Case and inflection classes: Testing the Form-Frequency-Hypothesis

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The Form-Frequency-Hypothesis

(1) Whenever a category A is expressed by more phonological material than category B, then category A is less frequent than category B.

Whenever category A is more frequent than category B, then category A will be expressed by a shorter or equally long form than category B.

Why we want to test the FFH:

- it is extremely general in its coverage (requires no assumptions about the nature of grammar) and has been applied to various phenomena,
- it is very specific in its effects,
- although it can be tested empirically, it has been criticized for the lack of empirical work.

Implication of the Form-Frequency-Hypothesis

The FFH, being a causal implication between frequency and form, requires that:

- **ALL** frequency asymmetries result in coding asymmetries in the expected direction, or at least in no asymmetry.
- **ALL** coding asymmetries also have a frequency asymmetry in the expected direction, or at least no asymmetry.

This in turn implies that

- form-frequency relations must be domain/phenomenon independent
- they do not necessarily need to hold cross-linguistically
  - The form-frequency effect must but observable in individual languages
  - Otherwise, observing FF correlations in cross-linguistic patterns is a random correlation, or both phenomena follow from a different explanation.
  - Then, the FFH would not be a proper explanation, but a correlation with no necessary causal relations.

Why case and inflection classes?

What we want to test:

- Do language-specific coding asymmetries correlate with the expected frequency asymmetry?
- Can this correlation be observed across languages?

NB: We want to avoid the confound of semantic complexity and 'markedness'.

Therefore, **case** and, more specifically, **inflection classes** are a suitable testing ground:

- There is no straightforward reason why, e.g., the dative should be semantically more complex than the genitive.
- Inflection classes withing a single language feature markers of different length.
- Inflection classes withing a single language have very different frequencies.
- Cases and their exponents are easy to search for it in an annotated corpus.

A note on inflection classes

- 'An inflectional class is a set of lexemes whose members each select the same set of inflectional realizations.'
- Inflection classes are morphomic, i.e. they are only relevant to morphology, whereas phonology, syntax, or semantic are not sensitive to them.

- In different inflection classes, we can find markers of distinct length within a single language.

$\rightarrow$ We can test the FFH in individual languages

$\rightarrow$ Comparing markers of different length from different inflection classes can avoid potential influence from semantic complexity and 'markedness'.

- Since inflection classes are found in many languages of the world, we can also compare the results for individual languages across languages.

An example from Gothic

Looking at, e.g., the nominative and accusative singular forms of nouns from two inflection classes in Gothic, we see inverted lengths of the case markers:

(2) *-ja* declension (Gothic)

a. *har-**jis*** ‘army-nom’
b. *har-**i*** ‘army-acc’

(3) *-jō* declension (Gothic)

a. *band-**i*** ‘band-nom’
b. *band-**ja*** ‘band-acc’

In (2), the nominative is longer than the accusative, whereas in (3), the accusative form is longer.

Is this reflected by the frequency of the forms?

Gothic inflection classes, *-a* declension

	Day				Word			
	Singular		Plural		Singular		Plural	
Nom	dags	–s	dagōs	–ōs	waúrd	–	waúrda	–a
Acc	dag	–	dagans	–ans	waúrd	–	waúrda	–a
Gen	dagis	–is	dagē	–ē	waúrdis	–is	waúrdē	–ē
Dat	daga	–a	dagam	–am	waúrda	–a	waúrdam	–am

Gothic inflection classes, *-ja* declension

	army				herdsman			
	Singular		Plural		Singular		Plural	
Nom	harjis	–jis	harjōs	–jōs	haírdeis	–eis	haírdjōs	–jōs
Acc	hari	-i	harjans	–jans	haírdi	-i	haírdjans	–jan
Gen	harjis	–jis	harjē	–jē	haírdeis	–eis	haírdjē	–jē
Dat	harja	–ja	harjam	–jam	haírdja	–ja	haírdjam	–jan

	race			
	Singular		Plural	
Nom	kuni	-i	kunja	–ja
Acc	kuni	-i	kunja	–ja
Gen	kunjis	–jis	kunjē	–jē
Dat	kunja	–ja	kunjam	–jam

Gothic inflection classes, *-ō* declension

	gift			
	Singular		Plural	
Nom	giba	–a	gibōs	–ōs
Acc	giba	–a	gibōs	–ōs
Gen	gibōs	–ōs	gibō	–ō
Dat	gibái	–ái	gibōm	–ōm

Gothic inflection classes, *-jō* declension

	band		
	Singular		Plural
Nom	bandi	–i	bandjōs –jōs
Acc	bandja	–ja	bandjōs –jōs
Gen	bandjōs	–jōs	bandjō –jō
Dat	bandjái	–jái	bandjōm –jōm

Gothic inflection classes, *-i* declension

	stranger				wife			
	Singular		Plural		Singular		Plural	
Nom	gasts	–s	gasteis	–eis	qēns	–s	qēneis	–eis
Acc	gast	–	gastins	–ins	qēn	–	qēnins	–ins
Gen	gastis	–is	gastē	–ē	qēnáis	–áis	qēnē	–ē
Dat	gasta	–a	gastim	–im	qēnái	–ái	qēnim	–im

Gothic inflection classes, *-u* declension

	son				property	
	Singular		Plural		Singular	
Nom	sunus	–us	sunjus	–jus	faíhu	–u
Acc	sunu	–u	sununs	–uns	faíhu	–u
Gen	sunáus	–áus	suniwē	–iwē	faíháus	–áus
Dat	sunáu	–áu	sunum	–um	faíháu	–áu

Gothic inflection classes, *-an* declension

	man				heart			
	Singular		Plural		Singular		Plural	
Nom	guma	–a	gumans	–ans	haírtō	–ō	haírtōna	–ō
Acc	guman	–an	gumans	–ans	haírtō	–ō	haírtōna	–ō
Gen	gumins	–ins	gumanē	–anē	haírtins	–ins	haírtanē	–a
Dat	gumin	–in	gumam	–am	haírtin	–in	haírtam	–a

Gothic inflection classes, *-ōn* declension

	tongue			
	Singular		Plural	
Nom	tuggō	–ō	tuggōns	–ōns
Acc	tuggōn	–ōn	tuggōns	–ōns
Gen	tuggōns	–ōns	tuggōnō	–ōnō
Dat	tuggōn	–ōn	tuggōm	–ōm

Gothic inflection classes, *-ein* declension

	wisdom			
	Singular		Plural	
Nom	frōdei	–ei	frōdeins	–eins
Acc	frōdein	–ein	frōdeins	–eins
Gen	frōdeins	–eins	frōdeinō	–einō
Dat	frōdein	–ein	frōdeim	–eim

Gothic inflection classes, *-r* declension

	sister			
	Singular		Plural	
Nom	swistar	–ar	swistrjus	–rjus
Acc	swistar	–ar	swistruns	–runs
Gen	swistrs	–rs	swistrē	–rē
Dat	swistr	–r	swistrum	–rum

Gothic inflection classes, *-nd* declension

	friend			
	Singular		Plural	
Nom	frijōnds	–s	frijōnds	–s
Acc	frijōnd	–	frijōnds	–s
Gen	frijōndis	–is	frijōndē	–ē
Dat	frijōnd	–	frijōndam	–am

Testing the FFH: The present approach

Corpora

We are using the Universal Dependencies Corpora (Silveira et al., 2014) for the following languages:

- Gothic (45k words)
- Latin (440k words)
- Ancient Greek (380k words) / Modern Greek (51k words)
- Russian (1m words)
- Czech (1.3m words)
- Polish (72k words)
- Finnish (only used for comparison, 181k words)
- Estonian (only used for comparison, 34k words)
- Turkish (only used for comparison, 46k words)
- Latvian (only used for comparison, 44k words)
- Lithuanian (only used for comparison, 40k words)

We chose these languages based on their availability in the corpus, their case paradigms and inflection classes.

Inter-corpora comparison

A comparability problem

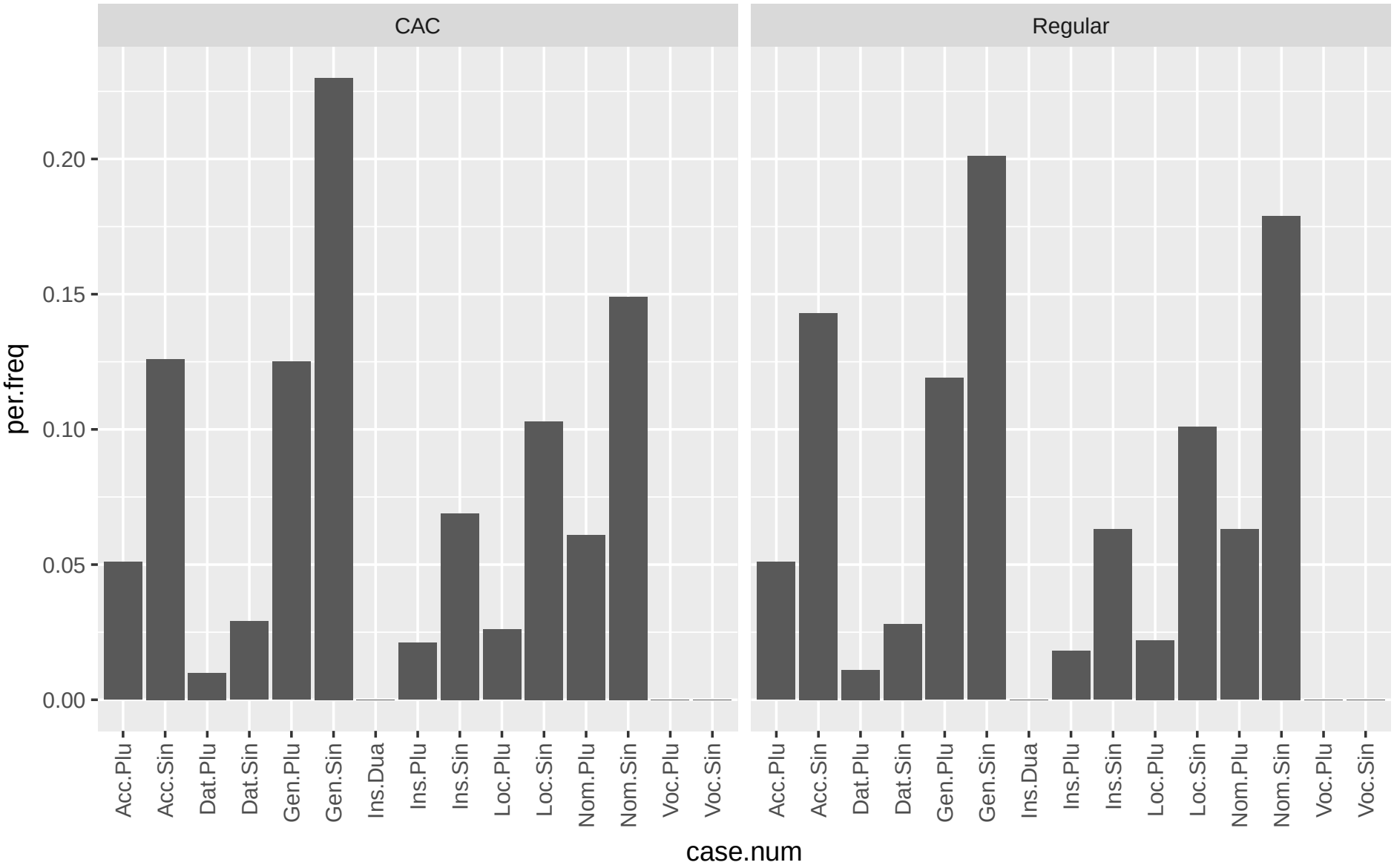
- As the corpora for the languages considered are not very homogeneous; we do not know to what extent the types of the corpora affect the use of different cases.

But: For Czech, Russian, Greek, and Latin, there are two different corpora available:

- Czech: Regular (1.3m words), CAC (482k words), overlap=0.01%
- Russian: Regular (87k words), SynTagRus (988k words), overlap=0%
- Greek: Regular (182k words), PROIEL (198k words), overlap=0.8%
- Latin: ITTB (280k words), PROIEL (159k words), overlap=0.006%

Therefore, we can compare the behaviour of different corpora for the same language in the UD data base with respect to case-number distribution.

Czech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Gen.Sin
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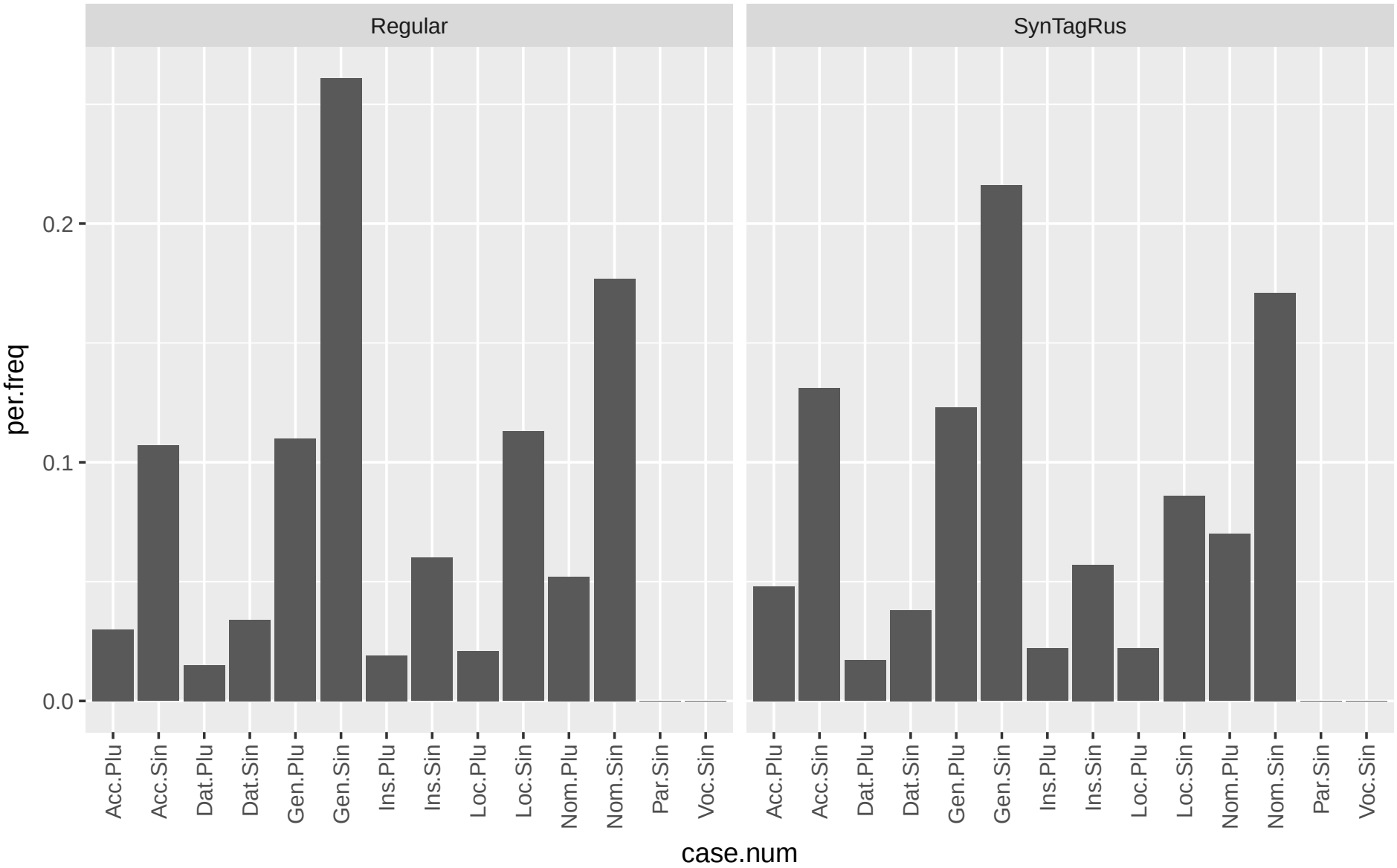
Loc.Plu
Loc.Sin
Nom.Plu
Nom.Sin
Voc.Plu
Voc.Sin
case.num

Russian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Acc.Sin
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Dat.Sin
Gen.Plu
Gen.Sin
Ins.Plu
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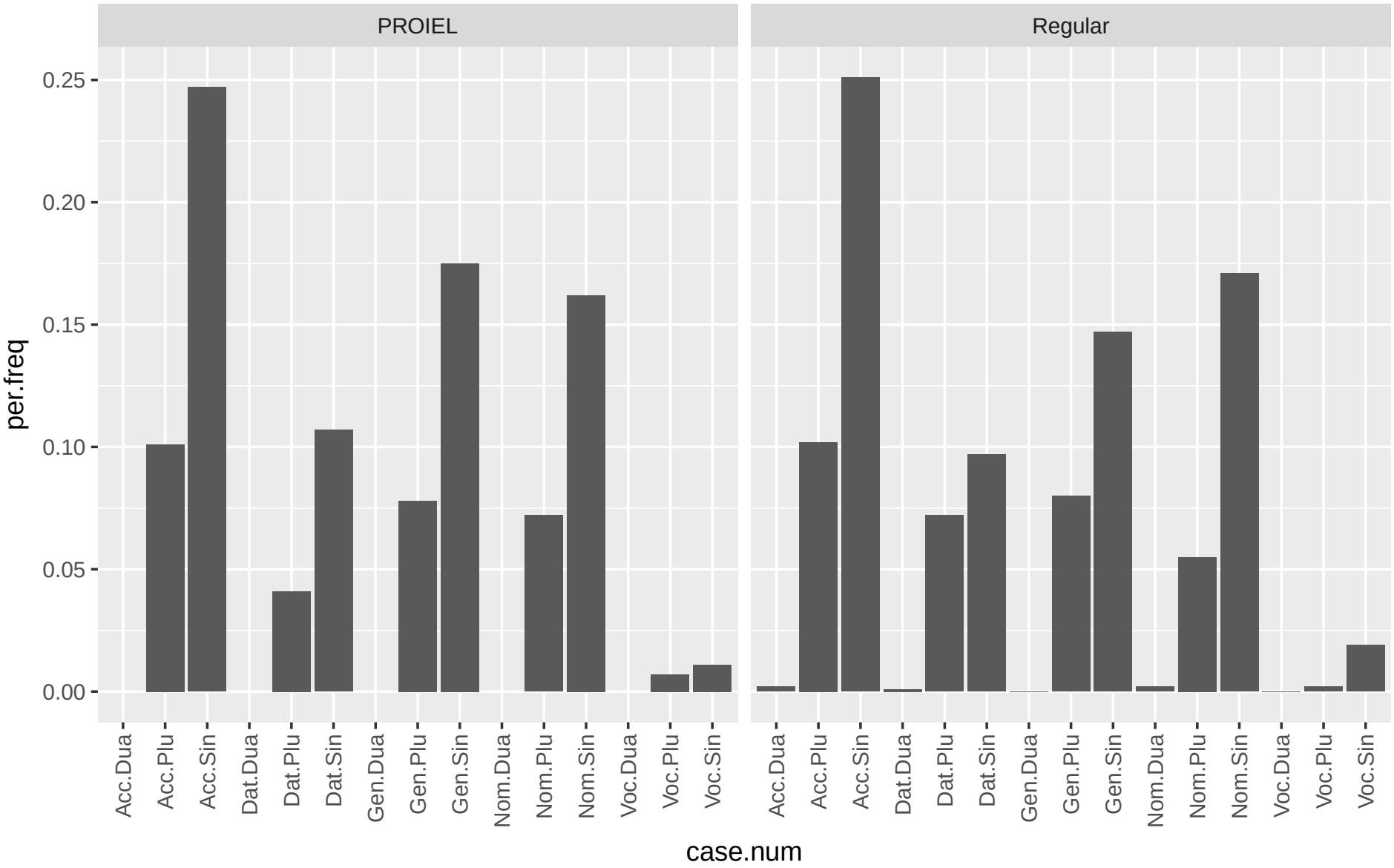
Loc.Plu
Loc.Sin
Nom.Plu
Nom.Sin
Par.Sin
Voc.Sin
case.num

Greek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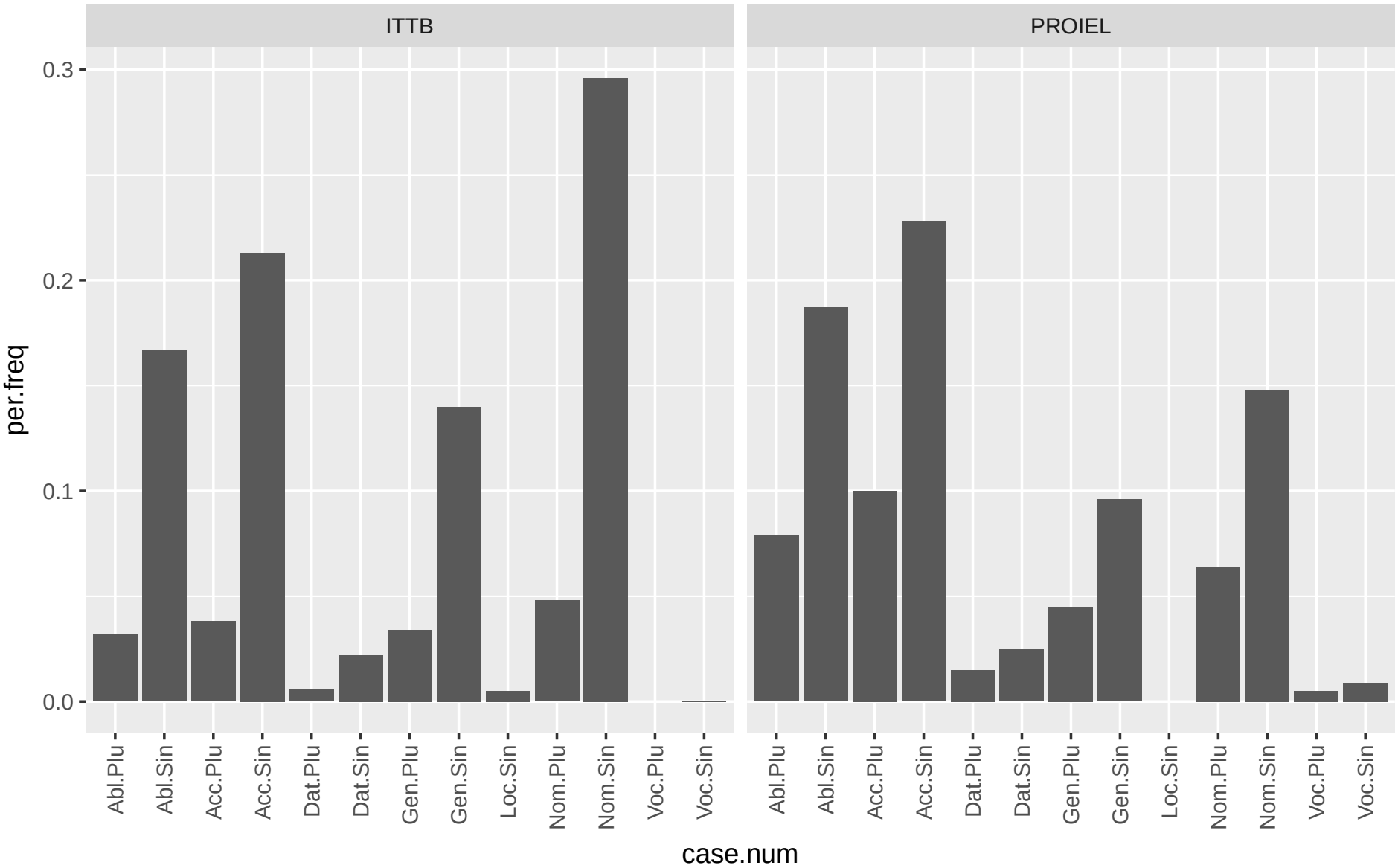
case.num

Latin


ITTB
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Gen.Plu
Gen.Sin
Loc.Sin
Nom.Plu
Nom.Sin
Voc.Plu
Voc.Sin
case.num

Inter-corpora comparison

- There seems to be no large inter-corpus variation in terms of case-number distributions for nominatives, accusatives, datives, and genitives.
- This suggests that for the present purpose, the UD corpora are comparable enough.

Are the frequency distributions of case universal?

Case frequencies. Are they universal?

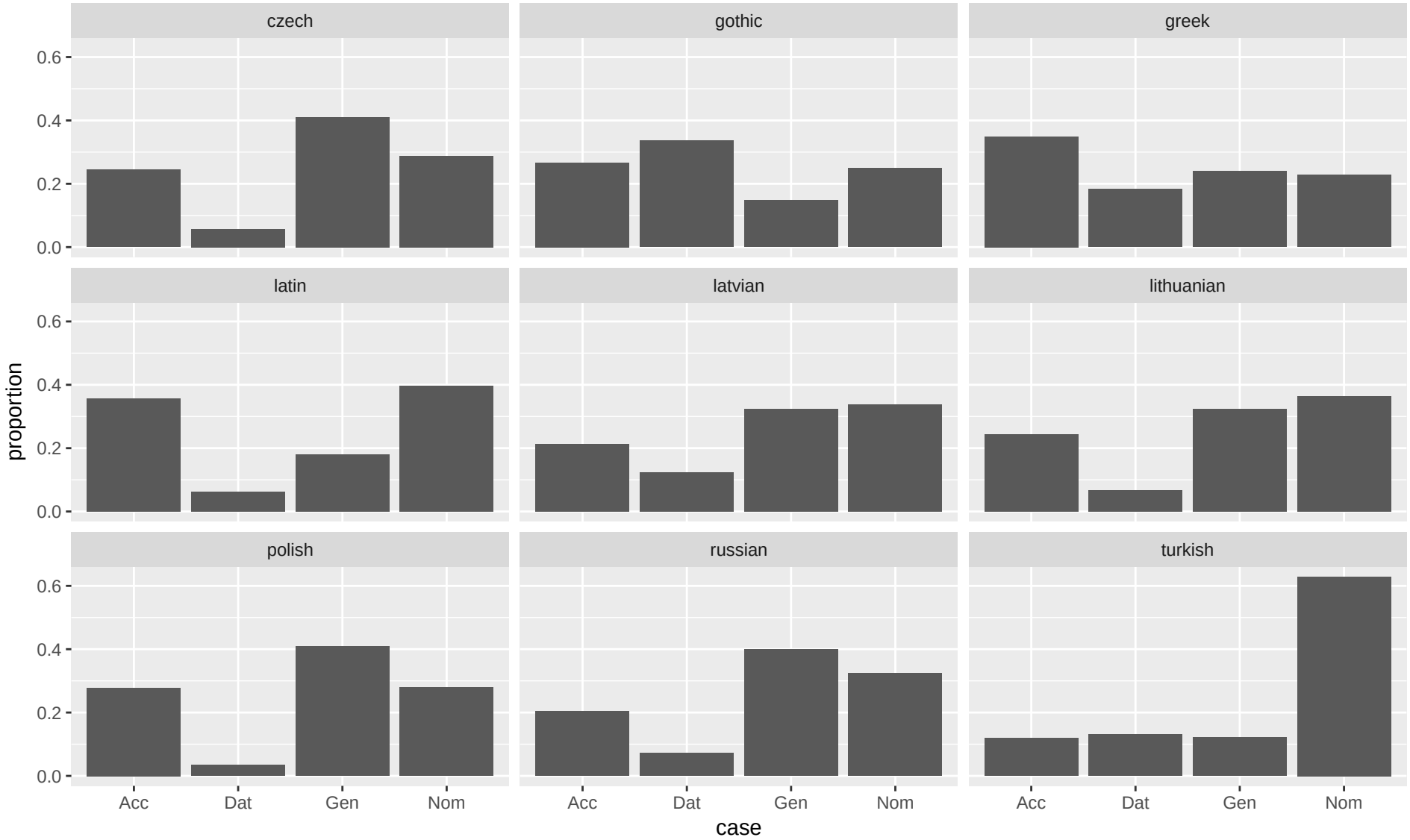
Frequency has been used in previous studies to explain coding asymmetries of case markers

However, it does not yet seem to be clear whether case frequency is language specific or stable across languages

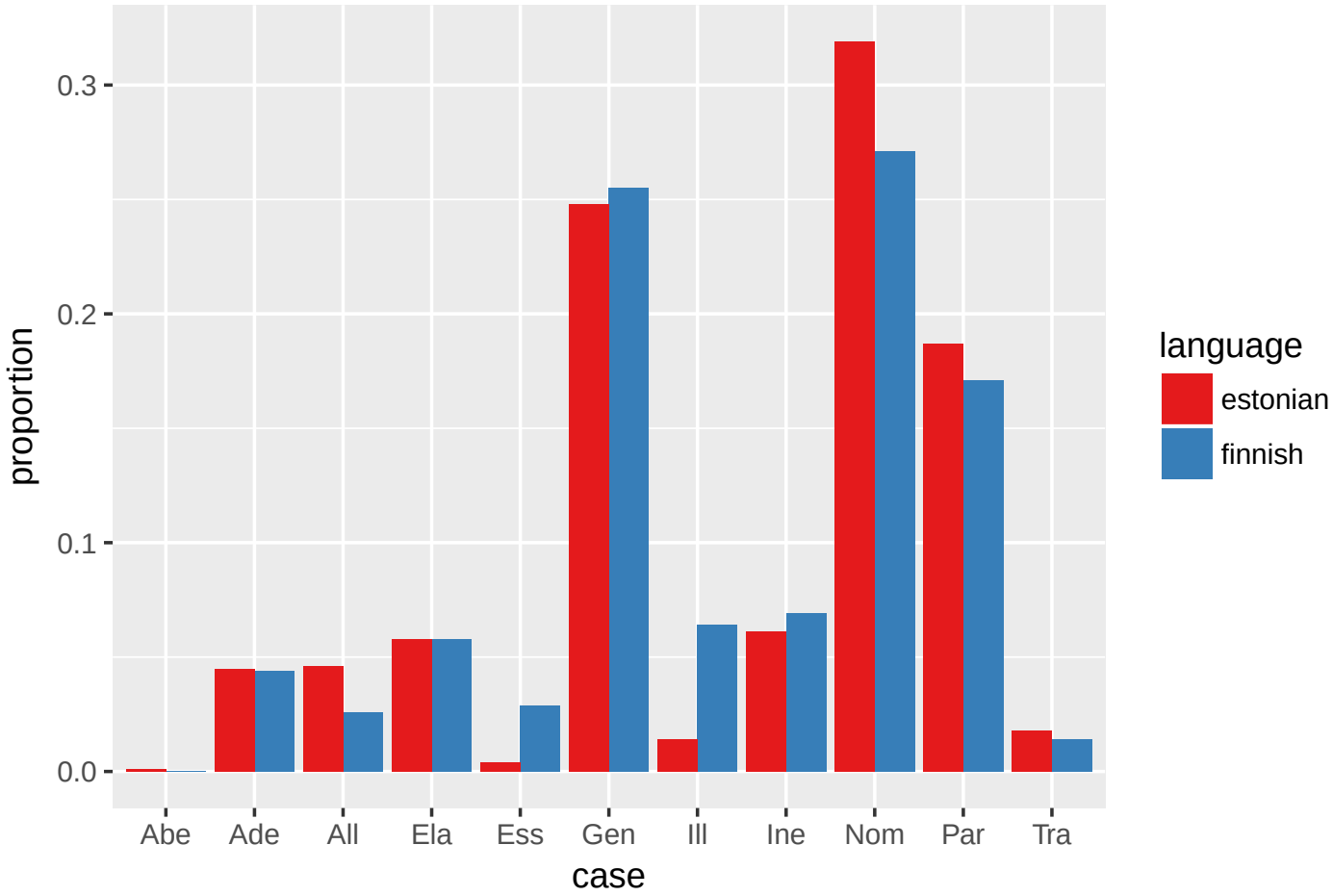
- → Can we say that accusative, in general, is more frequent than dative?
- → What if pronominal forms have different markers from nouns, can they still contribute to a potential frequency effect?

To address this issue, we looked at the frequencies of the nominative, accusative, dative, and genitive cases in different languages for nouns and pronouns.

Case frequencies



Case frequencies



Testing the FFH

Testing the FFH

Is there a correlation between the frequency of a given case marker and its length? Do we find this effect across languages?

For simplicity and comparability, we only focus on the nominative, accusative, dative (except modern Greek), and genitive cases.

Length is measured as the number of segments/moras (if possible):

(4) *tugg-**ōns*** ‘tongue’ (gen.sg, acc.pl) (Gothic)

- ō $\rightarrow$ 2
- n $\rightarrow$ 1
- s $\rightarrow$ 1

Token / type frequency and number of cases

We considered two kinds of frequency, token and type frequency. In addition, the number of cells a case marker fills (i.e. the number of case values it expresses) has been noted.
The three values are calculated as follows:

(5) lex_1-CM (nom.sg); lex_2-CM (nom.sg); lex_3-CM (nom.sg); lex_2-CM (dat.sg); lex_1-CM (dat.sg); lex_1-CM (nom.sg)

Token frequency How often does a given marker occur in the corpus?
$n_{token}(CM)=6$

Type frequency With how many different lexemes does a given marker occur in the corpus?
$n_{type}(CM)=3$

Number of cases How many cells of the paradigm does a case marker fill?
$n_{cases}(CM)=2$

Number of cases

An example for the number of cases from Modern Greek:

(6) the distribution of the marker [-is]: (Modern Greek)

*δυνάμ-**εις***	nom.pl	‘force’
*δυνάμ-**εις***	acc.pl	‘force’
*μάχ-**ης***	gen.sg	‘battle’

n_{cases} (CM)=3

Results. Ancient Greek

Coefficients

	Estimate	Std. Error	t value	Pr(>|t|)	
(Intercept)	2.0000	0.1166	17.152	<2e-16	***
token.freq.scaled	-0.2502	0.1181	-2.118	0.0409	*

R-squared: 0.1082

Coefficients

	Estimate	Std. Error	t value	Pr(>|t|)	
(Intercept)	2.0000	0.1171	17.086	<2e-16	***
type.freq.scaled	-0.2421	0.1186	-2.042	0.0483	*

R-squared: 0.1013

Coefficients

	Estimate	Std. Error	t value	Pr(>|t|)	
(Intercept)	2.0000	0.1146	17.446	<2e-16	*
ncases.numbers.scaled	-0.2826	0.1161	-2.434	0.0199	

R-squared: 0.138

Results. Modern Greek

Token frequency

Coefficients

	Estimate	Std. Error	t value	Pr(>|t|)	
(Intercept)	2.1364	0.2110	10.127	2.56e-09	***
token.freq.scaled	-0.4884	0.2159	-2.262	0.035	*

R-squared: 0.2037

Type frequency

Coefficients

	Estimate	Std. Error	t value	Pr(>|t|)	
(Intercept)	2.1364	0.2091	10.215	2.21e-09	***
type.freq.scaled	-0.5045	0.2141	-2.357	0.0287	*

R-squared: 0.2173

Results. Latin

Coefficients

	Estimate	Std. Error	t value	Pr(>|t|)	
(Intercept)	2.7436	0.1802	15.221	< 2e-16	***
token.freq.scaled	-0.6987	0.1826	-3.827	0.000484	***

R-squared: 0.2835

Type frequency

Coefficients

	Estimate	Std. Error	t value	Pr(>|t|)	
(Intercept)	2.7436	0.1767	15.528	< 2e-16	***
type.freq.scaled	-0.6472	0.1790	-3.616	0.00091	***
type.res.ncases	-0.4598	0.2126	-2.162	0.03731	*

R-squared: 0.3302

Results. Gothic

Token frequency

Coefficients

	Estimate	Std. Error	t value	Pr(>|t|)	
(Intercept)	2.7273	0.1172	23.27	< 2e-16	***
token.freq.scaled	-0.5913	0.1183	-5.00	6.65e-06	***

R-squared: 0.3205

Type frequency

Coefficients

	Estimate	Std. Error	t value	Pr(>|t|)	
(Intercept)	2.7273	0.1168	23.347	< 2e-16	***
type.freq.scaled	-0.5953	0.1179	-5.049	5.58e-06	***

R-squared: 0.3248

Results. Russian

Token frequency

Coefficients

	Estimate	Std. Error	t value	Pr(>|t|)	
(Intercept)	1.6400	0.1314	12.484	9.99e-12	***
token.freq.scaled	-0.4932	0.1341	-3.679	0.00125	**

R-squared: 0.3704

Type frequency

Coefficients

	Estimate	Std. Error	t value	Pr(>|t|)
(Intercept)	1.5775	0.3605	4.375	0.000293
type.freq.scaled	-0.5135	0.1284	-3.999	0.000705
bs(type.res.ncases, 3)1	1.6011	1.2647	1.266	0.220077
bs(type.res.ncases, 3)2	-2.1015	0.9180	-2.289	0.033074
bs(type.res.ncases, 3)3	0.3593	0.7403	0.485	0.632676

R-squared: 0.5081

Results. Polish

Token frequency

Coefficients

	Estimate	Std. Error	t value	Pr(>|t|)	
(Intercept)	1.1000	0.1287	8.546	2.71e-05	***
token.freq.scaled	-0.4183	0.1357	-3.083	0.0151	*

R-squared: 0.5429

Type frequency

Coefficients

	Estimate	Std. Error	t value	Pr(>|t|)	
(Intercept)	1.1000	0.1272	8.651	2.48e-05	***
type.freq.scaled	-0.4225	0.1340	-3.152	0.0136	*

R-squared: 0.554

Results. Czech

Token frequency, number of cases

Coefficients

	Estimate	Std. Error	t value	Pr(>|t|)	
(Intercept)	1.7600	0.1236	14.234	1.40e-12	***
token.freq.scaled	-0.6458	0.1262	-5.118	3.96e-05	***
token.res.ncases	-0.3959	0.1673	-2.366	0.0272	*

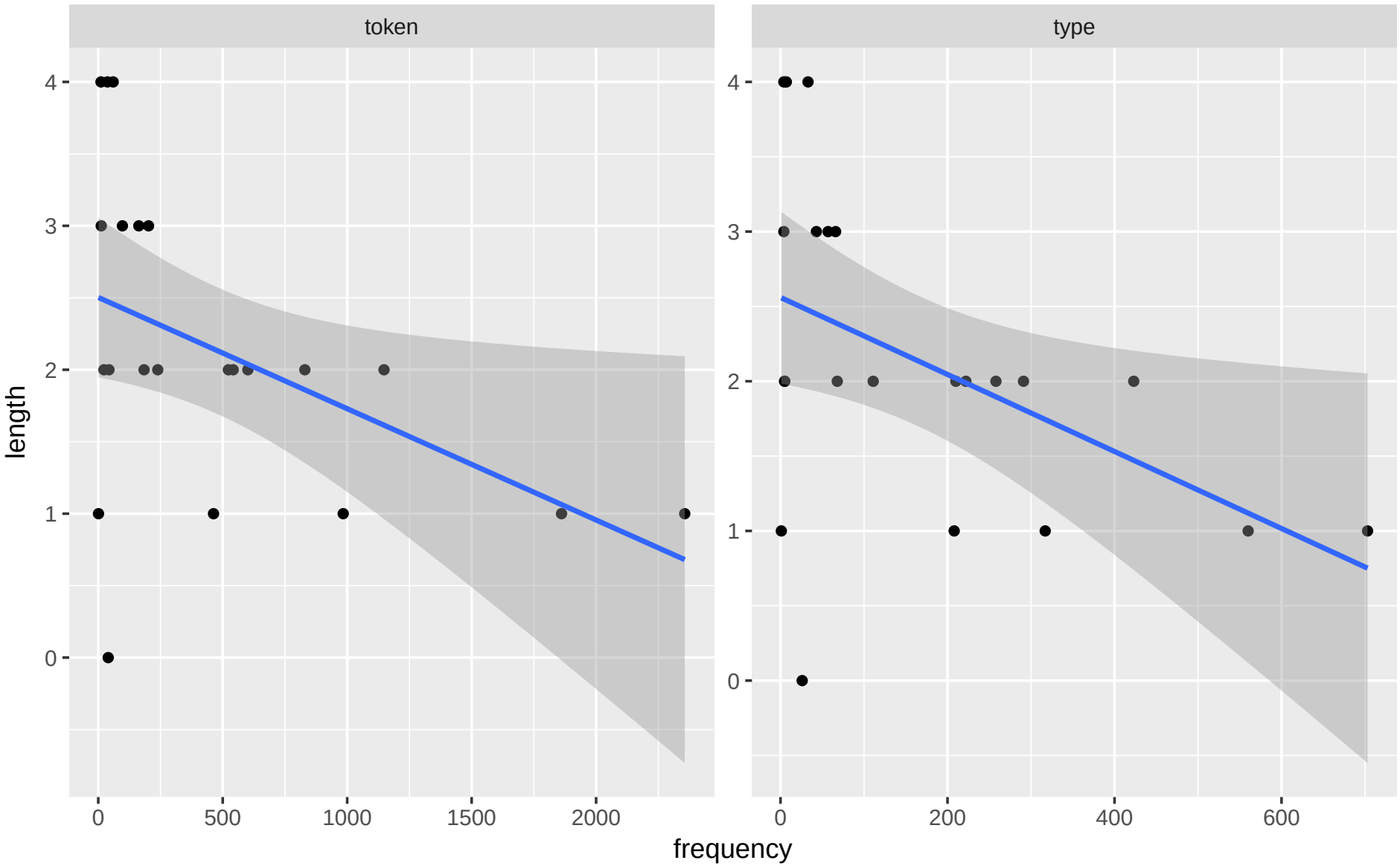
R-squared: 0.591

Type frequency, number of cases

Coefficients

	Estimate	Std. Error	t value	Pr(>|t|)	
(Intercept)	1.7600	0.1224	14.377	1.15e-12	***
type.freq.scaled	-0.6561	0.1249	-5.251	2.87e-05	***
type.res.ncases	-0.3830	0.1664	-2.302	0.0312	*

R-squared: 0.5991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type
length
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2
3
4
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2000
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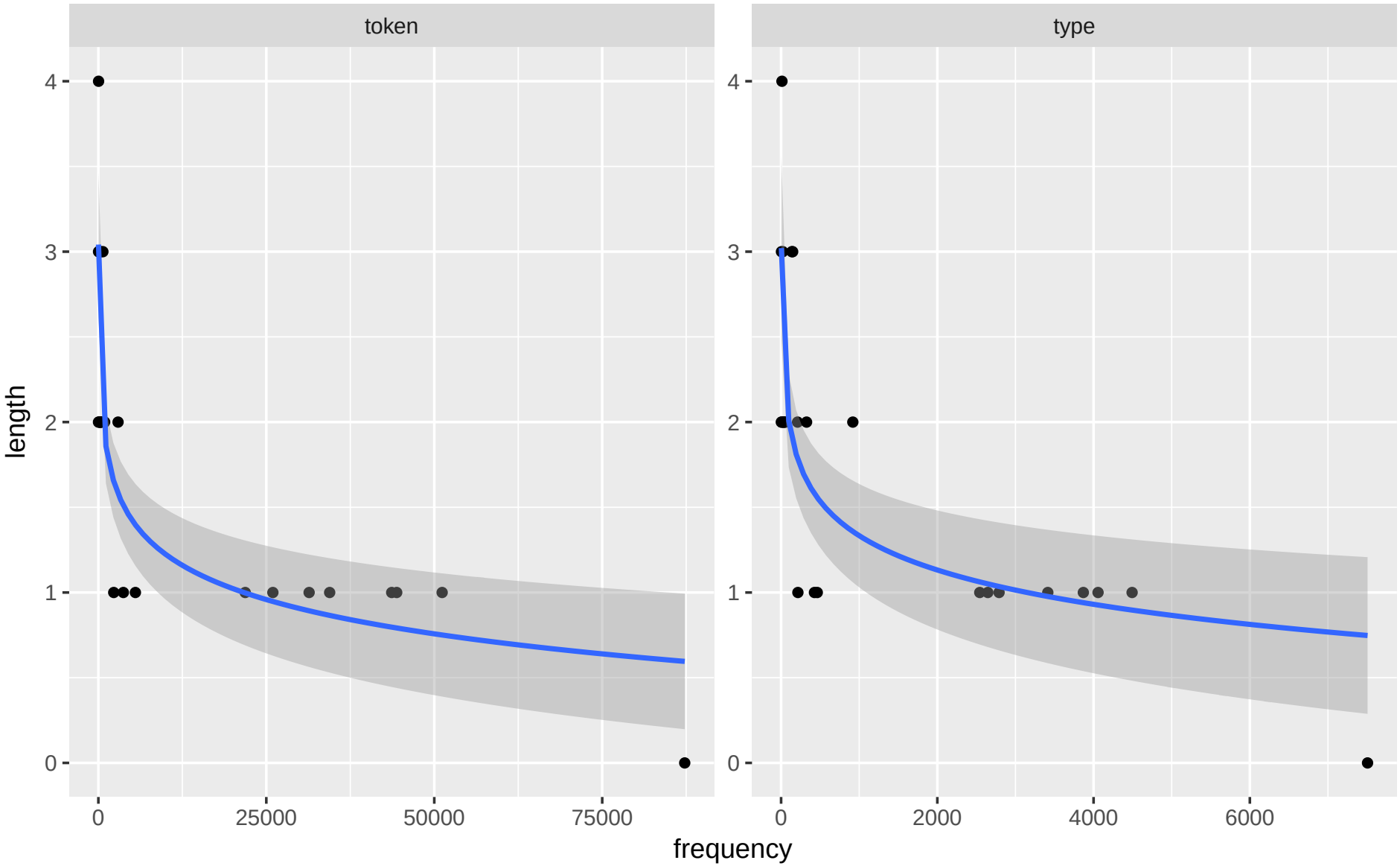
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type
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frequency
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3
4
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50000
75000
0
2000
4000
6000

To sum up

- Different languages exhibit different relative frequencies for how they use cases.
- No single explanation based on raw token frequency could cover any universal tendencies of case distributions.
- Although token frequency had some explanatory power for the length of the exponents, type frequency and distribution across cases were better predictors.
- The fact that type frequencies and distribution factors were slightly more important than raw frequencies suggests that the hearer oriented view of the FFH is somewhat more likely.