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5. Linguistic and Gestural Evolution: The Case of Analogue Verbal Traits in Sign Languages

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Abstract

Sign languages have plain verbal signs with fully lexicalized forms and directional and classifier verbal signs with flexible analogue components that have been analyzed as derived from gesture. With a linguistic evolutionary framework this proposal analyzes lexical and productive verbal traits as distinct adaptive strategies. Fixed conventionalized forms allow lexical verbal traits to express a relatively broad range of meanings and senses. Inventories of these traits are potentially very large and highly evolvable. Verbal signs with flexible productive components are able to express context-dependent aspects of meaning, but only within very narrow semantic ranges and are not polysemous. Inventories of these productive traits are relatively small, but highly plastic and change very slowly over time. The ranges of possible forms and meanings associated with these verbal traits are analyzed as reaction norms that are targeted by linguistic selection pressures that either change or maintain them over time, offering a way of unifying analyses of linguistic or grammatical and productive gestural traits.

5.1. Introduction

Once considered elaborated gestural systems, research since the 1960's has demonstrated that the natural sign languages (SL) of Deaf communities are full human languages with all of the same levels of organization and expressive power found in spoken languages (Armstrong, Stokoe and Wilcox 1995; Klima and Bellugi 1979). Researchers of SL initially took pains to demonstrate the differences between sign and gesture, showing that only signs are bound by linguistic constraints. More recently however, perspectives on gesture has changed as the important functions these elements serve in the acquisition and use of spoken languages have become clearer (Goldin-Meadow and Brentari 2017; McNeill 2005, 2012, 2016; Kendon 2000, 2004; Goldin-Meadow 2003; Özyürek 2012). Signers also gesture (Goldin-Meadow and Brentari 2017). Some gestures, like 'thumbs up', are learned and used in the same ways by both hearing and Deaf people. Other gestures like declarative pointers, appear to be universal with a large innate component (Tomasello and Call 2007; Kita 2003; Armstrong, Stokoe, and Wilcox 1995). Many lexical verbs like EAT and DRINK were derived

originally from gestures (Pfau and Steinbach 2006; Wilcox 2004). These signs preserve the iconicity of their source gestures but have been reanalyzed as morphemes that are phonologically and syntactically structured. There is variation in the ways lexical verbs like EAT while still representing instances of the same lexical item, but this is also true for lexical verbs in spoken languages. Whether or not they are derived from gestures, many verbal signs are 'plain', with conventionalized fixed forms that are relatively stable across contexts. Other verbal signs, including inflected directional verbs and classifier predicates behave differently, in that only parts of their form are fixed. Their other components are flexible and determined by context. These verbal signs are the focus of this analysis because although they are fully incorporated into SL grammars, they share imagistic and analogue properties with co-speech gestures used by non-signers.

All verbal signs denote states or events, assign argument roles and behave syntactically as verbs, but the nature and status of the flexible analogue components of directional and classifier verbal signs are areas of intense debate in the literature. There are debates about whether or not the referential components of directional verbs can be analyzed as agreement morphemes like those found in some spoken languages. There are other debates about whether the referential handshapes of classifier predicates can be analyzed in the same terms as classifier morphemes found in some spoken languages. These discussions hinge on important questions regarding the degree to which definitions and analyses based on spoken languages can be applied to SL. The current analysis will have little to contribute to these questions. Instead the focus here is on questions about the relationships and particularly evolutionary relationships between language, or more narrowly grammar and gesture in SL.

Many analyses of the evolution of human language assume that modern syntactic language evolved from older gestural systems (Arbib 2012; Corballis 2003; Armstrong, Stokoe, and Wilcox 1995). The recent and very rapid emergence of *de novo* SL from home-sign systems have been used as models of how full languages could have evolved from gestural systems (Arbib 2012; Goldin-Meadow 2005). If directional and classifier verbal signs are gestural or are derived from gestures as some have argued (Liddell 2003), then analyses of verbal systems in modern SL may provide additional important insights into these evolutionary processes. Assuming that diachronic processes tend to produce directional language changes from states with relatively less to relatively more conventionalization, grammaticalization and lexicalization, verbal systems in SL would seem to reflect general linguistic evolutionary pathways from the most flexible and gesture-like classifier predicates to the most lexicalized plain verbs. But these directional pathways are only part of a much more complex picture. In fact, the various groups of verbal signs are better viewed as adaptive products of linguistic evolutionary processes in their own right, rather than intermediate stages along derivational pathways.

Linguistic evolution arises competence, function, usage and cognition at the level of individuals or language agents, and it is reflected in the diachronic processes of grammaticalization, lexicalization and conventionalization at the language level, but in the technical sense it is used here, linguistic evolution occurs strictly at the level of populations. What a linguistic evolutionary analysis of verbal signs requires is a set of conceptual tools

that allow all of the relevant components of verbal signs, from the most flexible and analogue to the most fixed and categorical to be analyzed in the same evolutionary terms. This is accomplished here using a framework of linguistic *micro*-evolution developed from Jablonka and Lamb (2014) and others (Dor and Jablonka 2010; Ritt 2004) that is adapted directly from general evolutionary theory. Linguistic micro-evolution is defined here as a dimension of non-genetic cultural evolution that involves changes in the nature and frequency of learned linguistic traits within a linguistic population over time. Linguistic populations are defined as summations of all of the members of a regional, social or cultural group who communicate with each other using the same language or variety. Not all learned linguistic traits are evolvable, and these traits may or may not correspond to traditional units of linguistic analysis like phonemes, morphemes or even larger syntactic and discourse level constructions. Those traits that are potentially evolvable are collectively referred to here as *operational units of linguistic selection* (OULS). A population evolves linguistically as the pool of OULS traits it contains changes over time.

The first step in this analysis involves identifying within verbal signs those elements that are potentially evolvable and distinguishing them from other parts of language that cannot or do not evolve on this scale. Linguistic evolution occurs at every level of organization, but this analysis is restricted to OULS traits within verbal signs representing learned networks of form, meaning and function. There will always be some variation in the form, functions and meanings of OULS traits with a population because of the ways they are used and learned. This variation is what linguistic evolutionary processes target, allowing a trait to express a broader range of values or alternatively restricting possible values within a narrow range. When different groups of verbal signs are analyzed in this way, some clear patterns emerge. Lexicalized or fixed traits have forms that are limited within narrow ranges, but these traits can be used to express relatively broader ranges of meanings or senses. Analogue or flexible traits are expressed within broader ranges of possible forms, but are restricted to relatively narrow ranges of possible meanings. These patterns are alternative methods for pairing form and meanings with verbal signs and each comes with trade-offs. Verbal systems in SL include potentially very large inventories of fixed verbal traits that are adaptive because they are highly evolvable and can change very quickly. They also contain relatively small inventories of flexible traits that are adaptive because they are highly plastic and so change very slowly.

The next section discusses previous analyses of verbal signs and their components, followed in section 5.3 with a presentation of the current linguistic micro-evolutionary framework. Section 5.4 decomposes verbal signs into basic types of OULS traits and analyzes the ranges of values or reaction norms for each group in terms of form, meaning and function. The conclusion and a discussion of further potential applications of this linguistic evolutionary approach to SL and gestural systems are presented in section 5.5.

5.2. What Is in a Verbal Sign?

SL are diverse, but most documented SL have evolved broadly similar verbal systems (Sandler and Lillo-Martin 2006; Aronoff, Meir, and Sandler 2005). This analysis will be

restricted to the evolution of these 'typical' verbal systems, using American Sign Language (ASL) to illustrate the relevant points. The reader is referred to Lillo-Martin and Meier (2011) and the accompanying articles for detailed discussions of current issues regarding sign language agreement and to Emmorey (2003) for discussions of classifier predicates in various sign languages from different theoretical perspectives.

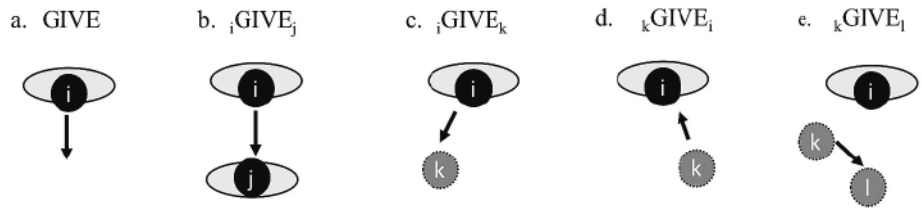
Across SL, the vast majority of verbs are mono-syllabic signs composed of handshape, movement and place of articulation (POA) or location parameters (Sandler and Lillo-Martin 2006; Brentari 1998). Because SL have both sequential and simultaneous morphology (Aronoff, Meir, and Sandler 2005), individual signs may be morphologically compositional. Setting aside additional issues of quantification and aspectual modification (Wilbur 2008; Metlay and Supalla 1995; Klima and Bellugi 1979), this allows for verbal signs composed of a single verb root, signs in which the handshape and movement represent the verb root with independnelty productive referential POA, and signs composed of referential handshapes and independently meaningful movements and POA. Their potential compositionality raises issues when developing verbal typologies for SL. Single verb roots may appear in both inflected and uninflected signs, and there are verbal signs without default forms. As a consequence, categories of verb roots may differ from categories of verbal signs that include verb roots and any other constituent parts. Despite differences in terms, there is general consensus that verbal signs fall into three broad groups. To distinguish verbal signs from verb roots and other constituents of verbal signs, verbal signs will be discussed first, and then in later sections these signs will be decomposed into their constituent parts. Each of these groups of verbal signs represents a distinct strategy for pairing form and meaning, and to avoid confusion with other labels these groups are labled P, D and C here.

The P group includes all verbal signs in which the handshape, movement and POA features represent lexically-specified phonological components of a single verb root. These signs are learned individually as units. This includes all instances of plain verbs but also all instances of uninflected or citation instances of directional verbs and frozen verbs derived from productive classifier predicates. Although the forms of many of the signs in this group are semantically motivated in some way (Wilbur 2008; Meir et al. 2007), this group includes relatively more signs with less iconic and more arbitrary features than the other two groups. The lexical status of these signs is not controversial, and these are the signs that are the easiest to describe and list in sign language dictionaries, glossed with their closest spoken language equivalents (i.e. EAT). Because their forms are fixed, these signs represent useful comparisons with signs in the D and C groups.

The D group of signs includes all instances of those verb roots termed directional, indicating and agreeing verbs that are inflected with directional markers. These signs are composed of a verb root with a lexically-specified handshape and movement features and independently productive referential POA, termed directional markers here (Sander and Lillo-Martin 2006; Brentari 1998). The signs in this group included directionally inflected variants of lexical spatial verbs (PUT, REMOVE), and also verbs of transfer (i.e. GIVE, SEND), communication (ASK, TELL), social interaction (HELP, SHOW), and visual perception (SEE, WATCH). The uninflected default variants of these verb roots are placed in the P group of signs. Directional markers referring to recipients, goals, beneficiaries or final locations of

these predicates in clausal Object position are obligatory. Sources or initial locations in Subject position are optionally marked (Cormier 2014; Sandler and Lillo-Martin 2006; Meir 2002). These directional markers direct the movements of these signs relative to the real or imagined locations in the signing space of referents assigned particular argument roles by the verb root. If the referent is physically present, the sign is directed towards that referent's actual position in space. If the referent is not present, the sign is directed towards an arbitrary referential location (R-loci) in the signing space associated with the referent within the discourse (Lillo-Martin and Meier 2011; Rathmann and Mathur 2011; Liddell 2011; Cormier, Wechsler, and Meier 1999). This is illustrated in the abstract in (1a-e) below assuming variants of GIVE:

(1) Variants of GIVE



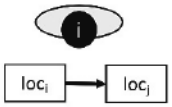
(1a) shows an uninflected default form of GIVE (a sign in the P group), contrasted with (1b) and (1c) in which the sign is inflected to refer respectively to a present referent and non-present referent represented by an R-loci as recipients of a transfer. In (1d) the signer is indicated as the recipient with a non-present referent as a source; the direction of sign is the reverse of that in (1b-1c). A transfer between two non-present referents is shown in (1e). Directional markers seem to share at least some of the functions of agreement morphemes found in many spoken languages and so were initially analyzed as agreement markers (Padden 1998; Fischer 1996). Subsequent syntactic analyses have supported these treatments (Wilbur 2013; Mathur 2012; Aronoff and Padden 2011; Lillo-Martin and Meier 2011; Rathmann and Mathur 2011; Quer 2011), but these systems in SL are very different from those in spoken languages (Cysouw 2011) and this treatment is controversial. Most influentially, Liddell (1995; 2003; 2011) has argued that because the forms of directional markers are analogue rather than categorical, they cannot be analyzed as grammatical agreement morphemes. Instead, given their similarities to deictic gestures, they should be analyzed as productive elements outside of the grammar.

The signs in the C group include those signs with referential grammaticalized handshapes, and independently meaningful and productive movement and POA components. All of these signs lack default citation forms, but their movements are generally analyzed as verb roots. These signs are referred to in the literature as classifier verbs, predicates or signs, as depicting verbs, verbs of motion and location, and poly-componential verbs. This group also includes the forms referred to as size-and-shape specifiers (SASS). The only parts of these signs that are lexicalized and fixed are the referential handshapes, which are organized into paradigms of morphemes that refer to arguments of these predicates as members of grammaticalized

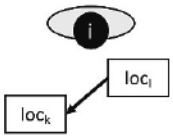
categories. These include: whole entities (i.e. vehicles, aircraft, animals); body parts (hands, wings, heads); the manipulation of an object with a hand or other grasping body part (mouth, claw); and the boundaries or dimensions of entities (flat, narrow, round, spherical). These handshapes have been analyzed as classifier morphemes (Zwisterlood 2013; Benedicto and Brentari 2004; Emmorey 2003), but because these elements in SL differ from classifier morphemes in spoken languages this treatment is debated (Aikhenvald 2008; Schembri 2003). Although they are restricted to expressing the location of the entity referred to by the handshape, the referential POA in these signs are sometimes referred to as markers of spatial agreement and analyzed together with non-spatial directional markers. They are flexible and analogue in the same ways and so both have been argued to be productive elements outside the lexicon (Liddell 2003; 2011). This line of reasoning also applies to the movements of these signs which together with the POA are used to depict the boundaries and dimensions of physical objects or the motion and locations of concrete entities in space. The relevant properties are illustrated with a whole entity classifier and are illustrated in (2). In (2a-b) the forms depict spatial paths or changes of location with movements in two different directions along the horizontal plane. In (2c) the form traces the manner of motion within a horizontal spatial plane but does not indicate changes in location over the course of an event:

(2) Whole Entity Classifier Predicates ( handshape)

a. 3:move.loc_i-loc_j
'the car moves from here to there'



b. 3:move.loc_k-loc_l
'the car moves from here to there'



c. 3:swerves
'the car swerved like…'

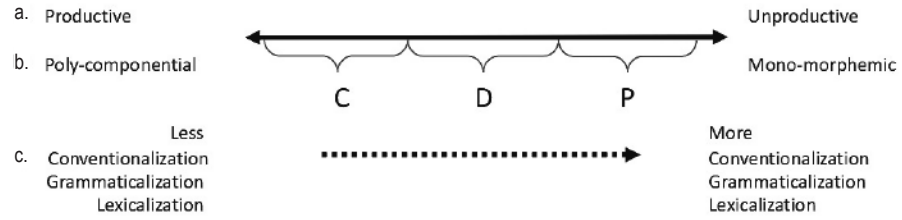
Although they have similar movements and POA, the variant of GIVE in (1e) and (2a-b) are semantically distinct. The movements in (2a-b) can only be interpreted as depicting spatial paths. The forms in (1b-e) denote transfers but these transfers may be of abstract entities and do not necessarily entail a spatial path between the source and recipient or a change in the location of the transferred entity. The recipients indicated in the final POA of (1b-d) are referred to as persons rather than locations; the initial and final POA in (2a-b) refer to locations of an entity in space. In (2c) the POA refers to the plane of motion rather than to particular locations within it. Although the POA in (1b-e) and (2) may be anywhere in the signing space, and the movements in classifier predicates like (2) may be in any direction, signs like these are well-formed. This is not the case for plain verbal signs whose lexicalized forms that cannot be productively modified in the same ways.

5.2.1. Approaches to Flexible Verbal Traits

The flexible components of signs in the D and C groups have raised questions as to whether these signs can be analyzed in the same terms as the fully lexicalized signs in the P group. These questions have been approached from different theoretical angles, not all of which are mutually exclusive. One approach to is to assume that verbal signs differ in the degree to which they are lexicalized and grammaticalized. Another is to assume that verbal signs are decomposable into some combination of linguistic and gestural or lexical and productive elements. A third approach is to decompose verbal signs entirely into linguistic traits, some of which exploit properties of space in the same ways that gestures do. Since these verbal signs and their parts must have evolved and must also be learned within SL, it is also possible that the verbal signs and systems in SL emerge from some combination of these options.

The three groups of signs identified above can be scaled relative to each other from the most to least productive (3a), from the most internally complex to mono-morphemic (3b), or from signs displaying the least to the most conventionalization, grammaticalization and lexicalization (3c):

(3) Verbal Signs on a Continuum



Diachronic processes of langauge change are cumulative and directional (Heine and Kuteva 2012; Brinton and Traugott 2006; Pfau and Steinbach 2006), so this continuum would seem to reflect a general pathway by which plain verbs are derived from directional signs and directional signs are derived from classifier predicates. Support for this pathway comes from plain verbs like DANCE and WRITE with forms clearly lexicalized or frozen from productive classifier predicates, and from directional verbs like GIVE and PUT which can be difficult to distinguish from handling classifier predicates despite their lexicalized verb roots. The fact that lexicalized forms can be productively reanalyzed or apparently delexicalized as productive classifier predicates (Sandler and Lillo-Martin 2006) however suggests that diachronic changes in SL are not always directional and that the derivational pathway represented in (3) is not the whole picture.

SL emerge wherever there is a sufficiently large Deaf population, but all documented SL are relativley young languages ranging in age from several centuries to only decades (Aronoff, Meir, and Sandler 2005). If diachronic processes are cumulative, and (3) represents a general derivational pathway by which typical verbal systems in SL emerge, the prediction would be that younger SL would have relatively small inventories of plain and directional

verbs and would rely heavily on classifier predicates. In older SL, classifier predicates and most directional signs would have been displaced by increasingly large inventories of plain verbs. This is not what has been found. Younger SL have relatively few sequential functional morphemes grammaticalized from lexical signs, but even the youngest have rich systems of sequential morphology of the sort required for classifier predicates (Aronoff, Meir, and Sandler 2005). Because plain verbs can be derived directly from gestures (Pfau and Steinbach 2006; Wilcox 2004) SL have both classifier predicates and plain verbs very early.

Many lexical verbs are derived or frozen from classifier predicates, but even the oldest SL retain productive classifier predicates. The loss of classifier predicates is extremely rare. In the single documented example, a village SL from Ghana named Adamorobe Sign Language (AdaSL), these signs appear to have been displaced with a system of serial verb constructions likely derived from the ambient spoken language (Nyst 2007). It is also very rare for SL to lack directional signs. Al-Sayyid Bedouin Sign Language (ABSL), a *de novo* village SL from Israel is one example (Sandler et al. 2005), possibly due to its very recent emergence. Mier's (2012) analysis of the emergence of directional markers in Israeli Sign Language indicates that directional signs are derived from existing plain verbs rather than classifier predicates, with markers indicating Objects emerging first followed by signs that mark both Objects and Subjects. If these findings can be generalized, they suggest that directional verbal signs evolve somewhat later than other verbal signs. It would seem to be the case then the frequencies of flexible verbal elements increase rather than decrease over time, even as inventories of fully lexicalized verbs grow larger.

Verbal signs within typical SL systems appear to emerge from multiple sources, rather than a single general pathway. Novel plain verbs can be created within SL as well as be derived from gestures and classifier predicates. Directional signs may be derived initialy from plain verbs, but once directional marking systems are in place, new directional verbs can be coined or derived from classifier predicates. New verbal traits are derived from whatever is available within the system, but what is available also changes over time. Rather than reflecting stages along a pathway, the continuum of verbal signs in (3) represents a product of multiple derivational processes operating in parallel. Groups of verbal signs are adapted for specific roles or niches within the context of other verbal signs within a particular SL. This would help to explain the diversity within documented SL, and also why SL with certain verbal systems do not seem to occur. Assuming directional diachronic changes and only the pathway in (3), it is possible to imagine hypothetical SL in which directional markers have been generalized across all plain verbs, or in which classifier predicates have been displaced by directional signs or in which all verbal signs have become fully lexicalized. Yet SL do not seem to evolve naturally in these directions.

Spoken utterances are often composites of lexical, grammatical and categorical content expressed through speech together with analogue and imagistic content expressed through co-speech gestures (McNeill 2016; Kendon 2004; Goldin-Meadow 2003). These co-speech gestures are similar to some of the flexible verbal components in SL, but in signed utterances all content is channeled through a single modality. This requires all levels of content to be organized and intergrated in SL differently than they are in spoken languages. Many accounts of flexible verbal signs argue that these signs represent combinations of linguistic and

gestural components, or alternatively of lexical and productive components (Lillo-Martin and Meier 2011; Rathmann and Mathur 2002, 2011; Liddell 2003, 2011). The nature of these combinations is debated, but all of these approaches attempt to address the fact that the forms of many signs display properties that cannot be represented lexically. This is referred to as the listability issue. Context-dependent aspects of meaning are not problematic, but the forms of flexible verbal signs reflect these aspects of meaning in ways that cannot be listed with individual entries in any plausibily-sized lexicon. Grammatical relationships between a verb and its Object are morphologically marked in many spoken languages but none of these agreement markers can be modified so as to refer to that Object in their actual physical position in a particular discourse context. These sorts of pragmatic contextual meanings are thus invisible or irrelevant for agreement morphemes, but they are expressed directly in directional markers.

Liddell (2003; 2011) argues for a conceptualization of language that encompasses the lexicon, the grammar and gesture as parts of a single system separated from each other by fuzzy and gradient boundaries. In this view, most analogue and imagistic aspects of meaning are expressed gesturally while categorical meanings are expressed using morphemes or linguistically. In SL, both categorical and analogue meanings are expressed with the same articulators and morphemes and gestures grade into each other. Verbal signs vary from the most lexicalized to the most productive, but all of these signs behave as verbs within the same system. Other approaches maintain distinctions between grammar and gesture as separate systems that interact with each other through interfaces. In order for flexible elements within verbal signs to participate in grammatical processes, they must be partially visible to syntax (Lillo-Martin and Meier 2011; Rathmann and Mathur 2002, 2011). This can be done by analyzing flexible traits as composed of a morpheme or bundle of grammatical features that is underspecified for both phonological form and semantic content. These missing pieces are provided in context through interfaces with gestural systems.

There are other approaches that analyze flexible verbal traits entirely in linguistic terms without reference to gesture. These accounts argue that rather than being gestural, flexible traits in SL through the interfaces between semantics and phonology (Wilbur 2013; Quer 2011). The phonological systems of spoken languages are constrained in ways that those of SL are not. In a spoken language, a 3rd person agreement morpheme can refer to anyone other than the speaker or addressee, but the actual referent of the morpheme is not represented in its grammatical features and cannot be reflected in its surface form. The phonological systems in SL allow these context-dependent meanings to be expressed in surface forms. The meanings that in spoken languages are inferred from context or expressed gesturally are in SL channeled through the phonological system. The forms and meanings of co-speech gestures and flexible verbal signs may be superficially similar, but only the latter are phonologically and grammatically structured.

5.3. Linguistic Evolution and the Evolution of Human Language

The current analysis argues that some of the questions regarding the verbal signs and systems in SL can be addressed in terms of evolutionary processes operating within individual

languages. The central assumption here is that evolution, in a technical sense, occurs in all systems that involve the differential success and survival of variation among heritable units of coded information (Jablonka and Lamb 2014; Dor and Jablonka 2010; Ritt 2004; Jackendoff 2002). These various inheritance systems may be otherwise entirely different, but general concepts from evolutionary theory first developed through analyses of biological evolution (Francis 2015; Pigliucci and Müller 2010; Mayr 2001) can be adapted and applied to non-genetic cultural inheritance systems. The focus here is on linguistic evolution, for more detailed but accessible overviews of biological evolution, the reader is referred to Mayr (2001), Francis (2015), and Dawkins (1976; 2005).

Not all changes represent evolution. Inanimate entities may change or transform over time and individual organisms develop over their lifetimes, but evolution occurs only at the population level. Very basically, biological evolution can be defined as changes in the frequences of alleles (gene variants) and alternative networks of interacting genes within a population over time (Jablonka and Lamb 2014; Mayr 2001). Populations, not the individuals within them, are the units that actually evolve. A biological population is a summation of all of the members of a group or species living in a region that are capable of interbreeding and producing fertile offspring (Mayr 2001). The definition of linguistic evolution adopted here parallels that of genetic evolution and is again defined as changes in the nature and frequency of acquired linguistic traits within a linguistic population over time. Humans are highly adaptable and mobile, so a linguistic population includes all of the individuals or language agents within a regional, social or cultural group who communicate with each other using the same language or variety that is acquired by new members from within the population. Each language is represented by at least one population, but populations may be composed of multiple sub-populations. Individuals may also acquire multiple linguistic systems and so may be members of multiple populations sequentially or simultaneously over their lifetimes. To help distinguish it from the evolution of human language itself as a species-level trait, the dimension and scale of evolution that is relevant here is termed linguistic micro-evolution. The same processes with enough isolation and time can produce macro-level changes resulting in new languages and dialects.

Linguistic micro-evolution occurs in all populations, but only within the constraints of the biologically evolved, language-ready brain shared by all modern human populations (Arbib 2012). All human populations have inherited the same genetic recipes to build and maintain the same modern brains from a shared ancestral population of early *Homo sapiens* who emerged in Africa an estimated 300,000 to 200,000 years ago (Seddon 2015). It is impossible to determine with any certainty what sorts of linguistic capacities the pre-modern ancestors and extinct cousins of modern humans with *Homo* may have had, but the evolution of the modern language-ready brain likely stretched over many thousands or hundreds of thousands of years. The evolution of language and the modern brain likely involved a positive feedback loop in which changes in the brain allowed for changes in communication systems, which in turn selected for further changes in the brain. Language-ready brains allow populations to evolve full human languages from more limited systems very quickly, as demonstrated by the emergence of *de novo* SL (Meir et al. 2010; Sandler et al. 2005; Senghas et al. 2004, 2005), but linguistic evolution requires a population. Individuals who

are unable to access the culturally-transmitted components of language cannot develop full languages on their own, as home-sign systems demonstrate (Goldin-Meadow 2005). Natural languages are diverse, but they are all equally expressive and adaptive. Any differences in relative linguistic population size or distribution are attributable to historical and geographic factors, not to properties of indivdiual languages. Because linguistic selection occurs within rather than between populations, languages themselves as abstract entities are not possible targets of selection. There is no mechanism by which acquired linguistic traits can alter genes. This prevents one population from evolving linguistic capacities that are not already shared by all other populations. The term evolution may be used informally to imply progress or improvement. In its technical sense, evolution is not directed and does not work towards any sort of goal or ideal. It operates on whatever traits are available and preserves what works. As a consequence, it does not even assume changes from simpler to more complex states.

The definition of linguistic micro-evolution offered here parallels that of biological evolution, but the two systems are different in terms of their units of inheritance and their units of selection. Humans, like all other sexually reproducing species evolve because there is genetic and phenotypic variation within populations resulting from random mutations and through the recombination and shuffling of parental genes that occurs during reproduction. Each individual recieves roughly half of the genes in their genotype from each parent. Genes are units of biological inheritance that multiply when they are copied and then physically transmitted from parents to offspring. Through extremely complex interactions with their environment, each genotype produces a unique phenotype representing the composite of all of an organism's physical and behavioral traits. In humans this includes cultural and linguistic traits. Phenotypic traits may be entirely genetically or environmentally determined, but most result from a combination of genetic and environmental factors. Most traits are also products of networks of interacting genes and most genes contribute to multiple traits (Francis 2015; Jablonka and Lamb 2014; Dawkins 1976). Counterintuitively, these interactions mean that innate traits may not be universal, and universal traits may not be innate. This may have important implications for debates about the innateness of language and linguistic universals as well as gesture.

Phenotypic traits interact directly with the environment and are potential targets of selection pressures. They are units of selection, but not units of biological inheritance. No phenotypic trait that an individual acquires over their lifetime can be transmitted genetically to offspring (Francis 2015; Jablonka and Lamb 2014; Mayr 2001). Traits that are favored by a particular environment provide their owners with reproductive advantages, allowing them to pass on more of their genes to the next generation relative to other individuals with other genes that produce different traits. This produces differential success among the genes with a population, with some increasing and others descreasing in frequencey over time (Francis 2015; Jablonka and Lamb 2014; Mayr 2001).

5.3.1. What Does and Does Not Evolve Linguistically

Linguistic micro-evolution occurs only within linguistic populations, but human language is extremely complex. Many components of language either do not or cannot evolve within

individual populations. Without material units of inheritance equivalent to genes, a major challenge for analyses of linguistic evolution involves identifying which traits are evolvable, referred to here as OULS traits, and distinguishing them from other non-evolving components of language. For example, the modern human brain, hands, vocal track and the visual and auditory systems are biologically evolved traits. These traits that change as they develop within individuals and vary within populations but these do not evolve within linguistic populations. Basic properties of the physical world such as spatial motion and location also change over time but do not evolve in any dimension.

The modern human faculty of language is an evolved species-level trait that is universal across all populations of modern humans. There is considerable discussion and debate regarding the nature of this faculty, its evolution and the degree to which the brain is specialized for language (Botha and Everaert 2013; Arbib 2012; Fitch 2010; Bickerton 2009; Christiansen and Kirby 2009; Corballis 2003; Armstrong et al. 1995), but these issues are beyond what linguistic micro-evolution can address. Whether it is considered part of language or a separate faculty, modern human gesture has co-evolved with language, and many aspects of gesture appear to be evolutionarily older than and likely precursors of modern language (Arbib 2012; Tomasello and Call 2007; Corballis 2003; Armstrong et al. 1995). This analysis assumes that the modern faculties of language and gesture, whatever they contain, must include all of the systems necessary for the acquisition and use of natural languages and gestural systems. These systems are conceptualized as evolved networks linking the perceptual and articulatory systems and the conceptual and intentional systems (Dor and Jablonka 2010; Jackendoff 1997, 2002, 2007).

Each of these networks is composed of distinct systems and sub-systems that operate in parallel, with each processing inputs and generating outputs in its own format and following its own principles of combination. In order to have evolved from prior less expressive systems and to develop within individuals, these networks must be modular but tightly integrated with each part of the system developing along its own genetically-governed pathway (Dor and Jablonka 2010).

These basic networks become elaborated and refined through learning. Learned traits represent small-scale interface rules and sub-networks of interactions within the broader linguistic and gestural systems (Jackendoff 2007). Not all learning involves linguistic traits that can evolve linguistically, so OULS traits represent only a sub-set of all the acquired traits relevant for language (Ritt 2004). All of the language agents within a population vary in their developmental histories and so also in their linguistic competences and behaviors. Some of this variation is in the form of OULS traits which multiply when they are performed and then are learned by other agents. OULS traits may be transmitted horizontally among peers as well as vertically between generations, but because they are learned as units, they are heritable and persist over time. Some OULS traits will be performed and learned more frequently than others, either by chance or because they have properties that offer advantages over competing traits in particular contexts (Jablonka and Lamb 2014). This produces differential success among the OULS traits within a population, and as new traits are introduced and existing traits are modified or fall out of use, the pool of OULS traits within a population will change. For these reasons, OULS traits represent both linguistic units of

inheritance (what multiplies) and the units of selection (what is favored or disfavored) (Jablonka and Lamb 2014; Dawkins 1976).

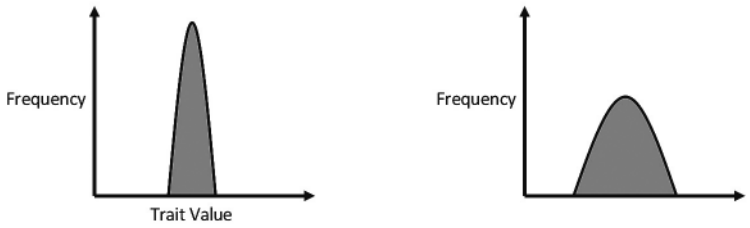
New OULS traits or variants may be introduced into a population through the creative recombination of existing elements, through the reanalysis or inexact reconstruction of a trait during learning, or through flow from one population into another. Once a trait is present, its success within a population depends on processes of drift and selection. Drift refers to chance non-adaptive changes, when one trait simply happens to multiply more frequently than otherwise equally adaptive traits. Most evolutionary changes within languages are likely due to drift, meaning that many changes will not alter function. Through selection, one OULS trait or variant is favored over alternatives in a particular environment because of its phonological, grammatical and/or semantic properties. Positive selection increases the likelihood that a trait will be expressed and then learned; negative selection does the opposite. Language use is goal-directed with agents assessing the relatively communicative values of individual traits and then exercising some control over when and if to express them. This means that linguistic evolution is not directed by language agents, but it is not entirely random (Jablonka and Lamb 2014). All successful OULS traits represent trade-offs among selection pressures pushing in different directions. Traits with higher information potential will be selected over those with less. Traits requiring lower processing effort either to use or to acquire will be selected over those requiring more. The social value of a trait may also enhance or decress its success (Dor and Jablonka 2010).

5.3.2. The Lexicon(s) and Inventories of Acquired Traits

As discussed above, the lexical status of flexible verbal signs is a major issue of debate. The analyses proposed by Liddell (2003; 2011) argue for a narrow conceptualization of the lexicon and its contents, but also gradient distinctions between lexical and productive traits. Other accounts, including Jackendoff (2007), argue for a much broader lexicon containing all parts of language that must be stored in long-term memory. Any analysis of verbal signs in SL must offer an account of the listability issue. At the same time, analyses of lexicon in any language must eventually address the problem of polysemy, in which individual lexical items are able to express multiple semantic senses (Pustejovsky 1998). An evolutionary approach offers new ways of addressing these questions, recognizing three distinct sorts or levels of the lexicon. At a type-level, a lexicon represents an inventory of all the lexemes, morphemes and syntactic constructions of a language. The contents of type-level lexicons are treated as idealized abstract entities which are stable over time and independent of the agents who use them. Type lexicons are not intended to represent the lexicons of individual agents or all of the components of a language. An agent-level lexicon in contrast contains only those items that a particular agent has actually learned. An agent-level lexicon changes as the agent learns and develops and may never include all of the items included in the type lexicon of a language. Differences in learning environments and the products of reanalysis and recombination will produce variation across the agent-level lexicons within the same language and variation in the representations of individual traits across agents. The aggregation or pool of all the acquired traits within populations represent population lexicons which evolve over time.

Treating type, agent and population lexicons separately offers a systematic way to account for the notion that lexical items are discrete units shared across a population but also for gradient boundaries between lexical or categorical and productive traits within a language. Traits vary across populations because of the ways that they are used and learned. Linguistic traits are used productively and creatively, so the same underlying trait will naturally be expressed with some variation in form, meaning and function. Traits are copied when they are expressed by one agent and then reconstructed from context and learned by others. Each copy of a trait will be reconstructed from different inputs in different contexts, so these copies will not be identical across the population. It may not be possible to list all of the possible variations in form for flexible traits in type lexicons, but this is not a problem for population lexicons where variation in form, function and meaning in the copies of the same trait across a population are expected. Across a population a single trait will be expressed within a range of values in form, meaning and function. These ranges are analyzed here as linguistic reaction norms, extending a concept from biological evolution referring to the range of phenotypic values that can be expressed by a particular gene or gene network (Francis 2015; Mayr 2001). A reaction norm may be relatively narrow, with values clustered tightly around a mean (4a), or relatively broad (4b):

(4) Reaction Norms



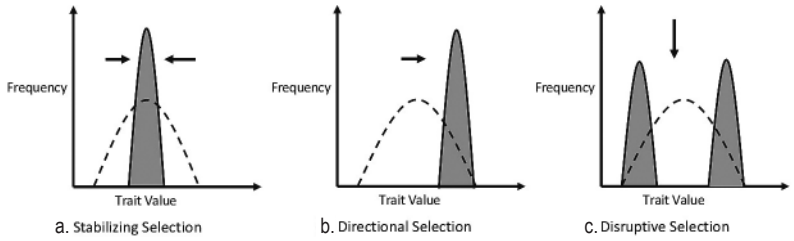
a. Narrow Reaction Norm b. Broad Reaction Norm

The forms of fixed verbal traits correspond to narrow phonological reaction norms, where possible well-formed variants fall within a narrow range, and values outside of this range are either ill-formed or represent other traits. The forms of flexible verbal traits are also phonologically constrained, but have much wider ranges of well-formed variants. The reaction norms of semantic values follow the reverse pattern. Traits with fixed forms may be semantically flexible and polysemous while traits with flexible forms are constrained within much narrower ranges such as spatial path and location. Plain verbs and classifier predicates represent the extremes of these two form/meaning mapping strategies. Co-speech representational gestures also have reaction norms of form and meaning, but both are very broad. This flexibility allows gestures to express a wide range of meanings with the same form, or the same meaning with a wide range of forms. As a consequence, the possible interpretations of these gestures out of context are far less constrained that those of verbal signs.

Reaction norms of OULS traits are constrained because they are ongoing targets of

selection processes, of which there are three basic types (Francis 2015):

(5) Selection Processes with Reaction Norms



Stabilizing selection (5a) favors mean values over extremes and maintains the status quo. Because divergent variants are constantly being produced, this process must be continuous. This represents the population level correlate of the productions of conventionalization, grammaticalization and lexicalization processes at the language level. Directional selection (5b) shifts a trait over time towards an extreme end of its initial range. This corresponds to phonetic erosion, semantic loss and changes in grammatical categories associated with grammaticalization (Heine and Kuteva 2012). Disruptive selection (5c) favors extreme over intermediate values, splitting a single initial trait into two or more. This process would correspond to the evolution of phonological and grammatical categorical distinctions, and the derivation of linguistic from initial gestural traits. The results of both directional and disruptive selection processes are maintained by stabilizing selection. The next section applies these notions of OULS and reaction norms to verbal signs.

5.4. Decomposing Verbal Signs into Operational Units of Linguistic Selection

All verbal signs of all types are assumed here to be products of linguistic evolution. The goal of this section is to identify within groups of signs the relevant types of OULS traits. These OULS traits may or may not represent morphemes, but each sort of OULS will have phonological, semantic and syntactic reaction norms. These traits are identified using criteria developed from Ritt (2004) and Jablonka and Lamb (2014). To qualify as a potential OULS trait, a candidate must vary across linguistic populations, within populations or within the same population over time. Candidates that vary across contexts or which change as they develop within individual agents do not necessarily pass this test. This test is intended to eliminate candidates that are innate or otherwise invariant, as they cannot evolve within populations. The candidate must also multiply within a population through transmission and learning as a unit, with copies being minimally faithful to originals. This test is intended to distinguish individual traits from well-formed compositional structures generated on-line, but this test does not specifically target morphemes. Idioms and other multi-morphemic constructions and gestures may pass, as long as they are learned and later used as units. Candidates that are conventionalized and shared across a population pass this test, but minority traits may also pass as long as they produce at least one copy of themselves.

Finally, candidates must display differential success. A candidate must have properties that either positively or negatively impact the likelihood that the trait will be expressed in particular contexts and thus potentially be learned. If they have been incorporated into linguistic systems, even traits that have evolved through drift pass this test. Constraints on grammatical function, phonological form and meaning are evidence of differential success. A candidate must pass all three tests to qualify as an OULS trait.

5.4.1. OULS Tests and Verbal Signs

If the tests of variation, multiplication and differential success are applied to the three groups of verbal signs presented above, only the signs in the P group pass as individual OULS traits. The signs in the P group vary across SL, they are learned as individual items and their interactions within the system are constrained phonologically, syntactically and semantically. Directional and classifier signs in the D and C groups fail the multiplication test because they are not learned as individual units. This is expected for these signs if they are compositional. The uninflected or default variants of directional verbs, representing verb roots, are placed in the P group and so these traits pass the multiplication test. This is also true for the grammaticalized handshapes of classifier signs, which are also learned as individual grammatical morphemes. This indicates that these signs need to be further decomposed and their constituent elements tested separately. This will be done in a later section. The analysis of plain verb roots is presented below illustrated using the highly iconic verb EAT, followed by discussions of whole entity and handling classifier handshapes as grammatical morphemes.

The sign EAT in ASL and the equivalent signs in other SL have forms that are very similar all of which are presumably derived from non-linguistic gestures mimicking putting food in the mouth (Meir et al. 2007). Based on these similarities across signing and non-signing populations, these iconic signs would seem to fail the variation test, but even highly iconic signs are evolvable. Despite the similarities in form and meaning between signs and gestures, signs like EAT are learned as verbs and are bound by linguistic constraints. There are phonologically ill-formed variants of EAT, and a range of well-formed variants that vary from the default form in constrained ways. The sign may be articulated at or near the signer's mouth but depending on context and the signer's posture, acceptable variants may be lower or articulated further from the default POA. Otherwise similar gestures however must be produced near the mouth to be reliably interpreted as 'eat'. These gestures are not grammatically or semantically constrained allowing the same form to express meanings like 'hungry?' or 'food' and other forms depict 'eat' as well. The similarities between the forms and meanings of EAT across SL and gestures for 'eat' are attributable to invariant properties of the human body and experience. All human populations consume food by bringing it to the mouth using the hands, with or without other utensils. Any gestures depicting this general concept will be similar across populations, as will linguistic forms that have been derived from them. These derivational processes involve reanalyzing existing gestures linguistically. They take on grammatical properties that determine their interactions with the linguistic system and their phonological and semantic reaction norms are narrowed, but these constrained ranges fall within the broader ranges of form and meaning of the

gestured from which they are derived. These OULS traits are indicated with curved brackets or {EAT}. Other lexicalized verb roots can be analyzed in a similar way whether they are derived from iconic gestures like EAT or are products of other lexical creation mechanisms (Brinton and Traugott 2006).

The grammaticalized handshapes of whole entity classifiers vary across SL and may be arbitrary forms. In ASL, these morphemes include handshapes referring to vehicles.

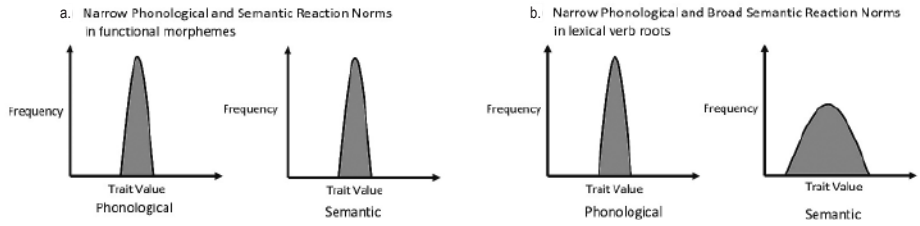
For ASL, these include handshapes referring to vehicles (3 or Z), aircraft (ILY or h), upright entities (1 or B) and animals (bent V or b). These morphemes must be learned as individual units and as members of grammaticalized paradigms within a particular SL. There are rather strict constraints on possible forms and on the categories of referents to which each handshape can refer. Each handshape represents an individual OULS trait, for example {3-vehicle} and {ILY-aircraft}.

The handshapes of handling classifiers, which express the grasping and manipulation of one entity by another (C or <; baby C or L; O or A; flat O or I and others) also pass the tests of multiplication and differential success, but their forms are similar across SL and also similar to gestures depicting handling and grasping. As with EAT above, these forms are grounded in human anatomy and experience and so tend to be similar across populations. This is also true for handshapes that express the grasping of an object with claws, paws or mouths. These forms are products of the linguistic reanalysis of handling gestures, but their iconicity is conserved. Deriving handling classifier handshapes results from disruptive selection processes that split continuums of gestural forms, for example that between <to A, into discreet ranges separated by categorical distinctions. The resulting forms are identified as either variants of the C handshape or variants of the O handshape, or {C-handle} and {O-handle} respectively. These results for lexicalized verb roots and classifier handshapes as grammatical morphemes are not surprising. What these tests indicate is that these units are individually evolved OULS traits. For handling classifier handshapes, like lexical verb roots derived from gestures like {EAT}, the forms and meanings expressed by these linguistic traits are narrower than those of gestural depictions of grasping produced by non-signers. These morphemes have evolved phonological and syntactic constraints on their interactions within linguistic systems that do not apply to ungrammaticalized gestures.

Classifier predicate handshapes are grammatical morphemes. Whole entity handshapes refer to the single participants in spatial events as members of one of a limited set of grammatical categories. Handling handshapes express some information about the size and shape of the object being manipulated and about the body part of the participant doing the manipulating (Benedicto and Brentari 2004). These ranges of meaning can be expressed as narrow semantic reaction norms, paired with narrow phonological reaction norms reflecting the tight constraints on their possible forms. Lexical verb roots are composed of handshape, movement and POA features, each of which can be represented in a separate reaction norm allowing even the most conventionalized of verb roots some flexibility of form. With fixed forms that do not express context-dependent aspects of meaning, lexical verb roots are able to have rather flexible and extendable meanings. A sign like EAT can be used to refer to any sort of consumption with the mouth (i.e. eating sandwiches, soup, noodles, fruit, and so on). Both grammatical morphemes and verb roots have narrow syntactic reaction norms.

Their phonological and semantic reaction norms pattern as follows:

(6) Reaction Norms for Grammatical Morphemes and Verb Roots



Paradigms of classifier handshapes seem to emerge rather quickly in SL (Senghas et al. 2004, 2005) and then reach a point of stability after which they change much more slowly. This is true for closed class grammatical morphemes in general, which evolve much more slowly than open class lexical morphemes. Inventories of grammatical morphemes also tend to be rather small compared with the large inventories of lexical verb roots which are continously added to and modified.

5.4.2. OULS Tests and Flexible Verbal Traits

This section focuses on the flexible components of signs in the D and C groups: directional markers, and the movements and POA of classifier predicates. These flexible verbal elements tend to be very similar across SL and to gestures used by non-signers that indicate referents in their physical positions and to depict size, shape and motion. If these elements qualify as OULS traits, there is the issue of determining what sorts of traits are required to produce the sort of forms found in D and C group signs. The argument here is that if these flexible elements of verbs are understood as expressions of underlying OULS traits, these traits are listable in principle, even when their possible surface forms are not. We begin with directional markers in the D group.

There are two ways to demonstrate that directional markers pass the variation test, despite their similarities across SL. First, the similarities in directional verbs and directional makers across the vast majority of documented SL suggest that these markers are in some sense an adaptation to the visual/motor modality. However, one SL has been documented without a system of directional markers, Al-Sayyid Bedouin SL (ABSL) (Arbib 2012; Sandler et al. 2005). This *de novo* village SL is very young, but it has not evolved directional markers on its own or borrowed them from the other SL in the region with which it is in contact. The second piece of evidence comes from Israeli SL (ISL), another very young SL (Meir 2012). In ISL the evolution of a typical directional marking system has been worked out in some detail using the production from three generations of signers representing different periods in the emergence of this community SL. A minority of signers in the oldest cohort produced directional signs marking both Objects and Subjects. In younger cohorts, Object marking became increasingly frequent, followed later with signs marked for both Objects and Subjects. As in many other SL, directional markers in ISL are constrained to

particular verbs including verbs of transfer, communication and social interaction and Subject marking is optional. These findings from ABSL and ISL demonstrate that directional makers pass the variation test, with these markers absent in one SL and developing over time in the other. Directional markers also pass the multiplication test, since they are compatible with only a sub-set of all verb roots and those verb roots must be learned individually. The fact that directional verb roots are uninflected in some contexts and that there are plain verbs that do not appear with directional markers in any context demonstrate that these traits pass the test of differential success as well.

The data from ISL suggest that these OULS traits evolve through a directional selection process in which traits that were initially only in the minority are selected for and then spread until they dominate the population. However, as Liddell (1995; 2003; 2011) has pointed out, directional markers encode aspects of location and spatial representations that not only cannot be encoded in the lexical verb roots but which are outside the grammar. In the terms of the current framework, these parts of directional verbal signs are invariant and cannot evolve linguistically. What seems to have evolved are ways of structuring the forms of directional signs to encode these aspects of contextual meaning in directional markers. Given that directional markers are sensitive to the semantics of verb roots and argument roles, a likely scenario involves these markers initially appearing as modifications of individual verb roots like GIVE, and then later being reanalyzed and generalized across verbs in particular semantic fields with particular argument roles. These markers have not been further generalized to all Objects or all Subjects in any documented SL. If this scenario is on the right track, then directional markers referring to recipients, beneficiaries, goals and sources would likely represent distinct OULS traits, represented here as {dm:recipient}, {dm:source} and so on. Once OULS traits of this kind had been derived they would automatically be applied to all new verb roots with the requisite argument structures. This scenario allows for individual verb roots, for example backwards verbs like COPY and TAKE to evolve and retain their own markers. In this view, inventories of individual SL may include dozens of distinct directional marking OULS traits. In combination with verb roots each of these traits marks particular argument roles, but with their flexible forms are able to indicate the referents of these roles either in their actual position in space or through R-loci.

Because they lack default forms the classifier signs in the C group raise a number of questions that cannot be addressed in any detail here, so the focus of this discussion will be on classifier predicates encoding spatial paths and manners of motion. These classifier signs are again very similar to co-speech representational gestures used by non-signers. It is in fact difficult to evaluate the movement and POA components of these signs separately against the OULS tests. Directional markers associated with lexical spatial verb roots like PUT pass as OULS traits as discussed above, so it is possible that some POA in classifier signs pass these tests for the same reasons. If this is the case, then the movement and POA of these signs may represent separate OULS traits. Alternatively, spatial paths semantically represent changes of location over time, in which case the movements and POA of signs encoding spatial paths may represent a single OULS trait. In signs encoding manner of motion, the POA may represent an OULS trait distinct from the movement.

As discussed above Adamorobe SL (AdaSL) is an extremely rare example of a SL without the sort of classifier system found in most other SL (Nyst 2007). AdaSL provides some evidence that classifier signs, and by extension their constituent parts, pass the variation test. AdaSL signers use serial verb constructions in contexts where other SL use classifier signs, and this is likely due to contact with the surrounding spoken language (Nyst 2007). Whatever the case, with regards to classifier signs, AdaSL indicates that variation is possible and that at least in the environment in which this SL evolved classifier signs can be targets of negative selection pressures. The near universality of classifier signs however suggests that these signs, like directional markers do not occur in SL by chance but rather are adaptations to the visual/motor modality.

The emergence of classifier predicates from gestures in Nicaraguan SL (ISN), a *de novo* community SL, provides additional evidence (Arbib 2012; Senghas et al. 2004; Senghas and Coppola 2001). Gestures representing spatial motion can depict paths ('down') or manners of motion ('rolling') or both simultaneously. In contrast, it is apparently impossible to lexicalize path and manner together in the same morpheme even if they are temporally and conceptually simultaneous. The movements in the classifier predicates produced by the founding members of the ISN population (cohort 1) included forms conflating both path and manner. The later cohorts 2 and 3, by which point ISN was a fully developed SL, these movements are restricted to encoding either path or manner but not both within the same sign. To compensate for this limitation, ISN signers like those in other SL can employ a series of path and manner classifier signs. These findings demonstrate varation between the movements of classifier signs and gestures, but also variation over time within ISN. Despite their iconcity, classifier signs are mastered relatively late by L1 signers and they are rather difficult for hearing L2 learners of SL to acquire (Emmorey 2002; 2003). Some of these difficulties may be attributable to their morphological handshapes, but these findings demonstrate that these signs pass the multiplication test. They must be learned, and they must be learned as a system. The differential success of these signs can be demonstrated with comparisons of lexical verb roots derived or frozen from productive classifier signs and the reanalysis of these lexicalized signs as productive classifier signs (Sandler and Lillo-Martin 2006). The freezing of plain verb roots like WRITE from productive classifier signs shows that at least for some functions, lexical verbal signs are favored over classifier signs. The on-line reanalysis or 'thawing' of these lexical verb signs into productive classifier predicates demonstrates that the reverse is also the case for other functions.

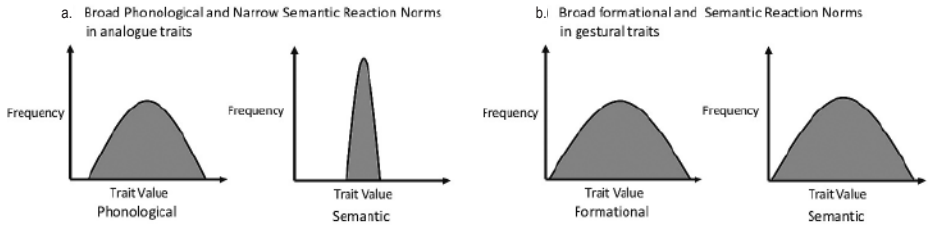
As with the physical positions in space of the referents of directional markers, there are aspects of the meanings of classifier signs that cannot evolve linguistically. The notions of spatial motion, velocity and direction are invariant properties of the physical world. Any forms that represent these notions in analogue or iconic ways, as classifier signs do, will necessarily be very similar across all populations, whether they are gestural or linguistic in nature (Emmorey and Herzig 2003). Since all other meanings and functions in SL must be expressed in the same modality, this creates a challenge for these languages. Not all directional movements encode spatial motion, so SL must evolve ways of ensuring that possible interpretations of an utterance are adequately constrained. Classifier signs with closed inventories of grammatical handshapes but flexible movements and POA restricted to spatial

meanings are a way of doing so that almost all SL have evolved and maintained. Signs outside these classifier predicate systems with similar movements and POA may have multiple senses, including spatial senses. Classifier signs in contrast are restricted to only spatial interpretations.

Relatively few distinct OULS traits are required to do this. The evidence from ISN indicates that movements depicting path and manner are separately targeted in whole entity classifier predicates, representing minimally two OULS traits provisionally represented here {spatial.path} and {manner.motion}. In practice these traits can be paraphrased as 'moves to' and 'moves like'. Handling classifiers also encode spatial paths or manners but on a different spatial scale from whole entity classifier signs and may involve different OULS movement traits. Body part classifier signs depicting the motion of a part relative to a whole likely involve other movement OULS traits as well. Signs depicting physical boundaries, sizes and shapes with movements would also require a distinct set of OULS traits. Regardless of how many distinct OULS traits are involved in classifier systems, each is restricted to expressing a narrow range of spatial meanings, like path or manner of motion. Within these ranges however, the possible forms of each trait are flexible enough to express all of the context-dependent aspects of meaning. For example, together with an appropriate handshape, the movement of a whole entity classifier sign can depict spatial paths over any distance in any direction, but not movements of part of the entity relative to the whole, or its size and shape within a single sign.

The flexible components of classifier signs and the directional markers discussed above have broad phonological reaction norms, paired with narrow semantic reaction norms (7a):

(7) Reaction Norms for Flexible Verbal Traits and Gestural Traits



The forms and meanings of these flexible verbal traits may be similar to those expressed gesturally by non-signers, but the corresponding reaction norms for gestures are not constrained in the same ways (7b). Co-speech gestures are functional, but in non-signing populations are not targeted by the same linguistic selection pressures that target verbal signs and their components in SL. As the emergence of ISN shows, gestural traits may become targets of linguistic selection pressures and new linguistic traits may be evolved from them very rapidly. In non-signing populations gestural traits may be targets of gestural selection pressures, but they do not represent OULS traits and are bound by grammatical constraints. Their adaptive values come from their flexibility. In contrast, in SL the adaptiveness of flexible verbal OULS traits arises in part from the semantic constraints on their possible meanings.

5.5. Conclusions

This analysis has presented a brief look at how notions adapted and extended from general evolutionary theory can be usefully applied to the linguistic micro-evolution that takes place within individual linguistic populations. On this view, fixed and flexible verbal traits represent alternative strategies for pairing form and meaning that are available in the visual/motor modality that the verbal systems of natural SL have evolved to exploit. Fixed or lexicalized forms allow for flexible meanings or polysemy across contexts. Flexible forms do not allow for polysemy, but instead allow a sign to express context-dependent meanings with a narrow semantic range. All of these verbal traits are grammaticalized in the sense that their interactions with other traits within the system are grammatically constrained, and as a consequence their possible interpretations are also constrained. These traits are also grammaticalized in the sense that within these grammatical systems they are targets of linguistic selection pressures as OULS traits. These OULS traits may be expressed with forms and meanings that are similar to gestural traits used by non-signers, but these gestural traits are not targets of the same linguistic selection pressures. As a consequence, the possible interpretations of gestures are much less constrained out of context than those of verbal signs. Inventories of verbal OULS traits with fixed forms are open-ended and may be potentially very large. These traits are adaptive because they are highly evolvable. New traits can be created and existing traits can be modified as needed and both spoken languages and SL exploit this form/meaning mapping strategy. SL also include relatively small inventories of grammaticalized but very productive traits with flexible analogue forms. These traits are adaptive because they are highly plastic; the form of the same underlying trait can be adjusted to express all of the meaning values within their respective semantic range without requiring any changes to the underlying OULS trait itself. With this plasticity, once these traits have been incorporated in a SL grammar, they evolve very slowly.

This brief proposal presents a rough sketch of some of the possible applications for a linguistic micro-evolutionary approah to some long-standing questions regarding verbal systems in SL at the population level by identifying general kinds of OULS traits within verbal signs. Despite its name, this framework does not attempt to trace the etymological histories for individual elements. Instead, this proposal analyzes the fixed and flexible components of verbal signs in terms of reaction norms as alternative strategies for mapping meanings onto forms that are available to SL. Linguistic micro-evolutionary processes are universal, but can only target existing OULS traits at the population level. There are properties of the visual/motor modality and spatial properties of the physical world that do not evolve linguistically, but many SL have evolved parallel ways of exploiting these invariant properties within their respective grammatical systems. The community attributes of SL populations are also relevant for their evolution. The populations of Community SL like ASL and ISL are largely composed of unrelated Deaf people. These SL populations tend to evolve typical verbal systems with similar mixes of fixed and flexible OULS traits relatively quickly. The populations of Village SL are quite different. These populations tend to be isolated and composed of closely related Deaf and hearing members. In these environments, at least some SL populations evolve verbal systems that are atypical relative to those of Community

SL. By distinguishing evolvable traits from invariant elements and taking the community attributes of a population into account, a linguistic micro-evolutionary framework may offer ways of explaining some of this variation across SL. This approach may also be relevant for analyses of human language from gestural systems (Arbib 2012; Corballis 2003; Armstrong et al. 1995). This analysis argues that the flexible linguistic traits evolve in modern SL as stable adaptive strategies for expressing certain meanings and not intermediate stages along pathways leading to traits with fixed forms like lexicalized verb roots.

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