Most Frequent Words as a Tool for Authorship Recognition

Radek Čech

Ján Mačutek

Acknowledgment

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Pavel Kosek (MU), Petra Mutlová (MU), Miroslav Kubát (OU)

Background

- theory of text
  - quantitative properties
  - regularities
  - mechanisms
  - laws

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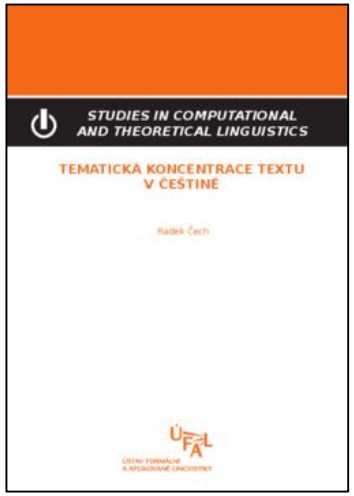
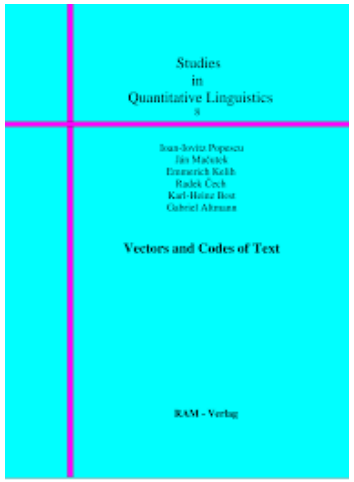
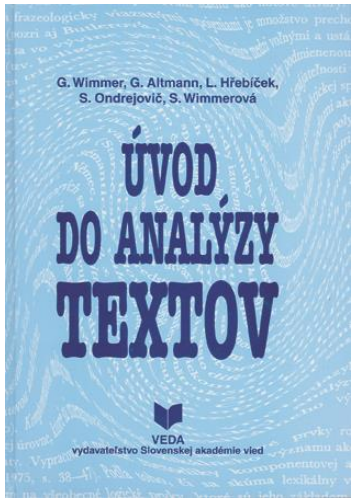
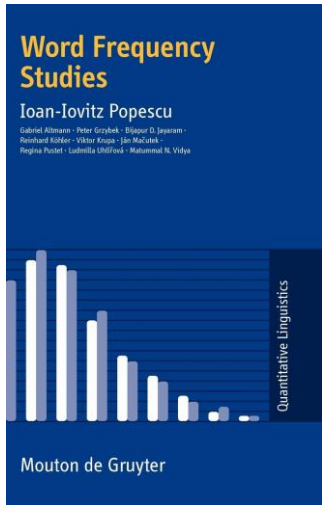
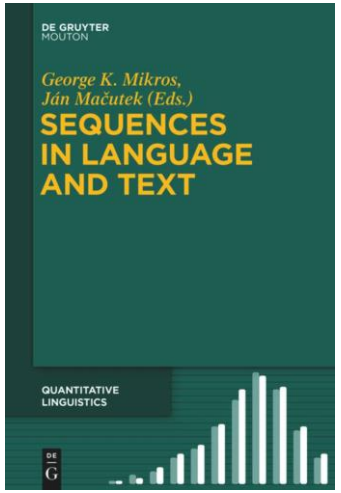






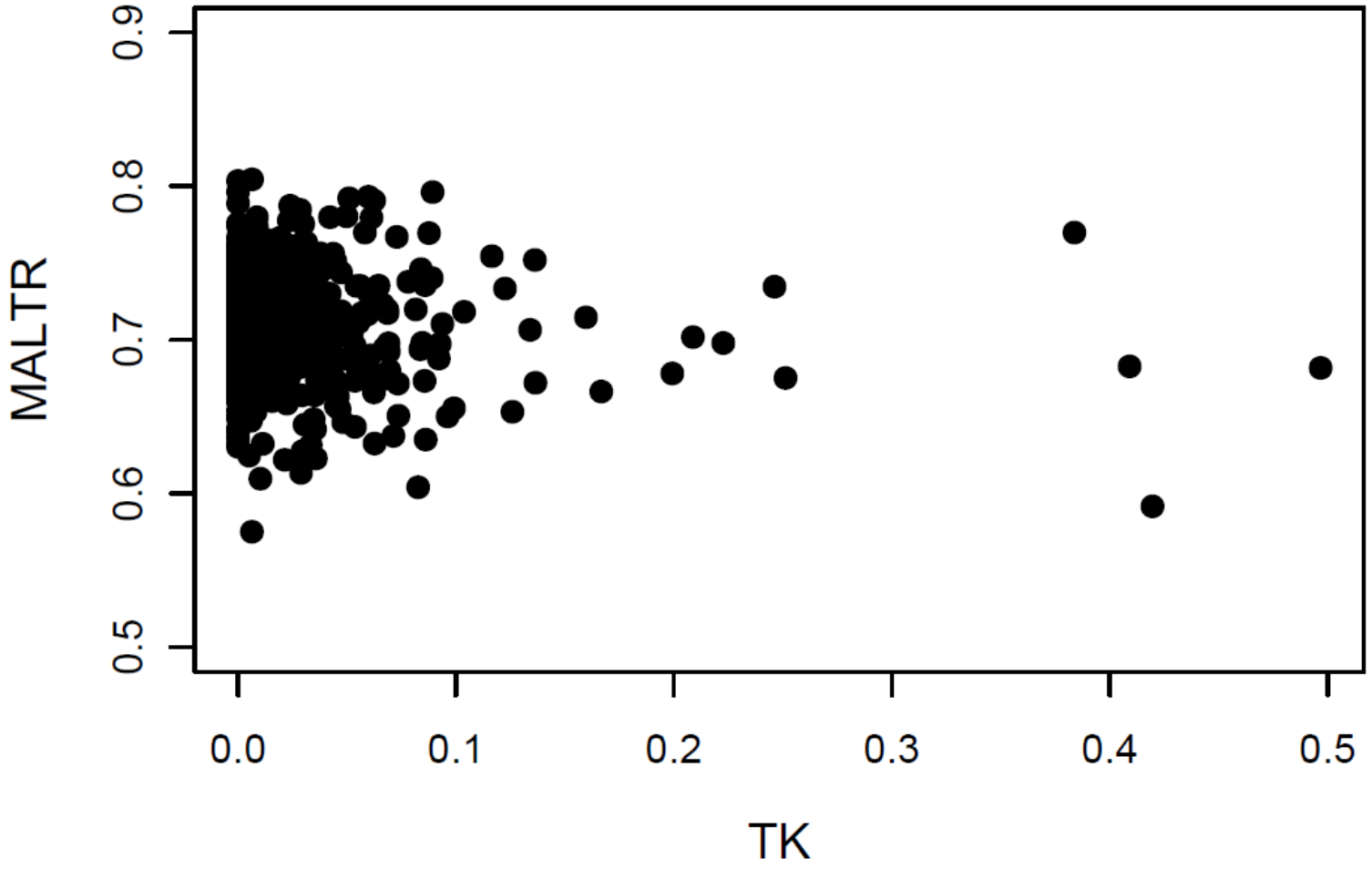




Theory of text (and language)

- relationships among particular properties (stochastic)
  - lexical diversity – text length
  - lexical diversity – thematic concentration
  - entropy – verb distances
  - distances between hapax legomena – lexical diversity
  - distribution of clause/sentence lengths – distances between hapax legomena
  - autosemantic text structure – thematic concentration

Theory of text (and language)

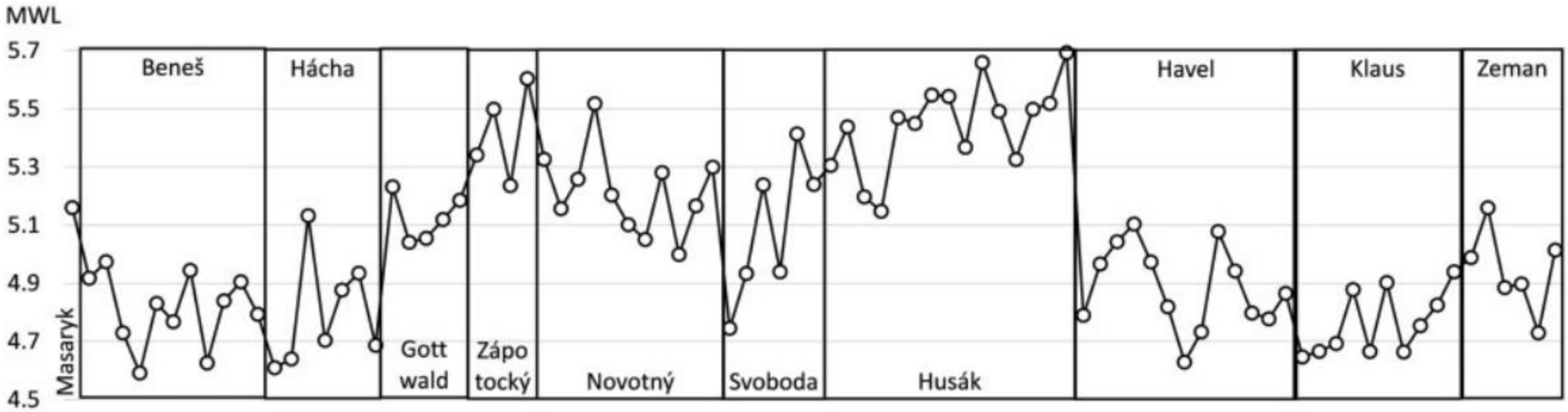


Theory of text (and language)

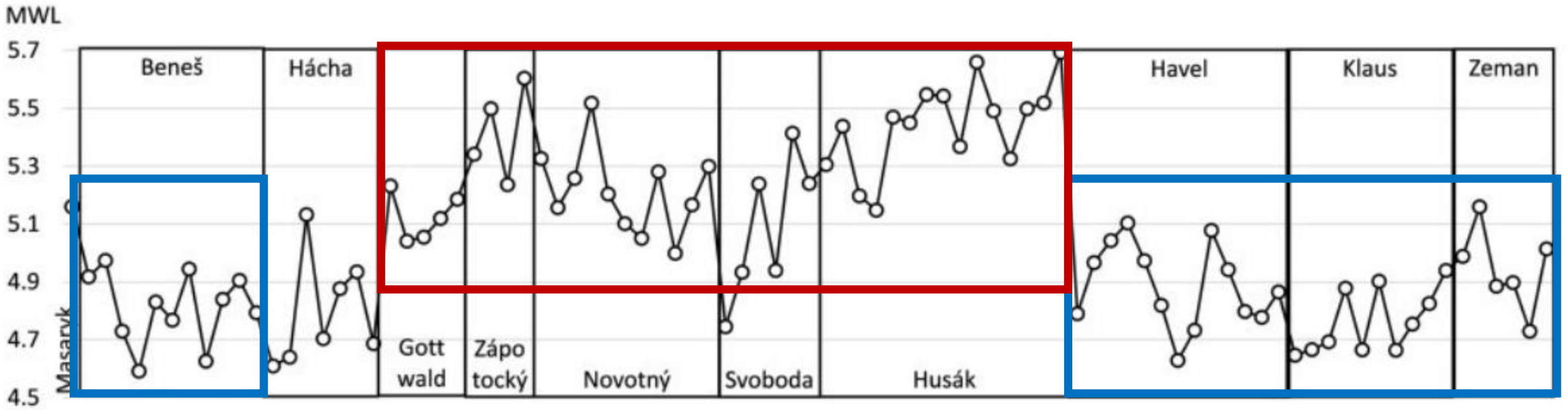
- relationships between particular properties and pragmatics
- stylometry

    - text type
    - genre
    - period
    - gender
    - political background / ideology
    - authorship

Mean word length



Mean word length



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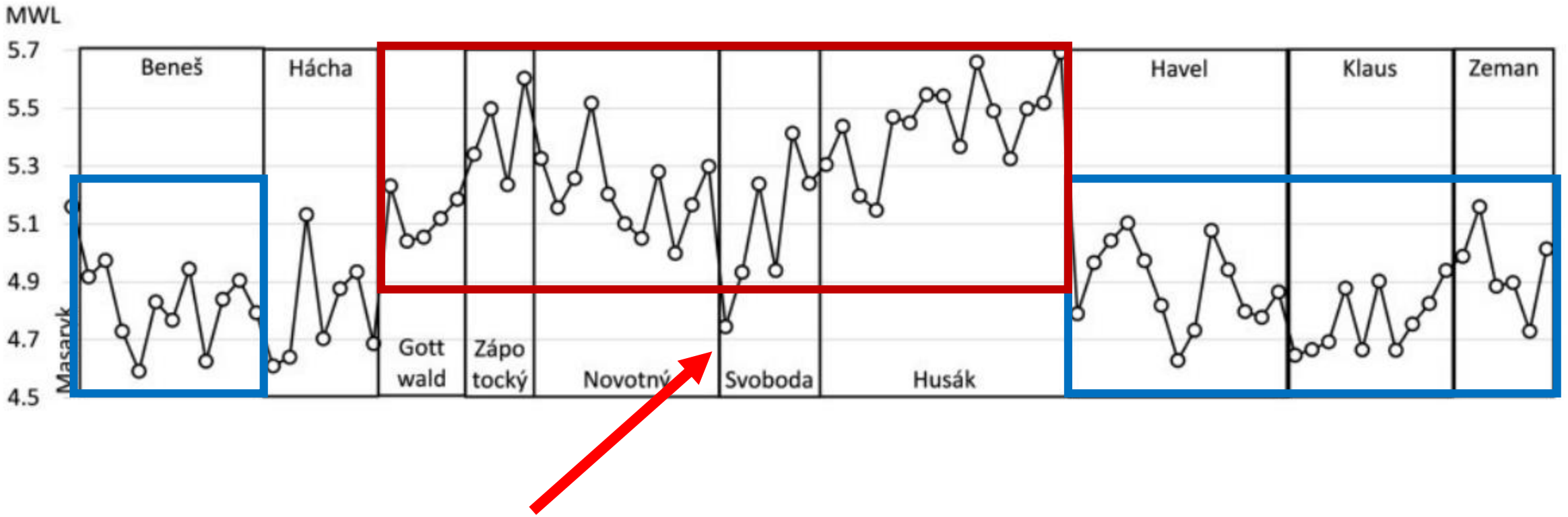
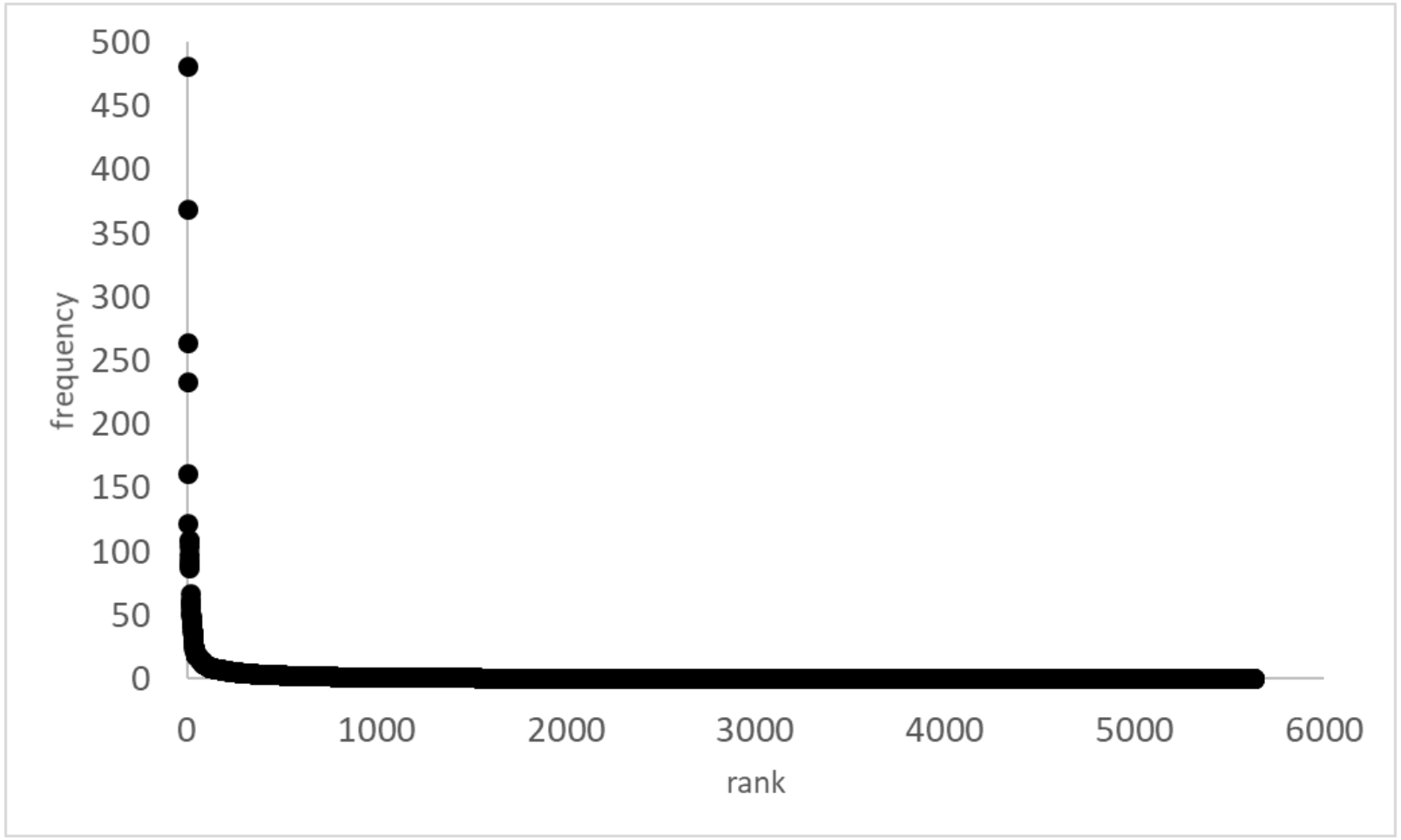


From theory to the application

Word frequencies and authorship

- lexical diversity / vocabulary richness
- proportion of hapax legomenon
- …
- proportion of the most frequent words

Most frequent words



J. Škvorecký: Eva byla nahá

Most frequent words

	Škvorecký: Eva byla nahá	
pořadí	slovo	f
1	a	481
2	se	369
3	na	264
4	v	234
5	jsem	161
6	s	122
7	z	110
8	američan	108
9	to	104
10	řekl	98
11	ale	94
12	do	91
13	že	89
14	řekla	87
15	dívka	67

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	Hrabal: Perlička na dně	
pořadí	slovo	f
1	a	2239
2	se	1203
3	to	1037
4	na	879
5	ale	514
6	tak	504
7	do	467
8	si	459
9	jsem	456
10	v	446
11	že	440
12	je	432
13	já	363
14	když	296
15	jak	283

	Hašek: Osudy…I.	
pořadí	slovo	f
1	a	7045
2	se	6061
3	na	3927
4	že	3469
5	to	3075
6	v	2585
7	je	1801
8	do	1749
9	s	1667
10	si	1534
11	když	1387
12	z	1375
13	tak	1308
14	jsem	1286
15	švejk	1188

Most frequent words

	Škvorecký: Eva byla nahá	
pořadí	slovo	f_rel
1	a	0.037
2	se	0.028
3	na	0.020
4	v	0.018
5	jsem	0.012
6	s	0.009
7	z	0.008
8	američan	0.008
9	to	0.008
10	řekl	0.007
11	ale	0.007
12	do	0.007
13	že	0.007
14	řekla	0.007
15	dívka	0.005

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1	a	0.054
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4	na	0.021
5	ale	0.012
6	tak	0.012
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13	já	0.009
14	když	0.007
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1	a	0.035
2	se	0.030
3	na	0.020
4	že	0.017
5	to	0.015
6	v	0.013
7	je	0.009
8	do	0.009
9	s	0.008
10	si	0.008
11	když	0.007
12	z	0.007
13	tak	0.007
14	jsem	0.006
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Distances between words / texts

$$\Delta_{(AB)} = \frac{1}{n}\sum_{i=1}^{n}\left|\frac{A_i - \mu_i}{\sigma_i} - \frac{B_i - \mu_i}{\sigma_i}\right|$$

n … the number of MFW

A, B … texts for the comparison

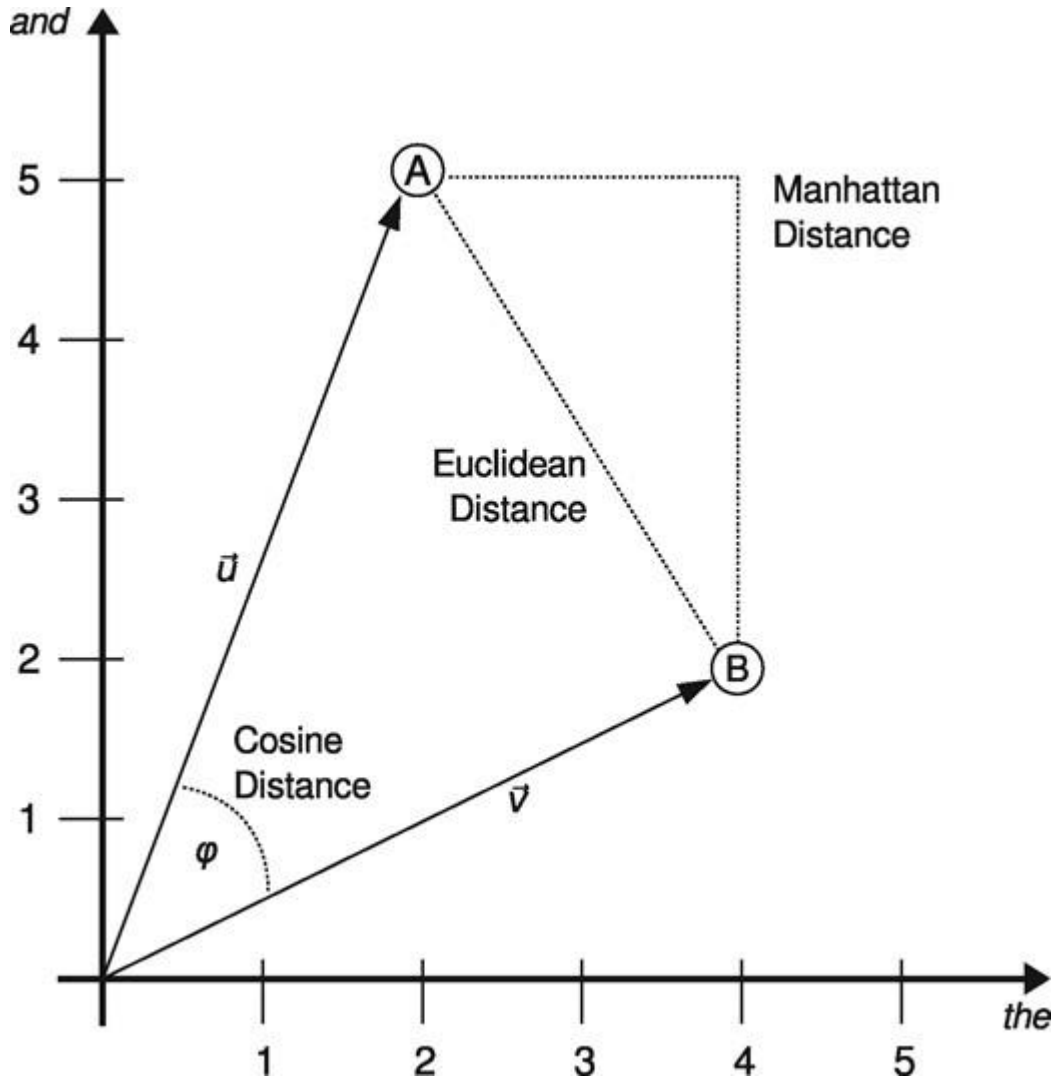
A_i … the frequency of a given word in the text A

B_i … the frequency of a given word in the text B

μ_i … the average frequency of a given word in corpus

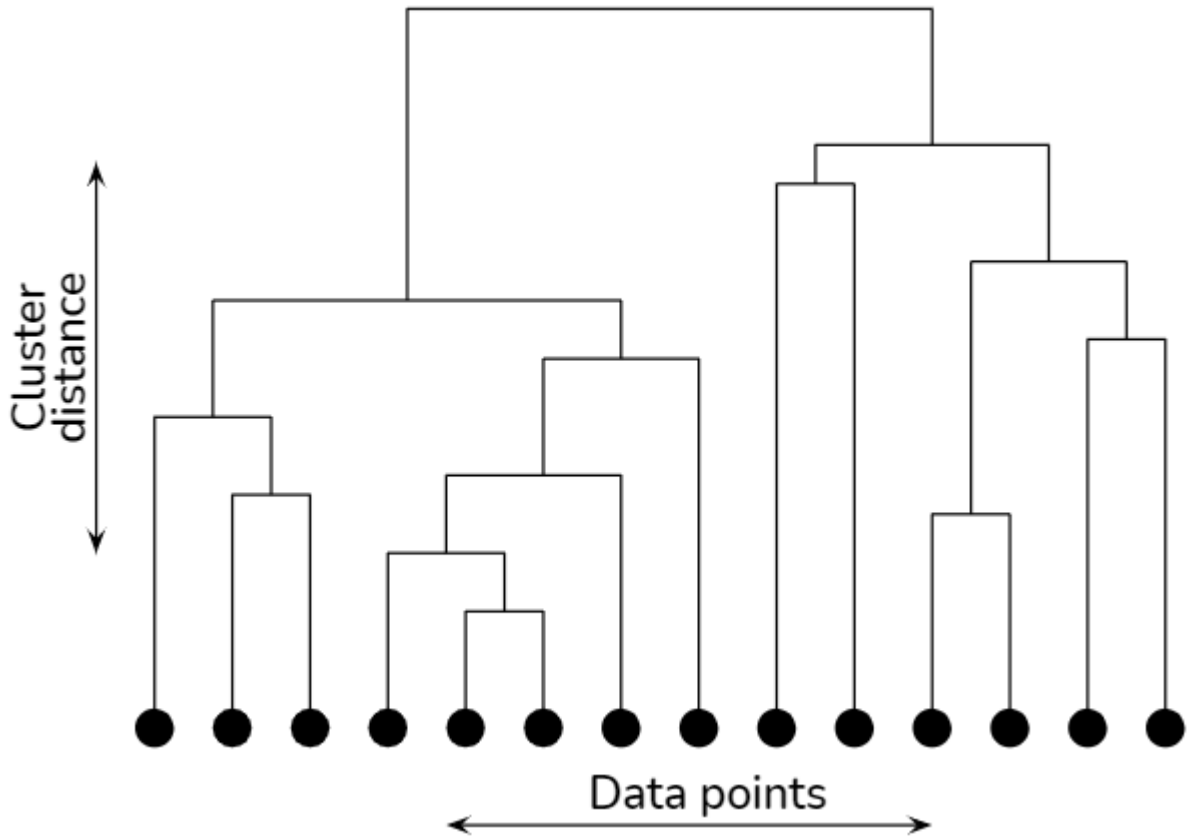
σ_i … the standard deviation of the frequency of a given word

Distances between words / texts



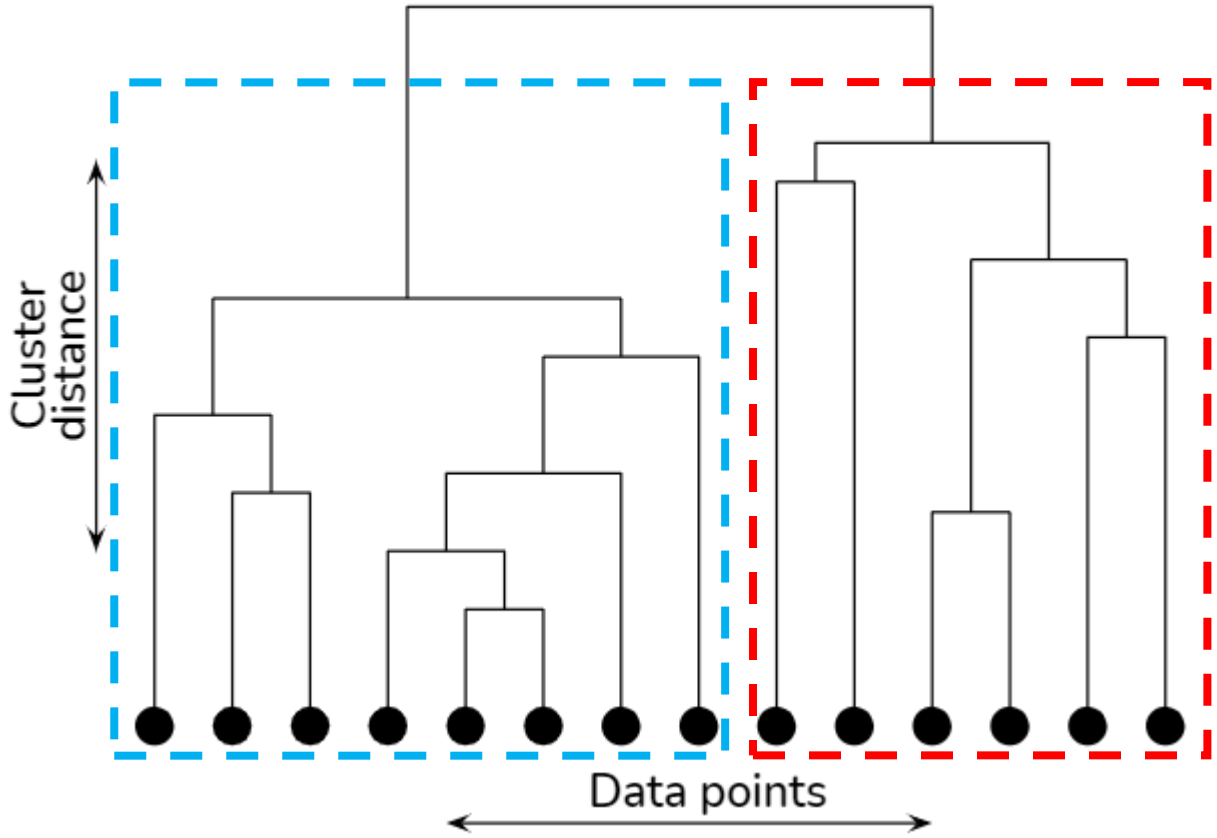
Evert et al. (2017)

Clustering



https://towardsdatascience.com/hierarchical-clustering-explained-e59b13846da8

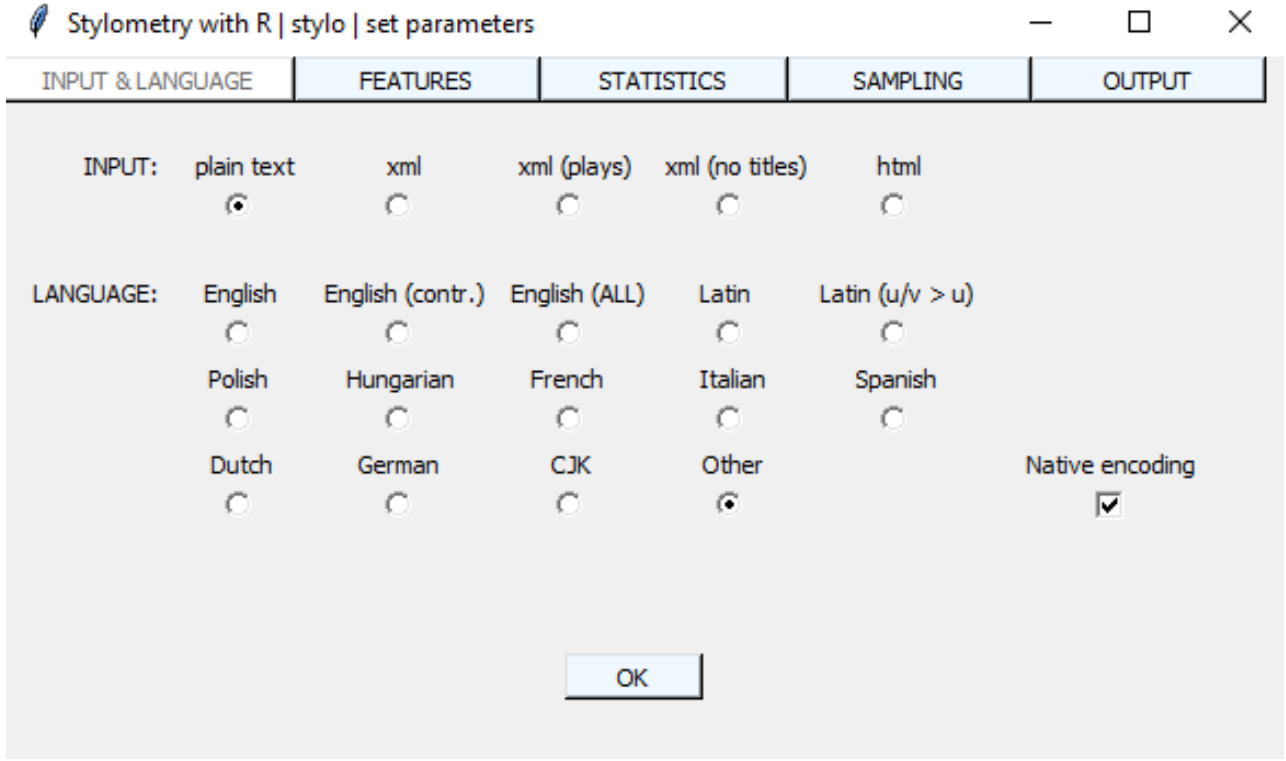
Clustering



https://towardsdatascience.com/hierarchical-clustering-explained-e59b13846da8

Stylo

- Eder, M., Rybicki, J., & Kestemont, M. (2016). Stylometry with R: a package for computational text analysis. *The R Journal*, *8*(1).



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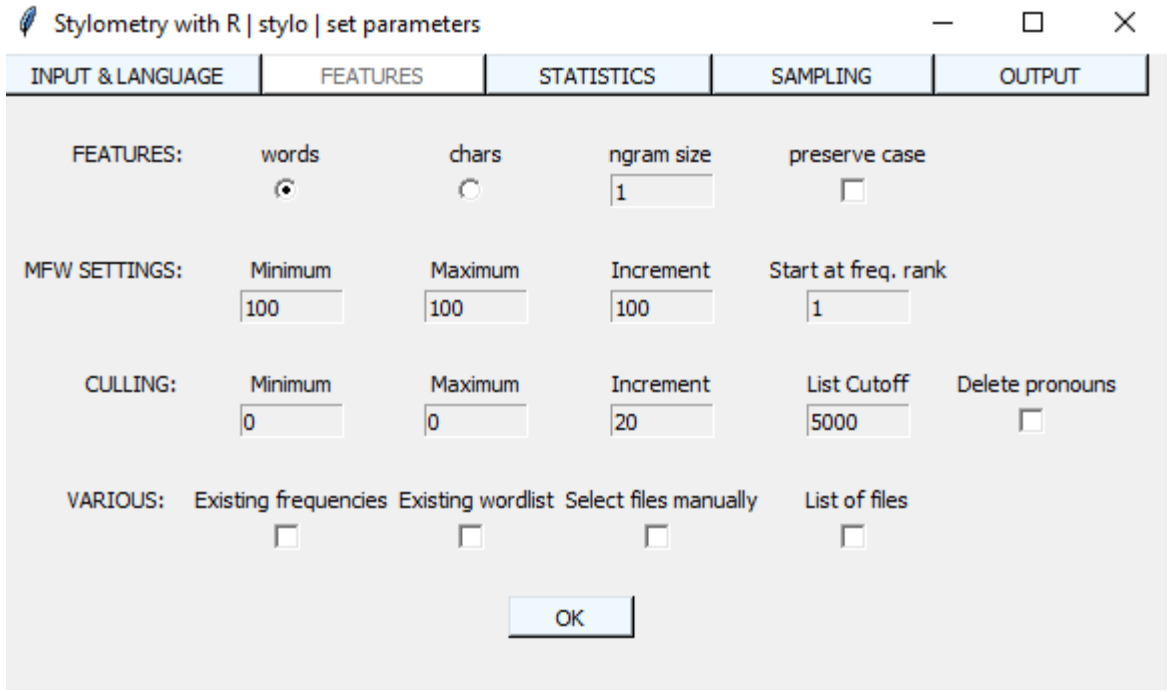
Stylometry with R | stylo | set parameters
INPUT & LANGUAGE
FEATURES
STATISTICS
SAMPLING
OUTPUT
FEATURES:
words
chars
ngram size
preserve case
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MFW SETTINGS:
Minimum
Maximum
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CULLING:
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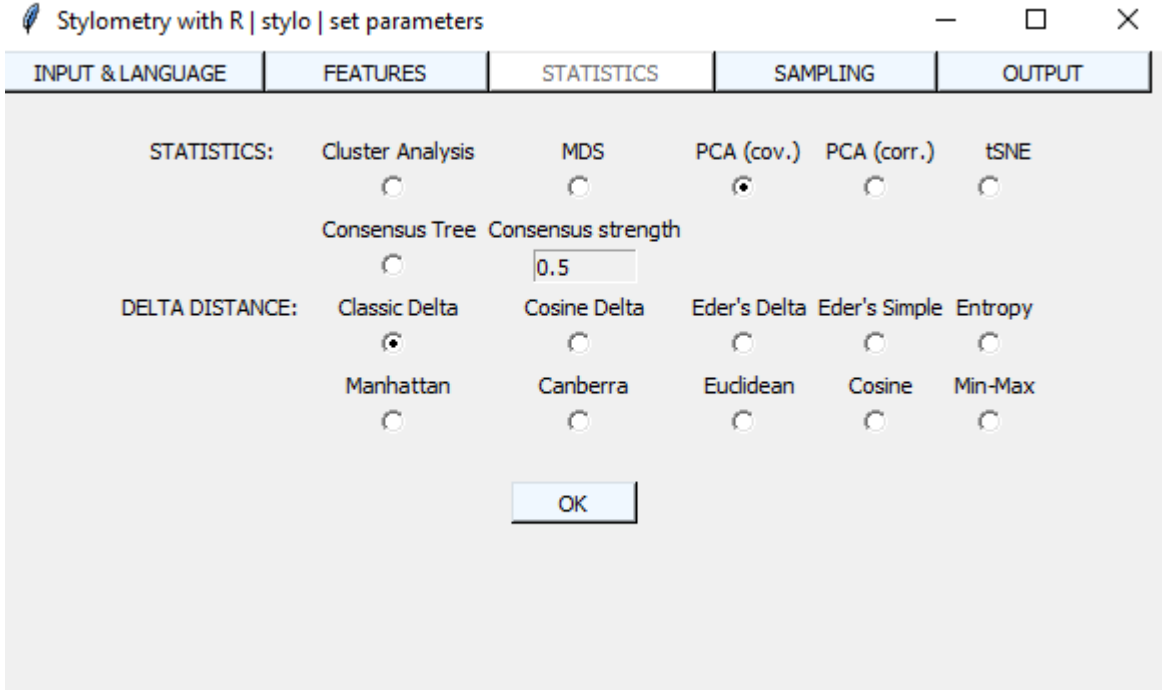
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STATISTICS:
Cluster Analysis
MDS
PCA (cov.)
PCA (corr.)
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Consensus Tree
Consensus strength
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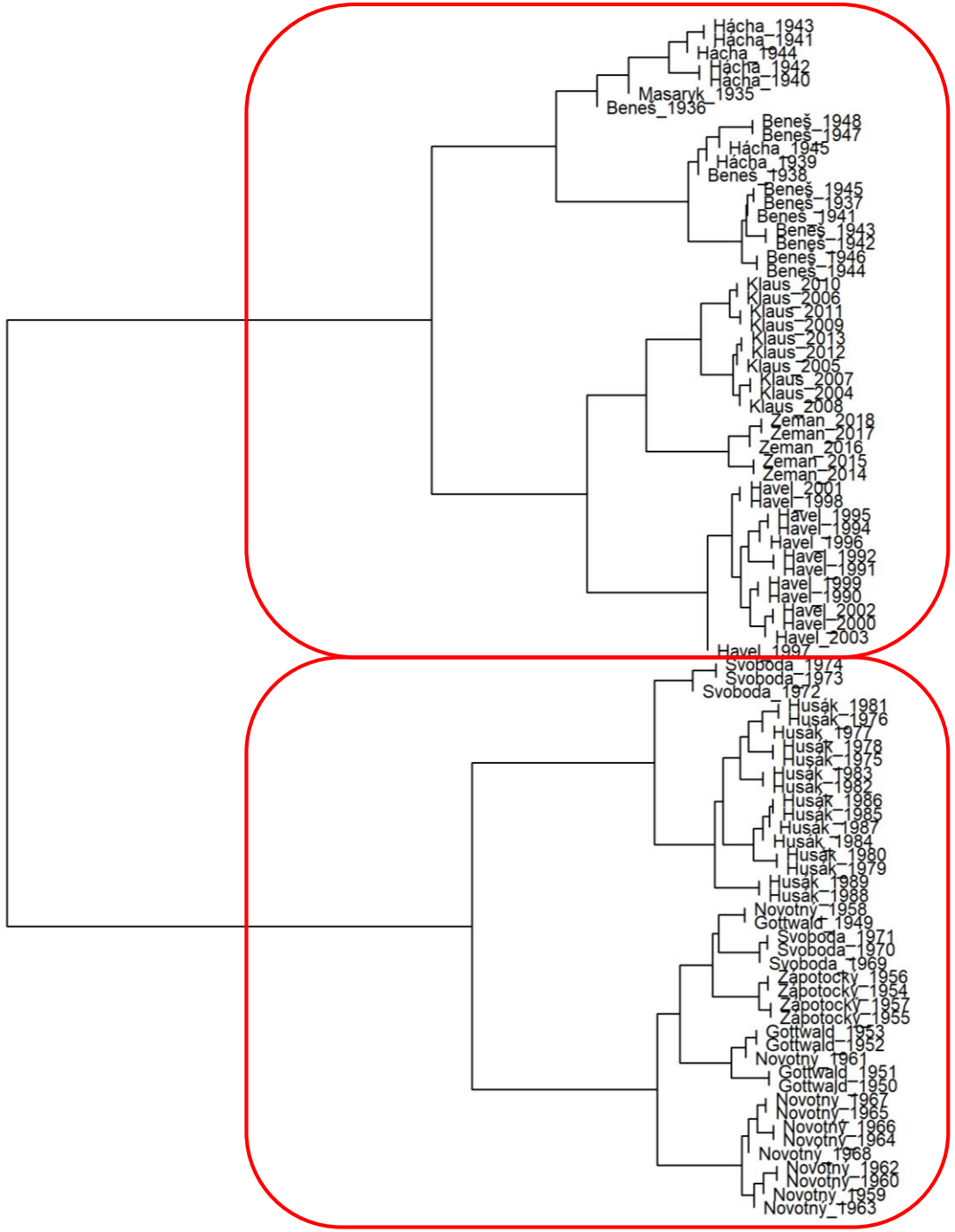
DELTA DISTANCE:
Classic Delta
Cosine Delta
Eder's Delta
Eder's Simple
Entropy
Manhattan
Canberra
Euclidean
Cosine
Min-Max
OK

Prezidentské projevy

- Kubát, M., Mačutek, J., Čech, R. (2021). Communists spoke differently. An analysis of Czechoslovak and Czech annual presidential speeches. Digital Scholarship in the Humanities, 36, 138-152.

- presedential speeches: 1935–2018

- 100 MFW, culling = 60 %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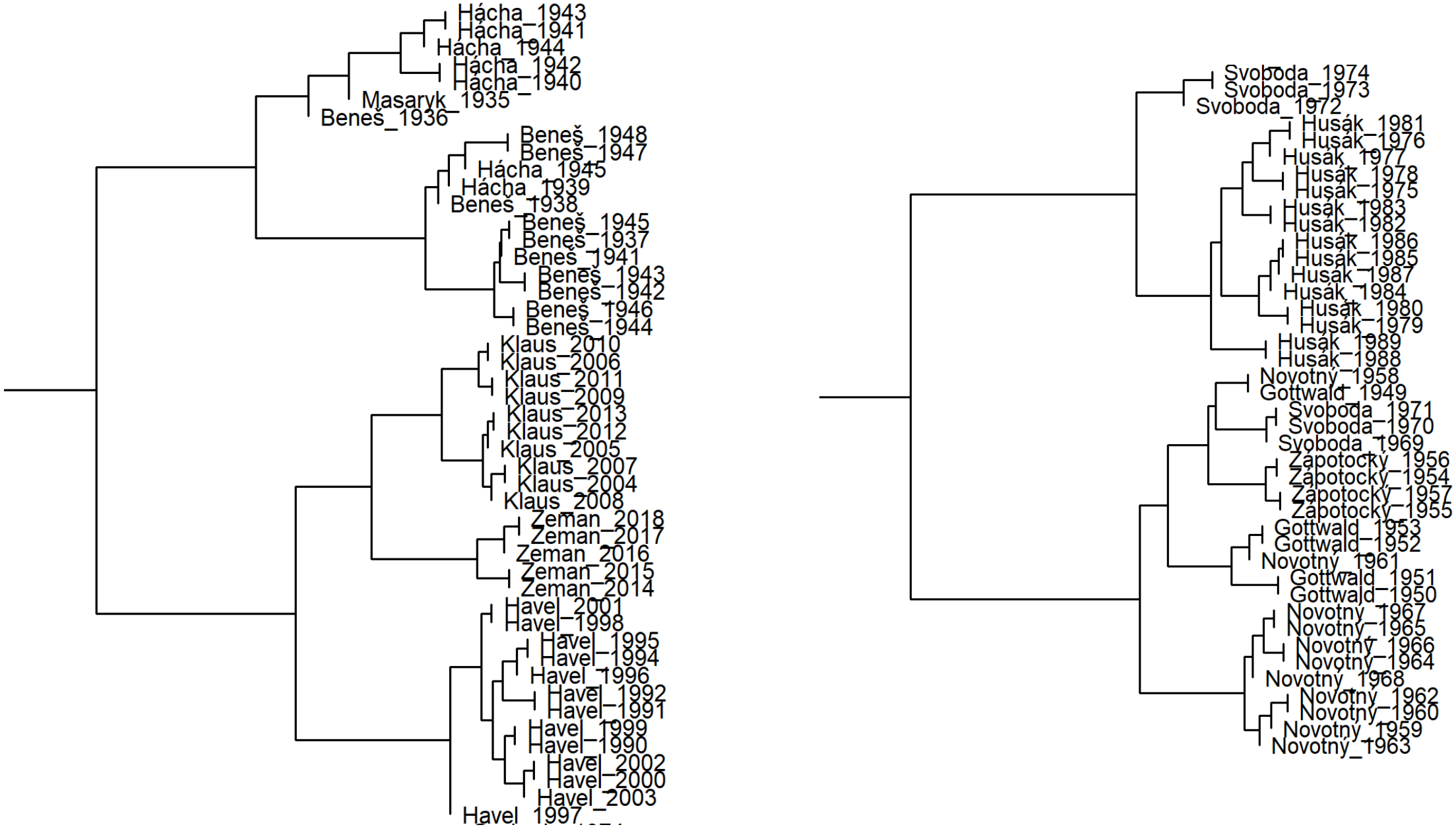
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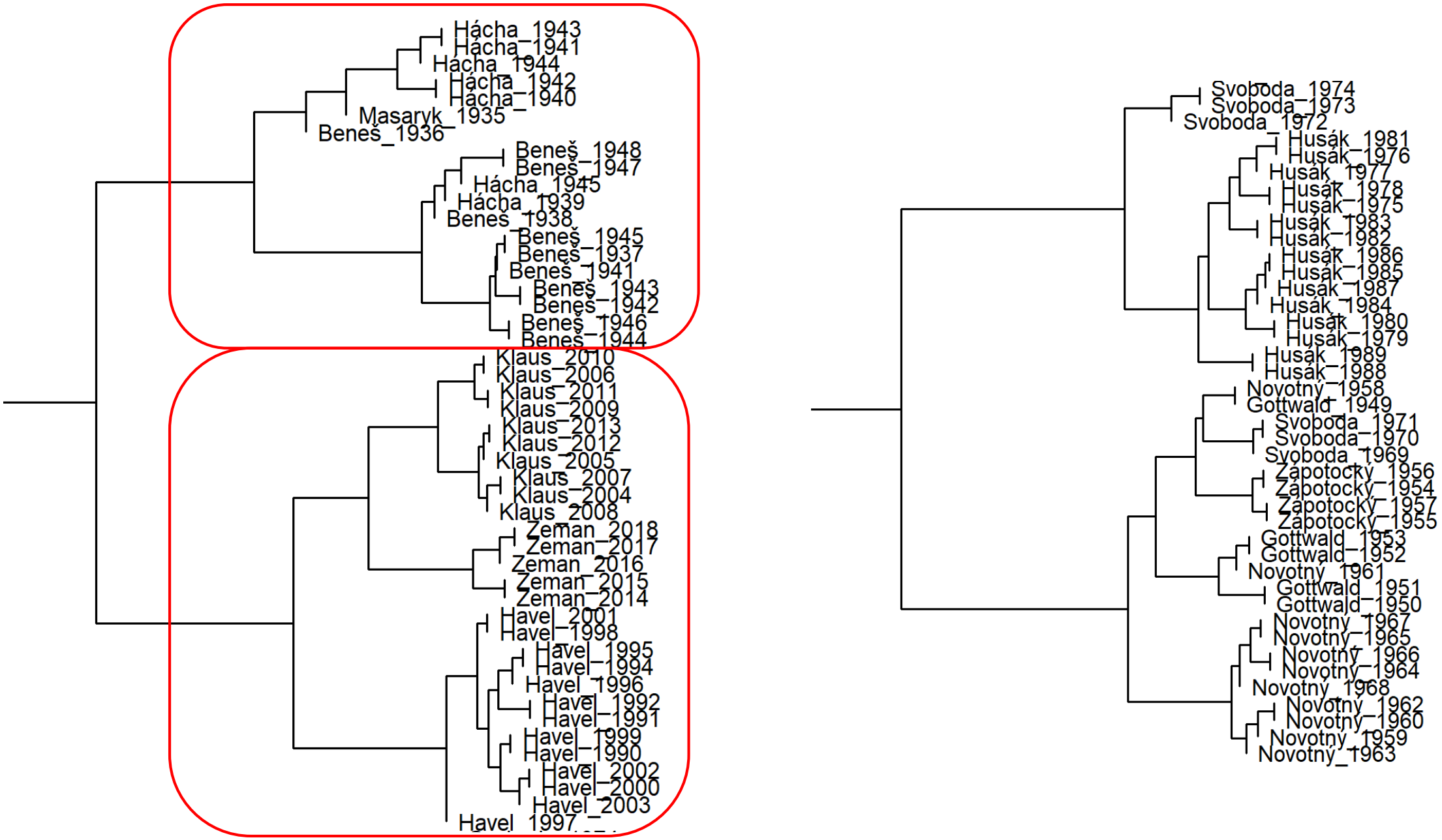
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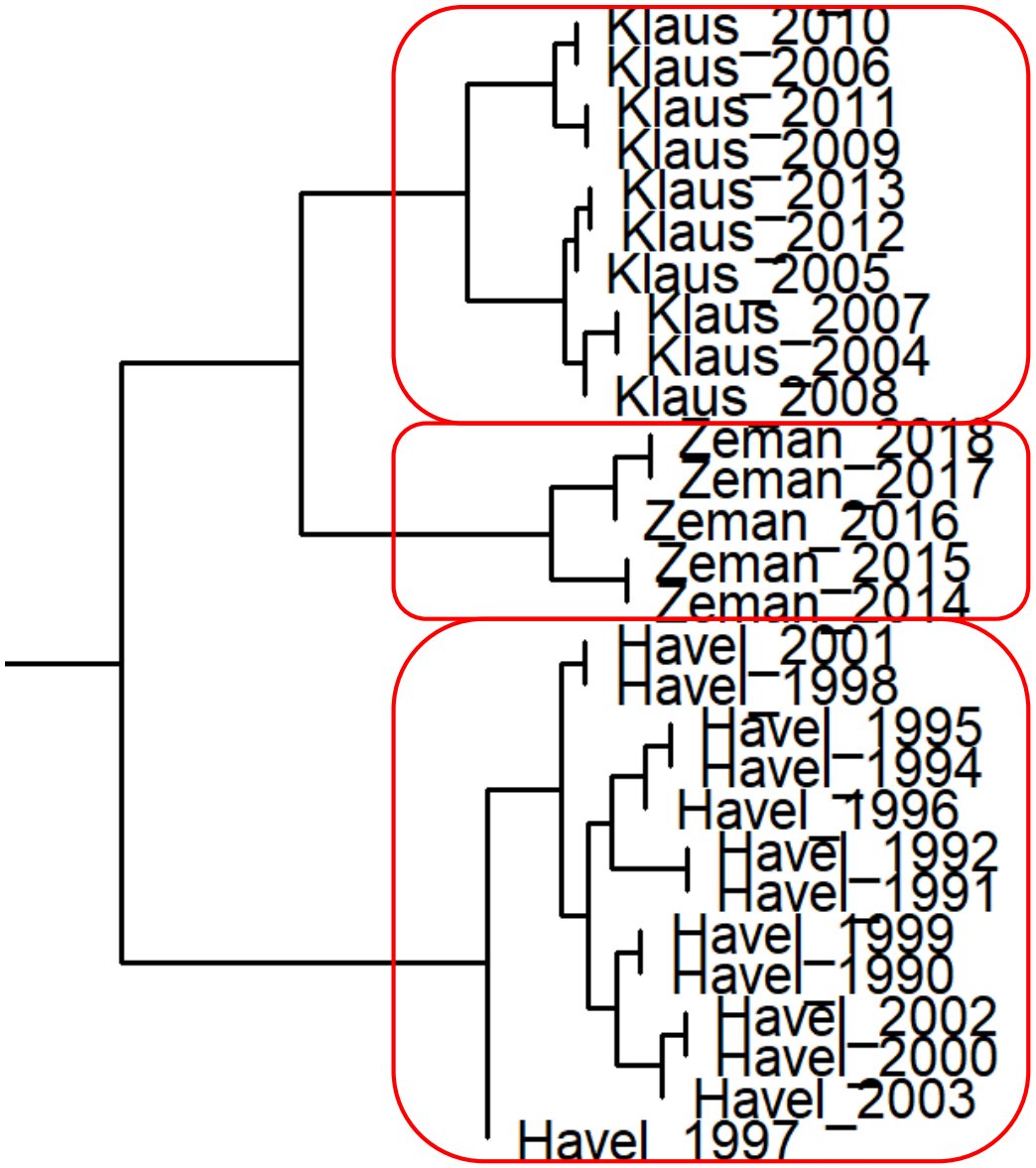
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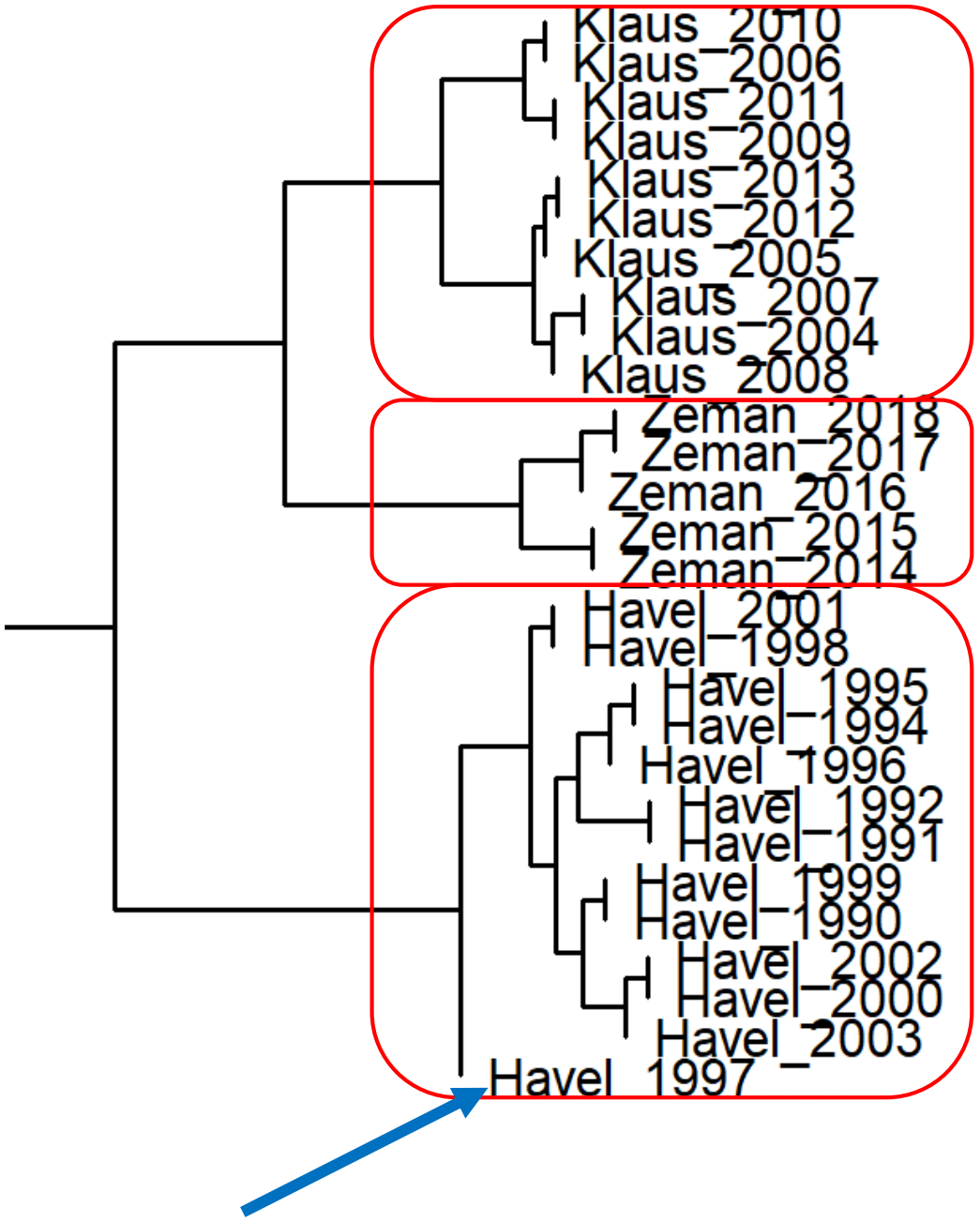
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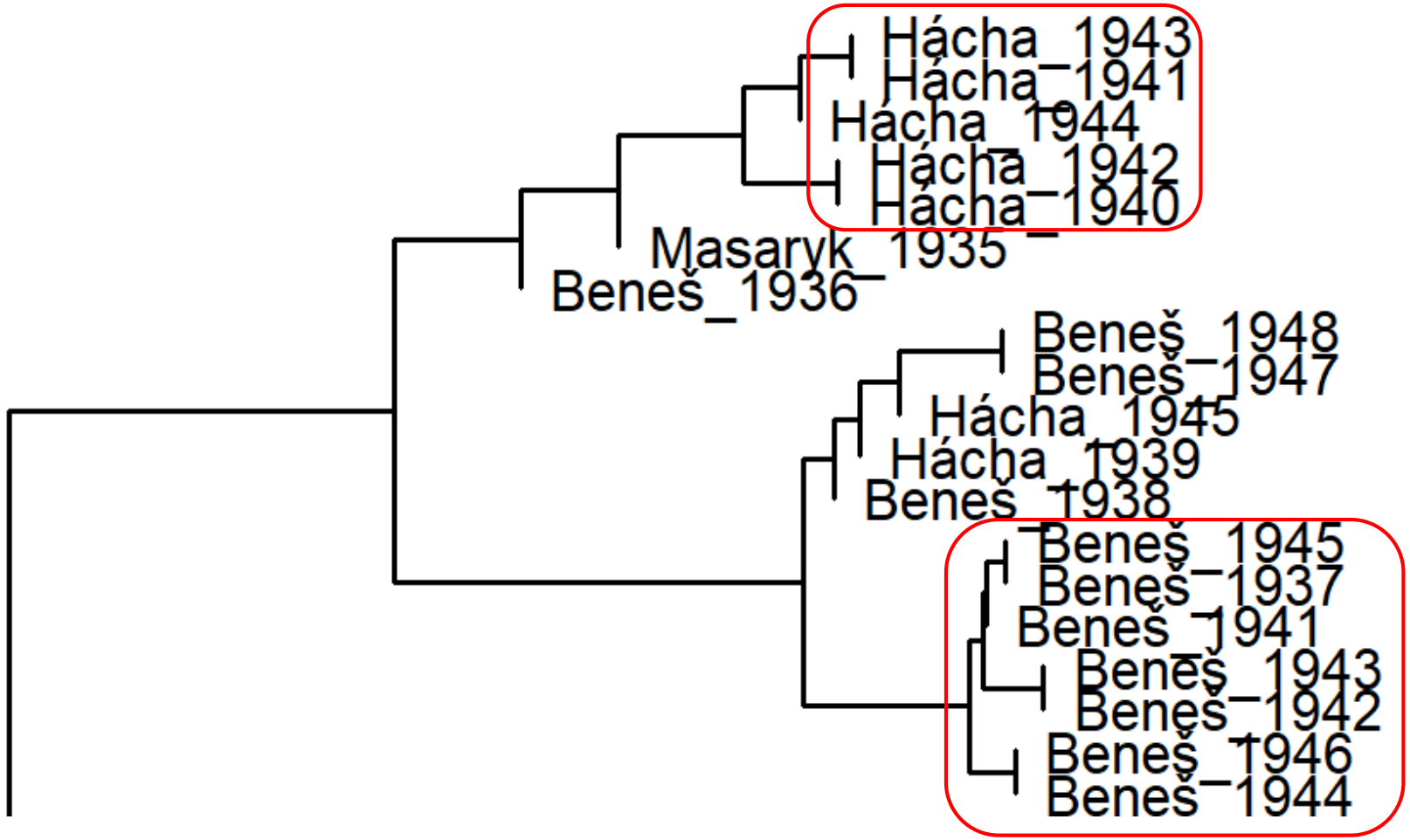
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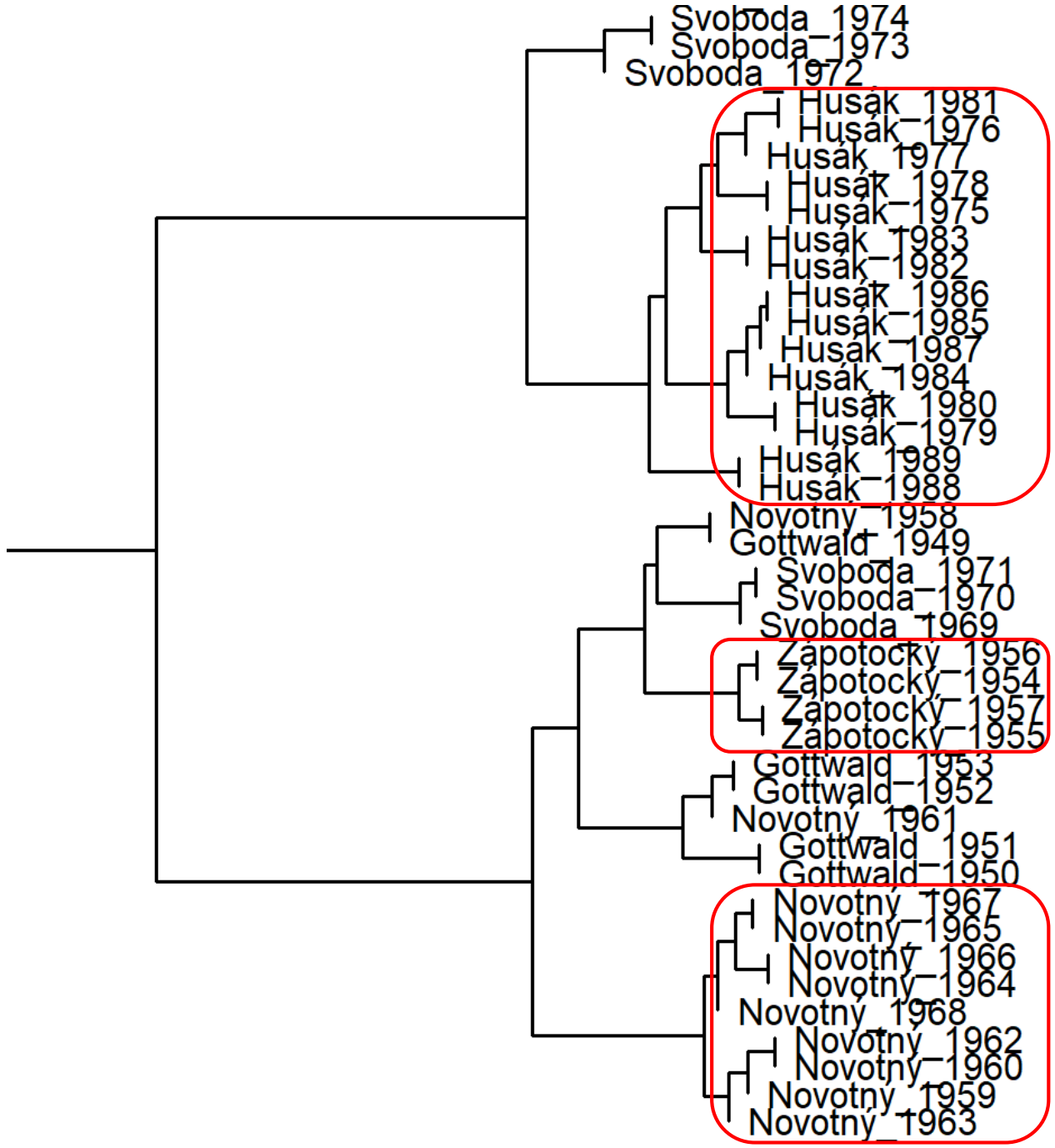
Svoboda_1974
Svoboda_1973
Svoboda_1972
Husák_1981
Husák_1976
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Husák_1979
Husák_1989
Husák_1988
Novotný_1958
Gottwald_1949
Svoboda_1971
Svoboda_1970
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Zápotocký_1956
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Gottwald_1953
Gottwald_1952
Novotný_1961
Gottwald_1951
Gottwald_1950
Novotný_1967
Novotný_1965
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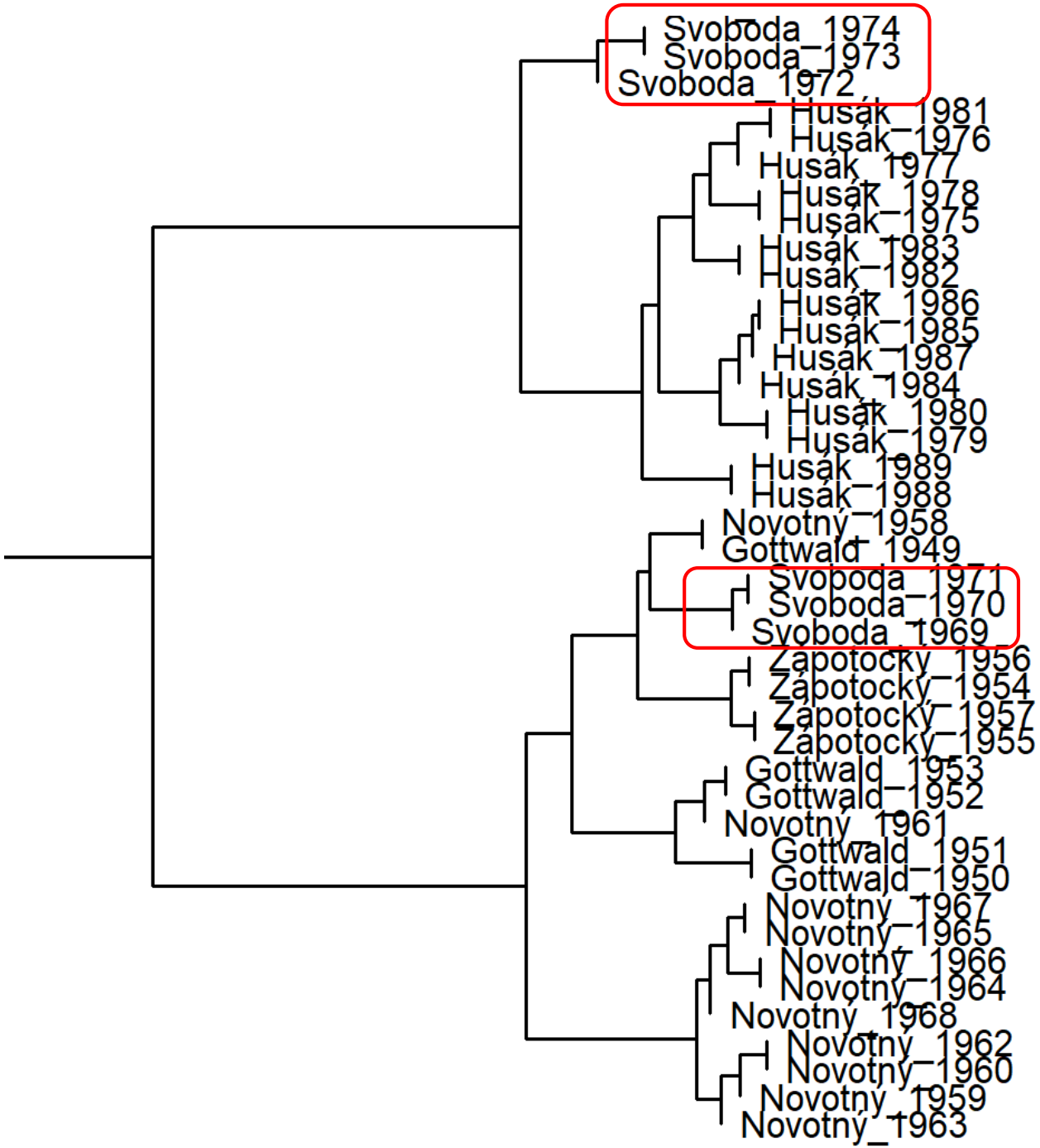
Novotný_1962
Novotný_1960
Novotný_1959
Novotný_1963


Svoboda_1974
Svoboda_1973
Svoboda_1972
Husák_1981
Husák_1976
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Husák_1978
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Husák_1989
Husák_1988
Novotný_1958
Gottwald_1949
Svoboda_1971
Svoboda_1970
Svoboda_1969
Zápotocký_1956
Zápotocký_1954
Zápotocký_1957
Zápotocký_1955
Gottwald_1953
Gottwald_1952
Novotný_1961
Gottwald_1951
Gottwald_1950
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Novotný_1965
Novotný_1966
Novotný_1964
Novotný_1968
Novotný_1962
Novotný_1960
Novotný_1959
Novotný_1963

Bible svatováclavská & comments

- Kosek, P., Čech, R. (2018). Stylové aspekty Bible svatováclavské – stylometrická analýza. In Zand, G., Newerkla, S.M. (eds.). Jezuitská kultura v českých zemích / Jesuitische Kultur in den böhmischen Ländern. Host, 195-209.

Bible svatováclavská & comments

- New Testament
  - Konstanc → Šteyer
- Old Testament
  - Šteyer → Barner
    - Job – divide

- „[…] (*domníváme se, že by se stylistickým rozdílem textu dalo zjistit, odkud překládal už jen Šteyer*) […]“ Vintr (1997)

Bible svatováclavská & comments

- comments
  - Šteyer: New Testament + Genesis
  - Barner: Old Testament

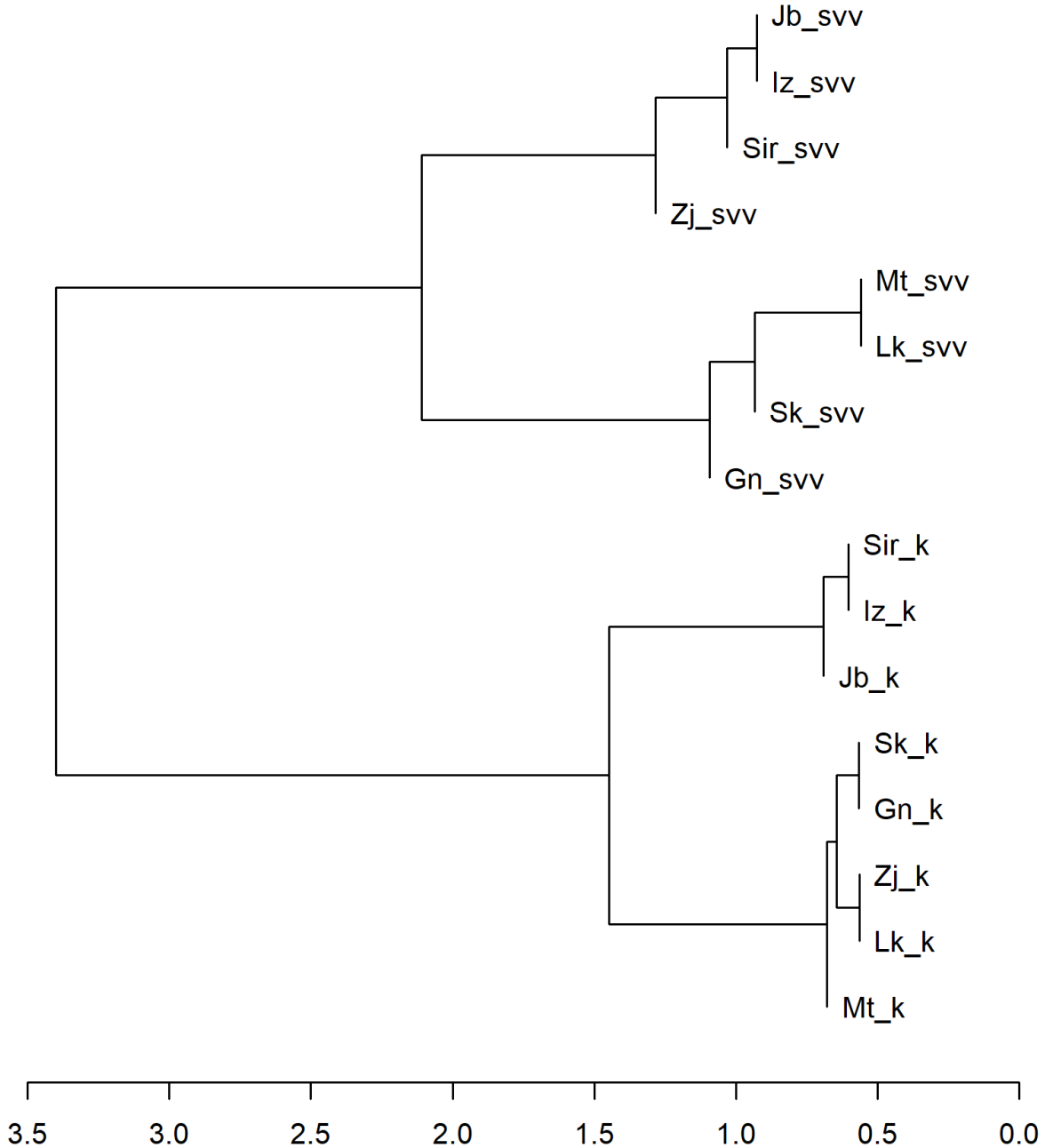
Bible svatováclavská & comments

- translation
- sacred text
- editing

Bible svatováclavská & comments

- New Testament
  - Mt, Lk, Sk, Zj
- Old Testament
  - Gn, Jb, Iz, Sir

- 100 MFW
- culling = 0


Jb_svv
Iz_svv
Sir_svv
Zj_svv
Mt_svv
Lk_svv
Sk_svv
Gn_svv
Sir_k
Iz_k
Jb_k
Sk_k
Gn_k
Zj_k
Lk_k
Mt_k
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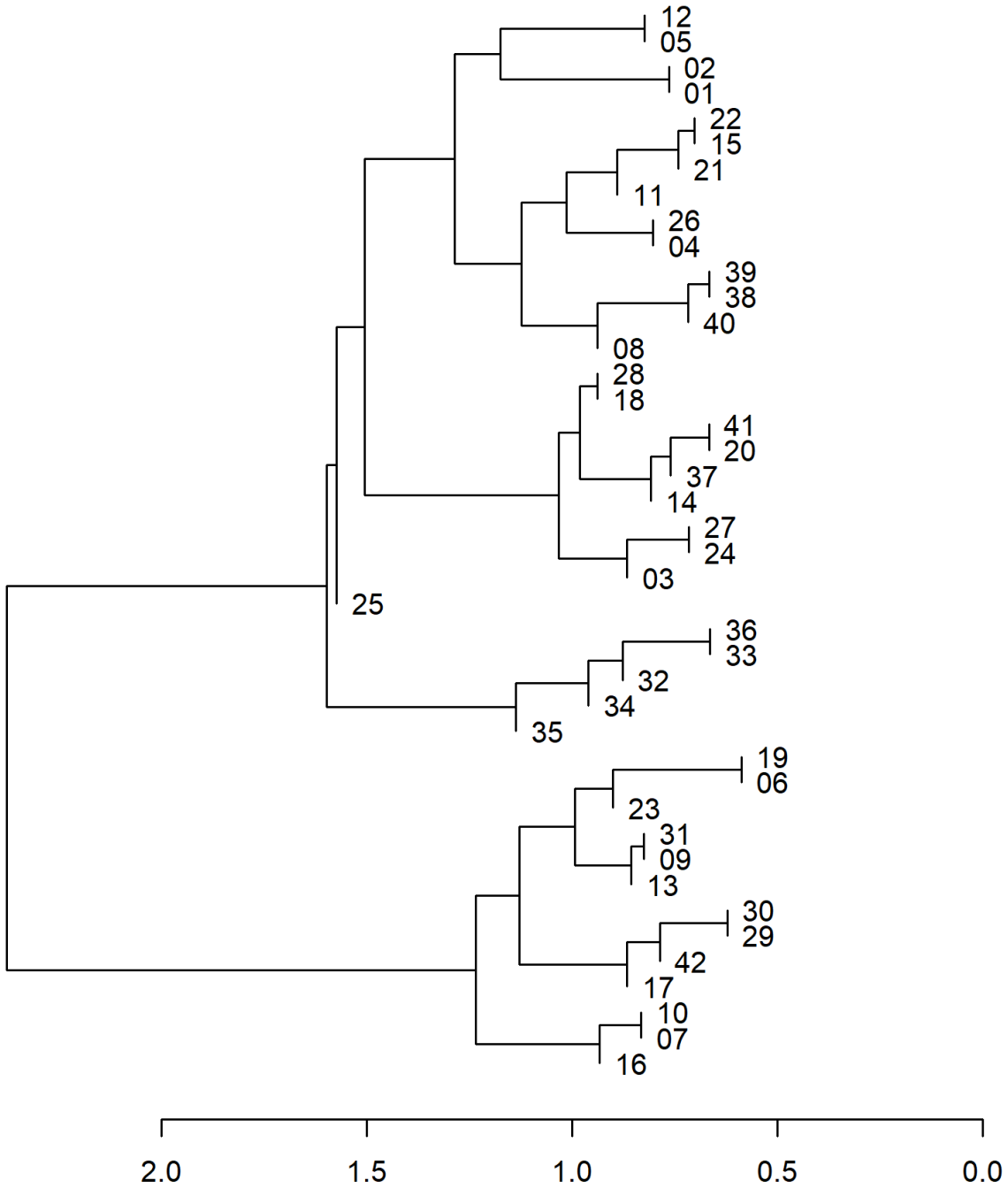
3.0
2.5
2.0
1.5
1.0
0.5
0.0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1.5
1.0
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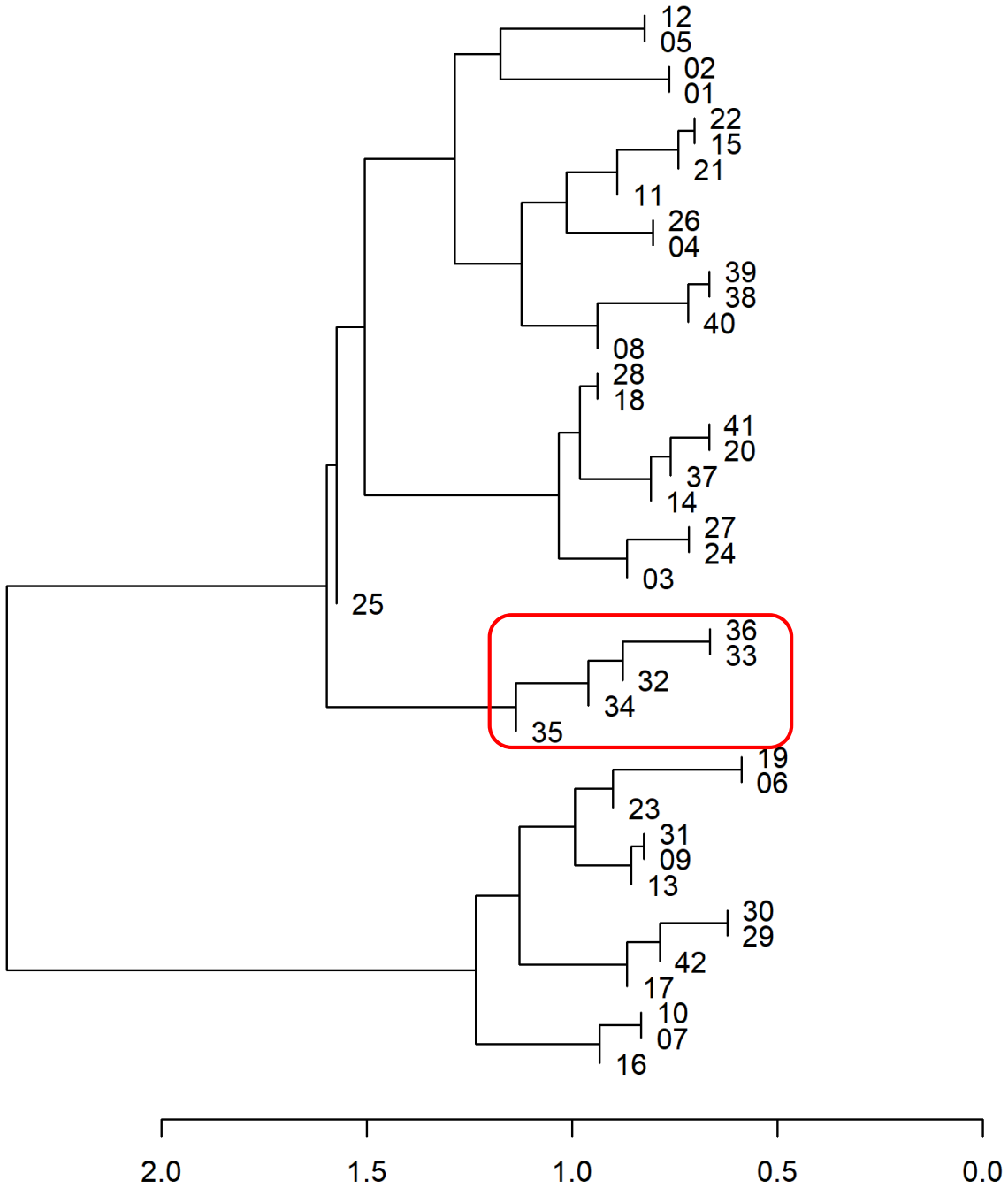
0.0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42
17
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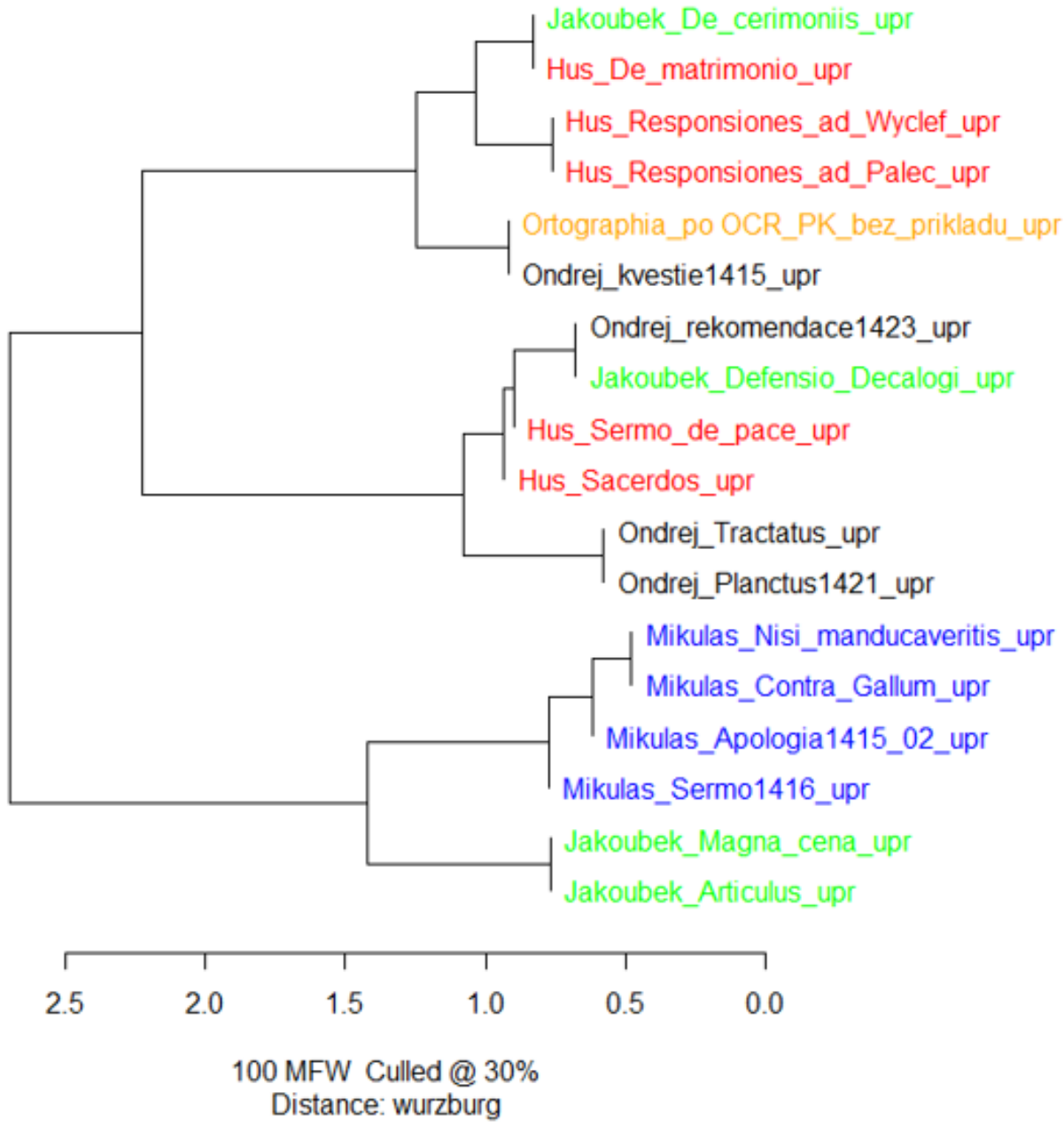
07
16
2.0
1.5
1.0
0.5
0.0

Ortographia Bohemica

- Jan Hus
  - De matrimonio, Responsiones ad Palec, Sacerdos, Sermo de pace
- Jakoubek ze Stříbra
  - Articulus, De cerimoniis, Defensio Decalogi, Magna cena
- Mikuláš z Drážďan
  - Apologia 1415, Contra Gallum, Nisi manducaveritis, Sermo 1416,
- Ondřej z Brodu
  - Kvestie 1415, Planctus 1421, Recomendace 1423, Tractatus,
- Petr z Pulky
  - Confutatio, Epistola, Sermo ite, De congruitate


Jakoubek_De_cerimoniis_upr
Hus_De_matrimonio_upr
Hus_Responsiones_ad_Wyclef_upr
Hus_Responsiones_ad_Palec_upr
Ortographia_po OCR_PK_bez_prikladu_upr
Ondrej_kvestie1415_upr
Ondrej_rekomendace1423_upr
Jakoubek_Defensio_Decalogi_upr
Hus_Sermo_de_pace_upr
Hus_Sacerdos_upr
Ondrej_Tractatus_upr
Ondrej_Planctus1421_upr
Mikulas_Nisi_manducaveritis_upr
Mikulas_Contra_Gallum_upr
Mikulas_Apologia1415_02_upr
Mikulas_Sermo1416_upr
Jakoubek_Magna_cena_upr
Jakoubek_Articulus_upr
2.5
2.0
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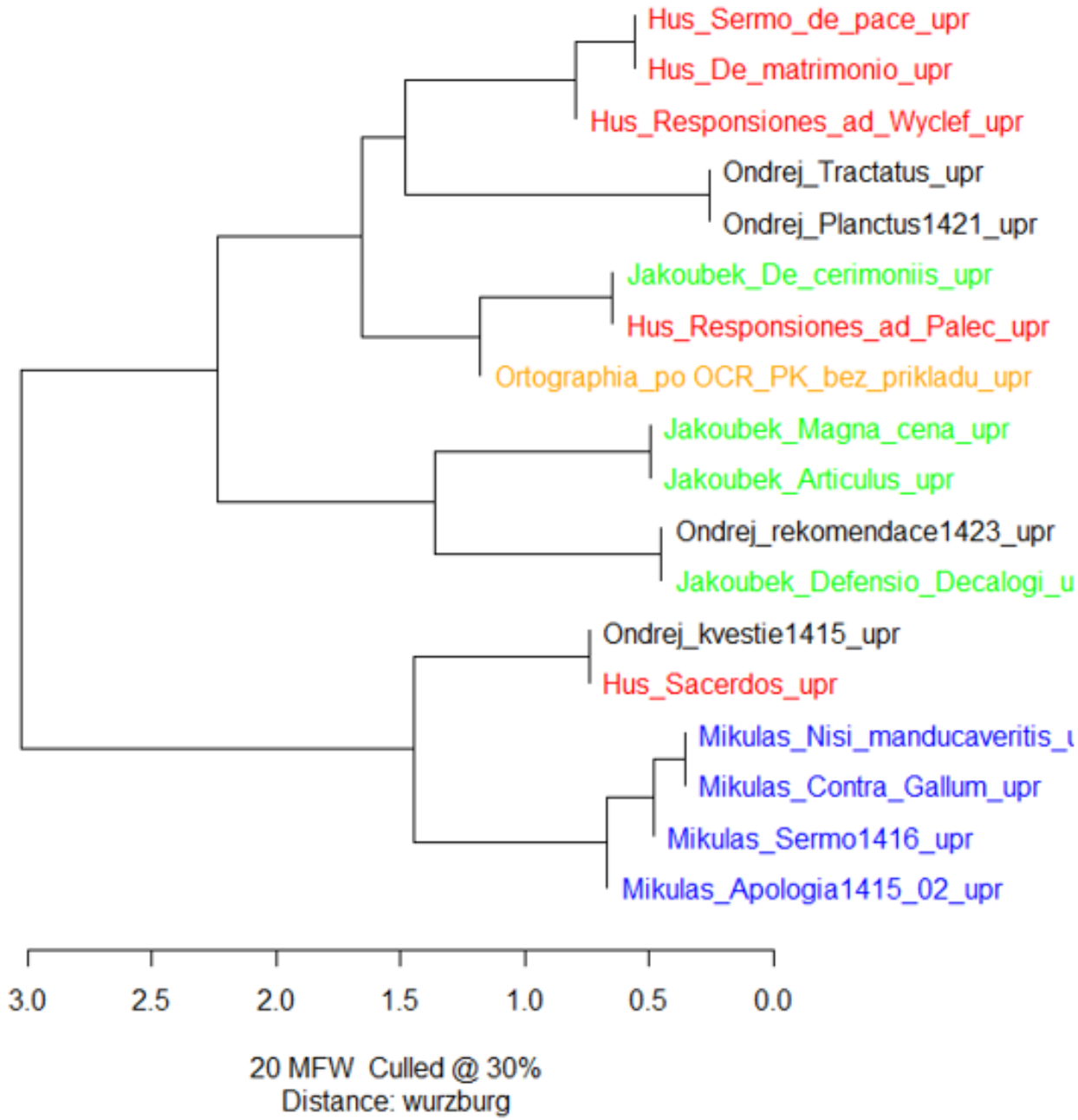
0.5
0.0
100 MFW Culled @ 30%
Distance: wurzburg


Hus_Sermo_de_pace_upr
Hus_De_matrimonio_upr
Hus_Responsiones_ad_Wyclef_upr
Ondrej_Tractatus_upr
Ondrej_Planctus1421_upr
Jakoubek_De_cerimoniis_upr
Hus_Responsiones_ad_Palec_upr
Ortographia_po OCR_PK_bez_prikladu_upr
Jakoubek_Magna_cena_upr
Jakoubek_Articulus_upr
Ondrej_rekomendace1423_upr
Jakoubek_Defensio_Decalogi_u
Ondrej_kvestie1415_upr
Hus_Sacerdos_upr
Mikulas_Nisi_manducaveritis_u
Mikulas_Contra_Gallum_upr
Mikulas_Sermo1416_upr
Mikulas_Apologia1415_02_upr
3.0
2.5
2.0
1.5
1.0
0.5
0.0
20 MFW Culled @ 30%
Distance: wurzburg

Ortographia Bohemica

- paraphrases, non-attributed quotations → analysis of 'authorial' parts

- Latin

Syntactic functions

- Čech, R., Mačutek, J., Kubát, M., Koščová, M. (2022). Does an author leave a syntactic footprint? In: Misuraca, M., Scepi, G., Spano, M. Proceedings of the 16th International Conference on statistical analysis of textual data. Naples: Vadistat Press, 221-228.

- presidential speeches: 1935–2018

Syntactic functions

- syntactic annotation (UD pipe)

- syntactic relations
  - UD → 37 universal syntactic relations
  - subject, object, indirect object, nominal modifier, adverbial modifier etc.

Syntactic functions

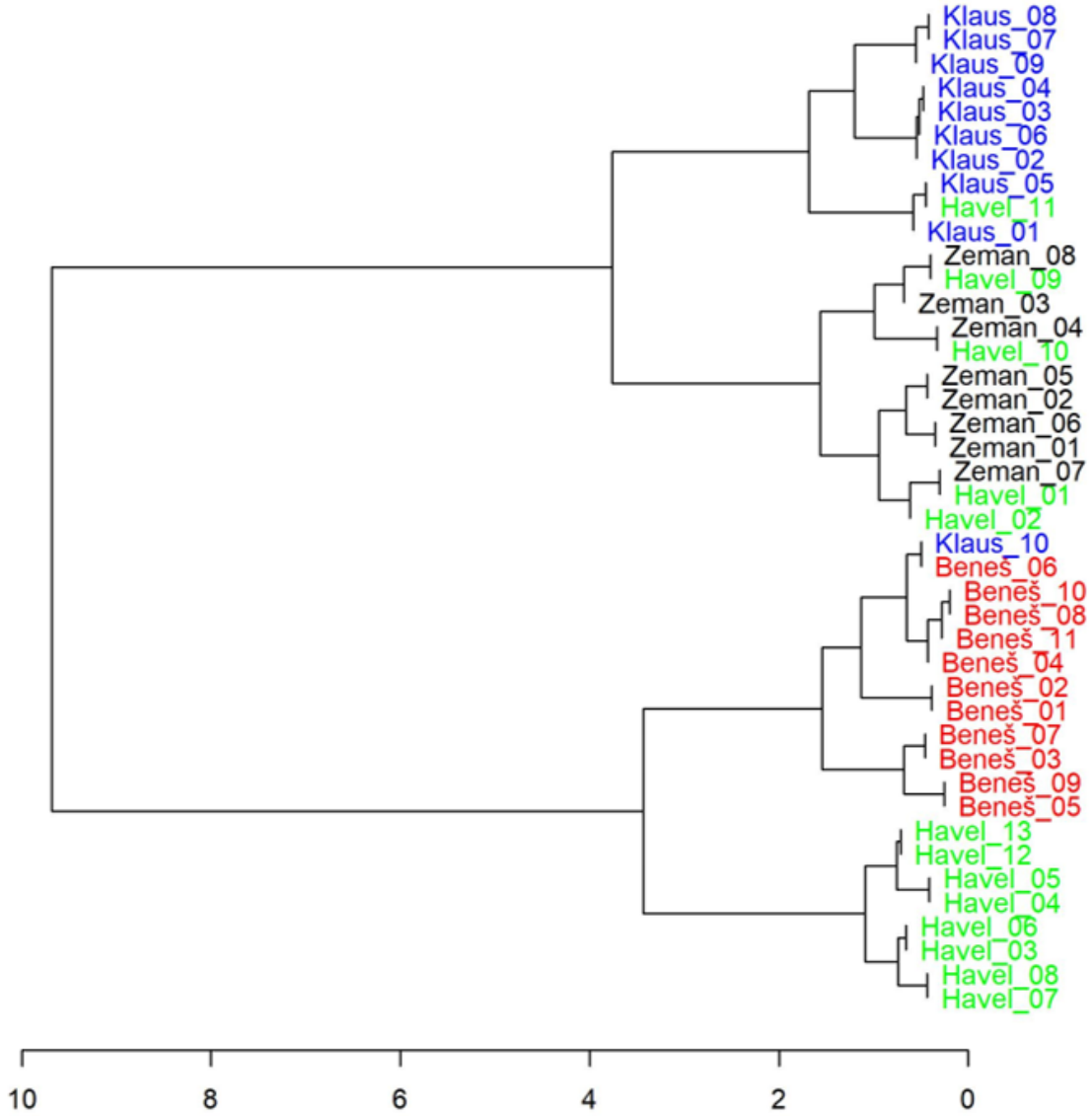
- Milí spoluobčané, když jsem vás před pěti lety v tento den poprvé oslovil, řekl jsem, že do našich srdcí se opět vrátila naděje

- amod nsubj mark aux obj case nummod obl case det obl obl advcl root aux mark case det obl expl:pv advmod ccomp obj

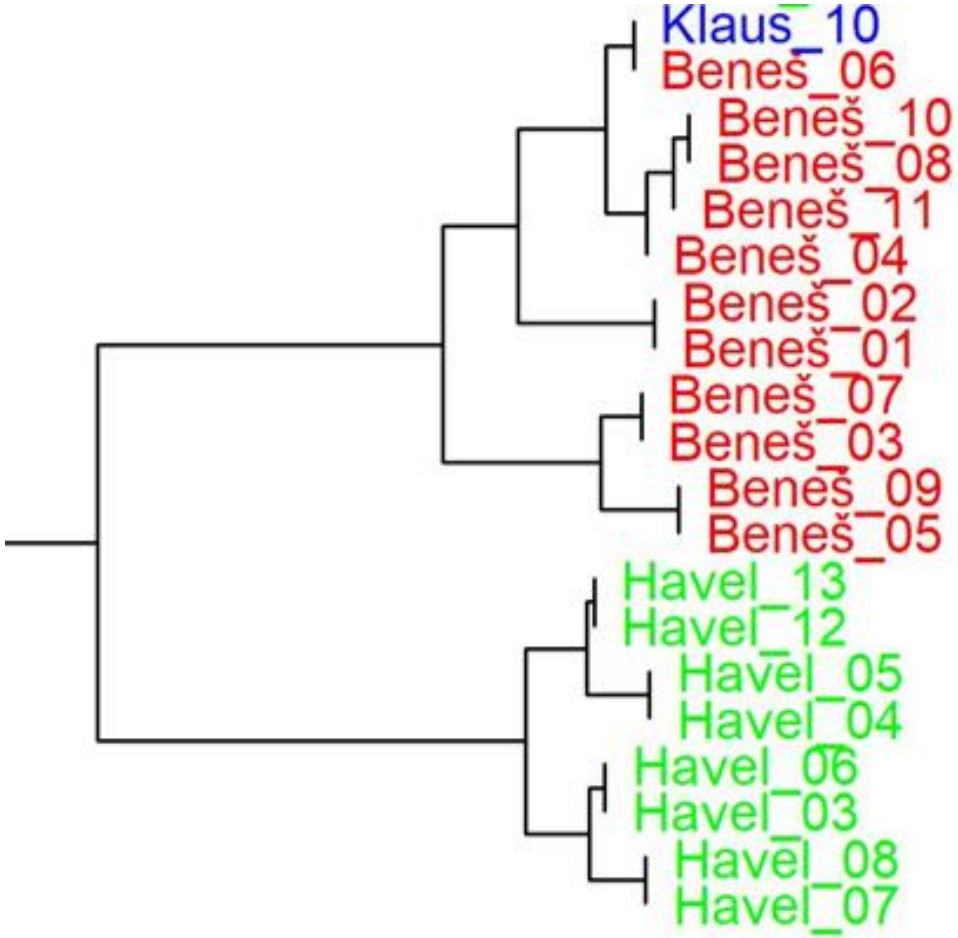
Syntactic functions

- democratic addresses
  - 22 most frequent syntactic relations
- communist addresses
  - 18 most frequent syntactic relations
- configuration
  - culling = 0
  - n-gram size = 1

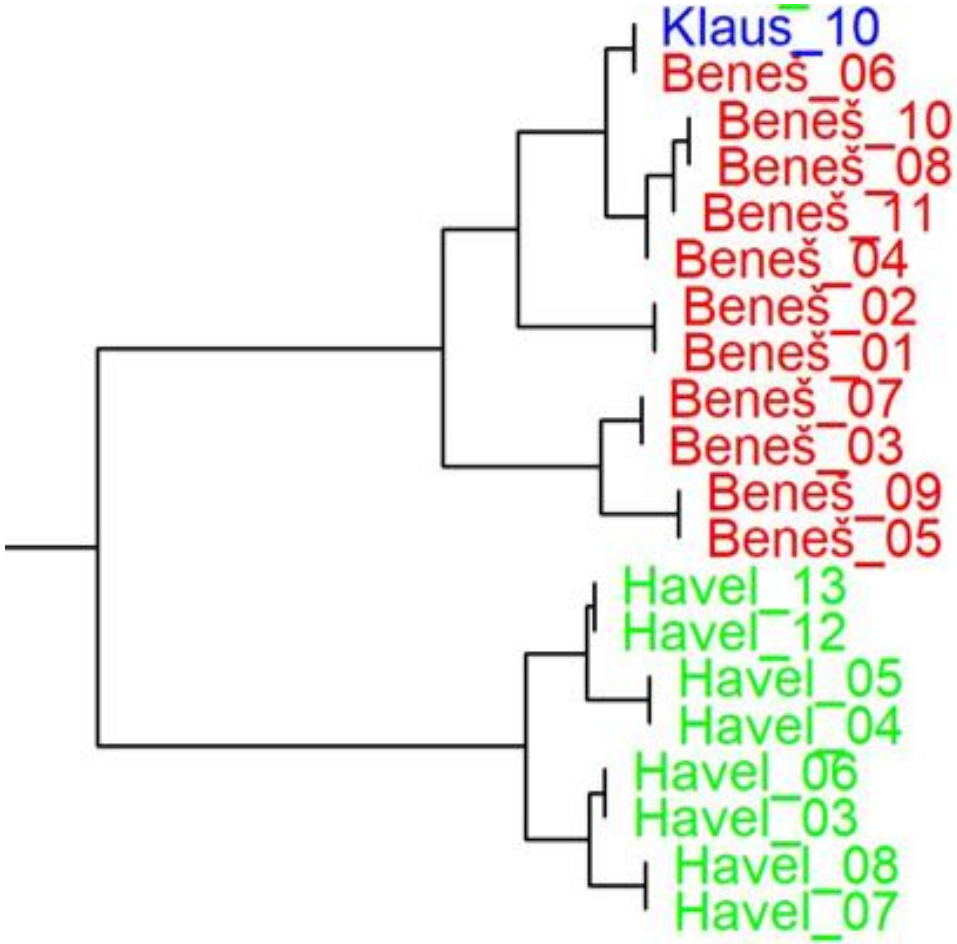
Results – democratic presidents

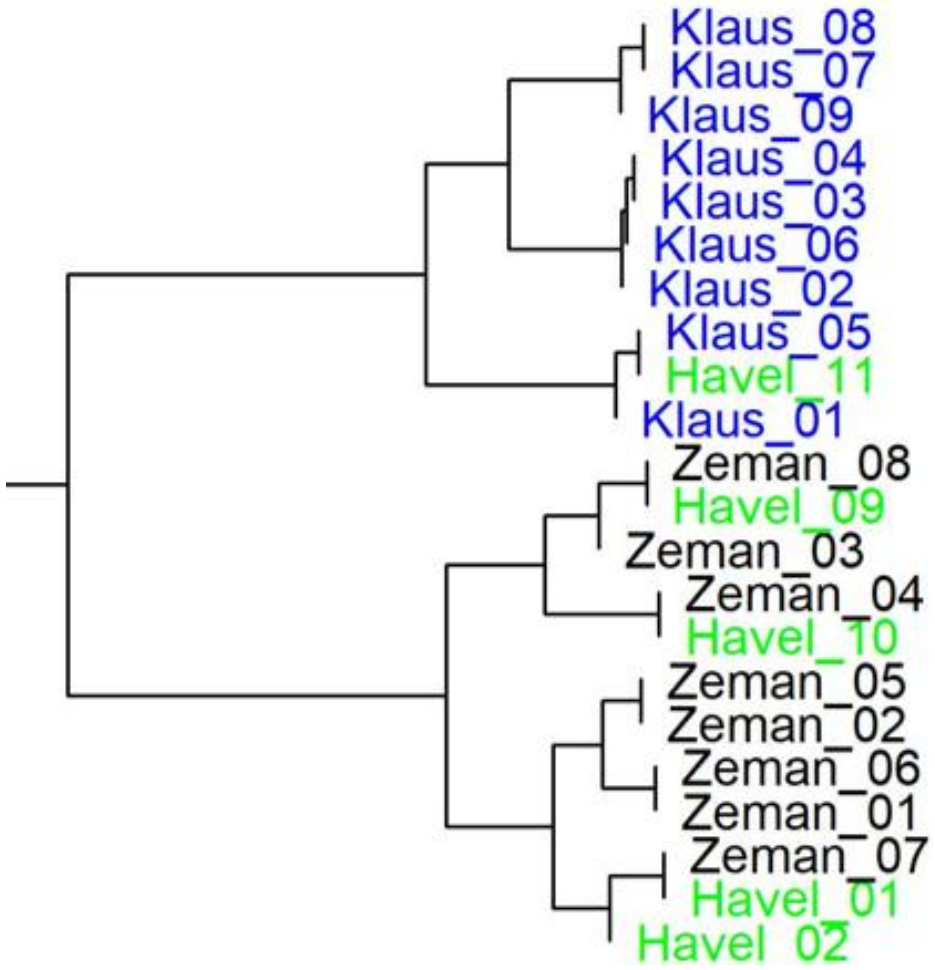


Results – democratic presidents

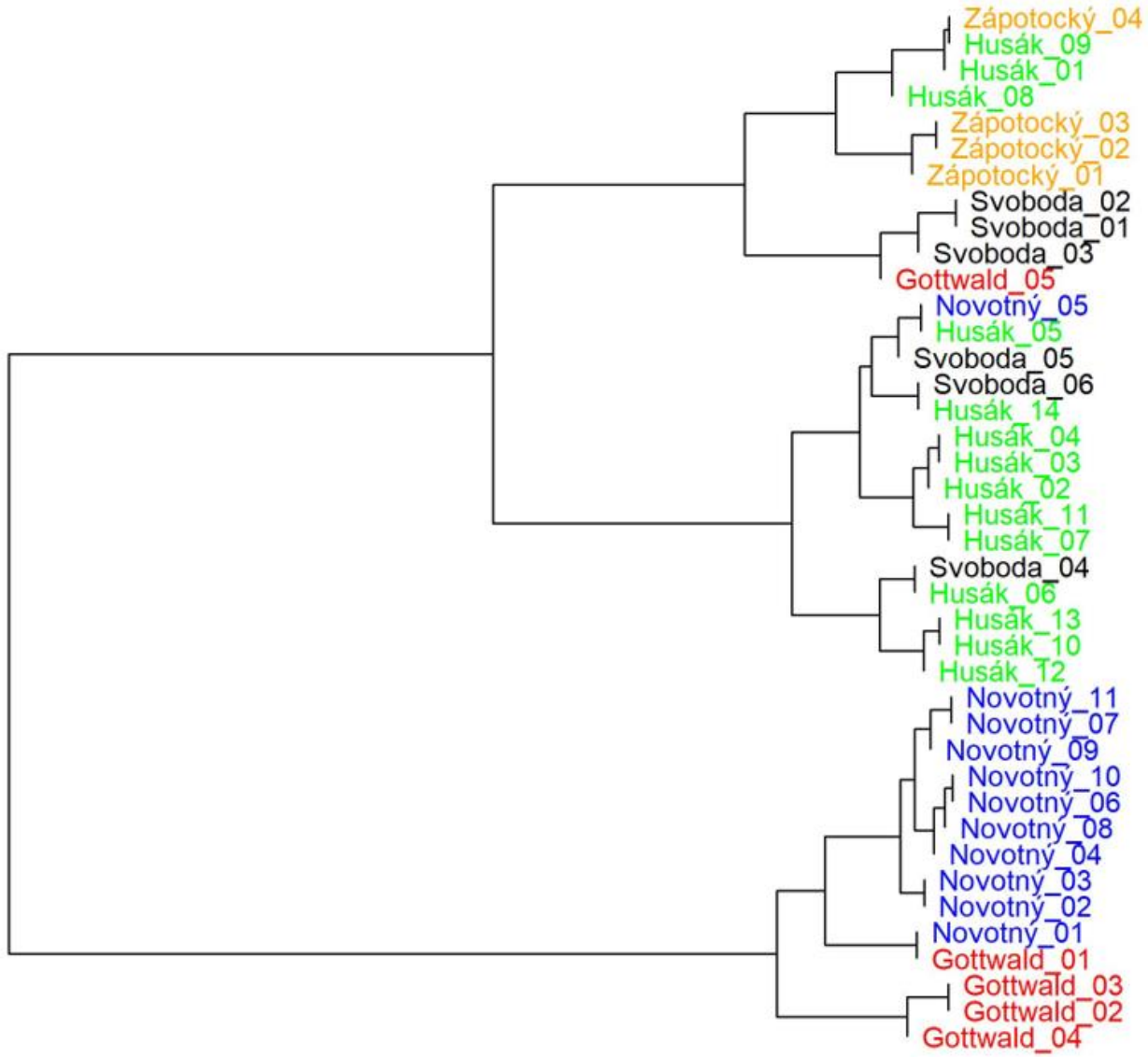


Results – democratic presidents

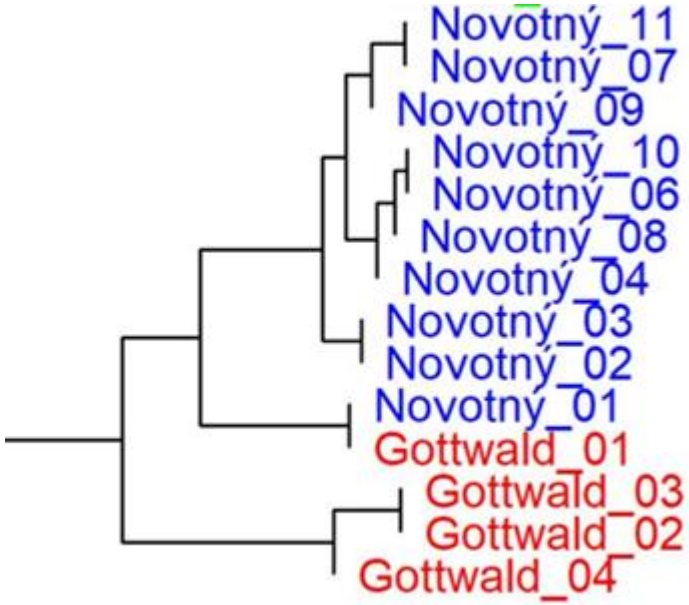




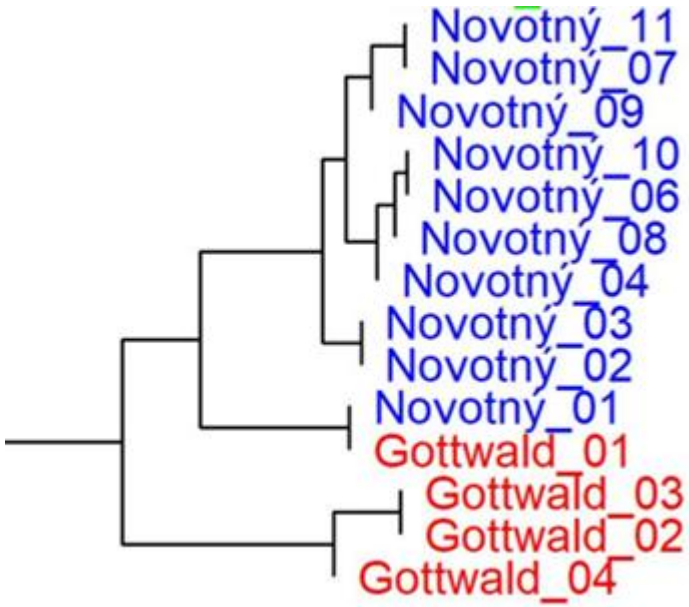
Results – communist presidents

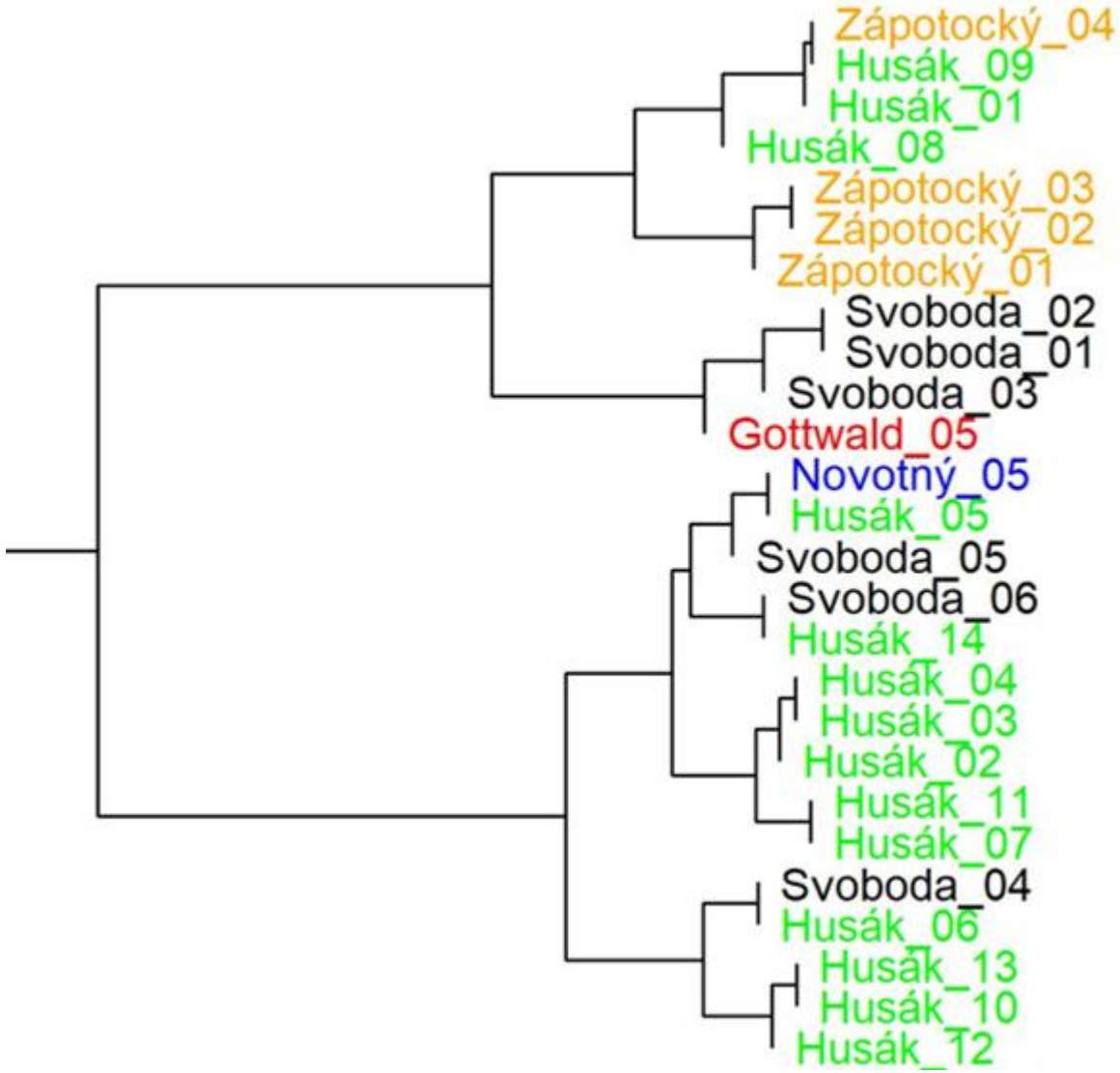


Results – communist presidents



Results – communist presidents

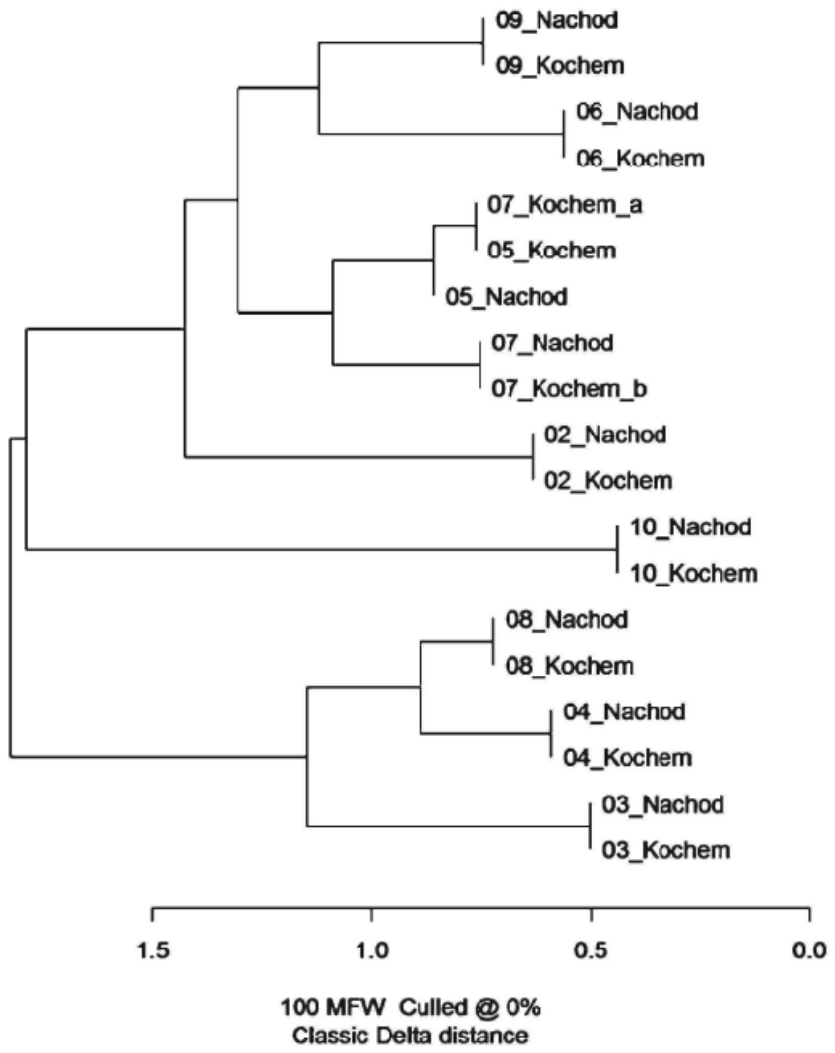




Baroque Prayers

- Kubát, M., Netolická, Š., Čech, R., Mačutek, J. (2021). Martin of Cochem's Golden Key of Heaven and its Czech Relatives: Quantitative Analysis of Baroque Prayers. Bohemistyka, 21, 283-294.

Baroque Prayers



Thank you
for your attention!