

# Multi-alignment

a central method to quantify models  
of linguistic diversity and change

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# Central Approach: Multi-alignment

- Alignments of words
- Alignments of sounds

***In linguistics,  
an alignment is a central result,  
not an intermediate method***

# Multi-alignment of words

- Based on a sentence-by-sentence alignment, induce word-by-word alignment
- Translations can be (and often are!) quite different
- Bi-text alignment is widely researched problem
- Multit-text alignment not so much

Kong Herodes blev skrækslagen , og Jerusalem begyndte at summe af rygter .

Als dies dem König Herodes zu Ohren kam , erschrak er , und mit ihm entsetzte sich auch ganz Jerusalem .

But Herodes the king heard , and was troubled , and all Urishlem with him .

Pegar Heródes heyrði þetta , varð hann skelkaður og öll Jerúsalem með honum .

Als des dr Kenig Herodes ghärt het , isch scha ( er ) arg vuschrocke un mit nem ganz Jerusalem ,

Kort voor lank het Herodes ook van die geleerdes uit die ooste se storie te hore gekom . Hy was baie omgekrap oor wat hulle oor die nuwe Joodse koning gesê het . So ook die res van Jerusalem .

Der König Herodes war total aufgebracht , als er das hörte , und nicht nur er , alle in Jerusalem waren das .

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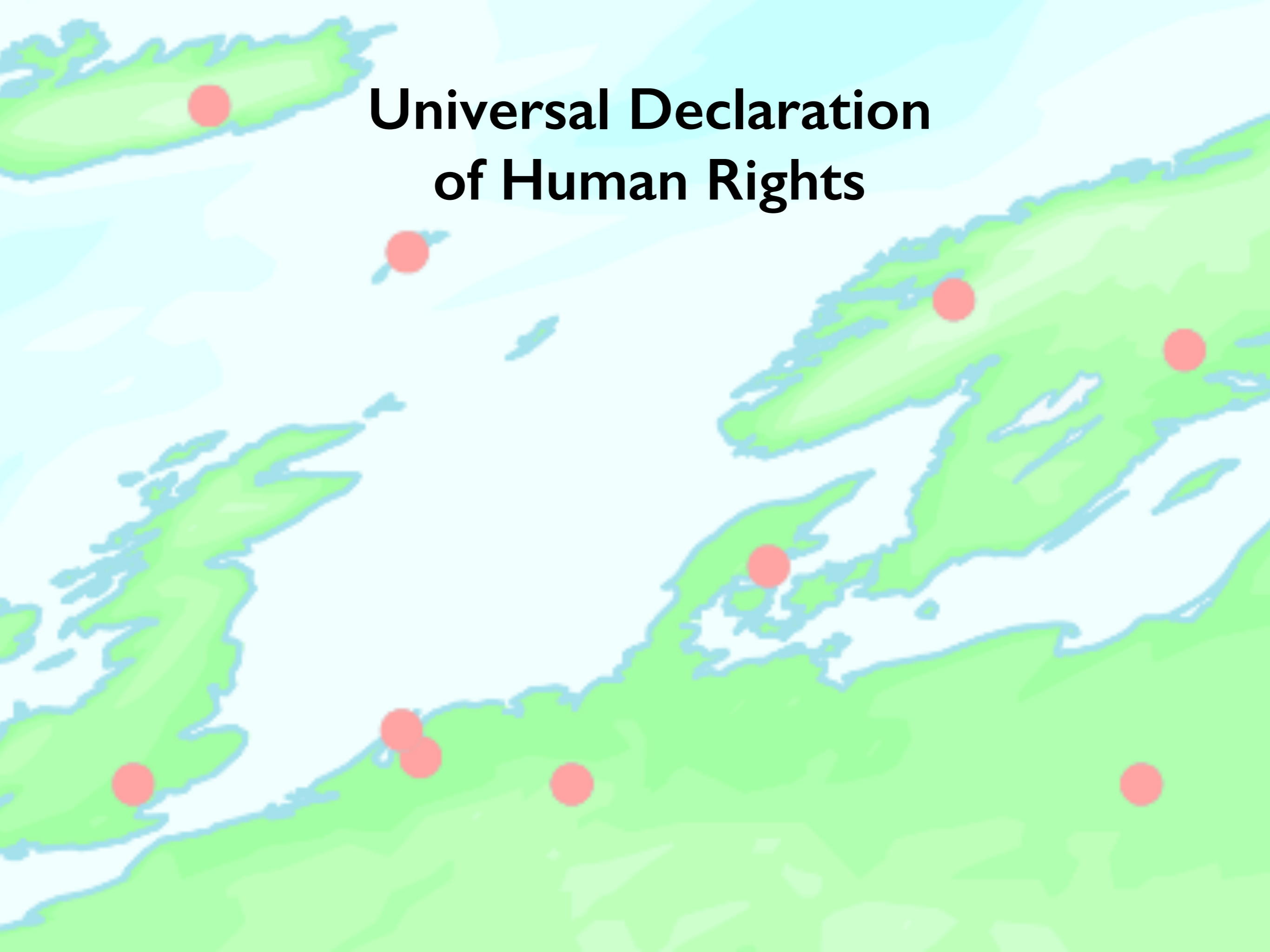
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# Universal Declaration of Human Rights







*in, im* German

*in* Dutch

*in* English

*yn* Frisian

*in* Afrikaans

*in* Scots

אין Yiddish

*í* Icelandic

*i* Swedisch

*i* Nynorsk

*i* Bokmål

*í* Faroese

*i* Danish

# Article 10

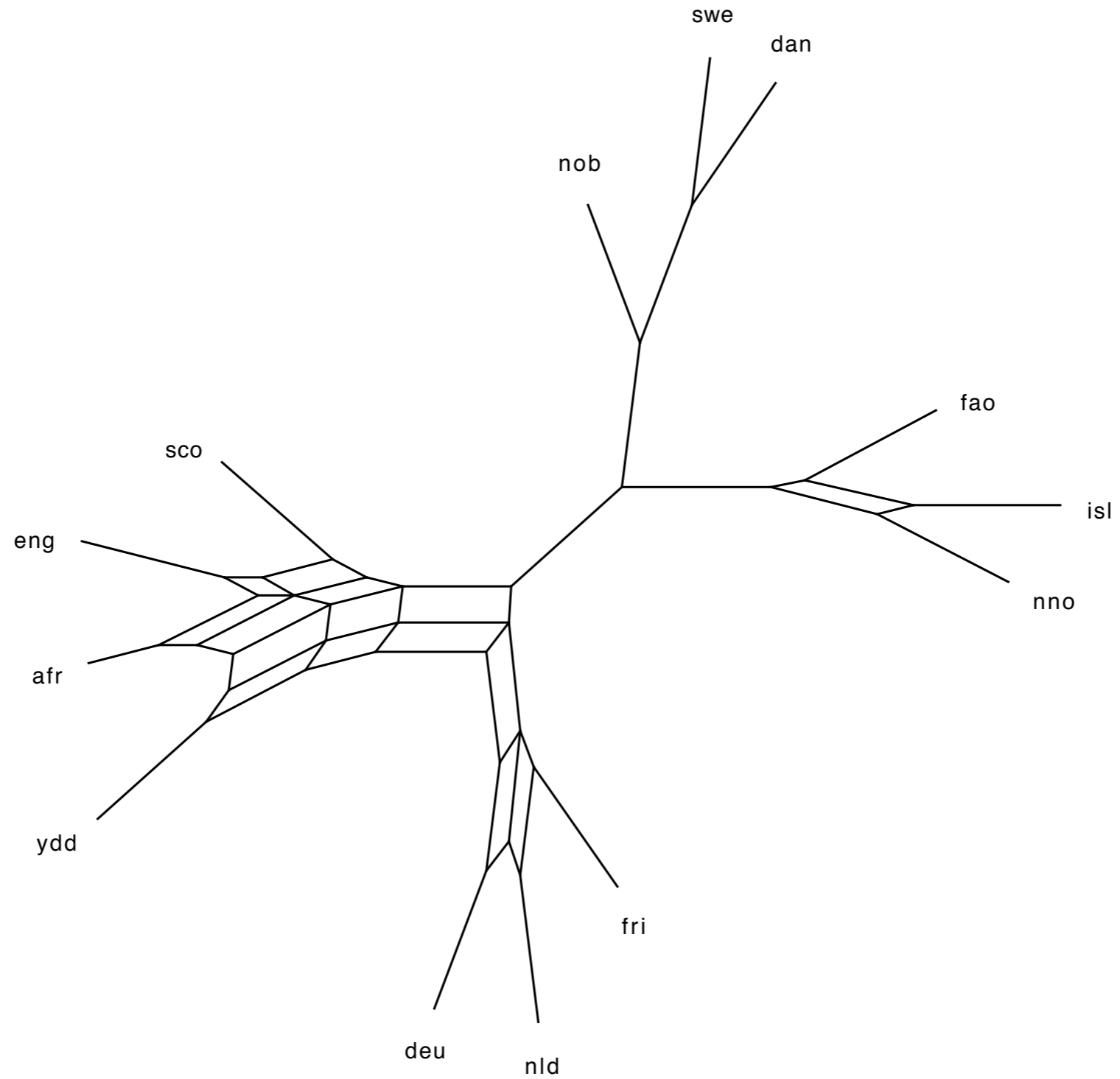
**English:** “everyone is entitled in full equality to a fair and public hearing by an independent and impartial tribunal , **in the determination of his rights and obligations and of any criminal charge against him .**”

**Afrikaans:** “elkeen het , in volle gelykheid , die reg tot ’n regverdige en openbare verhoor deur ’n onafhanklike en objektiewe tribunaal , **in die bepaling van sy regte en verpligtinge en die ondersoek van enige kriminele saak teen hom .**”

**German:** “jeder hat **bei der feststellung seiner rechte und pflichten** sowie bei einer gegen ihn erhobenen strafrechtlichen beschuldigung in voller gleichheit anspruch auf ein gerechtes und öffentliches verfahren vor einem unabhängigen und unparteiischen gericht .”

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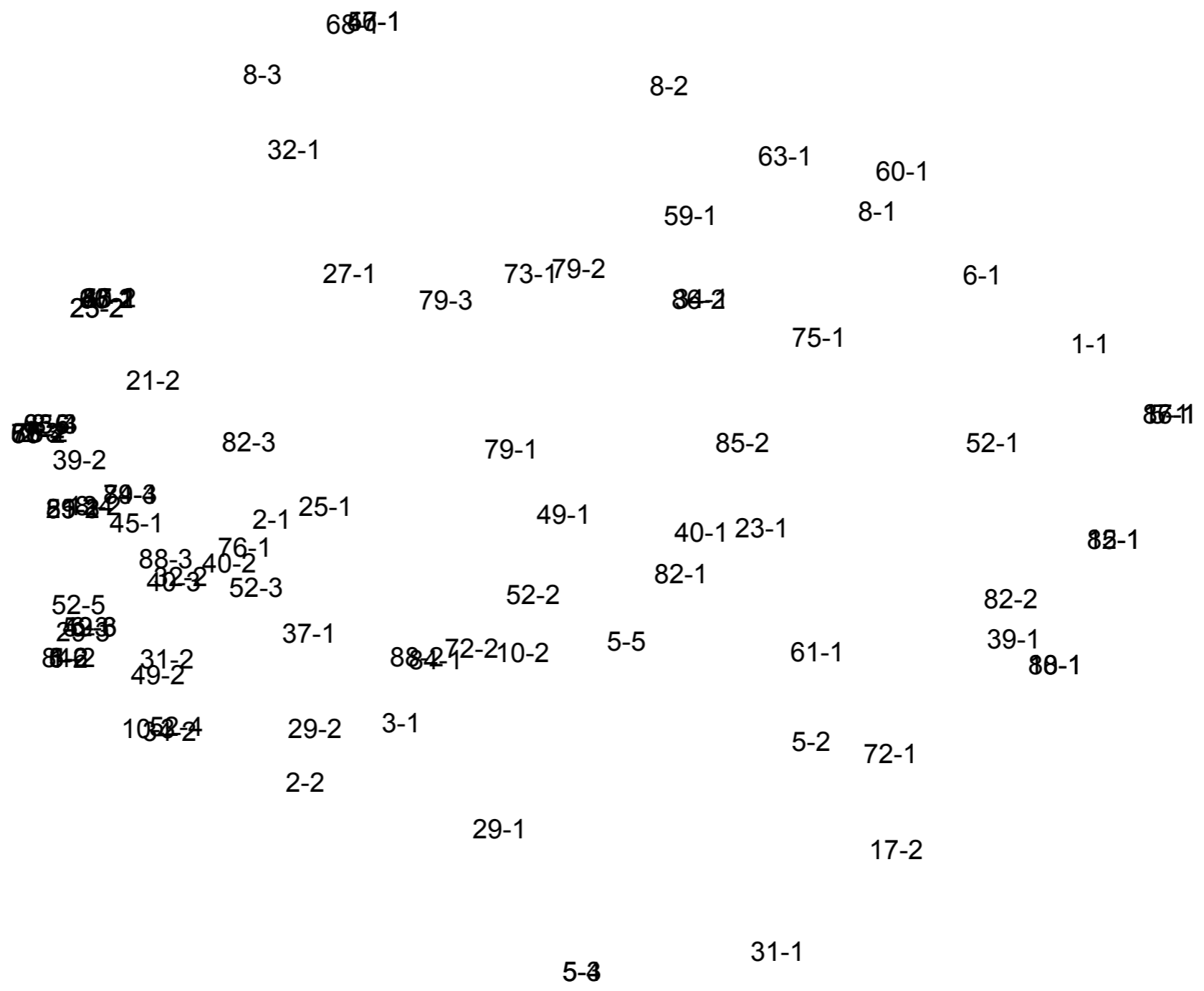
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**Consensus network of 4 optimal trees  
according to dollo Maximum Parsimony**

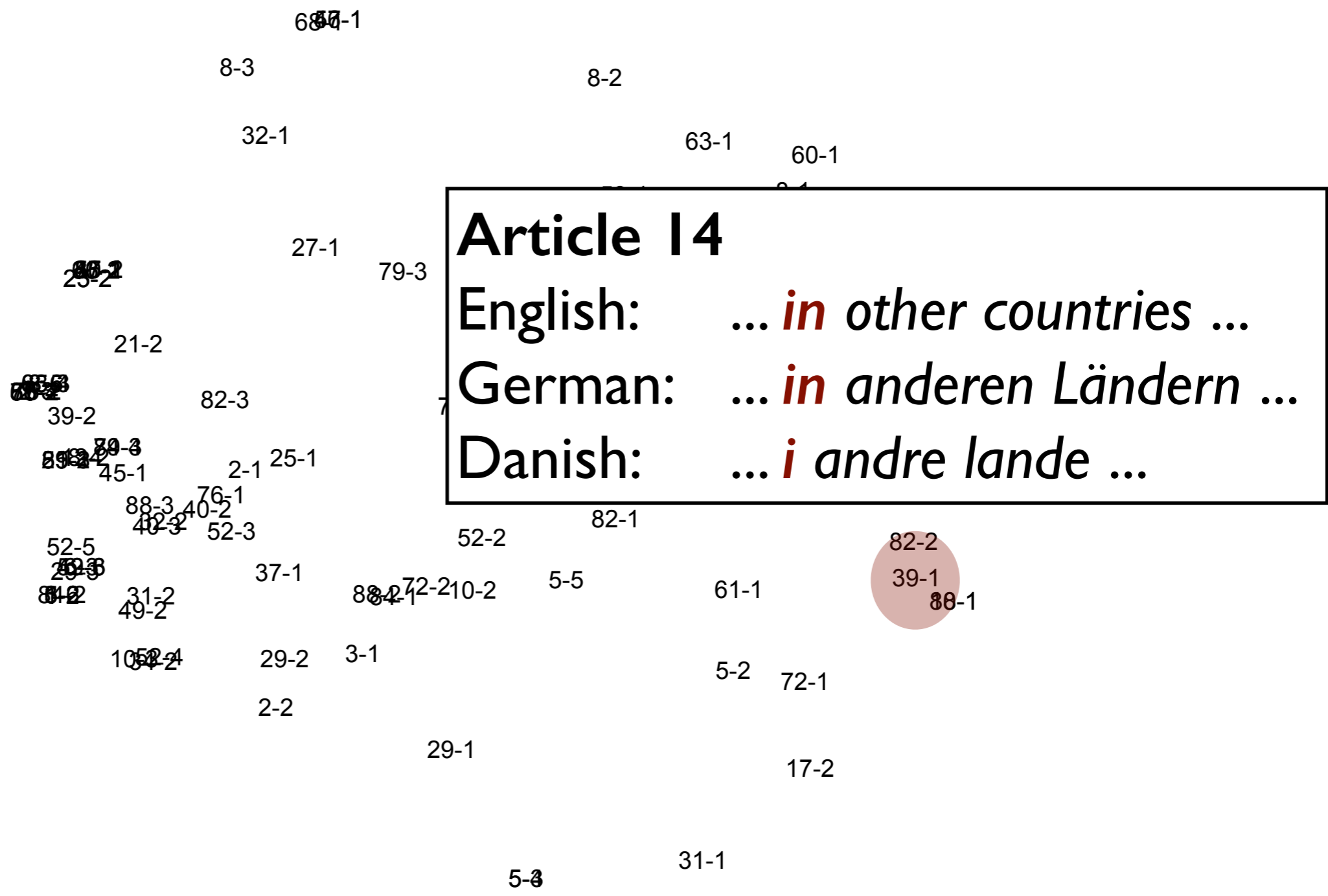
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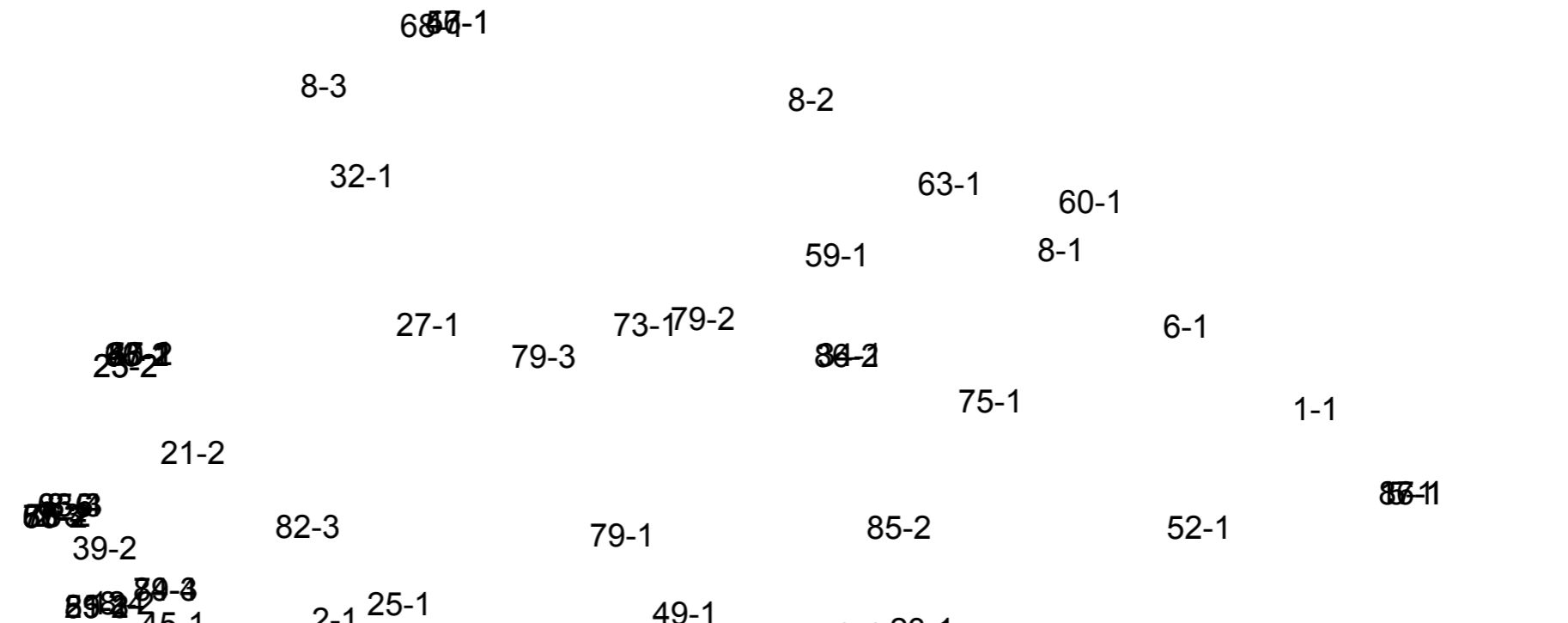


MDS (multidimensional scaling) of occurrences of *in*





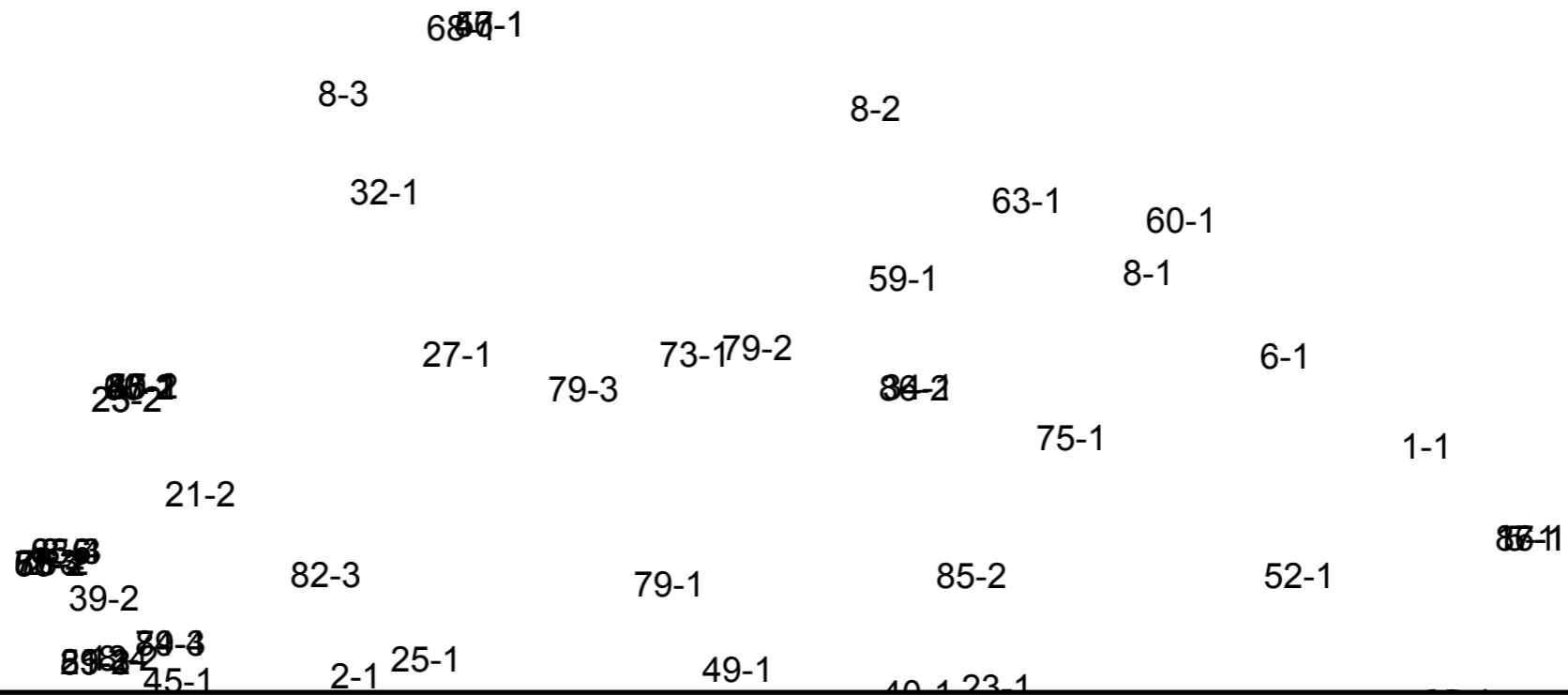
MDS (multidimensional scaling) of occurrences of *in*



**Article II**  
 English: ... *in* a public trial ...  
 German: ... *in* einem öffentlichen verfahren ...  
 Danish: ... *en* offentlig retshandling ...

5-3      31-1

MDS (multidimensional scaling) of occurrences of *in*



## Preamble

English: ... *their faith **in** fundamental human rights ...*

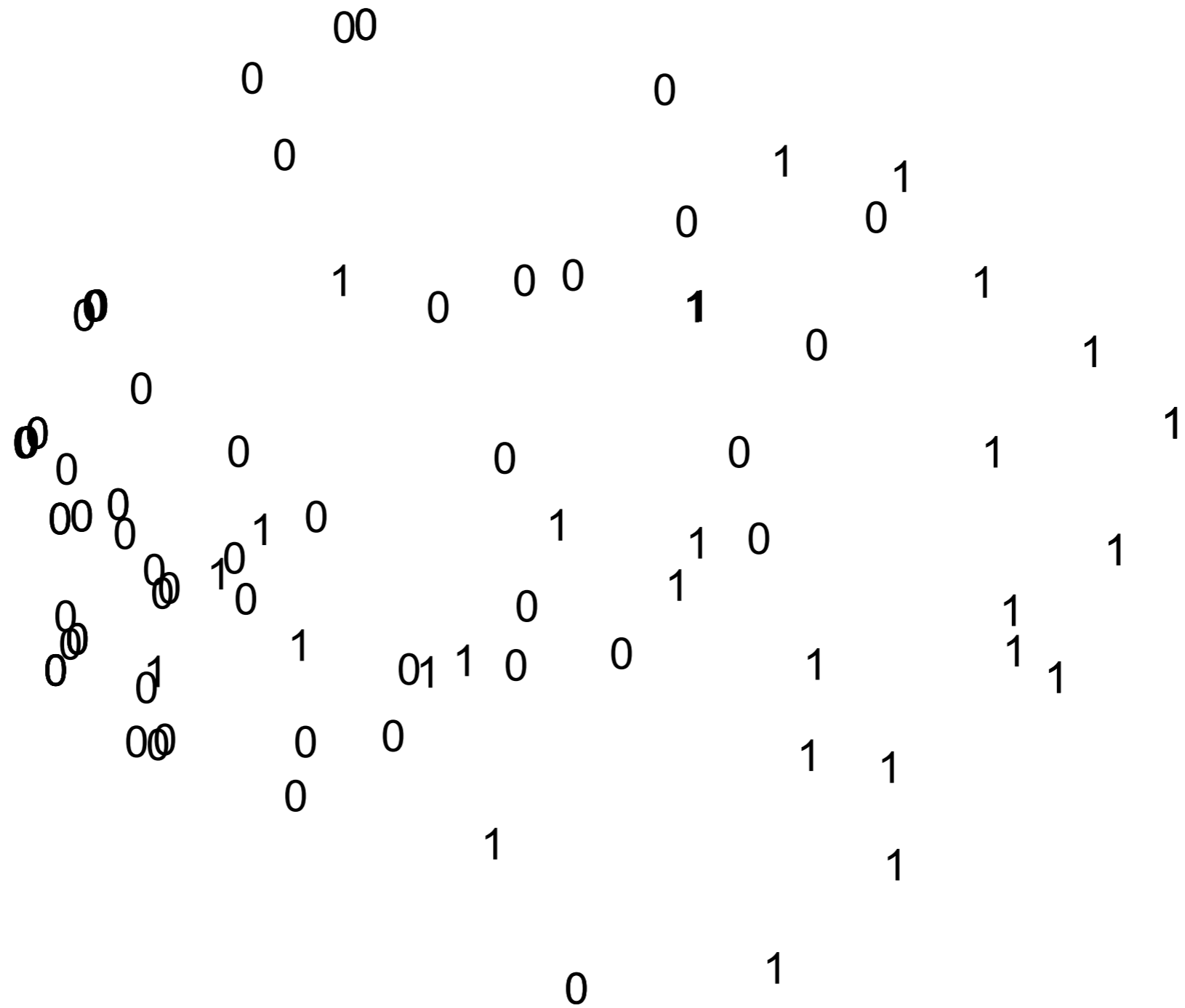
German: ... *ihren Glauben **an** die grundlegenden Menschenrechte ...*

Danish: ... *deres tro **på** fundamentale menneskerettigheder ...*

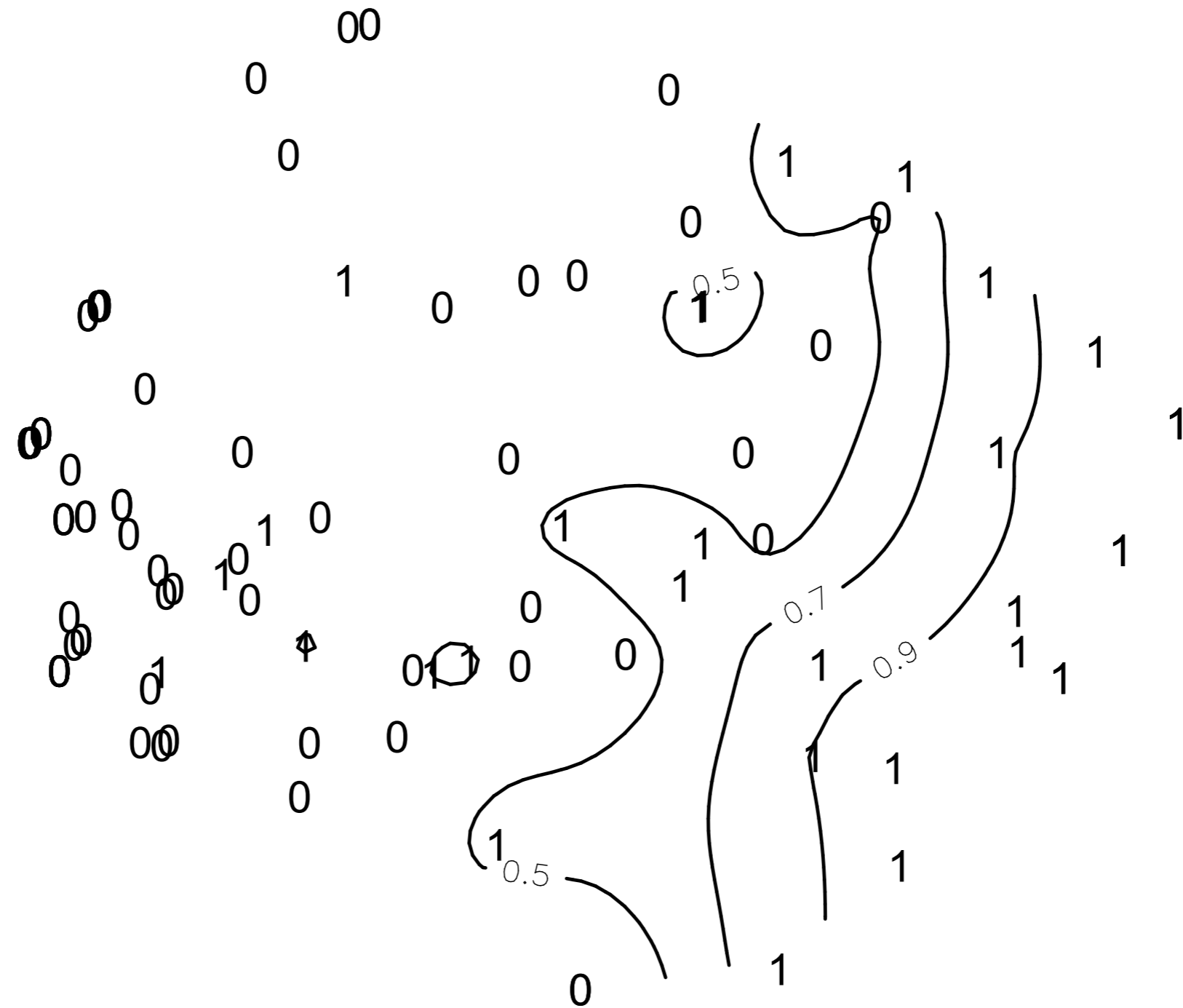


31-1

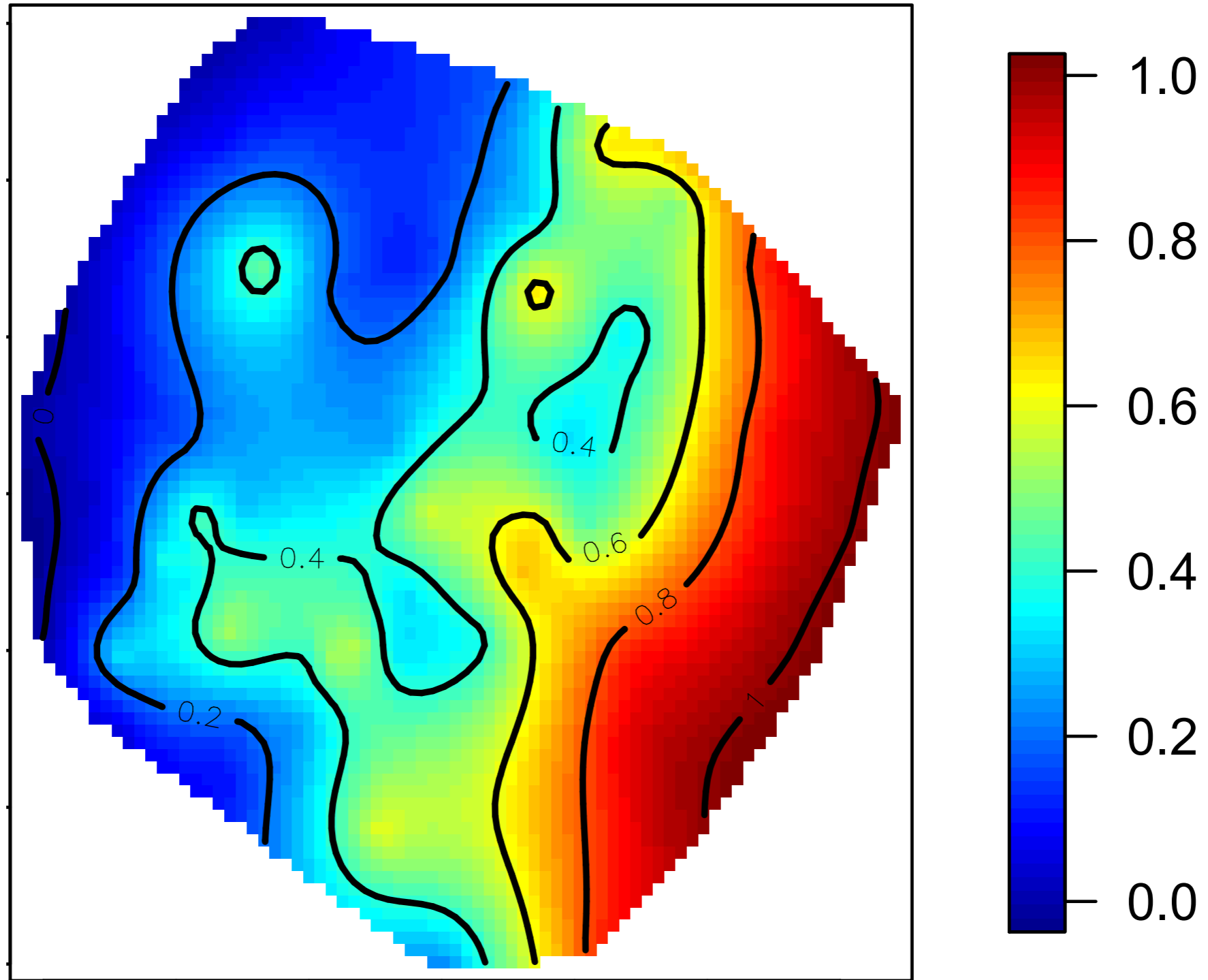
MDS (multidimensional scaling) of occurrences of *in*



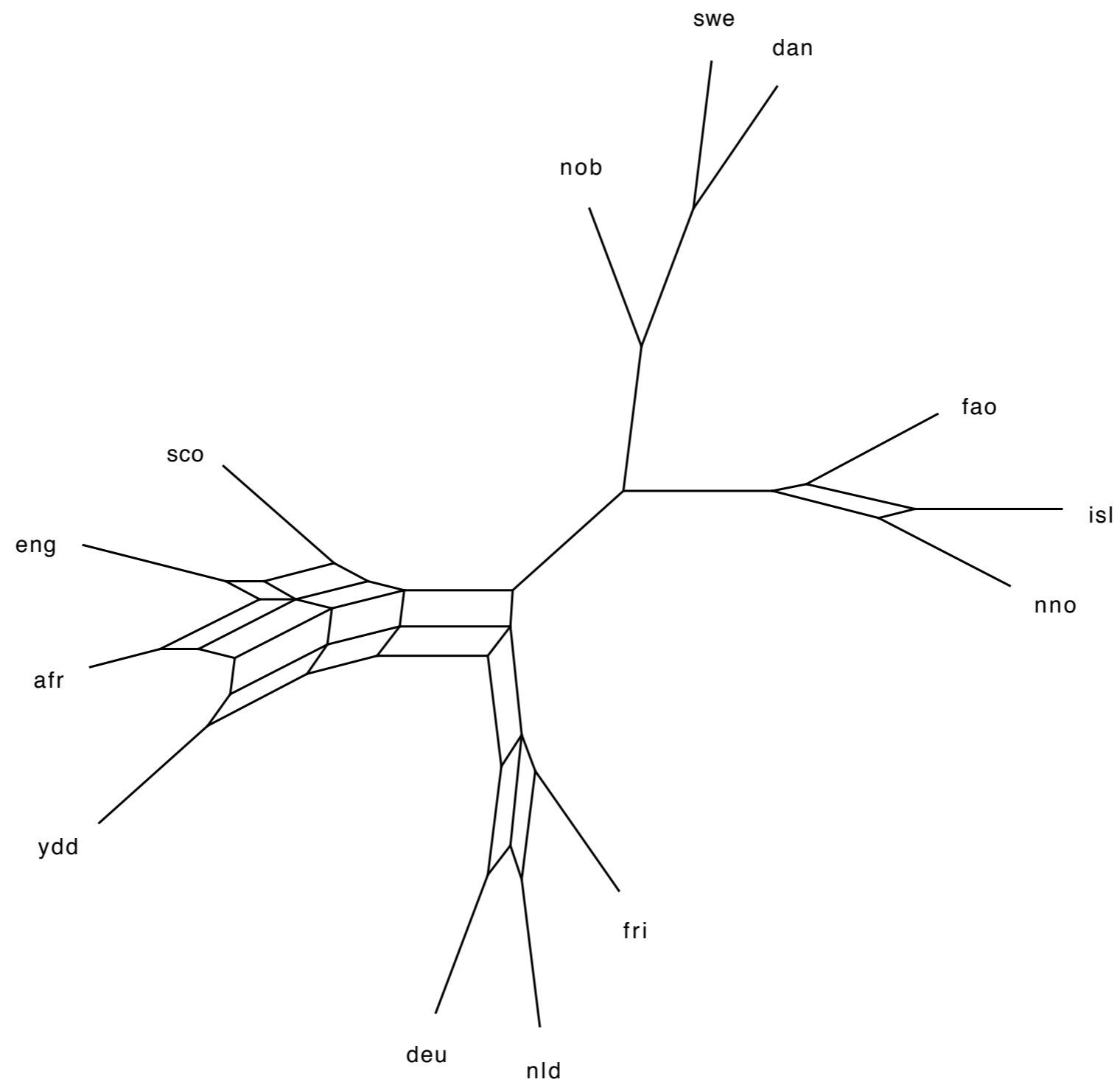
Occurrences of *in* in German (marked by '1')

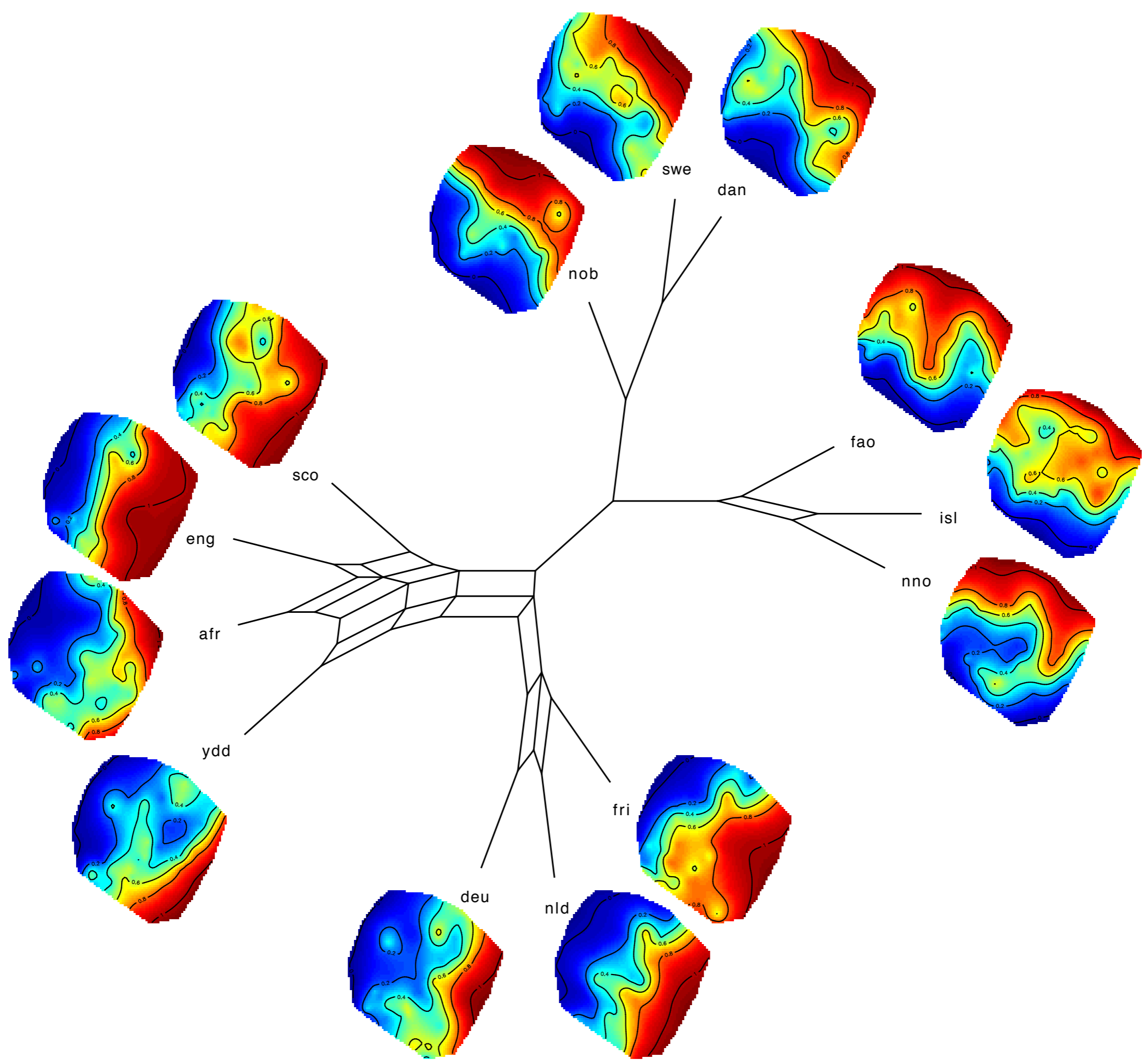


Probability of occurrence of German *in*



Probability of German *in* as colour scale







A stylized map of Southeast Asia and Oceania. The landmasses are colored in shades of green and yellow, while the surrounding waters are light blue. Several colored dots are scattered across the map: yellow dots are located in the Philippines, Indonesia, and New Zealand; a red dot is in the Malay Peninsula; and purple dots are in Australia and the Pacific Islands. A semi-transparent white rectangular box is centered over the map, containing the title text.

# Introducing the *Parallel Text Corpus*

# Parallel Text Corpus

- Universal Declaration of Human Rights
- Pamphlets of the Jehovas Witnesses
- Bible
- currently a private github repo: but I invite everybody to become a member

# Parallel Bible Corpus

- 1169 translations online (soon 1600+)
- 906 different ISO-639/3 codes (soon 1300+)
- In total more than 350 Million tokens
- More than 17 Million different wordforms
- <http://paralleltext.info/data>

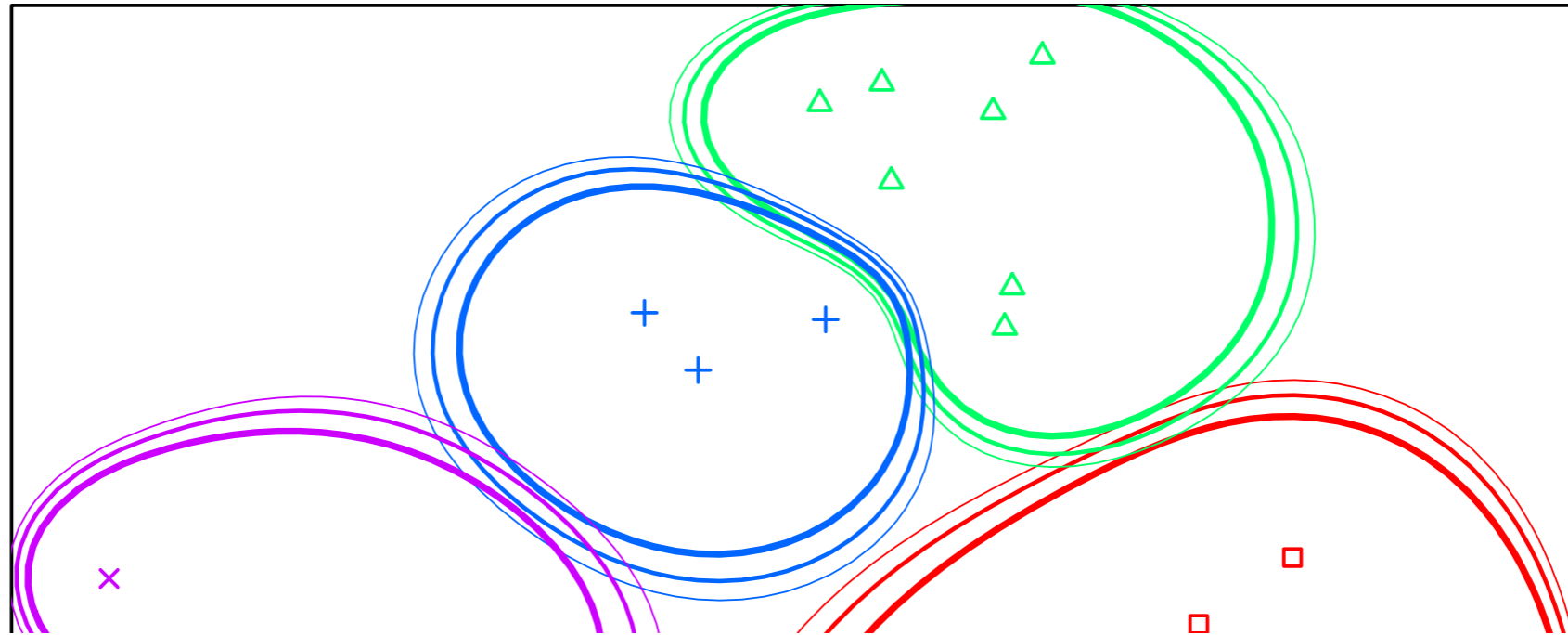
***Demo***

# Multiple Alignment

- Small-scale experiment
  - ▶ use *fastalign* for bitext-alignment on all pairs
  - ▶ build multi-text-alignment using graph clustering
- Only for 77 Germanic translations
- New Testament produced almost 100.000 Germanic alignments, which are directly comparable ‘words’

**trees and wood**

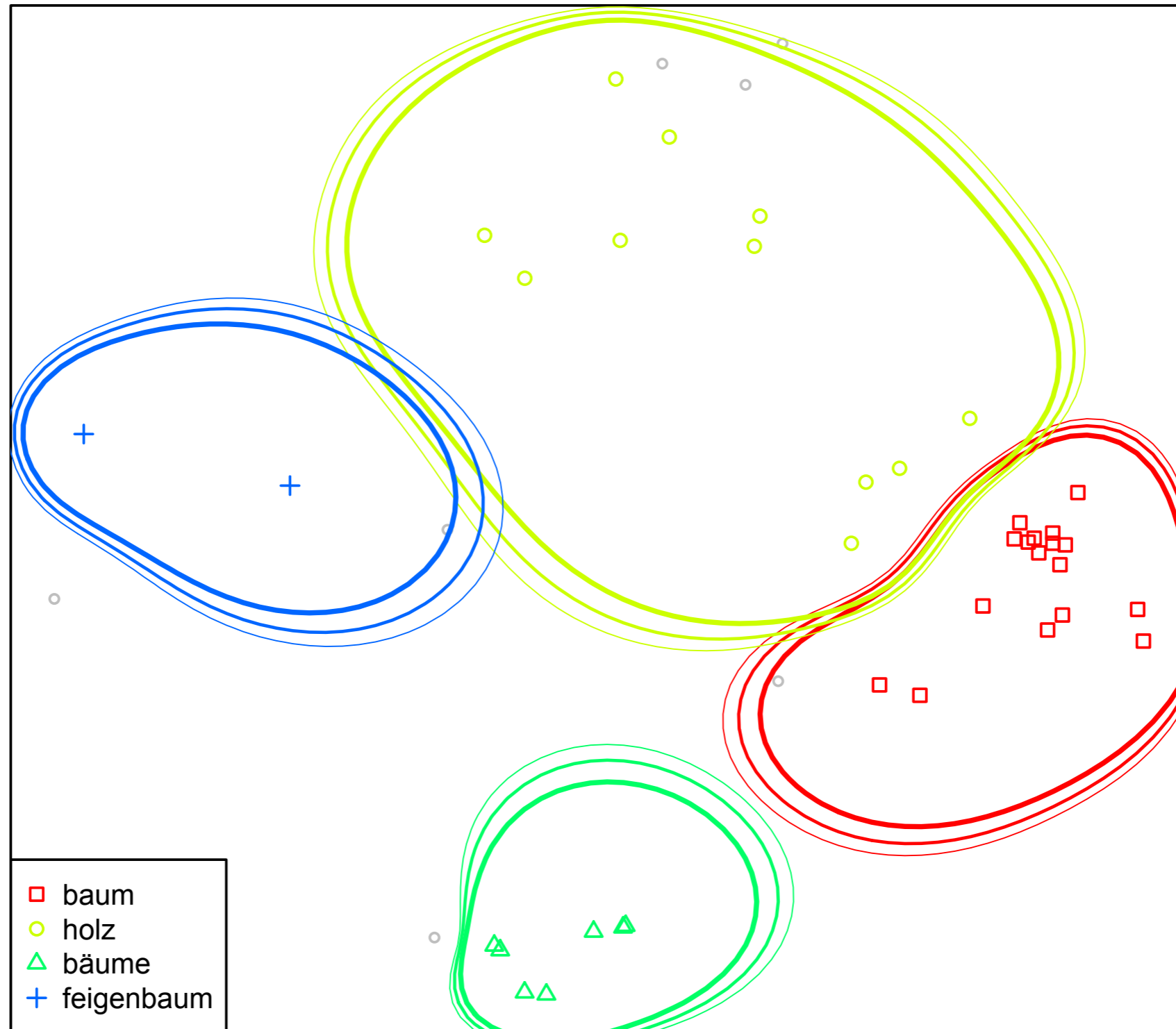
# afr-x-bible-1953.txt



	<u>tree</u>	<u>wood (stuff)</u>	<u>firewood</u>	<u>small forest</u>	<u>large forest</u>
German	<i>Baum</i>	<i>Holz</i>		<i>Wald</i>	
Danish	<i>træ</i>			<i>skov</i>	
French	<u><i>arbre</i></u>	<u><i>bois</i></u>		<u><i>forêt</i></u>	
Spanish	<u><i>árbol</i></u>	<u><i>madera</i></u>	<u><i>leña</i></u>	<u><i>bosque</i></u>	<u><i>selva</i></u>

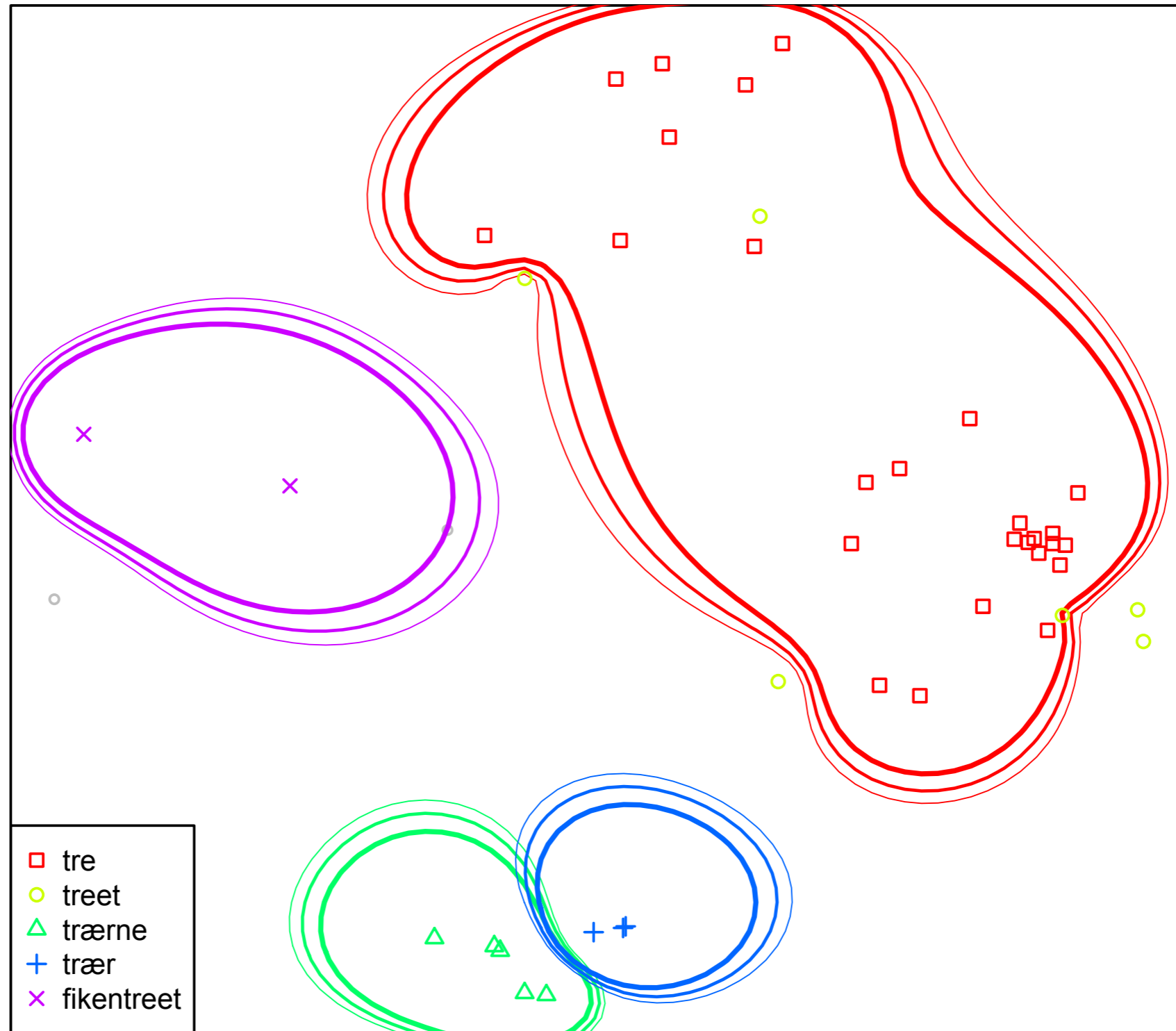
Louis Hjelmslev  
*Prolegomena to a Theory of Language* (1963)

# deu-x-bible-erben.txt



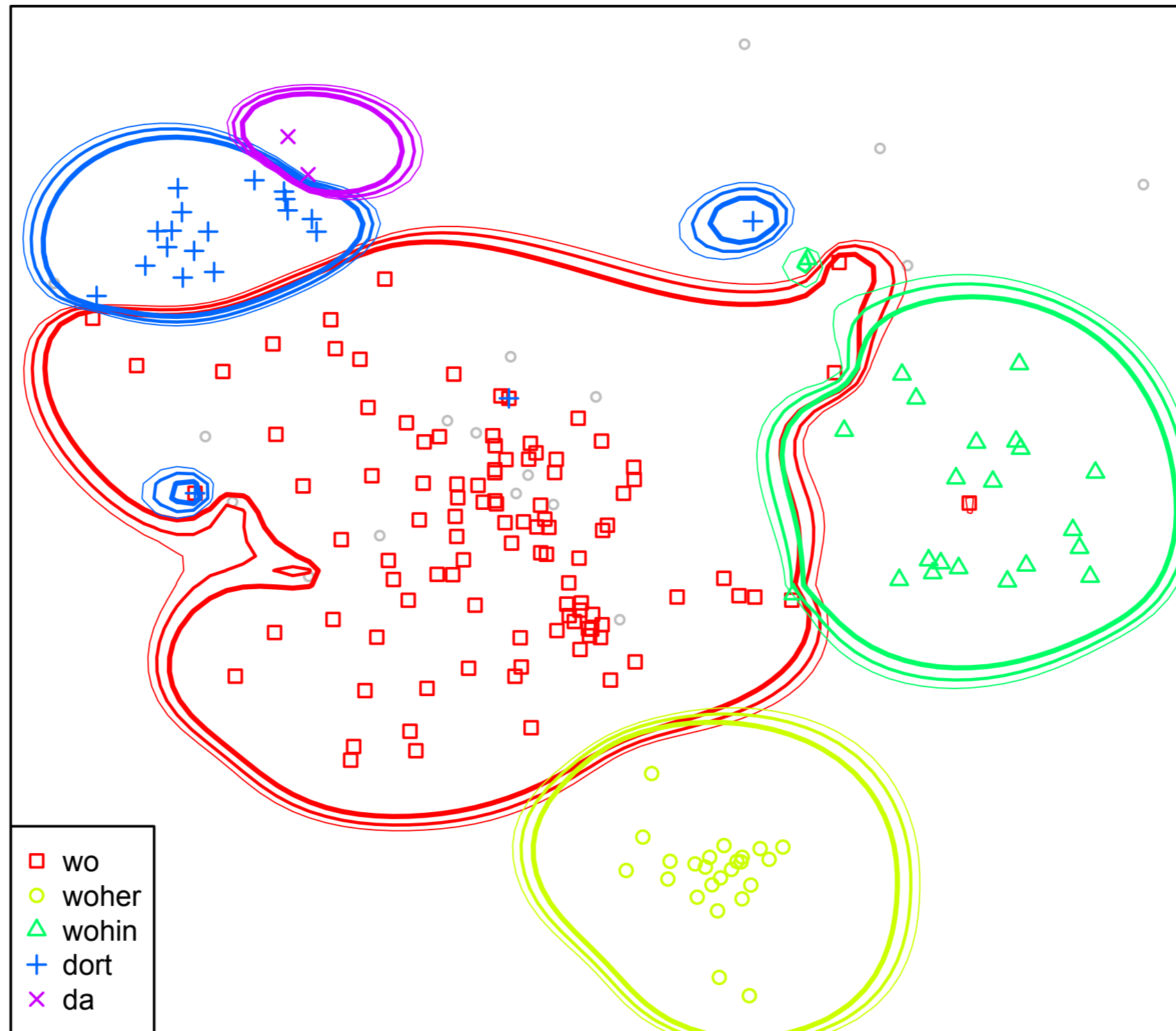


# nob-x-bible-2007.txt

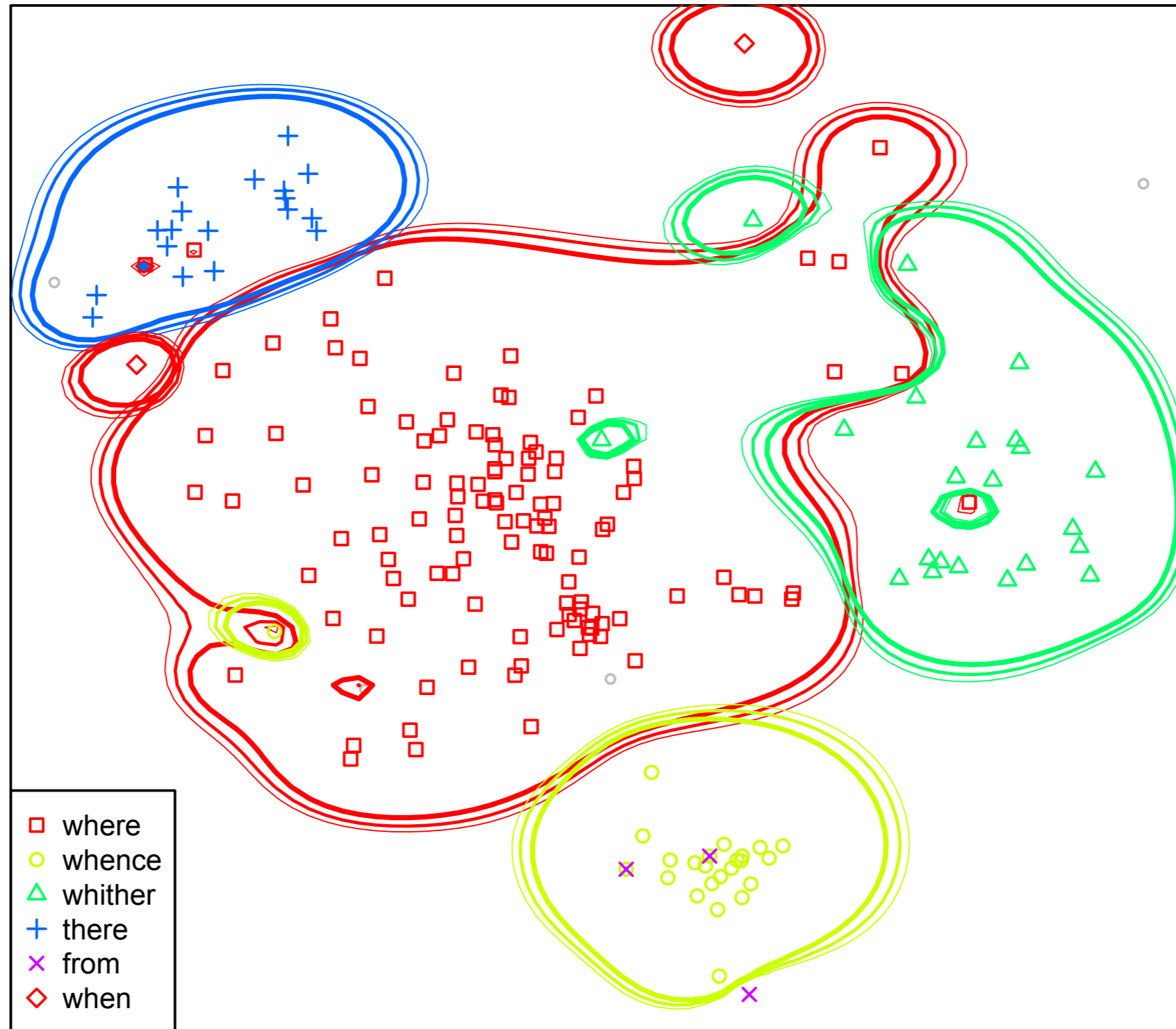


where

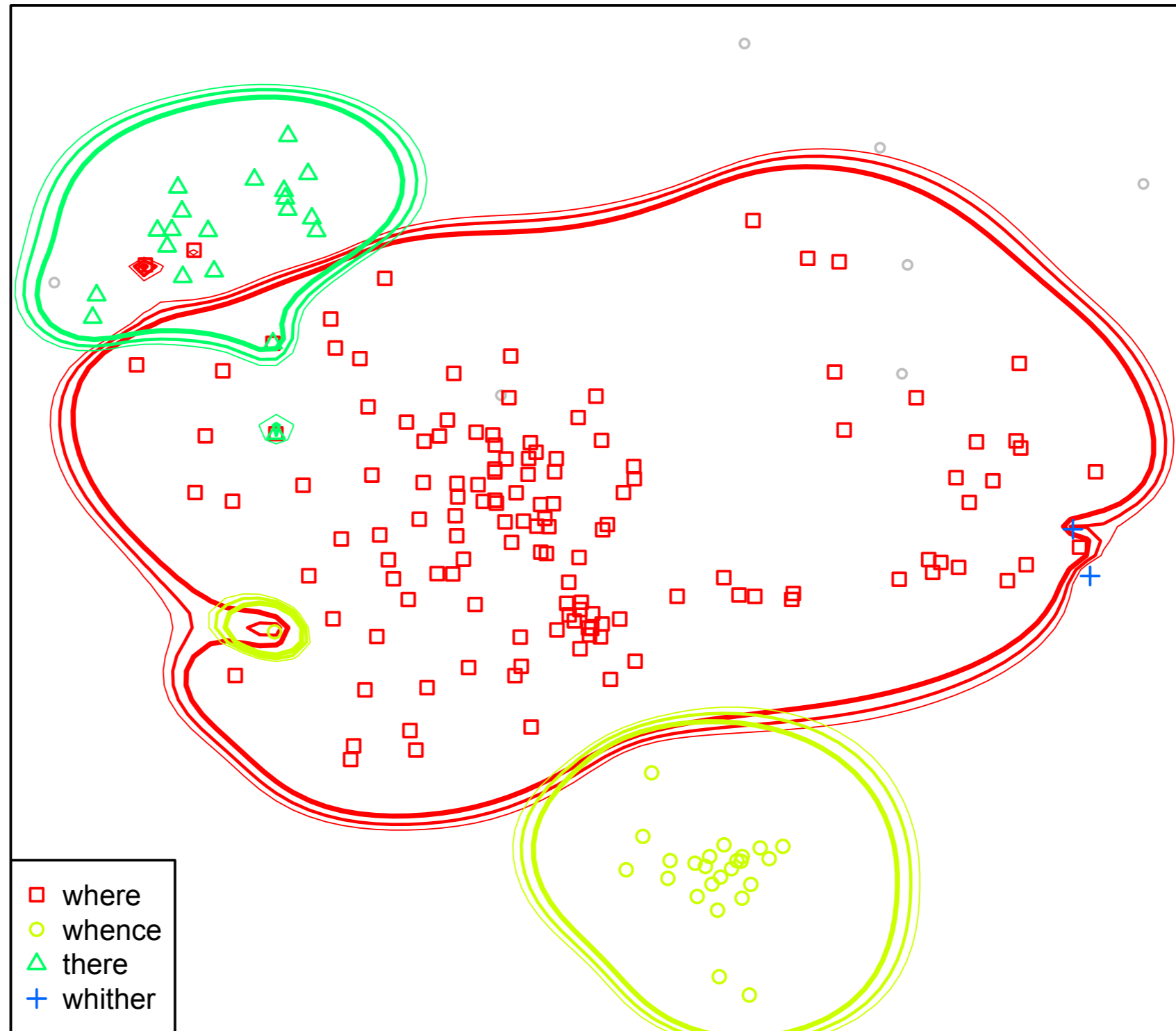
# deu-x-bible-pattloch.txt



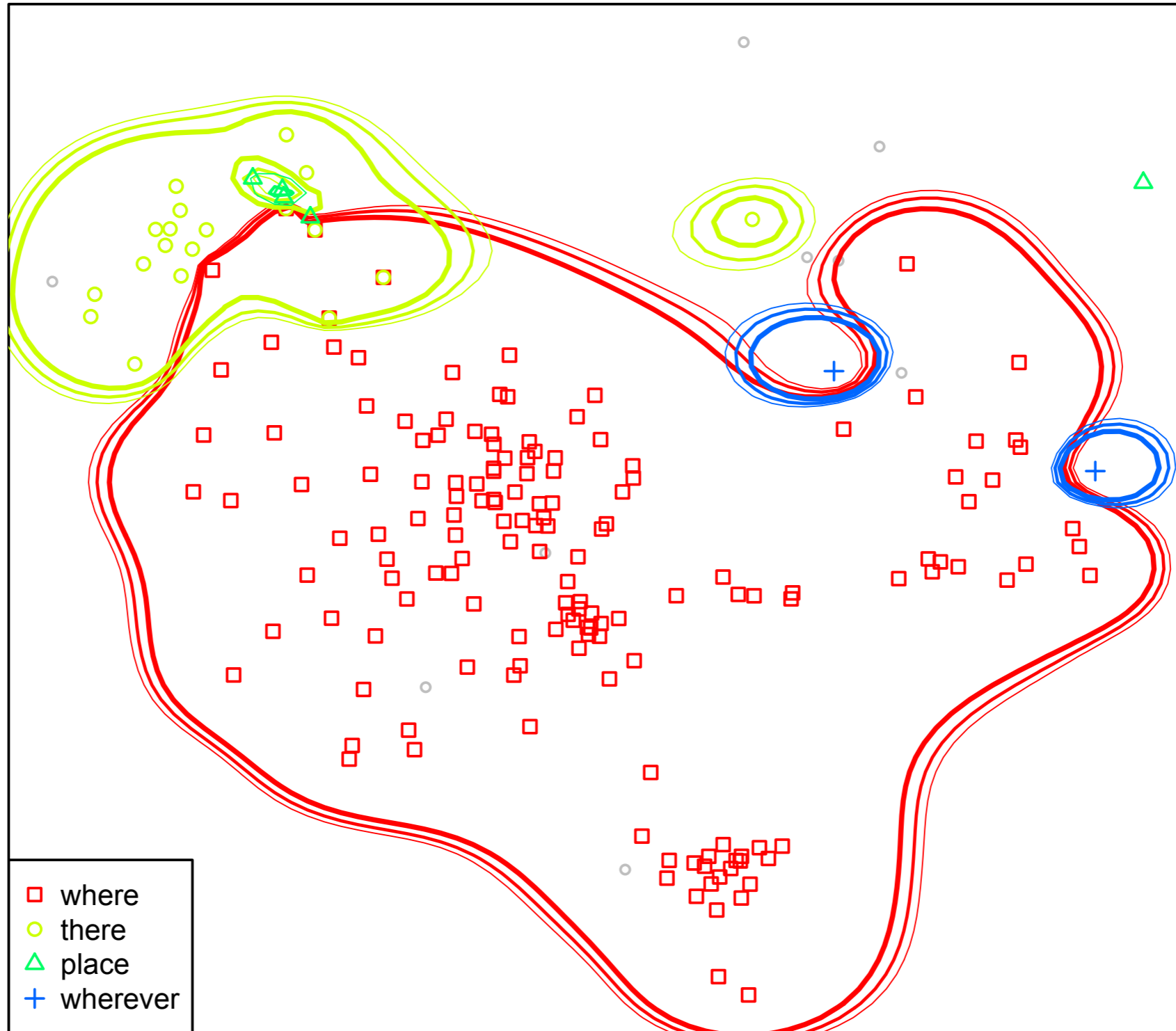
# eng-x-bible-kingjames.txt



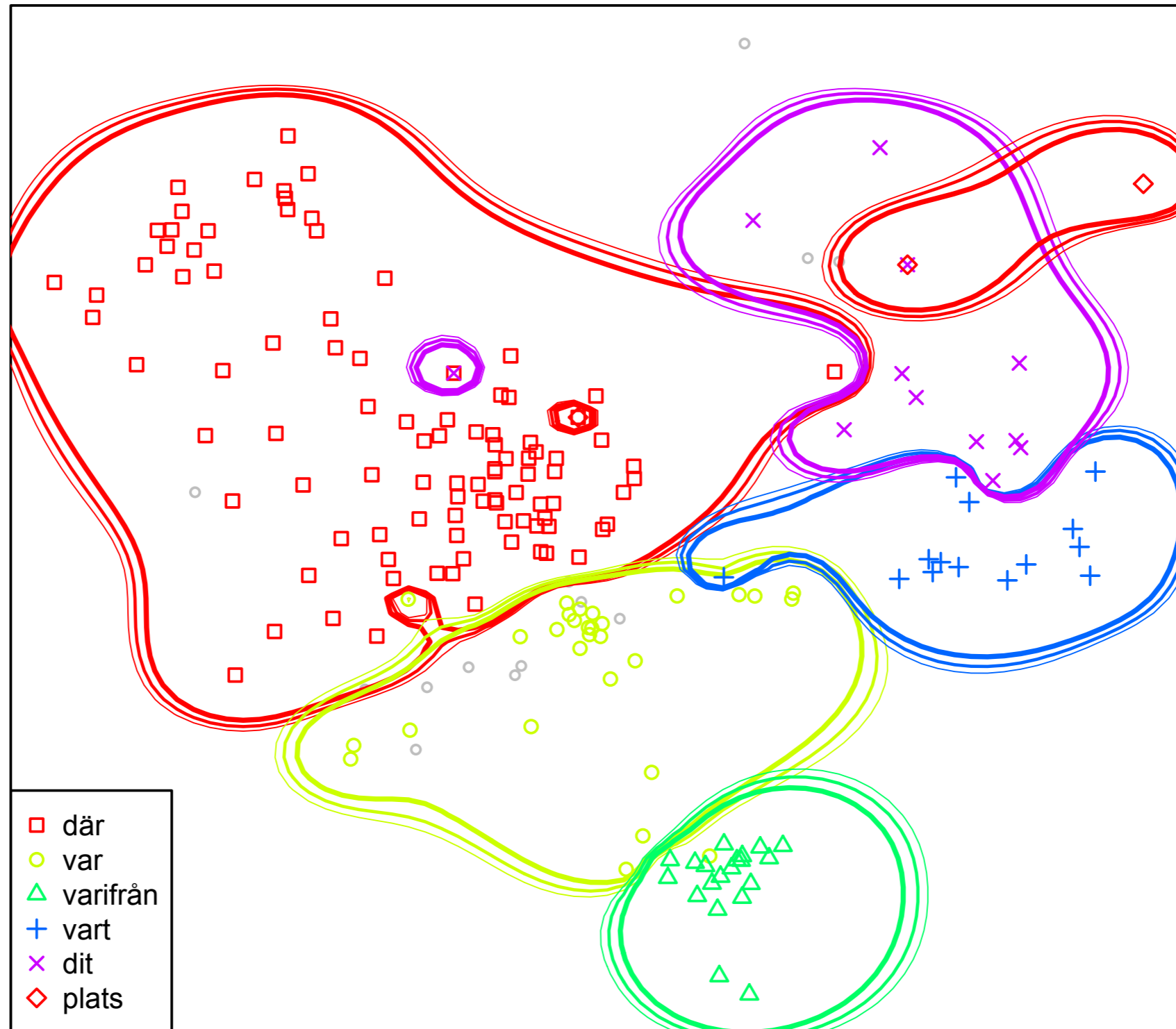
# eng-x-bible-darby.txt



# eng-x-bible-treeoflife.txt



# swe-x-bible-folk1998.txt



# Multi-alignment of Sounds

Lfd. Nr.	Stichwort	Transkription	Bemerkungen
1	Winter	178 'vɪntə <sup>h</sup> ʁ	ʁ = kontinuierlich ə bereits velarisierter
* 2	fliegen	56 'flaɪ→ə <sup>h</sup> tə	'fliegen die', Segmentierung unklar - kein geminiertes [t]
3	Blätter	23 'blɛ:də <sup>h</sup> ʁ	
4	Luft	103 lʊ <sup>h</sup> ft <sup>h</sup>	ʁ = kontinuierlich
5	hört	89 hɪ <sup>h</sup> t <sup>h</sup>	ʁ = kontinuierlich
6	gleich	78 ˌklɛ <sup>h</sup> ɪk <sup>h</sup>	folgt P
7	schneien	130 ʃnɛɪ <sup>h</sup> n	
8	Wetter	174 /	statt dem 'vɛtə <sup>h</sup> ʁ
9	tu	151 dɛ <sup>h</sup> ʊ	



Ort der Mundart/Kreis Astfeld/ Günthersheim	Aufnahme-Nr. I/62	Transkribent Angelika Braun	Listentyp A
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# Phonetischer Atlas von Deutschland

- Wenker-sentences recorded in the 1960s (with additions in the 1970s)
- Selected words from the recordings were transcribed on paper in the 1980s
- A joint project between Marburg and Groningen digitized the data in the 2000s
- In total 29530 words distributed over 183 locations and 186 cognate sets

Lfd. Nr.	Stichwort	Transkription	Bemerkungen
1	Winter	178 vɪntɐ	k = kontinuant b = kontinuant
2	fliegen	56 flaɪən	'fliegen die', Sequenzierung unklar - kein genügendes [tʰ]
3	Blätter	23 blætɐ	
4	Luft	103 lʊft	= kontinuant
5	hört	89 hœrt	= kontinuant
6	gleich	118 glɛɪç	
7	schneien	130 ʃnɛiən	
8	Wetter	17 vɛtɐ	statt dem 'vɛtəʀɔgə'
9	tu	151 tu	

Ort der Mundart/Kreis Astfeld/ Gandersheim	Aufnahme-Nr. I/62	Transkribent Angelika Trauer	Listentyp A
Planrechteck X 29	Aufnahmedatum 20.11.1965	Transkribiert von 14.6.1985 bis 24.7.1985	
besprochen von 24.07.1985 25.07.1985 UStv			

Lfd. Nr.	Stichwort	Transkription	Bemerkungen
1	Winter	178 'vɪntə <sup>h</sup>	ʔ = kontinuant ə bereit velarisier
* 2	fliegen	56 'flaɪ→ə <sup>h</sup>	'fliegen die', Sequenzie- rung unklar - kein geminiertes [t]
3	Blätter	23 'blɛ:də <sup>h</sup>	
4	Luft	103 lu <sup>h</sup> ft <sup>h</sup>	ʔ = kontinuant
5	hört	89 hɪ <sup>h</sup> t <sup>h</sup>	ʔ = kontinuant
6	gleich	78 klɛ <sup>h</sup> →ɪk <sup>h</sup>	folgt P
7	schneien	130 ʃnɛ→ɪən	
8	Wetter	174 /	statt demoa 'vɪtə <sup>h</sup> ʀɔŋə
9	tu	151 dɛ→u	

Ort der Mundart/Kreis	Aufnahme-Nr.	Transkribent	Listentyp
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# Phonetischer Atlas von Deutschland

X 27	20.11.1965	bis 24.7.1985
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- Digitised in X-SAMPA, converted back to match original transcriptions, minor corrections for consistency of encoding

- The data is transcribed in high phonetic detail (3786 different phonetic segments)

- We make the complete data available
  - ▶ electronically, separated by phonetic segments
  - ▶ as close as possible to the original source
  - ▶ including all idiosyncrasies
  - ▶ [github.com/cysouw/PAD](https://github.com/cysouw/PAD)

Lfd. Nr.	Stichwort	Transkription	Bemerkungen
1	Winter	vɪntə	kontinuant
2	fliegen	flaɪ→ətʰ	2 boreif, velarisier fliegen, fleue nung 'uklar' - kau semi-vowels, etc.
3	Plätter	ble:ɔtə	kontinuant
4	Luft	luɔftʰ	
5	hört	hœrt	kontinuant
6	gleich	kleɪk	folgt
7	gleich	kleɪk	
8	gleich	kleɪk	stark dekon 'vɪtə Rɔŋə
9	tu	deu	

LOCATION	WORD
Aachen	a:ph
Adorf	ɑ:b <sup>h</sup> ə
Ahrbergen	o̘→ɔ̘phə
Albersloh	ɑ:p <sup>h</sup> ə
Allna	ɑϕh
Altenberg	ʌfɛ
Altentrüdin	af
Altlandsberg	ɑ'fə'
Altwarp	o:ph
Astfeld	ɒ':p <sup>h</sup> ə
Atzendorf	afɛ
Ballhausen	ʌ'fə
Bardenfleth	ɔ̘:p̄ϕ
Barssel	ɒ:p <sup>h</sup> ə
Bempflingen	af:
Bennin	ɔ̘p <sup>h</sup>
Billingsbach	af
Bockelwitz	ʌvə
Bonn	ɑ:p'
Borstendorf	ɣf:
Breddin	ɒ:ph
Brelingen	ɑfβə
Bremscheid	ɒ':p <sup>h</sup> ə
...	...

A	FF	E
a:	ph	-
ɑ:	b <sup>h</sup>	ə
o̘→ɔ̘	ph	ə
ɑ:	p <sup>h</sup>	ə
ɑ	ϕh	-
ʌ	f	ɛ
ɑ	f	-
ɑ'	f	ə'
o:	ph	-
ɒ':	p <sup>h</sup>	ə
a	f	ɛ
ʌ'	f	ə
ɔ̘:	p̄ϕ	-
ɒ:	p <sup>h</sup>	ə
a	f:	-
ɔ̘	p <sup>h</sup>	-
ɑ	f	-
ʌ	v	ə
ɑ:	p'	-
ɣ	f:	-
ɒ:	ph	-
ɑ	f̄β	ə
ɒ':	p <sup>h</sup>	ə
...	...	...

● **Workflow:**

- ▶ Tokenisation of segments ([github.com/cysouw/qlcData](https://github.com/cysouw/qlcData))
- ▶ Automatic alignment using **LingPy** ([github.com/lingpy](https://github.com/lingpy))
- ▶ Manual correction using **Alignment Editor** ([github.com/digitallinguist/msa-editor](https://github.com/digitallinguist/msa-editor))
- ▶ Separation of cognates (e.g. *Samstag* vs. *Sonnabend*)
- ▶ Annotation of columns (e.g. many-to-one alignments, metathesis)
- ▶ Merging of complex columns and removing boundaries

```

# collection : 81 ("Augenblick")
# aligned by : LingPy-2.2 <www.lingpy.org>
# created on : 2013-11-27 13:16
# parameters : library_asjp_-5_0.5_0.3_neighbor_0.5__T
# modified   : 2013-12-01 15:53 by Michael Cysouw <cysouw@uni-marburg.de>
# modified   : 2013-12-17 by Jelena Prokic <prokic@uni-marburg.de>
#
:ANN      COLUMNID..... 1   2   3   4   5   6   7   8   9   10  11
#
:ANN      STANDARD..... .   Au  g   e   n   b   l   i   .   ck   .
:ANN      COMPLEX..... <   >   .   .   .   .   .   .   <   >   .
#
12336     Adorf..... -   e→ʊ ʋ   -   ŋ   b   l   e   -   kʰ   -
12322     Ahrbergen..... -   a→ōō ɣ   ə   m   b   l   ɪ   -   kʰ   -
12334     Albersloh..... -   e→ʊ -   -   m   β   l   ɪ   -   k   -
12271     Allna..... -   ɔ: -   -   -   p   l   æʰ   -   x   -
12320     Altenberg..... ɣ   ʏ   ʋ   ð   -   b   l   ɪ   -   k   -
12326     Altentrüdin.... -   e→ʊ ʋ   ə   -   p   l   ɪ   -   g   -
12179     Altlandsberg... -   aʰ→ʊ ɣ   -   ŋ   b   l   ɪ   -   k̟x   -
12230     Altwarp..... -   ōō -   -   ŋ   b   l   ɪ   -   k   -
12215     Astfeld..... -   ʊ: ɣ   ə   m   b   l   ɪ   -   kʰ   ə
12246     Ballhausen..... -   a→ʊ ɣ   -   n   p   l   ɪ   -   k   -
12243     Bardenfleth.... -   o: g   -   ŋ   b   l   ε   -   k̟x   -
12205     Barsel..... -   o: g   -   ŋ   p   l   ɪ   -   kʰ   -
12265     Bempflingen.... -   e→ʊ g   ə   -   b   l   ɪ   -   cʰ   -
12292     Bennin..... -   o: -   -   ŋ   b   l   ɪ   -   x   -
12268     Billingsbach... -   ɔ: x   ə   -   p   l   ɪ   -   k̟x   -
12307     Bockelwitz..... -   a→w ɣ   -   ŋ   b   l   ɪ   -   k   -
12281     Borstendorf.... -   ɔ: ɣ̟x   -   n   p   l   e   -   k   -
12267     Breddin..... -   oʰ: ɣ   -   ŋ   b   l   ɪ   -   x   -
12228     Brelingen..... -   o: -   -   m   p   l   ɪ   -   k   -

```

# MSA Editor

Choose Files 3 files Augenblick\_1013.msa View Edit Reload Save

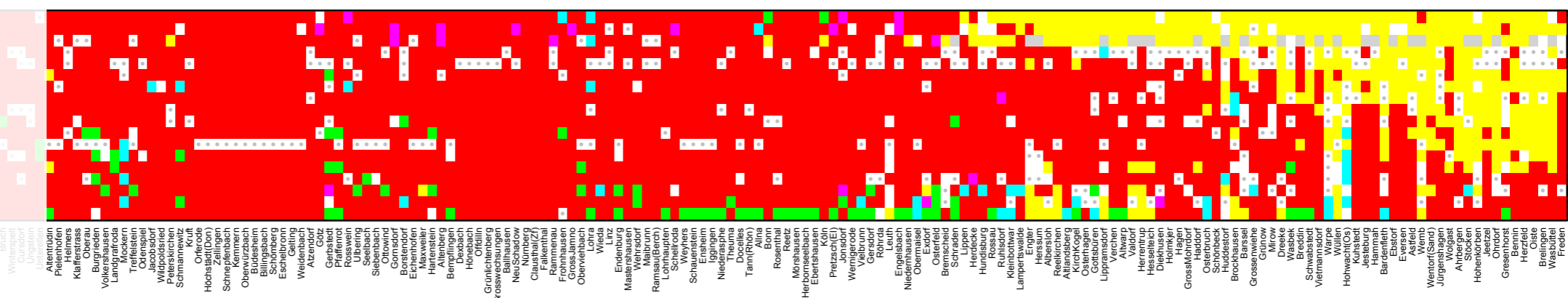
COLUMNID	1	2	3	4	5	6	7	8	9
STANDARD	Au	g	e	n	b	l	i	ck	(e)
Adorf	æ→u	ʁ	-	ŋ	b	l	ɛ	k <sup>h</sup>	-
Ahrbergen	æ→õ	ʁ	ə	m	b	l	ɪ	k'	-
Albersloh	æ→u	-	-	m	β	l	ɪ	k	-
Allna	ɔɪ	-	-	-	p	l	æ <sup>c</sup>	x	-
Altenberg	ʁʁ	ʁ	ã	-	b	l	ɪ	k	-
Altentrüdin	æ→u	ʁ	ə	-	p	l	ɪ	g	-
Altlandsberg	ɑ'→u	ʁ	-	ŋ	b	l	ɪ	k̄x	-
Altwarp	õu	-	-	ŋ	b	l	ɪ	k	-
Astfeld	ʊɪ	ʁ	ə	m	b	l	ɪ	k <sup>h</sup>	ə
Ballhausen	ɑ→u	ʁ	-	ŋ	p	l	ɪ	k	-
Bardenfleth	oɪ	g	-	ŋ	b	l	ɛ	k̄x <sub>+</sub>	-
Barssel	oɪ	g	-	ŋ	p	l	ɪ	k <sub>+</sub>	-
Bempflingen	æ→u	g	ə	-	b	l	ɪ	c <sup>h</sup>	-
Bennin	oɪ	-	-	ŋ	b	l	ɪ	x	-
Billingsbach	ɑɪ	x	ə	-	p	l	ɪ	k̄x	-
Bockelwitz	ɑ→u	ʁ	-	ŋ	b	l	ɪ	k	-
Borstendorf	ɔɪ	ʁx	-	ŋ	p	l	ɛ	k	-

[github.com/digitallinguist/msa-editor](https://github.com/digitallinguist/msa-editor)

# Correspondence Sets

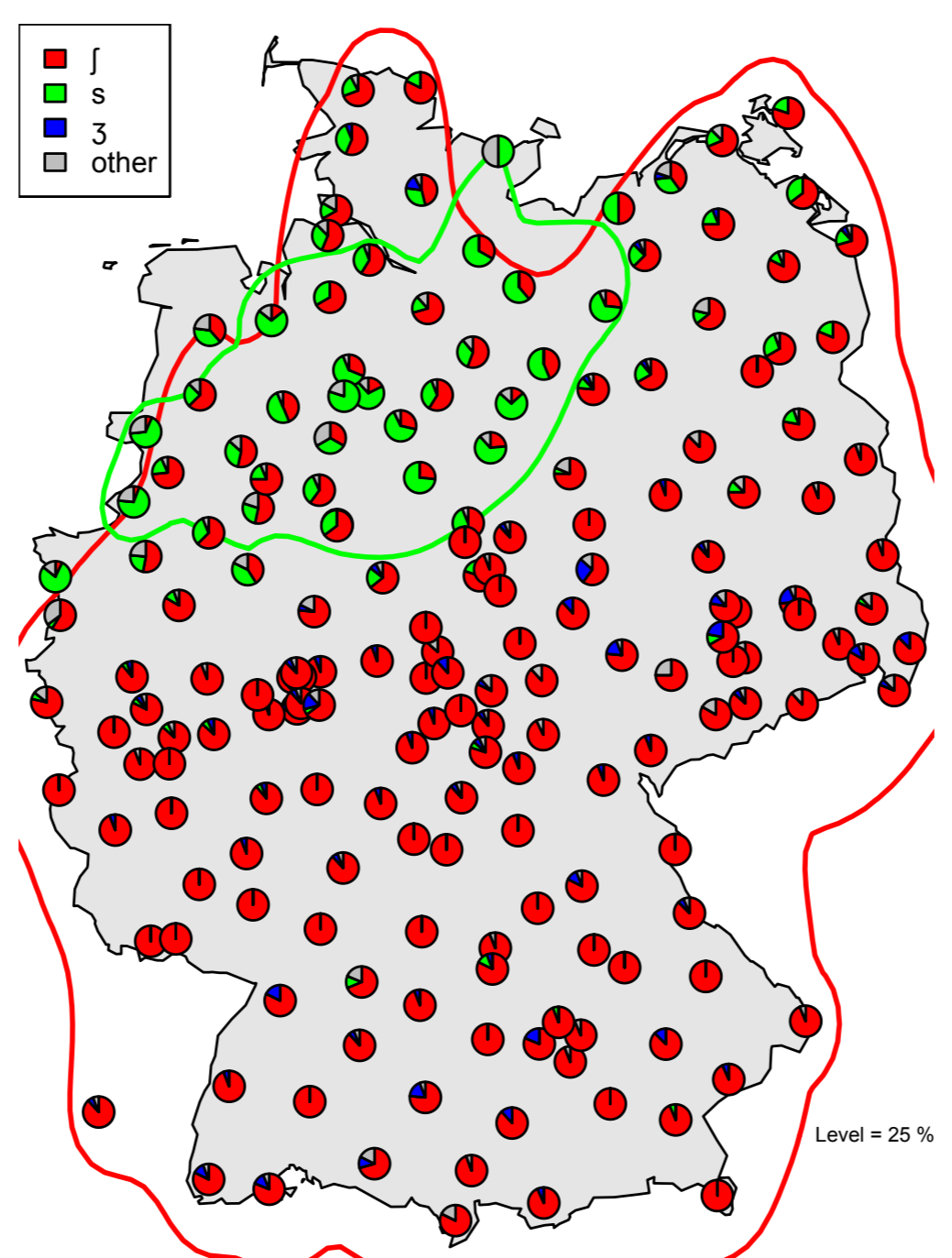
- more than 700 columns of aligned segments (“correspondences”)
- Comparative-historical linguistics uses clusters of correspondences (“correspondence sets”)
- Automatic clustering of columns is a good start, but needs correction
- Visualisations in R  
[github.com/cysouw/qlcVisualize](https://github.com/cysouw/qlcVisualize)

700 Wurst 5 s  
 172 Durst 4 s  
 142 Donnerstag 8 s  
 312 gestohlen 3 s  
 626 versteht 4 s  
 85 bestellt 3 s  
 581 Stueckchen 1 s  
 319 gestorben 3 s  
 534 schwarz 1 sch  
 188 eingeschlafen 5 sch  
 522 Schnee 1 sch  
 525 schneien 1 sch  
 516 schlechte 1 sch  
 538 Schwester 1 sch  
 530 schoene 1 sch  
 221 Fleisch 4 sch  
 587 Tisch 3 sch  
 156 Dreschen 7 sch



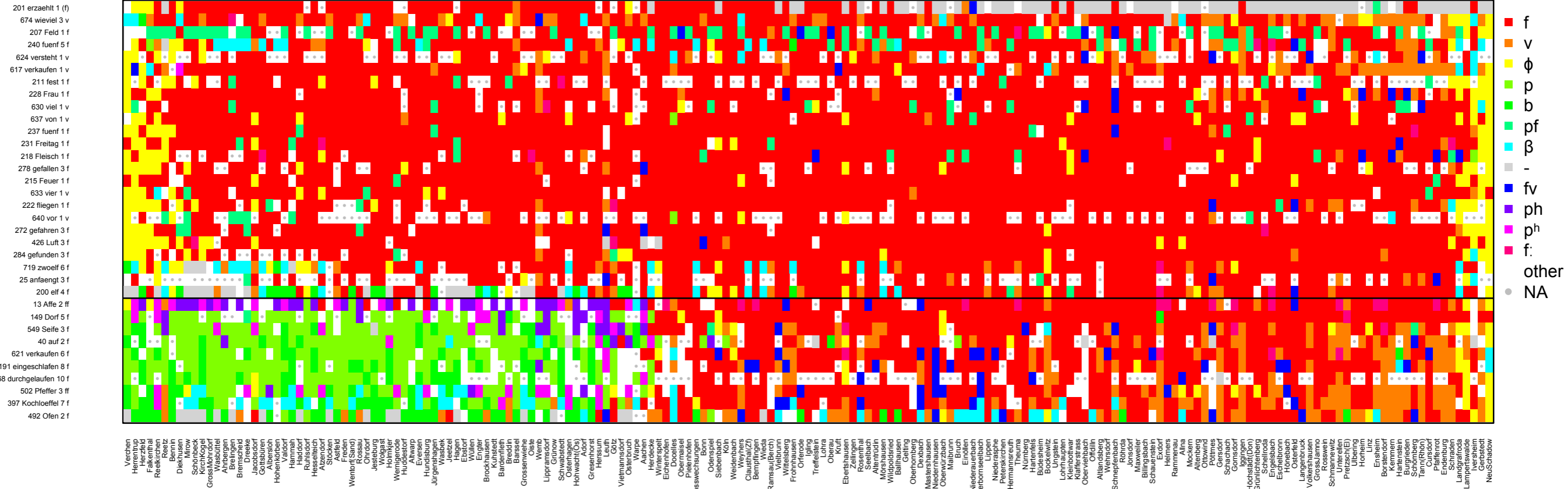
j  
 s  
 3  
 6  
 -  
 j:  
 other  
 NA

### Correspondences "sch"



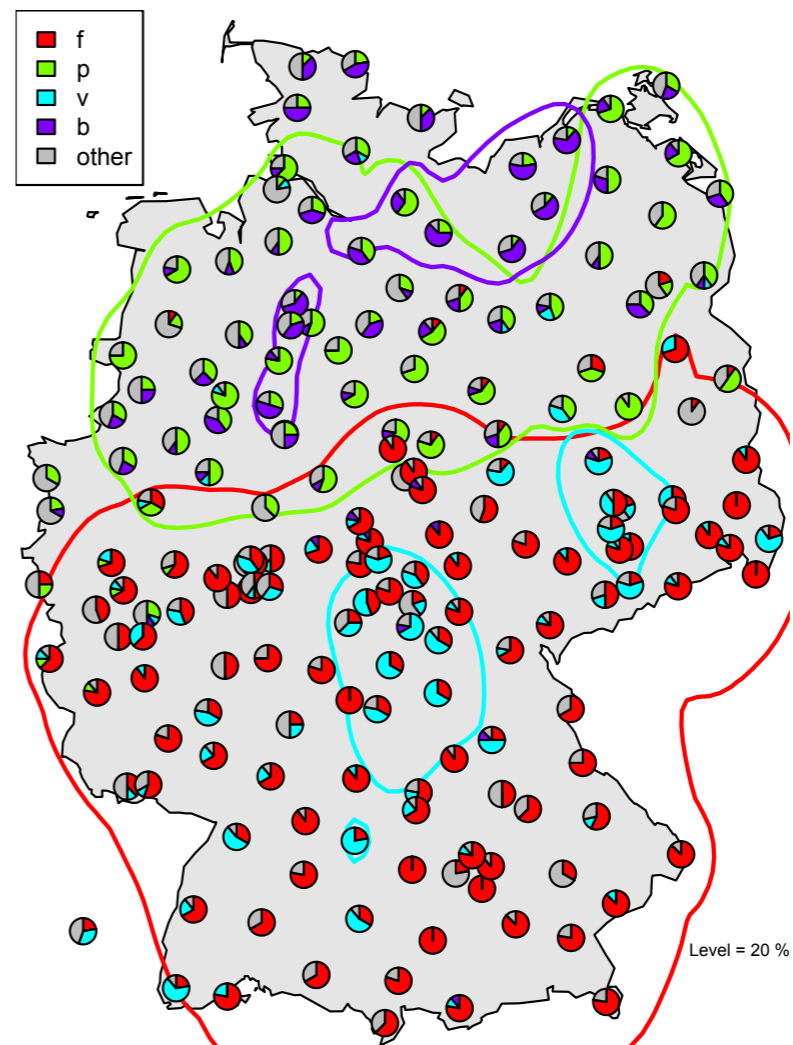
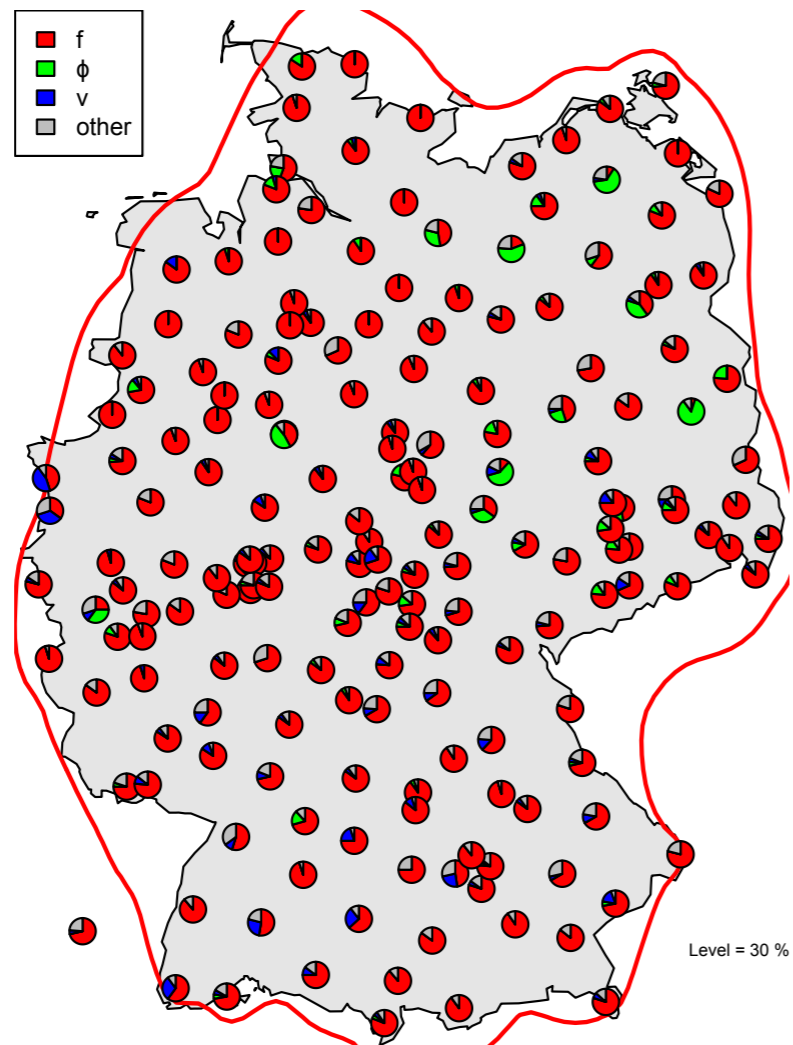
Functions *limage* ("level-image")  
 and *lmap* ("level-map")  
 from R-package *qlcVisualize*  
 (Cysouw 2015)





Correspondences "f"

Correspondences "f/p"



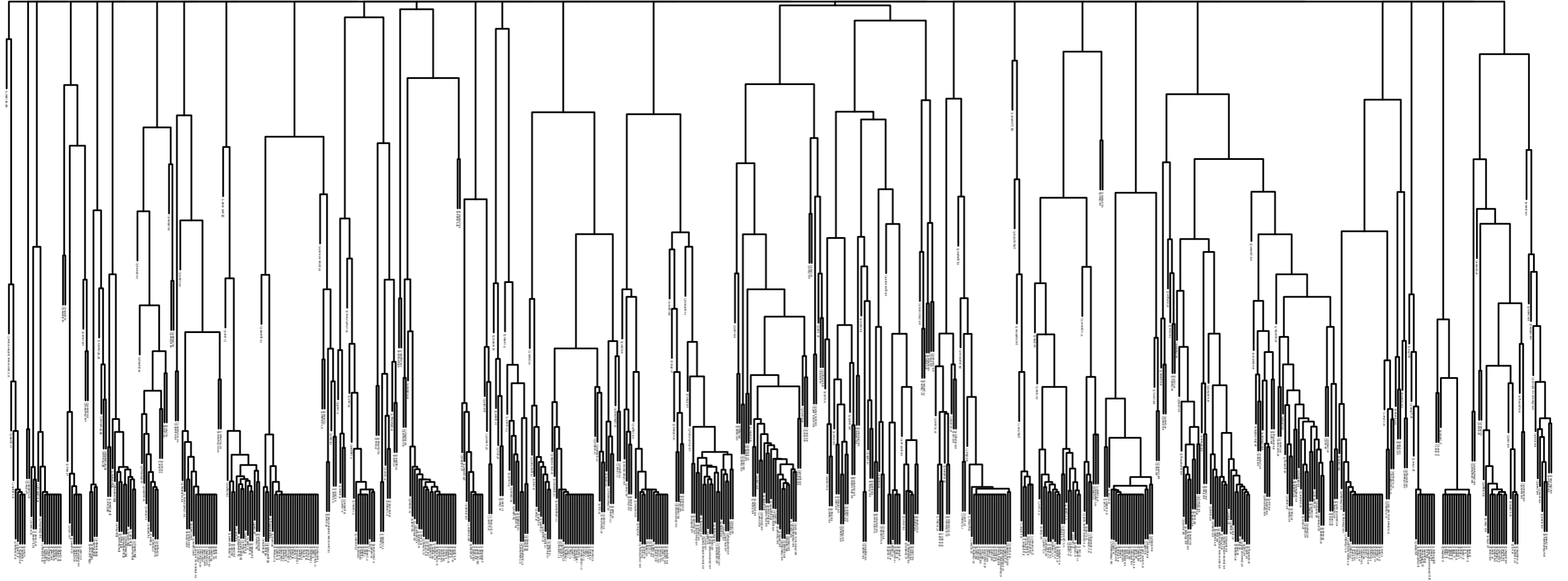
# Bulgarian dialect data

- Data from Jelena Prokić
- Taken from the *benchmark database of phonetic alignments* (BDPA)

List, Johann-Mattis and Jelena Prokić. (2014). A benchmark database of phonetic alignments in historical linguistics and dialectology. In: Proceedings of the International Conference on Language Resources and Evaluation (LREC), May 2014, Reykjavik. 288-294.

# Bulgarian dialect data

- Data from 197 villages for 152 words, resulting in 807 aligned columns
- There are many possible methods to cluster these into correspondence sets
- And they give different results!  
(though mostly smaller or larger sets)
- Here: a simple greedy clustering into 27 sets



v, t (when: 1)  
 't/ (this: 1)  
 't/ (yours: 1)  
 t/ t (such: 1)  
 t (Saturday: 5)  
 t/- (fear: 3)  
 t/- (the middle: 7)  
 t (old man: 2)

t/ti (son-in-law; brother-in-law: 3)

t/ti (ten: 1)

't/'tj (dark: 1)  
't/'tj (thin: 1)

l/l (wool: 3)  
l/l (yellow: 3)

l/l (deep: 3)

l/- (apple: 5)

l/'l (enter: 3)

l/lj (rooster: 5)

l (down: 4)  
l (hungry: 2)  
l (head: 2)  
l (pay: 3)  
l/'l (white: 3)  
l/- (ox: 3)  
l/lj (whole: 3)  
l/- (has come: 6)

l/j (key: 2)  
l/j (Sunday: 5)

'l/'lj (easy: 1)  
'l/'lj (lentils: 1)

'lj/'l (iron: 3)

'lj/'l (bread: 2)  
l/lj (the milk: 2)

l/lj (salt: 4)  
l/lj (apples: 5)

k/c (tong  
k/c (bar

k/- (today: 6)

k/c (wolf: 5)  
k/c (Monday: 10)  
k/c (person: 5)  
k/'d (where: 1)  
k/'c (key: 1)

k/'k (hand: 3)  
k/'k (river: 3)  
k/k (such: 3)

k/c (sand: 5)  
k/c (apple: 7)  
k/'k (which: 1)  
k/'k (the milk: 4)  
k (blood: 1)  
'k/k (horse: 1)  
'k/k (stone: 1)  
k (deep: 7)  
k/- (outside: 4)  
k (wait: 3)  
k/- (Friday: 5)  
k/'k (thin: 4)

p/b (bake: 2)  
p/b (pocket: 3)

p/b (bread: 4)

p/pi (rooster: 1)

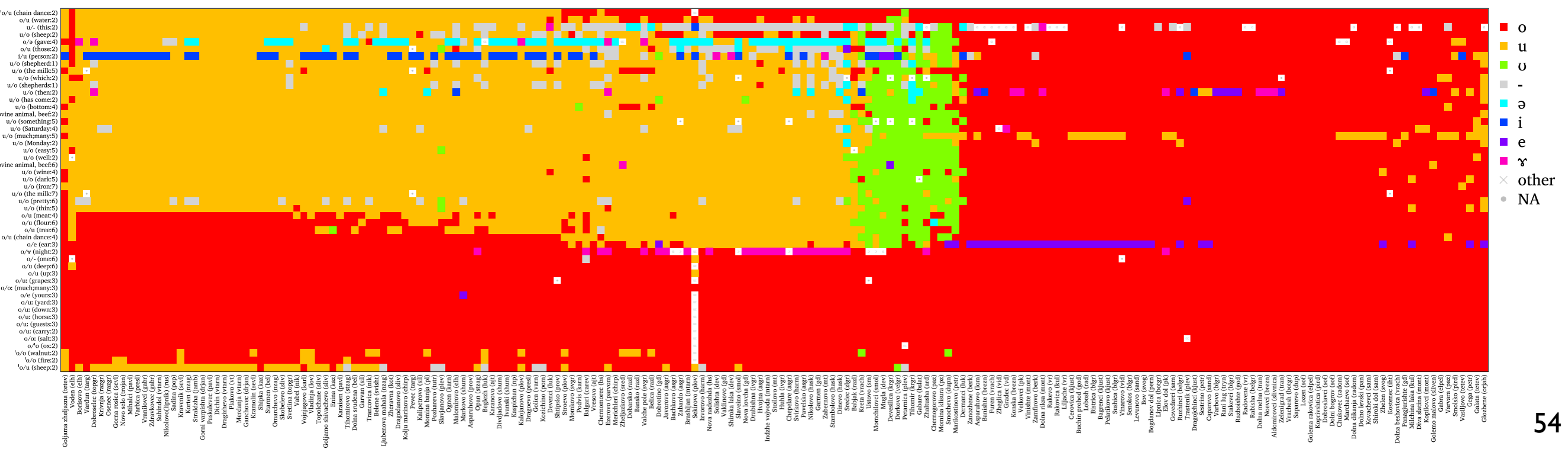
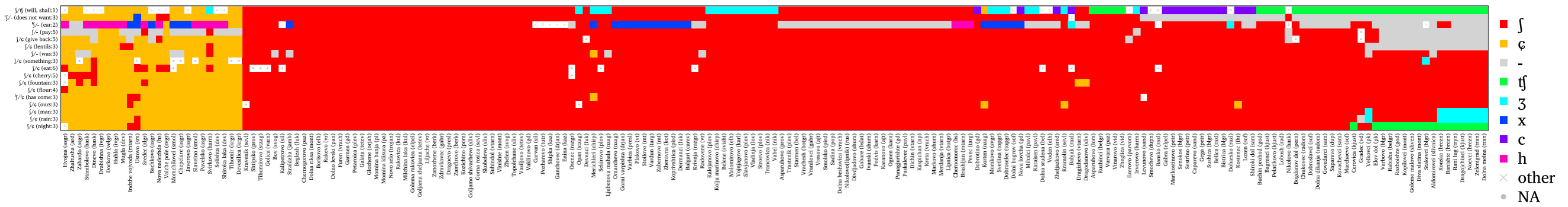
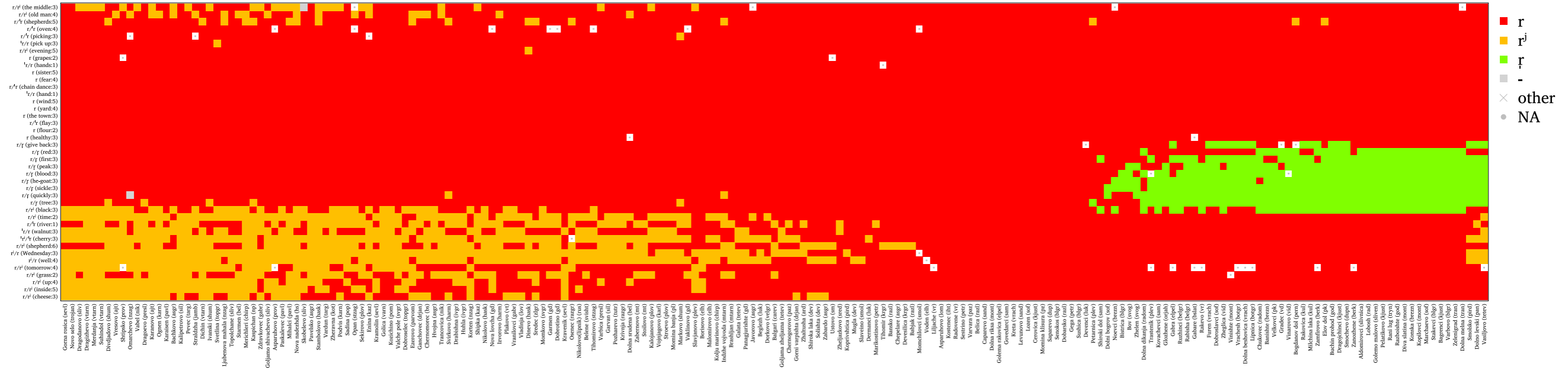
p/f (sickle: 5)  
'p/p (road: 1)  
p/p (first: 1)  
'p/p (he-goat: 1)  
p/p (pay: 1)  
p (Monday: 1)

'pi/'pi (ash: 1)  
'pi/'pi (Friday: 1)

'pi/'p (sand: 1)

x/f (dry: 3)

x/- (fear: 6)  
x/- (saw: 5)



# Proto-Bulgarian

	Labial	Dental	Palatal	Velar
Plosive	p b	t d		k g
Affricate		ts̄	tʃ̄	
Fricative	f v	s z	ʃ ʒ	
Nasal	m	n	nʲ	
Lateral		l		
Trill		r		
Approximant			j	

# Old Church Slavonic

	Labial	Dental	Palatal	Velar
Plosive	p b	t d		k g
Affricate		ts dz	tʃ	
Fricative		s z	ʃ ʒ	x
Nasal	m	n	nʲ	
Lateral		l	lʲ	
Trill		r	rʲ	
Approximant	v		j	



# Conclusion

- Multi-alignments are an ideal data structure to compare language variation and change
- Extracting multi-alignments from large data sets is not trivial, and bound to produce errors
- However, multi-alignments can be profitably discussed, collectively improved, and consensus can be reached
- Controversial high-level analyses (e.g. typological classifications, reconstruction) are independent of the multi-alignments