

Getting the Upper Hand on Sign Language Families: Historical Analysis and Annotation Methods

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Abstract

Sign languages are conventionalized linguistic systems that vary across communities of users and change as they are transmitted across generations or come into contact with other languages, signed or spoken. That is, the social and linguistic phenomena that are familiar from the study of spoken language families and historical linguistic analysis of spoken languages are also active in sign languages. The study of sign language families and histories, however, is not as developed as in spoken languages. Here, we discuss the methodological and circumstantial factors contributing to this disparity. We also report on the preliminary stages of a long-term, large-scale study of sign language families. We summarize the family structures suggested by a historical records analysis of 24 sign languages. Given the limitations of this approach for sign languages, however, we also propose a lexicostatistic analysis using contemporary quantitative methods and describe annotation tools and strategies that can facilitate this approach. This research is aimed at improving our understanding of the historical pressures that are shared across language modalities as well as the quantitative and qualitative differences that may exist in the diachrony of sign versus speech.

Keywords: historical linguistics, phylogenesis, language families, lexicostatistics, annotation tools

1 Introduction

Despite stark differences in how they are produced and perceived, sign languages and spoken languages share many properties. These include properties of linguistic architecture, such as duality of patterning (Hockett 1963) or the imposing of phonological structure on phonetic features, as well as properties related to the functions of language and its social context, such as conventionalization and the sharing of language across a community of users. These properties undergird familiar taxonomies of language. Phylogenetic analysis, for example, may taxonomically classify and group languages based on sociohistoric evidence as well as form- and meaning-based reasoning about language data. These methods are relatively well-developed for spoken languages, some of which are associated with rich proposals regarding lineages and relationships. As in other areas of linguistic study, however, disparities exist in how well we phylogenetically understand different language groups, and these disparities are especially acute across modalities. Here, we present the preliminary stages of a long-term, large-scale study of sign language families aimed at addressing this.

We begin in Section 2 by discussing the methodological and circumstantial factors contributing to our impoverished understanding of sign language phylogenetics. We then identify 24 geographically diverse sign languages that are included in this long-term study (Section 3) and summarize the family structures suggested by the historical records of these languages (Section 4). In Section 5, we describe the annotation methods we are using to complement this historic investigation with a lexicostatistic analysis. We close by discussing the future of this research and its potential to inform our understanding of sign language phylogeny and historical linguistics in general, as there may be both quantitative and qualitative differences in the diachrony of sign versus speech.

2 Phylogenetic analysis and sign languages

In 1960, the groundbreaking work of William Stokoe (Stokoe 1960) showed that American Sign Language (ASL) exhibits linguistic structure and warrants linguistic analysis. In subsequent decades, researchers extended this claim to other sign languages and made significant contributions showing that the system of rules underlying signed and spoken languages is essentially the same (see Sandler and Lillo-Martin 2006 and Pfau, Steinbach, and Woll 2012 for overviews). Until recently, however, similarities across sign languages have often been over-emphasized, contributing to the broader misunderstanding that sign languages do not and cannot exhibit the range of variation attested in spoken languages. Moreover, scant research exists on historical change and historical relations among sign languages.¹ Indeed, up to now there has been no large-scale, systematic study of sign language families.

Two limiting factors help explain the impoverishment in this area of research. One, information on the history of sign languages and Deaf communities is scarce and hard to reach and, two, the data necessary to conduct such a study has been unavailable or difficult to document. Where researchers have been able to confront and overcome these challenges, the scope of study has been small and largely focused on only the more well-studied sign languages such as ASL and French Sign Language (*Langue des signes française*, LSF); Woodward (2000), which we return to below, is an exception in terms of the sign languages studied

¹Some of the limited research available includes Frishberg (1975), Woodward (1978), and Klima and Bellugi (1979), which provide early discussions of historical analysis in sign languages; Shaw and Delaporte (2011), who present a careful historical comparison of ASL and French Sign Language; and Power, Grimm, and List (2019), which demonstrates computational investigation of relatedness across sign language manual alphabets.

(seven sign languages in Thailand and Vietnam) but still relatively limited in scope. While historical documentation remains an obstacle, recent technological advances can make the acquisition and analysis of empirical data less of an obstacle. Advances in collecting and storing video data have facilitated the development of sign language dictionaries and the entries in these dictionaries may be used for lexical comparison across sign languages and the inferential analysis of historical relations.

Lexical comparison and lexicostatistics are methods of linguistic investigation that aim at establishing relationships across languages by comparing phonological forms and assessing degree of cognacy across the lexicons of multiple languages. To feasibly begin such a study, one can use a pre-determined list of concepts and gather, for each of the languages investigated, the lexical item that expresses each concept. An early list used for this purpose — and the starting point of the list used in the present research — was developed by Morris Swadesh (see, for example Swadesh 1955; see Hoijer 1956; Sankoff 1970; Lohr 2000 for further assessment of the validity of this list). Motivated by critiques of previous lists used for this purpose, Swadesh took care to design the list to include only culturally independent concepts that were likely to be universally identifiable and expressed by simple lexical items. The list excludes concepts that depend on cultural artifacts (like “gun”, “car” etc.) and those that are recent innovations (like “computer”, “telephone”, etc.); it includes concepts for common animals (“bird”, “dog”, etc.), grammatical markers like interrogatives (“what”, “where”, etc.), frequent activities (“eat”, “work”, etc.), and other basic cross-cultural concepts. The list has been adapted for use with sign language by James Woodward (Woodward 2000) by eliminating personal pronouns and body parts, as both are likely to involve pointing gestures that are highly similar across sign languages regardless of historical relationship. The items included in Woodward’s list are provided in Table 2.

Referenced earlier, Woodward’s study — in addition to putting forward an adapted list for sign languages — examined relationships across seven previously un(der)documented sign languages used in areas of Thailand and Vietnam.² Woodward compared lexical items for the concepts in Table 2 and concluded that the seven languages represented three distinct language families. One family includes only Ban Khor Sign Language, a village sign language used in Thailand. The remaining two families include languages from both countries: the first comprises Original Chiangmai Sign Language (Thailand), Original Bangkok Sign Language (Thailand), and Hai Phong Sign Language (Vietnam) and the second comprises Modern Thai Sign Language (Thailand), Ha Noi Sign Language (Vietnam), Ho Chi Minh City Sign Language (Vietnam), and Hai Phong Sign Language (Vietnam). Unlike the present study, which uses dictionary data, Woodward’s data were collected by eliciting concept terms from members of the signing communities. Lexical items were compared and similarity was established based on subjective analysis of the four core parameters (i.e., handshape, location, palm orientation, and movement).

D. McKee and Kennedy (2000) applied the same method to compare ASL, Australian Sign Language (Auslan), British Sign Language (BSL) and New Zealand Sign Language (NZSL) using dictionary data. The goal was to verify the degree of similarity among the latter three languages, which are known to be historically related (Johnston and Schembri 2007), as compared to ASL, which is historically unrelated to this group of languages. Results aligned with

²Due to the relatively limited similarity in the four Thai sign languages he investigated, Woodward had concluded in earlier research that they comprise three distinct language families: one family includes two sign languages (Chiangmai Sign Language and Bangkok Sign Language), while Ban Khor Sign Language and Modern Thai Sign Language are two independent languages that belong to two separate language families. In the case of Vietnam, earlier lexical comparison had suggested that the three sign languages studied are members of a single language family.

Table 1: List of items included in the Woodward (2000) list

all	feather	man	sharp	where
animal	fire	meat	short	white
bad	fish	mother	sing	who
because	flower	mountain	sit	wide
bird	good	name	smooth	wife
black	grass	narrow	snake	wind
blood	green	new	snow	with
child	heavy	night	star	woman
count	how	not	stone	wood
day	hunt	old	stand	worm
die	husband	other	sun	year
dirty	ice	person	tail	yellow
dog	if	play	thin	full
dry	kill	rain	tree	moon
dull	laugh	red	vomit	brother
dust	leaf	right	warm	cat
earth	lie	river	water	dance
egg	live	rope	wet	pig
fat	long	salt	what	sister
father	louse	sea	when	work

these historical predictions. Moreover, results showed that Auslan, BSL, and NZSL are similar enough to ‘count as’ three dialects of the same language. McKee and Kennedy also assessed the validity of the concept list by applying the same methodology to two hundred items randomly selected from the dictionary. Results from randomly selected items shows a notable decrease in similarity. For example, there was 87% similarity between NZSL and Auslan on the Woodward list but only 45% similarity if the comparison is made between items that are randomly selected.

While it is clear that this method of comparison does not match the etymological sophistication of the comparative method, it seems nevertheless robust enough to establish likely historical relationships across sign languages. Yu, Geraci, and Abner (2018), however, discuss some issues concerning the form evaluation used in these studies. In particular, they point out that this procedure contains at least two steps in which annotator bias may be introduced. First, when trying to identify the individual parameters for each sign, and second when deciding whether parameter values are identical, similar or different. While the first bias is somehow implicit in any annotation study and can be mitigated by standard (albeit time intensive) procedures (e.g., checking for coding reliability), the second bias can be completely removed by applying a different procedure to compare the data, for instance by asking the annotator only to identify the articulatory properties of single signs and then objectively comparing the pairs of annotated values.

Another and more subtle problem of the direct application of lexicostatistics methodology to the case of sign languages is connected to the rate of historical change. In order to establish the degree of relatedness, Woodward (2000) and D. McKee and Kennedy (2000) adopted the metric proposed in Crowley (1992) and partially reproduced in Table 2. This

Table 2: Subgrouping levels in Lexicostatistics Crowley 1992, p. 173

Level of Subgrouping	Shared cognate percentage in core vocabulary
Dialects of a language	81-100
Languages of a family	36-81
Families of a stock	12-36
...	...

metric is informed by the finding that spoken languages replace approximately one fifth of their vocabulary every 1000 years and assumes that the rate of change across languages and time is stable. However, considering that many present day Deaf communities emerged around the Industrial Revolution (i.e., around 300 years ago, McBurney 2012), this timescale (and its concomitant percentage metrics) may simply be inapplicable to the study of sign languages. Moreover, even if a Deaf community predates the Industrial Revolution, evidence from BSL, Auslan, and NZSL makes clear that the rate of differentiation of core concepts is way faster in sign than in spoken languages. In fact, D. McKee and Kennedy (2000) report that NZSL and BSL share only 79% of the items in the Woodward's list — that is, the two sign languages exhibit a lexical divergence that is comparable to the one that occurs after 1000 years in spoken languages.

This may be because sign languages are, on the whole, younger than spoken languages and thus much more unstable and prone to rapid change. For example, Fischer (1975) found fairly sudden change in basic word order in a short time span in ASL. Another factor could be the more disparate nature of signing communities. For much of history, Deaf people were less likely to be in contact with each other and may have been less likely to maintain convergent lexicons (indeed, high degrees of lexical divergence have been documented even in relatively well-connected signing communities, Sandler, Aronoff, et al. 2011). Moreover, members of Deaf communities have highly variable language backgrounds, including in their age of acquisition of a sign language.³ Whatever the explanation, there are reasons to doubt the direct applicability of such spoken language metrics to the study of historical change in sign language. We leave for future research establishing the rate of divergence in sign language evolution and pursue instead a method that allows us to calculate language relatedness (and language distance) without necessarily being entrenched in an assumed timescale. The advantage of this method (not reported here in detail) is that there is no pre-determined threshold determining the degree of relatedness between languages or groups of languages.

3 Languages and Language Data

One of the most problematic aspects of conducting large-scale research in sign language is that very little is known about the grammar of specific sign languages, and this is true even

³As scientists and people, we support the right of all Deaf children to have access to a natural sign language and we encourage the reader to do their part to ensure this right is met. In the United States, nationwide efforts to guarantee sign language access are underway with the *Language Acquisition and Education for Deaf Kids* (LEAD-K) initiative, <https://www.facebook.com/ASL4DeafKids/>.

for those languages that have a relatively long tradition of study, like ASL. As noted above, however, many sign language dictionaries have appeared on the internet in recent years and many can be freely consulted. The empirical problem of gathering the relevant data, at least for research based on (parts of) the lexicon, has then been somewhat addressed. In this section, we report on the languages and data sources used in our sample.

Most of the data for our project come from the online sign language dictionaries included in the Spread the Sign platform (<https://www.spreadthesign.com>). Spread the Sign is a project to build an online multilingual video dictionary of the sign languages of Europe and other geographic regions (Cardinaletti 2016). At the time of writing, it contains 41 languages and a total of 525,982 video entries. We selected 20 geographically diverse sign languages from Spread the Sign, focusing on languages that had (at the time of data collection) an entry for at least 95 of the 100 items on the modified Swadesh list. In order to have a reasonable sample of Asian languages, we then added Hong Kong Sign Language,⁴ Taiwan Sign Language,⁵ and Japanese Sign Language.⁶ We also wanted to be able to build on previous research (D. McKee and Kennedy 2000), so we added NZSL to our data set using R. L. McKee and D. McKee (2013).⁷

A complete list of the 24 sign languages in our data is provided in Table 3 alongside their acronyms, geographic region, and data source. This sample includes four Asian languages, seven Eastern European languages, ten Western European languages, and four geographical outliers (ASL, Libras, NZSL, TĪD). We discuss historical relations among these sign languages in Section 4 below.

4 Evidence from Historical Records

Beginning in the 19th Century, many residential schools for the Deaf adopted the educational model invented by the French Rev. Charles-Michel de l'Épée. This educational model was based on the signs used by deaf children (i.e., Old French Sign Language) and when the educational model and/or educators migrated to other countries, including the United States, so too did the sign language. Such movements of people and languages are a key force of linguistic phylogenesis. As with other minoritized and/or non-written languages, however, first hand documentation on the history of sign languages and Deaf communities is limited.⁸ Secondary documentation is also, at best, scarce and often inaccessible. Our efforts to collect first and second hand historical information are ongoing and we thank a number of colleagues who have suggested resources and offered their assistance on this front. For the moment, we focus on the historical information that is reported in the *Ethnologue*.⁹ We summarize the information found there in Figure 1. Languages for which we have clear documentation of a parenthood relation are connected by straight arrows. Dotted arrows indicate possible relation of parenthood. Dotted connection lines without an arrow indicate historical evidence for a relation between the languages, albeit insufficient evidence to determine whether this relation is one of contact or genetics.

⁴LSD Visual Sign Language Dictionary, <http://www.sign-aip.net/sign-aip/en/home/index.php>

⁵Tsai, Tai, and Yijun (2017): <http://lngproc.ccu.edu.tw/TSL/indexEN.html>

⁶NHK Dictionary: <https://www2.nhk.or.jp/signlanguage/index.cgi>

⁷<https://www.victoria.ac.nz/lals/research/projects/online-dictionary-of-new-zealand-sign-language-project>

⁸Pélissier (1856), which includes a small grammar of Old LSE, is a notable exception. Still, this source is less than 200 years old.

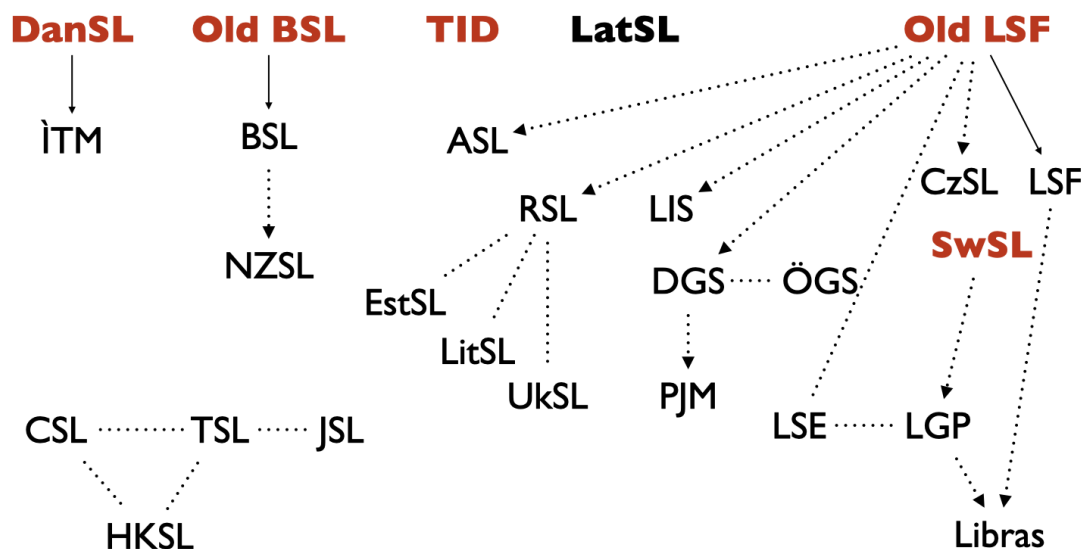
⁹<https://www.ethnologue.com/>

Table 3: List of languages included in the study

Language	Acronym	Geographic Region	Source
American Sign Language	ASL	Outlier	Spread the Sign
Austrian Sign Language	ÖGS	Outlier	Spread the Sign
Brazilian Sign Language	Libras	Outlier	Spread the Sign
British Sign Language	BSL	Western European	Spread the Sign
Chinese Sign Language	CSL	Asian	Spread the Sign
Czech Sign Language	CzSL	Eastern European	Spread the Sign
Estonian Sign Language	EstSL	Eastern European	Spread the Sign
French Sign Language	LSF	Western European	Spread the Sign
German Sign Language	DGS	Western European	Spread the Sign
Hong Kong Sign Language	HKSL	Asian	LSD Dictionary
Japanese Sign Language	JSL	Asian	NHK Dictionary
Icelandic Sign Language	İTM	Western European	Spread the Sign
Italian Sign Language	LIS	Western European	Spread the Sign
Latvian Sign Language	LatSL	Eastern European	Spread the Sign
Lithuanian Sign Language	LitSL	Eastern European	Spread the Sign
New Zealand Sign Language	NZSL	Outlier	R. L. McKee and D. McKee 2013
Polish Sign Language	PJM	Eastern European	Spread the Sign
Portuguese Sign Language	LGP	Western European	Spread the Sign
Russian Sign Language	RSL	Eastern European	Spread the Sign
Spanish Sign Language	LSE	Western European	Spread the Sign
Swedish Sign Language	SwSL	Western European	Spread the Sign
Taiwan Sign Language	TSL	Asian	Tsai, Tai, and Yijun 2017
Turkish Sign Language	TİD	Outlier	Spread the Sign
Ukrainian Sign Language	UkSL	Eastern European	Spread the Sign

Unsurprisingly, the emerging picture is that of a generalized influence of Old LSF over all European sign languages and ASL. Modern LSF is reported to have influenced Libras and LGP. LGP is also reported to be influenced by both LSE and SwSL, the latter of which may have emerged relatively independently. The former Soviet Union countries, Estonia, Lithuania, and Ukraine, are reported to have sign languages influenced by RSL, although nothing is said about LatSL in our source. No RSL influence is reported for other Eastern European sign languages like PJM and CzSL, though PJM is reported to derive from DGS. Strong contacts are also reported between DGS and ÖGS. As discussed in Section 2, NZSL is strongly related to BSL. İTM is reported to be directly derived from Danish Sign Language, which is not in our data set. The group of Asian languages is somehow interrelated, but the nature of the relations is somewhat unclear. TSL is reported to be derived from JSL and to have contacts with both CSL and HKSL. As for the other geographical outliers, it is well documented that ASL has strong connections with Old LSF, though we note that the claim that ASL genuinely stemmed from Old LSF has become controversial (Kegl 2008). Libras, again, is reported to have connections with both LGP and LSF (see also Wittmann 1991). Finally, TİD seems to be independent from any other sign language included in the sample, with an evolution that can be traced back to the Ottoman Empire (Miles 2000). These records thus provide

Figure 1: Language families for the sign languages in our sample, as suggested by historical records. In addition to the abbreviations in Table 3, DanSL is Danish Sign Language.



evidence of at least 4 different articulated sign language families: the Asian sign languages, as well as the sign language families rooted in Old LSF, Old BSL, and DanSL, respectively. For two of these families (Old BSL, Old LSF), there is historical evidence for evolutionary depth of at least three branches (though we do not commit ourselves to the linguistic divergence or stasis of languages serving as a parent node). This evidence is sufficient to establish the qualitative similarity between the phylogenetic structure of signed and spoken languages. We now turn to methods used for annotating the dictionary data from these languages.

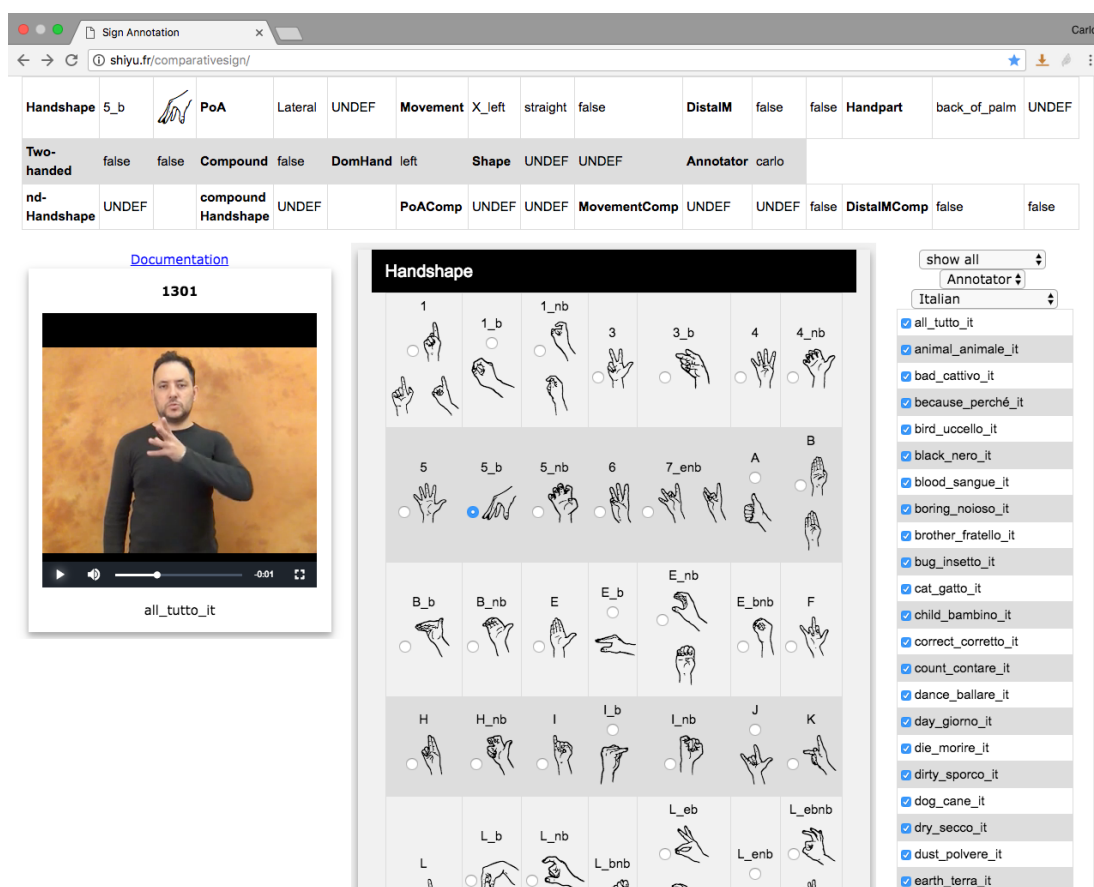
5 Annotation Methods

Our goal, again, is to verify and supplement historical information using comparative analysis of linguistic data — specifically, using lexicostatistic methods with more robust protections against researcher bias. Our methodology is still based on the idea that Woodward’s list represents a valid sample of core concepts for measuring distance among sign languages. We are also keeping the spirit of measuring language distance by looking at articulatory properties of signs. However, rather than looking at pairs of signs and establishing identity/similarity based on the global assessment of the signs, we propose instead to use a set of articulatory features that allow for more gradient comparison than the coarse-grained identification of the four core parameters. Comparison is made post-hoc by looking at the fine-grained annotations completed independently for individual lexemes; again, this helps guard against potential annotator bias.

In the recent years, sign language phonologists have proposed advanced models to describe articulatory properties of signs based on binary features (i.a., Brentari 1998; Van Der Kooij 2002; Sandler and Lillo-Martin 2006). Despite some differences in the conceptualization of movement and orientation, there is substantial overlap across these models. In this study, we adopted Brentari’s 1998 system to annotate the featural properties of signs. Here, we discuss them in turn according to which of the four core parameters they align with.

For handshape, we made the decision not to decompose handshape into features (though our handshape choices could be mapped onto featural complexes). Rather, we included 55 handshape codes intended to be representative of handshapes used in sign languages (see Figure 2). These 55 handshape codes are able to capture most handshape configurations in our data set; for handshapes that did not exactly match one of the 55 handshape options, the subjectively closest handshape was chosen. We also included information about whether the sign is two-handed or not. Our definition of two-handedness is theoretically informed, since we only counted as two-handed those signs in which the non-dominant hand is active in the articulation of the sign (Brentari 1998). For those signs in which the non-dominant hand is static, the non-dominant hand was treated as a location.

Figure 2: Outline of the workspace of the web-based annotation tool.



Location features are organized in two levels. At the macroscopic level, we included neutral space and four major regions. For signs produced in neutral space, the choice is between the horizontal, vertical, or lateral plane of articulation. For signs produced on the body, we included the following major body regions and sub-regions within them:

Head: *top, forehead, eye, cheek, nose, lip, mouth, chin, and below-chin*

Arm: *upper, elbow-front, elbow-back, forearm-front, forearm-back, forearm-ulnar, wrist-front, and wrist-back*

Hand: *palm, finger-fronts, back of palm, back of fingers, radial-side, ulnar-side, tip, and heel*

Torso: *neck, shoulder, clavicle, torso-top, torso-mid, torso-bottom, waist, and hips*

For movement, we distinguished proximal movement from distal movement. Distal movements include movement of the joints further from the trunk of the body, resulting in handshape and/or orientation change (also called *local* movement), whereas proximal movements include movement of the joints close to the trunk of the body, resulting in path movement across space. We coded movements for the direction and trajectory of movement, as specified below. Note that these movements can co-occur in signs and in our coding system; for example, a proximal movement in neutral space could also be coded as ‘yes’ for handshape and orientation change.

Direction: *X-axis up, X-axis down, Y-axis left, Y-axis right, Z-axis forward, and Z-axis backward*

Trajectory: *circular, arc and straight*

Handshape change: *yes / no*

Orientation change: *yes / no*

For orientation, which is treated as an aspect of handshape representation in more recent versions of Brentari’s model (Brentari 2011), we coded the part of the hand facing the plane or place of articulation. Eight distinctions were made: *palm, finger-fronts, back of palm, back of fingers, radial-side, ulnar-side, tip, and heel*. These are identical to the ones used to characterize fine-grained locations in the non-dominant hand when used as place of articulation.

This system was used to code dictionary entries corresponding to the concepts on Woodward’s modified Swadesh list. For two-part compounds, each unit of the compound was coded and the lexical item was flagged as being a compound sign. Though the dictionaries also occasionally included longer phrasal descriptions as the translation of a concept, we excluded these entries. We also excluded clearly fingerspelled sequences, though we acknowledge that the data set may include lexicalized fingerspellings (as well as signs where the handshape is the result of initialization).

A web-based annotation tool has been created where signs coming from online dictionaries are embedded and can be easily annotated. Figure 2 shows the organization of part of the workspace. On the left side of the workspace, the video of the to-be-annotated lexical entry plays in a loop. In the central part of the workspace, the annotator selects the relevant handshape; other features are selected by drop-down menus (not shown in the figure). On the right-side of the workspace, the annotator can select the language from a drop-down menu (LIS in the case at hand) and the individual items to be annotated. These appear in a double-language list: the language of the local hearing community (e.g., Italian) and English. Finally, the chart on top of the page summarizes the values selected for a particular item. The annotations created in this tool can be exported into a JSON file and this JSON file can be converted if necessary for statistical analysis. Additional discussion of this tool is provided in Yu, Geraci, and Abner (2018), which also provides proof of concept that the annotations can be used for historical linguistic analysis using quantitative methods similar to those in Dunn et al. (2005).

6 Concluding Remarks & Future Directions

An advantage of our proposed approach is that the researcher does not decide if lexical items across sign languages are related; rather, it is the analysis of formational features that are as-

sessed —objectively — for similarity. Moreover, this fine-grained featural data can be used to test theoretically-informed models of language change using existing proposals regarding historical development (e.g., Frishberg 1975) and iconicity (e.g., Östling, Börstell, and Courtaux 2018), though few models and studies along these lines exist (see S. Parkhurst and D. Parkhurst 2003 for a small study of genetics versus iconicity in sign language relatedness). Analysis of these data can, however, contribute to the development of the theoretical models themselves, in addition to its potential contribution to our understanding of the historical relations among sign languages. Finally, it is only in pursuit of research like this that we can develop a truly cross-modal understanding of diachronic language change.

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