Trimming Phonetic Alignments Improves the Inference of Sound Correspondence Patterns from Multilingual Wordlists

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The 5th Workshop on Research in
Computational Linguistic Typology and Multilingual NLP
06.05.2023

Goals

Trimming Phonetic Alignments

- Improve the regularity of automatically inferred correspondence patterns among cognate sets from related languages
- Eliminate noisy data: morphemes and non-cognate elements
- Shorten long-tail distribution of correspondence patterns with few occurrences

Correspondence Patterns in Linguistics

	I		II		II		I	
Language A	t	a	h	e	h	i	t	u
Language B	t^h	a	x	e	x	u	t^h	i
Language C	t	a	x	e	x	u	t	i
Language D	ts	a	x	e	x	u	ts	i

Figure: Corresponding alignment sites in a set of four fictitious languages.

Correspondence Patterns

- Patterns are formed by a set of sound correspondences
- Shared between multiple languages, not language pairs
- Recurring correspondence patterns form the basis for the reconstruction of proto-languages

Trimming in Historical Linguistics

Pacaraos	w	a	ɲ	u	+	k	u
Napo	w	a	ɲ	u	+	n	a
Pastaza	w	a	ɲ	u	+	n	a
Ayacucho	w	a	ɲ	u			
Jauja	w	a	ɲ	u			
Lamas	w	a	ɲ	u			

Figure: Trimming morphemes in Quechua. The root is combined with different morphemes in some varieties.

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Examples for trimming

- Trimming is often practiced without being made explicit
- Explicit examples are Payne (1991) and Cayón & Chacon (2022)

Trimming of Alignment Sites in Computational Biology

How does the trimming proceed?

- Trimming DNA sequence alignments
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Methods for trimming

- Removing sites with many gaps (Capella-Gutiérrez et al. 2009)
- Removing sites based on entropy values (Criscuolo & Gribaldo 2010)

Datasets Used in the Study

Data set	Lang.	Conc.	Cog.-Sets	Words	Source
CONSTENLACHIBCHAN	25	106	213	1216	Constenla Umaña (2005)
CROSSANDEAN	20	150	223	2789	Blum et al. (forthcoming)
DRAVLEX	20	100	179	1341	Kolipakam et al. (2018)
FELEKESEMITIC	21	150	271	2622	Feleke (2021)
HATTORIJAPONIC	10	197	235	1710	Hattori (1973)
HOUCHINESE	15	139	228	1816	Hóu (2004)
LEEKOREANIC	15	206	233	2131	Lee (2015)
ROBINSONAP	13	216	253	1424	Robinson & Holton (2012)
WALWORTHPOLYNESIAN	20	205	383	3637	Walworth (2018)
ZHIVLOVOBUGRIAN	21	110	182	1974	Zhivlov (2011)

Table: Number of languages, concepts, non-singleton cognate sets and total entries across the different datasets

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Standardized datasets

- Lexibank-datasets (List et al. 2022) are openly available
- Cognacy annotated manually by dataset creators

Trimming Strategies

Core-oriented

Language							
Language A	s	-	t	e	r	b	-
Language B	m	e	t^h	e	-	-	-
Language C	-	a	t	e	-	b	u
Language D	-	-	t	e	-	b	-
Gap proportion	0.5	0.5	0.0	0.0	0.75	0.25	0.75

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Language C	-	a	t	e	-	b	u
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Figure: Artificial example for the computation of gap profiles followed by trimming using the *core-oriented* (left) and the *gap-oriented* strategy (right).

Computational Details

- Minimal CV/VC skeleton is preserved in all settings
- Sites with more than 50% gaps are trimmed

Regularity thresholds

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- All words with more than 75% of regular patterns are analyzed as ‘regular’

Results

	Original		Core		Gap	
Dataset	P	W	P	W	P	W
CONSTENLACHIBCHAN	0.71	0.50	0.69	0.46	**0.76**	**0.51**
CROSSANDEAN	0.73	0.58	0.74	0.60	**0.75**	**0.64**
DRAVLEX	0.56	0.23	0.57	0.27	**0.61**	**0.31**
FELEKESEMITIC	0.55	0.22	0.58	0.25	**0.62**	**0.29**
HATTORIJAPONIC	0.58	0.33	0.57	0.33	**0.59**	**0.38**
HOUCHINESE	0.65	0.40	0.65	0.42	**0.69**	**0.45**
LEEKOREANIC	0.44	0.21	0.47	0.20	**0.52**	**0.22**
ROBINSONAP	0.64	0.36	0.65	0.37	**0.67**	**0.41**
WALWORTHPOLYNESIAN	0.66	0.40	0.66	0.40	**0.72**	**0.48**
ZHIVLOVOBUGRIAN	0.57	0.24	0.58	0.26	**0.61**	**0.28**

Table: Proportion of regular correspondence patterns (P) and regular words (W) across all datasets after trimming.

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Summary

- Gap-oriented trimming shows the best results for all datasets
- Datasets with low internal diversity show the fewest improvements

Comparing the Random Model

Dataset	Core	Gap
CONSTENLACHIBCHAN	0.58	0.00
CROSSANDEAN	0.02	0.00
DRAVLEX	0.00	0.00
FELEKESEMITIC	0.17	0.01
HATTORIJAPONIC	0.40	0.00
HOUCHINESE	0.05	0.00
LEEKOREANIC	0.54	0.06
ROBINSONAP	0.34	0.00
WALWORTHPOLYNESIAN	0.11	0.00
ZHIVLOVOBUGRIAN	0.12	0.05

Table: Percentage of models with random deletion of alignment sites that achieved higher regularity than the respective trimming model.

Successful Removal of Irregular Patterns

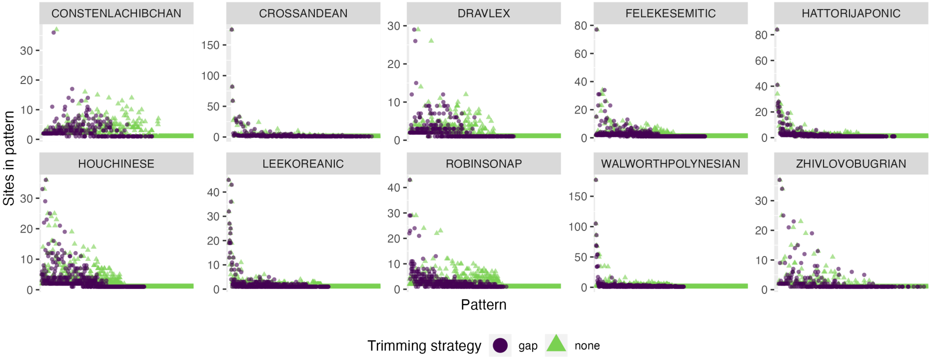

Figure: Distribution of alignment sites per pattern with gap-oriented trimming and without. Each point on the x-axis represents one correspondence pattern.

Example I: Successful Trimming in Chibchan

Boruca	-	-	b	ɾ	u	-	ŋ	-	-	-
Cabecar	-	-	b	-	u	-	ɺ	i	t	u
Chimila	-	-	b	-	u	h	ŋ	a	ʔ	-
Malayo	-	-	b	-	ɨ	-	n	-	-	-
Ngabere	ŋ	ɯ	b	ɾ	ɯ	-	-	-	-	-
Proto-Chibchan			^{m}b		ũ		^{n}d			

Figure: Gap-oriented trimming for the cognate words of ASHES

Evaluation

- Reconstruction provided by Pache (2018)
- Trimming identifies problematic alignment sites and removes them

Example II: Problematic Trimming in Chibchan

Boruca	d	i	ʔ
Bribri	d	i	ʔ
Buglere	tʃ	i	-
Cogui	n	i	-
Ngabere	ɲ	ɤ	-
Proto-Chibchan	ⁿd	i	ʔ

Figure: Trimming for the cognate words of WATER

Evaluation

- Reconstruction provided by Pache (2018)
- Our strategy erroneously eliminates a site that includes reconstructed segments

Outlook

What we have

- Trimming improves the regularity of inferred correspondence patterns
- Shortening of the distribution tail of patterns with few alignment sites
- Promising transfer of trimming to historical linguistics

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Where we want to go

- Find the best thresholds for gaps and regularity
- Use inferred correspondence patterns for sound reconstruction

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