LexStat: Automatic Detection of Cognates in Multilingual Wordlists

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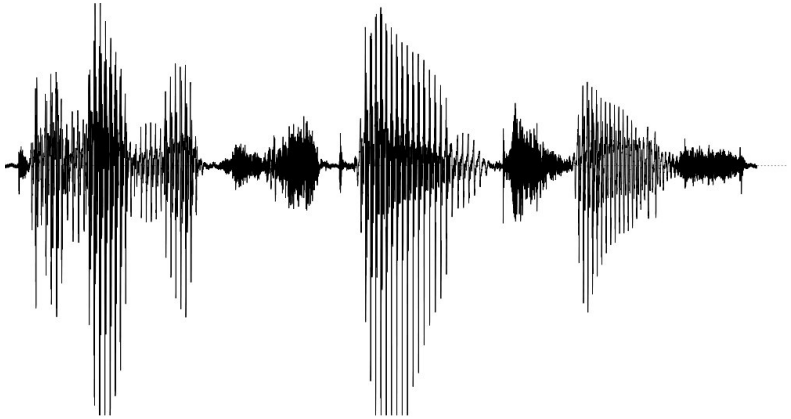
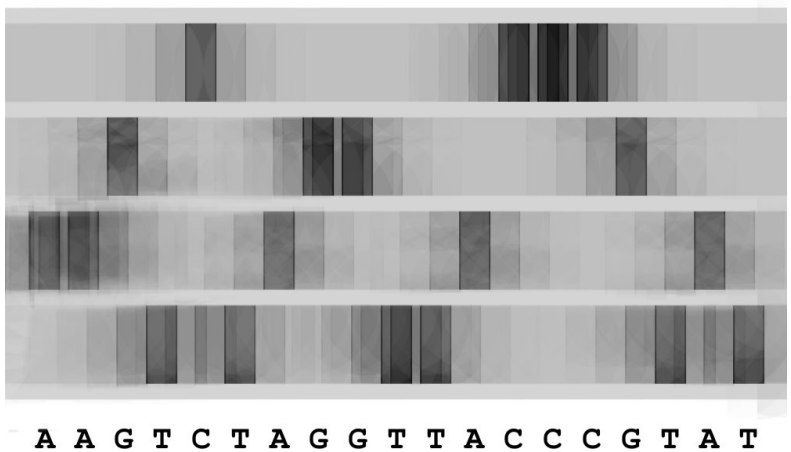
Structure of the Talk



Keys to the Past



Charles Lyell on Languages

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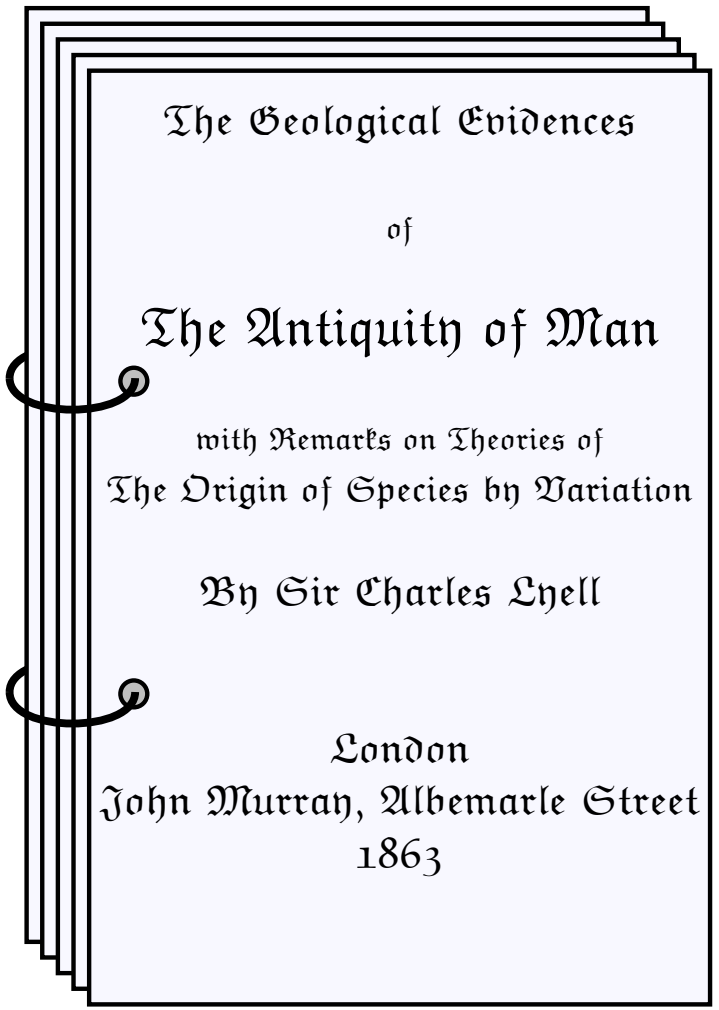

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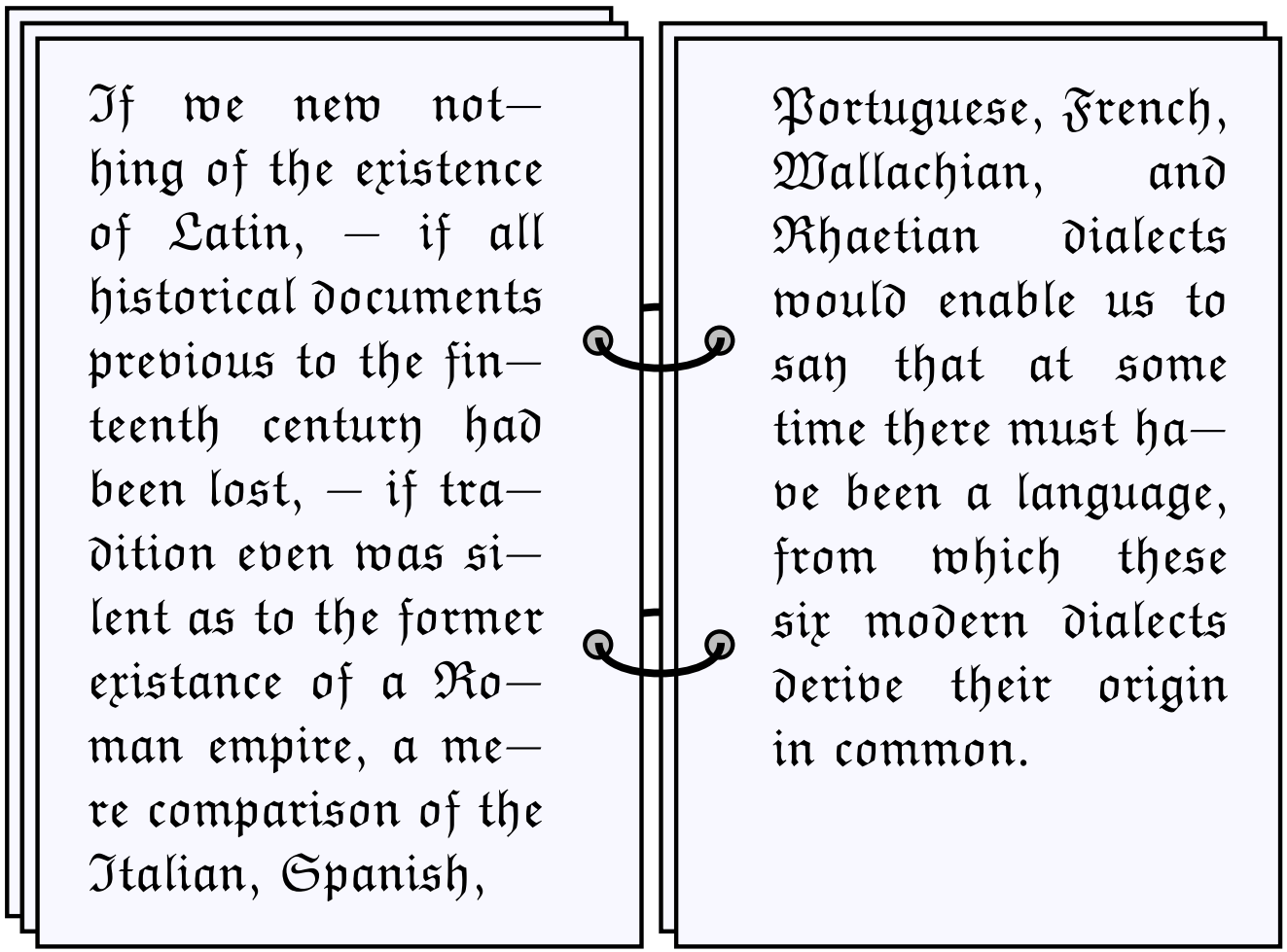

Uniformitarianism and Abduction

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	Present Events or Patterns
+	Known Laws
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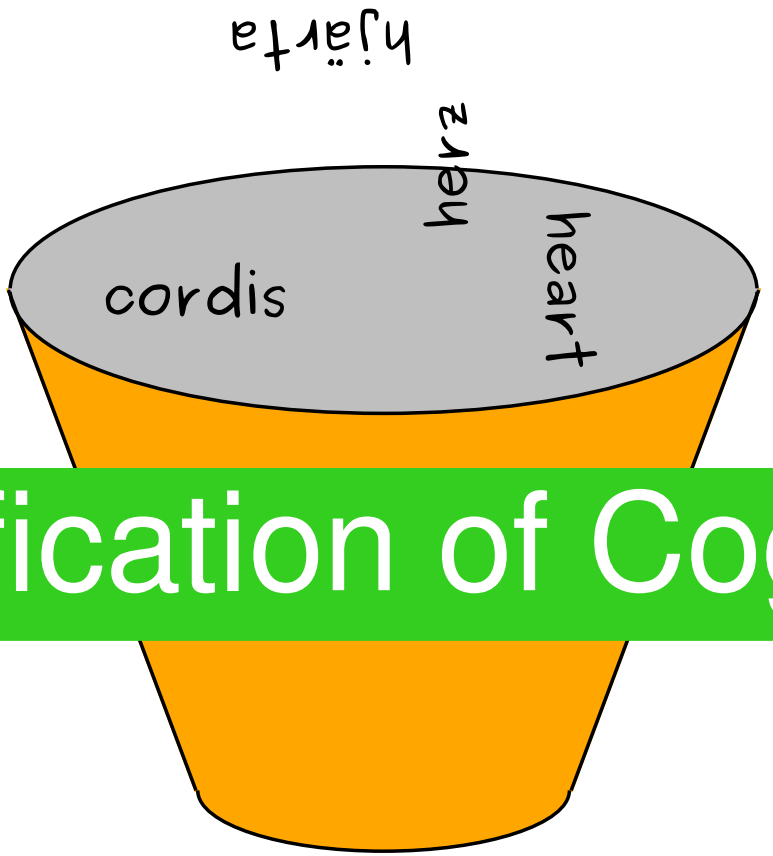
Abduction

Present Events or Patterns	Similarities Between Languages
+ Known Laws	+ Language Change
=> Abduction of Historical Facts	=> Inference of Proto-Languages



Identification of Cognates

The Comparative Method

Basic Procedure

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- Finish when the results are satisfying enough.

The Comparative Method

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Meaning	German	Dutch	English
"tooth"	*Zahn* [ts aːn]	*tand* [t ɑnt]	*tooth* [t ʊːθ]
"ten"	*zehn* [ts eːn]	*tien* [t iːn]	*ten* [t ɛn]
"tongue"	*Zunge* [ts ʊŋə]	*tong* [t ɔŋ]	*tongue* [t ʌŋ]

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Meaning	Shanghai	Beijing	Guangzhou
“nine”	[tɕ iɤ^{35}]	Beijing [tɕ iou^{214}]	[k ɐu^{35}]
“today”	[tɕ iŋ^{55}tsɔ^{21}]	Beijing [tɕ iɚ^{55}]	[k ɐm^{53}jɐt^{2}]
“rooster”	[koŋ^{55} tɕ i^{21}]	Beijing[kuŋ^{55} tɕ i^{55}]	[k ɐi^{55}koŋ^{55}]

Automatic Approaches

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Alignment Analyses

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In alignment analyses, sequences are arranged in a matrix in such a way that corresponding elements occur in the same column, while empty cells resulting from non-corresponding elements are filled with gap symbols.

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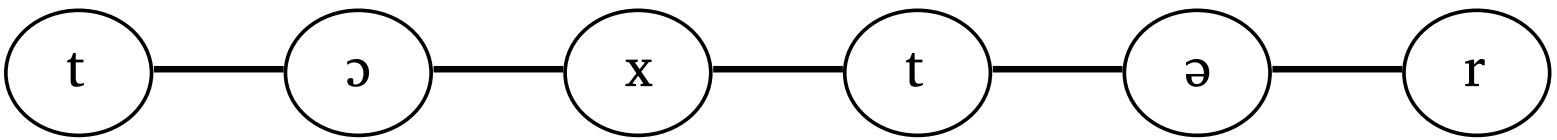

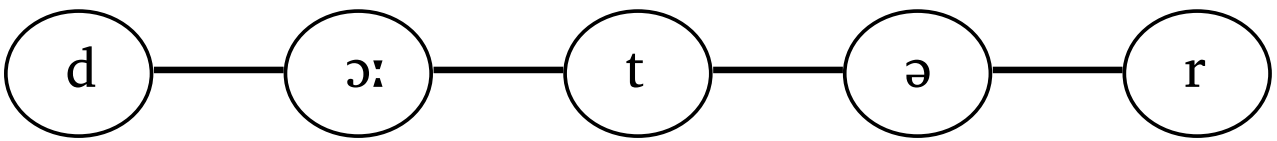

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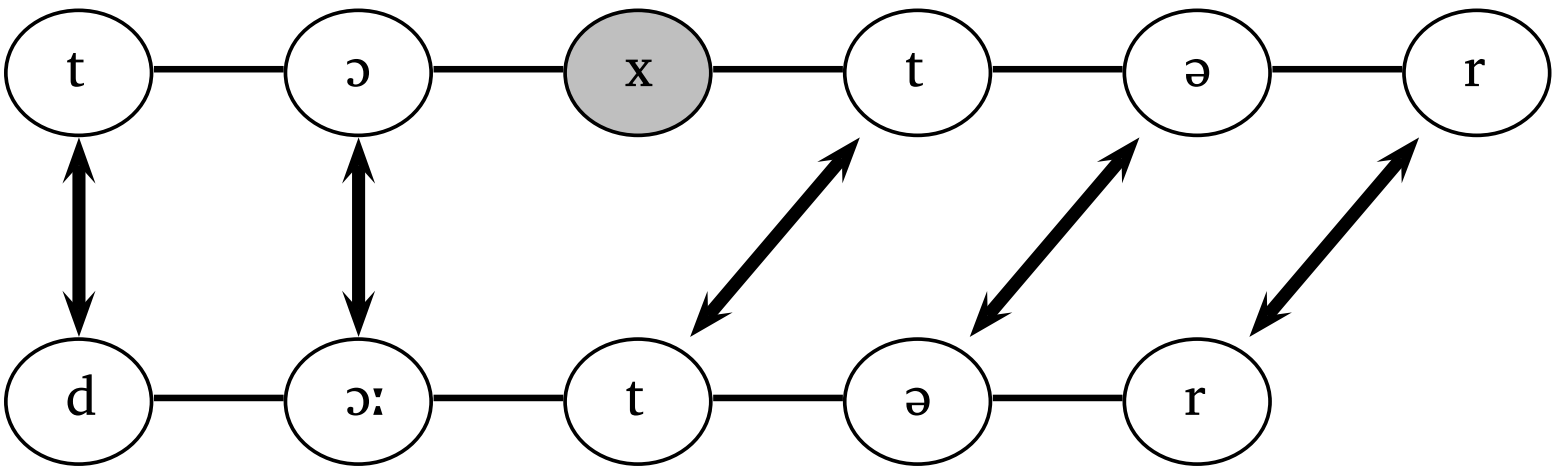

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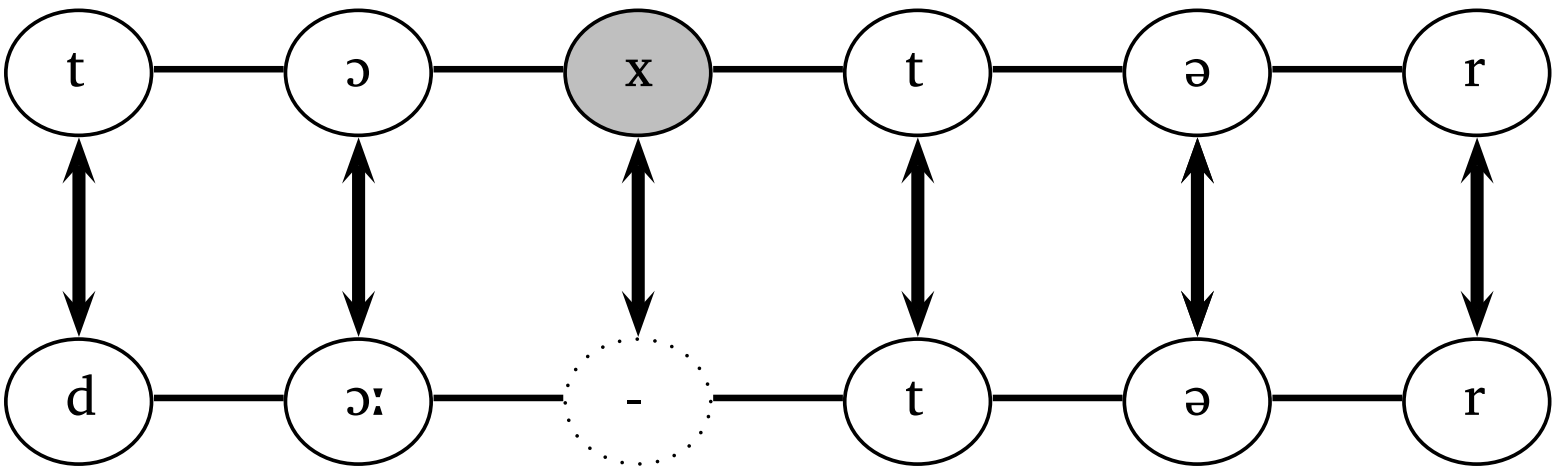

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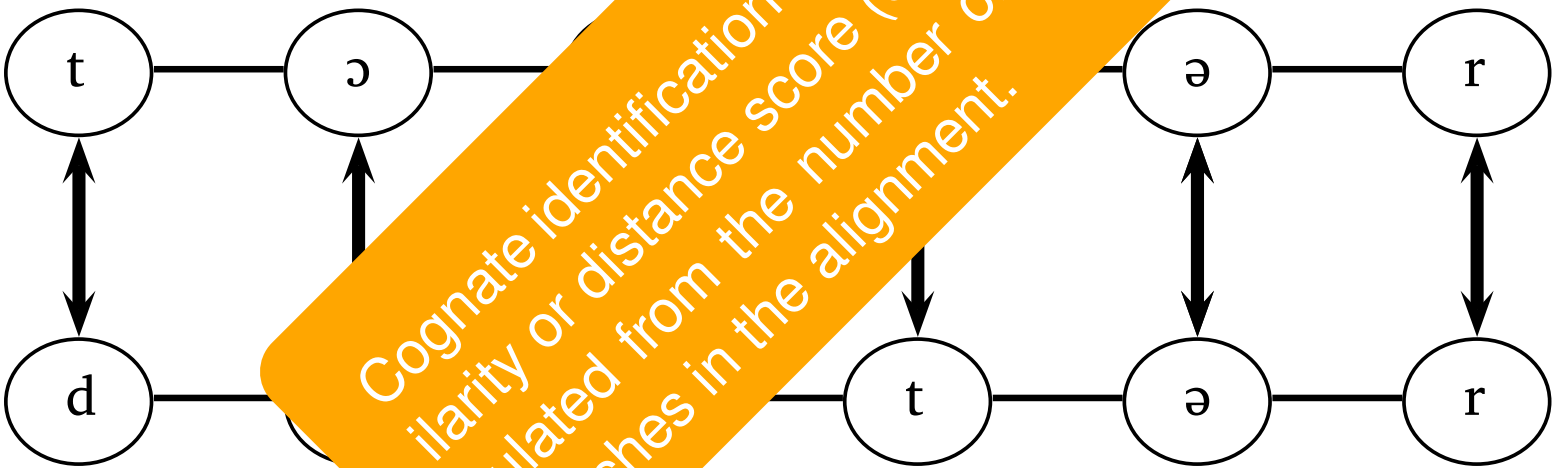

Cognate identification is usually based on a similarity or distance score (e.g., edit-distance) calculated from the number of matches and mismatches in the alignment.

Automatic Approaches

Sound Classes

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Sounds which often occur in correspondence relations in genetically related languages can be clustered into classes (types). It is assumed "that phonetic correspondences inside a 'type' are more regular than those between different 'types'" (Dolgopolsky 1986: 35).

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k	g	p	b
tʃ	dʒ	f	v
t	d	ʃ	ʒ
θ	ð	s	z

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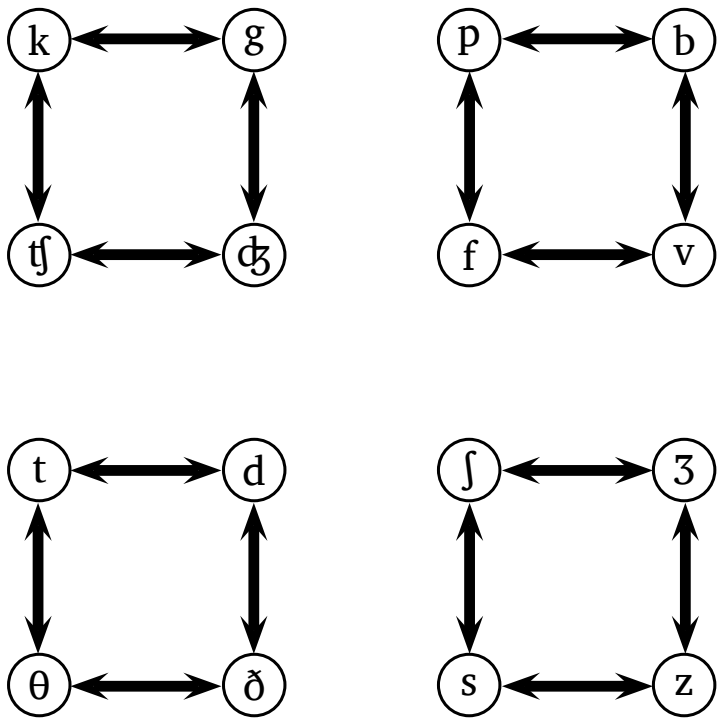

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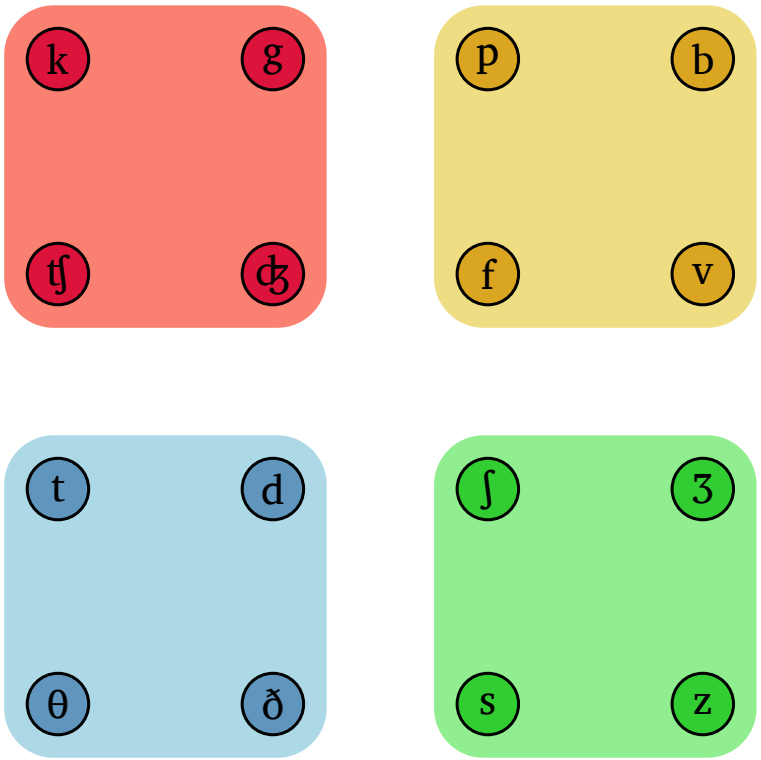

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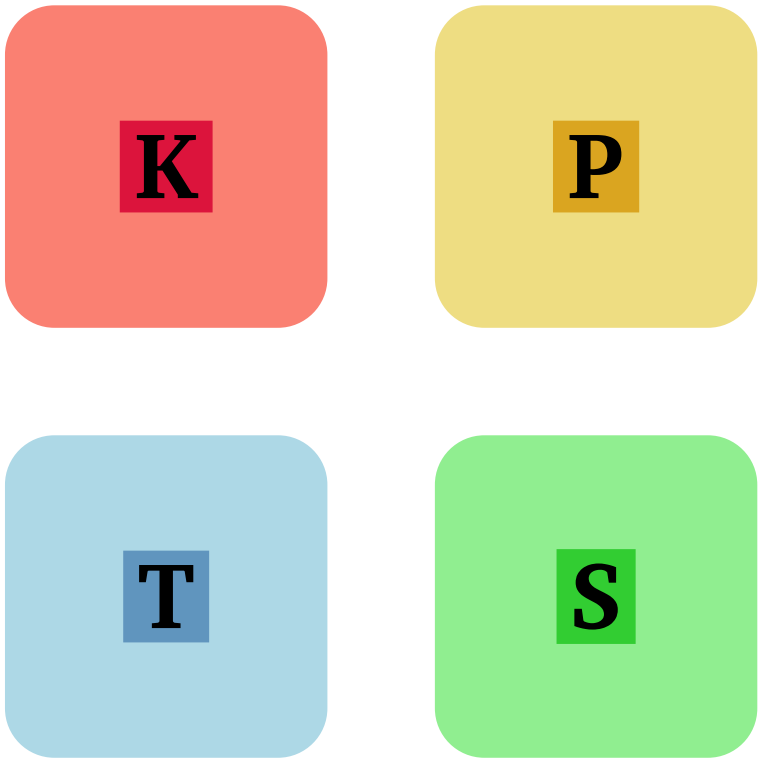

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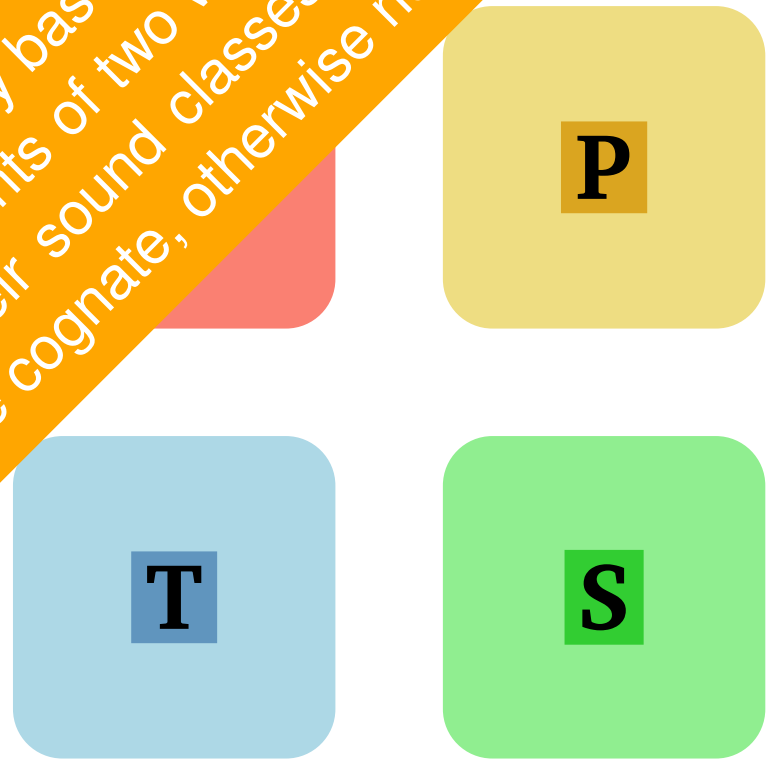
Cognate identification is usually based on comparing the first two consonants of two words: If they match regarding their sound classes, the words are judged to be cognate, otherwise not.



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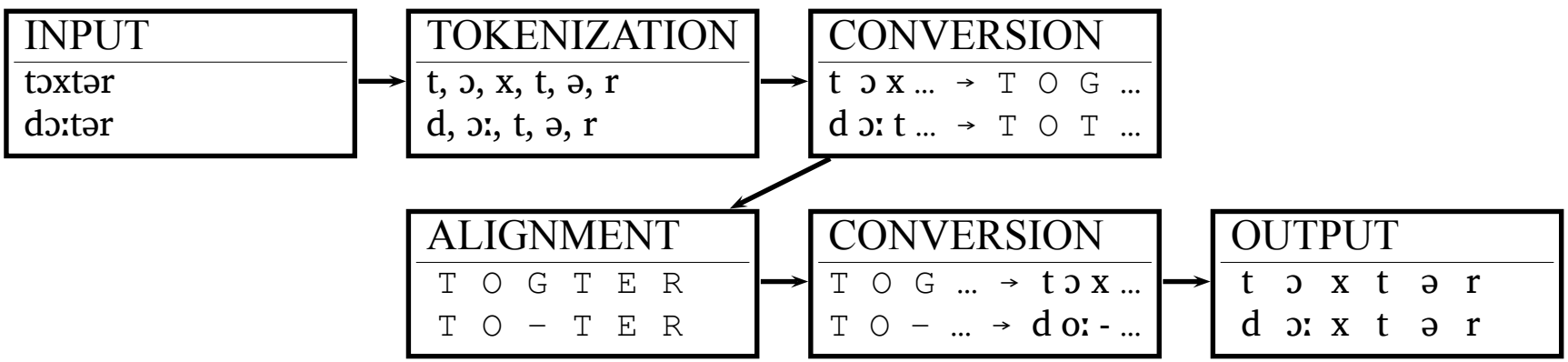

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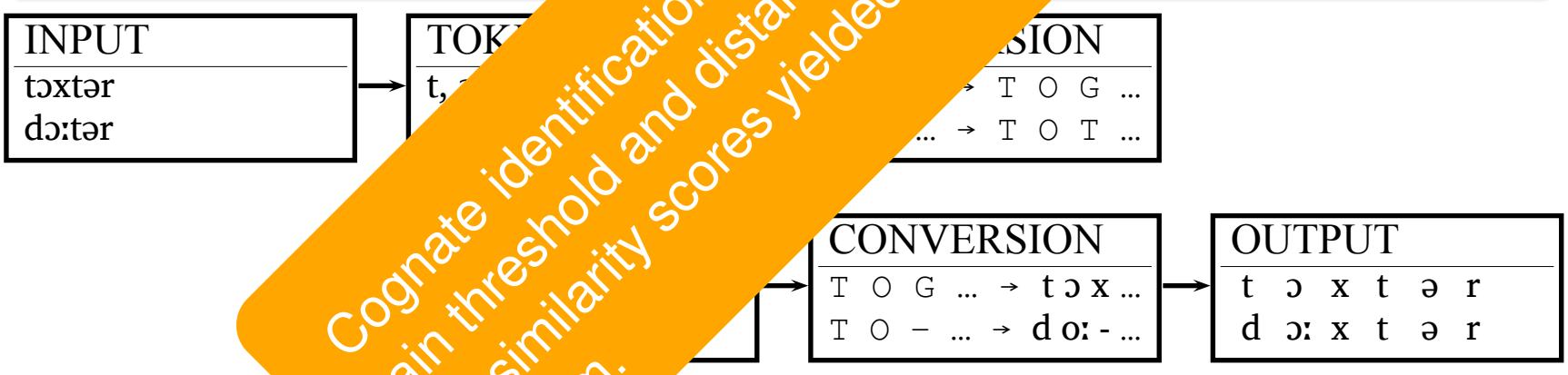
Cognate identification may be based on a certain threshold and distance scores derived from the similarity scores yielded by the alignment algorithm.



Traditional vs. Automatic Approaches

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Similarity

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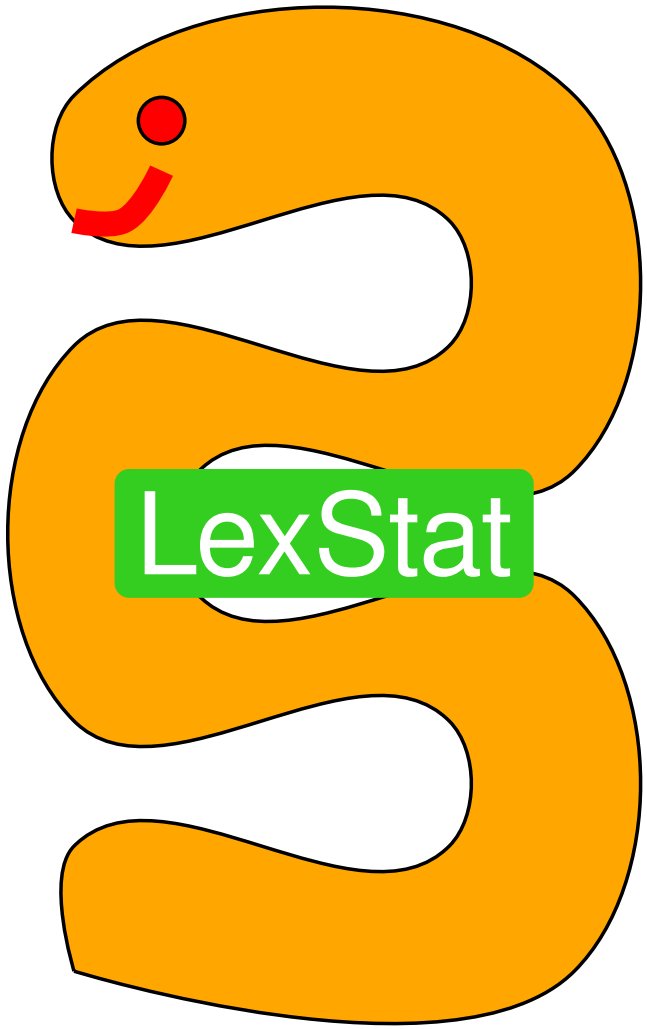
Almost all current automatic approaches are based on a language-independent similarity measure, while the comparative method applies a language-specific one. All automatic approaches will therefore yield the same scores for phenotypically identical sequences, regardless of the language systems they belong to.


LexStat

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	Sequence Output	information regarding sequence clustering is written to file using a specific format

Implementation

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- The current release of LingPy (lingpy-1.0) provides methods for pairwise and multiple sequence alignment (SCA), automatic cognate detection (LexStat), and plotting routines (see the online documentation for details).
- LexStat can be invoked from the Python shell or inside Python scripts (examples are given in the online documentation).

Input and Output

ID	Items	German	English	Swedish
1	hand	hant	hænd	hand
2	woman	fraʊ	wʊmən	kvina
3	know	kɛnən	nəʊ	çɛna
3	know	vɪsən	-	veːta
…	…	…	…	…

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1	hand	hant	1	hænd	1	hand	1
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3	know	kɛnən	5	nəʊ	5	çɛna	5
3	know	vɪsən	6	-	0	ve:ta	6
…	…	…	…	…	…	…	…

Input and Output

Basic Concept: *belly* (ID: 4)			
CogID	**Language**	**Entry**	**Aligned Entry**
6	Danish	ɔnʌliwˀ	--
7	German	baux	b au x
7	Dutch	bœyk	b œy k
7	Swedish	buk	b u k
7	Norwegian	bʉːk	b ʉː k
8	English	bɛlɪ	--
9	Swedish	maːge	m aː g e
9	Norwegian	mɑːgə	m ɑː g ə
9	Danish	mæːvə	m æː v ə
10	Icelandic	kʰvɪːðʏr	--

Internal Representation of Sequences

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Sound Classes and Prosodic Context

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- All sequences are also represented by *prosodic strings* which indicate the prosodic environment (initial, ascending, maximum, descending, final) of each phonetic segment (List 2012).
- The information regarding sound classes and prosodic context is combined, and each input sequence is further represented as a sequence of tuples, consisting of the sound class and the prosodic environment of the respective phonetic segment.

Scoring-Scheme Creation

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Attested Distribution

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- carry out global and pairwise alignment analyses of all sequence pairs occuring in the same semantic slot
- store all corresponding segments that occur in sequences whose distance is beyond a certain threshold

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Calculation of Similarity Scores

- Calculation of *log-odds scores* from the distributions.

Scoring-Scheme Creation

English	German	Att.	Exp.	Score
#[t,d]	#[t,d]	3.0	1.24	6.3
#[t,d]	#[ts]	3.0	0.38	6.0
#[t,d]	#[ʃ,s,z]	1.0	1.99	-1.5
#[θ,ð]	#[t,d]	7.0	0.72	6.3
#[θ,ð]	#[ts]	0.0	0.25	-1.5
#[θ,ð]	#[s,z]	0.0	1.33	0.5
[t,d]$	[t,d]$	21.0	8.86	6.3
[t,d]$	[ts]$	3.0	1.62	3.9
[t,d]$	[ʃ,s]$	6.0	5.30	1.5
[θ,ð]$	[t,d]$	4.0	1.14	4.8
[θ,ð]$	[ts]$	0.0	0.20	-1.5
[θ,ð]$	[ʃ,s]$	0.0	0.80	0.5

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#[t,d]	#[ʃ,s,z]	1.0	1.99	-1.5
#[θ,ð]	#[t,d]	7.0	0.72	6.3
#[θ,ð]	#[ts]	0.0	0.25	-1.5
#[θ,ð]	#[s,z]	0.0	1.33	0.5
[t,d]$	[t,d]$	21.0	8.86	6.3
[t,d]$	[ts]$	3.0	1.62	3.9
[t,d]$	[ʃ,s]$	6.0	5.30	1.5
[θ,ð]$	[t,d]$	4.0	1.14	4.8
[θ,ð]$	[ts]$	0.0	0.20	-1.5
[θ,ð]$	[ʃ,s]$	0.0	0.80	0.5

Scoring-Scheme Creation

	Initial	**Final**
English	*town* [taʊn]	*hot* [hɔt]
German	*Zaun* [tsaun]	*heiß* [haɪs]
English	*thorn* [θɔːn]	*mouth* [maʊθ]
German	*Dorn* [dɔrn]	*Mund* [mʊnt]
English	*dale* [deɪl]	*head* [hɛd]
German	*Tal* [taːl]	*Hut* [huːt]

Sequence Clustering

	Ger.	Eng.	Dan.	Swe.	Dut.	Nor.
Ger. [frau]	0.00	0.95	0.81	0.70	0.34	1.00
Eng. [wʊmən]	0.95	0.00	0.78	0.90	0.80	0.80
Dan. [kvenə]	0.81	0.78	0.00	0.17	0.96	0.13
Swe. [kvinːa]	0.70	0.90	0.17	0.00	0.86	0.10
Dut. [vrɑuʊ]	0.34	0.80	0.96	0.86	0.00	0.89
Nor. [kʊinə]	1.00	0.80	0.13	0.10	0.89	0.00

Sequence Clustering

	Ger.	Eng.	Dan.	Swe.	Dut.	Nor.
Ger. [frau]	0.00	0.95	0.81	0.70	0.34	1.00
Eng. [wʊmən]	0.95	0.00	0.78	0.90	0.80	0.80
Dan. [kvenə]	0.81	0.78	0.00	0.17	0.96	0.13
Swe. [kvinːa]	0.70	0.90	0.17	0.00	0.86	0.10
Dut. [vrɑuʊ]	0.34	0.80	0.96	0.86	0.00	0.89
Nor. [kʊinə]	1.00	0.80	0.13	0.10	0.89	0.00
Clusters	1	2	3	3	1	3

v o l – d e m o r t

v – l a d i m i r –

v a l – d e m a r –

Evaluation

Gold Standard

Gold Standard

File	Family	Lng.	Itm.	Entr.	Source
GER	Germanic	7	110	814	Starostin (2008)
ROM	Romance	5	110	589	Starostin (2008)
SLV	Slavic	4	110	454	Starostin (2008)
PIE	Indo-Eur.	18	110	2057	Starostin (2008)
OUG	Uralic	21	110	2055	Starostin (2008)
BAI	Bai	9	110	1028	Wang (2006)
SIN	Sinitic	9	180	1614	Hóu (2004)
KSL	varia	8	200	1600	Kessler (2001)
JAP	Japonic	10	200	1986	Shirō (1973)

Evaluation Measures

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Set Comparison

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Precision, Recall, and F-Score are calculated by comparing the cognate sets proposed by the method with the cognate sets in the gold standard (see Bergsma & Kondrak 2007).

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Pair Comparison

Evaluation Measures

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Precision, Recall, and F-Score are calculated by comparing the cognate sets proposed by the method with the cognate sets in the gold standard (see Bergsma & Kondrak 2007).

Pair Comparison

Pair comparison is based on a pairwise comparison of all decisions present in testset and goldstandard.

Tests

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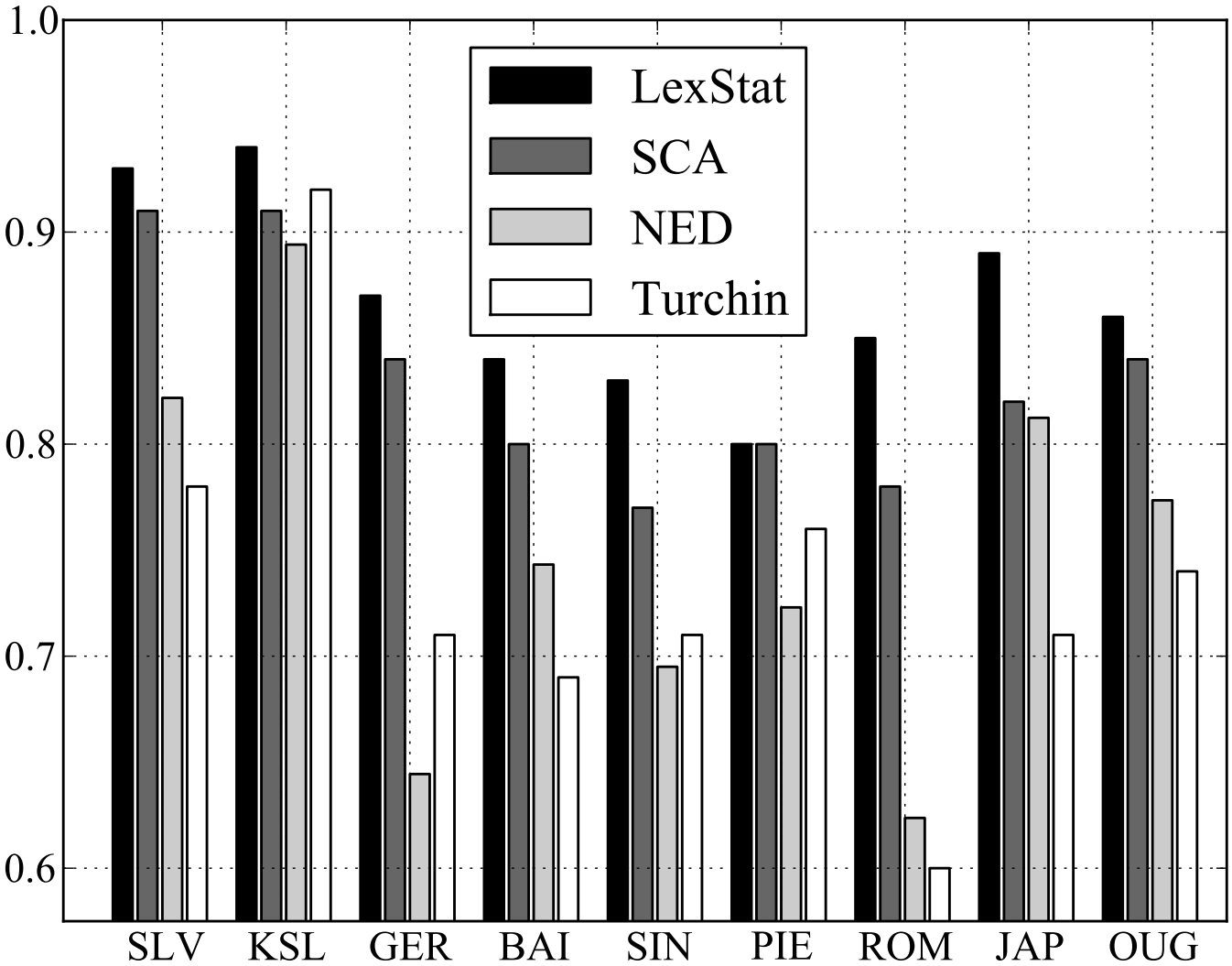
- SCA – language-independent distance scores derived from sound-class-based alignment analyses (List 2012)
- LexStat – language-specific distance scores

General Results

General Results

Score	LexStat	SCA	Simple Alm.	Sound Cl.
Identical Pairs	0.85	0.82	0.76	0.74
Precision	0.59	0.51	0.39	0.39
Recall	0.68	0.57	0.47	0.55
F-Score	0.63	0.55	0.42	0.46

General Results



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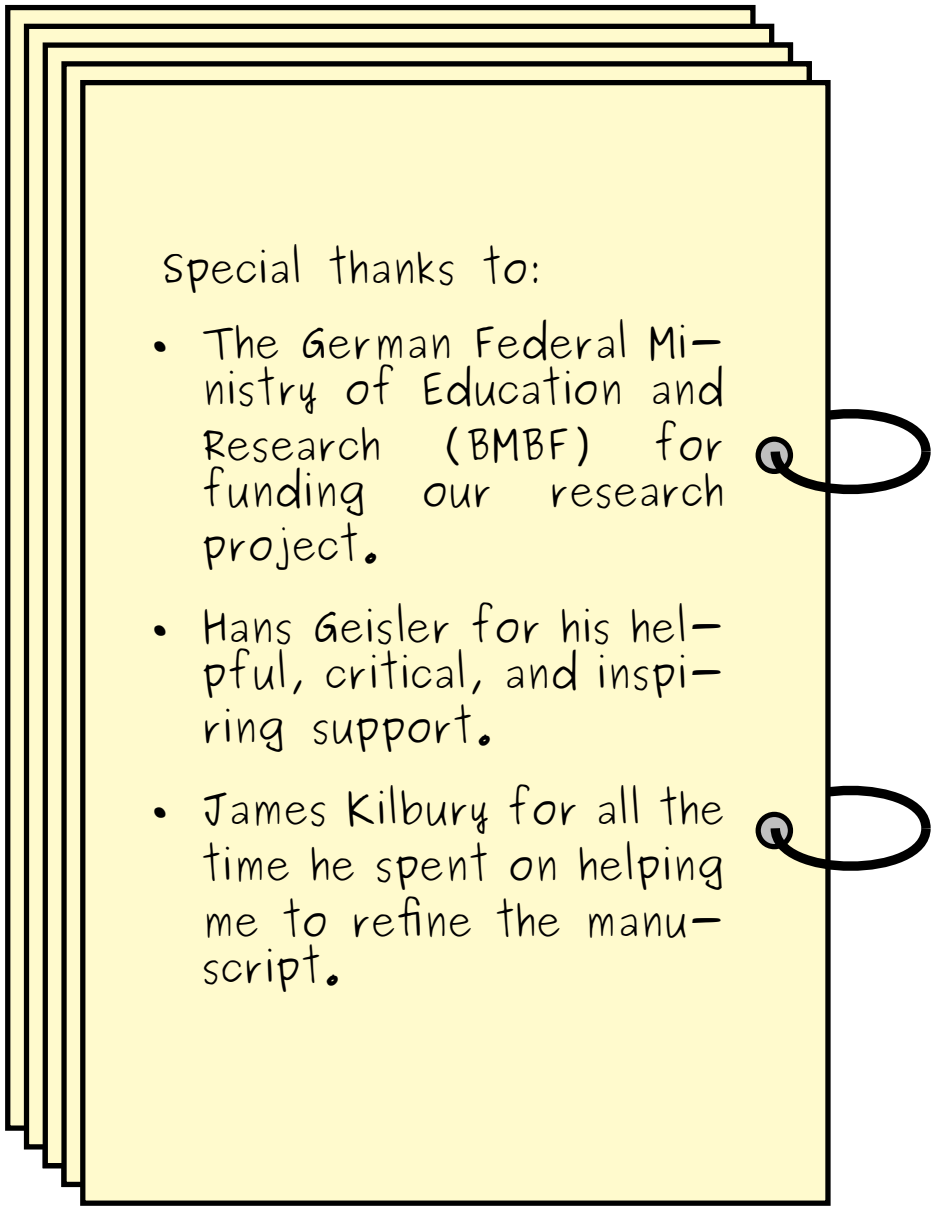
	LexStat	**SCA**	**Simple Alm.**	**Sound Cl.**
Borrowings	50%	61%	49%	53%
Chance Resemblances	17%	42%	89%	31%


What's next?
*deh3-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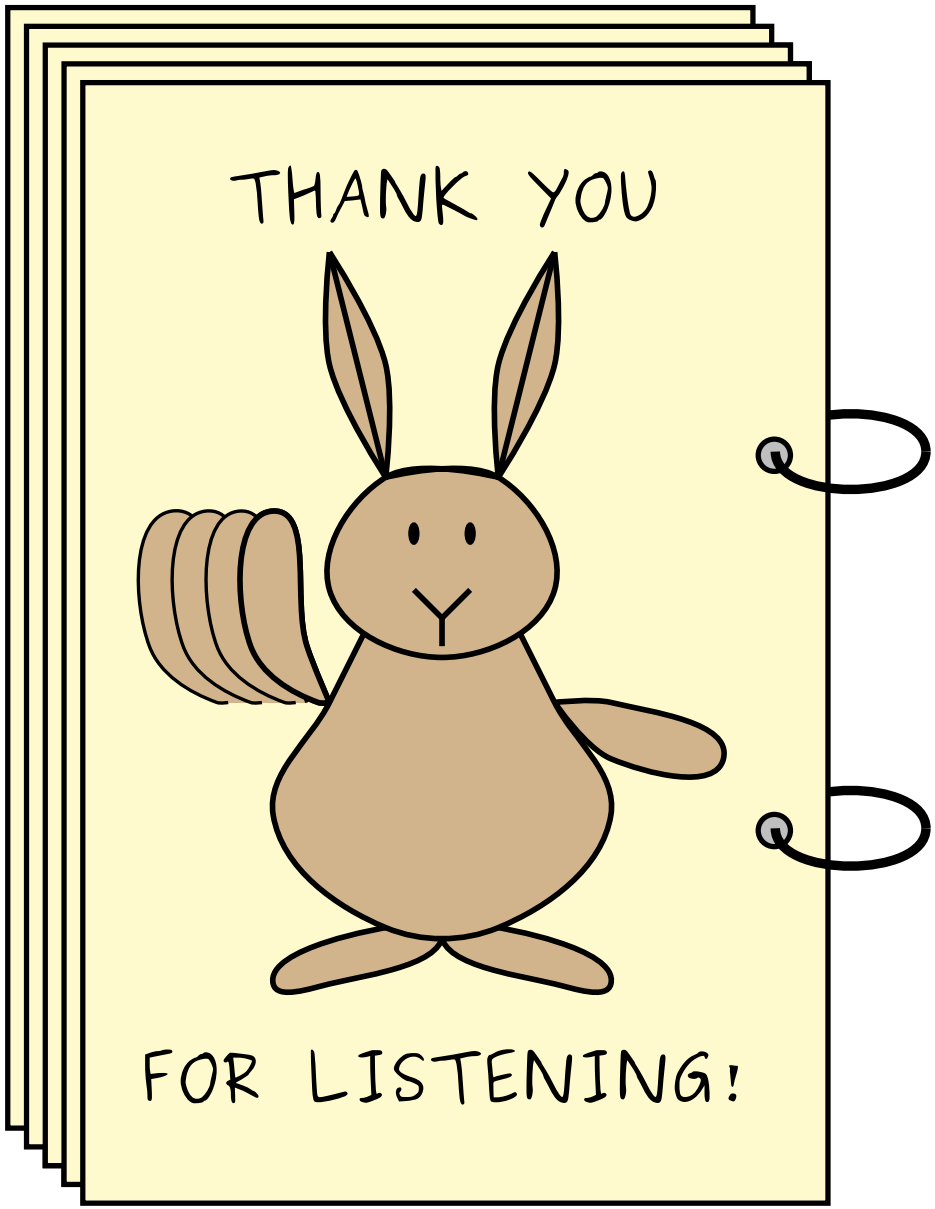
• James Kilbury for all the time he spent on helping me to refine the manuscript.


THANK YOU
FOR LISTENING!