An approach to path movement in the diachronic study of sign languages: Biomechanics and nonarbitrariness.

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Sign languages seem not to be amenable to traditional historical reconstruction via the comparative method, making it difficult to replicate the successes achieved in the diachronic study of spoken languages. We propose to alleviate this difficulty with an alternative approach that draws upon nonarbitrariness and biomechanics, especially the drive for reducing articulatory effort. We offer a demonstration of this approach, which can add confirmation to known relationships between sign languages and new evidence in support of suspected relationships, helping to fill in a methodological gap in the diachronic study of sign languages.

Keywords: sign languages; historical change; articulatory effort; nonarbitrariness

1. Introduction

We demonstrate an approach to studying historical relatedness of sign languages that can help with recognizing and measuring lexical similarity across sign languages. We ask what it means to see "sameness" in movement by focusing on nonarbitrary form/meaning relationships and biomechanics. *Nonarbitrariness* here is an umbrella term for what is known in the literature as iconic, depictive, associative, and mimetic. The term is chosen to help the reader keep in mind that the basic tenet of arbitrariness in investigations of spoken language histories is not assumed here. We outline a range of principles operative in sign languages that are biomechanical and pertain to the drive for ease of articulation. These principles can serve as metrics for determining similarity/sameness of movement in sign languages.

§2 offers a brief overview of issues that complicate the diachronic study of sign languages. §3 outlines characteristics of movement in signs that we will rely on. In §4, we exemplify how nonarbitrariness is important to recognizing potential cognates and we exemplify the biomechanical principles outlined in §3 with lexical items from an old sign language and its modern daughters. Our conclusions are in §5.

2. Issues that complicate the historical study of sign languages

Despite more than forty years of research (since Frishberg 1975 and Woodward 1978; see Power 2022 for an overview of how thinking about sign languages has changed in the course of this research) and a recent blossoming of studies, fundamental questions persist in studying the historical development and relationships of sign languages. In particular, determining genetic relatedness among sign languages is not straightforward (Abner et al. 2020; Padden 2011; Wilcox & Occhino 2016; Woodward 2011).

Four facts unique to sign languages complicate investigation: one at the individual-person level, one at the societal level, and two having to do simply with language. Further, data availability is an issue. And, finally, whether there is regularity of change in sign languages is debateable.

2.1 Transmission of language

Since only a small percentage of deaf children are born to (deaf) signing parents, deaf children acquire a sign language through association with deaf people outside their families, often at an age older than the age at which hearing children in hearing households and children (deaf or hearing) in deaf households acquire language, making schools for the deaf of crucial importance to the transmission of sign languages (Fenlon & Wilkinson 2015) and opening up the possibility that this unique type of language transmission might have properties that influence historical change.

2.2 Extent of borrowing

The schools themselves contribute complications regarding borrowing. The first school for the deaf in a country is often established by bringing in teachers from another country. In these settings, the language(s) used by the instructors mixes with the varieties of signing that the students bring (largely homesigning, Goldin-Meadow 2014). Because the first school then tends to serve as the parent school for the national sign language, the resultant language contact permeates the language, so much so that some sign languages have been analyzed as creoles, including ASL (Fischer 1996; Woodward 1978) and British Sign Language (Edwards & Ladd 1983). This analysis is problematic, at least regarding ASL (Lupton & Salmons 1996; Kegl 2008). Further, DeGraff (2005) challenges whether creoles really do form an exceptional class on phylogenetic and/or typological grounds. Nevertheless, the point that sign languages and creoles have widespread language contact as a norm in their history is well-taken (Quinto-Pozos & Adam 2015).

Connected to this point is a factor not unique to sign languages, but its importance to sign languages is growing: deaf people globally are interacting with each other digitally to the point of creating social venues that have taken on the social-cohesion functions that deaf clubs used to serve in earlier decades (Valentine & Skelton 2008, 2009). Digital travel of this sort raises the possibility of sign languages borrowing excessively, thus becoming less distinct from one another (at least regarding the lexicon), and of some being lost, which happens with spoken languages when population movement occurs (Bromham et al. 2022). This raises the spectre of whether horizontal transmission invalidates natural models of linguistic evolution (phylogenetic trees). While Greenhill and colleagues (2009) argue that this danger does not, in fact, constitute a threat to diachronic study of spoken languages, we know of no comparable studies on sign languages. And while some have suggested ways of teasing apart borrowing from genetic relationships in the area of morphology (Johanson & Robbeets 2012), we see no obvious ways of applying these methods to the range of morphological processes in sign languages.

2.3 Rate of change

Sign languages change more quickly than spoken languages (at least with respect to the rate of differentiation of core concepts; McKee & Kennedy 2000), where one generation may sign quite differently from the next earlier one (Schembri et al. 2010). This effect can be great enough to obscure historical similarities (Abner et al. 2020).

2.4 Nonarbitrariness

Sign languages tend to absorb gestures from the community of the ambient spoken language (de l'Épée 1784; Shaffer 2002; Shaw & Delaporte 2011; Wilcox 2004) as well as create gestures, both of which can be nonarbitrary (Goldin-Meadow 2014; McNeill 2000) and both of which can then get lexicalized (Janzen 2012; Xavier & Wilcox 2014). While gestures can be of many types, the development from natural gesture discourses in the early stages of a sign language into conventional signs points in this direction (Supalla 2013). Thus, the newly formed lexical items can be similar in sign languages that are not genetically related (Janzen & Shaffer 2002).

Connected to this point is a factor not unique to sign languages, but more prevalent in them: nonarbitrary form/meaning mappings. Handbooks of historical linguistics that analyze spoken languages typically start from the principle that regular sound change is associated with the arbitrariness of linguistic form and pay little attention to nonarbitrariness. Spoken languages vary in the amount and type of nonarbitrariness in their lexicons (Dingemanse et al. 2015; Dingemanse et al. 2020; Radden 2021), and do not exploit the full range of opportunities for nonarbitrariness available to them. For example, even though the bouba/kiki effect is robust across cultures (Ćwiek et al. 2020), words having to do with the senses of audition and touch are more likely to be nonarbitrary than words having to do with the visual shape of objects (Winter et al. 2017). Lupyan and Winter (2018) attribute the lack of full exploitation of nonarbitrariness in spoken languages to semantics; iconic forms are so connected to specific contexts and sensory depictions that they inhibit easy conveyance of abstract meanings. Dautriche and colleagues (2017) show that, given a natural language's phonotactic rules, its lexicon uses a smaller portion of the phonological space available to it, where this phonological clustering may be due to nonarbitrariness. Still, what nonarbitrariness there is in spoken languages can be informative to diachronic studies; similarities in nonarbitrariness can uncover semantic networks that reveal motivated diachronic change (Carling & Johansson 2014).

In comparison, opportunities for nonarbitrariness in sign languages are abundant and robust (Guerra Currie et al. 2002; Lepic et al. 2016; Pietrandrea & Russo 2007; Pizzuto et al. 1995). Sign languages make generous use of encoding real-world visual information into signing (Brennan 2005), resulting in multiple strategies of nonarbitrariness and in patterns of such strategies within a given sign language (Padden et al. 2013). This is not because sign languages are exotic (see Braithwaite 2020) and it cannot be exclusively because they are "young" (where many have claimed they are young, but see Cantin & Encrevé 2022 for evidence that some sign languages go back at least to the early Middle Ages); the nonarbitrariness of sign languages is due mostly to modality differences. As Johnston (1996: 65) puts it, "…the fact that our experience, as a whole, is visual, temporal, and spatial means that language that has visual and spatial resources for representation has greater means for mapping onto those very visual and spatial qualities."[1] To approximate the many types of nonarbitrariness found in sign languages, spoken languages must avail themselves of co-speech gestures (Reddy 1979; McNeill 1992).

We follow Perniss and colleagues (2010) in viewing lexical items as nonarbitrary if they exhibit regular correspondences between form and meaning motivated by experience with the real world. Many signs originate via metaphor, metonymy, synecdoche, or movement associated

[1] Temporality is left out of Johnston's contrast between spoken and sign language resources for nonarbitrariness with good reason. Spoken languages do use temporal nonarbitrariness, witness matches between temporal representations and syntactic word order (e.g. Tai 1985; and see Blything et al. 2015; Clark 1971; Münte et al. 1998; Pyykkönen & Järvikivi 2012). Sign languages, however, make a greater range of matches between temporal representations and syntactic order (Napoli et al. 2017; Napoli & Sutton-Spence 2021).

with the signified entity (Adam et al. 2007; Hoiting & Slobin 2007; Malaia & Wilbur 2012; Meir 2010; Perniss & Özyürek 2008; Russo 2004; Taub 2001; Wilcox 2000) or derive from cross-modal linked mappings (Napoli 2017) or via indicating, such as pointing to a body part (Ferrara & Hodge 2018) or otherwise describing (Ferrara & Halvorsen 2017). Accordingly, unrelated languages with little or no contact might have the same or similar signs for a given meaning.

At the same time, languages that are genetically related, such as American Sign Language (ASL) and Italian Sign Language (*lingua dei segni italiana*, LIS), can have distinct nonarbitrary signs for the same concept. For example, TREE and DANCE are both signed with whole-entity classifiers in ASL, but in LIS, TREE is signed with an outline-perimeter classifier, while DANCE is signed with embodiment.[2] Which properties of the real world are used as the base for a sign can vary so much it can be difficult to guess at a sign or to recognize the nonarbitrary nature of a sign's form without knowing its meaning; that is, nonarbitrariness is not to be confused with transparency (Occhino et al. 2017; Pizzuto & Volterra 2000).

Further, a sign's nonarbitrary origins can be lost when it becomes part of an organized linguistic system (Verhoef et al. 2016), so much so that many signers do not see visual intent in their own conventionalized signs (Cuxac & Sallandre 2007; Klima & Bellugi 1979). Add to this the fact that sign language communities are subject to pressures that aim toward standardization (involving language politics, educational matters, and language ownership, see Adam 2015; Eichmann 2009; Pfau & Steinbach 2006), which standardization can also bleach nonarbitrary origins.

Therefore, not only may unrelated languages appear related due to shared nonarbitrariness, true genetic relationships may be obscured. The result is that neither the presence nor absence of shared nonarbitrariness can be relied upon solely for determining shared history. Still, with this caveat in mind, astute attention to nonarbitrariness may help us better understand sign language change (Currie et al. 2010; Greenhill et al. 2009).

2.5 Availability of data

Two additional complicating facts are ones that sign languages share with many spoken languages. First, sign languages have historically not been written down; there is little to no data available from periods preceding the invention of video recording and, for many sign languages, no data available until recently (Brentari 2019: 243 ff). A notable exception is French Sign Language (*langue des signes française*, LSF), where we have written descriptions and illustrations of signs from Old LSF provided in large part by members of the clergy (Blanchet 1850; de l'Épée 1784; Degérando 1827; Ferrand ca. 1785; Lambert 1865; Laveau 1868; Pélissier 1856; Sicard 1808). Additionally, ASL is described and sometimes illustrated in some early texts (Brown 1856; Higgins 1923; Long 1910; Michaels 1923), and original film sources (including those by George Veditz of the National Association of the Deaf) are being reformatted and made available to Deaf World (Supalla 2001, 2004; Supalla & Clarke 2015), allowing for study of a range of phenomena (Supalla et al. 2020). Ongoing longitudinal work compares films of other languages over relatively short periods of time, such as Portuguese Sign Language of the Azores (Moita et al. 2018) and Nicaraguan Sign Language (The Hearing Review 2019). For arguments that language change in progress mirrors diachronic developments, see Bailey and colleagues (1991); and for sign languages, Frishberg (1975), Radutzky (1989), and Geraci and colleagues (2011).

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[2] By convention, signs are in small capitals. For ease of cross-linguistic comparison, we use English glosses.

Second, for many sign languages, we do not have contemporary data corpora to allow reliable comparative or internal reconstruction. Important initiatives are changing this, including the SIGN-HUB research project (sign-hub.eu/project). This is a four-year project funded by the European Union's Horizon 2020 Research and Innovation Programme. SIGN-HUB is collecting data from six sign languages, including from elderly signers (Quer & Boronat 2016, 2017; Geraci et al. 2019), which promises to be an important source for apparent time analysis of diachronic change in these languages. Additionally, Global Signbank (https://signbank.cls.ru.nl/) is a lexical database for sign languages administered through Radboud University. The number of languages housed there is growing, as is the amount of data on each (Crasborn et al. 2020). Lexical items are annotated for articulatory features (Börstell et al. 2020). Another ongoing initiative is the Sign Change Project, compiling and annotating data from 13 sign languages in two putative language families to develop a theoretically-informed, quantitative model of sign change and phylogenetic relations (Power et al. 2021). Added to this are initiatives for individual sign languages, more of which are being undertaken all the time, such as the lexical database FLexSign for French Sign Language (LSF; Périn et al. 2023). Since the way one annotates or transcribes data is critical to the kinds of questions those data can be used to answer and to the possibilities for comparison between studies, various scholars have developed web-based tools for annotating articulatory features of signs in such corpora, allowing a lexico-statistical approach based on articulatory features (Abner et al. 2020; Yu et al. 2018).

2.6 Dearth of regular phonological change

An articulatory-based approach to diachronic study in linguistics is motivated to some degree by the Neogrammarian hypothesis of regularity in sound change (Leskien 1876: xxviii; Osthoff & Brugman 1878: xiii), a powerful tool in the historical analysis of spoken languages. However, linguists have been unable to identify regular correspondences in sign languages (Moser 1990; Power 2022) and, as we argue below, for good reason. Of course, spoken languages do not change in a perfectly regular way (Labov 1981), but the difference between modalities is stark. For example, in the development of modern English, the Middle English long high front vowel /iː/ generally diphthongized to /aɪ/ in all words as part of the Great Vowel Shift (Luick 1896; Jespersen 1909), but we do not see analogous cases of regular phonological change in a given sign language, such as the B-handshape changing to the 5-handshape in all signs, or all two-handed signs becoming one-handed, or all signs articulated on the forehead changing location to the cheek.

It is possible that there is a lack of regular phonological diachronic change in sign languages (Wilbur & Petersen 1997), and that may be due partially to the fact that such changes are at the sublexical level, but sign languages generally have few sublexical rules. The list in Section 3.2 below are examples of processes that occur in casual conversation, but none of them is obligatory in any context we know of. Others that truly seem obligatory include Mandel's (1981) finding that only the selected fingers of a handshape can make contact with a location on the body and can move (secondary movement), and Brentari and Poizner's (1994) finding that the timing of handshape change within a lexical item is linked to the duration of path (primary) movement. There are also arguments for sublexical phonological rules based on syllable constraints (Brentari 1998; Uyechi 1996) and the domain of reduplication in iterative aspect (Sandler 2017). Feature spreading at the sublexical level can happen between a manual parameter and a nonmanual parameter (Loos & Napoli 2021; Woll & Sieratzki 1998). However, most proposed phonological rules are at a higher level; they involve compound formation (Brentari 2019, especially §8.3; Liddell & Johnson 1986; Sandler 1989, 1993) or spreading of features between roots and affixes (Sandler et al. 2011) or from one lexical item to another within a syntactic phrase (where often it's a nonmanual parameter that spreads: Bank et al. 2015: 45; Neidle et al. 2000; but sometimes a weak hand can spread to the next sign: Brentari & Crossley 2002; Sandler 1999). In a realm of few sublexical phonological rules to start with, and of a tighter link between form and meaning than that found in spoken languages, regular phonological change would be unlikely.

An alternative account is that there is, in fact, regular phonological historical change in sign languages, but it is difficult to discern. Along this line, Napoli and Ferrara (2021) argue that relationships between the phonological parameters at the sublexical level are obscured without consideration of nonarbitrariness. It could be, then, that regular phonological historical change does take place for some appropriate phonological unit yet to be acknowledged.

Accordingly, ferreting out genetic relationships between sign languages solely on the basis of segmental phonology should be difficult. We expect diachronic change in sign languages to be affected by the drive for ease of articulation – as happens in spoken language – but also, due to nonarbitrariness, to be open to changes influenced by meaning. Since semantic change is largely sporadic rather than regular (Lehrer 1985: 283; Hock 2003: 456), this sporadic characteristic may be transmitted to the phonology via the tight link between phonetics and meaning in sign languages, so that the inherent resistance of regular change in the semantics is shared with the phonology (Taub 2001: 229). This supposition is supported by how phonological change in spoken languages similarly resists regularity when there is a tight link of the articulatory form to the semantics, as with onomatopoeia and other expressive or mimetic lexical items (Jespersen 1922: 288, 406; Joseph 1987; Mithun 1982). We propose that this same link inhibits change in sign languages, just to a greater degree due to the more extensive nature of nonarbitrariness.

3 Movement in sign languages

It is generally assumed that the appropriate degree of similarity one must demonstrate in order to argue that two sign languages are historically related involves comparison of the distinctive manual phonological parameters/categories: handshape, location, orientation, and movement (although some argue orientation is a feature of handshape; Sandler 1989). McKee and Kennedy (2000: 48) propose that two signs count as related only if they differ by at most one parameter. Here we seek to contribute to the discussion on how similarity measures are to be interpreted with respect to movement.[3]

3.1 Movement

The movement parameter has been reported by signers to be the most salient parameter for recognizing signs, either alone for non-native signers or in combination with other parameters for native signers (Corina & Hildebrandt 2002; Corina & Knapp 2006; Dye & Shih 2006; Orfanidou et al. 2009), thus understanding how movement changes is critical to historical study. The

[3] The factors we discuss below are articulatory, and do not necessarily correlate to perceptions of movement similarity on the part of signers and nonsigners, which can differ significantly (Poizner 1983).

movement parameter is complex, at minimum involving direction of movement, shape of path, iteration, size of path, dynamics, and speed. For our purposes, iteration involves repeated movement in the same direction; thus, moving forward and then backward along the same path is not iteration, just a return movement, but moving forward, then backward, and then forward again is iteration (Wilbur 2005).

There are two types of movement based on joint articulation: primary and secondary. Primary movement involves articulation of the shoulder and/or elbow joint, causing the entire hand to trace a route through space or on the body. Primary movement is often called path movement; the route it traces is a path. Secondary movement involves the other joints of the manual limb (radioulnar, wrist, base knuckles, interphalangeal knuckles) and does not cause the entire hand to trace a path. Nevertheless, secondary movement can cause most of the hand to trace a route through space. For example, in the ASL sign BOUNCE, articulated with a 5-handshape and wrist flexion and extension, the fingers and palm (but not the wrist) trace a visually salient up-down line through space. The important distinction between the two types of movement is that primary movement always involves the entire hand, including the wrist, moving along a path, while secondary movement always keeps at least the wrist in a fixed location (though it might rotate in place due to radioulnar articulation).

3.2 Motivated possible historical changes to the movement parameter

A number of processes that occur in conversational signing affect the articulatory shape of sign languages with respect to movement (Napoli et al. 2014), most often for articulatory ease by reducing mass, acceleration, or distance traveled. In #1-9 here, we catalogue some of those processes as a list of motivated possible types of changes, which, when "undone" can reveal "sameness" of movement and, thus, be used to recognize historical relatedness.

(1) *Iteration Loss*: Repeated movement along a path in a given direction is reduced to a single movement in that direction, reducing distance traveled and acceleration forces from direction changes, as found in lexicalization of compounds (Corina & Sandler 1993; Liddell & Johnson 1986; Wilbur 2017).

(2) *Weak Drop*: A two-handed sign with reflexively symmetric movement across the midsagittal plane changes to a one-handed sign by not using the nondominant hand at all (Frishberg 1975; Padden & Perlmutter 1987; Zimmer 2000), halving the total amount of moving mass.

(3) *Weak Freeze*: A two-handed sign with reflexively symmetric movement changes to a two-handed sign with only one hand moving by keeping the nondominant hand static in a fixed position Mak & Tang 2011; Padden & Perlmutter 1987), reducing the total amount of moving mass.

(4) *Joint Freeze*: One or more joints are subtracted from the articulation of a sign (via freezing of joint(s)), reducing the total amount of moving mass, with the shoulder and elbow being particularly prone to freezing (Meier et al. 2008; Napoli et al. 2014).

(5) *Joint Graft*: One or more joints are added to the articulation of a sign, usually the radioulnar or (most commonly) the wrist, in conjunction with Joint Freeze of a more proximal joint, maintaining the overall visual shape of the path (Crasborn & Kooij 2003; Frishberg 1975; Meier et al. 2008; Napoli et al. 2014; Radutzky 1989).

(6) *Torque Reduction*: Movement changes to avoid incidental torso twisting or rocking, reducing the reactive effort needed to maintain a stable torso, with twisting being more unstable than rocking (Sanders & Napoli 2016a, b).

(7) *Lowering*: The location at which a sign is articulated is lowered, reducing the lift needed in raising the hands to a higher location (Tyrone & Mauk 2010).

(8) *Location Undershoot*: Movement to a target location is cut short, reducing the distance traveled (Brentari & Poizner 1994; Mauk 2003; Poizner et al. 2000).

(9) *Midsagittal Symmetry*: Other types of symmetry give way to reflexive symmetry across the midsagittal plane, reducing cognitive effort of muscle coordination (Frishberg 1975; Napoli & Wu 2003) and facilitating perception (Ferrara & Napoli 2019; Mechsner et al. 2001).

These motivated possible types of changes are based on the biomechanical drive for ease of articulation. With respect to Joint Graft (#5), it is typical of a complex process called distalization (Mirus et al. 2001) or joint migration (Poizner et al. 2000). In distalization a more proximal joint freezes and a more distal joint is grafted – where the process overall reduces effort. Napoli and colleagues (2014), find that joint freezing occurs in 97% of the conversational variants of signs in their data set, while joint grafting occurs in only 29%. Hence, we have chosen to list Joint Freeze separately from Joint Graft.

3.3 Utility

The processes in §3.2 are optional and none is without qualification. Consider perhaps the most obvious example of effort reduction: Weak Drop (#2). Frishberg (1975) found for ASL that signs articulated on the face tend to become one-handed, while signs made below the neck tend to become two-handed; Radutzky (1989) found the same for LIS. This tendency is predicted from Siple (1978)'s observation that signs made outside the foveal vision of the addressee require help in being visually perceived – thus they should be larger and both hands should move, whereas signs on the face can be smaller and one hand can do the job by employing a wide range of handshapes. Consistent with this finding, Caselli and colleagues (2022) show for ASL that signs with high frequency are articulated closer to the face than those with low frequency, and that high frequency signs with rare handshapes occur closer to the signer's face than those with common handshapes. Battison (1974) and Brentari (1998) found that signs in which both hands move symmetrically can undergo Weak Drop, but signs in which symmetrical movement is out-of-phase (alternating) do not. Tkachman and colleagues (2018) correlate this to the fact that in-phase symmetrical movement is usually not repeated, while out-of-phase movement is (which they attribute to vestigial locomotor central pattern generators in the brain). Brentari (1998) notes for ASL that Weak Drop is inhibited if the two hands have continuous contact during the movement, but Kooij (2001) finds no such inhibition in Sign Language of the Netherlands. Siedlecki and Bonvillian (1993) find that among children, Weak Drop is more likely if both hands are in contact with the body.

Weak Drop clearly has a range of potential inhibiting factors, most of which just might lend themselves to a unified account. In order to see this, consider first Sanders and Napoli (2016a); they look at 24 languages, and find that all exhibit a drive to reduce the effort needed to resist torque, as evidenced in the shape of their lexicons. In particular, twisting signs occur in a lesser proportion than rocking signs, which occur in a lesser proportion than signs that induce neither twisting nor rocking. This uniformity of lexical distribution of different types of signs holds across sign languages which vary from being very young to centuries old, and suggests that sign languages have a drive to maintain a somewhat stable level or proportion of different types of torque-inducing movement in signs over time. Keeping this in mind, we also note that there are many signs in many languages that have lexical iteration (cf. #1), use two moving hands (cf. #2 and #3), articulate the shoulder and or elbow joint (cf. the combination of #4 and #5), are made high in signing space (cf. #7), and call for a relatively long movement path at least in their citation form (cf. #8).

We suggest that sign languages tend to exhibit a somewhat stable level or proportion of all types of allowable movement in signs over time – which stability protects utility. Gibson and colleagues (2019) offer a review of recent work on spoken languages that addresses how languages achieve utility – that is, a balance between efficiency and complexity. The notion of communication relevant to their review is the information-theoretic view:

> First, an information source selects a message to be transmitted. Next, the message is encoded into a signal, and that signal is sent to a receiver through some medium called a channel. The receiver then decodes the signal to recover the intended message. Successful communication takes place when the message recovered at the destination is equal to the message selected at the source, or diverges from it only slightly. (p. 391)

Efficiency for them means that the message is accurately interpreted, regardless of its context, with minimal effort on the part of the interlocutors, quantified via the length of messages: short messages are most efficient. Complexity for them is about learnability, where languages must be infinitely expressive, but still learnable; simpler systems are more easily learned. Languages achieve utility largely through being compositional, where, to a great degree, the meaning of novel expressions is a predictable function of its parts. However, as Gibson and colleagues note (p. 400), iconicity and systematicity are also important players in utility; children may bootstrap their way into learning a language via nonarbitrariness. Kirby and colleagues (2014) argue that compositionality plus iterated learning can overcome the poverty-of-the-stimulus problem and can allow a framework for language emergence. Similarly, Dingemanse and colleagues (2015) consider experimental results in iterated learning that suggest the importance of the role of repeated cultural transmission in creating and maintaining systematicity. Koplenig and colleagues (2022) conducted a large-scale quantitative cross-linguistic study of written language, concluding that the trade-off is (at least partially) shaped by the social environment in which languages are used.

Sign languages also develop means toward efficiency based on nonarbitrariness. Nonarbitrariness aids children in acquisition of sign languages (Caselli & Pyers 2017, 2020; Ortega et al. 2017; Thompson et al. 2012; Vinson et al. 2008), and deaf parents are aware of this: they often modify nonarbitrary signs in ways that obviate the shared features between the sign and its meaning (Perniss et al. 2018). Thompson and colleagues (2010) show how nonarbitrariness speeds response time and improves accuracy in a picture and sign matching test. Slonimska and colleagues (2023) examine experimental evidence from earlier studies (Slominska et al. 2020, 2021, 2022) that show how simultaneous and nonarbitrary constructions in LIS evolve and are used for communicative efficiency.

Maintaining a wide range of different movements in sign languages allows for different nonarbitrary associations. If loss of a biomechanical feature will lead to unrecognizability of the nonarbitrary part of the sign, the utility of a language is decreased by that loss; thus, effort-reduction processes in sign languages should be curtailed by the need to maintain recognizability (Napoli & Liapis 2019). The loss of any particular type of movement could reduce the communicative potential of the language. For Weak Drop, in particular, maintaining two hands allows for different nonarbitrary relationships between the hands – where those relationships can carry a wide variety of meanings (Börstell et al. 2016; Crasborn 2011; Lepic et al. 2016; Kooij 2002). Hence, utility might demand that no movement type should be entirely abandoned in a sign language.

Certainly, attributing a given historical change or lack of one to the trade-off between efficiency and complexity is not straightforward; other factors may come into play in both spoken languages (Levshina 2020) and sign languages. Nevertheless, given the richness of nonarbitrariness in sign languages, we believe the trade-off needs to be considered. Hence, we plow forth.

4 Examples of this dual approach to analyzing the movement parameter

We here exemplify how the approach of considering nonarbitrariness and biomechanics can allow one insight into whether the movement of two signs is similar enough that they might possibly be cognates.

4.1 Data set

Our examples come from the spreadthesign.com (STS) database, run by the European Sign Language Centre in Örebro, Sweden. The lexical entries are presented in whichever language the user has selected for reading the website (we selected American English, the default setting) and the database can be searched by main entry in this selected language in many categories, which may be syntactic (Nouns, Verbs, Sentences, etc.) or semantic (Architecture, Military & Weaponry, At the hair salon, etc.). These main entries do not reflect well-defined lexemes, a problem with most sign language databases (Johnston and Schembri 1999). For example, Fenlon and colleagues (2015:176) point out that the STS main entries EXCITED and ENTHUSIASTIC would be grouped into the same lexeme in a properly lemmatized dictionary of British Sign Language, but in STS, they are separate entries containing different videos depicting different signers, with no indication that the two signers are in fact signing the same lexeme. It seems unlikely that this lexicographical shortcoming would be systematically skewed to favor or disfavor any particular one among the processes (1-9) listed in §3.2, let alone all of them. Additionally, STS rarely points out contemporary variants of a sign, which variants might serve as better candidates for cognates than the lexical items in the database. Since our goal, as we have stated, is to demonstrate possible historical processes at work, not to argue for a particular genetic relationship, we take the STS database to be adequate to this purpose, with the understanding that properly lemmatized dictionaries which list variants to the extent possible would yield more reliable results and should be used when available.

For a detailed quantitative phonetic study, the ideal would be to use high quality, multi-camera video data, recorded using a motion sensing input device such as *Kinect*, with its accompanying software (Puupponen et al. 2014). The videos we analyze, instead, are available on the Internet and were not collected for exacting linguistic study. Further, we used our bare eyes to make judgments of joint movements. Still, we believe our analysis is adequate to the task of demonstrating the approach we propose since the cameras always catch the full movement of the manual articulators and since whether a joint in the manual articulators moves is relatively apparent to bare vision.

We restrict our examples to confirmed or hypothesized members of the Old LSF family because much of the work in this area is available to us. Discussion of the origins of Old LSF are found in Cagle (2010) and Lane (1980). For description of the spreading of Old LSF via teachers from the initial school fanning out to establish schools in other countries, see Berthier (1852). The Old LSF family has been claimed to be large: Wittmann (1991) lists a total of 30 languages that are at least potentially within it (and see earlier editions of Ethnologue; Simons & Fennig 2019).

Beyond documents about the history of deaf education in various countries, a variety of linguistic studies contribute to our knowledge of sign language families, including the Old LSF family. Anderson and Peterson (1980) applied the comparative method to European sign languages. We do not have access to that work; however, Power et al. (2020) report them[4] as finding evidence for two families: South-West European (consisting of three main branches: French, Polish, and Spanish lineages) and North-West European (consisting of British, German, and Swedish lineages).

Napoli and colleagues (2011) examined direction of path movement in the sign languages of America, France, Italy, Australia, and the United Kingdom to try to use phonetic information to confirm deaf-education evidence that the first three are in one family and the other two, in another. Their corpora were entire dictionaries, and their findings confirmed the memberships of the two families. They then applied their method to studying a sixth language proposed to be in the Old LSF family, for which the historical evidence regarding deaf education was more controversial: Nicaraguan Sign Language. Their results cast doubt on that proposal.

Power and colleagues (2020) compared manual alphabets across many sign languages using a neighbor-net based on simple (Hamming) pairwise distances, calculated from the standard-coded CogID binary matrix – to arrive at a set of members in what they call the French group, with important differences from Wittmann (1991), and from the claims of Anderson and Peterson (1980). First, they find a Spanish group distinct from the French group. Second, they argue that, while an Austrian-origin group of sign languages have manual alphabets that initially make them appear to be in the French-origin group (with the exception of Iceland), that fact is due to early but minimal contact. Thus, the Austrian group is not a member of the French group. Third, their net includes two more languages in STS -- Greek SL and Finnish SL – as well as others not in STS. They offer extensive discussion of both the dispersal of Old LSF from the late sixteenth to the late nineteenth century in support of their findings.

4.2 Nonarbitrariness

[4] Actually, Power et al. (2020) refer to only Anderson – but we assume this is a typo.

When comparing lexical items, one must first check for nonarbitrariness. Members of the same family might well choose different nonarbitrary ways to present sense, and thus confound the issue of finding cognates. We first show an instance in which nonarbitrariness shows sign are not cognates. We temper that with another instance in which movement is similar, but, in light of nonarbitrariness, we conclude the signs are most likely not cognates, which we then confirm by checking with an Old LSF dictionary.

First, consider COOK (Figure 1) from ASL, LIS, and LSF. Though the development of ASL is complex (Tabak 2006)[5], it is clear that ASL and LSF share a common ancestor. Shaw and Delaporte (2011, 2015) demonstrate how individual lexical items in ASL came from Old LSF. For the history of LIS as influenced by LSF, see Radutzky (1992), Corazza (1994), Pinna and colleagues (1994). The initial school for the deaf in Rome emphasized lip-reading, which Italian lends itself to readily (Volterra & Bates 1989) and which may account for the prevalence of mouthing today (Ajello et al 1997; Roccaforte 2018), although mouthing is not a core component of the grammar (Giustolisi et al. 2017).

ASL LIS LSF

Figure 1: COOK in three potential members of the Old LSF family

In ASL the nondominant hand is a classifier for a flat object (unmoving) while the dominant hand is like a spatula, flipping one way then the other (via radioulnar articulation) – as in cooking a steak or pancakes. In LIS the hands move out-of-phase in vertical lines, like bubbles rising in a pot of boiling water – as in cooking pasta. In LSF the nondominant hand behaves as though it is holding the side of a bowl (unmoving) while the dominant hand is like a spoon or whisk, moving in a circle above the (unseen) bowl – as in whipping up egg whites or cream. No one should try to derive these movements from the same source.

On the other hand, sometimes movements can be similar, but nonarbitrariness indicates different sources. Here we compare an LSF example to an example of Pakistani Sign Language. The Indo-Pakistani sign languages of India (IPSL-I, notated on STS as both "English (India)" and "Hindi") and Pakistan (IPSL-P, notated on STS as "Urdu") might belong to the Old LSF family (Desai 1930; Stevens 1923; Woodward 1993), although the evidence for this is weaker than the evidence for ASL and LIS. Though Zeshan (2003: 157) states that "IPSL is not known to be related to other sign languages of either Asia or Europe", we consider the possibility that the IPSL dialects may belong to both the Old LSF and Old British Sign Language (BSL) families, via a connection between Old IPSL and Irish Sign Language (ISL), which itself was

[5] Martha's Vineyard Sign Language (MVSL) plays a role in the development of ASL. Note that Groce's (1985) hypothesis that MVSL was influenced by a sign language of Kent, England is argued against in Kitzel (2014).

originally influenced by BSL (via teachers of the deaf) and later by LSF (via nuns from Dublin visiting Paris to learn how to teach deaf students) (Adam 2012; Burns 1998; Woll et al. 2001). Early writings show pockets of deaf people in India had been using sign languages for centuries (Dennis 2005). In the deaf school in Bombay, a number of Irish nuns and brothers were instructors, and they were accustomed to teaching in ISL. Thus, ISL likely mixed with the varieties of indigenous sign languages that the students brought to the Indian schools (McBurney 2012), and due to ISL's mixed history, we therefore have a potential second-generation link connecting the dialects of IPSL to both Old LSF and Old BSL.

Given this suggestive evidence of relatedness, consider ATTENTION in ISPL-P and LSF (Figure 2). The sign we are calling IPSL-P_2 is no longer available on STS, but it remains available on the web (https://media.spreadthesign.com/video/mp4/40/429725.mp4).

IPSL-P_2 LSF

Figure 2: ATTENTION in two potential members of the Old LSF family

The starting point in IPSL-P_2 is the outer sides of the eyes, and in LSF, below the eyes. In both, the movement path is straight, and ends at a point in front of the very upper part of the signer's chest, and primary movement involves extension of the elbow and, possibly a very slight rotation of the shoulder joint. The LSF sign, however, also involves an extremely short iteration of the path at the very end (we refer the reader to STS, rather than trying to represent this in the image), as though after the hands hit the end point of the movement path, they bounce.

Setting aside their near identity of primary movement, these signs seem to be built on different approaches to the sense of attention. The handshapes are telling. The flat-B-handshapes at the sides of the eyes in IPSL-P_2 rely on the iconicity of hands as blinders, restricting eye gaze to straight ahead. Since the hands do block out visually peripheral information, this iconic source is concrete. Other potential members of the Old LSF family use **the blinder iconicity** (such as ASL and LIS), and many other sign languages not in the Old LSF family by anyone's reckoning use the blinder iconicity (where we conflate the flat-B and regular B-handshapes: Johnson & Liddell 2012; Ormel et al. 2017), including that of Great Britain, Germany, and China (the Chinese sign is a compound, the second element of which is the relevant part). Additionally, we note that in the sign language of Brazil (*língua brasileira de sinais,* Libras), CONCENTRATE uses this blinder iconicity, where Libras' history is well studied (Campos de Abreu 1994; Noberto et al. 2014), Quadros & Campello 2010; Ramsey & Quinto-Pozos 2010; Xavier and Agrella 2015). Campello (2011) studied the first dictionary of Libras, Gama's (1875) collection of lithographs (Sofiato 2011), and found that LSF was integrated into an already existing indigenous sign language of Brazil. Thus, it appears this iconic source was widely available within the Old LSF family and outside it.

However, the blinder iconicity is not apparent for the LSF sign. Again, handshape is telling. Upward-pointing 1-handshapes initially face towards the speaker, indicating eye (as seen in EYE in LSF), and then slightly rotate to face almost contralaterally while both interphalangeal joints bend, curling the fingers. This handshape change is not an orientation change (Wilbur 1979; finger orientation is the direction in which the hand-internal finger bones (the metacarpals) point), which remains up throughout. The final location is emphasized via the bounce.

While the handshape change from 1 to (super)bent-1 is legitimate at the sublexical level (that is, the selected finger is the one that undergoes change; Brentari 2011), it's hard to imagine an iconic or articulatory motivation within the blinder iconicity. Further, the final bounce is decidedly odd. There is a difference between repetition of movement inherent to the lexical item – iteration – and repetition morphologically motivated – often called reduplication. Certainly, iteration in conversation is often inexact, repeating only a part of the path (which reduction happens even in morphological reduplication; MacLaughlin et al. 2000). Still, the citation form of a sign (as in STS) usually shows full iteration; plus, in conversation, iteration, even if its path is reduced, consists generally of more than a bounce unless the sign occurs in final position in a phrase, where iteration can be lost entirely (Nespor & Sandler 1999). The iteration in the LSF sign occurs only on the bent-1-handshape, so it belongs only to the part of the sign after the handshape change. This behavior is not typical of simple signs; it looks suspiciously like that of a compound that has not been lexicalized (Liddell & Johnson 1986) or reduced (Lepic 2016). We propose the iconicity is a metaphor on taking the eyes (in the first part of the sign) and putting them in a particular place (in the second part of the sign): the **put-eyes-here metaphor**. In the sign language of Mexico (*lengua de señas mexicana*, LSM) ATTENTION also seems to use the put-eyes-here metaphor, where LSM has been argued to be in the Old LSF family (Guerra Currie 1999; Guerra Currie et al. 2002; Hendriks and Dufoe 2014; Jullian Móntañes 2001; Quinto-Pozos 2006, 2008; Ramsey & Quinto-Pozos 2010).

Despite the strong similarity in the movement parameters of ATTENTION in IPSL-P_2 and LSF, these signs are not cognates. We support that with information from two Old LSF dictionaries.

Lambert's dictionary of Old LSF was published in 1865. The year in which LSF instructors were involved in the establishment of schools for the deaf for India and Pakistan was 1895 (via ISL, for which no date is given for the Irish nuns' visit to Paris, but which is presumably not much before they brought it to India and Pakistan). Thus, Lambert's dictionary offers an appropriate check for our speculation, where the dictionary includes descriptions and a drawing.

Delaporte published a dictionary of Old LSF in 2007, in which he gives examples from a textbook written by the deaf poet Pélissier (1856, unavailable to us), who was a teacher at the Paris Deaf Institute in the mid 1800s, and who explained sign language to other teachers of the deaf (Quartararo 2008). Thus, this dictionary, also, is of great value.

Considering the blinders iconicity, we propose a source sign in Old LSF with B-handshapes focusing one's attention by blocking out extraneous visual information. We find no such sign in the Lambert dictionary, nor in the Delaporte dictionary. But there are signs in the Delacorte dictionary that suggest that using the B-handshape as a blinder was an iconic base in Old LSF. (Here we name those signs in French, rather than English, to help the interested reader locate them in the sources.) PARLER EN CACHETTE 'speak in secret' (p. 112, attributed to IVT

1990) puts the B-handshape beside one side of the mouth, then moves it to beside the other side of the mouth, to block visual access to the lips. CHANGER D'AVIS 'change opinion (p. 126, attributed to IVT 1986) has the B-handshape beside the eye change direction via radioulnar articulation, as though what one could see has now changed (CHANGER 'change' alone is a B-handshape in neutral space with the same radioulnar articulation, p. 125). CLASSE 'class (as in school)' (p. 139) has the B-handshape beside the eye move down to hit the weak hand, as though directing the gaze toward a particular point (Delacorte relates this sign to learning). Hence, we stand firm beside the proposal that Old LSF recognized the blinders iconicity of the B-handshape beside the eye. Perhaps it was so widely prevalent, it was considered more gesture than sign and thus overlooked by the scholars.

Considering the put-eyes-here metaphor, we note Lambert's (1865: 73) Old LSF sign PRUDENT in Figure 3, where PRUDENT and ATTENTION in LSF are identical. It is unclear from Lambert's drawing whether element two of this compound is iterated, but the dotted lines appear to indicate that the axis of movement is away-toward the body.

Figure 3: PRUDENT in Old LSF (Lambert 1865: 73)

Delaporte (2007: 71) gives three signs under the entry ATTENTION (Figure 4). The first he attributes to Pélissier (1856) with the gloss PRUDENT. He offers the iconicity of managing or controlling via reins (and this is the sign on STS for MANAGE in LSF, ASL, and LIS, with out-of-phase movement). The second and third he attributes to IVT (1986) with the gloss ATTENTION. He offers the explanation that these two forms for ATTENTION are compounds made of pointing to the eyes then controlling via reins, in one case, and taking care, in the other case.

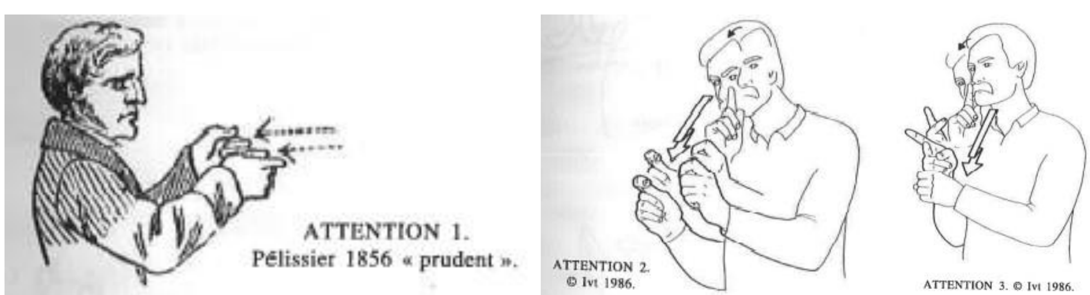


Figure 4: PRUDENT and two variants of ATTENTION in Old LSF (Delaporte 2007:71)

Perhaps the sign in Figure 3 and the middle sign in Figure 4 were variants of each other. Either could be the source sign(s) for the put-eyes-here signs in the modern languages. It seems the original metaphor was not put-eyes-here, but eyes-control in Old LSF.

There are two major take-aways from this demonstration. First, consideration of nonarbitrariness must go hand-in-hand with consideration of biomechanics. Second, semantic shift is part of the historical puzzle in sign languages just as in spoken languages (Deo 2015; Traugott 2012). A one-to-one approach to meaning based on an English (or any other language) translation of each sign is unlikely to consistently yield the true set of cognates that must be considered.

4.3 Biomechanics

Here we offer two examples from members of the Old LSF family for each of the biomechanical processes listed in §3.2. When one looks in STS at the sign languages for which membership in the Old LSF family has been proposed, there are many potential examples for these processes, however, most lack entries in the Old LSF dictionaries that we have access to.

<u>Iteration loss</u>
Consider KNOW (Figure 5). In Old LSF, CONNAÎTRE has iteration (Delaporte 2007: 155). Today KNOW has iteration in IPSL-I, but not in LSF. It appears Iteration Loss has applied in LSF.

Old LSF (iteration)

IPSL-I (iteration)

LSF (no iteration)

Figure 5: KNOW in Old LSF, IPSL-I, and LSF

Another example is the two-handed sign NAME in Old LSF (NOM, Delaporte 2007: 412) and LSF versus the one-handed sign in Spanish Sign Language (*lengua de signos española*, LSE**)**. The possibility that LSE was influenced by LIS presents itself, since the Jesuit scholar Lorenzo Hervás y Panduro visited the school for the deaf in Rome after which he helped to found the first public school for the deaf in Spain in Barcelona in 1800 with Joan Albert i Martí (Quer et al. 2010).

Weak Drop

Consider MILK (Figure 6). In Old LSF LAIT, two hands move vertically out of phase with iteration (Delaport 2007: 339). In IPSL-I, two hands make the same movement, but Libras has only one hand, with a shorter movement path, maintaining iteration It appears Weak Drop has applied in Libras.

Old LSF (two hands)

IPSL-I (two hands)

Libras (one hand)

Figure 6: KNOW in Old LSF, IPSL-I, and LSF

Another example is two-handed BIOLOGY in Old LSF (BIOLOGIE, Delaporte 2007: 96) and LSF versus the one-handed sign in Libras.

Weak Freeze

Consider SENTENCE (Figure 7). In Old LSF PHRASE (Delaporte 2007: 340), the hands move away from each other, with out-of-phase secondary radioulnar movement. SENTENCE in LSF likewise has two moving hands, but only the strong hand moves in ASL. It appears Weak Freeze has applied in ASL.

Old LSF (both hands move)

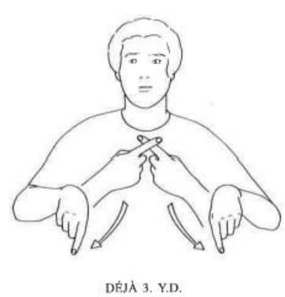
LSF (both hands move) ASL only one hand moves

Figure 7: SENTENCE in Old LSF, IPSL-I, and LSF

Another example is INTERPRET. In Old LSF (DECHIRER, Delaporte 2007: 282) and IPSL-I, two hands move. But in ASL, the weak hand is frozen.

<u>Joint Freeze</u>

Consider ALREADY (Figure 8). In Old LSF DÉJÀ (Delaporte 2007: 185), the elbow, the radioulnar, and the wrist articulate In LIS, the elbow and radioulnar articulate. And in ASL, only the radioulnar articulates. It appears Joint Freeze has applied once in LIS and twice in ASL.



Old LFS

LIS ASL

Figure 8: ALREADY in Old LSF, LIS, and ASL

Another example is FINISH. In Old LSF (FINI, Delaporte 2007: 185) and in LSF, the elbow, radioulnar, and wrist articulate, versus in Libras, where only elbow and wrist articulate. It appears Joint Freeze applied in Libras.

<u>Joint Graft</u> (as part of Distalization)
Consider COLOR(S) (Figure 9). In Old LSF COULEURS (Delaporte 2007: 186), the hand moves in front of the lips, from one side to the other, with the fingers trilling; shoulder joint and the base knuckles of the hand articulate. In IPSL-I, the same joints articulate, however the starting position is with the elbow lifted and the palm oriented downward, and the handshape is different, where only the selected fingers trill. In Libras the internal hand movement is the same as in Old LSF, but the direction of movement is from the mouth forward, which happens via elbow articulation. It appears that Distalization applied in Libras.

Old LSF

IPSL-I Libras

Figure 9: COLOR in Old LSF, IPSL-I, and Libras

Another example is STEAL. In Old LSF VOLER (Delaporte 2007: 626), the shoulder, elbow, and radioulnar articulate (shoulder movement is necessary to bring about a curve in the path). In ASL, the shoulder articulates (in this video), so it appears Joint Freeze applied twice. In LSF, the radioulnar and wrist articulate, so it appears Distalization applied.

Torque Reduction

Consider SNOW (Figure 10). In Old LSF NEIGE (Delaporte 2007: 409), the movement is a translation symmetry, where both hands move in a diagonal from high to low, with a bit of a zig-zag in the middle of the movement. In LSF the movement path is straight (it has no zig-zag), but still diagonal. In LIS the movement path is straight and vertical (symmetrical across the midsagittal plane). It appears Torque Reduction has applied in LIS.

Old LSF

LSF

LIS

Figure 10: SNOW in Old LSF, LSF, and LIS

Another example is SERVER. In Old LSF SERVEUR (Delaporte 2007: 1986), both hands move horizontally in the same direction with iteration. In ASL the movement is the same, but without iteration (see the first half of the compound on STS). In LSF, the sign is one handed, and the direction of movement is forward – away from the signer – with a slight zig-zag pattern and no iteration (see the second half of the compound on STS). It appears Torque Reduction and then Weak Drop have applied in LSF.

Lowering

Consider WHITE (Figure 11). In Old LSF for BLANC (Delaporte 2007: 98), movement starts at the side of the neck and moves forward diagonally. WHITE in LSF today is the same, but in LIS the starting point is the center of the chest. It appears Lowering has applied in LIS.

Old LSF

LSF LIS

Figure 11: WHITE in Old LSF, LSF, and LIS

Another example is CURIOUS. In Old LSF CURIEUX (Delaporte 2007: 173), the C-handshape moves in a circle in front of the forehead. In LSF and LSM, that movement is in front of the nose and mouth. It appears Lowering has applied in LSF and LSM.

<u>Location Undershoot</u>

With Location Undershoot, usually one is discussing the endpoint of movement. However, if a movement has a clear starting and ending point, one could look at either location, since the point regarding effort reduction is the shortening of the movement path. Consider DEAF, which is a sign that in some sign languages can have movement go in either direction via metathesis (Sandler 1986). In Old LSF SOURD, SOURD-MUET (Lambert 1865: 77), the 1-handshape moves between the ear and the mouth. DEAF in LIS shows the same endpoints for the movement. In ASL, however, one endpoint is below the ear (and we note from our own experience that it often starts on the cheek) and the other is on the side of the chin. It appears Location Undershoot has applied in ASL. We also include the sign in Cuban Sign Language (*lengua de senas cubana*, LSC(u)), because the end points are so easy to see: not quite at the ear and not quite at the mouth. The history of LSC(u) is understudied; however, it might be influenced by Old LSF via LSE, since a Spanish teacher introduced the manual alphabet around 1924 (Calderón Verde et al. 2018).

Old LSF

LIS

ASL

LSC(u)

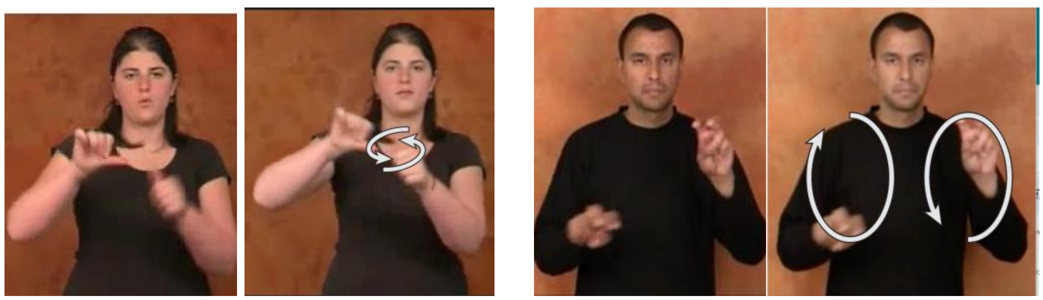
Figure 12: DEAF in Old LSF, LIS, ASL, and LSC(u)

Another example is FORK. In Old LSF (FOURCHETTE, Lambert 1865: 78) and in ASL the hand moves from the palm of the nondominant hand to the mouth. In LSM the hand scoops off the nondominant palm and moves upward only to the level of below the throat. It appears Location Undershoot has applied in LSM.

Midsagittal Symmetry

Consider TOURNAMENT (Figure 13). In Old LSF TOURNOI (Delaporte 2007: 592) the hands draw circles in out-of-phase symmetry across a horizontal plane in front of the speaker. LSF maintains that plane of symmetry, but ASL has symmetry across the midsagittal plane. It appears that Midsagittal Symmetry has applied in ASL.

Old LSF



LSF ASL

Figure 13: TOURNAMENT in Old LSF, LSF, and ASL

Another example is PROTEST. In Old LSF PROTESTER (Delaporte 2007: 499), one hand moves forward and the other moves diagonally upward, with iteration. This is a translation symmetry but not one that would produce much torque. In LSF the hands move forward as a unit (one on top of the other) without iteration; since they are touching, they are as close to symmetrical across the midsagittal plane as they can be. In IPSL-P both hands move diagonally upward, with reflexive symmetry across the midsagittal plane. It appears Midsagittal Symmetry has applied in both LSF and IPSL-P.

5 Discussion

Recognizing iconicity is critical to diachronic studies. Without such recognition, signs that have similar meaning and movement, but, perhaps other seemingly inexplicable differences, would appear to be cognates. Further, biomechanical processes that reduce effort appear to have applied in various daughters in the Old LSF family.

We suggest as a useful guiding principle that earlier forms of a sign tend to be more transparently nonarbitrary and use more articulatory effort (perhaps in order to make nonarbitrariness transparent), while later forms tend to be less transparently nonarbitrary and use less articulatory effort (as generations of signers introduce natural fluidity and efficiency). This general trend toward reduction of articulatory effort would show up most prominently in the movement parameter (especially path movement due to the larger masses being moved by shoulder and elbow articulation). Changes in the handshape parameter may also be driven by articulatory effort reduction, but the articulatory savings will be much smaller, so perceptual concerns may weight more heavily. Thus, as a starting point for considering biomechanics, the movement parameter is an obvious choice.

Nonarbitrariness itself may be an explanation for why sign languages do not immediately appear to be subject to Neogrammarian regularity. The inherent resistance to regular change in semantics can spread to the phonetics/phonology where nonarbitrariness is pervasive. We do not suggest that arbitrary signs may be subject to regular change, however. This would be difficult to test, since it is hard to argue that a given sign did not originate from a nonarbitrary one, given the many sources of nonarbitrariness. Even if nonarbitrary signs could be neatly categorized separately from arbitrary signs, their numbers may be so small that there would be no meaningful difference between regular change and sporadic change.

As we explored the Old French dictionaries, we were struck by how often an LSF sign was close to the source Old LSF sign. Napoli and colleagues (2011) looked at direction of movement in signs, and found that LSF appeared to be more conservative with regard to diachronic change in direction of movement when compared to ASL and LIS, as was BSL when compared to Auslan. They suggested that, within sign languages, daughters that were origin-bound (remained in the home country) were more conservative than daughters in the diaspora. Such a proposal is anathema to studies on spoken languages (Lehmann 1962; Crowley 1992; Joseph & Janda 2004), but that need not cast doubt on it. As pointed out in §2, the indigenous sign language of a country (which contains a mix of gestures and homesign, as well as community-originated signs) is extensively affected by the sign language brought into a deaf school from an outside source (in these cases, from Old LSF) and, importantly, vice-versa. While two spoken languages might be very different and thus affect one another in only a limited/inhibited way in an immigration situation, sign languages often have many lexical similarities (due to nonarbitrariness) and, perhaps universally, many syntactic and semantic similarities (Wilbur 2008; Napoli & Sutton Spence 2014; Napoli et al. 2017) – thus influences of one on the other might feel less foreign. Accordingly, diaspora sign languages might well change more rapidly and drastically than origin-bound sign languages.

Many questions remain. We list a few, first regarding arbitrariness then regarding biomechanics.

There is variation in signing across the lexicon and the components of the grammar, correlating with many of the same demographic factors speech variation correlates to (age, socioeconomic class, gender, race, ethnic background, region, sexual orientation), but also due to factors particular to sign language communities that we have already discussed, including the highly variable nature of sign language acquisition and the ways in which it is transmitted (Fenlon et al. 2013; Kusters & Lucas 2022; Lucas et al. 2009; McCaskill et al. 2011; McKee & McKee 2011; Schembri et al. 2009, 2018; Siu 2016; Stamp 2015). Given the centrality of nonarbitrariness to our approach, variation in signing raises thorny questions regarding data. While signers recognize nonarbitrariness in many signs (Sehyr et al. 2019), signers can and do disagree about the nonarbitrary motivation for a sign, where nonarbitrariness may be less contextually dependent (that is, more transparent) for signs with a concrete meaning (e.g., CHICKEN) than for those with an abstract meaning (Fitch et al. 2021). Folk etymologies offering an account of perceived nonarbitrariness can arise in sign languages and exhibit a kind of collective reality, like they do in spoken languages (Rundblad & Kronenfeld 2000). Such folk etymologies can lead to changes in articulation responsive to that folk etymology (e.g., LESBIAN, see discussion in Mirus et al. 2019). These facts lead us to two imposing questions.

First, how do signs whose nonarbitrary motivation is not recognized fit into our picture, given that the need for recognizability that Napoli & Liapis (2019) pose might not be operative in the same way?

Second, how do signs whose non arbitrary motivation is variably perceived fit into our picture, particularly if they undergo articulatory change responsive to the different perceptions?

Turning now to biomechanics, we ask many questions.

To what extent is diachronic change inhibited by the need for recognizability? Are there particular kinds of rules that are inhibited or are all?

Can languages be characterized by use of a particular biomechanical process? Russell and colleagues (2011) look at variation in ASL and argue that Lowering is a kind of Undershooting in variation in signs canonically formed at the face, head, or neck. Lowering is also analyzed as a change in progress in ASL (Lucas et al. 2002), in Auslan (Schembri et al. 2009, who relate it to historical patterns identified in British Sign Language), and in Hong Kong Sign Language (Siu, 2016). Perhaps this synchronic variation repeats a diachronic tendency across many languages.

What are the proper primitives to use in the description of the movement parameter? In our research we have isolated joint articulation, axes/planes of movement, and iteration. Might there be others?

Sometimes two biomechanical processes can reduce effort. For example, if the hands move in some symmetry other than across the midsagittal plane, one could change the plane of symmetry by applying Midsagittal Plane (reducing cognitive effort) or one could apply Weak Drop. Is there a ranking to the processes? If so, is that ranking language specific?

What other kinds of biomechanical processes that reduce energy might there be that account for diachronic change? For example, we found that signs with circular paths in Old LSF often had daughters with straight paths. Depending on starting and ending point and whether or not iteration is involved, such a change might reduce energy.

Does the limitation/inhibition of biomechanical processes of reducing effort shed light on sign languages in other ways? For example, is it an additional explanation for why signers of one language often catch on to another sign language more quickly than speakers of one language catch on to another spoken language (Zeshan 2015; Napoli 2017)? Are signers accustomed to applying biomechanical principles to reduce effort in daily conversation, and given the higher degree of nonarbitrariness in sign languages than in spoken languages, are they then able to mentally undo that effort reduction to recognize underlying nonarbitrary sources?

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Competing Interests
The authors have no competing interests to declare.

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