

Phonemic Inventory as a Phylogenetic Characteristic

Steve Moran & Michael Cysouw
LMU Munich

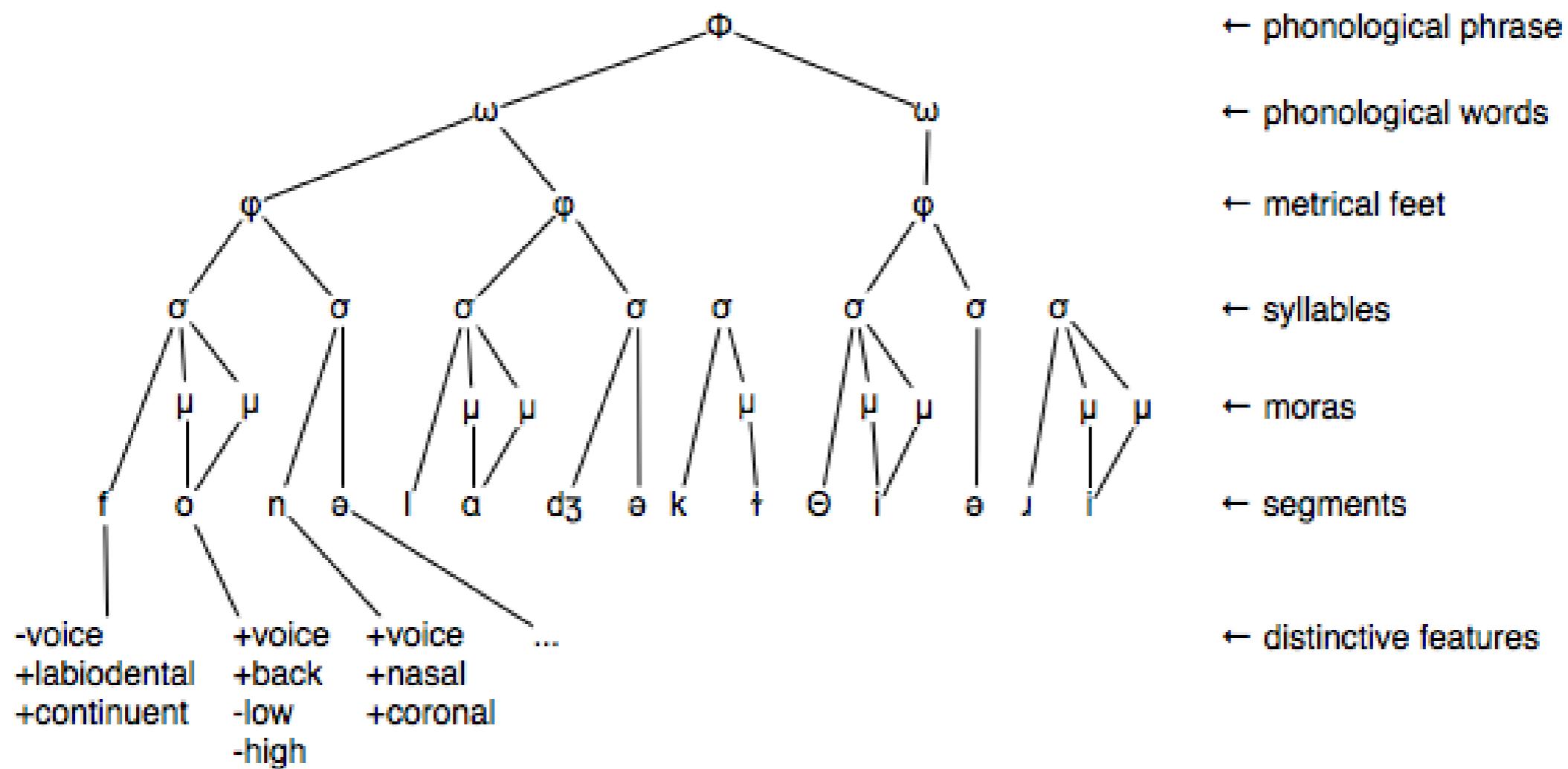
Reconstruction without lexicon?

- Underlying model of historical linguistics:
 - ▶ Soundchange
 - ▶ Changes in phoneme system ?
- Can we use the structure of phoneme systems for reconstruction ?

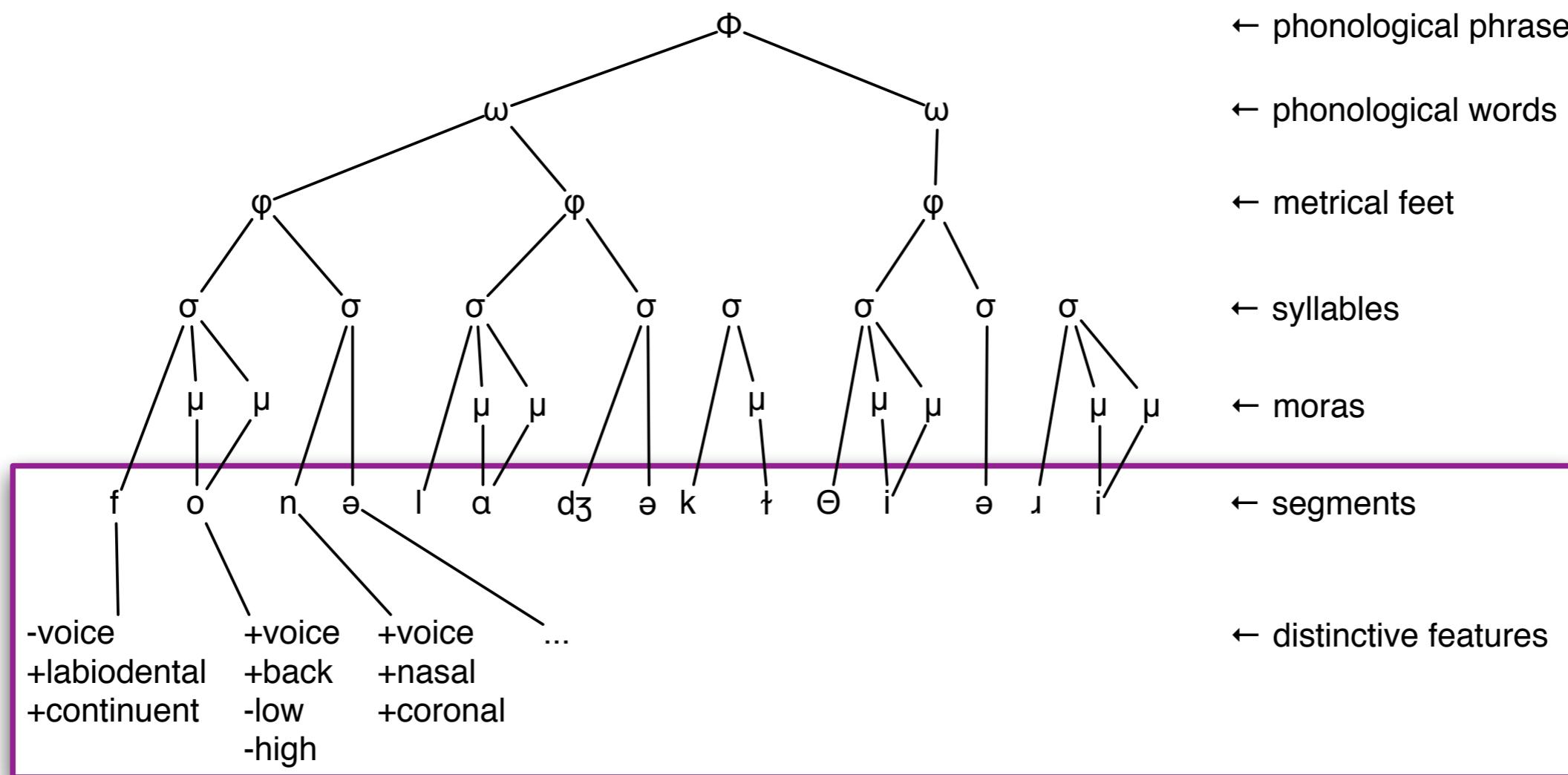
Phoible

Phoneme Inventory Database

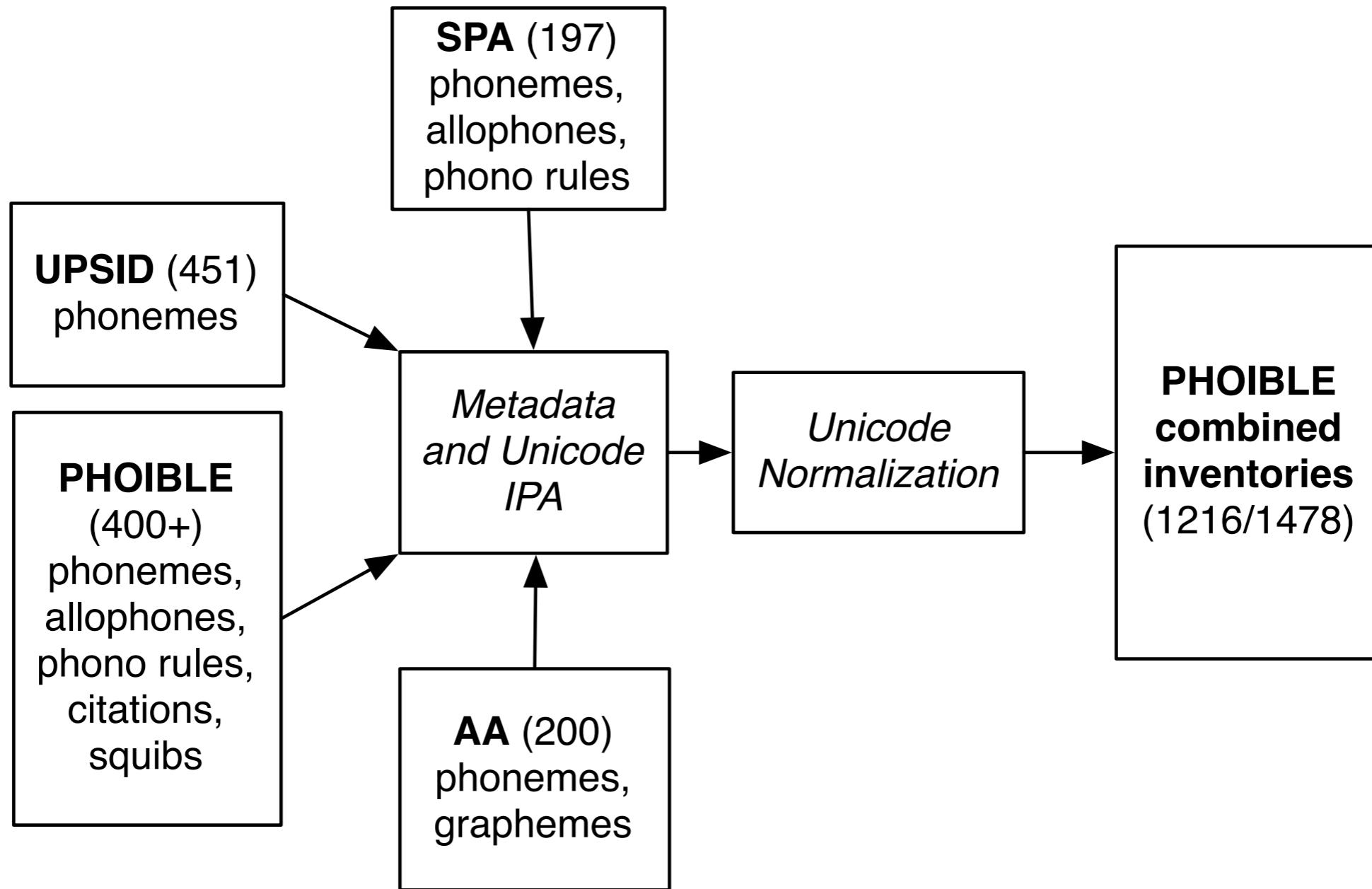
Where are we ?



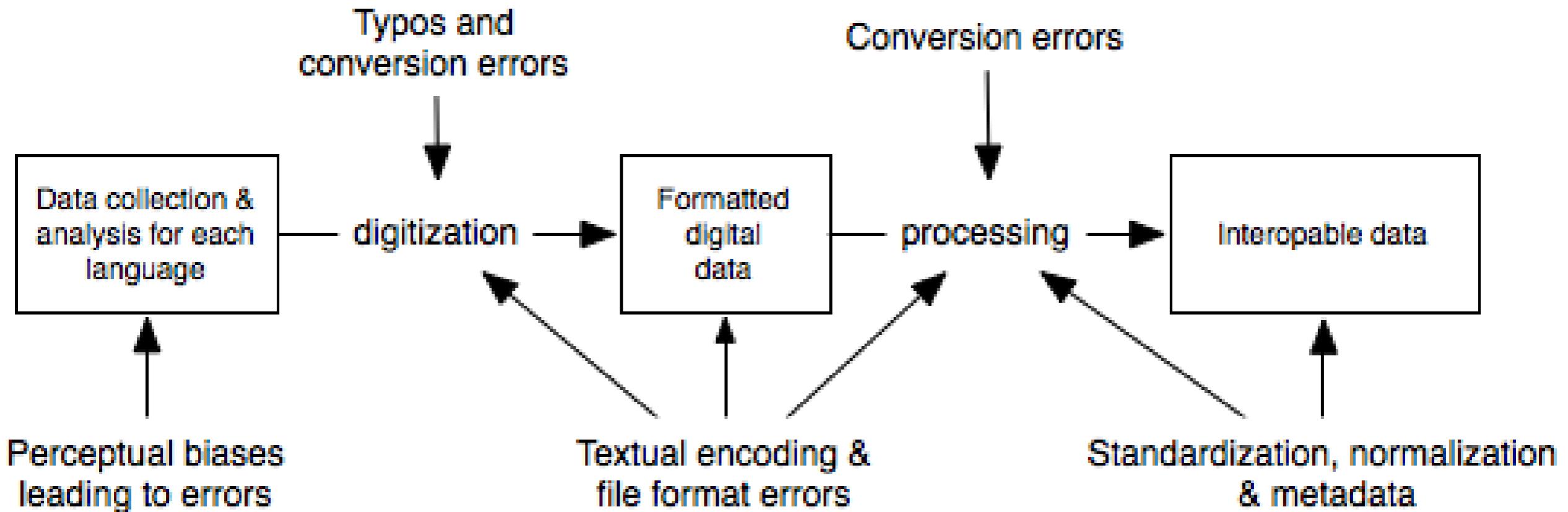
Where are we ?



PHOIBLE resources



Workflow to add segments



Challenges

- Transcription is an impressionistic analysis
- Language documentation varies in its descriptive adequacy
- Different theoretical models are used in writing language descriptions
- The comparative linguist should not typologize on the descriptive linguists' analytical preferences (Hyman 2008)

Different analyses, same language

Table 2.1: Analyses of vertical vowel system of Kabardian (Hyman 2008:99)

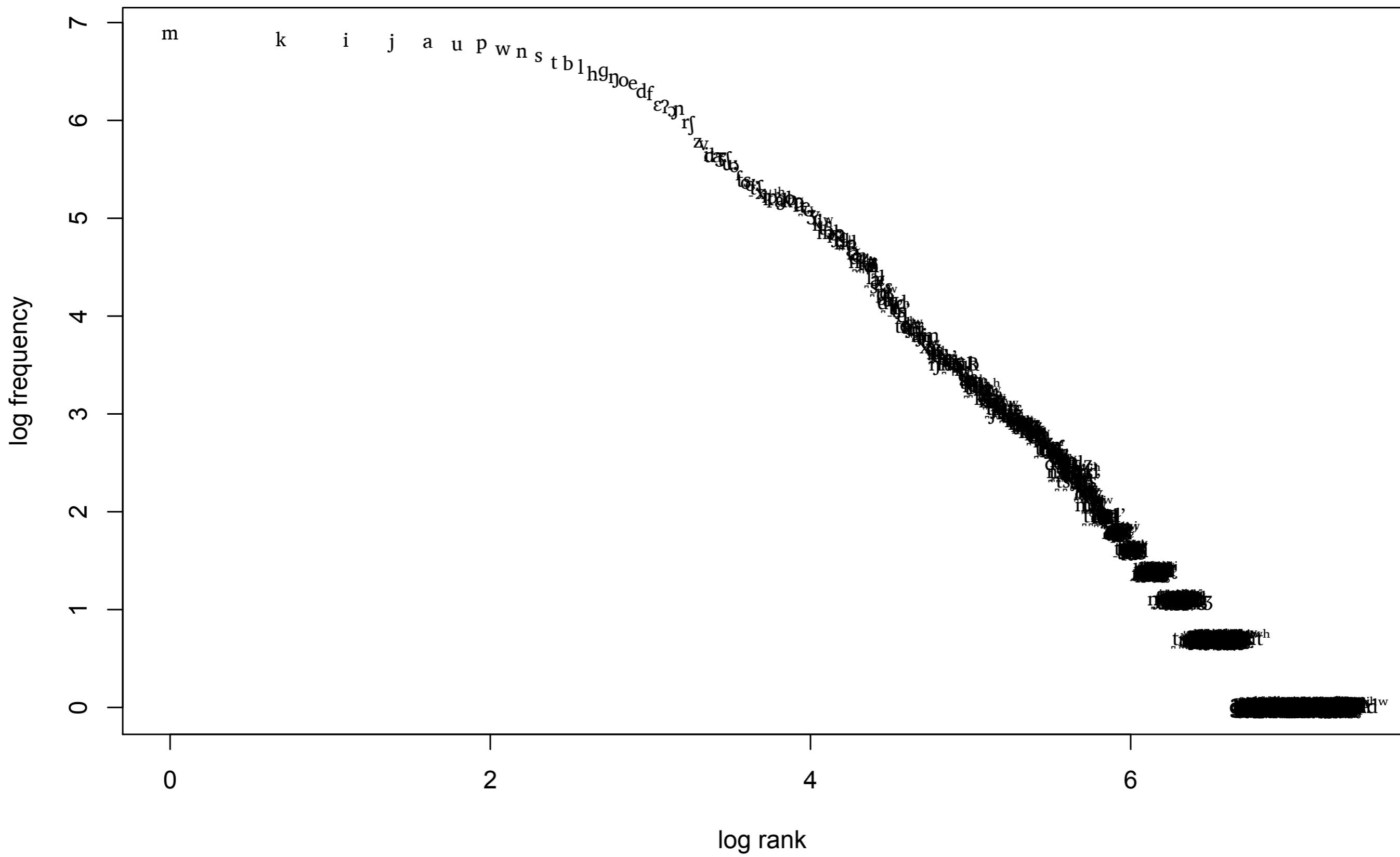
Ladefoged & Maddieson 1996	/i ə a/
Halle 1970	/ə a/
Anderson 1978	/a/
Kuipers 1960	No vowels

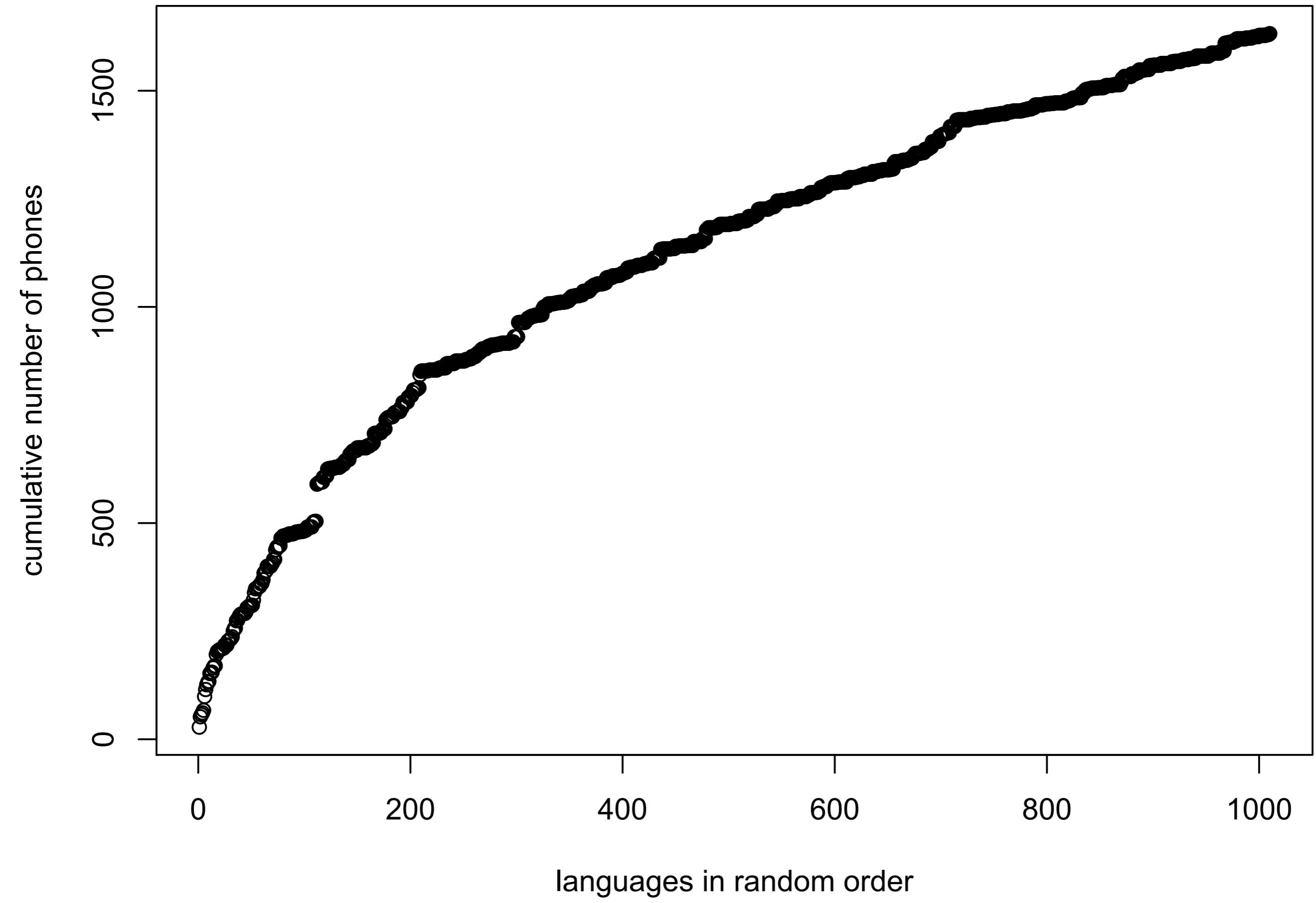
Deciphering descriptions

- Linguistic analyses must be extracted from language descriptions
- Poor descriptions ?
- Phonemes in loanwords and other marginal phonemes ?
- Unusual/rare descriptions ?
 - ▶ ‘half voice’
 - ▶ ‘p-tense’

Keep as close as possible to the sources

- Result: PHOIBLE now contains
- **1500 Inventories**
("doculects", 1235 distinct ISO 639-3 codes)
- **1953 Segment Types**
("claimed focal phonetic value of phoneme")





Mapping distinctive features to segment types

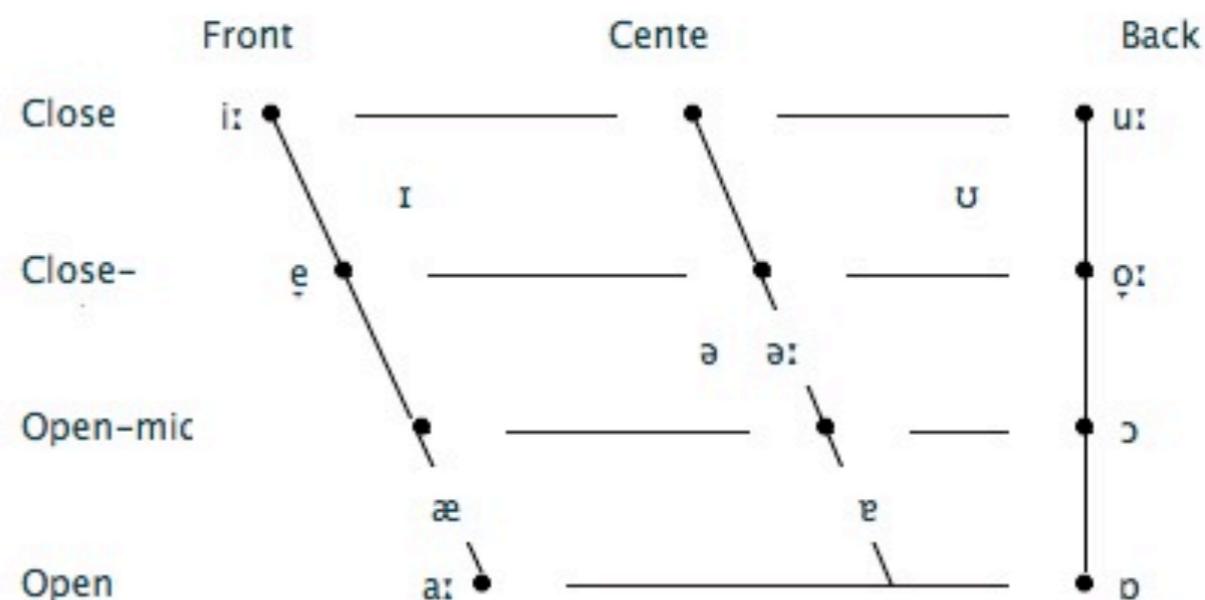
- Features are the atoms that combine compositionally to form a segment
- /i/ is { -labial, -round, +high, ...}
- Available distinctive feature systems lack typological representation
- There are way more segments than expected!

English

	Bilabial	Labio Dental	Dental	Alveolar	Post Alveolar	Retrofle	Palatal	Velar	Uvular	Pha- ryngeal	Epig- lottal	Glottal
Plosive	p ^h b		t ^h d					k ^h g				?
Nasal	m			n				ŋ				
Trill												
Tap/Flap												
Fricative		f v	θ ð	s z	ʃ ʒ			x				h
Affricate												
Lateral Fricative												
Lateral Affricate					tʃ dʒ							
Approximant						ɹ	j					
Lateral Approximant				l								

Clicks	Voiced Implosives	Ejectives(')
Bilabial	Bilabial	Bilabial
Dental	Dental/alveo	Dental/alveo
(Post)alveola	Palatal	Palatal
Palatoalveoli	Velar	Velar
Alveolar later	Uvular	

Other Symbols w w



Feature specifications for natural classes of sounds

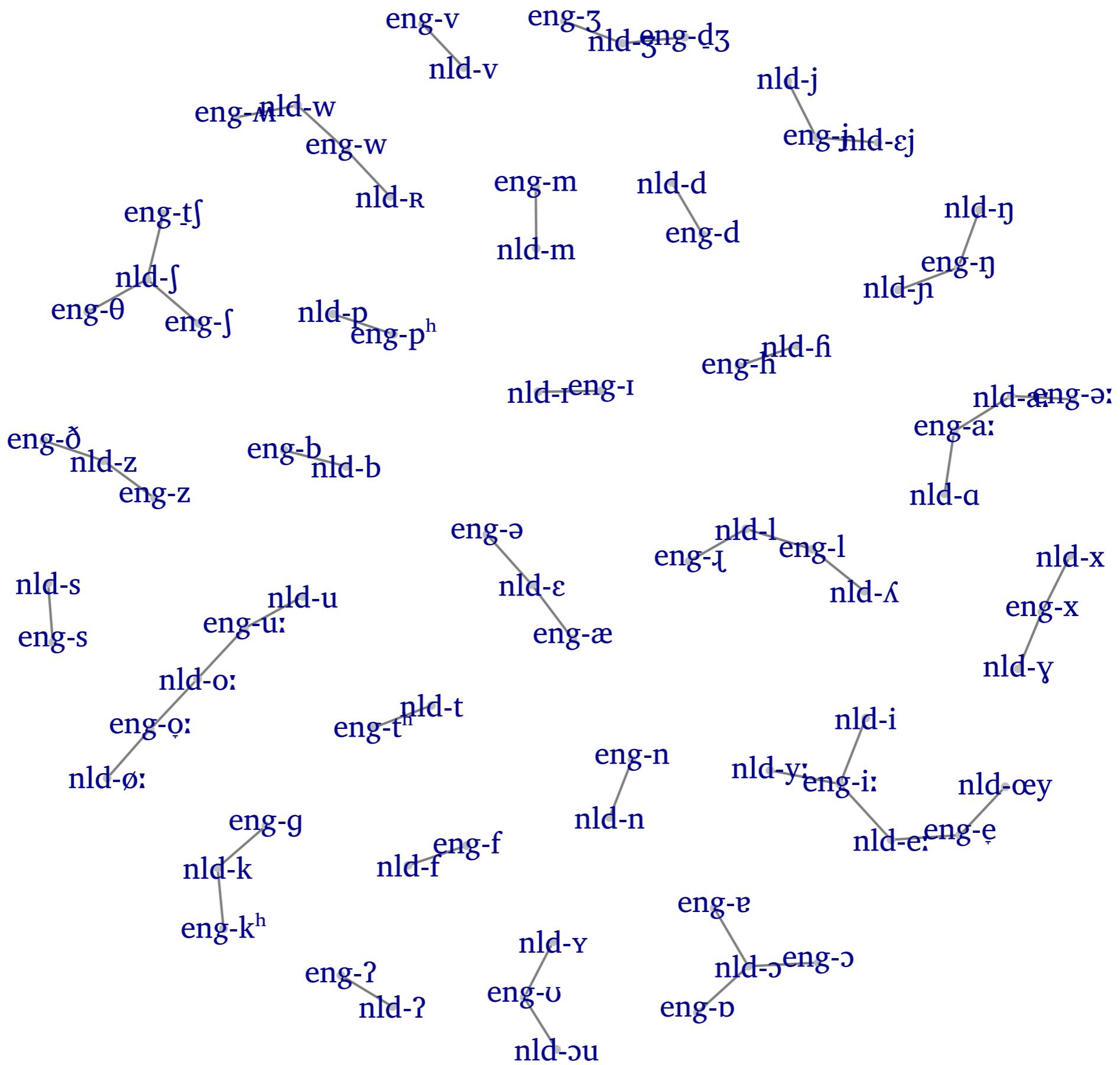
Class of sounds	Feature specification
Vowels	[+syllabic]
Glides	[-syllabic] [-consonantal]
Liquids	[+consonantal] [+approximant]
Nasals	[+sonorant] [-approximant]
Fricatives	[-sonorant] [+continuant]
Affricates	[-continuant] [+delayed release]
Stops	[-delayed release]
Stops & Affricates	[-continuant]
Liquids & Glides	[-syllabic] [+approximant]
Liquids, Glides, & Nasals	[-syllabic] [+sonorant]

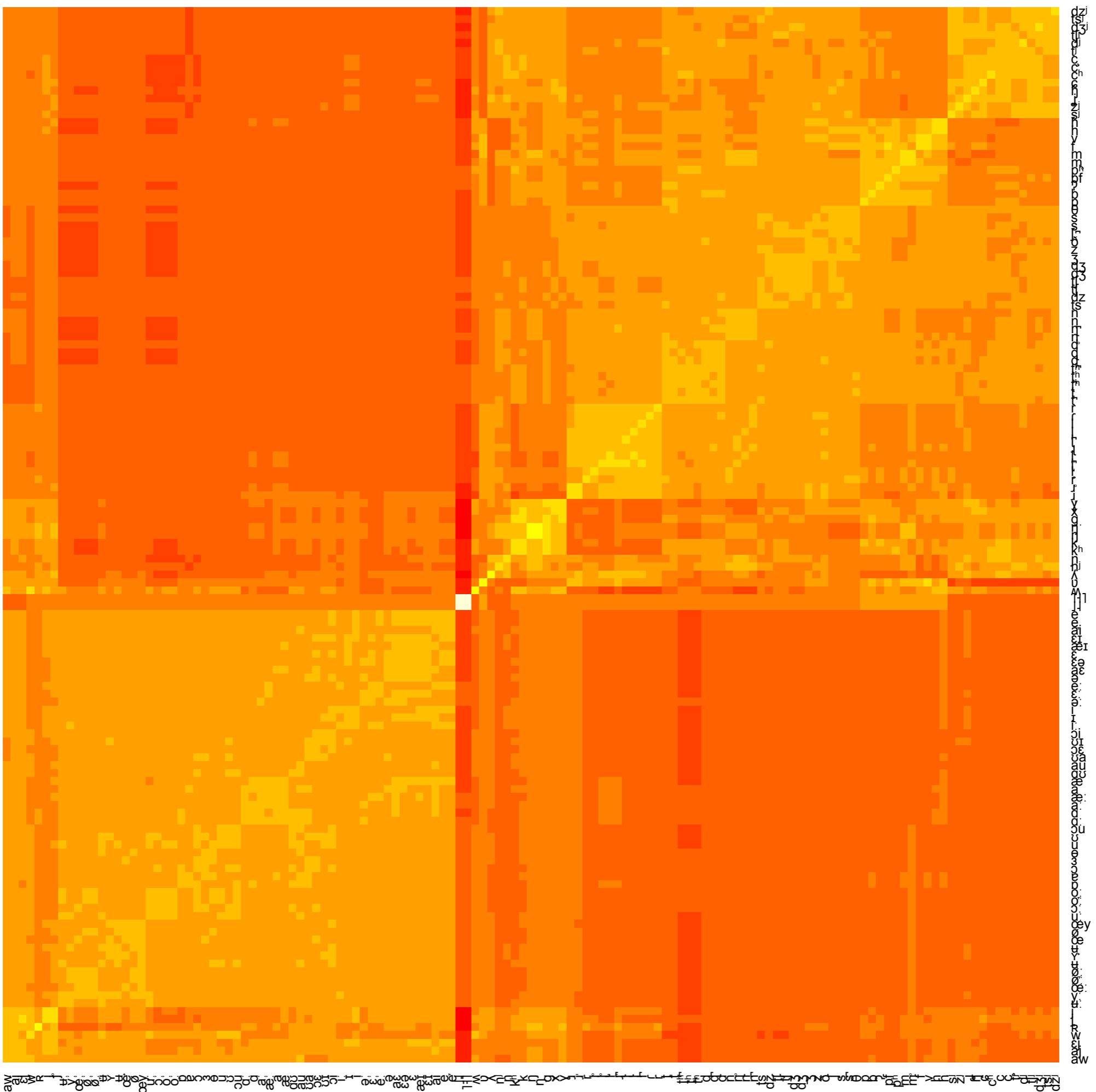
Using inventories for reconstruction

- The test:
- Can we (algorithmically) at least distinguish North Germanic from West Germanic
- ...
- nope, didn't work (until now)

The Problem

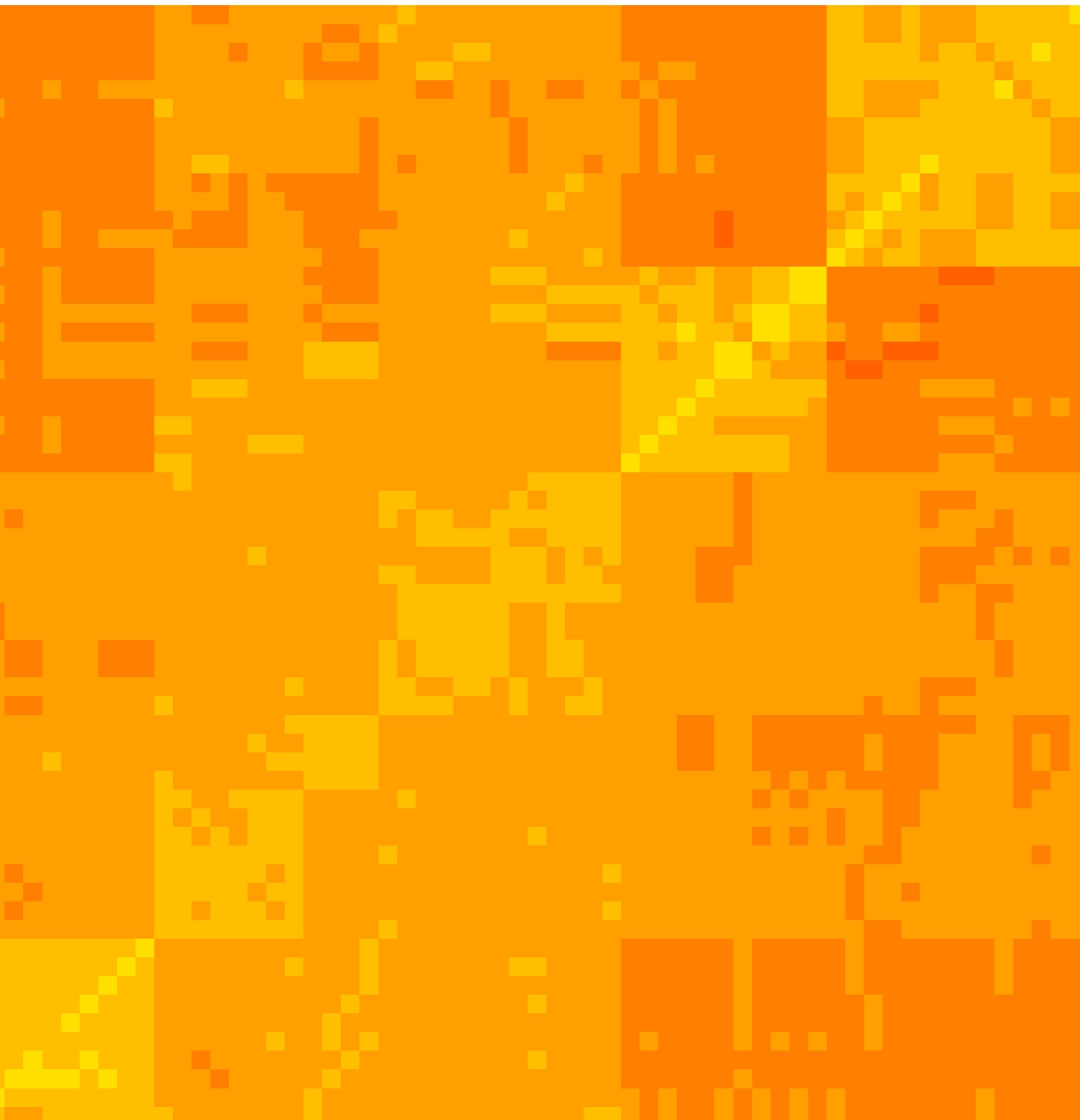
- Reconstruction assumes comparable characteristics (“aligned characters”)
- How to “align” phoneme systems across languages?

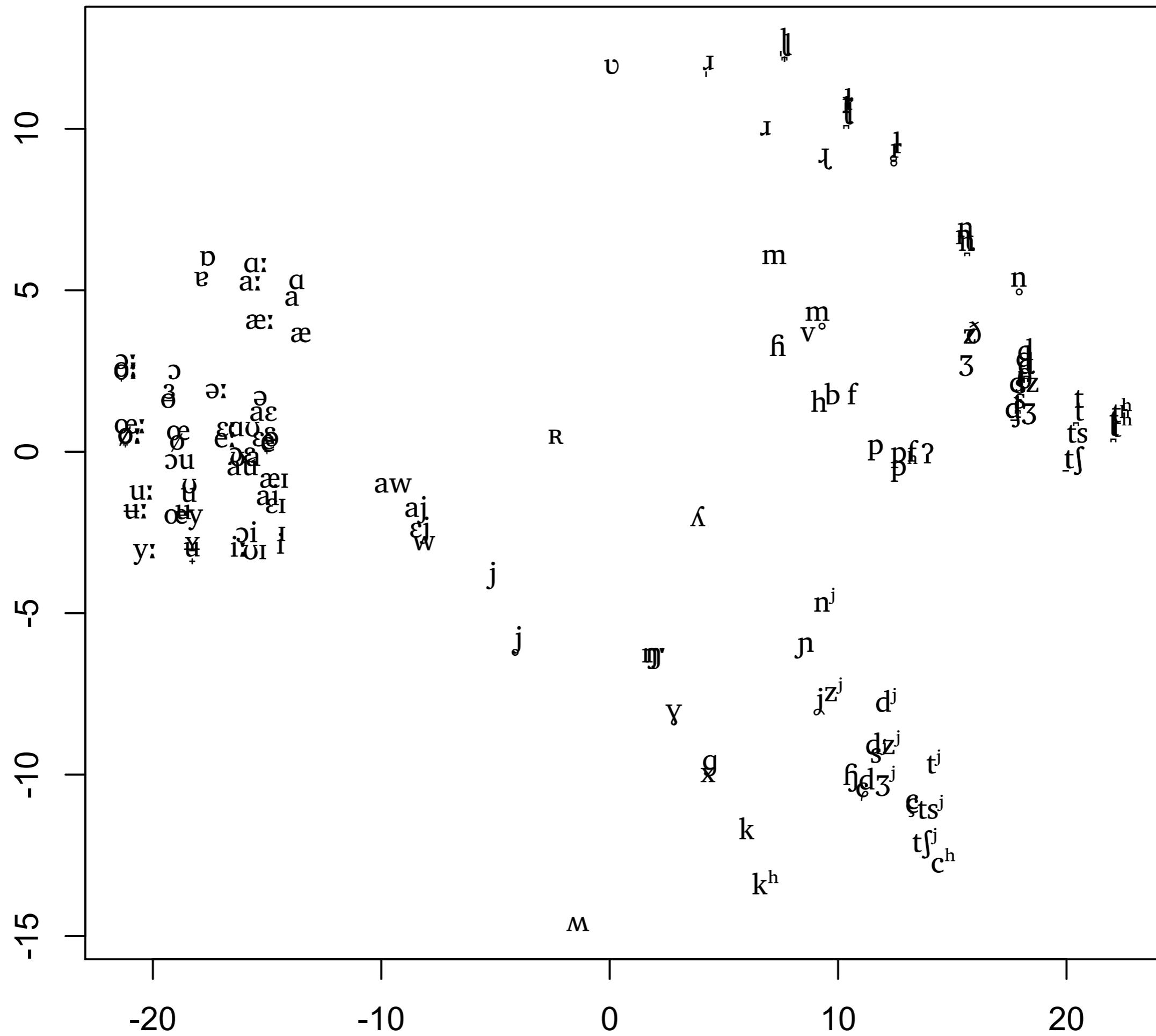


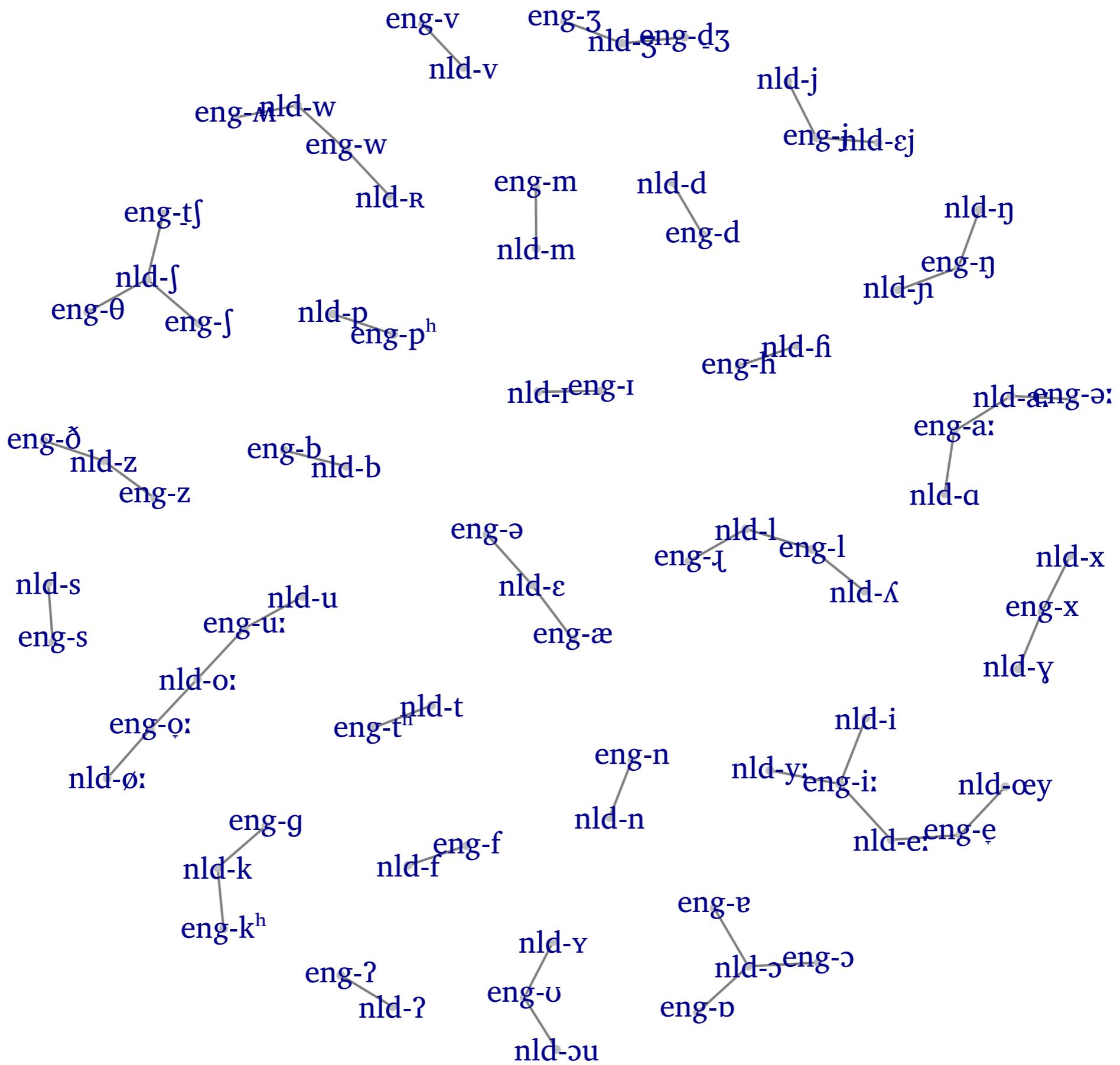


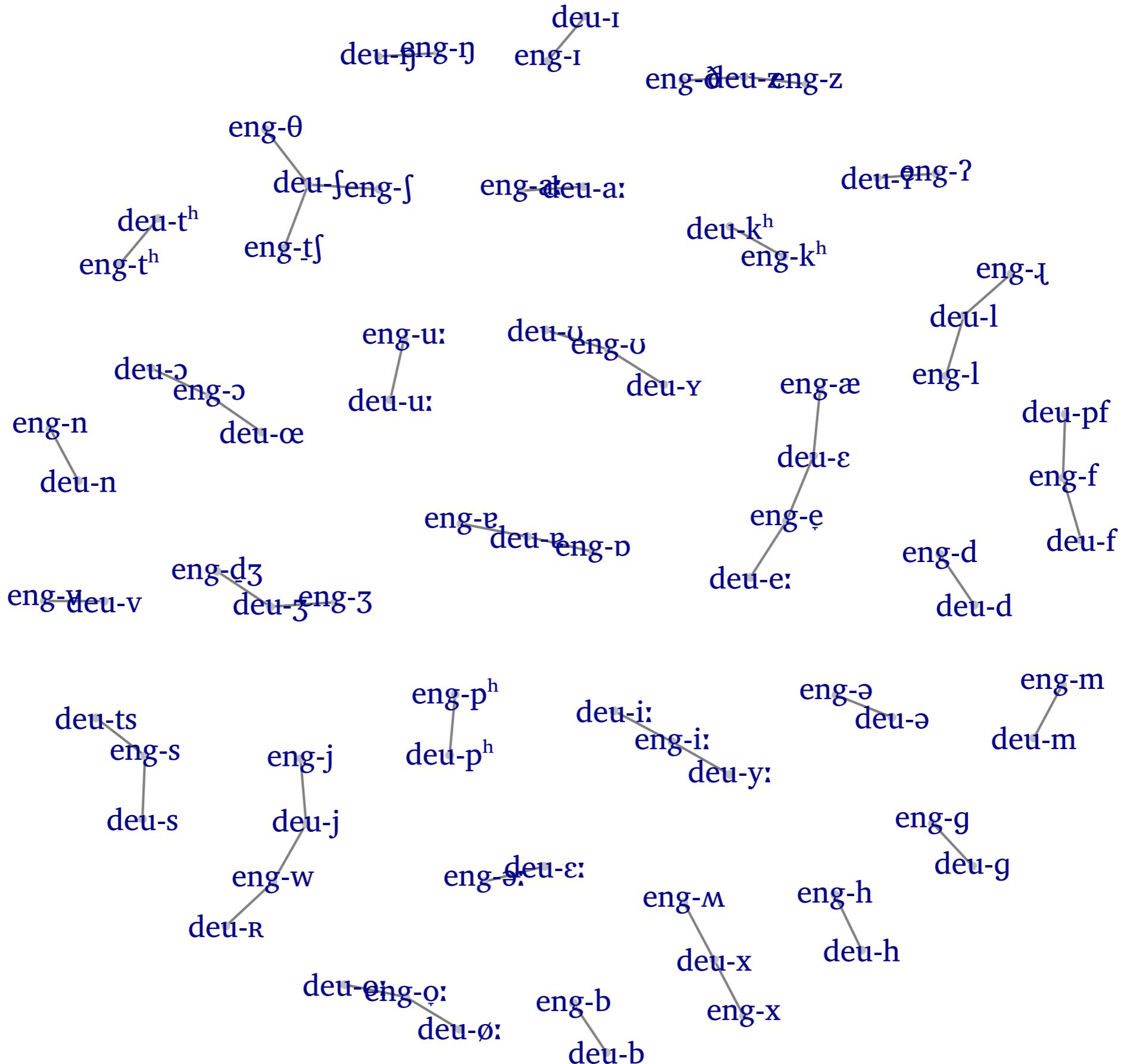
၁၈၁၂ ခုနှစ်၊ ဧပြီလ၊ ၁၅ ရက်နေ့တွင် မန္တလေးရာမြို့၏ အနောက် ၁၃၆၀။၀၀၀ ရွှေပွဲ ဖော်လုပ်မှု ပါဝါ ပေါ်လေသည်။

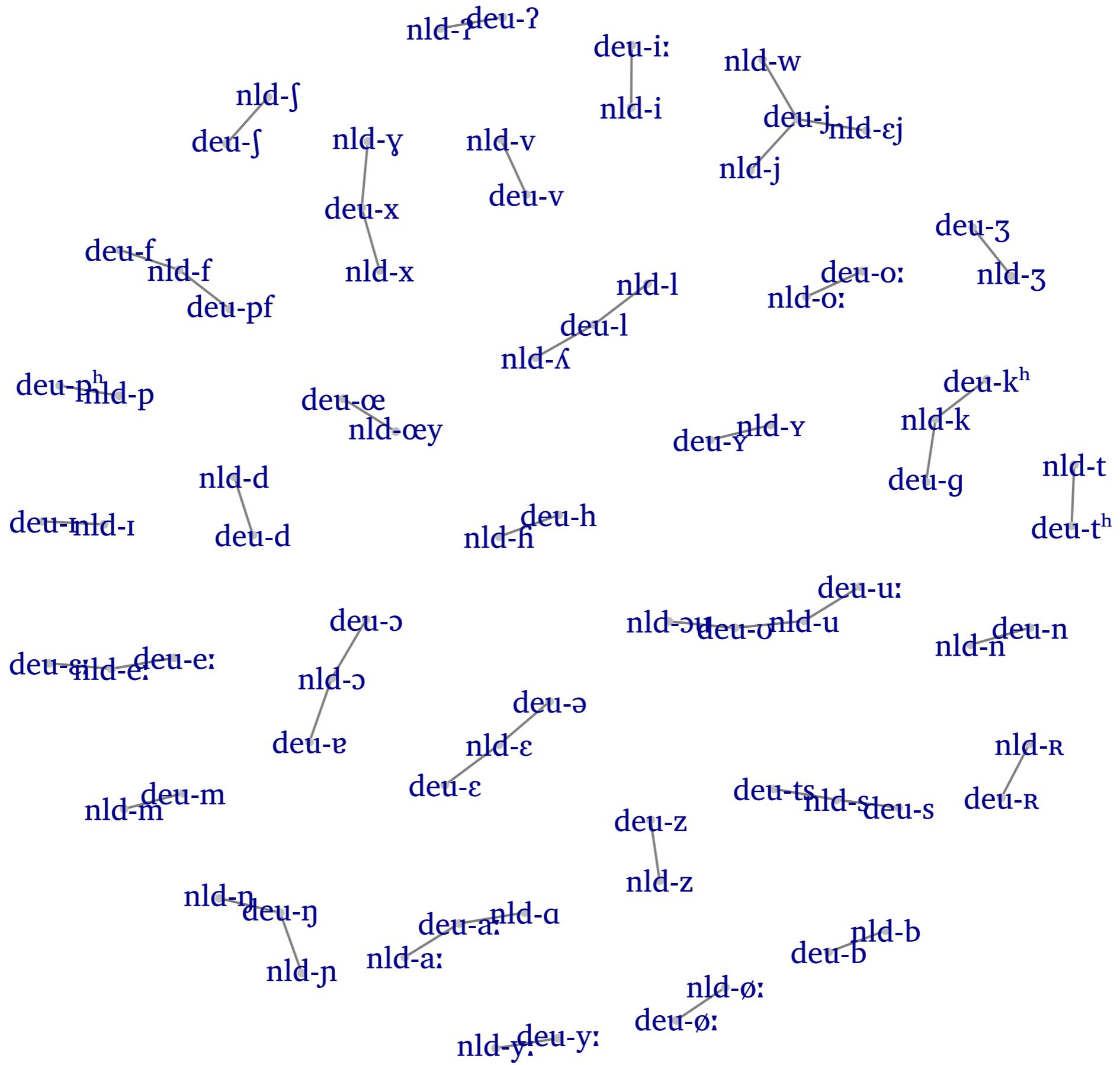
Digitized by srujanika@gmail.com

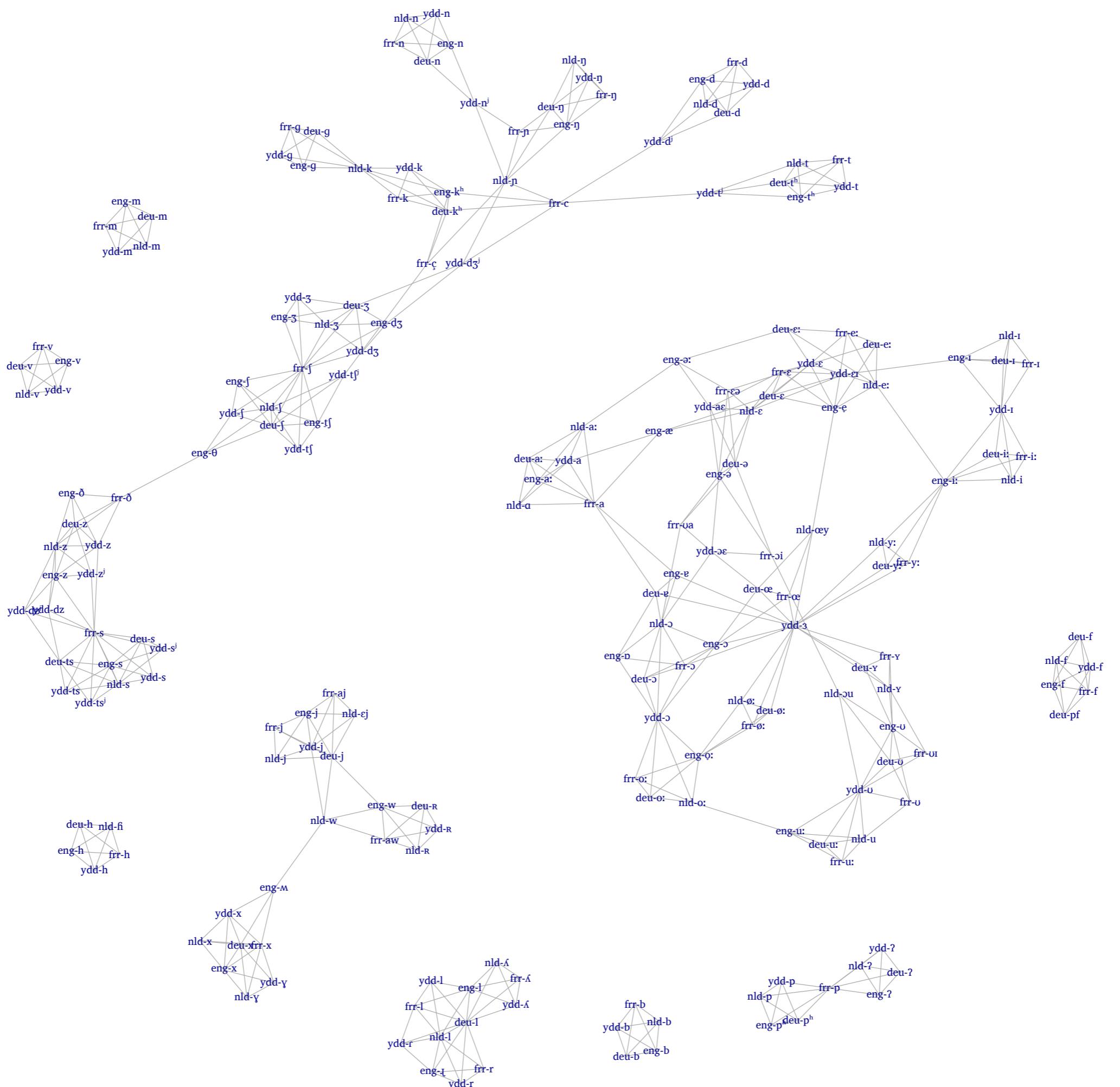


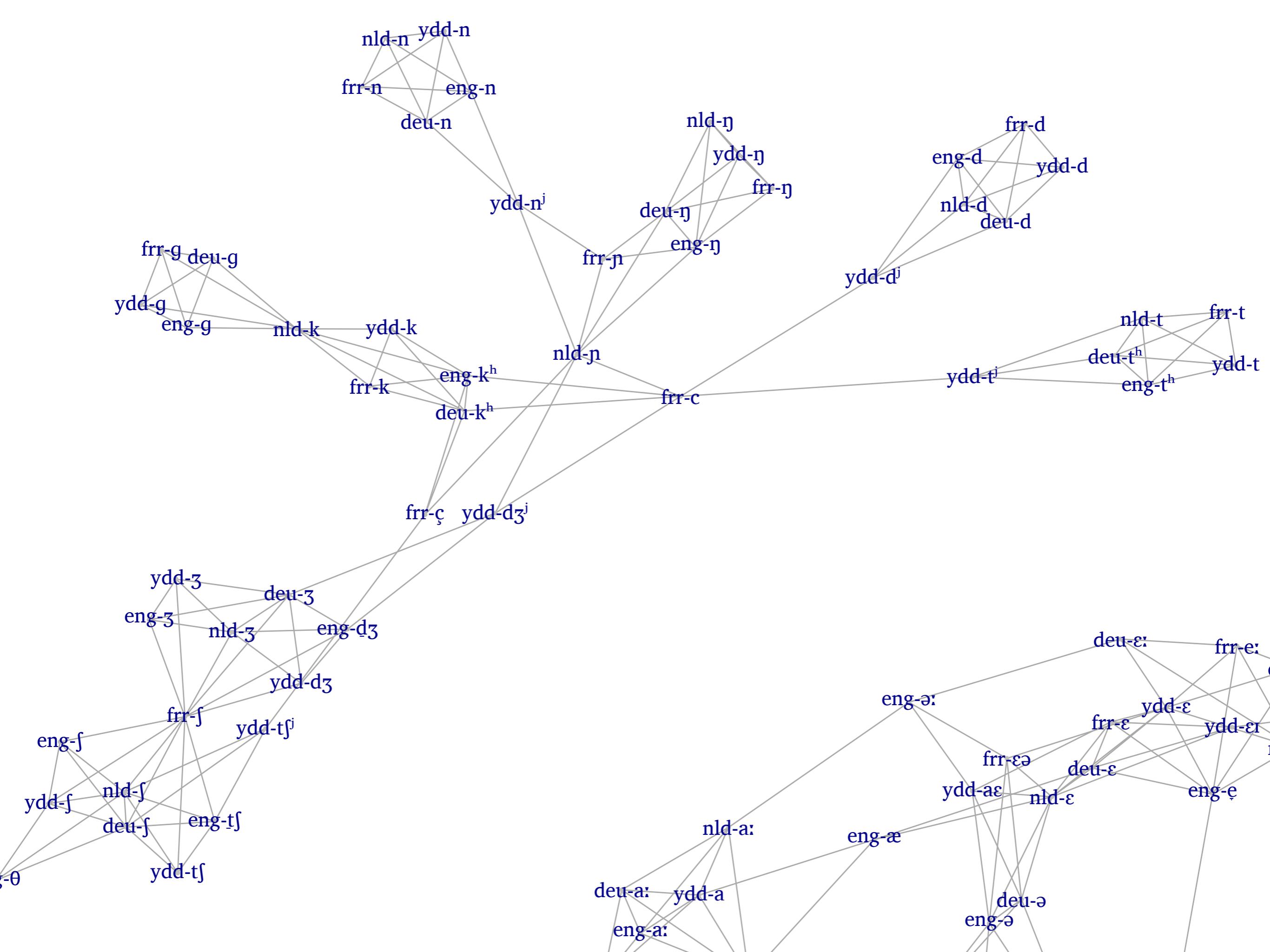


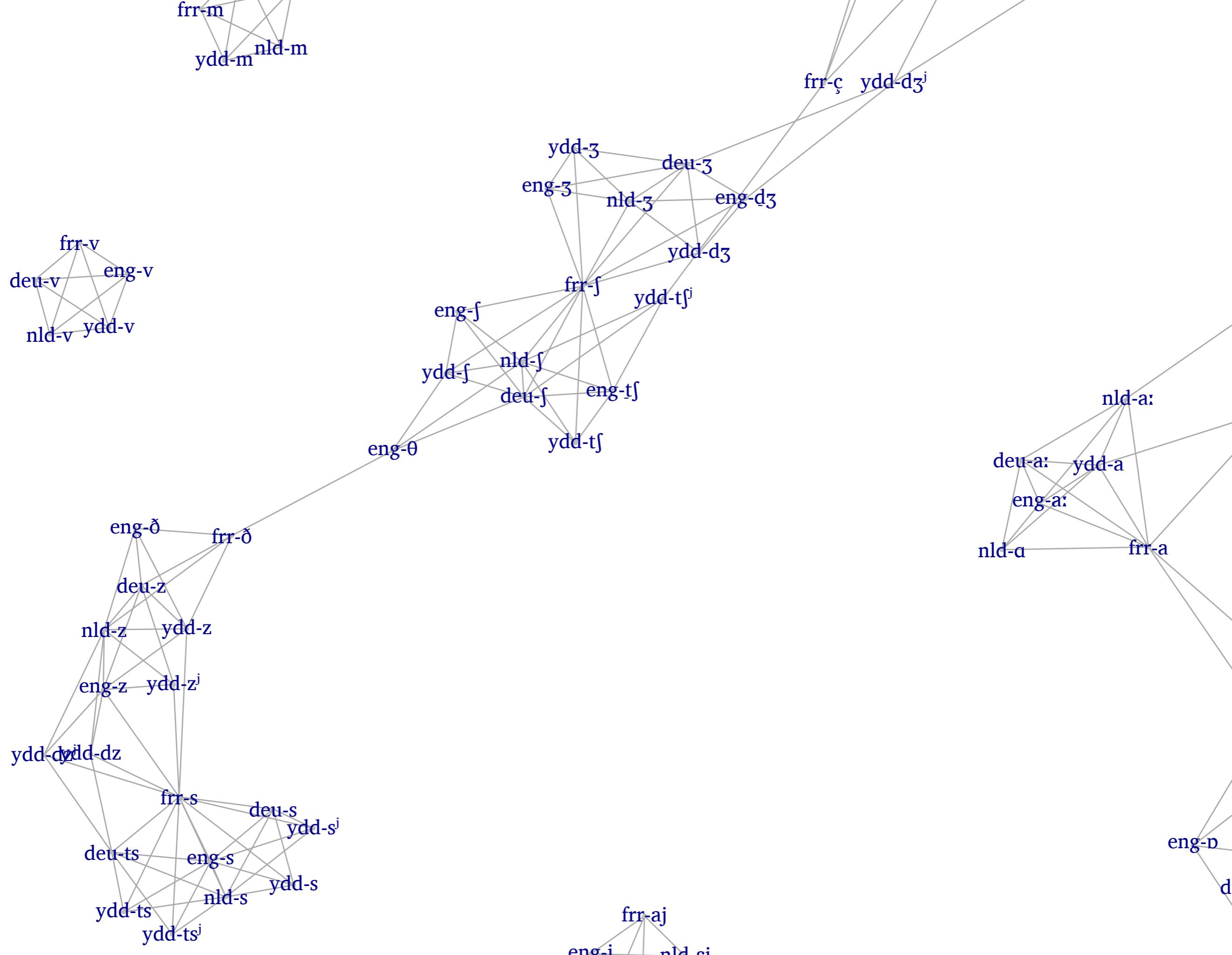


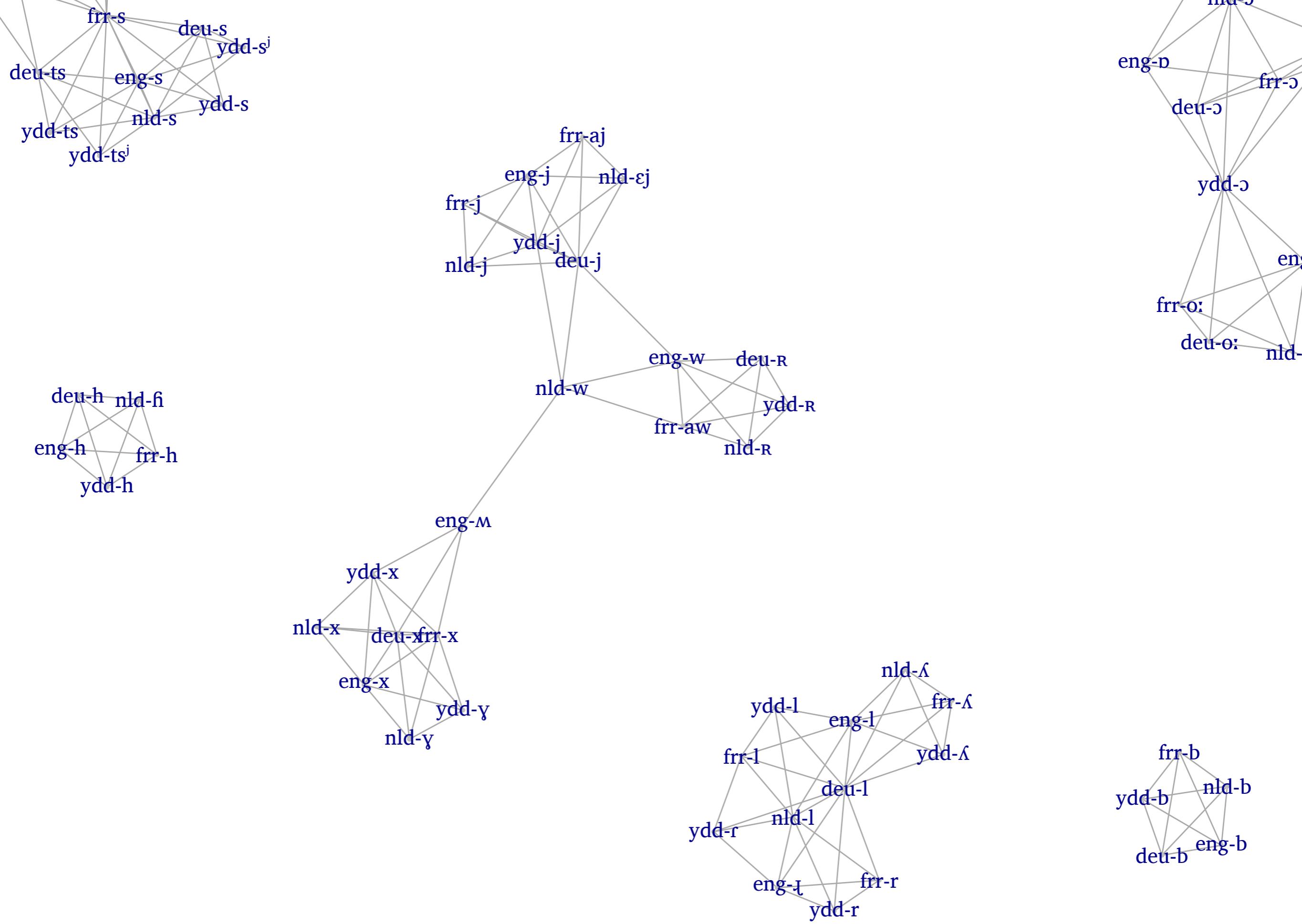


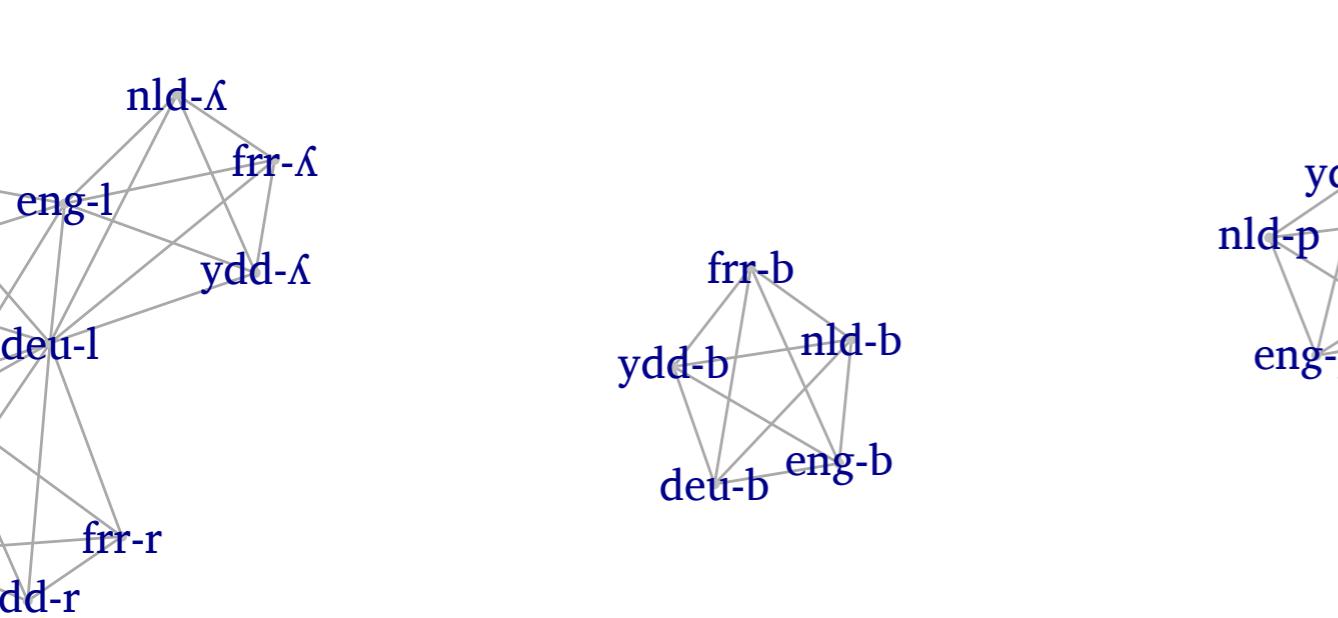
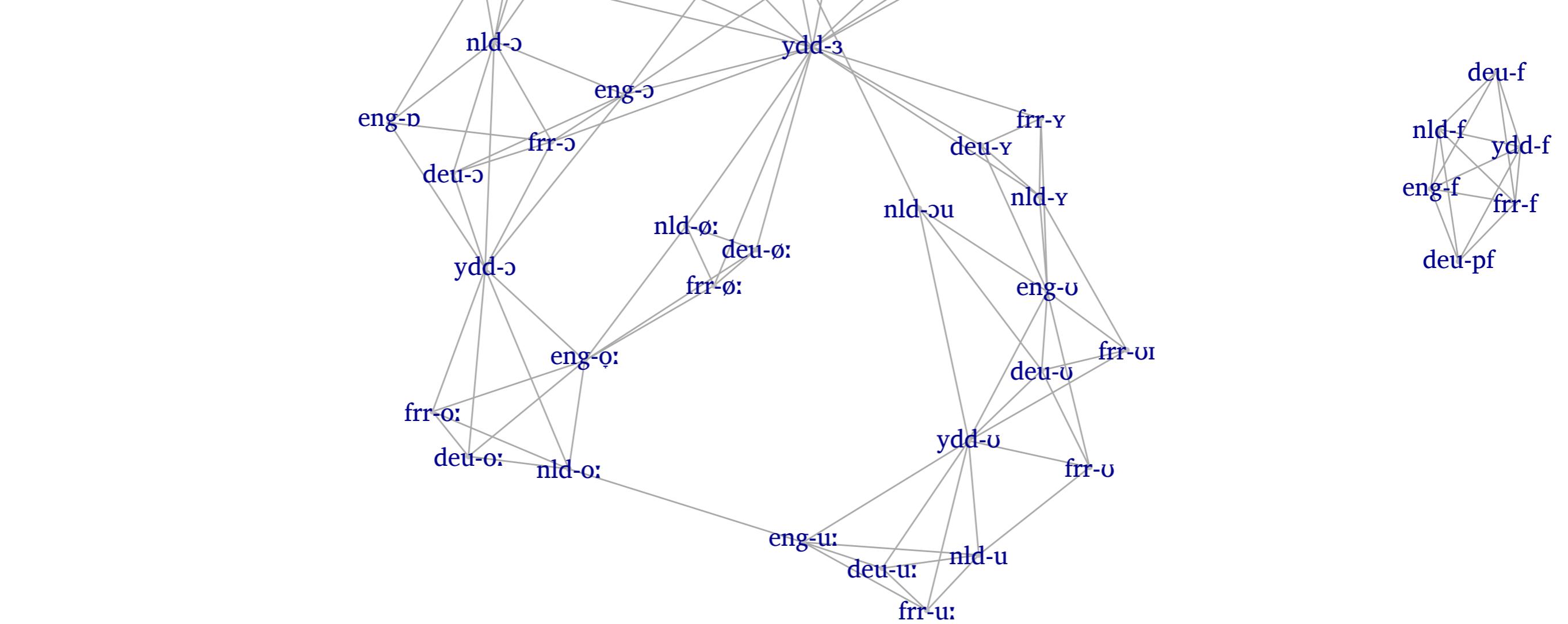


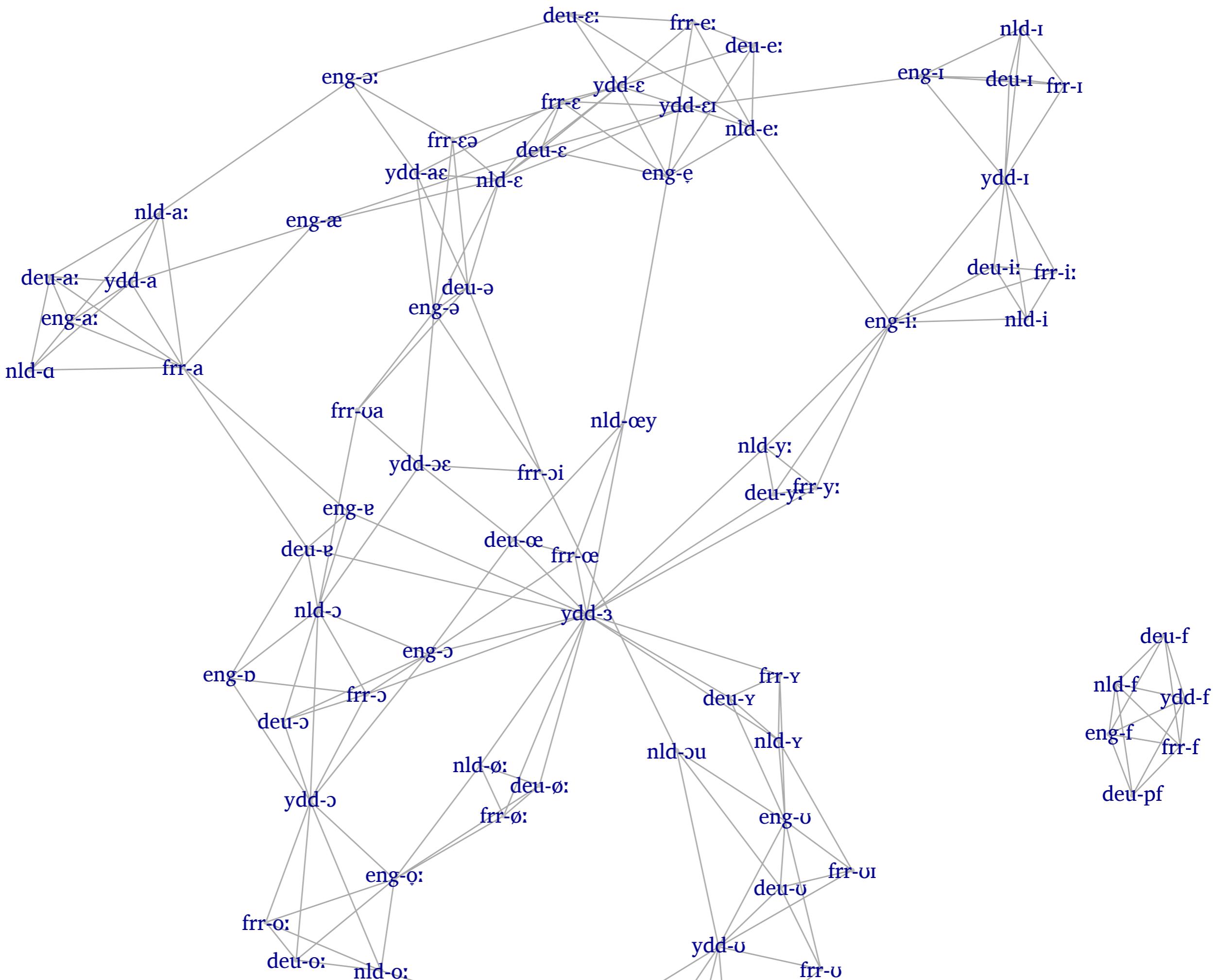


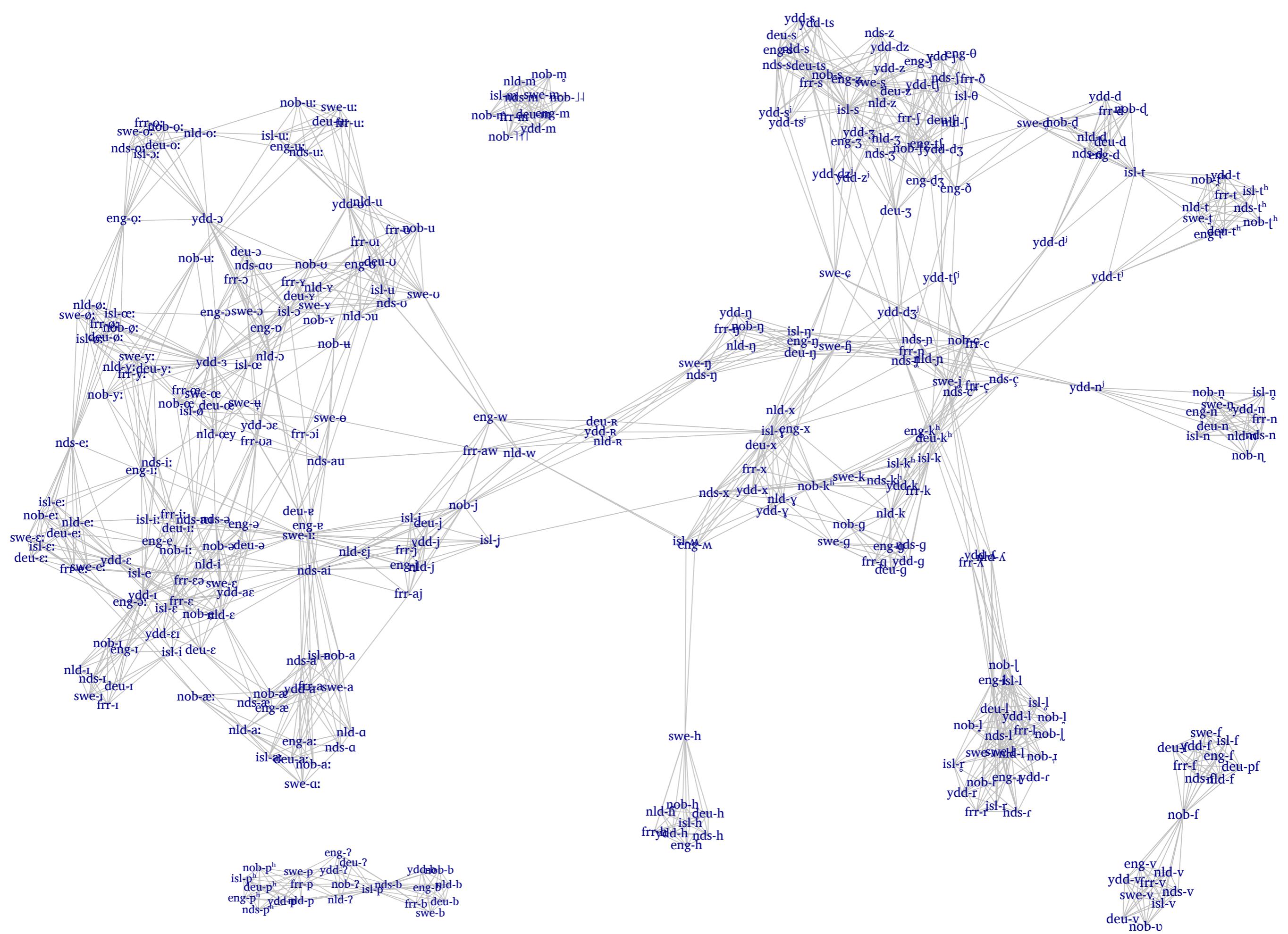












Characterizing Inventories

- Count identical segments
- Typological characteristics based on features
 - ▶ feature-clusters
 - ▶ feature variation
 - ▶ feature interaction
- Alignment to closest shared phones

Characterizing Inventories

- Count identical segments
- Typological characteristics based on features
 - ▶ feature-clusters
 - ▶ feature variation
 - ▶ feature interaction
- Alignment to closest shared phones

Characterizing Inventories

- Count identical segments
- Typological characteristics based on features
 - ▶ feature-clusters
 - ▶ feature variation
 - ▶ feature interaction
- Alignment to closest shared phones

Characterizing Inventories

- Count identical segments
- Typological characteristics based on features
 - ▶ **feature-clusters**
 - ▶ feature variation
 - ▶ feature interaction
- Alignment to closest shared phones

	l	m	n	ʃ	i:	ə	ð	ɛ	ɔ	s	a:	ʊ	w	k ^h	v	o:	ŋ	dʒ	t ^h	w	b	g	tʃ	x	u:	d	z	θ	p ^h	a	f	ʒ	æ	ɑ	ɿ	h	j	ɪ	ə
atr	0	0	0	0	-	-	0	-	-	0	-	-	0	0	0	-	0	0	0	0	0	0	0	0	0	0	-	0	0	-	-	0	0	0	0	-			
fortis	-	-	-	-	0	0	-	0	0	-	0	0	-	-	-	0	-	-	-	-	-	-	-	0	-	-	-	0	-	-	-	-	0						
tone	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0					
click	-	-	-	-	0	0	-	0	0	-	0	0	-	-	0	-	-	-	-	-	-	-	0	-	-	-	0	-	0	0	-	-	0						
implosive	-	-	-	-	0	0	-	0	0	-	0	0	-	-	0	-	-	-	-	-	-	-	0	-	-	-	0	-	0	-	-	0							
syllabic	-	-	-	-	+	+	-	+	+	-	+	+	-	-	+	-	-	-	-	-	-	-	+	-	-	-	+	-	-	-	-	+							
stress	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-							
long	-	-	-	-	+	-	-	-	-	+	-	-	-	+	-	-	-	-	-	-	-	-	+	-	-	-	-	-	-	-	-	+							
consonantal	+	+	+	+	-	-	+	-	-	+	-	-	+	+	-	+	+	+	+	-	+	+	+	+	-	+	-	-	+	-	+	-							
sonorant	+	+	+	-	+	+	-	+	+	-	+	+	-	+	-	+	-	-	-	-	+	-	-	-	+	-	-	+	+	-	+	-							
continuant	+	-	-	+	+	+	+	+	+	+	+	+	-	+	-	+	-	-	-	+	+	-	+	+	-	+	+	+	+	+	-	+							
delayedrelease	0	0	0	+	0	0	+	0	0	+	0	0	+	-	+	0	0	+	-	0	-	+	0	-	+	0	+	0	0	+	0	-	0						
approximant	+	-	-	-	+	+	-	+	+	-	+	+	-	-	+	-	-	-	-	+	-	-	-	+	-	-	+	-	+	-	+	-	+						
tap	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-						
trill	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-						
nasal	-	+	+	-	-	-	-	-	-	-	-	-	-	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-						
voice	+	+	+	-	+	+	+	+	+	-	+	+	-	+	+	+	+	+	+	-	+	+	+	-	+	-	+	+	+	-	+	-	+						
spreadglottis	-	-	-	-	-	-	-	-	-	-	-	-	+	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-						
constrictedglottis	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+						
labial	-	+	-	-	-	-	-	-	+	-	-	+	+	-	+	+	-	-	-	+	-	-	-	+	-	-	+	-	-	-	-	-	-	-					
round	-	-	-	-	-	-	-	-	+	-	-	+	+	-	+	+	-	-	-	+	-	-	+	-	-	+	-	-	-	-	-	-	-	-					
labiodental	-	-	-	-	-	-	-	-	-	-	-	-	-	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-						
coronal	+	-	+	+	-	-	+	-	-	-	-	-	-	-	+	+	-	-	-	+	-	-	+	+	-	-	-	+	-	-	-	-	-						
anterior	+	0	+	-	0	0	+	0	0	+	0	0	0	0	0	0	0	-	+	0	0	0	-	0	0	+	0	0	0	-	0	0	0	0					
distributed	-	0	-	+	0	0	+	0	0	-	0	0	0	0	0	0	0	0	+	-	0	0	0	+	0	0	0	+	0	0	-	0	0	0					
strident	-	0	-	+	0	0	-	0	0	+	0	0	0	0	0	0	0	0	+	-	0	0	0	+	0	0	0	+	0	0	-	0	0	0					
lateral	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-					
dorsal	-	-	-	-	+	+	-	+	+	-	+	+	+	-	+	+	-	-	+	-	+	-	+	-	-	+	-	-	+	-	+	-	-	+					
high	0	0	0	0	+	-	0	-	-	0	-	+	+	0	-	+	0	0	+	0	+	+	0	0	0	0	-	0	0	+	0	-	0						
low	0	0	0	0	-	-	0	-	-	0	+	-	-	0	-	0	0	-	0	-	0	-	0	0	0	0	+	0	0	-	0	-	0						
front	0	0	0	0	+	-	0	+	-	0	-	-	-	0	-	0	0	-	0	-	0	-	0	0	0	0	-	0	0	+	-	0	0	-					
back	0	0	0	0	-	-	0	-	+	0	-	+	+	-	0	+	-	0	0	+	0	-	0	0	0	0	+	0	0	-	0	0	-	0					

	l	m	n	ʃ	i:	ə	ð	ɛ	ɔ	s	a:	ʊ	w	k ^h	v	o:	ŋ	dʒ	t ^h	w	b	g	tʃ	x	u:	d	z	θ	p ^h	a	f	ʒ	æ	ə	ɿ	h	j	ɻ	ɛ	e:
atr	0	0	0	0	-	-	0	-	-	0	-	-	0	0	0	-	0	0	0	0	0	0	0	0	0	0	0	-	0	0	-	-	0	0	0	0	-			
fortis	-	-	-	-	0	0	-	0	0	-	0	0	-	-	-	0	-	-	-	-	-	-	-	-	0	-	-	0	-	-	-	-	0							
tone	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0							
click	-	-	-	-	0	0	-	0	0	-	0	0	-	-	0	-	-	-	-	-	-	-	-	0	-	-	0	-	-	0	-	-	0	-						
implosive	-	-	-	-	0	0	-	0	0	-	0	0	-	-	0	-	-	-	-	-	-	-	-	0	-	-	0	0	-	-	-	0	-							
syllabic	-	-	-	-	+	+	-	+	+	-	+	+	-	-	+	-	-	-	-	-	-	-	-	+	-	-	-	+	-	-	-	+	-							
stress	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-							
long	-	-	-	-	-	+	-	-	-	+	-	-	-	+	-	-	-	-	-	-	-	-	-	+	-	-	-	-	-	-	-	-	+							
consonantal	+	+	+	+	-	-	+	-	-	+	-	-	+	+	-	+	+	+	+	-	+	+	+	+	-	+	+	-	-	+	-	+	-							
sonorant	+	+	+	-	+	+	-	+	+	-	+	+	-	-	+	-	+	-	-	-	-	-	-	+	-	-	+	-	+	-	+	-	+							
continuant	+	-	-	+	+	+	+	+	+	+	+	+	-	+	-	+	-	-	-	-	+	+	-	+	+	-	+	+	+	-	+	-								
delayedrelease	0	0	0	+	0	0	+	0	0	+	0	0	+	-	+	0	0	+	-	0	-	-	+	0	-	+	-	0	+	0	0	+	0	-	0					
approximant	+	-	-	-	+	+	-	+	+	-	+	+	-	-	+	-	-	-	-	-	-	-	-	+	-	-	+	-	+	-	+	-	+							
tap	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-							
trill	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-							
nasal	-	+	+	-	-	-	-	-	-	-	-	-	-	-	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-							
voice	+	+	+	-	+	+	+	+	+	-	+	+	-	+	+	+	+	+	+	-	+	+	+	-	+	+	+	+	+	-	+	-	+							
spreadglottis	-	-	-	-	-	-	-	-	-	-	-	-	-	+	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-							
constrictedglottis	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+							
labial	-	+	-	-	-	-	-	-	+	-	-	+	+	-	+	+	-	-	-	-	+	-	-	-	+	+	+	-	-	+	-	-	-							
round	-	-	-	-	-	-	-	-	+	-	-	+	+	-	+	+	-	-	-	-	+	-	-	-	+	-	-	-	+	-	-	-	-							
labiodental	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-							
coronal	+	-	+	+	-	-	+	-	-	-	-	-	-	-	+	+	-	-	-	-	+	-	-	+	+	+	-	-	-	+	-	-	-							
anterior	+	0	+	-	0	0	+	0	0	+	0	0	0	0	0	0	0	0	-	0	0	0	-	0	0	0	-	0	0	0	0	0	0							
distributed	-	0	-	+	0	0	+	0	0	-	0	0	0	0	0	0	0	0	+	-	0	0	0	+	0	0	0	+	0	0	-	0	0							
strident	-	0	-	+	0	0	-	0	0	+	0	0	0	0	0	0	0	0	+	-	0	0	0	+	0	0	0	+	0	0	-	0	0							
lateral	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-							
dorsal	-	-	-	-	+	+	-	+	+	-	+	+	+	-	+	+	-	-	-	+	-	-	-	+	-	-	-	+	-	-	+	-	+							
high	0	0	0	0	+	-	0	-	-	0	-	+	+	0	-	+	0	0	+	0	+	+	0	0	0	0	-	0	0	+	0	-	0							
low	0	0	0	0	-	-	0	-	-	0	-	-	0	-	-	0	0	-	0	-	0	-	0	0	0	0	+	0	0	-	0	-	0							
front	0	0	0	0	+	-	0	+	-	0	-	-	-	0	-	-	0	0	-	0	-	-	0	0	0	0	-	0	0	+	-	0	0							
back	0	0	0	0	-	-	0	-	+	0	-	+	+	-	0	+	-	0	0	+	0	-	+	0	0	0	+	0	0	-	0	0	-	0						

Characterizing Inventories

- Count identical segments
- Typological characteristics based on features
 - ▶ feature-clusters
 - ▶ **feature variation**
 - ▶ feature interaction
- Alignment to closest shared phones

	l	m	n	ʃ	i:	ə	ð	ɛ	ɔ	s	a:	ʊ	w	k ^h	v	o:	ŋ	dʒ	t ^h	w	b	g	tʃ	x	u:	d	z	θ	p ^h	a	f	ʒ	æ	ɑ	ɿ	h	j	ɪ	ɛ
atr	0	0	0	0	-	-	0	-	-	0	-	-	0	0	0	-	0	0	0	0	0	0	0	0	0	0	-	0	0	-	-	0	0	0	0	-			
fortis	-	-	-	-	0	0	-	0	0	-	0	0	-	-	-	-	-	-	-	-	-	-	-	-	-	0	-	-	0	0	-	-	-	0					
tone	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
click	-	-	-	-	0	0	-	0	0	-	0	0	-	-	-	-	-	-	-	-	-	-	-	-	0	-	-	0	-	-	0	0	-	-	-	0			
implosive	-	-	-	-	0	0	-	0	0	-	0	0	-	-	-	-	-	-	-	-	-	-	-	-	0	-	-	0	-	-	0	-	-	-	0				
syllabic	-	-	-	-	+	+	-	+	+	-	+	+	-	-	-	-	-	-	-	-	-	-	-	-	+	-	-	-	+	-	-	-	-	-	+				
stress	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-				
long	-	-	-	-	+	-	-	-	-	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	-	-	-	-	-	-	-	-	-	+				
consonantal	+	+	+	+	-	-	+	-	-	+	-	-	+	+	-	+	+	+	+	-	+	+	+	-	+	+	-	-	+	-	-	+	-	-	+				
sonorant	+	+	+	-	+	+	-	+	+	-	+	+	-	-	+	-	+	-	-	-	+	-	-	-	+	-	-	+	+	-	+	-	+	-	+				
continuant	+	-	-	+	+	+	+	+	+	+	+	+	-	+	-	-	-	-	-	+	+	-	+	+	-	+	+	+	+	+	+	+	-	+					
delayedrelease	0	0	0	+	0	0	+	0	0	+	0	0	+	-	+	0	0	+	-	0	-	-	+	0	-	+	-	0	+	+	0	0	0	+	0	-	0		
approximant	+	-	-	-	+	+	-	+	+	-	+	+	-	-	+	-	-	-	-	+	-	-	-	-	+	-	-	+	+	-	+	-	+	-	+				
tap	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-				
trill	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-				
nasal	-	+	+	-	-	-	-	-	-	-	-	-	-	-	-	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-				
voice	+	+	+	-	+	+	+	+	+	-	+	+	-	+	+	+	+	+	+	-	+	+	+	-	+	-	+	+	+	-	+	-	+	-	+				
spreadglottis	-	-	-	-	-	-	-	-	-	-	-	-	+	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-				
constrictedglottis	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+				
labial	-	+	-	-	-	-	-	-	+	-	-	+	+	-	+	+	-	-	-	-	+	-	-	-	+	-	+	+	-	-	+	-	-	-	-				
round	-	-	-	-	-	-	-	-	+	-	-	+	+	-	+	+	-	-	-	-	+	-	-	-	+	-	-	-	+	-	-	-	-	-	-				
labiodental	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-				
coronal	+	-	+	+	-	-	+	-	-	-	-	-	-	-	-	+	+	-	-	-	+	-	-	+	+	+	-	-	-	+	-	-	-	-	-				
anterior	+	0	+	-	0	0	+	0	0	+	0	0	0	0	0	0	0	-	+	0	0	0	-	0	0	+	+	+	0	0	0	-	0	0	0	0			
distributed	-	0	-	+	0	0	+	0	0	-	0	0	0	0	0	0	0	0	+	-	0	0	0	+	0	0	0	+	0	0	-	0	0	0	0	0			
strident	-	0	-	+	0	0	-	0	0	+	0	0	0	0	0	0	0	0	+	-	0	0	0	+	0	0	0	+	0	0	-	0	0	0	0	0			
lateral	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-			
dorsal	-	-	-	-	+	+	-	+	+	-	+	+	+	-	+	+	-	-	-	+	-	-	-	+	-	-	-	+	-	-	+	-	-	+	-	+			
high	0	0	0	0	+	-	0	-	-	0	-	+	+	0	-	+	0	0	+	0	+	+	0	0	0	0	-	0	0	-	0	0	+	0	-	-			
low	0	0	0	0	-	-	0	-	-	0	+/-	-	-	0	0	-	0	0	-	0	-	-	0	0	0	0	+	0	0	+	0	-	0	-	0				
front	0	0	0	0	+	-	0	+	-	0	-	-	-	0	-	-	0	0	-	0	-	-	0	0	0	0	-	0	0	+	-	0	0	+	0	-	-		
back	0	0	0	0	-	-	0	-	+	0	-	+	+	-	0	+	-	0	0	+	0	-	0	+	0	0	0	+	0	0	-	-	0	0	-	0	-	0	

Characterizing Inventories

- Count identical segments
- Typological characteristics based on features
 - ▶ feature-clusters
 - ▶ feature variation
 - ▶ **feature interaction**
- Alignment to closest shared phones

Characterizing Inventories

- Count identical segments
- Typological characteristics based on features
 - ▶ feature-clusters
 - ▶ feature variation
 - ▶ feature interaction
- Alignment to closest shared phones

k t^h l m_o ʌ l R d ʌ:

ydd

nld

frr

nds

swe

isl

nob

eng

deu

k t^h l m_o ɿ l R d ɿ:

ydd

nld

frr

nds

swe

isl

nob

m_o

eng

deu

	k	t ^h	l	m _o	ɥ	l	R	d	ɥ:
ydd				m					
nld				m					
frr				m					
nds				m					
swe				m					
isl				m					
nob				m _o					
eng				m					
deu				m					

	k	t ^h	l	m _o	ɥ	l	R	d	ɥ:
ydd	k	t	l	m	3	1	R	d	3
nld	k	t	l	m	œy	1	R	d	y:
frr	k	t	l	m	y:	1	aw	d	y:
nds	k ^h	t ^h	l	m	au	1	ŋ	d	u:
swe	k	t	l	m	ɥ	1	ŋ	d	y:
isl	k	t ^h	l	m	∅	1	y	t	u:
nob	k ^h	t ^h	l	m _o	ɥ	l	j	d	ɥ:
eng	k ^h	t ^h	l	m	i:	1	w	d	u:
deu	k ^h	t ^h	l	m	y:	1	R	d	y:

Part of the problem

t - d (Dutch, Yiddish, Frisian)

t^h - d (English, German, Low German)

t - t^h (Icelandic)

ʈ - ɖ (Swedish)

ʈ^h - ɖ (Norwegian)

Conclusion

- No success yet
(though only limited testing)
- We have to even deeper analyze historical linguistic argumentation
- Use assumed family-trees to fine-tune the methods (i.e. find out what works best)
- Use even fancier maths ...