Towards a sustainable handling of inter-linear-glossed text in language documentation

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Efforts on language documentation have been increasing in the past. While the amount of digital data of the world's languages is increasing, only a small amount of the data is sustainable, since data reuse is often exacerbated by idiosyncratic formats and a negligence of standards that could help to increase the comparability of linguistic data. The sustainability problem is nicely reflected in the current practice of handling inter-linear-glossed text, one of the crucial resources produced in language documentation. Although large collections of glossed texts have been produced so far, the current practice of data handling greatly exacerbates the reuse of data. In order to address this problem, we propose a first framework for the computer-assisted, sustainable handling of inter-linear-glossed text resources. Building on recent standardization proposals for word lists and structural datasets, combined with state-of-the-art methods for automated sequence comparison in historical linguistics, we show how our workflow can be used to lift a collection of inter-linear-glossed Qiang texts (an endangered language spoken in Sichuan, China), and how the lifted data can assist linguists in their research.

CCS Concepts: • **Applied computing** → *Language translation.*

Additional Key Words and Phrases: Sino-Tibetan, inter-linear-glossed text, computer-assisted language comparison, standardization, Qiang

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1 INTRODUCTION

With many of the world's spoken languages being threatened by extinction, efforts on language documentation have been increasing in the past, as reflected in a constantly growing amount of various resources, ranging from short grammatical sketches, via short wordlists, up to extensive dictionaries, detailed grammars, and corpora in various forms and formats. Depending on the original interests of the researchers, but also on the funding upon which scholars base their research, language documentation follows a range of rather different purposes, as reflected in *typological surveys*, surveys oriented towards *historical language comparison*, *language revitalization efforts*, efforts reflecting *political motives* (such as the dialect surveys conducted by Chinese scholars in the 1950s [23]), and efforts reflecting *missionary goals* (such as surveys conducted by religious organizations).

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While the amount of digitally available data on the worlds' languages is steadily increasing, with more and more languages being documented, only a very small proportion of the language resources that are produced account for *sustainability*. Sustainability – in the context of scientific research – is hereby understood as a resource that complies to the principles of FAIR data as outlined by Wilkinson et al. [28]: resources should be *findable*, *accessible*, *interoperable*, and *reusable*.

Due to the different objectives of scholars working in the field of language documentation, we face a situation where specifically the re-usability of language resources is largely exacerbated. This starts from the fact that some resources are still only produced in print, and even if they are produced digitally, they are rarely *machine-readable*, as they are shared in form of PDF documents, which cannot be converted to computer-friendly resource formats, such as spreadsheet tables or lightweight databases. Even if the data are shared in tabular, basically machine-readable form, they are often not *interoperable*, because they lack *standardization*, and in order to access one specific resource, huge efforts are needed in order to lift the data to a level where they could be easily reused in computer-based or computer-assisted frameworks oriented towards *cross-linguistic comparison*.

One might argue that it is not the primary purpose of language resources, such as, for example, dictionaries, to be parsed by a computer application, but rather by humans who want, for example, to teach an endangered language in school. But it is important to keep in mind that even humans tend to prefer digital dictionaries over resources written in prose and printed only on paper, and the easier a given resource can be searched, the more lasting will be its impact, specifically among younger generations. In addition, the current lack of sustainability of linguistic resources makes it very difficult, if not even impossible at times, to develop targeted applications in the field of *natural language processing* (NLP), specifically for endangered and poorly documented languages.

Most NLP applications are not only "blind" to language-specific aspects, since – specifically for poorly documented languages – the resources are lacking, but additionally – since large language resources used for the study of big languages (English, Chinese) are often of poor quality – ignore linguistic knowledge to a large degree. In order to side-step the problem of lack of documentation, researchers in NLP now have started to try and impute missing data from cross-linguistic typological databases, given that the data-hungry business of NLP can often not cope with datasets small in size [25]. In fact, prediction (or *retrodicton*) of missing features can indeed be useful, not only in the typological sphere but also for the lexicon, as scholars report in an ongoing experiment of word prediction of Kho-Bwa languages (Tibeto-Burman) [2]. But in order to allow for a successful integration of linguistic resources that could help NLP applications to improve it approaches, specifically also when dealing with smaller and endangered languages, it is important to improve on the general sustainability in language documentation.

While some steps in this direction have been already undertaken in the future, with new standards being proposed for the handling of word lists and structural data in historical linguistics and language typology [5], or initial frameworks having been developed for the handling of rhyme annotation [21], we want to draw the attention to *inter-linear-glossed text* as one of the crucial resources produced by language documentation efforts. Although large collections of inter-linear-glossed text have been produced so far, and scholars use it across all subfields of linguistics, including opposing camps, the current usage practice largely lacks sustainability, being – despite its formal nature – mostly oriented towards manual digestion.

In the following, we want to propose a first framework for the computer-assisted, sustainable handling of inter-linear-glossed text (IGT). After discussing our general strategy to increase the sustainability of linguistic resources, which follows closely the recommendations of the Cross-Linguistic Data Formats initiative (https://cldf.clld.org, [5], Section 2), we will present a detailed (but still rudimentary) proposal for the standardization of inter-linear-glossed

text (Section 2), and illustrate, how this framework can be successfully applied to lift the data of a small corpus of Qiang texts (Section 4), an endangered language, spoken in the northwest part of Sichuan Province in China [8, pp. 1-5]. We conclude by discussing further application possibilities for our framework and point to problems that need to be addressed in the nearer future (Section 5).

2 SUSTAINIBILITY OF LINGUISTIC RESOURCES

Given that linguists create linguistic resources with different purposes in mind, the resources – specifically those on endangered and low-resource languages – differ widely. While it is clear that there are generally different type of resources, and that not all linguists plan to create a dictionary of the languages they want to document, the problem does not lie in the broad categories (dictionary, grammar, text corpus, wordlist), but in the way in which the broad categories most scholars would agree upon are created and shared.

As an example, consider the seemingly simple problem of creating *comparative wordlists* for a couple of languages of interest. While the basic format, according to the standard notion of the linguistic sign, would require a triple of *language*, *concept*, and *form*, we find standardization issues in all three of these basic components. Language names, although referring to the same language variety, may vary widely, both for historical reasons (e.g., because language names in the past may have had a derogatory attitude), but also for reasons that are not always made explicit in published studies. Concepts are usually denoted with help of *elicitation glosses* [19], but elicitation glosses that are intended to denote the same concepts vary widely, even if the same language for elicitation has been used [14]. Word forms, finally, are the least standardized of all items one encounters in wordlists, given that scholars usually do not provide phonetic transcriptions, but rather turn to orthographies, where available, or make use of quasi-phonological transcriptions that they consider more convenient for typing, but which are rarely explained with respect to the intended phonetic values.

While the problems may seem severe, initial standardization efforts have been done in the past years, and they have also shown that is possible to successfully enhance existing datasets, by applying a procedure that could be called *retro-standardization*. Instead of changing existing resources manually, semi-automatically, or automatically, retro-standardization adds several annotation layers to existing datasets that allow for an easy conversion of the original data into a format that is machine-readable and cross-linguistically comparable.

These efforts have been most prominently propagated by the Cross-Linguistic Data Formats initiative (CLDF, https://cldf.clld.org, [5]). The basic idea of CLDF is to address comparability problems involving linguistic data by introducing *reference catalogs*, i.e. meta-databases that offer information for those entities which are crucial for cross-linguistic comparison. As the most prominent example, the Glottolog catalog (https://glottolog.org) offers information on language names, geographic locations, and basic genealogical classifications [6]. In order to make sure that it is clear which languages a given resource documents, all that needs to be done is to list the *Glottocodes*, the identifiers provided by Glottolog, for each language that occurs in the resource. Similarly, the Concepticon project (https://concepticon.clld.org, [17]), offers standard identifiers for elicitation glosses and links existing concept lists to those identifiers in order to illustrate the huge variation that can be encountered in concept elicitation. For word forms, the recent Cross-Linguistic Transcription Systems initiative (CLTS, https://clts.clld.org, [16]) provides standard identifiers for speech sounds which are themselves linked to different transcription systems and thus offer a convenient way to check if a given transcription complies to the standard defined by a given system [1].

CLDF reference catalogs do not stop with providing identifiers to which the original data could be linked. In addition, specific tools are provided that facilitate the process of linking. While identifying languages in Glottolog is already made easy by the web application, the Python API that comes along with it allows scholars proficient in Python programming

to use the data provided with Glottolog inside of Python scripts. Concepticon offers commandline tools that allow for an automated mapping of elicitation glosses to the Concepticon identifiers in multiple languages, which can as well be applied from within Python scripts. CLTS offers a range of strategies to normalize transcription data, specifically when provided in the broad version of the IPA that is at the core of the reference catalog. Additionally, scholars can make use of *orthography profiles* [24] that allow for a semi-automated conversion of transcriptions in a given resource into the standards supported by CLTS. All in all, these tools, which are well-documented and also illustrated in several online tutorials, greatly facilitate the process of *retro-standardization* [13].

With respect to inter-linear-glossed text, the situation is still different. Although annotation tools exist, as, for example provided by the Summer Institute of Linguistics' FieldWorks program (https://software.sil.org/fieldworks/), their application is exacerbated by a lack of cross-platform support (with many tools working only on Windows machines), but also by a large degree of freedom offered by the respective software. Since the majority of IGT is still produced in research articles, and not in form of standardized databases, errors in the glossing procedure are still rather common, as can be seen when checking a random resource provided by ODIN, the largest agglomeration of inter-linear-glossed text examples taking from linguistic resources [10].

Our strategy for working towards an increase of sustainability in language documentation, with a specific focus on inter-linear-glossed text is two-fold, following the idea of retro-standardization, as it has been proposed by the CLDF initiative. First, we want to increase scholar's awareness regarding available standards and the advantages of using them. Second, we want to make it as easy as possible for scholars to produce their data in the way they know, while encouraging them to open backdoors for quick retro-standardization of their data. The basic idea is to provide initial standards that come close to the formats which scholars already use, but are strict enough to allow for a quick processing by a machine. The advantage of such an approach is that data can be automatically checked for errors which may be easily introduced in typing, while at the same time opening a door for quick retro-standardization with help of computer tools which we will present in detail in the following sections.

3 PROPOSALS FOR STANDARDIZING INTER-LINEAR-GLOSSED TEXT

In the following, we will present our proposals for a flexible standardization framework of inter-linear-glossed text in detail. After briefly discussing the role that inter-linear-glossed text plays in language documentation, we will explain the basic ideas behind the CLDF initiative in more detail, and then present a workflow for the retro-standardization of resources that offer inter-linear-glossed text.

3.1 Inter-linear-glossed text

Inter-linear-glossed text is a commonly used way of presenting the structure by which phrases in foreign languages are built. The basic idea is to gloss each word of a phrase in a certain language by grammatical and lexical glosses in order to elucidate how the respective language expresses a certain circumstance. Technically, IGT demands at least two separators. First, words in the language that is being glossed need to be distinguished, which could be done by a simple white-space character, wich is often represented by a tab-stop, in ordert to support a visual alignment of the original text and the glosses. Second, all meaningful grammatical and lexical units, that is, the *morphemes* inside a word need to be marked, which is usually done with the help of the dash character ("-"). Apart from this, there are different rules to distinguish *lexical* from *grammatical* glosses. The most common way consists in writing grammatical glosses in abbreviated form in capital letters, and providing a legend for the meaning of the abbreviations. Lexical glosses are usually not standardized and simply follow the analysis of the researcher with respect to the utterance under

question. Table 1 provides an example of a piece of IGT in German along with the lexical and grammatical glosses and the translation.

Die	**Katze**	**sitz-t**	**auf**	**den**	**Matratz-en**
ARTIC.NM.SGL.F	cat	sit-3.SG	on	ARTIC.DT.PLR.F	matress-PLR

The cat sits on the matresses.

Table 1. Simple example sentence of IGT in German.

Although there have been efforts to standardize IGT with respect to the usage of grammatical glosses, one can encounter a lot of variation with respect to the implementation of the principle. Scholars tend to provide their own abbreviations in the introduction or the appendix of the work, and they also tend to use their own transcription systems (if the language under question has no standardized orthography). Ideally, the information on the grammatical glosses and the transcription systems are exemplified in the studies providing IGT, but the fact that IGT is not following any strict principles – and is barely checked by computational methods for internal consistency – results in a large variation that makes it difficult to make actual use of large IGT collections such as the ones provided, for example, by the ODIN project [10].

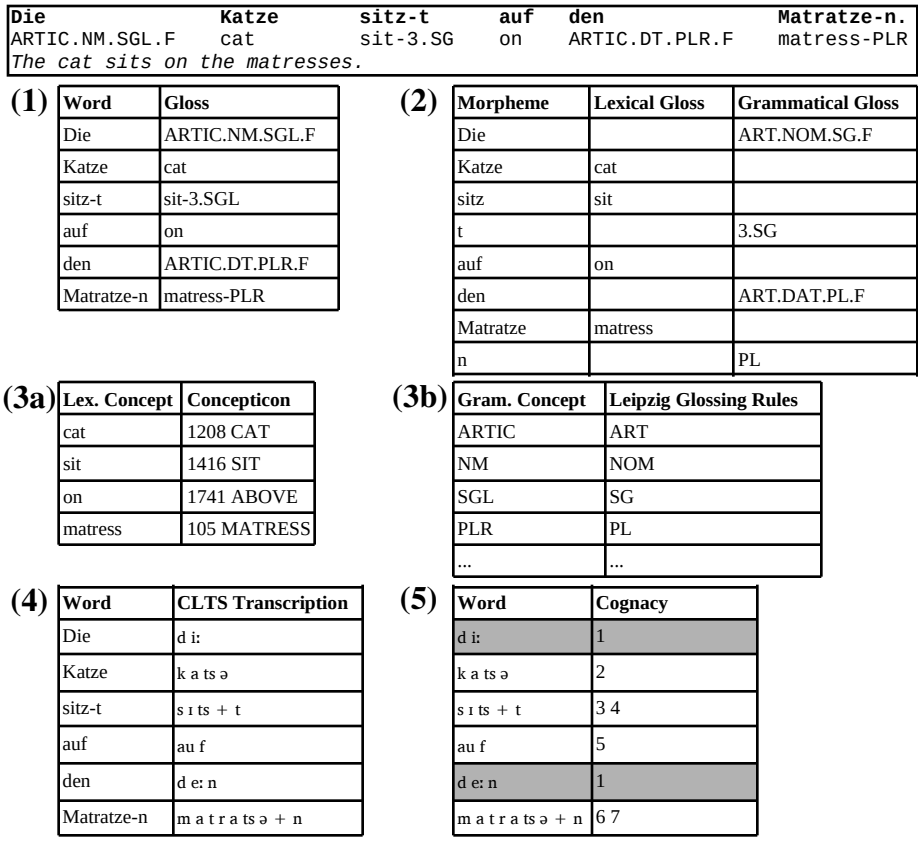
While it cannot be denied that there is a certain awareness of the problem of incomparability of IGT from a cross-linguistic perspective, with quite a few journals demanding IGT to follow the popular *Leipzig Glossing Rules* [3], the lack of a computer-assisted *testing* whether a given sample of IGT provided in an article or a database conforms to a given standard makes it extremely difficult to compare IGT corpora *across* the studies in which it was originally proposed. Since most linguists digest IGT examples piece by piece, without expecting to use them for corpus studies or extended NLP applications. As a result, the majority of IGT corpora produced at the moment is largely incomparable and not amenable for quantitative comparison, at least not beyond the scope of the resource in which they were originally produced. This is extremely unfortunate, given the wealth of information that IGT could offer for cross-linguistic investigations. Although there *are* large resources of digitally available IGT, as it is provided, for example, by the PanGloss project (https://lacito.vjf.cnrs.fr/pangloss/), the Dictionaria project (https://dictionaria.clld.org), or the ODIN corpus [10], there is no way to unify the available resources in a common framework. This is a pity, since IGT offers – at least in theory – many possibilities for interesting analyses that could drastically increase the amount of resources that scholars who work on quantitative applications in NLP, historical linguistics, and linguistic typology have at their disposal. In cases where dictionaries are lacking, one could use larger IGT collections of the same language to construct *wordlists* for cross-linguistic comparison. Where grammatical surveys are lacking, IGT could help to extract *structural features* about a certain language. Finally, if the transcriptions in which IGT is shared were *standardized*, it could give hints not only to *phoneme inventories* but also to the potential usage frequency of the phonemes employed by a given language.

3.2 Workflow for retro-standardization of inter-linear-glossed text resources

Our workflow for the retro-standardization of inter-linear-glossed text is rather straightforward and seeks to standardize those aspects of a given resource for which reference catalogs as propagated by the CLDF initiative are supported. A minimal example of inter-linear-glossed text consists of two entities. First, there is a *text* that is divided into *sentences*, which are themselves divided into *phrases*. Phrases again consist of a sequence of *words* which are themselves divided

into *morphemes* (or *morphs*). Second, a sequence of glosses is aligned to the text, with each gloss providing lexical or grammatical semantic information for each morpheme.

While general rules for text glossing have long since been proposed[3], these rules only standardize the outer appearance of inter-linear morpheme glossing, while they do not provide any additional recommendations with respect to the way in which, for example, the text should be written, or which elicitation glosses should be used. Since, with the Concepticon project and the CLTS initiative, new reference catalogs are available by now, we think it is time to see to which degree these catalogs can be used to enrich the information that is provided in collections of inter-linear glossed text.



Die	Katze	sitz-t	auf	den	Matratze-n.
ARTIC.NM.SGL.F	cat	sit-3.SG	on	ARTIC.DT.PLR.F	matress-PLR

The cat sits on the matresses.

(1)

Word	Gloss
Die	ARTIC.NM.SGL.F
Katze	cat
sitz-t	sit-3.SGL
auf	on
den	ARTIC.DT.PLR.F
Matratze-n	matress-PLR

(2)

Morpheme	Lexical Gloss	Grammatical Gloss
Die		ART.NOM.SG.F
Katze	cat	
sitz	sit	
t		3.SG
auf	on	
den		ART.DAT.PL.F
Matratze	matress	
n		PL

(3a)

Lex. Concept	Concepticon
cat	1208 CAT
sit	1416 SIT
on	1741 ABOVE
matress	105 MATRESS

(3b)

Gram. Concept	Leipzig Glossing Rules
ARTIC	ART
NM	NOM
SGL	SG
PLR	PL
...	...

(4)

Word	CLTS Transcription
Die	d iː
Katze	k a ts ə
sitz-t	s ɪ ts + t
auf	au f
den	d eː n
Matratze-n	m a t r a ts ə + n

(5)

Word	Cognacy
d iː	1
k a ts ə	2
s ɪ ts + t	3 4
au f	5
d eː n	1
m a t r a ts ə + n	6 7

Fig. 1. Five-stage workflow for the normalization of IGT resources. The text example on top of the figure is converted checked for consistency with respect to words and glosses in (1), and then checked for consistency with respect to lexical and grammatical glosses (2). Lexical and grammatical glosses are mapped to Concepticon (3a) and Leipzig Glossing Rules (3b), respectively. All words are transcribed according to the CLTS transcription system (4), and language-internal cognacy is annotated (5).

Following the general idea of the CLDF initiative of linking resources to the major reference catalogs which have been proposed so far, our workflow towards a retro-standardization of IGT resources thus consists of the following five steps. In a first step, we *standardize* a given IGT resource by making sure that the basic principle of glossing is followed consistently. Starting from a digital IGT resource, we thus check that all *words* in a phrase have at least one *glossed complex* that explains them (1). In a second step, we make sure that each *morpheme* in a word is given a distinct *gloss*

(be it grammatical or lexical) (2). In a third step, we try to extract *concept lists* for grammatical and lexical glosses, by creating a *concordance* of each pair of a morpheme and its corresponding gloss in the IGT resource. By automatically distinguishing lexical from grammatical elicitation glosses, this creates two concept lists, one grammatical concept list, and one lexical concept list (3). Having created the concept lists, we try to link the entries in the lexical concept list to the Concepticon resource, and the grammatical concept list to the abbreviations and additional instructions that are usually provided along with a given resource of IGT. In the future, we hope to be able to further link the grammatical glosses to reference catalogs similar to Concepticon, but devoted to abbreviations and elicitation glosses for grammatical concepts in linguistic resources (see, for example, the idea of creating a *Grammaticon* as a counterpart of the Concepticon by Haspelmath [7]). In a fourth step, we try to normalize the transcription system by linking each sound segment that occurs in a given IGT resource to the standard transcription systems (called B(road-coverage)IPA) proposed by the CLTS initiative (4). In a last step, we try to identify *language-internal cognate words* in the IGT resource by clustering all morphemes that show a certain degree of phonetic similarity and are glossed by the same elicitation gloss into the same *word family* (5).

Once having enriched a given IGT resource in this way, we can present the data in a combined form, in which each instance of the original IGT is accompanied by the additional information that we added during the retro-standardization process. To illustrate how this information can be successfully combined, we create a light-weight web-application in which scholars can *query* the resource for grammatical and lexical concepts, and word forms. Figure 1 illustrates this workflow in a schematic way.

4 APPLICATION EXAMPLE WITH DATA FROM QIANG (TIBETO-BURMAN)

In the following, we will illustrate how our workflow can be applied to a concrete IGT resource. The supplementary material provides all data and code needed to replicate the experiments we have carried out in this context, but since our work also includes steps of manual refinement, scholars may come to different results when following our example.

4.1 Materials: An inter-linear-glossed corpus of Qiang texts

Qiang 羌 (also called Rma) is a Tibeto-Burman language spoken by both ethnic Qiang and ethnic Tibetans in the mountainous area along the upper Min river 岷江 in the Rgnaba-Tibetan-Qiang Autonomous Prefecture of western Sichuan, China. Qiang is not a traditionally written language. It is an endangered language that is in many places being replaced by local varieties of Mandarin [4]. The present Qiang data come from a collection of texts from LaPolla and Huang's 2003 description of the Ronghong variety spoken in northwestern Mao County 茂 [9]. The grammar includes an appended six transcribed and annotated texts recorded by three different native speakers. The authors give a free translation into English and Chinese for the texts, but do not provide a line-by-line translation.

In order to make the data amenable for digital treatment, the texts were first digitized and stored in a simple text format which closely renders the format of the glossed text in the original PDF version of the resource, but uses tabstops as standard separators on the word level. In a second stage, these data were parsed into the basic input format currently required by our software package.

4.2 Methods: A Python package for IGT processing

The code needed to apply the workflow for the retro-standardization of IGT resources is provided in form of a small Python library (*pyigt*), available from the supplementary material accompanying this study. The code makes use of third-party libraries for a variety of tasks, specifically the LingPy Python library for quantitative tasks in historical

linguistics (http://lingpy.org, [18]), which we use not only for data handling, but also for the automated detection of language-internal cognates [20, 22]. With respect to the design, our *pyigt* library resembles *PoePy*, a Python library for the quantitative handling of rhyme data (https://github.com/lingpy/poepy, [15, 21]). In the following, we will illustrate all steps of our workflow in detail.

4.2.1 Input formats. The input format required for our workflow is a plain text file in tab-separated form, with the first line providing the column headers and the following lines representing each one phrase of a give IGT resource. The first column of this tabular data schema is reserved for a numerical identifier (`ID`), while the order of the remaining columns is arbitrary, following the header. Assuming that a given IGT resource needs to provide at least two separation levels for the phrase, our tool expects white-space as a word separator, and the dash character - as a morpheme-level separator, both in the word forms (`PHRASE`) and in the glosses (`GLOSS`). In order to group phrases to sentences, an identifier for sentences should be submitted (`SENTENCE_ID`), and texts can be distinguished by supplying a text identifier (`TEXT`). Figure 2 shows the first lines of the IGT resource on Qiang.

ID	TEXT	SENTENCE_ID	PHRASE_ID	PHRASE	GLOSS
1	Text 1	1	1	zəp-le: ŋ̊i-ke: pe-ji	earth-DEF:CL WH-INDEF:CL become-CSM
2	Text 1	1	2	qeˈlotʂu-ʁɑ, mutu-lɑ mujuqu ʐguə-zi	in.the.past-LOC heaven-LOC sun nine-CL
3	Text 1	1	3	we-i, zəp-le: ə-tɕhəqhɑ-ʐ̩-əi. mə ŋ̊ɑ ɣlu	exist-HS earth-DEF:CL DIR-burn-CAUS-HS older.brother COM younger.sister
4	Text 1	2	4	jə-tʂ-ŋuəŋ̊i, zuɑmə-ɸu o-ʐgu-tɑ	two-CL-TOP cypress-tree one-CL-LOC
5	Text 1	2	5	i-pi-χuɑ-ŋ̊i, ɦo-mu-xtɕu-wei. steke-tɑ mi peˈʐ̩ə-s	DIR-hide-because-ADV DIR-NEG-burn-HS later-LOC people raise(child)-NOM

Fig. 2. Data representation in the standard input format employed in the workflow.

4.2.2 Consistency checks on IGT data (1). Once the data is prepared in the format as specified in the preceding section, it can be directly parsed by our library and checked for inconsistencies. This check, which is often only done by eyeballing glossed text resources before publication, turned out to be very useful, since it helped us to identify a couple of inconsistencies in the digital version of the data, which were introduced during the process of digitization.

4.2.3 Creation of lexical and grammatical concordances (2). Once the data has passed the first stage of consistency check, lexical and grammatical concordances can be prepared. In this stage, our workflow checks additionally, if the glosses match also at the morpheme-level with the words in the resource. In addition, given that grammatical functions often appear in complexes (such as *case*, *number*, and *genus* in many European inflecting languages), this stage introduces a third separator on the level of the glosses, which is used to separate multiple grammatical functions from each other. While the Leipzig Glossing Rules recommend to use a dot for this purpose, the Qiang resource consistently used a colon for this purpose.

The computation of the grammatical and lexical concordances yielded a total of 302 distinct grammatical forms linked to 53 grammatical concepts, and as many as 968 lexical forms linked to 591 lexical concepts. The most frequently occurring grammatical form was the interjection [ɦa], which we found as many as 355 times in the data, and the

most frequently expressed grammatical meaning is represented by numerous directional prefixes (708 examples). The most frequently occurring lexical form was [jə] "say", with 139 occurrences, and the most frequently expressed lexical meaning turned out to be "one" with 206 examples (representing different forms). All in all, this analysis did not yield any surprises, but it helped us to further eliminate problems in the glosses, as we could identify erroneous glosses that go back to the process of digitization as well as spelling errors in the original resource. An example for a problem in the digitization is the wrong rendering of the word *uncle's* as *unclefls*, which is due to the internal rendering of the apostrophe character in the PDF copy of the grammar. We did not identify many obvious errors (e.g. in spelling) going back to the original source itself, which shows that the resource was thoroughly prepared. An example for a spelling error is the elicitation gloss "daugher" which occurs two times in the original data and obviously refers to "daughter".

4.2.4 Mapping lexical and grammatical concepts to reference catalogs (3). Having extracted lexical and grammatical concept lists, we can *map* the lexical concepts to the Concepticon reference catalog. To ease the mapping procedure, the Concepticon Python API offers an automated mapping routine that checks a given elicitation gloss in a resource against those elicitation glosses that have been used in the 275 resources that have so far been linked to the Concepticon. As a result, the process of concept mapping is greatly enhanced, and it did not take us much time to manually refine the automated mappings.

Having linked the lexical concepts to Concepticon has the advantage of enabling us to check to which degree the concepts in the resource could be used in other applications. Word lists, for example, are important for historical language comparison, but aggregating word lists from different resources is extremely tedious. Once different resources are linked to the Concepticon reference catalog, however, aggregation is simple, since we can automatically check to which degree different resources overlap with respect to the concepts they employ. Thus, of the 591 concepts reflected in the Qiang resource, we find an overlap of 112 concepts compared to the comparative word list collection established by Sagart et al. for their phylogenetic study on Sino-Tibetan languages [26]. A comparison with the concept list of 100 basic vocabulary items proposed by Morris Swadesh [27] shows that the Qiang resource only covers 56 of these concepts. This information is crucial, as it can help scholars who seek to create comparative wordlists from different resources to check quickly if the coverage across different datasets is high enough.

In a similar way, the grammatical concepts offer extremely valuable information, as they can give immediate hints with respect to the grammatical categories which are expressed in a given language. Since no reference catalog for elicitation glosses pointing to grammatical concepts has been established so far, we compared the grammatical concepts in the resource with the list of abbreviations listed in the original resource. In a second step, we added the standard abbreviations suggested by the Leipzig Glossing Rules to the grammatical concept list. While the Qiang resource mostly coincided with the Leipzig Glossing Rules, we find a few interesting cases of divergence. Thus, while the abbreviation PRS is used by LaPolla and Huang in order to refer to a *prospective aspect suffix*, the abbreviation refers to the *present* tense in the Leipzig Glossing Rules. On the other hand, Lapolla and Huang use *INDEF* to refer to an *indefinite marker*, while the Leipzig Glossing Rules suggest to abbreviate this as *INDF*. While these comparisons may seem pedantic, they greatly exacerbate an automated comparison across resources. Furthermore, the similarity of abbreviations used in different IGT resources but referring to completely different things shows that a careful comparison of linguistic resources can only be done when referring to the original list of abbreviations. In order to guarantee the future comparability of linguistic resources, we need a reference catalog for grammatical elicitation glosses, as well as general efforts to advocate these standards when producing IGT resources.

Pulmonic Consonants

Place → / ↓ Manner	Labial				Coronal						Dorsal						Laryngeal			
	Bilabial		Labio-dental		Linguo-labial		Dental		Alveolar		Palato-alveolar		Retroflex		Alveolo-palatal		Palatal		Velar		Uvular		Pharyngeal / Epiglottal		Glottal	
Nasal		m								n nʲ										ŋ		ɴ				
Stop	p	pʰ b							t	tʰ d								c ɟ	k	kʰ g	q	qʰ			ʔ	
Sibilant affricate										ʦ ʦʰ dz				ʈʂ ʈʂʰ ɖʐ		tɕ tɕʰ dʑ									
Non-sibilant affricate																										
Sibilant fricative										s z				ʂ ʐ		ɕ ʑ										
Non-sibilant fricative		ɸ β		f v		θ ð												ç ʝ		x ɣ		χ ʁ		ħ ʕ		h ɦ
Approximant										ɹ ɻ								j								
Flap or tap		ⱱ		ʋ		ɾ				ɾ				ɽ												
Trill		ʙ				ʀ				r				ɽr								ʀ				
Lateral affricate										tɬ dɮ																
Lateral fricative										ɬ ɮ																
Lateral approximant										l								ʎ			ʟ					
Lateral flap																		ʎ̆		ʟ̆						

Fig. 3. Consonant chart produced by the EDICTOR tool from the standardized transcriptions.

4.2.5 Standardizing transcriptions (4). As discussed in detail by Anderson et al. [1], the current linguistic practice of phonetic transcription bears not only many pitfalls, but can barely seen as reflecting a coherent standard. In order to standardize the transcription system employed in a given resource, it is important to identify all distinct sound segments in the data, which can at times be represented by more than just one transcription symbol. While this may sound trivial at first sight, the procedure can turn out to be very tedious, specifically in those cases where a consistent description of the transcription system employed in a given resource is missing.

What has turned out to be extremely helpful in retro-standardizing transcription systems so far is the application of *orthography profiles*, an idea proposed by Moran and Cysouw [24], which consists of a simple table, in which all *graphemes* in a given resource are contrasted with their standardized counterpart. While the original preparation of orthography profiles is tedious, the LingPy software package offers a convenient algorithm for their first creation which also tries to link the transcription symbols to the standard proposed by the CLTS initiative, and which we implemented in our workflow. Once an initial, automated orthography profile has been produced, it can be easily manually corrected.

When adjusting the original transcriptions, it turned out that we did not have to correct many of the transcriptions in the original data. The most notable deviations from the standard transcription system proposed by the CLTS reference catalog was the usage of a normal [h] in order to mark aspiration (which should be represented by a superscript [ʰ]). In addition, we found that the authors often used the letter [a] instead of the letter [ɑ] in order to denote an unrounded open back vowel, although the former variant is not described in the phonology section of the grammer. We also found instances where orthographical spelling was used instead of the phonetic transcriptions, as in the case of *zz*, which reflects – at least according to the phonological description in the grammar – to a voiced alveolar affricate [dz].

Figure 3 shows a classical IPA chart of all the consonants in the Qiang resource, which was automatically created from the standardized transcriptions with help of the EDICTOR (https://digling.org/edictor/, a web-based tool for the creation of etymological dictionaries [12], which supports the standards proposed by the CLTS reference catalog. As can be seen from this chart, the data does not provide any surprises, but it helps to evaluate a given transcription system and to compare the one we extracted from the glossed texts with the one reported in the grammar.

4.2.6 Identifying language-internal cognates (5). Once created and manually corrected, the orthography profile allows us to convert the original transcriptions into the standardized transcription system and segment the data into sound segments at the same time. This has the great advantage that the data in this form can be easily fed to algorithms for automated sequence comparison as they are provided by LingPy, and as they are needed for the final step of our retro-standardization workflow.

Since IGT resources taken alone never indicate whether two word forms that diverge slightly represent the same lexeme or not, the lexical and grammatical concordances which we created cannot replace a dictionary. What is needed, as a final step, is to make sure that all word forms which stem from the same lexeme, but which differ due to inflection or allomorphic variation, are assigned to the same lexeme entry.

ID	DOCULECT	CONCEPT	CONCEPT TYPE	FORM	TOKENS	OCCURRENCES	WORD FORMS	CROSSID
537	Qiang	market	lexicon	tʂhaq	tʂʰ a/ɑ q	2	tʂhaq tɑ	606
538	Qiang	market	lexicon	tʂhə	tʂʰ ə	1	tʂhə ʐeků tɑ	606
539	Qiang	market	lexicon	tʂhɑq	tʂʰ ɑ q	2	tʂhɑq tɑ	606

Fig. 4. Three slightly diverging word forms denoting "market" in the IGT resource.

In order identify the lexemes in our data which are reflected by different word forms, we make use of methods for automated sequence comparison in order to produce an initial clustering of similar lexemes into language-internal cognate sets [11]. The result of this analysis is a Qiang wordlist that can be conveniently inspected in the aforementioned EDICTOR tool.

The benefits of this conversion become immediately evident when inspecting the data in detail. As can be seen from the example in Figure 4, we can find three different word forms in the column FORM which all denote the concept "market" in the corpus, which occur together as many as five times. While the two word forms, the first and the third, only differ by their vowel, the second form differs also in the lack of a final consonant. When comparing the differences with our standardized version of the transcription in the field TOKENS, one can see that the difference between [a] and [ɑ] has been accounted for through our orthography profile, in which we already made the decision that [a] is meant to reflect [ɑ]. The segmented form as rendered by the EDICTOR tool still lists this form with a super-script *a*, since we deliberately marked all cases of *a* being meant to represent [ɑ] in our orthography profile.[1] For the form [tʂ ə], it is difficult to judge if this is a distinct word or a transcription problem. In any case, what we can clearly see from this example, is, that the procedure of retro-standardizing IGT resources can directly help to improve the resources by pointing to transcription problems.

4.2.7 Exporting the data. As a final step of our workflow, the Python library allows to export the retro-standardized resource to a web-based application that can be used to browse through the IGT examples, searching for lexical and grammatical glosses as well as specific word forms. Given that resources in book form are hard to inspect efficiently, this *concordance browser* offers a very convenient way for typologists and comparative linguists to dive deeper into a given resource. The concordance browser is available from the supplementary material accompanying this study. Figure 5 illustrates its basic usage.

[1] This is done by writing the original sound segment and the interpreted sound segment separated by a slash in the replacement column of an orthography profile, thus, underlyingly, the form reads [tʂ a/ɑ q] and is rendered as superscript by the EDICTOR.

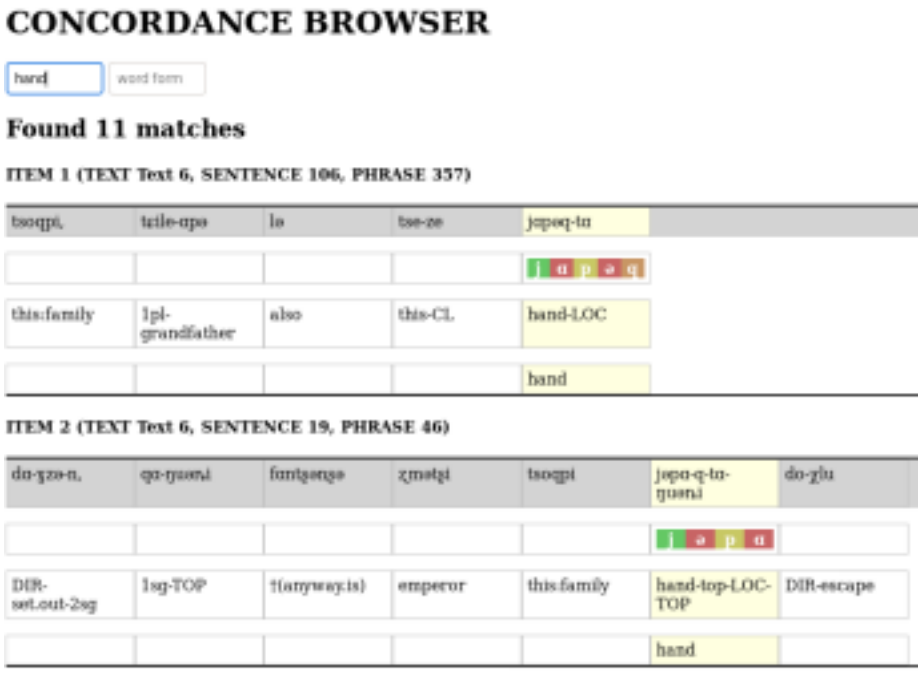


Fig. 5. Searching for occurrences of "hand" in the IGT resources of Qiang with help of the automatically generated *Concordance Browser*.

4.3 Examples

In order to illustrate how the concordance browser constructed from the retro-standardized dataset can be used to shed light on actual linguistic questions, consider the annotation of the hearsay marker [(j)i]. When searching for the grammatical concept "HS", referring to the hearsay marker in Ronghong Qiang, a search with help of the concordance browser yields 24 results, of which the majority of examples has the form [i] (7 occurrences) or [ji] (6 occurrences), as in [oqpi ɦio-pə-i], glossed as `family DIR-become-HS`, which can be translated as "became a family". However, in several of these examples, the form corresponding to the hearsay marker appears as [wei], thus containing a bilabial glide initial which is not present in any of the other examples. While it is difficult to confirm this for all 8 examples it seems there that this form reflects an under-analyzed [-w] morpheme which LaPolla and Huang identify as being part of the 'non-actor person marking suffixes' elsewhere in their grammar (see e.g., page 120, 143). We therefore think that it is possible that this morpheme is incorrectly being marked as the HS marker, at least in some of the examples, as, for example, in [ɦio-mu-xtɕu-wei], glossed as `DIR-NEG-burn-HS`, which can be translated as '(they) weren't burned' (Text 1, Phrase 5), or in [de-l-wei], glossed as `DIR-give-HS`, '(god) gave it to them' (Text 2, Phrase 5).

The analysis of the hearsay marker in the Ronghong variety of Qiang is but one small example of how our retro-standardization can help to shed light on a given IGT resource. If more resources were retro-standardized in the way illustrated here, we think, the great service that inter-linear-glossed text provides for typologists and comparative linguistics, can further be increased.

5 OUTLOOK

In this study we have proposed an initial framework for the consistent handling and the retro-standardization of IGT resources in language documentation studies. By illustrating how a concrete resource of a highly endangered Sino-Tibetan language can be successfully retro-standardized and presented in a way that facilitates not only the linguistic but also the computational investigation of the language data, we have tried to show that retro-standardization as well as a sustainable data handling is not *per se* impossible, as scholars often fear, but can even be carried out much more quickly and efficiently than usually assumed. The workflow we propose integrates neatly into previous standardization efforts in the field of computational historical linguistics and computational linguistic typology and requires only a minimal amount of familiarity with the command line in order to be applied successfully.

In the future, we hope to expand our workflow further. First, we want to integrate it more closely with different formats currently used in larger IGT collections, such as PanGloss, ODIN, or the Dictionaria project. Second, we want to discuss with colleagues to which degree it might be possible to establish a reference catalog for grammatical elicitation glosses. Third, we want to integrate our workflow more closely with the CLDF initiative and ideally make a full-fledged proposal to integrate IGT resources along with concept lists, word lists, and list of grammatical elicitation glosses into the standard formats of linguistic data resources currently offered by CLDF.

SUPPLEMENTARY MATERIAL

The supplementary material contains the source code, the data, and additional instructions on how to use them in order to replicate the analyses discussed here. It can be downloaded from the Open Science Foundation at https://osf.io/n4vrk/?view_only=719c26b98c89443fbb6543234e702f19.

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