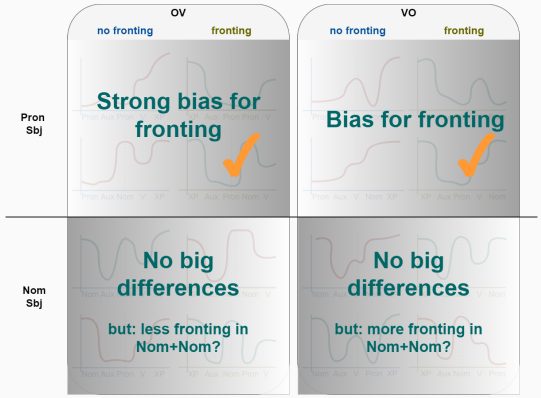


Study 2 Results: Given VO and Pron Sbj

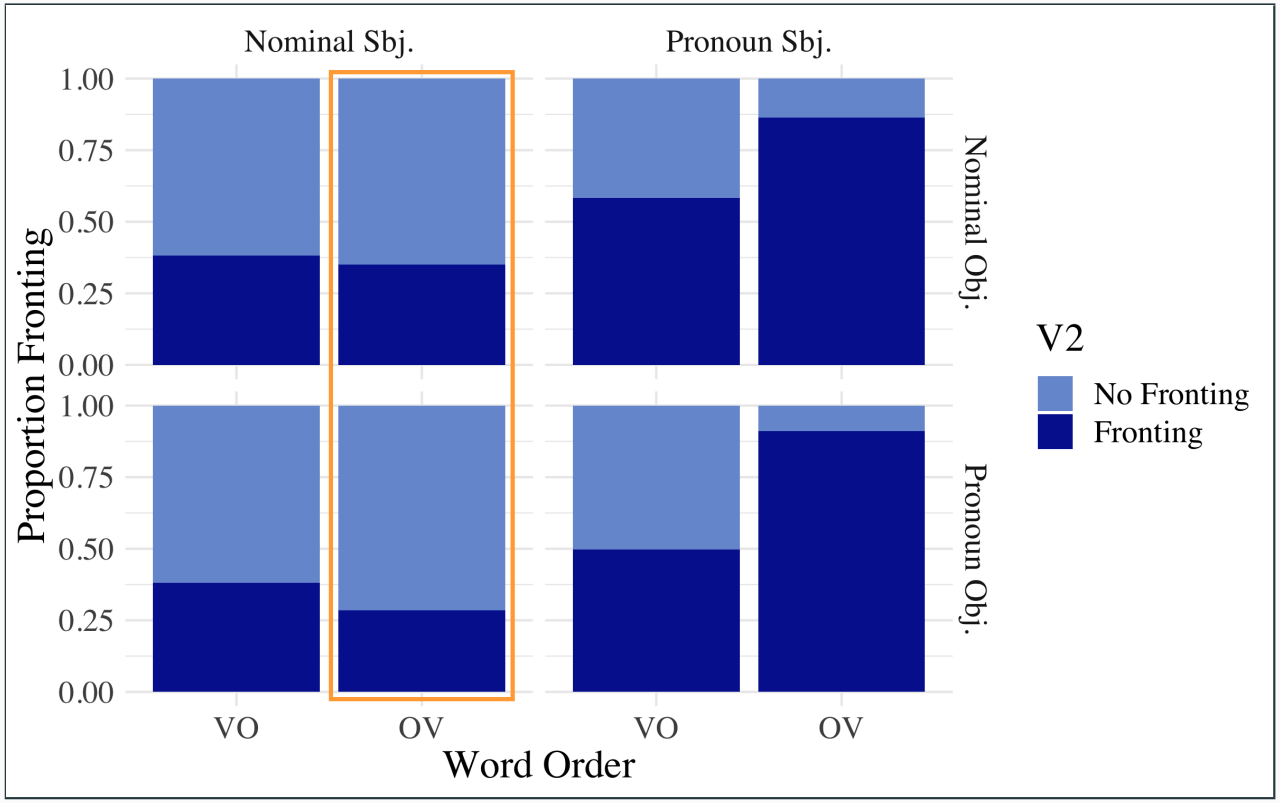


Bias for fronting

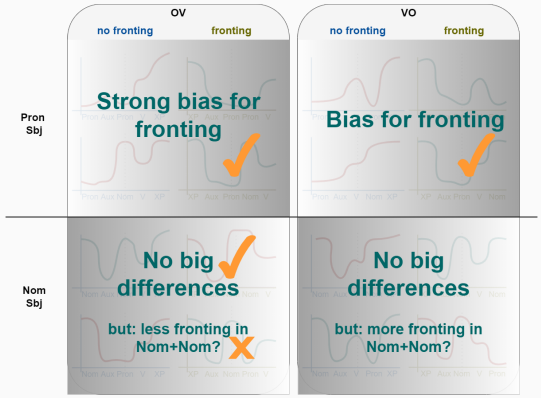
- Stronger (>50%) for Pron Sbj + Nom Obj
- Avoidance of maximal asymmetry



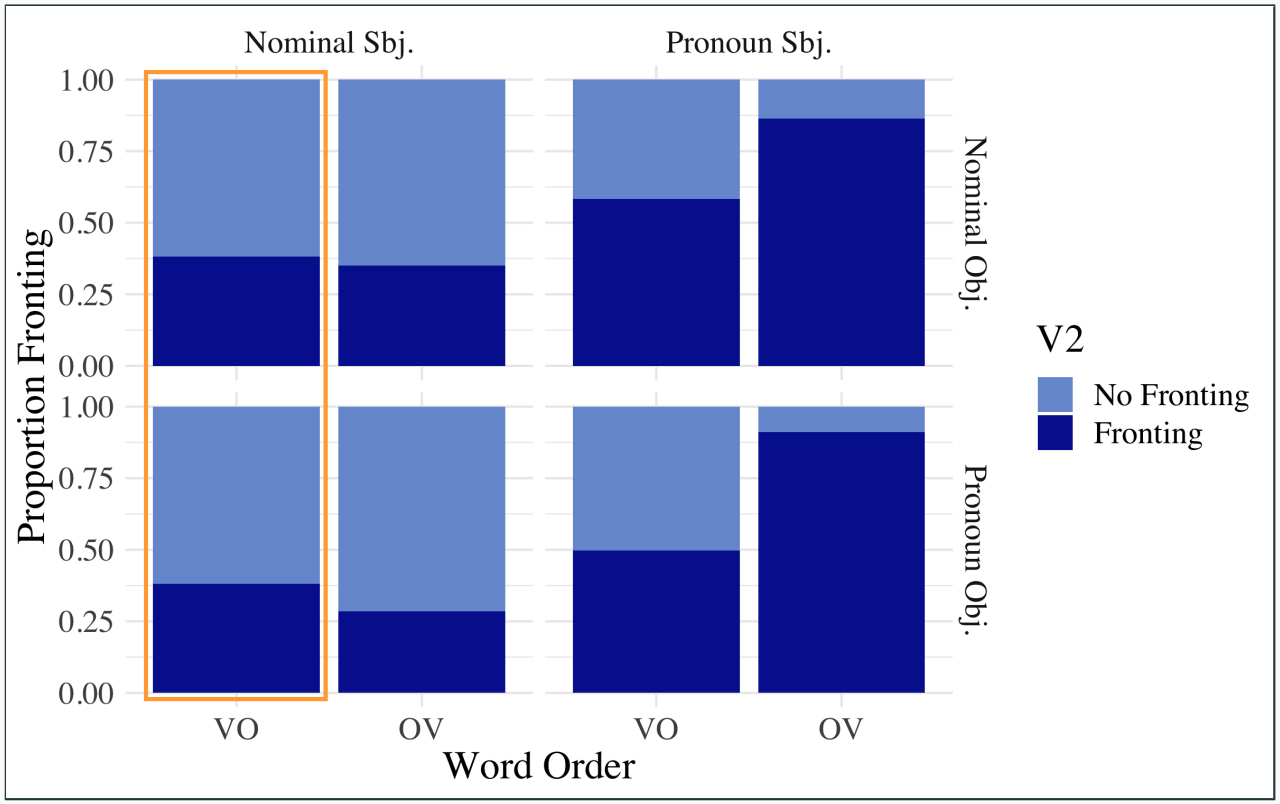
Study 2 Results: Given OV and Nom Sbj



- Less fronting than in VO overall
- No big difference between Pron/Nom Objs, but not the direction we'd expected (less fronting to avoid Nom+Nom)



Study 2 Results: Given VO and Nom Sbj



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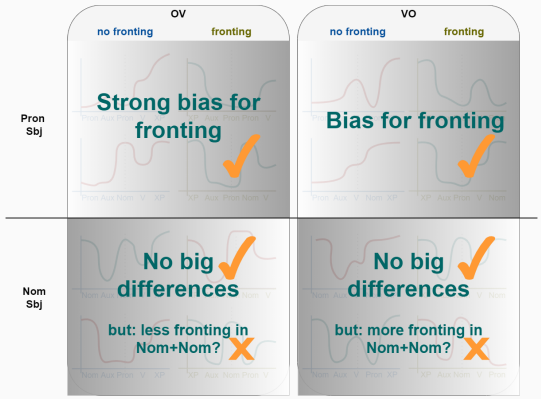

Information Uniformity and Language (a crash course)

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Theoretical Implications

- As in Study 1, Study 2 shows speakers use the syntactic resources available to optimize for information uniformity in planning.

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  2. Speakers then select right- or left-headed *v*P/VP.
  3. Then, movement
     (i.e. fronting modulates information uniformity under the constraint of OV or VO, rather than vice versa).
     (cf. Speyer, 2010 where Sbj type conditions topicalization in English)

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     (cf. Speyer, 2010 where Sbj type conditions topicalization in English)
- Explains lack of CRE for OV within V2 "contexts".

- Time Separation Theorem (Kauhanen & Walkden, 2018): given this order of operations, once the basic lexical content is decided, maximum/minimum uniformity is strictly bounded.

Acknowledgements, and thanks for listening!

Questions?

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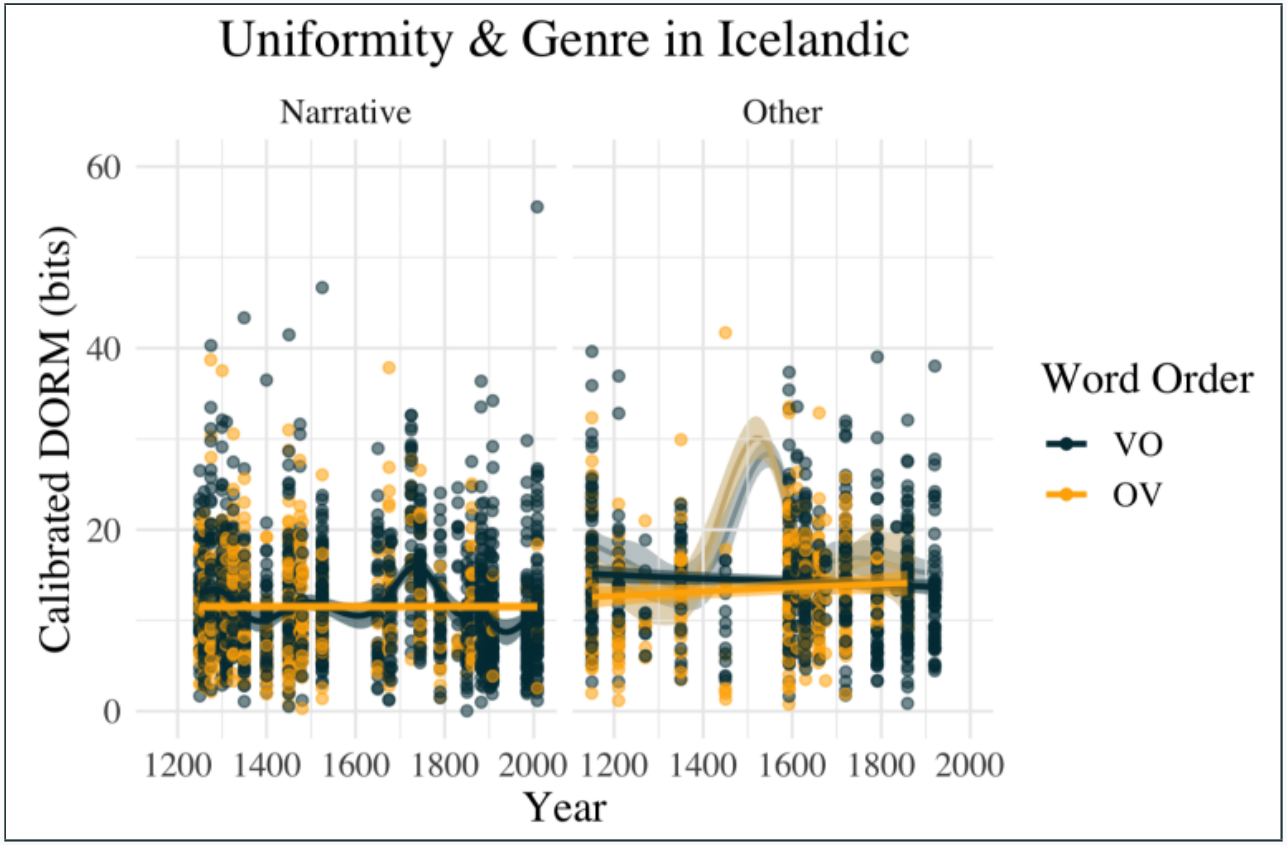
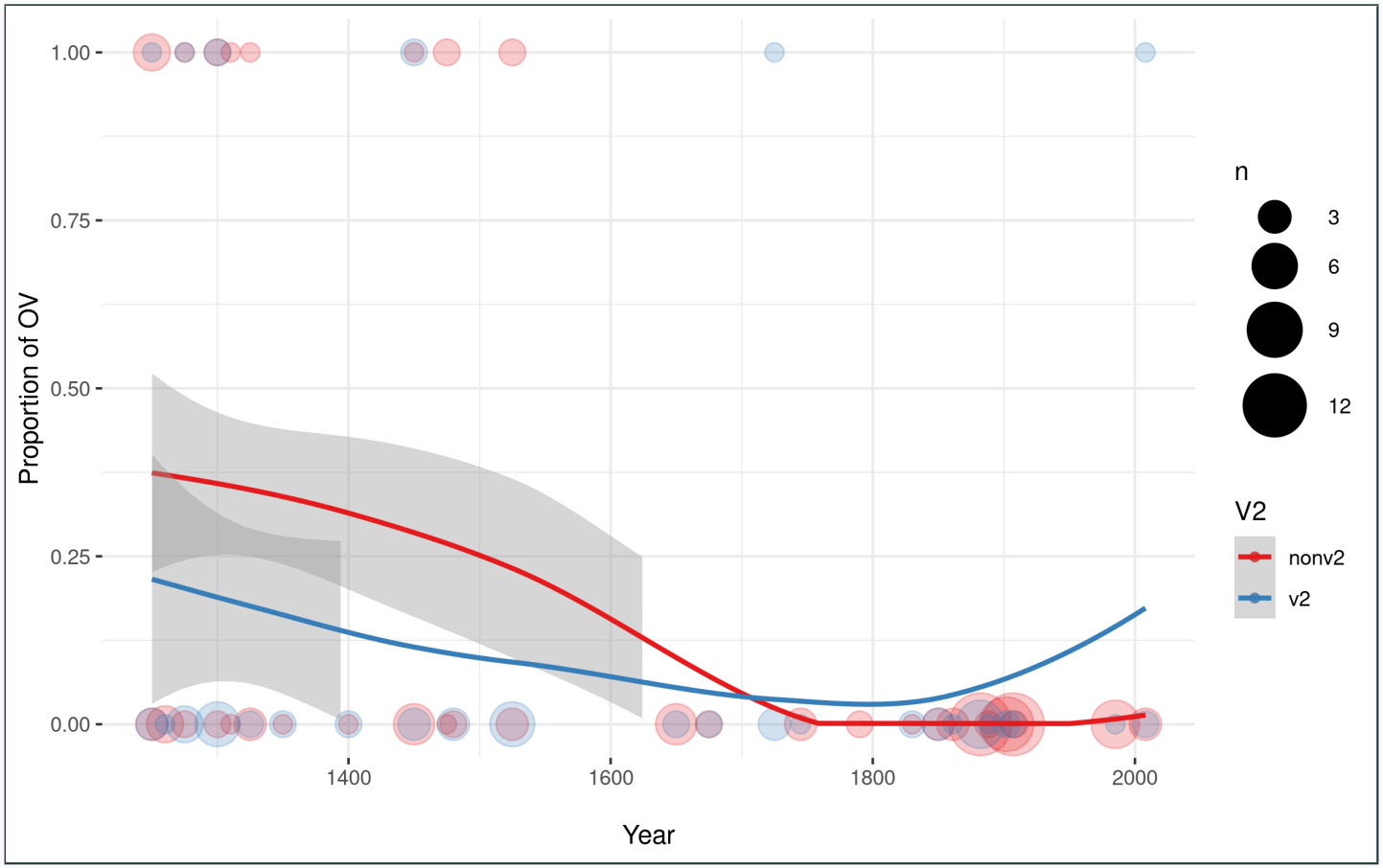
Study 1 Results:
Information density remains constant through OV-to-VO

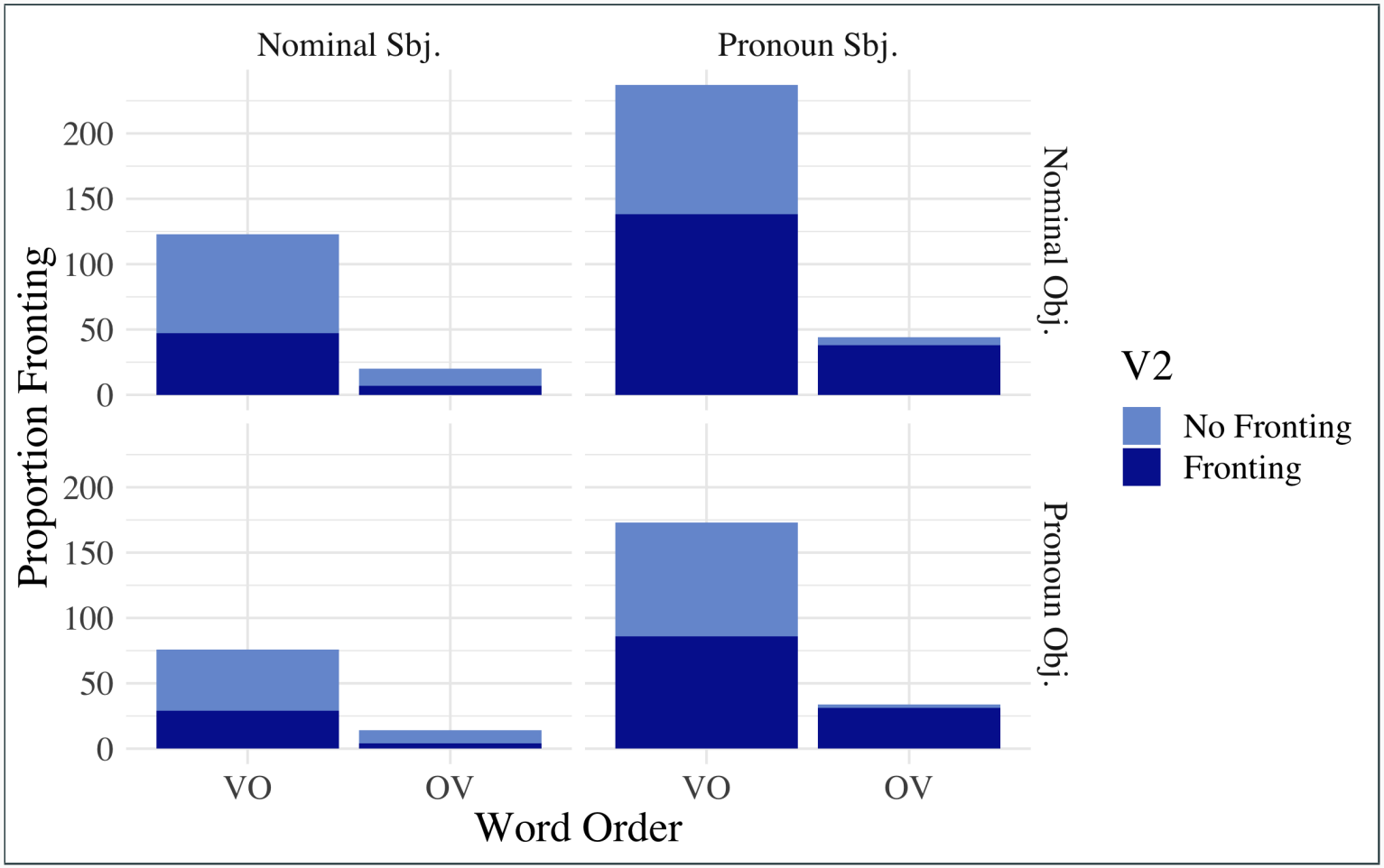


- The average uniformity of sentences is constant across the history of Icelandic.

Study 2 Results:
OV disfavoured by adjunct-fronting through OV-to-VO



Study 2 Results:
Count data for V2 in Icelandic



DORM: Deviation of the Rolling Mean

en	eg	skal	sjá	yður	aftur
6.79	6.15	10.1	9.25	6.15	10.4

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en		eg	skal	sjá	yður	aftur
6.79		**6.15**	10.1	9.25	6.15	10.4
	6.47					

DORM: Deviation of the Rolling Mean

en		eg		skal	sjá	yður	aftur
6.79		**6.15**		**10.1**	9.25	6.15	10.4
	6.47		**8.12**				

DORM: Deviation of the Rolling Mean

en		eg		skal		sjá	yður	aftur
6.79		6.15		**10.1**		**9.25**	6.15	10.4
	6.47		8.12		**9.67**			

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6.79		6.15		10.1		**9.25**		**6.15**	10.4
	6.47		8.12		9.67		**7.70**		

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6.79		6.15		10.1		9.25		**6.15**		**10.4**
	6.47		8.12		9.67		7.70		**8.29**	

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6.79		6.15		10.1		9.25		6.15		10.4
	6.47		8.12		9.67		7.70		8.29	

Sample variance of rolling means = 1.33 bits

low DORM → more uniform

high DORM → more lopsided

UIDO: Uniform information density optimisation

- Algorithm that finds the most uniform distribution of a given set of values (Cuskley et al., 2021)
- Not absolute lowest DORM possible; but robust enough and computationally tractable.
- For a given array of values (e.g. information values of words in a sentence):
  - the array of information content values is ordered greatest to least
  - starting with the second and penultimate value in the array and moving inward, every other number is swapped, mixing up the large and small values
  - DORM is calculated for the resulting array
  - if this is lower than the original DORM, the array is kept
  - otherwise, the algorithm proceeds with the original array.
- Useful calibration for interpreting utterance DORMs & establishing a baseline, as well as current study use