Reconstructing Meaning Change from Parallel Corpora

Michael Cysouw and Jelena Prokić

Ludwig-Maximilians-Universität München

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Overview

1. Introduction
2. Experiment
3. Results
4. Further developments
5. Conclusions

Reconstructing history

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- Under this (strongly extensionalistic) definition of meaning, variation in meaning becomes readily measurable
- Differences in meaning between cognates reveal historical processes

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  - Collect the distribution of cognate forms over these contexts
  - Different distributions across languages can be interpreted as the result of historical events

Corpus

- Universal Declaration of Human Rights
- 13 Germanic languages
  - 6 prepositions: *in*, *under*, *with*, *through*, *for*, *against*
- 12 Slavic languages
  - 7 prepositions: *about*, *according to*, *before*, *for*, *from*, *in*, *on*

Distribution of the prepositions

- Find the distribution of each preposition within every paragraph in the text
- Example:

  These rights and freedoms may in no case be exercised contrary to the purposes and principles of the United Nations.

  Diese Rechte und Freiheiten dürfen in keinem Fall im Widerspruch zu den Zielen und Grundsätzen der Vereinten Nationen ausgeübt werden.

  Deze rechten en vrijheden mogen in geen geval worden uitgeoefend in strijd met de doeleinden en beginselen van de Verenigde Naties.

Distributional frequencies

- Relationships between the languages are inferred based on the distributional frequencies of the prepositions
- Example: Distribution of the preposition *in*

	Paragraph 1	Paragraph 2	Paragraph 3	Paragraph 4
German	1	1	0	0
English	1	2	0	0
Dutch	1	0	1	0
Frisian	2	1	2	1

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  - NN: produces a tree if the data is tree-like, and network is the data is network-like

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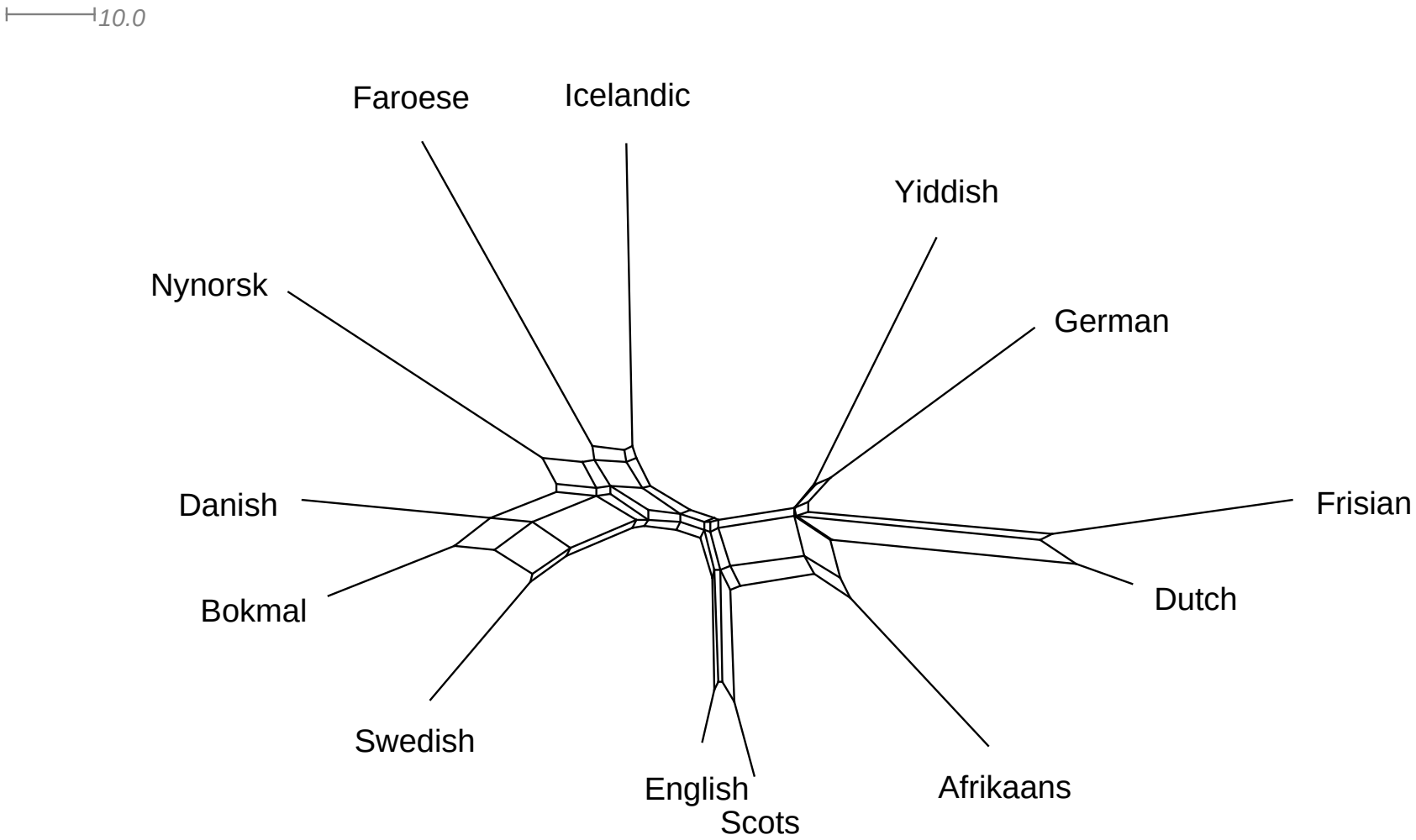
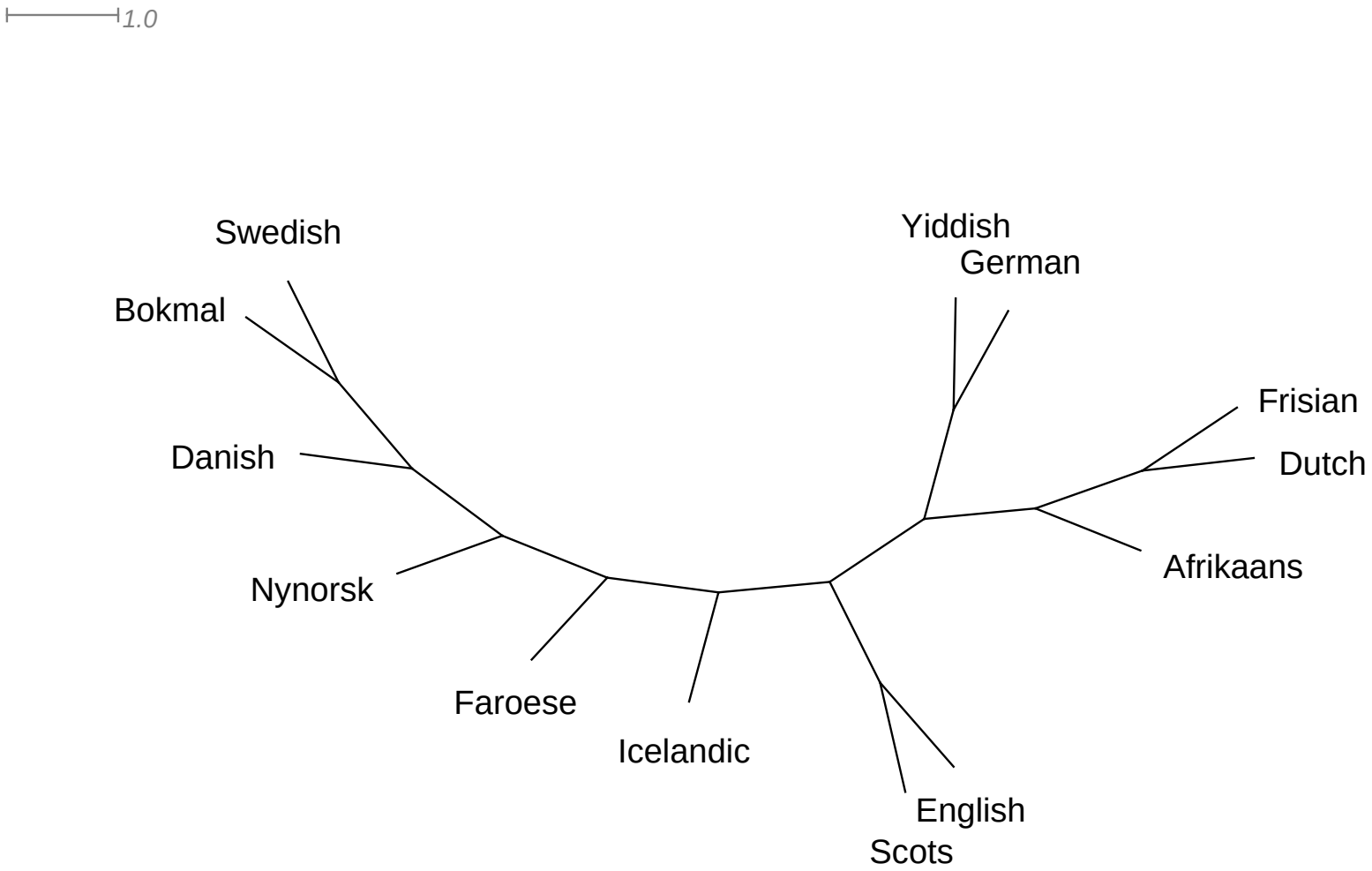
  - join all the analyses into a single tree
  - parsimony methods: search for the tree (grouping of the languages) that require the least amount of evolutionary change

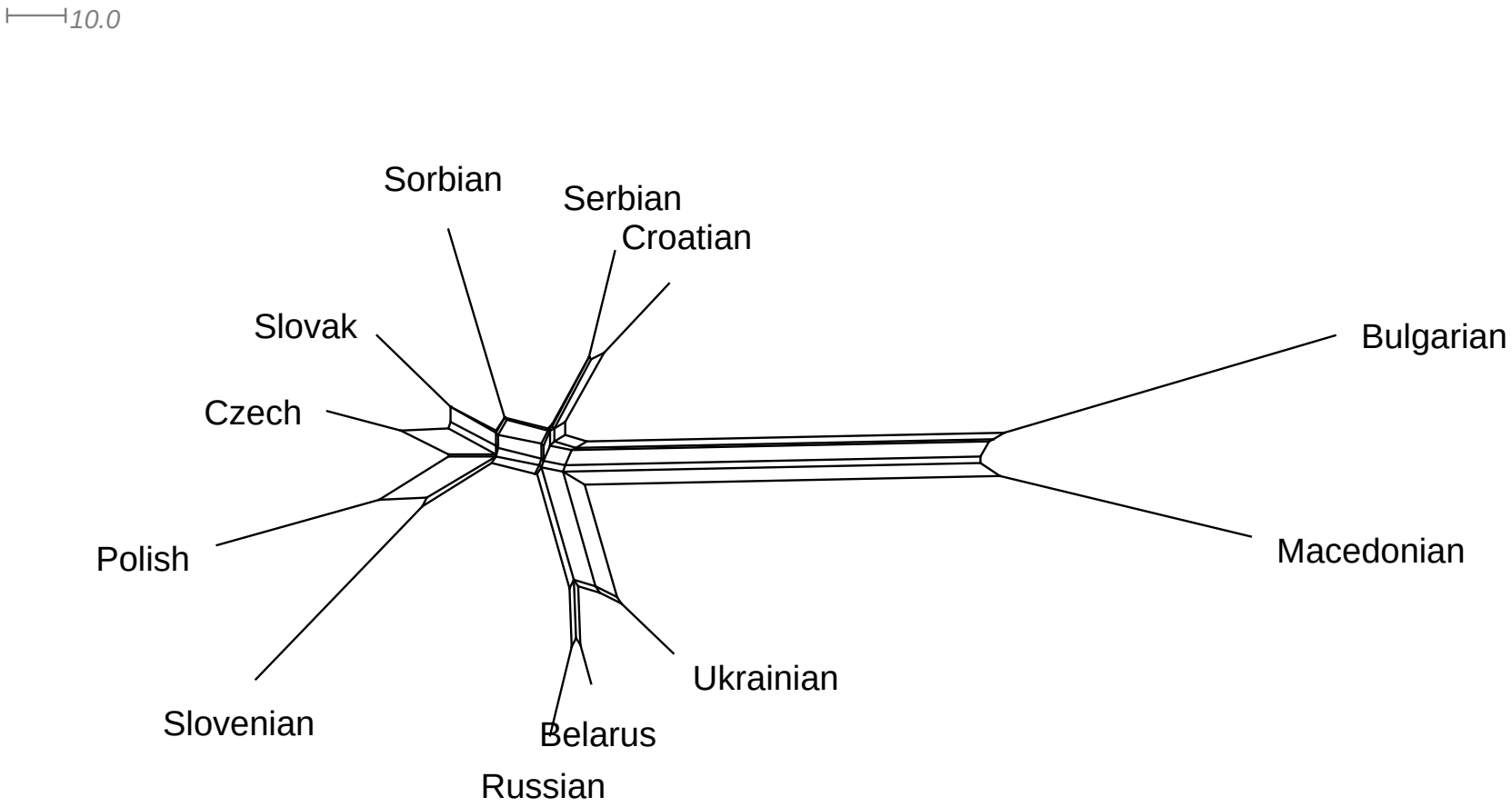
Germanic data: Neighbor-net



Germanic data: Maximum parsimony



Slavic data: Neighbor-net



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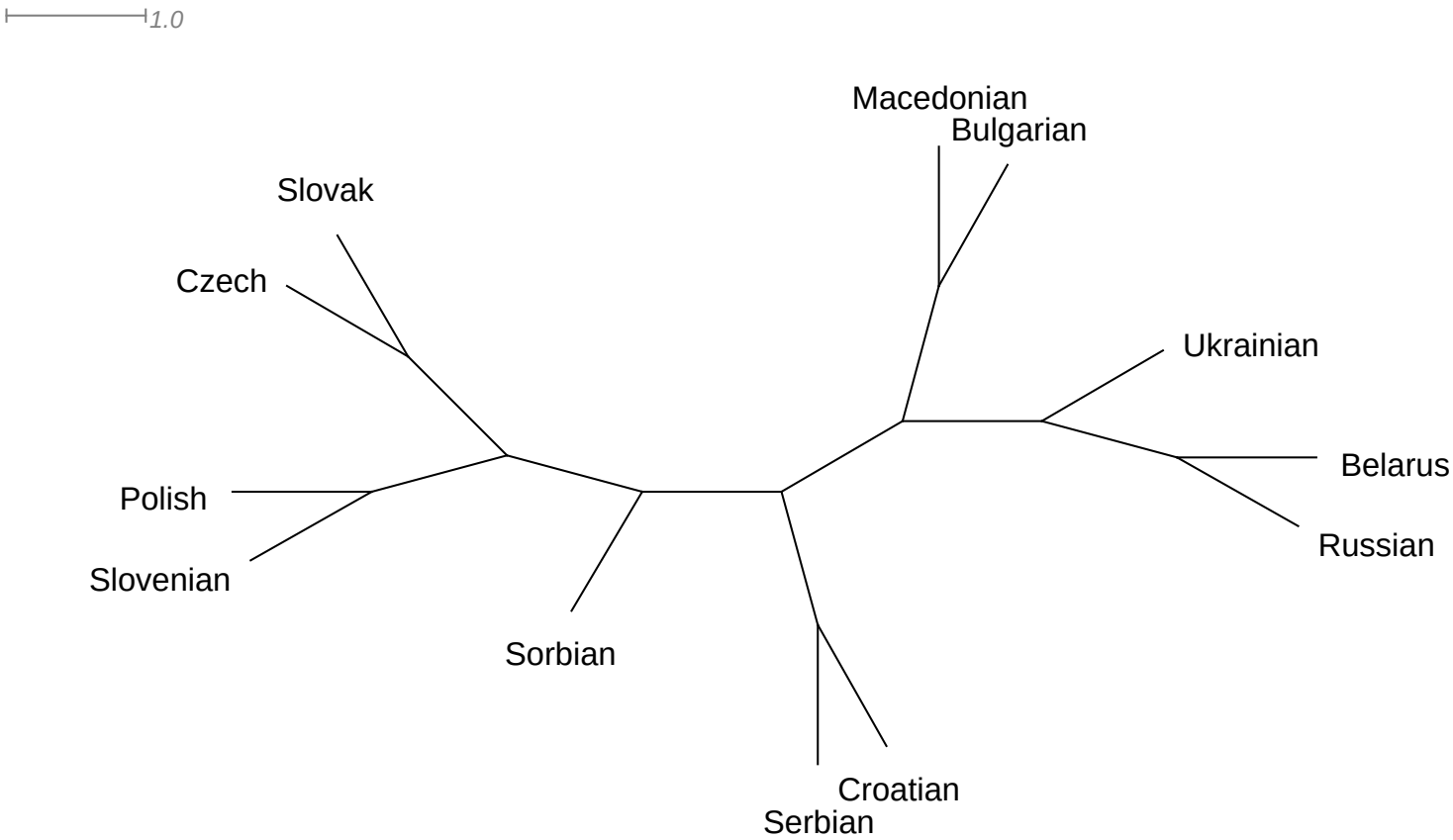


Proposal 1: Improve alignment

- Until now: count the number of prepositions per paragraph
- Better: try to align equivalent prepositions in the text

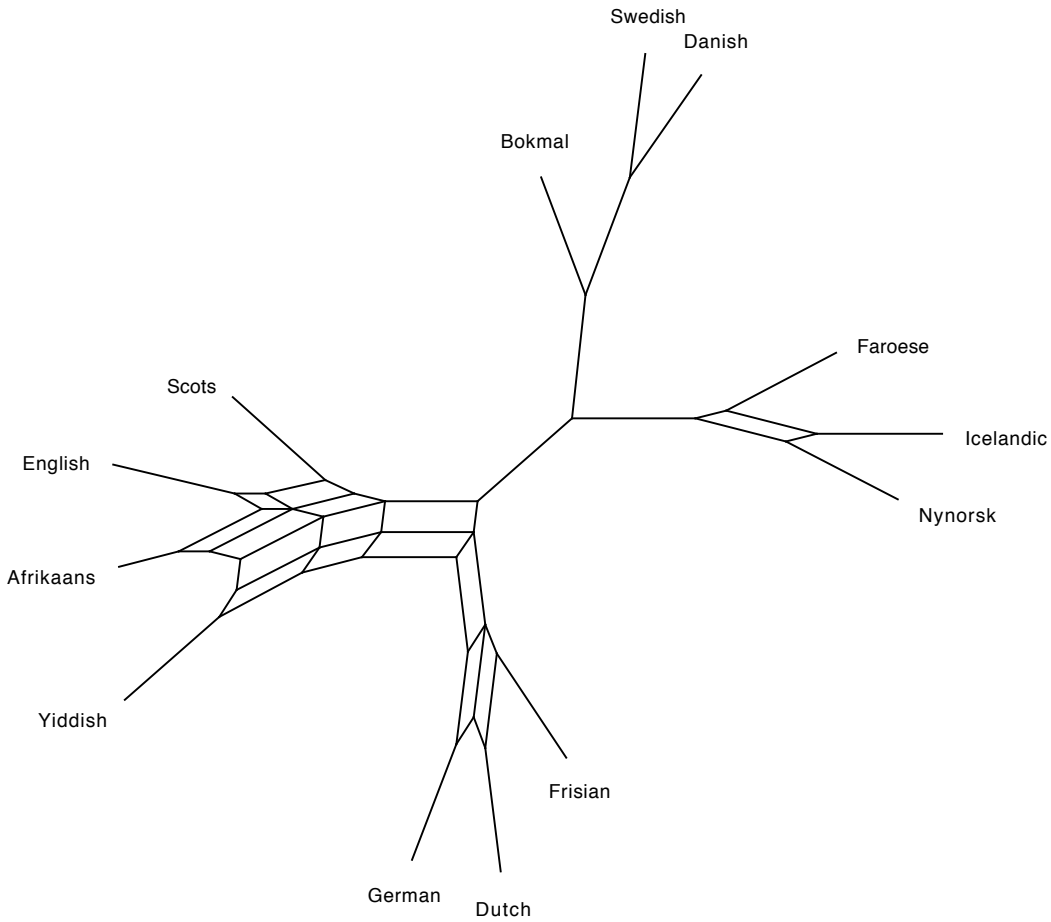
Preamble, paragraph 5

- English:
  Whereas the peoples of the United Nations have **in** the Charter reaffirmed their faith **in** fundamental human rights, **in** the dignity and worth of the human person and **in** the equal rights of men and women and have determined to promote social progress and better standards of life **in** larger freedom,
- German:
  da die Völker der Vereinten Nationen **in** der Charta ihren Glauben an die grundlegenden Menschenrechte, an die Würde und den Wert der menschlichen Person und an die Gleichberechtigung von Mann und Frau erneut bekräftigt und beschlossen haben, den sozialen Fortschritt und bessere Lebensbedingungen **in** grösserer Freiheit zu fördern,

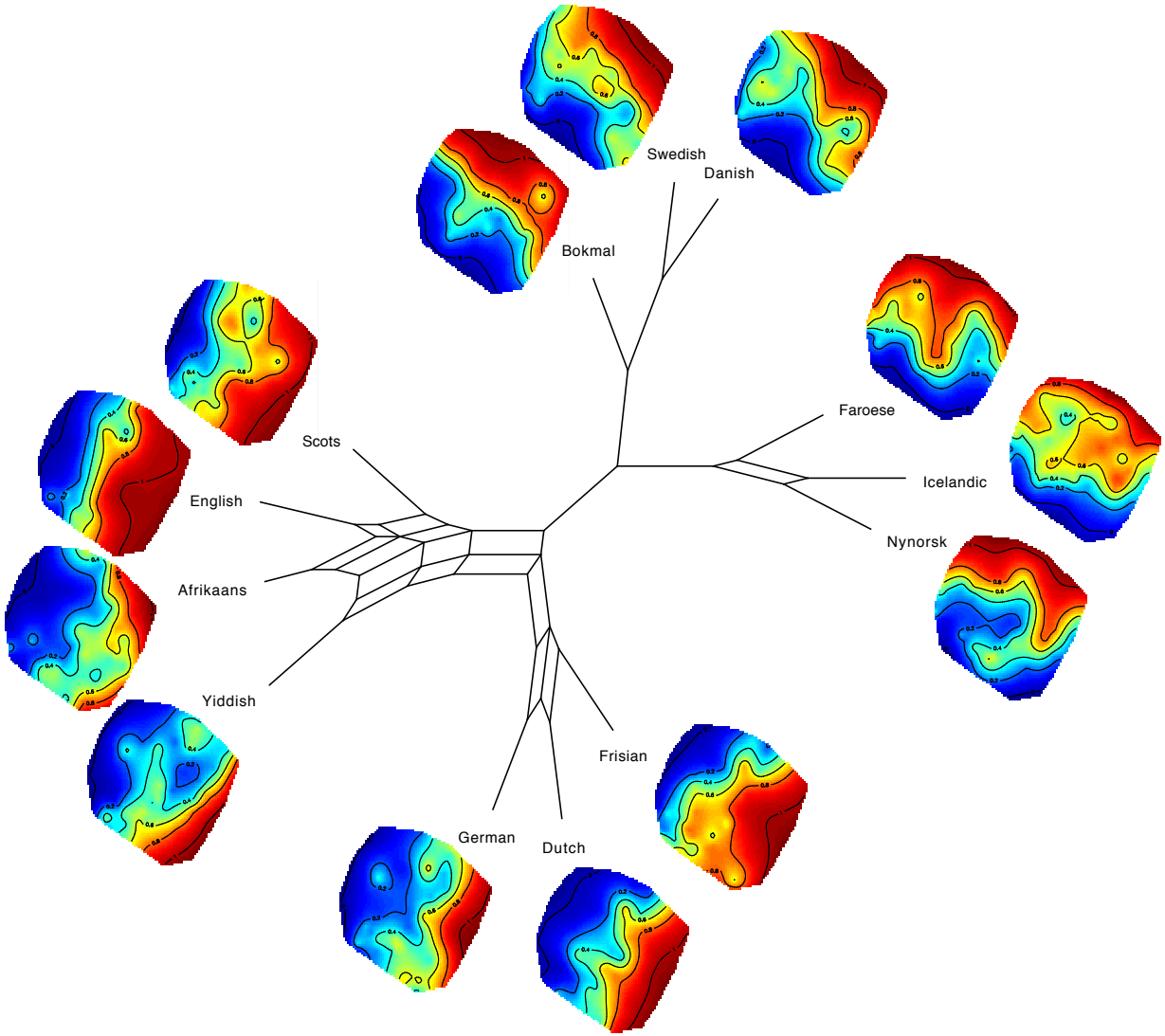
Language Frequency Positions in paragraph 5

Language	Frequency	Aligned					
German	2		1				1
English	5		1	1	1	1	1
Scots	5		1	1	1	1	1
Dutch	5		1	1	1	1	1
Frisian	6	1	1	1	1	1	1
Afrikaans	5		1	1	1	1	1
Yiddish	4		1	1	1		1
Nynorsk	3		1			1	1
Faroese	3		1			1	1
BokmI	1		1				
Swedish	1		1				
Danish	1		1				
Icelandic	1						1

Consensus network of 4 optimal trees according to dollo Maximum Parsimony



Differences in the distribution of 'in'



Proposal 2: Generalize this approach even further

- Define meaning of 'in' by the collection of words in its context
- Compare contextual vectors across languages

Step 1: Language specific contextual vectors

English	Frequency	German	Frequency
the	15	der	7
of	8	verkündeten	3
and	5	mit	3
with	4	Erklärung	3
which	4	dieser	3
this	4	die	3
rights	4	den	3

Step 2: Link words across languages

- Use the parallelism between the languages to estimate translational probability

$$sig(w, v) = \lambda^k \cdot e^{-\lambda} \cdot k!$$

$$\lambda = \frac{\text{frequency of word w} \cdot \text{frequency of word v}}{\text{number of contexts}}$$

k = frequency of co-occurrence of words w and v

Step 3: Compare contextual vectors across languages

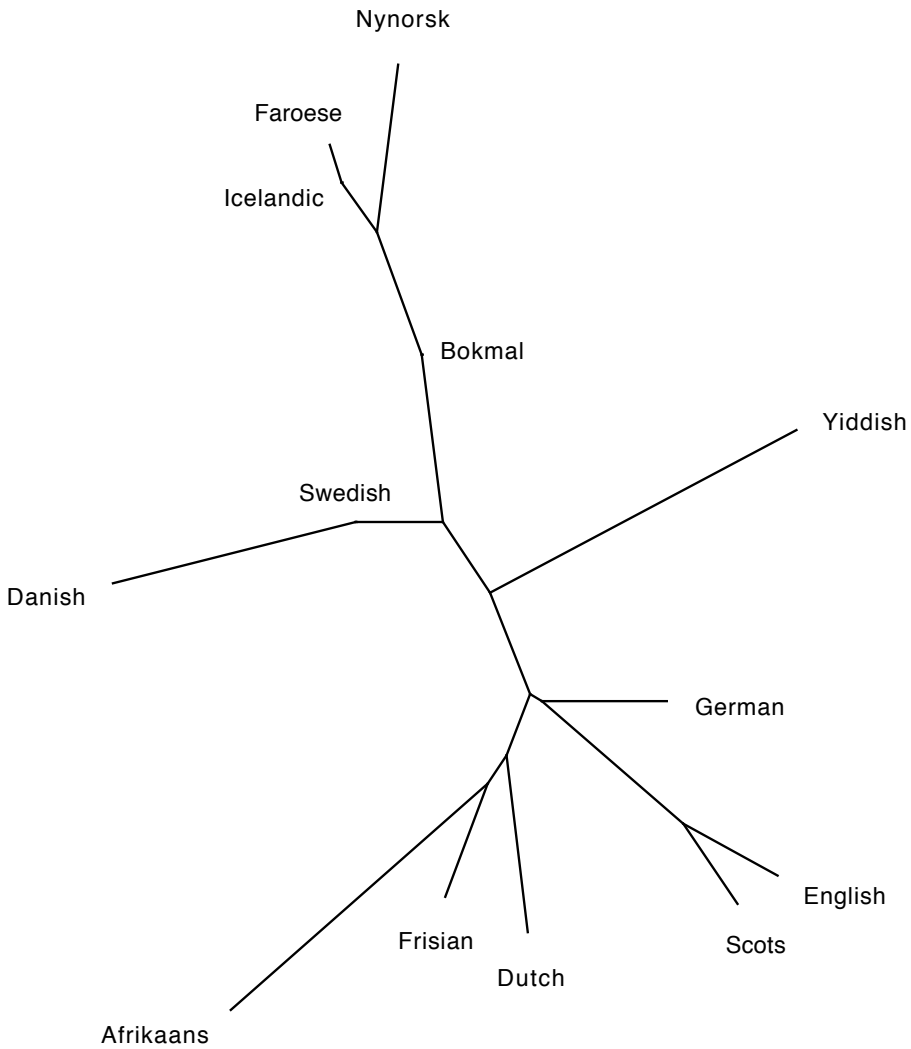
- Linked vector comparison

$$\cos \alpha_{linked}(f, g) = \frac{f^T \cdot \frac{1}{S} \cdot g}{\sqrt{(f^2)^T \cdot \frac{1}{S} \cdot 1_{(g \times f)} \cdot \frac{1}{S} \cdot g^2}}$$

f, g = frequency vectors of contextual words

S = matrix of translational probabilities

Neighbour-joining tree from the linked vector comparison



Conclusions

- Using a distributional definition of meaning is highly useful for language comparison
- Parallel texts are an easy way to obtain comparable contexts across languages
- Differences in the distribution of words in parallel texts is a way to approach differences in meaning of those words
- Meaning differences are phylogenetic informative