

Unstable Grounds for Beautiful Trees? Testing the Robustness of Concept Translations in the Compilation of Multilingual Wordlists

David Snee, Luca Ciucci, Arne Rubehn, Kellen Parker van Dam,
Johann-Mattis List

Chair for Multilingual Computational Linguistics, University of Passau, Passau, Germany

Abstract

Multilingual wordlists play a crucial role in comparative linguistics. While many studies have been carried out to test the power of computational methods for language subgrouping or divergence time estimation, few studies have put the data upon which these studies are based to a rigorous test. Here, we conduct a first experiment that tests the robustness of concept translation as an integral part of the compilation of multilingual wordlists. Investigating the variation in concept translations in independently compiled wordlists from 10 dataset pairs covering 9 different language families, we find that on average, only 83% of all translations yield the same word form, while identical forms in terms of phonetic transcriptions can only be found in 23% of all cases. Our findings can prove important when trying to assess the uncertainty of phylogenetic studies and the conclusions derived from them.

1 Introduction

While the quantitative turn in historical linguistics has been met with a considerable amount of skepticism for a long time (Holm, 2007; Geisler and List, 2022), phylogenetic methods – originally developed to infer phylogenies of biological species – have by now become the new state of the art in the field, replacing more traditional methods for subgrouping almost completely. Given that most linguistic approaches to phylogenetic reconstruction make use of lexical data, *multilingual wordlists* play a crucial role in phylogenetic reconstruction in historical linguistics.

The compilation of multilingual wordlists itself is quite tedious. Starting from a list of concepts, scholars must translate the concepts into all target languages under investigation. The translation into the target languages, however, is no standardized procedure, but may require various steps, including the consultation of informants, the consultation of

published resources, or the inspection of archived material. In all these cases, scholars who compile a wordlist must weight their evidence carefully, in order to avoid errors. Given the complexity of this process, it is no surprise that errors can easily slip into the translations. A given concept may lack a direct translational equivalent in a given language, or there may be several good candidates from which scholars must select the most appropriate ones. As a result, there is a great risk that multilingual wordlists compiled for phylogenetic studies show a considerable amount of idiosyncrasies that might have an impact on the phylogenies scholars compute from them.

Studies that try to measure the amount of inconsistency in multilingual wordlists – introduced by the translation of concepts into target languages – are lacking so far. Here, we present a first attempt to shed light on the robustness of the concept translation task, taking advantage of the fact that recent efforts have produced large-scale repositories of standardized multilingual wordlists (List et al., 2022). In the following, we will give a short overview on previous discussions and studies that focus on the translation of concepts in multilingual wordlist compilation (§ 2). After this, we introduce the materials and methods by which we try to evaluate the robustness of concept translation (§ 3). Having presented the results (§ 4), we discuss them in more detail and share some ideas to improve the enterprise of wordlist compilation in historical linguistics (§ 5).

2 Background

Phylogenetic approaches rely on multilingual wordlists compiled through lexicostatistic methods, dating back to Swadesh’s foundational work (Swadesh, 1950, 1952, 1955). A multilingual wordlist in this context is a list of concepts translated into one or more target languages (List, 2014).

Although typically emphasizing their difference with respect to Swadesh’s lexicostatistics, modern phylogenetic approaches all build on this onomasiological (i.e. *concept-based*) approach that takes the concept as the major aspect by which languages are compared. Building on Geisler and List (2010), we can identify five major steps in the typical workflow applied in modern approaches to phylogenetic reconstruction. Starting from the compilation of a concept list (1: *concept list compilation*), the concepts are translated into the target languages (2: *concept translation*) in order to create an initial *comparative wordlist*. This wordlist is then used as the basis for the identification of cognate words (3: *cognate identification*). Having converted the information on cognate words into a numerical or computer-readable format (4: *cognate coding*), scholars then employ their phylogenetic method of choice in order to compute a phylogeny of the languages in question (5: *phylogenetic reconstruction*).

Up to now, most critics of lexicostatistics and its modern equivalents have concentrated on either the stage of cognate identification or the resulting phylogenetic methods. Cognate identification is often criticized as being flawed due to undetected borrowings (Donohue et al., 2012). When disputing over phylogenetic methods, there have been long-standing debates about the complexity of the models employed, as reflected in the debate about the age of Indo-European, where models differing in complexity yielded quite different age estimates (Bouckaert et al., 2012; Chang et al., 2015; Kassian et al., 2021; Heggarty et al., 2023).

What has much less often been discussed in the context of phylogenetic methods, however, are the first two stages of the workflow, that is, the stage of concept list compilation, and the stage of concept translation. While it has been clear for a long time that different concept lists often yield different phylogenies (Chén, 1996; McMahon et al., 2005), a closer discussion regarding the impact of concept lists on the results of phylogenetic analyses has not been carried out so far. The same holds for the translation of concepts into target languages. While Geisler and List (2010) found that concept translation across Romance languages in two independently compiled multilingual wordlists differs by about 10%, and List (2018) and Häuser et al. (2024) could show that selecting but one out of several translations for the same concept in the same language can have direct consequences on the re-

sulting phylogenies, no closer investigation regarding the degree of variation in concept translation or the impact of concept translation on phylogenetic analyses has been conducted up to now.

3 Materials and Methods

3.1 Materials

In order to investigate variation in word choice across multilingual wordlists, it is important to find wordlists that have been compiled independently for the same language varieties, containing at least a certain subset of identical concepts. In order to identify such data, we checked datasets published as part of the Lexibank repository (<https://lexibank.cldf.org>, List et al. 2022), searching specifically for those cases where several languages from the same language family or subgroup are available in the form of multilingual wordlists created by different authors.

Lexibank uses Cross-Linguistic Data Formats (CLDF, <https://cldf.cldf.org>, Forkel et al. 2018) to standardize multilingual wordlists along the three dimensions of language, meaning, and form. Languages are linked to Glottolog (<https://glottolog.org>, Hammarström et al. 2024) in order to ensure that languages can be easily identified across sources, even if they are given different names in the original datasets. Concepts are mapped to Concepticon (<https://concepticon.cldf.org>, List et al. 2025a), a reference catalog for semantic glosses used to elicit concepts in concept lists. This facilitates the aggregation of wordlists from different sources to allow the identification of common concepts for which different wordlists provide translations in their target languages. Phonetic transcriptions in Lexibank are unified with the help of the Cross-Linguistic Transcription Systems reference catalogue (CLTS, <https://clts.cldf.org>, List et al. 2024), a standardized subset of the International Phonetic Alphabet that has a generative component by which detailed transcriptions of more than 8,000 speech sounds can be created and compared (see Anderson et al. 2018 and Rubehn et al. 2024).

Checking the Lexibank data in the most recent version of the repository (2.0, Blum et al. 2025a), we identified 10 groups of languages corresponding to 9 different language families, in which two and more multilingual wordlists from different datasets could be compared. The 10 groups stem from 18 different datasets, with two

Group	Dataset A	Dataset B	Concepts			Languages			Synonymy	
			A	B	$A \cap B$	A	B	$A \cap B$	A	B
Bai	allenbai (Allen, 2024)	wangbai (Wang, 2024)	499	412	208	9	10	2	1.01	1.02
Chadic	kraftchadic (Kraft, 2024)	gravinachadic (Gravina, 2024)	429	717	325	67	48	5	1.04	1.10
Chinese	beidasinitic (Beijing University, 2024)	liusinitic (Lilí et al., 2024)	738	202	102	18	19	12	1.18	1.17
Dravidian	dravlex (Kolipakam, 2024)	northeuralex (Dellert, 2024)	100	954	94	20	107	4	1.39	1.02
Indo-European	iecor (Heggarty et al., 2024)	starostinpie (Starostin, 2024)	170	110	88	160	19	15	1.01	1.05
Japonic	leejaponic (Lee and Hasegawa, 2024)	robbeetstriangulation (Robbeets, 2025)	210	254	152	59	101	6	1.01	1.03
Koreanic	leekoreanic (Lee, 2024)	robbeetstriangulation (Robbeets, 2025)	246	254	175	15	101	13	1.01	1.01
Tupian	galuciotupi (Galucio et al., 2024)	gerarditupi (Ferraz Gerardi and Reichert, 2024)	100	242	70	23	38	5	1.02	1.00
Uralic	northeuralex (Dellert, 2024)	syrjaenuralic (Syrjänen et al., 2024)	954	173	147	107	7	5	1.12	1.17
Uto-Aztecan	utoaztecan (Greenhill et al., 2025)	davletshinaztecan (Davletshin, 2024)	121	100	92	46	9	3	1.22	1.00

Table 1: Selected language groups along with their original datasets and additional statistics employed in this study. References to the datasets follow the most recent publication of the data as part of the Lexibank repository. Information on the original studies in which the data were published for the first time are provided by the more recent standardized editions. The table lists the number of concepts and languages (along with the intersection), as well as the synonymy (measured by dividing the number of words by the number of concepts).

datasets (NorthEuralex, see Dellert et al. 2020, and RobbeetsTriangulation, see Robbeets et al. 2021) offering two groups each. From these 10 wordlist pairs, each consisting of two multilingual wordlists covering at least two language varieties, we manually selected 70 language pairs, making sure that all pairs represent identical languages to the best of our knowledge. Table 1 provides an overview on the 10 groups of language pairs that we compiled for this study, along with the number of matching concepts, matching language pairs, and synonymy statistics on the wordlists. Figure 1 shows the geographical distribution of the 70 languages in our sample.

3.2 Wordlist Comparison

We compare wordlists in terms of their (1) matching Glottocodes, (2) manually selected language pairs, and (3) matching concepts. Paired language varieties within each wordlist comparison are initially identified based on matching Glottocodes. This results in a total of 75 Glottocode matches across all language families to be compared. Upon closer examination of the data, it becomes clear that Glottocode comparisons alone do not allow for the comparison of identical language varieties as different subvarieties are at times encoded with

the same Glottocode both inside the same dataset and in separate datasets. To quantify the effect of this discrepancy, language pairs are also manually selected based on consultation with each dataset’s metadata, resulting in a total of 70 language pairs for analysis. Language pairs are then examined based on matching concepts, which are identified with the help of the Concepticon mappings provided by Lexibank.

3.3 Comparing Concept Translations

Since phonetic transcriptions in Lexibank’s datasets are unified, following the system recommended by the CLTS reference catalog, one might expect that differences in concept translation can be simply identified by comparing transcriptions across different datasets directly, using string identity as a criterion to assess if two translations are identical or not. However, word form comparisons using phonetic data are still error-prone as datasets often differ with respect to details in the concrete realization of phonetic transcriptions (Anderson et al., 2018). Since variation in phonetic transcription is a norm rather than an exception (Anderson et al., 2023), we have to find a metric that allows us to distinguish those cases where two translations are identical even if the phonetic transcriptions dif-

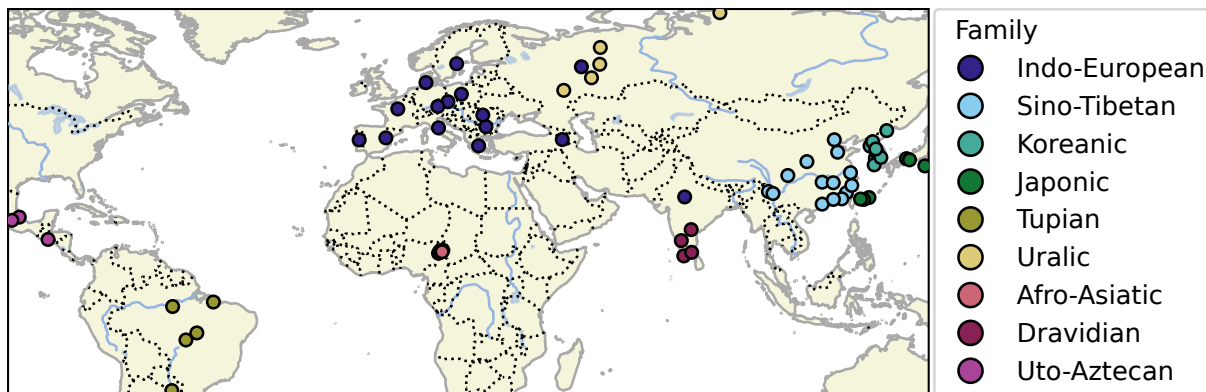


Figure 1: Location of the languages investigated in our study. For each of the 70 languages, two wordlists were identified in the Lexibank repository (for a full list of languages see file `values.csv` in the supplement).

fer slightly from those cases where two translations point to two different words. In order to address this problem, we decided for an automated approach that measures the phonetic similarity of sound sequences, rather than their identity with respect to the symbols used in transcriptions.

Our approach makes use of the Sound-Class Based Phonetic Alignments algorithm (SCA, List, 2012b), which was originally designed to align words phonetically, but which comes along with a measure for phonetic distances that ignores minor transcription differences. SCA distance scores derived from phonetic alignments carried out with the help of the SCA algorithm, have been shown to work quite well in the task of automated cognate detection (List, 2012a) and borrowing identification (Miller and List, 2023). SCA distance scores range between 0 (near identity of phonetic sequences) and 1 (very low similarity). Assuming that a score below 0.5 points to differences resulting from phonetic transcriptions, while scores higher than 0.5 result from differences stemming from different translations, we employ SCA distances as a proxy to detect whether two translations are *similar* (reflecting only phonetic variation) or *different* (reflecting true differences in translation).

In addition to the automated identification of translation differences with the help of SCA distances, we also computed the average SCA distances for all language pairs in our sample, as well as the edit distance (also known as *Levenshtein distance*, Levenshtein, 1966), both in its original and its normalized form (where we divide the distance by the longer of the two sequences, see List 2014, 178). All in all, these metrics should allow us to assess the amount of differences in concept translations across multilingual wordlists fairly well.

3.4 Preprocessing

Lexibank occasionally contains data in which morpheme boundaries are marked with the help of a plus symbol (+). Since morpheme boundaries would unnecessarily confuse phonetic alignment algorithms, introducing extra noise that we are not primarily interested in, we deleted all morpheme boundary markers from the sound sequences before comparing them. For the same reason, we also decided to ignore tone markers in the data. These do not occur in all datasets, but are instead mostly restricted to South-East Asian languages. Since tone annotation in phonetic transcription can vary considerably, probably even more than the transcription of consonants and vowels, we also ignored all tones in datasets from South-East Asian languages.

3.5 Evaluation

In order to test whether this approach is suitable to provide useful information on translation differences, we created a test set. Using EDICTOR (List et al., 2025b), translation differences were annotated for all language and concept pairs in the Indo-European datasets of our sample. This allowed us to use the manual annotations as a gold standard and to assess the suitability of SCA distance scores to identify true differences in concept translation. Results of this comparison are reported in the form of precision, recall, and F-Scores (List, 2014, 191–192).

3.6 Implementation

All methods are implemented in Python. We use LingPy to compute SCA distances and edit distances (<https://pypi.org/project/lingpy>, Version 2.6.13, List and Forkel, 2023). For the han-

dling of wordlist data in CLDF format, we use CL Toolkit (<https://pypi.org/project/cltoolkit>, Version 0.2.0, List and Forkel, 2022). For the inspection and manual annotation of wordlist data, EDICTOR was used (List et al., 2025b). For the creation of the map in Figure 1, CLDFViz was used (Version 1.3.0, Forkel, 2024). In order to download the data in its most recent versions defined by the Lexibank 2 repository (Blum et al., 2025a), we used PyLexibench (Häuser et al., 2025, <https://pypi.org/project/pylexibench>).

4 Results

4.1 Handling Phonetic Variation

As mentioned before, we are interested in finding a way to identify words that reflect the same original word form that is represented in slight variations in the phonetic transcriptions. Having a reliable automated approach for this task is important in order to allow us to investigate differences in concept translation on a larger amount of data.

To test how well the SCA distances can help us to identify words that only vary by phonetic transcription, we conducted a test study in which we annotated all hand-selected language pairs from the Indo-European group, indicating for each pair of words whether they were identical – despite potentially diverging phonetic transcriptions – or different. This dataset of 15 manually annotated language pairs was then compared with the results derived from our automated approach using the SCA distance. The results of this analysis are shown in Table 2. As the table illustrates, there are only minor differences between the automated and the manual annotation, with F-Scores of 0.98 on average for all 15 language pairs. We conclude from this that using SCA distances with a threshold of 0.5 provides a very good approximation to distinguish between identical word forms with potentially diverging transcriptions and word forms that reflect true differences in concept translation, allowing us to derive major conclusions when testing it on additional datasets.

4.2 Variation in Concept Translation

We conducted two tests on the 10 datasets. During the first test, we compared all languages by matching Glottocodes with each other. If more than one variety was assigned the same Glottocode in a given dataset, all possible pairs were assembled and average values for word pair identity, similarity,

Language	Precision	Recall	F-Score
Armenian (Eastern)	0.99	0.99	0.99
Bulgarian	1.00	0.99	0.99
Czech	1.00	0.99	1.00
Danish	1.00	0.95	0.97
French	0.99	0.99	0.99
German	1.00	0.95	0.98
Greek	0.97	0.99	0.98
Hindi	0.99	0.99	0.99
Polish	1.00	0.99	1.00
Portuguese	1.00	0.96	0.98
Romanian	0.98	0.96	0.97
Russian	1.00	0.99	0.99
Spanish	1.00	0.98	0.99
Swedish	0.99	0.97	0.98
Italian	0.97	0.96	0.96
TOTAL	0.99	0.98	0.98

Table 2: Comparison of the evaluation study on Indo-European. Precision and recall are calculated per concept, counting true and false negatives and positives for all possible pairings within the same concept slot for identical languages. F-Scores are based on the harmonic mean calculated from precision and recall.

and SCA distances were computed. In the second experiment, only those language pairs were considered that we had identified as reflecting the same varieties (to the best of our knowledge). In all cases, we computed the identity of the sound sequences that appeared as translations for the same concepts, the *similarity* (with those pairs defined as similar whose SCA distance was below our threshold of 0.5), and the SCA distances. If more than one translation was available for the same concept in a given language variety, all possible pairs were compared and the average value of the individual scores was computed.

The results of the comparison based on matching Glottocodes are shown in Table 3, those of the comparison based on hand-selected language pairs are in Table 4. As can be seen from the tables, the results do not differ too much from each other, at least as far as their tendencies are concerned. Nevertheless, a closer inspection of the differences between the two approaches reveals that the linking of languages to Glottocodes shows some major problems in the datasets on the Chadic, Japonic, and Koreanic groups. In all three dataset pairs (Japonic and Koreanic data in one pair are both taken from the same study of Robbeets et al. 2021), we find that links to Glottolog could be improved. The data by Robbeets et al. (2021), for example, provides the

Family	Pairs	↑ Identical	STD	↑ Similar	STD	↓ SCA	STD	↓ NED	STD	↓ ED	STD
Bai	2	0.32	0.12	0.83	0.02	0.20	0.04	0.44	0.10	1.33	0.32
Chadic	10	0.07	0.05	0.71	0.14	0.32	0.10	0.54	0.11	3.34	0.63
Chinese	12	0.39	0.11	0.77	0.05	0.24	0.04	0.38	0.06	1.66	0.25
Dravidian	4	0.06	0.04	0.79	0.02	0.25	0.03	0.57	0.08	3.30	0.44
Indo-European	15	0.31	0.22	0.94	0.03	0.09	0.05	0.30	0.13	1.48	0.56
Japonic	7	0.28	0.19	0.74	0.24	0.27	0.17	0.40	0.20	2.09	1.02
Koreanic	9	0.06	0.04	0.74	0.21	0.31	0.14	0.59	0.12	3.01	0.72
Tupian	6	0.32	0.19	0.73	0.32	0.29	0.21	0.39	0.25	2.01	1.22
Uralic	6	0.19	0.12	0.85	0.06	0.17	0.08	0.42	0.13	2.26	0.78
Uto-Aztecan	4	0.34	0.22	0.88	0.03	0.18	0.06	0.32	0.11	1.79	0.85
TOTAL	75	0.23	0.13	0.80	0.07	0.23	0.07	0.44	0.10	2.23	0.74

Table 3: Major results per dataset for our comparative study, comparing all languages that show matching Glottocodes with each other, in terms of Identical (phonetic strings match perfectly) and Similar word pairs (phonetic strings show SCA distance beyond our threshold of 0.5), as well as averaged SCA distances, normalized edit distance, and traditional edit distances. Highest similarities are marked in bold font, lowest similarities are shaded in gray.

same Glottocodes for historical and modern varieties of Japanese and Korean. Any comparison that matches solely by Glottocode will therefore run the risk of comparing data from different stages of the same language. This example shows that scholars who base their analyses on Glottocodes should take particular care in selecting the most representative varieties. Especially when aggregating languages from different sources, one should make sure to provide extra checks on top of CLDF that would ensure that the same language varieties are being compared. Matching Glottocodes are an extremely good proxy, but they do not provide a guarantee that languages varieties from different sources really match.

What we can also see from the table is that we have extremely low values on phonetic identity in both comparisons, while phonetic similarity (as reflected in SCA distance scores beyond the value 0.5) shows a drastic increase. This proves the usefulness of computing SCA distance scores instead of comparing whether sound sequences are fully identical or not. It also shows (as we have already seen in the previous section) that SCA distances seem to provide quite sensitive results when it comes to assessing the near-identity of sound sequences reflecting slight transcription differences.

When considering only the phonetic similarity scores, which point to differences in lexeme choice when it comes to translating a concept into a given language variety, it seems remarkable that – apart from Indo-European, where differences make up only 6% – we find that differences between wordlists that we would expect to represent identical language varieties show a considerable amount

of variation. On average, only 83% of all word pairs for our hand-selected sample of language pairs taken from different sources seem to be truly the same. In the remaining 17% of cases, we find that the concepts were translated differently. Recalling that Geisler and List (2010) report differences of about 10% with respect to lexeme choice in the Romance partition of the Indo-European dataset they compared, we can conclude that the numbers are even worse when looking at data from more language families.

That Indo-European data shows the lowest variation in our study should not come as a surprise. First, the language family has been studied in much more detail than any other language family in the world. Second, the principles by which Heggarty et al. (2023) compiled their data have been heavily influenced by the principles laid out by the Moscow school of historical linguistics (Kassian et al., 2010), from which the second dataset on Indo-European languages in our sample was taken (Starostin, 2005). Figure 2 illustrates the dominance of Indo-European, in representing all 70 pair comparisons in a bar chart with increasing lexical variation. As can be seen from the example, with the exception of the Indo-European datasets that show the highest similarity with respect to the translation of the concept lists into the target languages, there is no real trend that might hint to major problems with the data in particular language groups or language families. Instead, it seems that what we find in our experiments can be considered as the kind of variation that one would expect when considering the task of having independent people translate a concept list into the same language.

Family	Pairs	↑ Identical	STD	↑ Similar	STD	↓ SCA	STD	↓ NED	STD	↓ ED	STD
Bai	2	0.32	0.12	0.83	0.02	0.20	0.04	0.44	0.10	1.33	0.32
Chadic	5	0.11	0.03	0.79	0.04	0.27	0.02	0.48	0.06	3.00	0.36
Chinese	12	0.39	0.11	0.77	0.05	0.24	0.04	0.38	0.06	1.66	0.25
Dravidian	4	0.06	0.04	0.79	0.02	0.25	0.03	0.57	0.08	3.30	0.44
Indo-European	15	0.31	0.22	0.94	0.03	0.08	0.03	0.29	0.11	1.39	0.51
Japonic	6	0.31	0.18	0.83	0.05	0.21	0.07	0.34	0.10	1.75	0.54
Koreanic	13	0.06	0.03	0.82	0.09	0.25	0.06	0.54	0.06	2.76	0.45
Tupian	5	0.38	0.13	0.86	0.05	0.21	0.05	0.29	0.05	1.53	0.34
Uralic	5	0.23	0.08	0.87	0.02	0.14	0.04	0.37	0.06	2.00	0.50
Uto-Aztecan	3	0.24	0.14	0.87	0.01	0.20	0.04	0.37	0.08	2.16	0.54
TOTAL	70	0.24	0.12	0.84	0.05	0.21	0.06	0.41	0.10	2.09	0.70

Table 4: Major results per dataset for our comparative study, comparing all 70 hand-selected language pairs in terms of Identical (phonetic strings match perfectly) and Similar word pairs (phonetic strings show SCA distance beyond our threshold of 0.5), as well as averaged SCA distances, normalized edit distance, and traditional edit distances. Highest similarities are marked in bold font, lowest similarities are shaded in gray.

4.3 Types of Variation in Concept Translation

In order to gain a better understanding of the sources of variation in concept translation, we carried out a more detailed analysis of the differences in the Indo-European and the Tupian data. From this comparison, we can identify two major kinds of translation differences. First, translations can point to completely different words. Second, translations may reflect the same word, but they differ morphologically.

As an example for completely different words provided as translations for the same concept in the same target languages, consider cases like the concept **MEAT**, translated correctly into French as [vj̃r:d] in the Indo-European dataset by Heggarty et al. (2023), while the Indo-European dataset by Starostin (2005) provides two translations, [vj̃d] and [fɛʁ], the latter pointing specifically to “flesh”. Since one of the two forms is identical with the form in the first dataset, we count this translation difference as 0.5 in our calculations. We can see that the reason for the additional translation in the dataset by Starostin (2005) results from a lack of specification in the concept that was being compared. As an additional example, consider Tupian data for Paraguayan Guaraní, where [gwasu] in Galucio et al. (2015) is glossed as “big” (cf. Estigarribia, 2020, 56) in the original data and matched with the Concepticon gloss **BIG** in the Lexibank dataset. This word form may also be rendered as “be big”, as in Gregores and Suárez (1967, 224), if one does not recognize in Paraguayan Guaraní the existence of an adjective class, for which “little evidence exists” (Estigarribia, 2020, 15). Conversely, Ferraz Gerardi and Reichert (2021) provide the

word form [posogue] for the concept **BIG**, which could be translated into English as “huge” or “gigantic” (Guasch and Ortiz, 2008, 720). This example illustrates how subtle semantic differences influence lexical choice, leading to differences in the lexical forms selected for inclusion in a wordlist. The use of periphrastic phrasing with multiple word forms in contrast to a single word form also contributes to differences in concept translation between the datasets. Take the concept **STAND** in Italian as an example. Heggarty et al. (2023) provide the form [sta:reimpjɛ:di], which consists of three word forms: a verb, a preposition and a noun. By contrast, Starostin (2005) specifies the single verb form [stare] for the same concept. In particular, for systems which implement automatic cognate detection, such as SCA, this kind of concept translation dissimilarity can be problematic as they often rely on surface phonetic similarity between comparative word forms. Many true cognates could therefore be missed, even if a common word form is present in the forms being compared.

Morphological variation also causes notable differences in concept translation. In Tupian, this involves a lack of consensus on the citation form of inflected parts of speech (mainly nouns and verbs) across different languages, associated with a limited availability of complete inflectional paradigms. Generally, the two wordlists differ in their tendency to report inflected forms (Galucio et al., 2015) in contrast to roots (Ferraz Gerardi and Reichert, 2021). As an example, consider cases of different morphological forms in Paraguayan Guaraní. Here, some nouns have what are traditionally considered alternating roots with initial consonant [t], [h], or

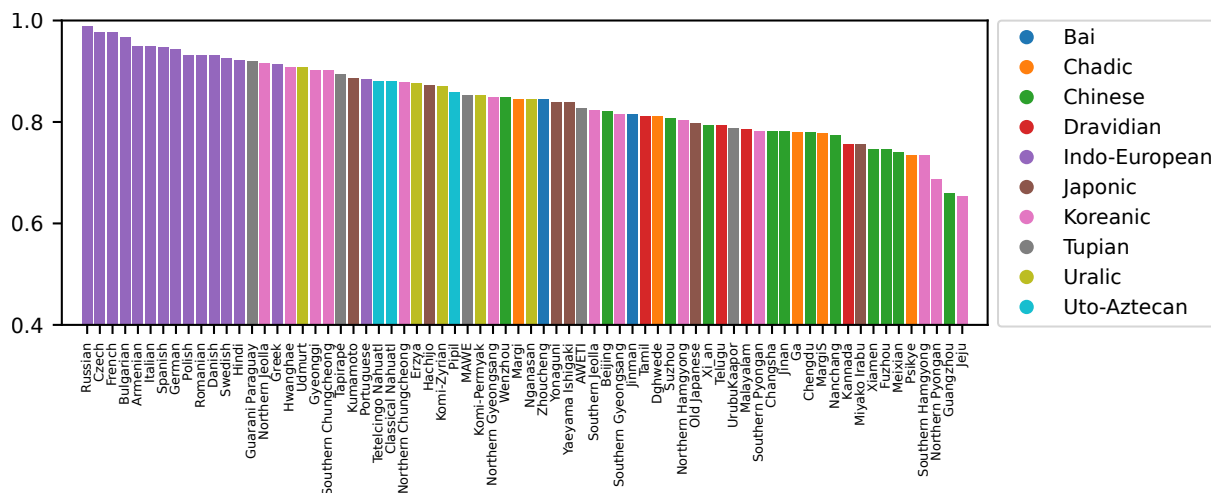


Figure 2: Comparison of all language pairs in the sample. The plot shows the hand-curated collection of 70 language pairs in our sample, colored by language family. The scores on the y-axis indicate the identified proportion of similar word pairs, showing an SCA distance beyond 0.5, ranked by their scores from left (high similarity) to right (low similarity).

[r]. The initial consonant may be treated as a prefix (Estigarribia, 2020, 63), with [t-] expressing, for instance, the “absolute or non-possessed form”. Galucio et al. (2015) have a tendency to report the Paraguayan Guaraní forms with [t-], while Ferraz Gerardi and Reichert (2021) tend to only report the prefixless root. This issue is not unique to Tupian languages; similar mismatches arise from differing representations of inflectional morphology in other datasets. For example, in the Czech data for the concept SAY Heggarty et al. (2023) use the perfective form [rɪ:tst], whereas Starostin (2005) provides the imperfective form [rɪ:kat]. Root allomorphy in Paraguayan Guaraní also contributes to differences between Galucio et al. (2015) and Ferraz Gerardi and Reichert (2021). Take, for example, the concept COME in Paraguayan Guaraní. It exhibits root allomorphy, appearing as [ju] or [u] (Estigarribia, 2020, 146–147). Galucio et al. (2015) represent both allomorphs whereas Ferraz Gerardi and Reichert (2021) only include [ju]. While a manual analysis would most likely treat these differences as marginal, characterizing the variants as identical translations of the original concept into the target language in question, there are cases where morphological variation can yield substantial differences in the translations. As an example, consider the two forms for YELLOW in Urubú-Ka’apor. Based on Kakumasu and Kakumasu (2007, 56, 116, 200, 204), the representation in Galucio et al. (2015) is a suffix meaning “yellow” [-ju], while Ferraz Gerardi and Reichert (2021) in-

dicating the third person form of the “descriptive verb” “be yellow” [itawa].

5 Discussion and Conclusion

Our results confirm the findings of Geisler and List (2010), who emphasize that concept translation may cause larger discrepancies between wordlists compiled independently by different scholars. While Geisler and List (2010) report differences of about 10% for the Romance language partition in the two Indo-European datasets they compared, our results, taking data from 9 different language families into account, show that the differences are typically even larger, with only 83% of concept translations reflecting the same underlying word forms on average. Figure 2 also demonstrates the magnitude of variation which occurs in concept translation between individual language varieties, also within the same language family, with some varieties such as Russian achieving the exceptionally high similarity score of 0.99 and others like Jeju scoring 0.65. Many factors of course impact this variation, not least the increased standardization present in certain language varieties we examined, but also perhaps sociolinguistic factors such as dialect contact, semantic extension and cultural salience, which is beyond the scope of our current study. It is also worth noting that certain language families such as Tupian also contain many unknowns, it is therefore expected to have a certain level of disparity in these datasets. While we have not tested the impact that differences in concept

translation may have on phylogenetic reconstruction, we consider our results robust enough to call for the attention of scholars who use phylogenetic methods to answer big picture questions about human prehistory.

Although we think it is far too early to discard phylogenetic methods, we think that it would be useful for phylogenetic approaches to take potential problems resulting from the concept translation stage during the wordlist compilation seriously and make sure to apply certain measures to increase the robustness of their inferences. These measures could include tests on sampling errors, as outlined in [Feld and Maxwell \(2019\)](#), involve additional tests on inter-annotator agreement ([McDonald et al., 2019](#)) during concept translation, or entail conducting robustness tests similar to the bootstrap in phylogenetic reconstruction.

In any case, the declared goal of phylogenetic approaches should be the same as for traditional historical linguistics. [Ratcliffe \(2012\)](#) suggests that an ideal test of the reliability of the traditional comparative method for linguistic reconstruction would be to “take two teams of researchers trained in the comparative method, put them in the libraries, keep them in isolation from each other and see what they come up with” ([Ratcliffe, 2012](#), 240). While it is clear that such experiments are still lacking in traditional historical linguistics, it seems important that scholars working in the field of historical language comparison, no matter if they work computationally or manually, maintain a mindset that does not take the reliability of their data for granted.

As far as our own experiments are concerned, we are still in the early stages of this research. Additional experiments – potentially even including additional data from language families that do not feature in the sample presented here – will be needed to get a better understanding of the potential impact of concept translation on phylogenetic analysis. It is possible that phylogenetic methods turn out to be robust enough to yield similar results in terms of subgrouping and divergence time estimates, even if the wordlists that they employed show a certain amount of differences in the translations. Without detailed analyses, however, we cannot be sure, and should not exclude the possibility that concept translation has a direct impact on the results of phylogenetic reconstruction analyses.

In addition to phylogenetic reconstruction, it would also be important to test to which degree concept translation might influence the results of other

studies that make use of multilingual wordlists. Among these, the most important candidates that we can identify are global studies on sound symbolism or similar phenomena ([Wichmann et al., 2010](#); [Johansson et al., 2020](#)), as well as studies that make use of cross-linguistic colexification data ([Jackson et al., 2019](#); [Tjuka et al., 2024](#); [Rubehn and List, 2025](#)). Recently introduced methods for language affiliation without phylogenetic reconstruction ([Blum et al., 2025b](#)) may also suffer from variation in concept translation. In any case, the last word on the robustness of multilingual wordlists has not yet been spoken, and more tests are needed to understand the full implications of the findings that we reported in this study.

Supplementary Material

The data, code, and detailed instructions needed to replicate this study are curated on Codeberg (<https://codeberg.org/calcc/concept-translation-study>, Version 1.0) and archived with Zenodo (<https://doi.org/10.5281/zenodo.15653036>).

Limitations

The most important limitation to our current study is the uneven distribution of data across language families and varieties. For instance, we have 15 comparative varieties for Indo-European, while we only have two for Bai. There is also a disparity in the number of matching concepts between matching language varieties which allows us to achieve a more extensive sample of certain paired varieties. At the moment, we do not see how these limitations could be addressed consistently. In the long run, it seems that we must try to increase the number of comparisons by trying to identify more datasets that were independently compiled for the same languages.

Funding Information

This project was supported by the ERC Consolidator Grant *ProduSemy* (PI Johann-Mattis List, Grant No. 101044282, see <https://doi.org/10.3030/101044282>). Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or the European Research Council Executive Agency (nor any other funding agencies involved). Neither the European Union nor the granting authority can be held responsible for them.

Author Contributions

DS and JML initiated the study. DS coded the data, LC, AR, and KPvD provided assistance in questions on data. AR and KPvD provided assistance in questions on the code, DS and JML wrote the code base and analyzed the data. DS and JML wrote the first draft, LC contributed manual analyses of the results on Tupían and Indo-European languages and assisted in writing. All authors read and commented on the revised draft and agree with its final contents.

References

- Bryan Allen. 2024. *CLDF dataset derived from Allen's "Bai dialect survey" from 2007*. Zenodo, Geneva.
- Cormac Anderson, Tiago Tresoldi, Thiago Chacon, Anne-Maria Fehn, Mary Walworth, Robert Forkel, and Johann-Mattis List. 2018. *A cross-linguistic database of phonetic transcription systems*. *Yearbook of the Poznań Linguistic Meeting*, 4(1):21–53.
- Cormac Anderson, Tiago Tresoldi, Simon J. Greenhill, Robert Forkel, Russell Gray, and Johann-Mattis List. 2023. *Variation in phoneme inventories: Quantifying the problem and improving comparability*. *Journal of Language Evolution*, 8(2):149–168.
- Beijing University. 2024. *CLDF dataset derived from Beijing University's "Chinese dialect vocabularies" from 1964*. Zenodo, Geneva.
- Frederic Blum, Carlos Barrientos, Johannes Englisch, Robert Forkel, Simon J. Greenhill, Christoph Rzym-ski, and Johann-Mattis List. 2025a. *Lexibank 2: Pre-computed features for large-scale lexical data [version 1; peer review: 3 approved]*. *Open Research Europe*, 5:126.
- Frederic Blum, Steffen Herbold, and Johann-Mattis List. 2025b. *From isolates to families: Using neural networks for automated language affiliation*. In *Proceedings of the Association for Computational Linguistics 2025*, pages 1–12.
- Remco Bouckaert, Philippe Lemey, Michael Dunn, Simon J. Greenhill, Alexander V. Alekseyenko, Alexei J. Drummond, Russell D. Gray, Marc A. Suchard, and Quentin D. Atkinson. 2012. *Mapping the origins and expansion of the Indo-European language family*. *Science*, 337(6097):957–960.
- Will Chang, Chundra Cathcart, David Hall, and Andrew Garret. 2015. *Ancestry-constrained phylogenetic analysis supports the Indo-European steppe hypothesis*. *Language*, 91(1):194–244.
- Bǎoyà Chén. 1996. *Lùn yǔyán jiēchù yǔ yǔyán liánméng [Language contact and language unions]*. Yǔwén, Běijīng.
- Albert Davletshin. 2024. *CLDF dataset derived from Davletshin's "Proto-Aztecan languages" from 2012*. Zenodo, Geneva.
- Johannes Dellert. 2024. *CLDF dataset derived from Dellert et al.'s "NorthEuraLex (version 0.9)" from 2020*. Zenodo, Geneva.
- Johannes Dellert, Thora Daneyko, Alla Münch, Alina Ladygina, Armin Buch, Natalie Clarius, Ilja Grigorjew, Mohamed Balabel, Hizniye Isabella Boga, Zalina Baysarova, Roland Mühlenbernd, Johannes Wahle, and Gerhard Jäger. 2020. *NorthEuraLex: A wide-coverage lexical database of Northern Eurasia*. *Language Resources and Evaluation*, 54:273–301.
- Mark Donohue, Tim Denham, and Stephen Oppenheimer. 2012. *New methodologies for historical linguistics? Calibrating a lexicon-based methodology for diffusion vs. subgrouping*. *Diachronica*, 29(4):505–522.
- Bruno Estigarribia. 2020. *A grammar of Paraguayan Guarani*. University College London Press, London.
- Jan Feld and Alexander Maxwell. 2019. *Sampling error in lexicostatistical measurements: A Slavic case study*. *Diachronica*, 36(1):100–120.
- Fabício Ferraz Gerardi and Stanislav Reichert. 2021. *The Tupí-Guaraní language family: A phylogenetic classification*. *Diachronica*, 38(2):151–188.
- Fabício Ferraz Gerardi and Stanislav Reichert. 2024. *CLDF dataset derived from Gerardi and Reichert's "The Tupí-Guaraní language family: A phylogenetic classification" from 2021*. Zenodo, Geneva.
- Robert Forkel. 2024. *CLDFViz: A Python library providing tools to visualize data from CLDF datasets [Software Library, Version 1.3.0]*. Zenodo, Geneva.
- Robert Forkel, Johann-Mattis List, Simon J. Greenhill, Christoph Rzym-ski, Sebastian Bank, Michael Cysouw, Harald Hammarström, Martin Haspelmath, Gereon A. Kaiping, and Russell D. Gray. 2018. *Cross-linguistic data formats, advancing data sharing and re-use in comparative linguistics*. *Scientific Data*, 5:180205.
- Ana Vilacy Galucio, Sérgio Meira, Joshua Birchall, Denny Moore, Nilson Gabas Júnior, Sebastian Drude, Luciana Storto, Gessiane Picanço, and Carmen Reis Rodrigues. 2015. *Genealogical relations and lexical distances within the Tupian linguistic family*. *Boletim do Museu Paraense Emílio Goeldi. Ciências Humanas*, 10(2):229–274.
- Ana Vilacy Galucio, Sérgio Meira, Joshua Birchall, Denny Moore, Nilson Gabas Júnior, Sebastian Drude, Luciana Storto, Gessiane Picanço, and Carmen Reis Rodrigues. 2024. *CLDF dataset derived from Galucio et al.'s "Lexical distances within the Tupian linguistic family" from 2015*. Zenodo, Geneva.

- Hans Geisler and Johann-Mattis List. 2010. [Beautiful trees on unstable ground: Notes on the data problem in lexicostatistics](#). In Heinrich Hettrich, editor, *Die Ausbreitung des Indogermanischen. Thesen aus Sprachwissenschaft, Archäologie und Genetik*. Reichert, Wiesbaden. The document was submitted in 2010 and is still waiting for publication.
- Hans Geisler and Johann-Mattis List. 2022. [Of word families and language trees: New and old metaphors in studies on language history](#). *Moderna*, 24(1-2):134–148.
- Richard Gravina. 2024. [CLDF dataset derived from Gravinás's "Proto-Central Chadic" from 2014](#). Zenodo, Geneva.
- Simon J. Greenhill, Hannah J. Haynie, Robert M. Ross, Angela M. Chira, Johann-Mattis List, Lyle Campbell, Carlos A. Botero, and Russell D. Gray. 2025. [CLDF dataset accompanying Greenhill et al.'s "Origin of Uto-Aztecan" from 2022](#). Zenodo, Geneva.
- Emma Gregores and Jorge A Suárez. 1967. *A description of colloquial Guaraní*, volume 27 of *Janua Linguarum. Series Practica*. Mouton & Co., The Hague and Paris.
- Antonio Guasch and Diego Ortiz. 2008. *Diccionario Castellano–Guaraní Guaraní–Castellano. Sintáctico-fraseológico-ideológico*, 13th edition. CEPAG, Asunción.
- Harald Hammarström, Martin Haspelmath, Robert Forkel, and Sebastian Bank. 2024. [Glottolog \[Dataset, Version 5.1\]](#). Max Planck Institute for Evolutionary Anthropology, Leipzig.
- Luise Häuser, Robert Forkel, and Johann-Mattis List. 2025. [Pylexibench — Generating data for Lexibench with a Python package](#). *Computer-Assisted Language Comparison in Practice*, 8:25–37.
- Luise Häuser, Gerhard Jäger, and Alexandros Stamatakis. 2024. [Computational approaches for integrating out subjectivity in cognate synonym selection](#). In *Proceedings of the Society for Computation in Linguistics 2024*, pages 162–172, Irvine, CA. Association for Computational Linguistics.
- Paul Heggarty, Cormac Anderson, and Matthew Scarborough. 2024. [CLDF dataset derived from Heggarty et al.'s "Indo-European cognate relationships database" from 2023](#). Zenodo, Geneva.
- Paul Heggarty, Cormac Anderson, Matthew Scarborough, Benedict King, Remco Bouckaert, Lechoslaw Jocz, Martin Joachim Kümmel, Thomas Jügel, Britta Irslinger, Roland Pooth, Henrik Liljegren, Richard F. Strand, Geoffrey Haig, Martin Macák, Ronald I. Kim, Erik Anonby, Tijmen Pronk, Oleg Belyaev, Tonya Kim Dewey-Findell, Matthew Boutilier, Cassandra Freiberg, Robert Tegethoff, Matilde Serangeli, Nikos Liosis, Krzysztof Stroński, Kim Schulte, Ganesh Kumar Gupta, Wolfgang Haak, Johannes Krause, Quentin D. Atkinson, Simon J. Greenhill, Denise Kühnert, and Russell D. Gray. 2023. [Language trees with sampled ancestors support a hybrid model for the origin of Indo-European languages](#). *Science*, 381(6656).
- Hans J. Holm. 2007. [The new arboretum of Indo-European "trees": Can new algorithms reveal the phylogeny and even prehistory of Indo-European?](#) *Journal of Quantitative Linguistics*, 14(2-3):167–214.
- Joshua Conrad Jackson, Joseph Watts, Teague R. Henry, Johann-Mattis List, Peter J. Mucha, Robert Forkel, Simon J. Greenhill, Russell D. Gray, and Kristen Lindquist. 2019. [Emotion semantics show both cultural variation and universal structure](#). *Science*, 366(6472):1517–1522.
- Niklas Erben Johansson, Andrey Anikin, Gerd Carling, and Arthur Holmer. 2020. [The typology of sound symbolism: Defining macro-concepts via their semantic and phonetic features](#). *Linguistic Typology*, 24(2):253–310.
- James Y. Kakumasu and Kiyoko Kakumasu. 2007. *Dicionário por tópicos Kaapor-Português*. Associação Internacional de Linguística—SIL Brasil, Cuiabá.
- Alexei S. Kassian, George Starostin, Anna Dybo, and Vasilii Chernov. 2010. [The Swadesh wordlist: An attempt at semantic specification](#). *Journal of Language Relationships*, 4:46–89.
- Alexei S. Kassian, Mikhail Zhivlov, George Starostin, Artem A. Trofimov, Petr A. Kocharov, Anna Kuritsyna, and Mikhail N. Saenko. 2021. [Rapid radiation of the inner Indo-European languages: An advanced approach to Indo-European lexicostatistics](#). *Linguistics*, 59(4):949–979.
- Vishnupriya Kolipakam. 2024. [CLDF dataset derived from Kolipakam et al.'s "DravLex:" from 2018](#). Zenodo, Geneva.
- Charles H. Kraft. 2024. [CLDF dataset derived from Kraft's "Chadic wordlists" from 1981](#). Zenodo, Geneva.
- Sean Lee. 2024. [CLDF dataset derived from Lee's "Sketch of language history in the Korean peninsula" from 2015](#). Zenodo, Geneva.
- Sean Lee and Toshikazu Hasegawa. 2024. [CLDF dataset derived from Lee and Hasegawa's "Bayesian phylogenetic analysis supports an agricultural origin of Japonic languages" from 2011](#). Zenodo, Geneva.
- Vladimir I. Levenshtein. 1966. [Binary codes capable of correcting deletions, insertions, and reversals](#). *Soviet Physics Doklady*, 10(8):707–710.
- Johann-Mattis List. 2012a. [LexStat: Automatic detection of cognates in multilingual wordlists](#). In *Proceedings of the EACL 2012 Joint Workshop of Visualization of Linguistic Patterns and Uncovering Language History from Multilingual Resources*, pages 117–125, Stroudsburg.

- Johann-Mattis List. 2012b. [SCA: Phonetic alignment based on sound classes](#). In Marija Slavkovic and Dan Lassiter, editors, *New directions in logic, language and computation*, pages 32–51. Springer, Berlin and Heidelberg.
- Johann-Mattis List. 2014. *Sequence comparison in historical linguistics*. Düsseldorf University Press, Düsseldorf.
- Johann-Mattis List. 2018. [Tossing coins: Linguistic phylogenies and extensive synonymy](#). *The Genealogical World of Phylogenetic Networks*, 7(2).
- Johann-Mattis List, Cormac Anderson, Tiago Tresoldi, and Robert Forkel. 2024. [Cross-Linguistic Transcription Systems \[Dataset, Version 2.3.0\]](#). Max Planck Institute for Evolutionary Anthropology, Leipzig.
- Johann-Mattis List and Robert Forkel. 2022. [CL Toolkit: A Python library for the processing of cross-linguistic data \[Software Library, Version 0.2.0\]](#). Zenodo, Geneva.
- Johann-Mattis List and Robert Forkel. 2023. [LingPy: A Python library for quantitative tasks in historical linguistics \[Software Library, Version 2.6.13\]](#). MCL Chair at the University of Passau, Passau.
- Johann-Mattis List, Robert Forkel, Simon J. Greenhill, Christoph Rzymiski, Johannes Englisch, and Russell D. Gray. 2022. [Lexibank, a public repository of standardized wordlists with computed phonological and lexical features](#). *Scientific Data*, 9(316):1–31.
- Johann-Mattis List, Annika Tjuka, Frederic Blum, Alžběta Kučerová, Carlos Barrientos Ugarte, Christoph Rzymiski, Simon J. Greenhill, and Robert Forkel, editors. 2025a. [CLLD concepticon 3.3.0](#). Max Planck Institute for Evolutionary Anthropology, Leipzig.
- Johann-Mattis List, Kellen Parker van Dam, and Frederic Blum. 2025b. [EDICTOR 3: An interactive tool for computer-assisted language comparison \[Software Tool, Version 3.1\]](#). MCL Chair at the University of Passau, Passau.
- Liú Lǐlǐ, Wáng Hóngzhōng, and Bǎi Yíng. 2024. [CLDF dataset derived from Liú et al.'s "Collection of basic words in Chinese dialects" from 2007](#). Zenodo, Geneva.
- Nora McDonald, Sarita Schoenebeck, and Andrea Forte. 2019. [Reliability and inter-rater reliability in qualitative research: Norms and guidelines for CSCW and HCI practice](#). *Proceedings of the ACM on Human-Computer Interaction*, 3(CSCW):1–23.
- April McMahon, Paul Heggarty, Robert McMahon, and Natalia Slaska. 2005. [Swadesh sublists and the benefits of borrowing: An Andean case study](#). *Transactions of the Philological Society*, 103:147–170.
- John E. Miller and Johann-Mattis List. 2023. [Detecting lexical borrowings from dominant languages in multilingual wordlists](#). In *Proceedings of the 17th Conference of the European Chapter of the Association for Computational Linguistics*, pages 2599–2605, Dubrovnik, Croatia. Association for Computational Linguistics.
- Robert R. Ratcliffe. 2012. [On calculating the reliability of the comparative method at long and medium distances: Afroasiatic comparative lexica as a test case](#). *Journal of Historical Linguistics*, 2(2):239–281.
- Martine Robbeets. 2025. [CLDF dataset derived from Robbeets et al.'s "Triangulation of Transeurasian languages" from 2021](#). Zenodo, Geneva.
- Martine Robbeets, Remco Bouckaert, Matthew Conte, Alexander Savelyev, Tao Li, Deog-Im An, Kenichi Shinoda, Yinqiu Cui, Takamune Kawashima, Geonyoung Kim, Junzo Uchiyama, Joanna Dolińska, Sofia Oskolskaya, Ken-Yōjiro Yamano, Noriko Seguchi, Hirotaka Tomita, Hiroto Takamiya, Hideaki Kanzawa-Kiriyama, Hiroki Oota, Hajime Ishida, Ryosuke Kimura, Takehiro Sato, Jae-Hyun Kim, Bingcong Deng, Rasmus Bjørn, Seongha Rhee, Kyou-Dong Ahn, Ilya Gruntov, Olga Mazo, John R. Bentley, Ricardo Fernandes, Patrick Roberts, Ilona R. Bausch, Linda Gilaizeau, Minoru Yoneda, Mitsugu Kugai, Raffaella A. Bianco, Fan Zhang, Marie Himmel, Mark J. Hudson, and Chao Ning. 2021. [Triangulation supports agricultural spread of the Transeurasian languages](#). *Nature*, 599(7886):616–621.
- Arne Rubehn and Johann-Mattis List. 2025. [Partial colexifications improve concept embeddings](#). In *Proceedings of the Association for Computational Linguistics 2025*, pages 1–15.
- Arne Rubehn, Jessica Nieder, Robert Forkel, and Johann-Mattis List. 2024. [Generating feature vectors from phonetic transcriptions in cross-linguistic data formats](#). *Proceedings of the Society for Computation in Linguistics*, 7(1):205–216.
- Sergey A. Starostin. 2005. [Indo-European files in DBF/VAR](#). In George Starostin, editor, *The Tower of Babel*. RGGU, Moscow.
- Sergey A. Starostin. 2024. [CLDF dataset derived from Starostin's "Indo-European files in DBV/VAR" from 2005](#). Zenodo, Geneva.
- Morris Swadesh. 1950. [Salish internal relationships](#). *International Journal of American Linguistics*, 16:157–167.
- Morris Swadesh. 1952. [Lexico-statistic dating of prehistoric ethnic contacts: with special reference to North American Indians and Eskimos](#). *Proceedings of the American Philosophical Society*, 96(4):452–463.
- Morris Swadesh. 1955. [Towards greater accuracy in lexicostatistic dating](#). *International Journal of American Linguistics*, 21:121–137.

Kaj Syrjänen, Terhi Honkola, Kalle Korhonen, Jyri Lehtinen, Outi Vesakoski, and Niklas Wahlber. 2024. *CLDF dataset derived from Syrjänen et al.'s "Shedding more light on language classification" from 2013*. Zenodo, Geneva.

Annika Tjuka, Robert Forkel, and Johann-Mattis List. 2024. Universal and cultural factors shape body part vocabularies. *Scientific Reports*, 14(10486):1–12.

Feng Wang. 2024. *CLDF dataset derived from Wang's "Language contact and language comparison" from 2004*. Zenodo, Geneva.

Søren Wichmann, Eric W. Holman, and Cecil H. Brown. 2010. Sound symbolism in basic vocabulary. *Entropy*, 12(4):844–858.