Empirical Phonology

Classifying consonant systems
2019-07-17, 08:00-10:00

Dafydd Gibbon

Bielefeld University
Jinan University, Guangzhou

Empirical ~~Experimental~~ Phonology

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Two classification tasks

Classification of the perception of Mandarin tones by Chinese dialect speakers by a sociophonetic survey method

Classification of Kru (Niger-Congo) dialects using legacy dialect survey data of consonant systems

Classification of the perception of Mandarin tones by Chinese dialect speakers by a sociophonetic survey method

ABSTRACT

- Preliminary to a larger scale dialect study
- Novel online sociophonetic survey of the ascription of pitch descriptors to tones
- Respondents rated the applicability of descriptors of pitch contour and height to recordings of tones on a 5-point Likert scale.
- Each response contained meta-data, with self-reported experience with regional varieties of Chinese.
- Descriptive results:
  - differences in variability between pitch contour and pitch height descriptors
  - some dependence between descriptor scores and regional dialect (categorial tone perception)
- Evaluation: ANOVA + hierarchical classifiers with dendrogram visualisation for comparison with dialect areas
- Strategic result: fit for purpose in follow-up extensive study

INDEX TERMS

Mandarin Chinese
multidialectal survey
categorial tone perception
pitch descriptor
regional variability
dialect
sociophonetics

OSCAR

wwwhomes.uni-bielefeld.de/gibbon/OSCAR/OSCAR_cmn01/

CONTACT

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GOALS

Test of new method

- multidialectal comparison
- contrast with previous bidialectal and bilingual comparisons
- exploratory rather than confirmatory

Sociophonetic focus

- assignment of descriptors of perceived pitch
  - to standard Mandarin (Pǔtōnghuà) tones
  - by native speaker responders from different regions
- comparison of height and contour descriptors
- focus on inter-rater variability
  - contrast with inter-rater reliability
- preparation for a large-scale multidialectal study
- longer-term goal of relating pitch descriptor assignments
  - to self-ascribed regional dialects
  - to linguistic dialect classification

USING AND STUDYING SPEECH PERCEPTION

Auditory perception underlies transcription

- continuous perception
- categorial perception

Transcription is one kind of

- documentation of categorial perception
- usually with the International Phonetic Alphabet

  or with special alphabets for prosody or speech pathology

Annotation is

- segmentation: assignment of signal time-stamps
- classification: to symbols of a transcription

Perceptual experiments, e.g.:

- judgment
- transcription, transcription marking
- reaction time

DIFFERENT APPROACH: ONLINE OPINION SURVEY

Task of assigning pitch descriptors to tones

- metalinguistic documentation of perception
  - cf. judgment paradigm of auditory phonetics and phonology
- sociophonetics, ‘folk linguistic’ opinions

There are many formats for opinion surveys

- open interview
- closed set (standard: Likert scale)
  - for this test:
    - audio input and Likert scale response to a statement:
      - strongly agree
      - agree
      - don’t care
      - disagree
      - strongly disagree

Dr. Rensis Likert
1903-1981

Likert scale 1932
(Ph.D. thesis)

DIFFERENT APPROACH: ONLINE OPINION SURVEY

Task of assigning pitch descriptors to tones

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  - cf. judgment paradigm of auditory phonetics and phonology
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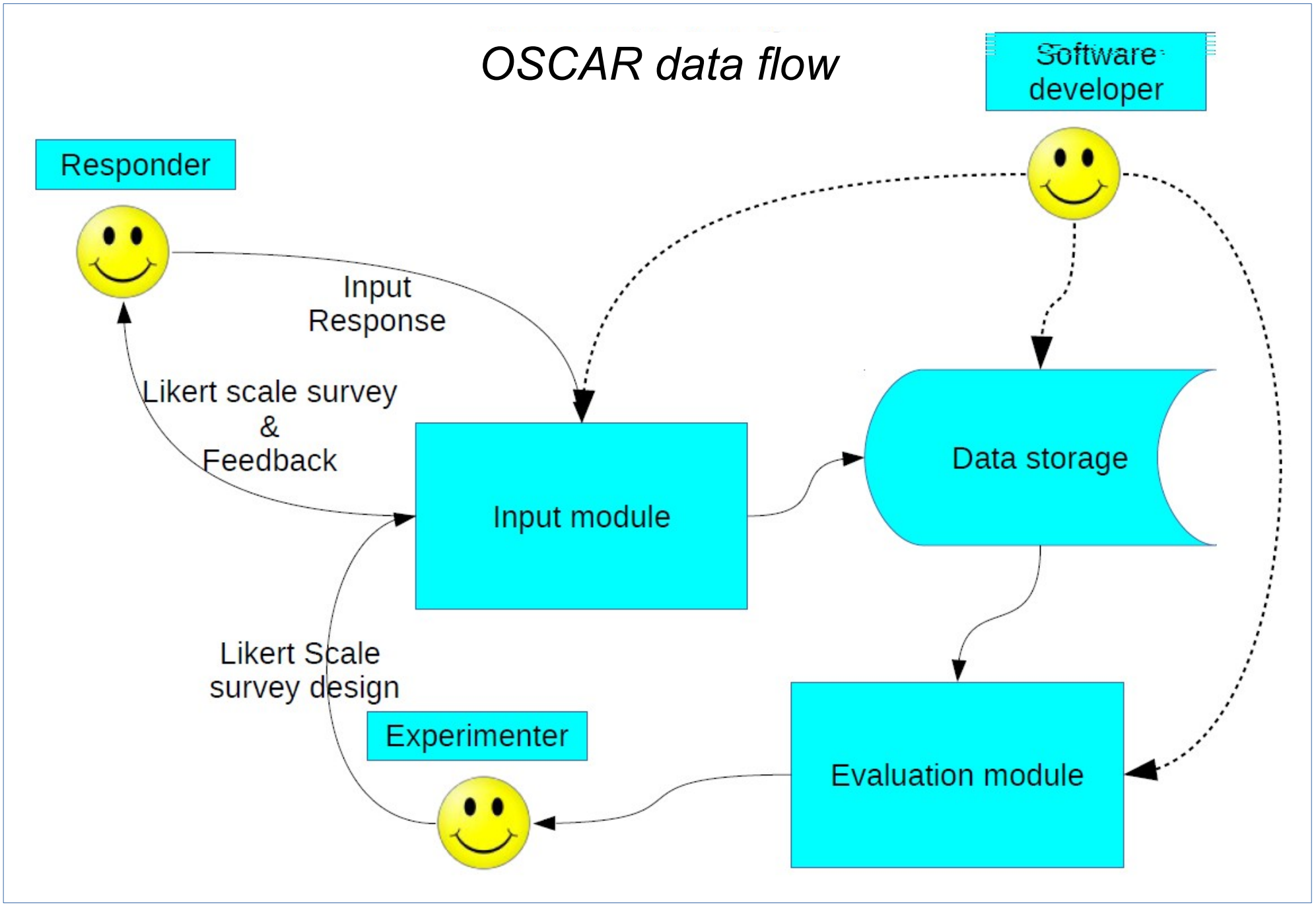
Custom online tool OSCAR

- input:
  - responder metadata: age group, sex, L1, regional variety
  - single-page Likert format survey form
    - list of tones + pitch descriptor choices
- output:
  - for responders: notification of (in-)completeness of responses
  - for experimenter: automatic evaluation

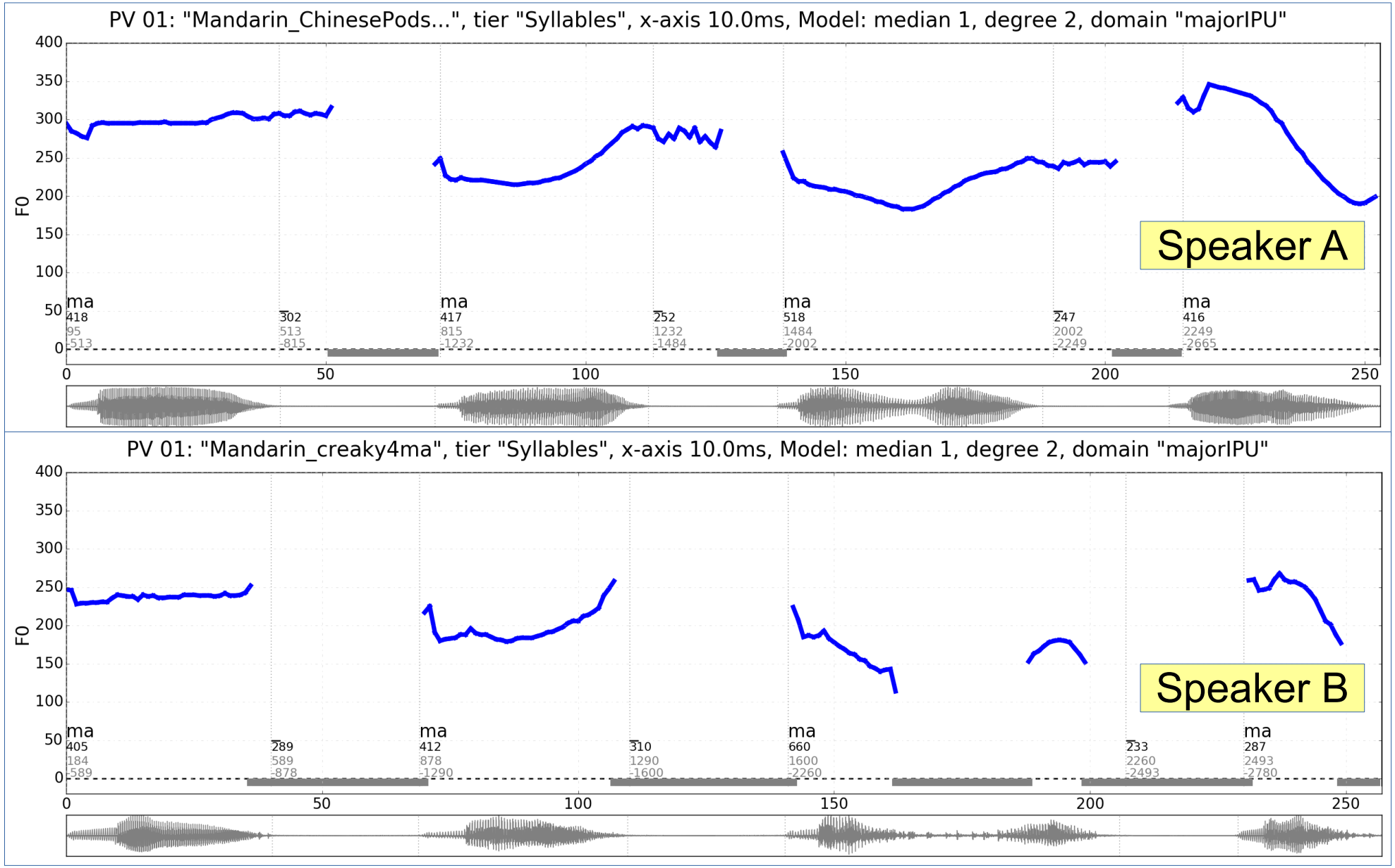

OSCAR data flow
Software developer
Responder
Input
Response
Likert scale survey
&
Feedback
Input module
Data storage
Likert Scale
survey design
Experimenter
Evaluation module

TASK

Stimuli

- 16 tone items:
  - 4 tones
  - 2 tokens each
  - 2 female speakers, standard Beijing Mandarin
- for all responders:
  - same randomised token order
  - no adjacent repetitions

Mandarin lexical tones

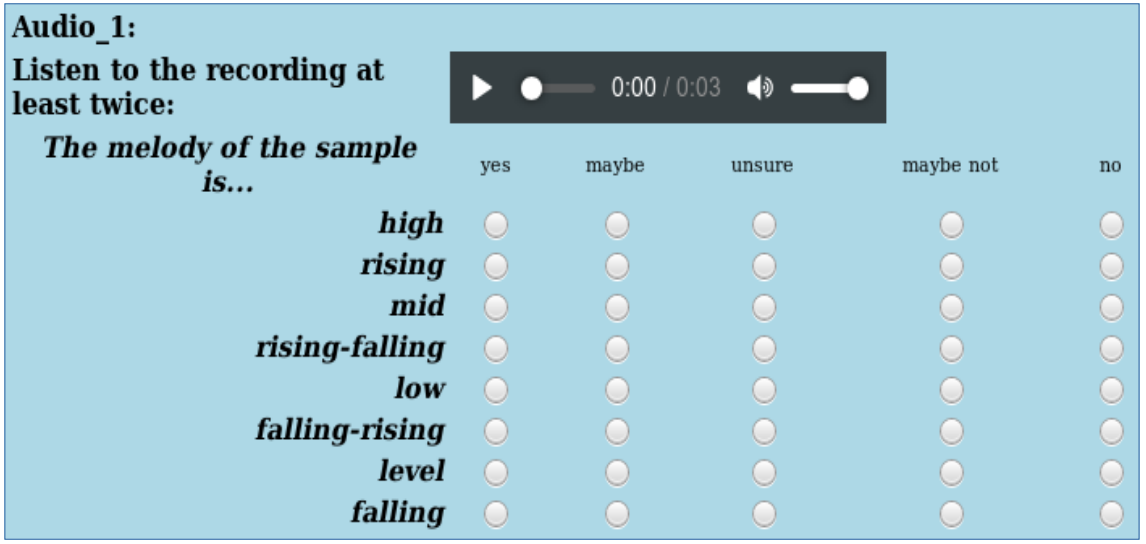


INPUT TASKS

Descriptors:

- 8 pitch descriptors
  - contours: *level*, *rise*, *fall-rise*, *rise-fall* (distractor), *fall*
  - heights: *high*, *mid*, *low*
- 5-point rating scale, Likert-like format
  - yes, maybe, not sure, maybe not, no
- coded for evaluation: 5,4,3,2,1

OSCAR Graphical User Interface



INPUT TASKS

Metadata:

OSCAR: Opinion Survey Collation And Reporting

OSCAR_cmn01 Survey

Speech Perception Survey: Pronunciation Style

Section A: In Section A of the questionnaire, 4 background questions are asked about your personal information. Please answer all questions.

Section B: In Section B, 8 questions about your impressions of the melody of the samples are asked: whether the melody goes up or down, is high or low, etc. For each question, please indicate on all rows to what extent you agree with the description.

Procedure:

- **Please deal with the recordings and the questions one by one: first listen to the audio (as many times as you like, but at least twice), then answer the questions for that recording.**
- **Kindly complete all questionnaire items in Sections A and B.**
- **All survey questions are on this page.**

Section A

Age: *18-25:* ○ *26-45:* ○ *46-65:* ○ *Over 65:* ○

Gender *Female:* ○ *Male:* ○

First language:

Which regional variety of your language do you speak?

Section B

- Please listen to each recording at least twice (a transcript is provided).
- Then for each description (sarcastic, appropriate, etc.) click on your impression of whether you *strongly agree, agree, have no opinion, disagree* or *strongly disagree* with the statements associated with the examples.
- Then please give your ideas about what causes this impression.

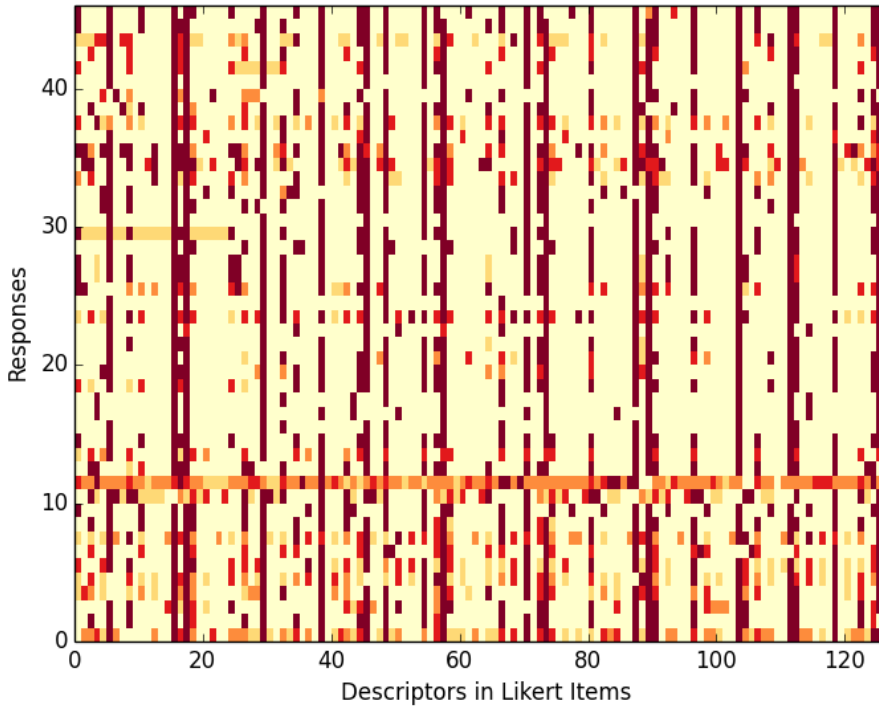
Before continuing with discussion of the results:

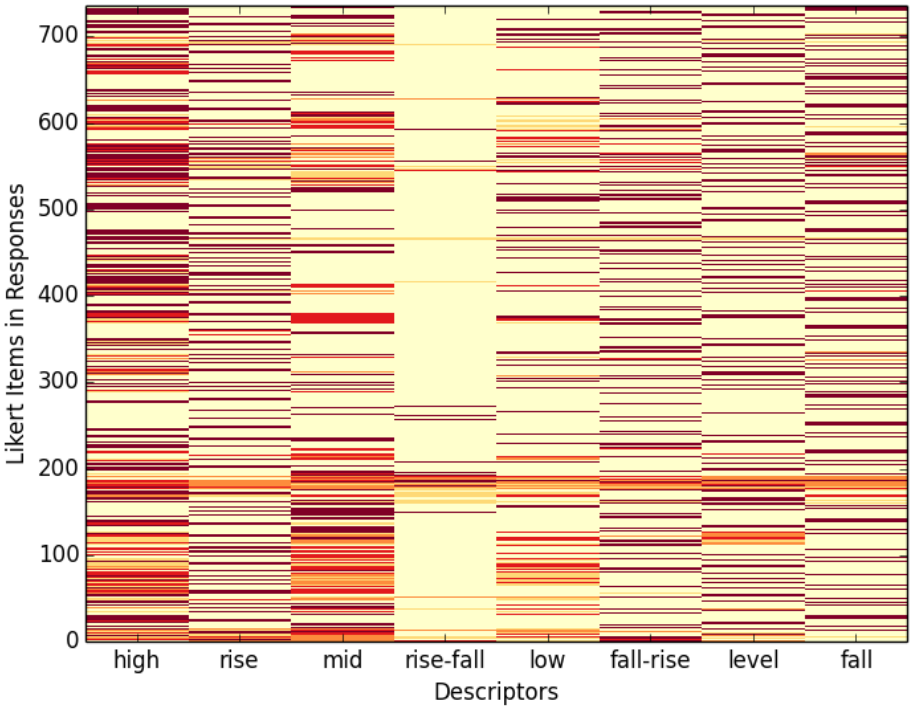
Please do this experiment yourself!

http://wwwhomes.uni-bielefeld.de/gibbon/OSCAR/OSCAR_cmn01/

(Note: the server is slow, so please be patient!)

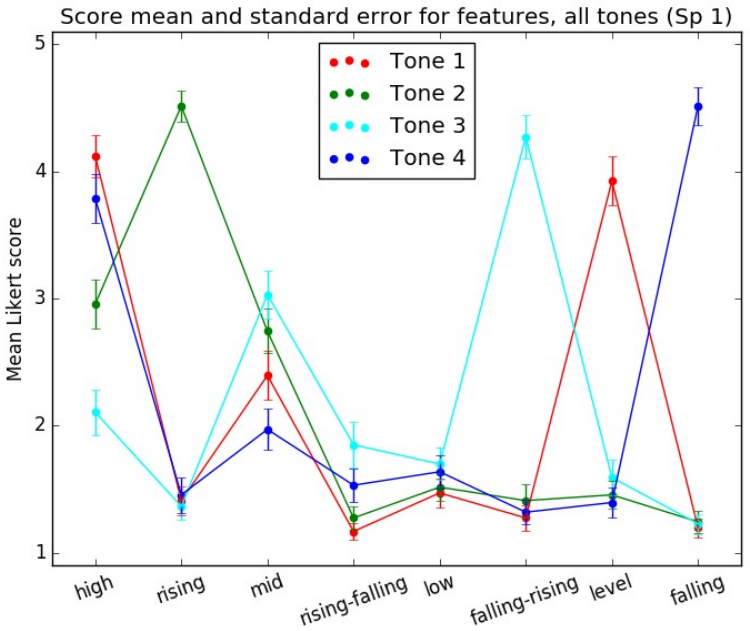
A first overview of the data: heat maps

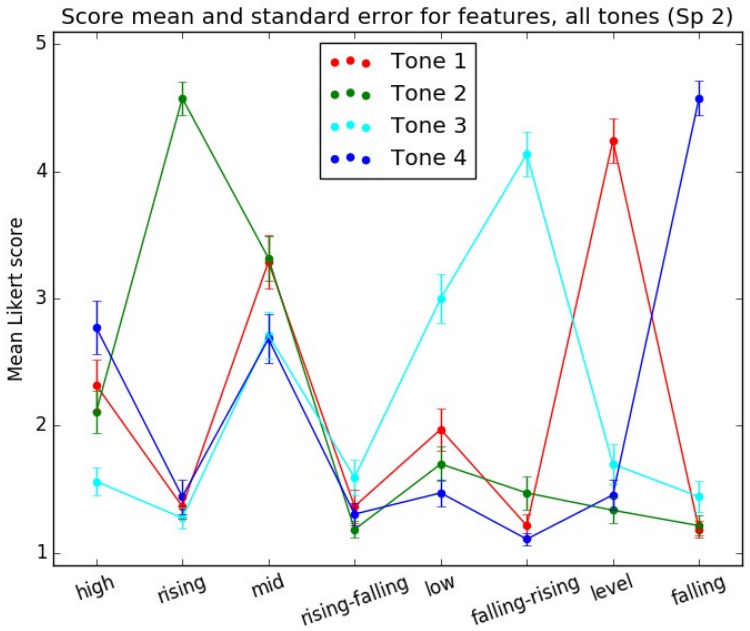




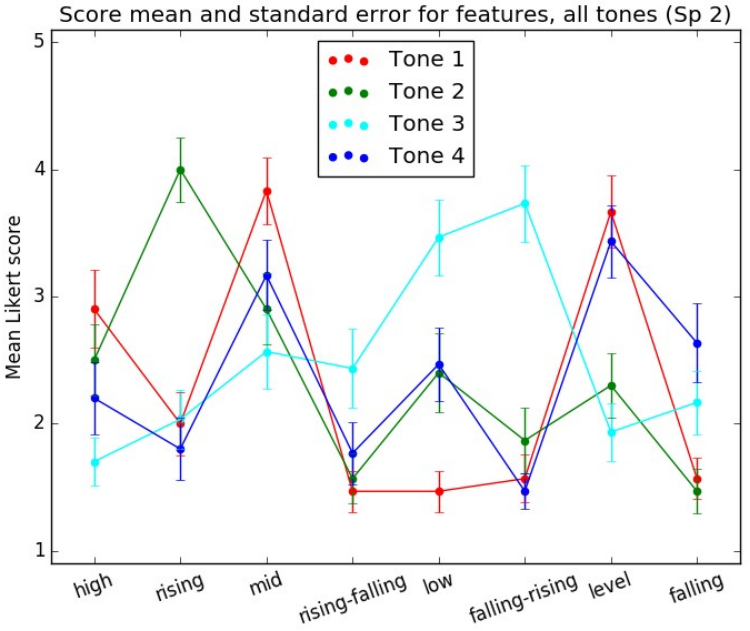
Variability in Mandarin Tone Perception

Mandarin responders (n=33)





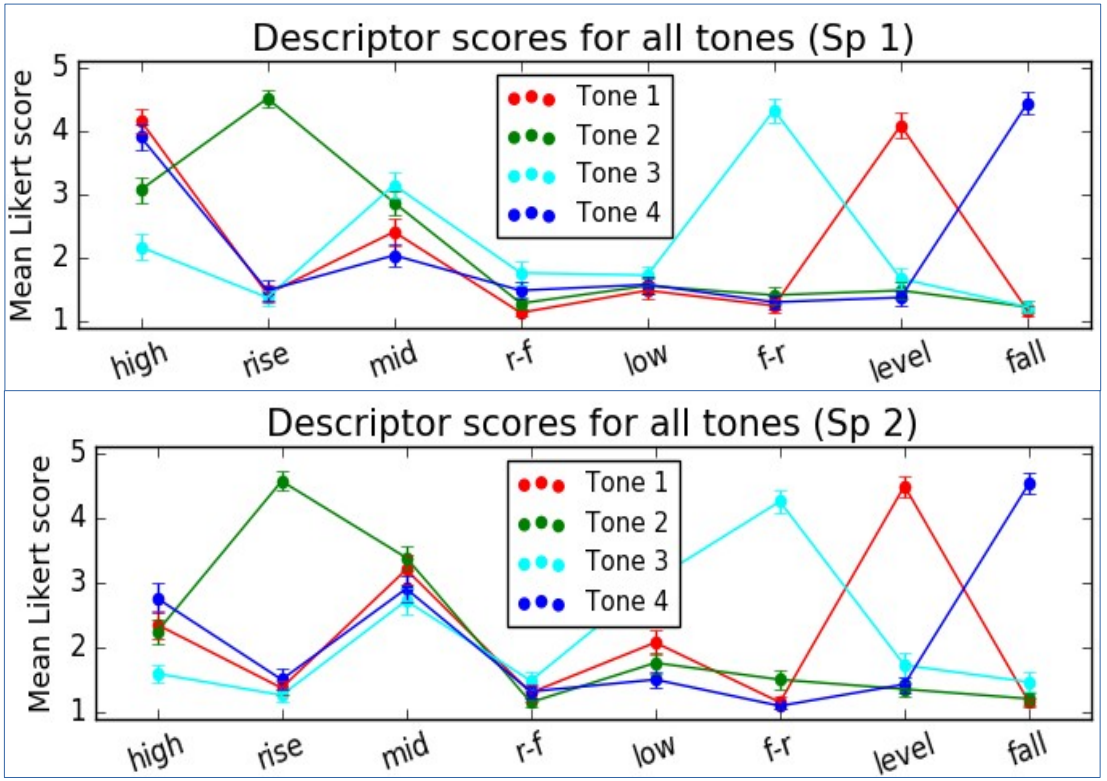
German (&c.) responders (n=15)



DESCRIPTOR DISTRIBUTION

Inter-speaker variability:

- *mid* varies for tones, not so much for speakers
- Speaker B: *low* varies strongly, but not Speaker A
- Speaker A: higher *high* score → overall higher pitch?

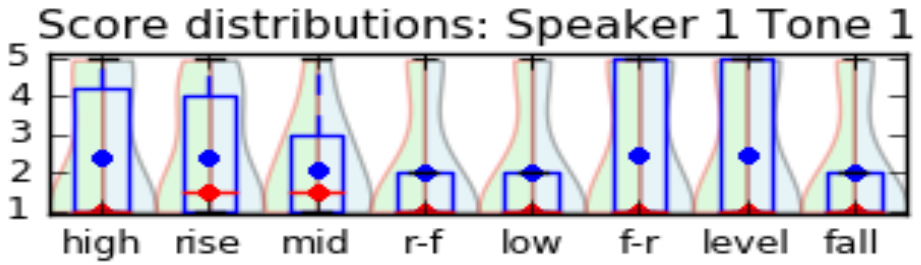


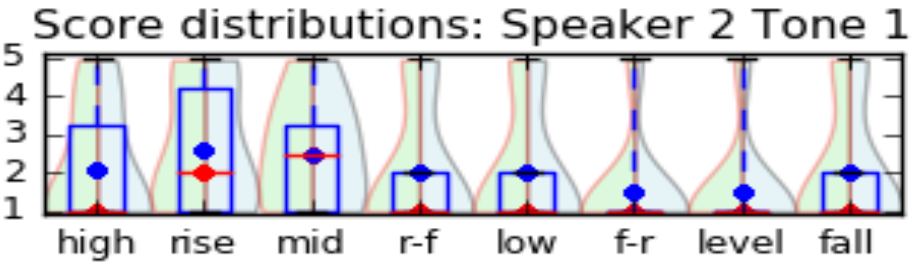
DESCRIPTOR DISTRIBUTION

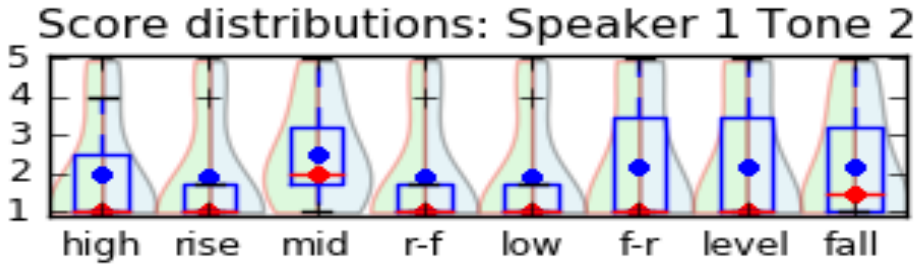
- Contour descriptors:
  - ‘canonical tone descriptors’:
    - high skewed distribution for high scores
    - cf. Mandarin tones:
      - Tone 1: *level*, Tone 2: *rise*, Tone 3: *fall-rise*, Tone 4: *fall*
      - Neutral tone not included
      - Distractor tone rise-fall: low
- Height descriptors
  - ‘non-canonical’
    - high, mid, low
    - low scores:
      - skewed distributions
      - bimodal distributions
      - broad distributions

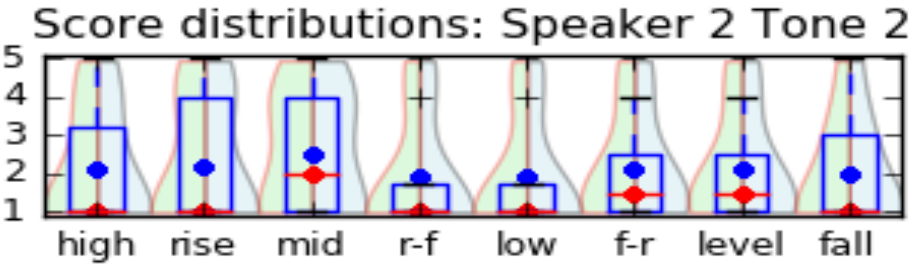
SpA	high	rise	mid	r-f	low	f-r	level	fall
T1	4.12	1.41	2.39	1.17	1.47	1.27	3.92	1.20
T2	2.95	4.52	2.74	1.27	1.52	1.41	1.45	1.24
T3	2.11	1.36	3.03	1.85	1.70	4.27	1.59	1.23
T4	3.79	1.45	1.97	1.53	1.64	1.32	1.39	4.52
SpB	**high**	**rise**	**mid**	**r-f**	**low**	**f-r**	**level**	**fall**
T1	2.32	1.36	3.29	1.36	1.97	1.21	4.24	1.18
T2	2.11	4.58	3.32	1.18	1.70	1.47	1.33	1.21
T3	1.56	1.27	2.71	1.59	3.00	4.14	1.70	1.44
T4	2.77	1.44	2.68	1.30	1.47	1.11	1.45	4.58

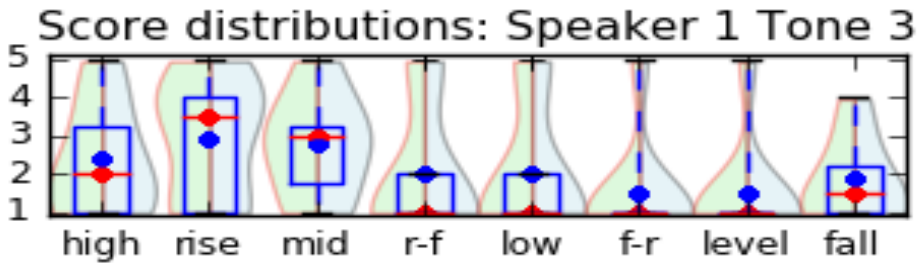
DESCRIPTOR DISTRIBUTION: kernel density plots (violin plots)

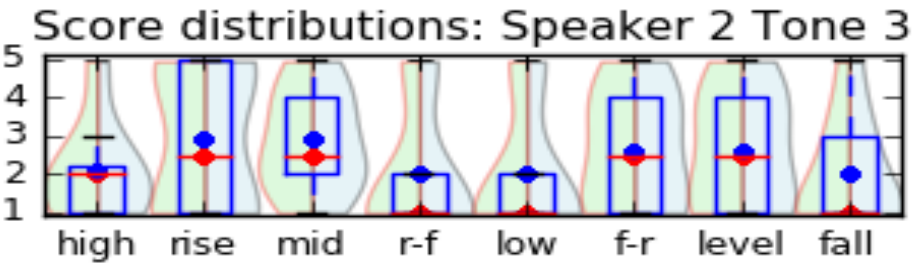


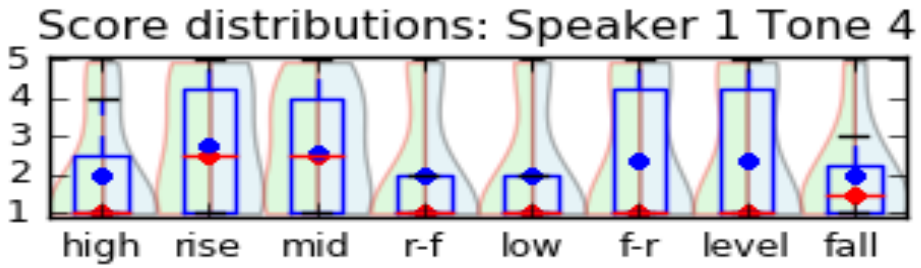


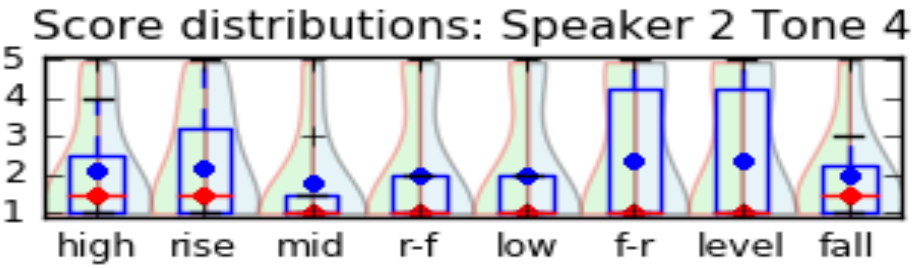












DESCRIPTOR DISTRIBUTION

- Inter-speaker variability:
  - some inter-speaker variability
    - pitch height descriptor *mid* varies for tones but not so much for speakers
    - *low* varies strongly for Speaker B but not for Speaker A
    - higher score of *high* for Speaker A: overall higher pitch
- MANOVA
  - fixed factors: tone type, pitch descriptor, dialect, speaker, with interactions
  - significant effects: dialect region, pitch descriptor
  - strong interactions
    - tone + descriptor, speaker + descriptor
    - dialect + tone + shape (multiinteraction)

DESCRIPTOR DISTRIBUTION: MANOVA

Fixed factors:

- tone type, pitch descriptor, dialect , speaker, with interactions

Significant effects:

- dialect region, pitch descriptor

Strong interactions:

- tone + descriptor, speaker + descriptor
- multiinteraction: dialect + tone + shape

Factors	Df	Sum Sq	Mean Sq	F	p
dial	16	480	30	12.966	<0.001
descr.	1	123	123.19	53.252	<0.001
tone:descr.	1	130	130.39	56.365	<0.001
sp.:descr	1	38	38.26	16.54	<.0001
dial:tone:descr	16	89	5.58	2.413	<0.01

HIERARCHICAL CLUSTERING

Method:

- a distance matrix is maintained at each iteration; the *d*[*i*,*j*] entry corresponds to the distance between cluster and components (here: Pearson distance)
- distance matrix updated to reflect distance of the newly formed cluster with remaining clusters
- classifiers:
  - Nearest Point Algorithm.
  - Farthest Point Algorithm (Voor Hees Algorithm)
  - Unweighted Pair Group Method with Averaging
  - Weighted Pair Group Method with Averaging
  - Unweighted Pair Group Method with Centroid Averaging (Median)
  - Weighted Pair Group Method with Centroid Averaging (Median)
  - Ward variance minimization (incremental)

https://docs.scipy.org/doc/scipy/reference/generated/scipy.cluster.hierarchy.linkage.html

HIERARCHICAL CLUSTERING

Pearson Distance classification, 7 clustering algorithms

→ Ward incremental variance minimisation

Comparison with geographical location

- Shandong+Hebei:
  - geographically close, N. Mandarin
- Hunan, Hakka, Henan:
  - geographically close, historically related
- others:
  - prosodic typology partly plausible, geography and history less so

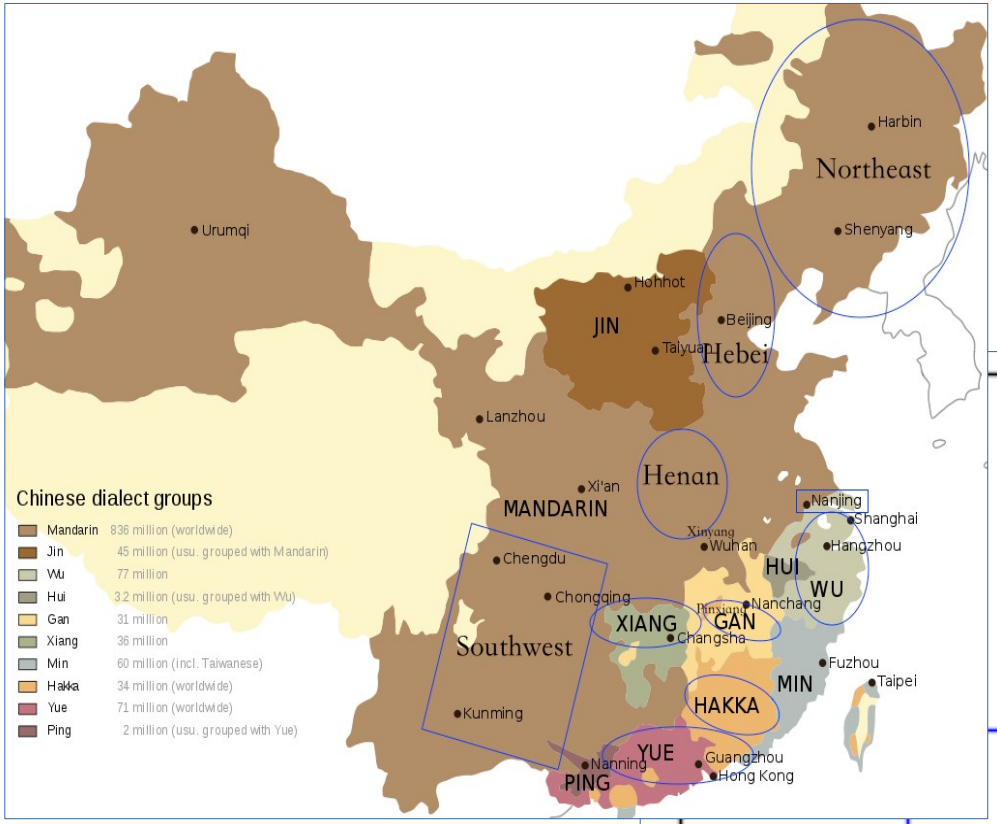
Noise due small data set with large number of classes

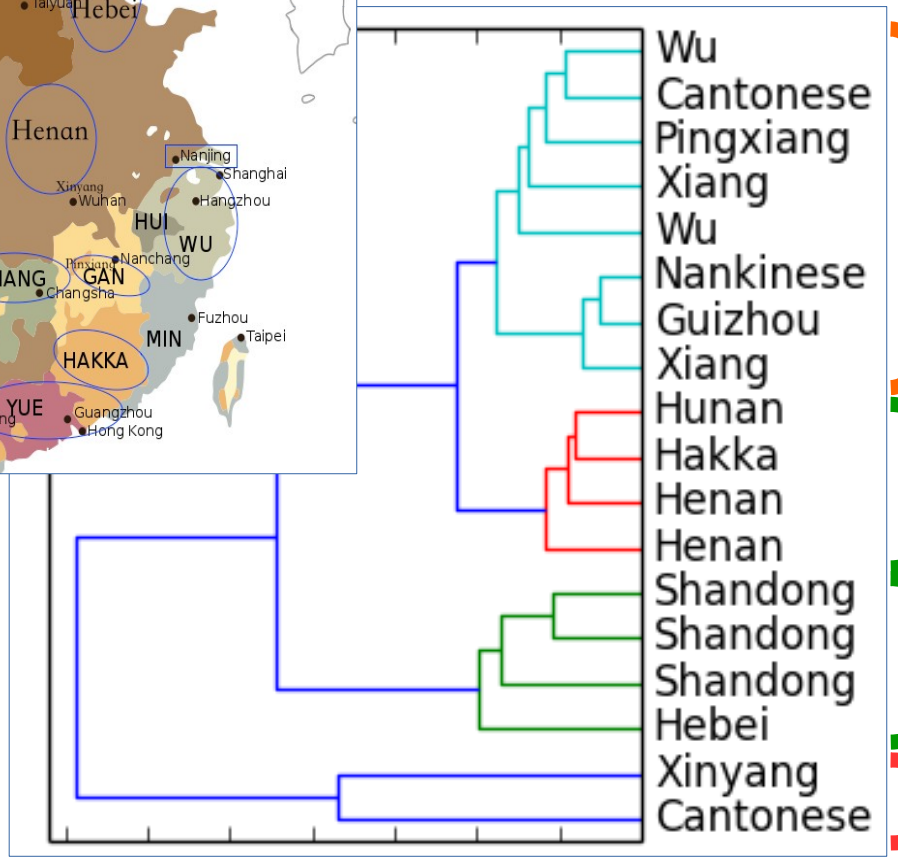
- inaccuracies and normative element in self-ascription
- language graduates, strong influence of standard Mandarin

HIERARCHICAL CLUSTERING

Geographically and/or historically distant pairs:

WU-Cantonese, Nankinese-Guizhou, Henan-Hebei-Wu, Henan-Hebei, Xiang-Wu, Xinyang-Cantonese





Xiang, Wu, Pingxiang, Cantonese: *typol. rel.: 5-9 tones, 2 registers*

geog. close, hist. related

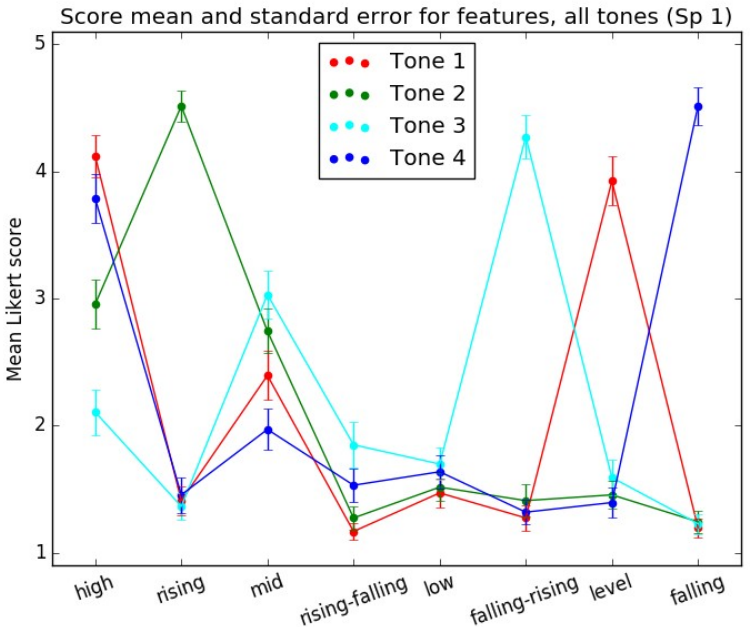
geog. close, N. Mandarin

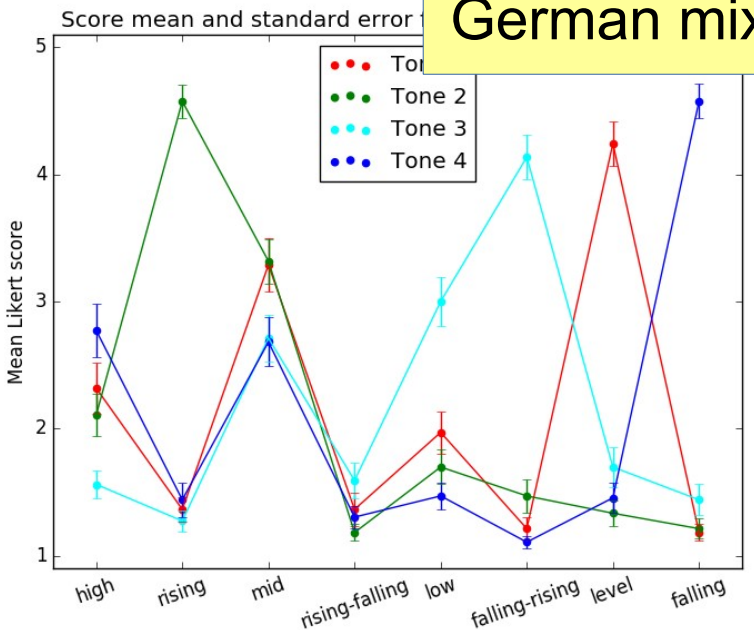
implausible

Variability in Mandarin Tone Perception

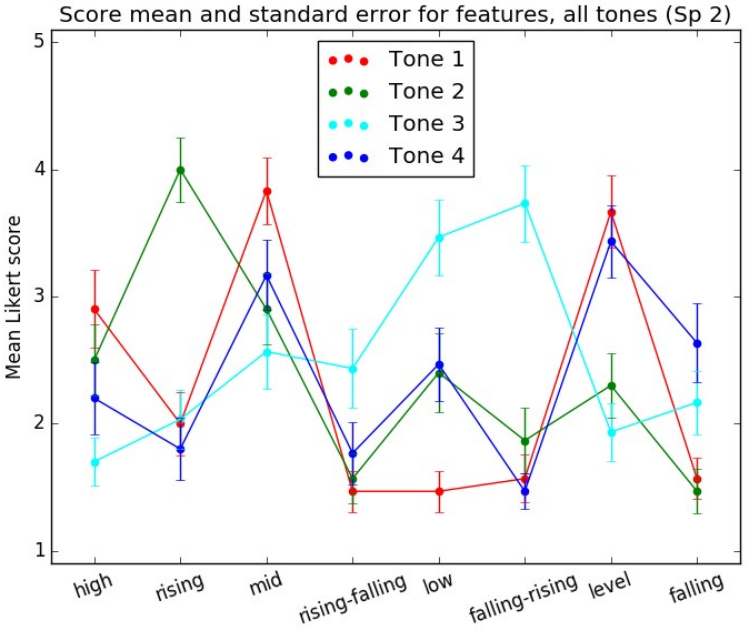
Mandarin
vs.
German mixed

Mandarin responders





German (&c.) responders

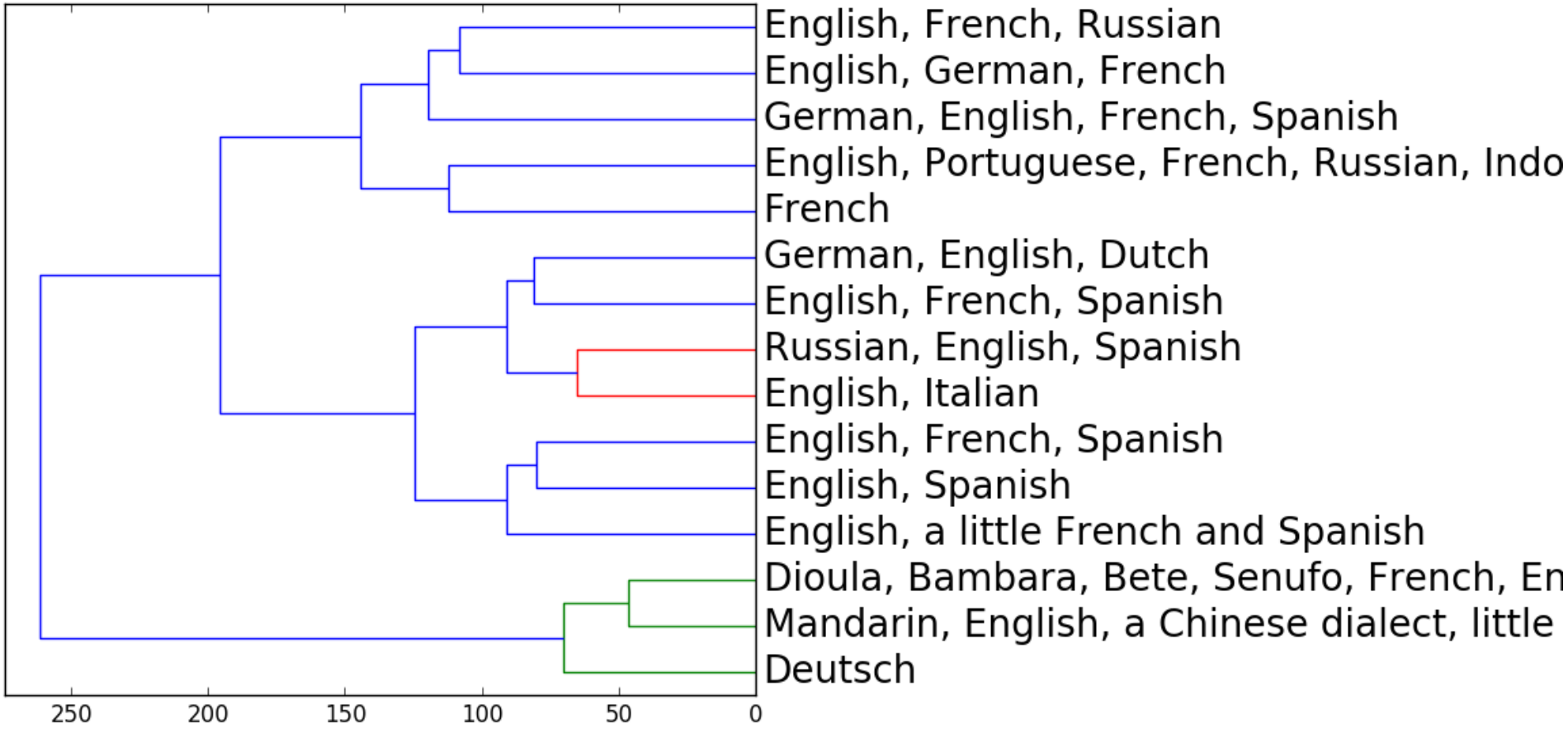


Mandarin
vs.
German mixed

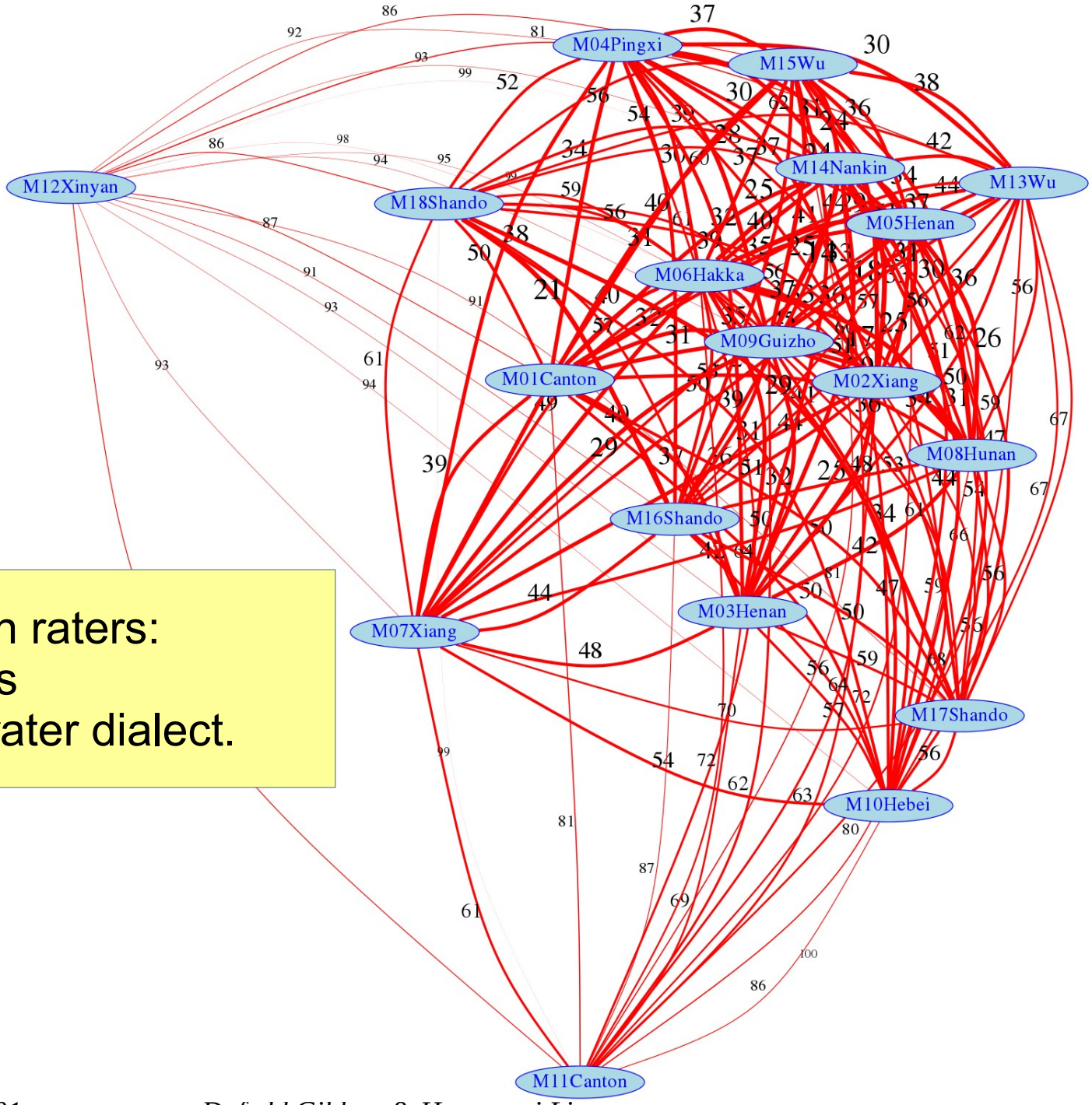
HIERARCHICAL CLUSTERING

An experiment with an *ad hoc* group of German linguistics students, plus guests.

Check the clusters – do any seem particularly interesting?



Variability in Mandarin Tone Perception



Distances between raters:

1) over all ratings
2) labelled with rater dialect.

CONCLUSIONS

Main descriptive outcomes

- expected: contour unlike height descriptors
  - canonical descriptors more consistent: categorial perception
- significant effects
  - dialect, descriptor; interactions for tone + descriptor, speaker + descriptor, dialect + tone + descriptor

Classification

- partly plausible classification results
- despite small dataset – but more data needed

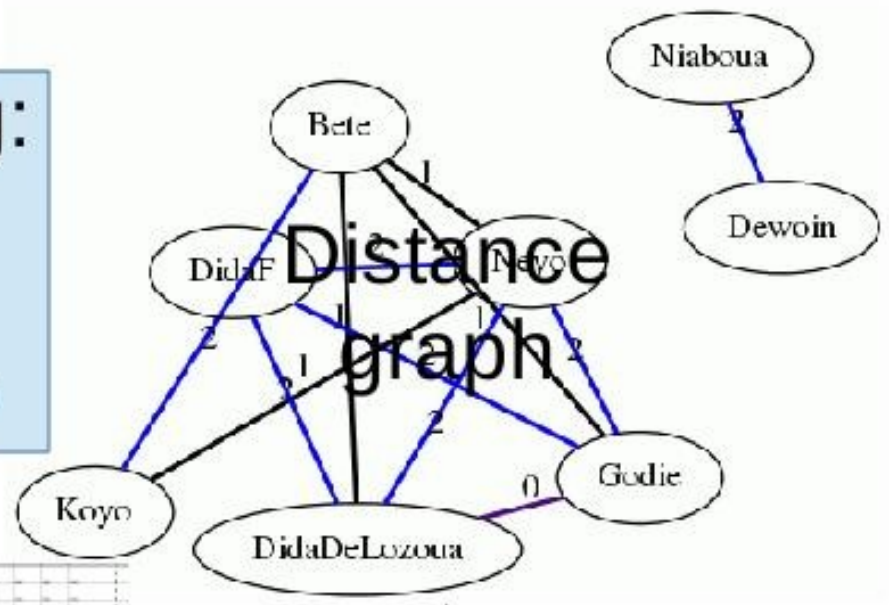
Main strategic outcome

- the novel method is fit for purpose for planning
  - a larger dialect survey
  - more complex contextual data: tone sandhi, accent, intonation
  - more systematic dialect classification for self-ascription
  - more speakers, gender balance, socio-economic information

Classification of Kru (Niger-Congo) dialects using legacy dialect survey data of consonant systems

Dialects of Kru: Workflow

Preprocessing:
1. scan/type
2. correct
3. create CSV



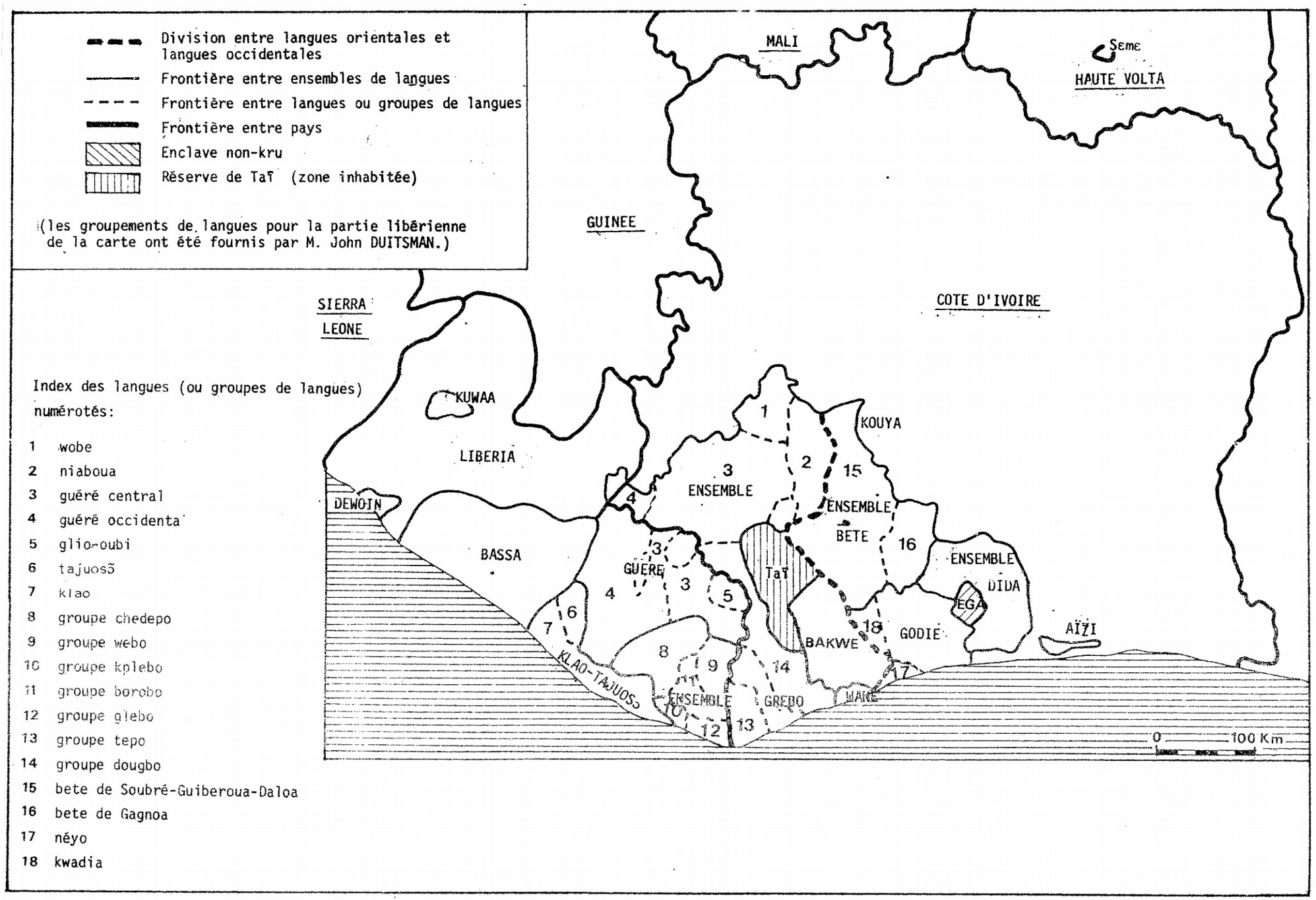
Data input: CSV

GraphViz

Levenshtein Edit Distance comparison

Distance matrix

Dialects of Kru



Dialects of Kru

Godié de Dakpadou et Lagako (Marchese, 1975)

p	t	c	k	kp	kw
b	d	ɟ	g	gb	gw
f	s				
v	z				
ß	l	j	ɣ		w
m	n	ɲ	ŋ		ŋw

Koyo (Kokora, 1976, p. 23)

p	t	c	k	kp	c^w	c^j
b	d	ɟ	g	gb		
f	s					
v	z					
ß	l	j	ɣ(2)		w	
m	n	ɲ	ŋ			

Dida de Lozoua (Gratrix)

p	t	c	k	kp	kw
b	d	ɟ	g	gb	gw
f	s				
v	z				
ß	l	j	ɣ	w	
m	n	ɲ	ŋ	ŋw	

đida-f (vata) (Siméon, Dugas, Kaye, Koopman, 1981)

p	t	c	k	kp	kw
b	d	ɟ	g	gb	gw
f	s				
v	z				
m	n	ɲ	ŋ	ŋm(3)	
ß	l	j	ɣ	w	

Dialects of Kru

IO parameters

Input table CSV separator:

semicolon ▾

Graphics format:

GIF bitmap graphics (smallest files) ▾

Output type:

- ◉ *parametrised LED graph*
  (properties of same attributes in same field position)
- ○ *parametrised SIRD graph*
  (use only if properties in different fields are different, i.e. sets)
- ○ *CSV* ○ *HTML* ○ *XML formatted input data*
- ○ *CSV* ○ *HTML* ○ *XML output of LED distance matrix*
- ○ *CSV* ○ *HTML* ○ *XML output of LED distance triples*

Graph parameters

Graph engines (from AT&T GraphViz package):

- ◉ *neato spring model*
- ○ *dot undirected graph model*
- ○ *twopi centred circle model*
- ○ *circo circle model*

Numerical parameters:

0 ... 6 *range of distances to be processed (check distance matrix for full data range)*

6 *random seed for neato spring model (trial and error)*

minimal scaling ▾

90 *% graph width (percent of window)*

```
<i>Language Atlas mining:</i><br>Consonant sets of Kru
languages.<br>Data source: Marchese, Lynell. 1984. <i>Atlas
Linguistique des Langues Kru.</i> 3&egrave;me
```

title, comment, etc. (HTML formatting permitted)

Dialects of Kru

Kru dialect consonant table in CSV format

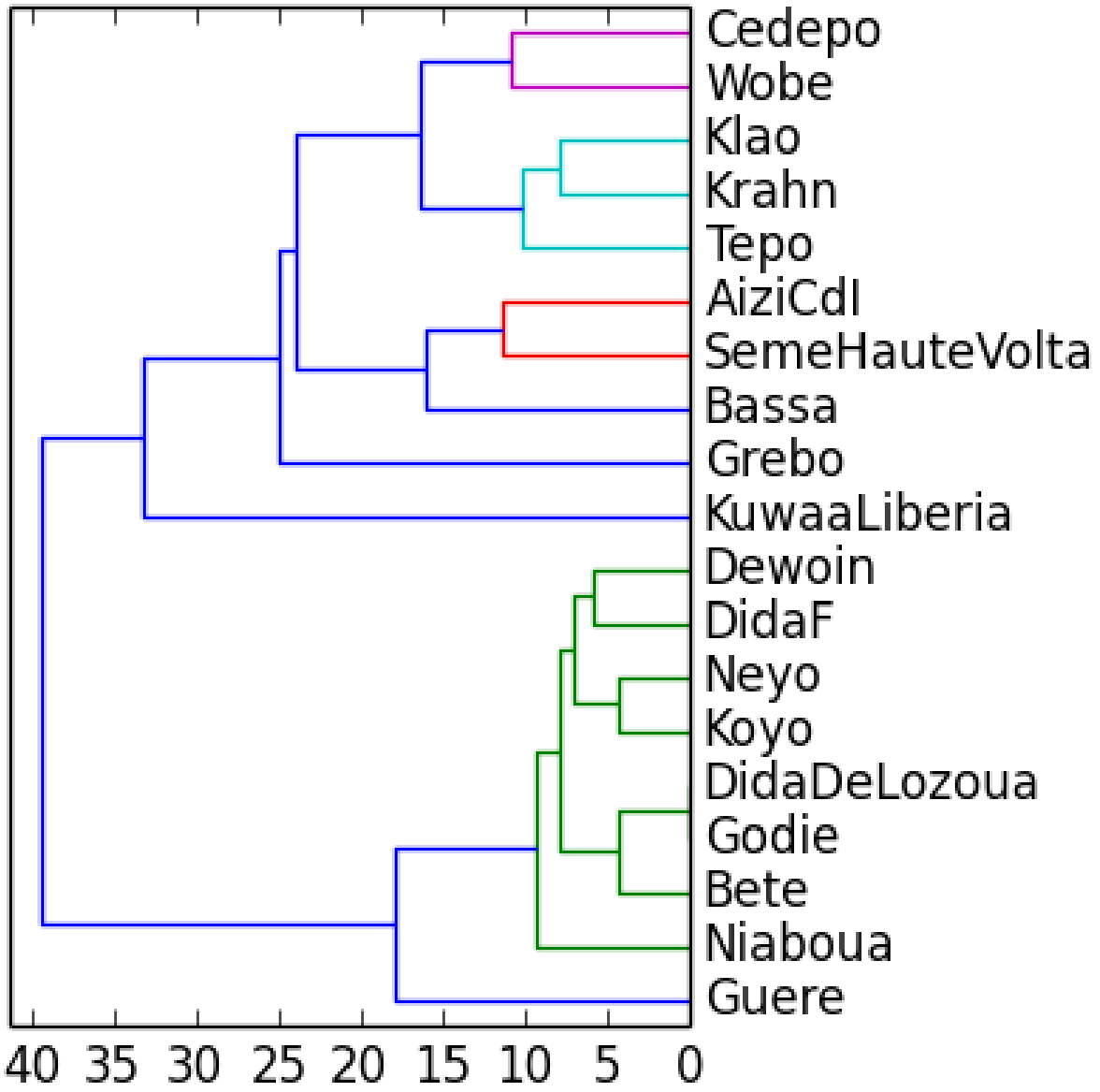
```
Bete;p;t;c;k;kp;kw;_;b;d;C;_;g;gb;_;f;s;_;v;z;_;_;_;B;_;l;j;x;w;m;n;J;N;Nw;_;_;_;_;_;_;_;_;_;_
Godie;p;t;c;k;kp;kw;_;b;d;C;_;g;gb;gw;f;s;_;v;z;_;_;_;B;_;l;j;x;w;m;n;J;N;Nw;_;_;_;_;_;_;_;_;_;_
Koyo;p;t;c;k;kp;kw;kj;b;d;C;_;g;gb;_;f;s;_;v;z;_;_;_;B;_;l;j;x;w;m;n;J;N;_;_;_;_;_;_;_;_;_;_;_
Neyo;p;t;c;k;kp;kw;_;b;d;C;_;g;gb;_;f;s;_;v;z;_;_;_;B;_;l;j;x;w;m;n;J;N;_;_;_;_;_;_;_;_;_;_;_
DidaDeLozoua;p;t;c;k;kp;kw;_;b;d;C;_;g;gb;gw;f;s;_;v;z;_;_;_;B;_;l;j;x;w;m;n;J;N;Nw;_;_;_;_;_;_;_;_;_;_
DidaF;p;t;c;k;kp;kw;_;b;d;C;_;g;gb;gw;f;s;_;v;z;_;_;_;B;_;l;j;x;w;m;n;J;N;_;Nm;_;_;_;_;_;_;_;_;_;_
Wobe;p;t;c;k;kp;kw;_;b;d;C;_;_;gb;_;f;s;_;_;_;_;_;_;_;_;_;;_;w;m;n;J;_;Nw;Nm;km;_;_;_;_;_;_;_;_;_
Guere;p;t;c;k;kp;kw;_;b;d;C;_;g;gb;gw;f;s;_;v;z;_;_;_;B;D;l;j;_;w;m;n;J;_;Nw;Nm;km;_;_;_;_;_;_;_;_;_
Krahn;p;t;c;k;_;kw;_;b;d;C;_;_;gb;_;f;s;_;_;_;_;_;_;_;_;l;_;_;w;m;n;J;_;_;_;_;_;_;_;_;_;_;_;_;_
Cedepo;p;t;c;k;kp;kw;_;b;d;C;_;_;gb;_;f;s;_;_;_;_;h;_;_;_;l;_;_;_;m;n;J;_;_;Nm;_;_;_;_;_;_;_;_;_;_
Klao;p;t;c;k;kp;kw;_;b;d;C;_;_;gb;_;f;s;_;_;_;_;_;_;_;_;l;j;_;w;m;n;J;_;_;Nm;_;_;_;_;_;_;_;_;_;_
Niaboua;p;t;c;k;kp;kw;_;b;d;C;_;g;gb;gw;f;s;_;v;z;_;_;_;B;_;l;j;_;w;m;n;J;_;_;_;_;_;_;_;_;_;_;_;_
Dewoin;p;t;_;k;kp;kw;_;b;d;C;_;g;gb;gw;f;s;_;v;z;_;_;_;B;_;l;j;_;w;m;n;J;N;_;_;_;_;_;_;_;_;_;_;_;_
Bassa;p;t;c;k;kp;_;_;b;d;C;dj;g;gb;_;f;s;_;v;z;_;h;hw;B;_;l;_;_;w;m;n;J;_;Nw;_;_;_;_;_;_;_;_;_;_;_
Grebo;p;t;c;k;kp;_;_;b;d;C;_;g;gb;_;f;s;_;_;_;_;h;hw;_;_;l;j;_;w;m;n;J;N;Nw;Nm;_;_;hm;hn;hl;_;_;_;_;_
Tepo;p;t;c;k;_;kw;_;b;d;C;_;g;gb;_;f;s;_;_;_;_;h;_;_;_;l;j;_;w;m;n;J;N;_;Nm;_;_;_;_;_;_;_;_;_;_;_
KuwaaLiberia;p;t;_;k;kp;kw;_;b;d;C;_;_;_;_;f;s;_;_;_;_;_;_;_;_;l;j;x;w;m;n;J;N;_;_;_;_;_;_;_;mb;nd;nC;Ng;Nmgb
SemeHauteVolta;p;t;c;k;kp;_;_;b;d;C;_;g;gb;_;f;s;S;v;_;_;h;_;_;_;l;j;_;w;m;n;J;_;_;_;_;gm;_;_;_;_;_;_;_;_
AiziCdI;p;t;c;k;kp;_;_;b;d;C;_;g;gb;_;f;s;S;v;z;Z;_;_;_;_;l;j;_;w;m;n;J;N;_;_;_;_;_;_;_;_;_;_;_;_
```

Dialects of Kru

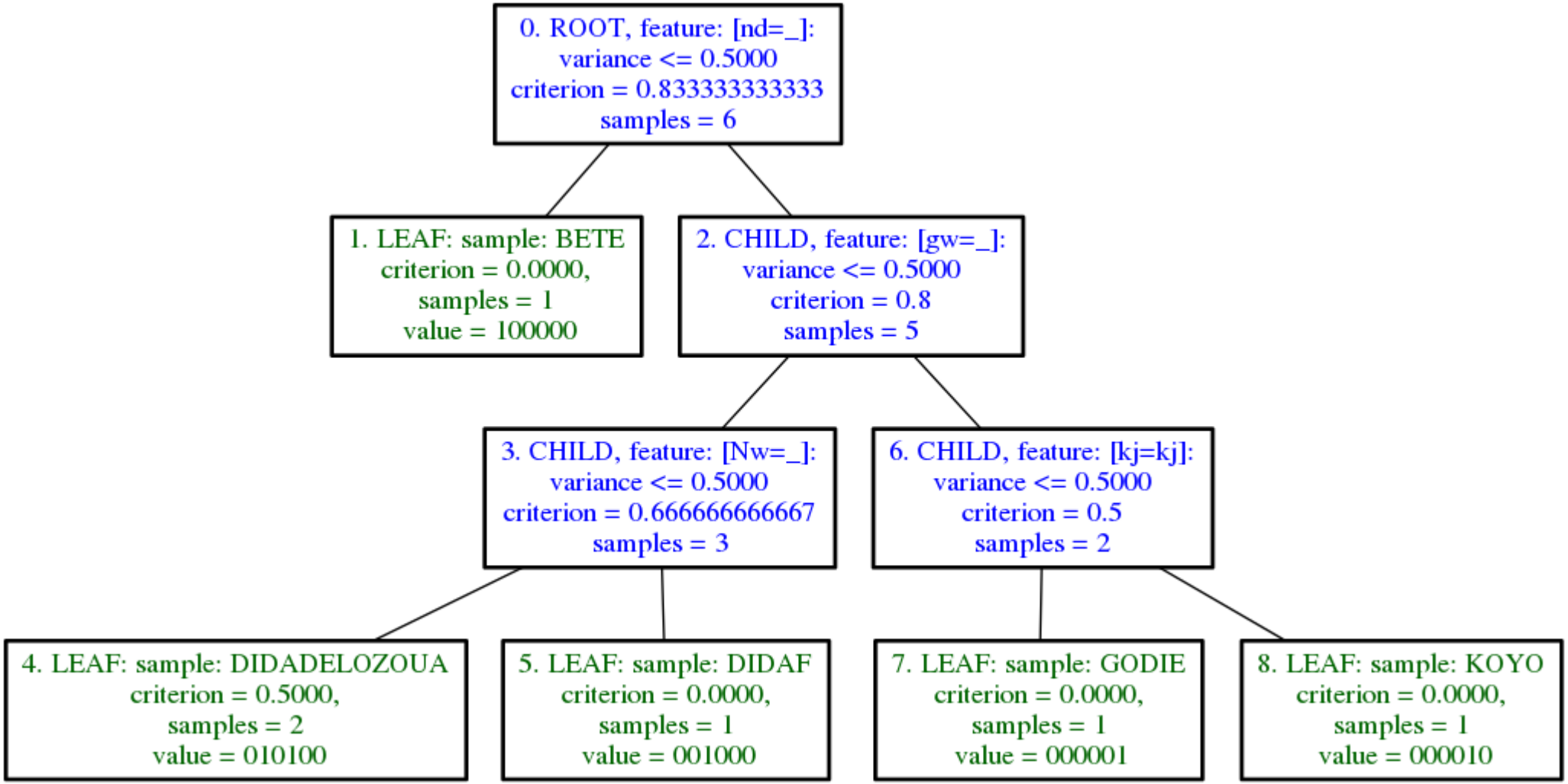
Kru dialect consonant vector distance table

Bete	0																		
Godie	1	0																	
Koyo	2	3	0																
Neyo	1	2	1	0															
DidaDeLozoua	1	0	3	2	0														
DidaF	3	2	3	2	2	0													
Wobe	10	11	12	11	11	11	0												
Guere	6	5	8	7	5	5	8	0											
Krahn	9	10	9	8	10	10	6	11	0										
Cedepo	11	12	11	10	12	10	6	11	4	0									
Klao	8	9	8	7	9	7	4	8	3	3	0								
Niaboua	4	3	4	3	3	3	10	4	7	9	6	0							
Dewoin	4	3	4	3	3	3	12	6	9	11	8	2	0						
Bassa	7	8	9	8	8	10	12	9	10	10	11	7	9	0					
Grebo	11	12	13	12	12	12	11	13	12	10	9	13	13	10	0				
Tepo	8	9	8	7	9	7	8	10	5	5	4	8	8	11	7	0			
KuwaaLiberia	12	13	12	11	13	13	14	18	11	13	10	14	12	19	17	12	0		
SemeHauteVolta	9	10	9	8	10	10	11	11	8	8	7	7	9	8	10	7	15	0	
AiziCdI	6	7	6	5	7	7	12	10	9	11	8	6	6	9	11	8	14	5	0

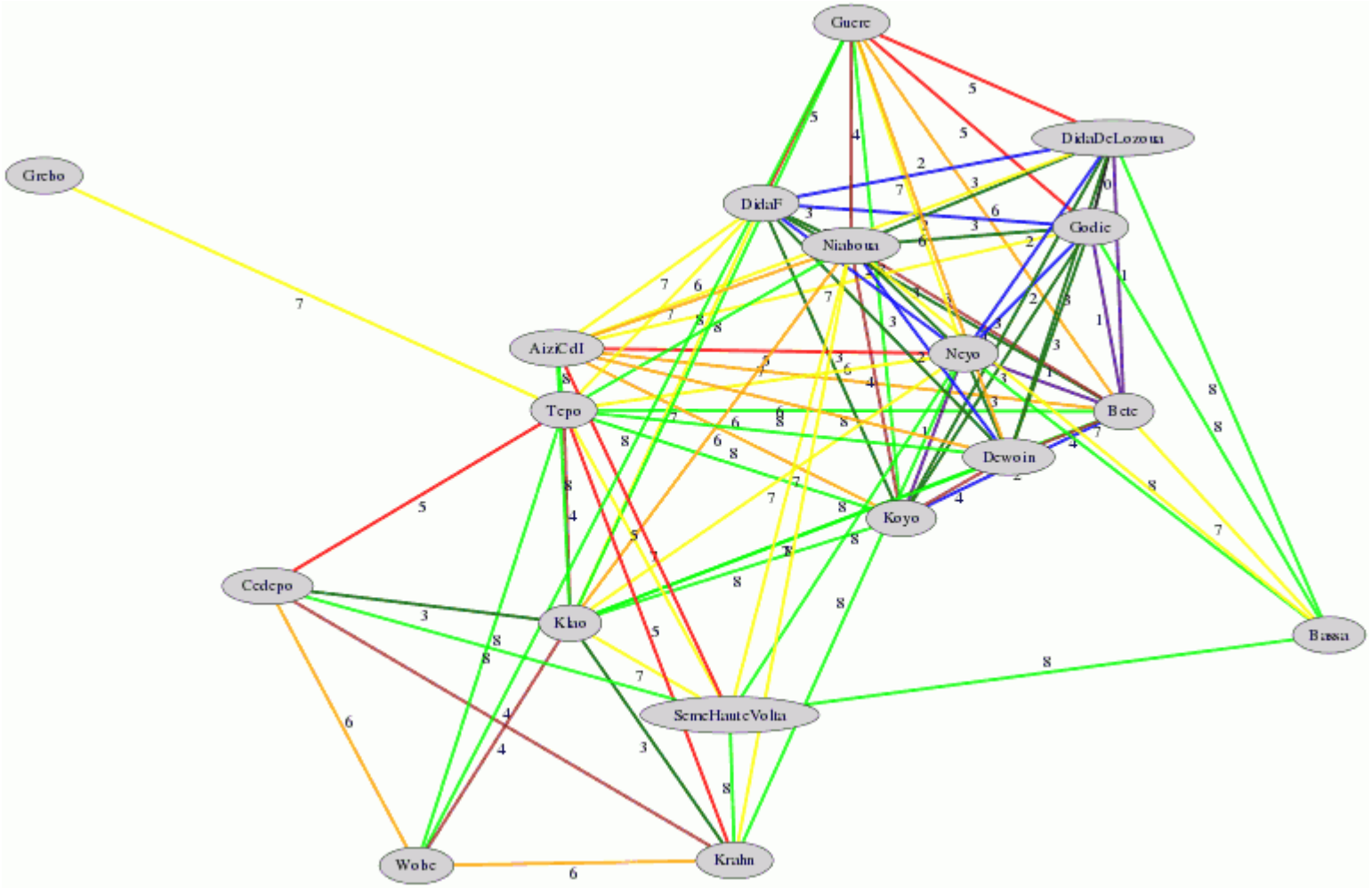
Dialects of Kru – classification by consonant inventories



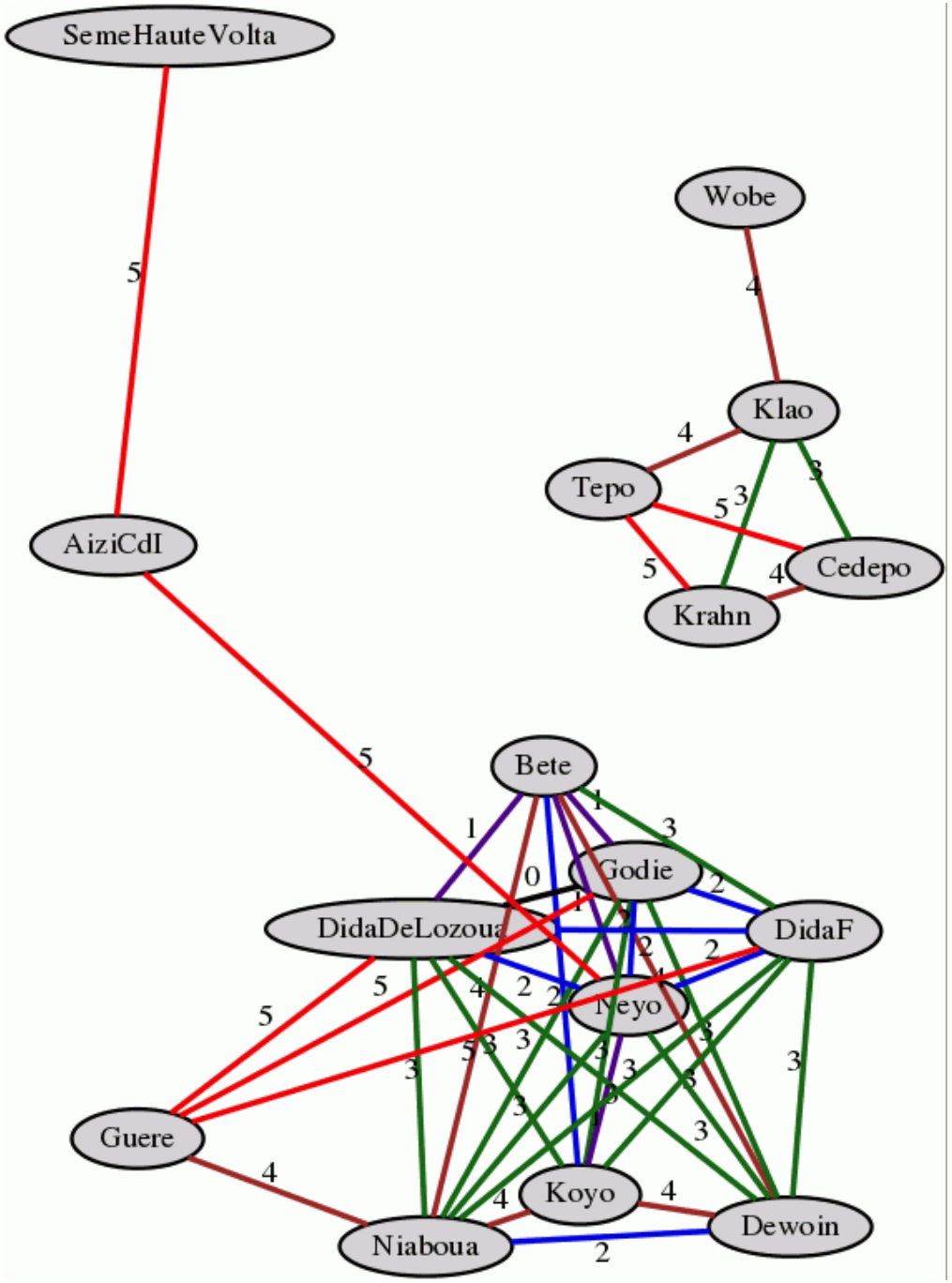
Dialects of Kru – consonant importance hierarchy



Dialects of Kru – virtual distance map



Dialects of Kru – virtual distance map



Now please check it out!

http://wwwhomes.uni-bielefeld.de/gibbon/DistGraph/

Thanks for your attention!