Nat Lang Linguist Theory
DOI 10.1007/s11049-011-9128-2

The gradual emergence of phonological form in a new language

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Received: 24 March 2009 / Accepted: 2 December 2009

Abstract The division of linguistic structure into a meaningless (phonological) level and a meaningful level of morphemes and words is considered a basic design feature of human language. Although established sign languages, like spoken languages, have been shown to be characterized by this bifurcation, no information has been available about the way in which such structure arises. We report here on a newly emerging sign language, Al-Sayyid Bedouin Sign Language, which functions as a full language but in which a phonological level of structure has not yet emerged. Early indications of formal regularities provide clues to the way in which phonological structure may develop over time.

Keywords Phonology · Duality of patterning · Sign language

In the middle of the last century, André Martinet and Charles Hockett discovered a notable feature of human language that Martinet (1960) called *double articulation*

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Published online: 23 April 2011

and Hockett (1960) called *duality of patterning*, and which the latter identified as the last of his thirteen design features of human languages. Duality of patterning, which is found in all known spoken languages and not in the natural communication systems of animals, is the existence in a linguistic system of two levels of combinatorial structure. At the first level, meaningful elements (morphemes and words) are combined into larger meaningful units; at the second level, phonology, meaningless elements (speech sounds) are combined to form the sound signals of the meaningful elements of the first articulation.[1]

The combination of morphemes and words is no surprise. There is no other way to develop a system for expressing meaningful propositions. But the fact that, at the sound level too, words are made up of combinations of elements is certainly noteworthy, as both Hockett and Martinet emphasize. Here is how duality of patterning works, taking Hockett's own example: the meaningless English speech sounds /t/, /æ/, and /k/ are combined at the phonological level to form the signals of meaningful elements: /tæk/ (*tack*), /kæt/ (*cat*), and /ækt/ (*act*). The independence of the phonological level of structure in language is seen not only in the recombination of sounds but in their internal structure (e.g., features, feature classes, hierarchies) and in their behavior in the system (systematic alternations). For example, in English, nasal sounds assimilate from adjacent stops features belonging to the place of articulation class: *beanbag* becomes *bea*[*m*]*bag*; *greengrocer* becomes *gree*[ŋ]*grocer.* The meaningless level of structure is the phonological level, and its existence is evidence for duality of patterning, so that use of the terms *duality of patterning* and *phonology* or *phonological level of structure* are in some ways interchangeable. We take the phonological level to include the combinatory units (phonemes), as well as features and their organization, alternations, and conventionalized constraints on form. Any and all of these properties in effect provide evidence for duality of patterning, since they inherently involve a set of meaningless combinatorial elements which make up meaningful words.[2]

Striking examples of the power of dual patterning are binary signaling systems like Morse code or computer machine language. Morse code has only two signals: short (dot) and long (dash). If these signals were themselves meaningful, then the system could express only two meanings. But because the meaningful elements are not individual signals but combinations of signals which in turn stand for letters, also meaningless, the system is capable of combining these symbols to create (at least in theory) an infinite number of meaningful words. Similarly, the binary computer code of 0 and 1 works because the meaningful signals result from the combinations of the meaningless 1 and 0. Natural languages provide a larger set of meaningless primitives, although some languages, such as Central Rotakas (Robinson 2006), have as

[1] Zwicky and Pullum elevated this independence into a principle, which they called the principle of phonology-free syntax (Zwicky and Pullum 1986). This principle appears to be violated in a few very limited cases of agreement, where the agreeing element may copy the first or last segment of the controller (Dobrin 1998), but these cases are very rare.

[2] A reviewer pointed out that phrasal level phonology and prosody also exemplify duality of patterning. We strongly agree, and refer the reader to discussions of the phrasal phonology and prosody of sign language in Nespor and Sandler (1999); and Sandler (1999, 2011a, to appear), Wilbur (2000), and references cited there, and to our work on the emergence of prosody and syntax in ABSL (Sandler et al. 2008, to appear).

few as 11 phonemes with which to create potentially vast vocabularies of meaningful morphemes and words.

Because every known spoken language has a dual system, it is tempting to believe that a language cannot exist without duality of patterning. Pinker and Jackendoff (2005:212) explain that "A combinatorial sound system is a solution to the problem of encoding a large number of concepts (tens of thousands) into a far smaller number of discriminable speech sounds (dozens). A fixed inventory of sounds, when combined into strings, can multiply out to encode a large number of words, without requiring listeners to make finer and finer analogue discriminations among physically similar sounds." Jackendoff (1999) proposes that phonology developed prior to combinatorial syntax in his model of language evolution.

The existence of dual patterning is not a logically necessary property of languages, however; it is instead an empirical observation. Hockett himself points out in his seminal article on the topic that what makes duality so interesting is its unexpectedness: "There is excellent reason to believe that duality of patterning was the last property to be developed, because one can find little if any reason why a communicative system should have this property unless it is highly complicated" (Hockett 1960:95). It was because of this that Hockett placed duality in the last spot among his thirteen design features.

Hockett argued that duality of patterning became useful only as the size of the signal set in the language system grew:

> If a vocal-auditory system comes to have a larger and larger number of distinct meaningful elements, those elements inevitably come to be more and more similar to one another in sound. There is a practical limit, for any species or any machine, to the number of distinct stimuli that can be discriminated, especially when the discriminations typically have to be made in noisy conditions. (ibid.)

It is this practical limit on discriminability that leads to duality, according to Hockett.[3] Thus, although all known spoken languages have dual patterning, it is not a logical necessity for language to have begun with tens of thousands of meaningful units, and in the absence of a large set of signals to be discriminated there is no need for duality. Following this reasoning, there is no need for the first human languages to have had dual patterning.

The connection of the vocal-auditory channel in language to Hockett's argument about duality has been overlooked. The vocal-auditory channel is the first design feature he lists, and at least three other design features are directly tied to it. William Stokoe's *Sign Language Structure*, which added languages in a different transmission channel to our thinking about human language, was published the same year (1960) that Hockett published his celebrated work on design features, and had not yet had an impact on thinking about language.

The manual-visual modality could have an impact on the number of holistic signals that could be amassed in a communication system before duality becomes necessary. First of all, the manual-visual modality more easily accommodates iconically

[3] Animal communication systems help us to appreciate Hockett's information-based argument about duality. No animal communication system has a large set of discrete signals; hence none has the need for dual patterning, by Hockett's reasoning (Anderson 2002).

motivated signs, while the vocal-auditory modality significantly restricts the possibility of iconicity, requiring a more arbitrary relation between sound and meaning. This suggests that a gesture based language could acquire a greater inventory of interpretable holistic signals before requiring duality of patterning. In addition, the visual system has the capacity to perceive and interpret simultaneously presented aspects of a visual array, while the auditory system is much more limited in this regard.[4] Finally, given the sheer size of the visual cortex vis à vis the rest of the human brain, we might speculate that humans are capable of interpreting complex visual signals more easily than auditory ones, even in the absence of systematic internal structure. Taken together, it is possible to imagine that small, gradient differences in the shape of the hand or the trajectory of movement could convey different, transparently interpretable concepts, without organizing the individual formational parameters into a system of discrete meaningless units. It is thus conceivable that humans can discriminate and store a larger number of holistic visual signs that bear transparent relationship to their meanings than holistic auditory signals, which necessarily bear an arbitrary relationship to their meanings.

Because sign languages are transmitted in the visual medium and are, in some respects, iconically motivated, one might not expect sign languages to have phonology. Instead, each sign might be a holistic, meaningful unit, precluding the existence of a meaningless level of structure. But for Stokoe, a primary argument for calling American Sign Language (ASL) a true language was the fact that it indeed had phonological structure (Stokoe 1960). Stokoe's observation about ASL phonology has since been extended to other established sign languages around the world, so that linguists have come to see duality of patterning as a feature that is somehow built into the essence of the human language faculty and independent of the medium of transmission, though we know of no discussion of how such duality might be encoded in the human genome (cf. Dediu and Ladd 2007).

The question of how a phonological level arises in language has never been addressed on an empirical basis, and we offer the work reported here as a first step. In a new language, we observe unexpected variance on the one hand, and budding formal regularity on the other. We use these phenomena to frame issues to be addressed in future research—our own, and that of other investigators. When William Stokoe observed patterns in American Sign Language and used them to argue for phonology in that language, the groundwork was laid for further phonological and psycholinguistic investigation. This resulted in deeper understanding of the nature of phonology in sign language, and of the essential nature of phonology in human language more generally. In a similar way, we hope that our research program, of which the present study of a nascent sign language is a part, will lead to more documentation and comparison of structure and variation at the formal level.

We will argue in this article that Al-Sayyid Bedouin Sign Language (ABSL) proves Hockett to have been correct about the relative timetable for the emergence of dual patterning. ABSL is new and, like other sign languages, it is communicated through sight rather than through sound, possibly lending the system more options for

[4] See Brentari (2002), Meier (2002) and references there for valuable discussions of the physical differences between the two modalities.

conveying a larger array of concepts iconically than a spoken language has. ABSL might therefore get along very well without dual patterning, and, as we will argue, it does. Our data suggest that, unlike other, older sign languages, a phonological system has not crystallized in ABSL, at least not yet. This young language thus shows us that, although a visually-based language can have dual patterning (which most sign languages do), such a language can at least start off without duality. While spoken language might have had to develop duality earlier in its history for the reasons given, the number of holistic auditory signals that humans are capable of distinguishing is not actually known. Our findings thus have relevance with respect to the emergence of spoken language as well, as they imply that language can be richly communicative without duality. Nonetheless, as we will demonstrate, the kernels of a phonological system are already emerging in ABSL.

According to Hockett (1960) and to Pinker and Jackendoff (2005), duality of patterning arises because the message set gets larger and larger, making discrimination between signals more and more difficult, especially in noisy conditions. Thus, duality is seen as a product of interaction among individuals in a community who together create large vocabularies of conventional signals and must distinguish them from one another. Individuals may independently develop formal regularities in their language (Goldin-Meadow et al. 1995), and the possible emergence of phonological organization in an individual will ultimately add to our understanding of the emergence of phonology in the language of a community. However, it is the language of the community that is our focus here. We pose the basic question: Can it be said that there is a phonological system in ABSL, as there is, for example, in American Sign Language or English? We return to this issue in Sect. 2.4 and in the conclusion to this article.

The general outline of the paper is as follows. Taking examples mainly from Israeli Sign Language (ISL), the language used by the majority of Israel's 10,000-member deaf community, we begin in Sect. 1 by demonstrating what it means for a sign language to have phonology.[5] We then go on to argue in Sect. 2 that ABSL, a sign language used in an insular, homogeneous community of about 120–150 deaf signers (and an unknown number of hearing signers), has not yet organized its articulatory level into a system of meaningless units with a structure of its own. This does not mean that Al-Sayyid signers do not have a real language. Functional and linguistic evidence offered in Sect. 3 shows clearly that they do—but it is a language without a fully fledged phonological system. Finally, by closely observing a lexical system of classifier affixes, the signing of members of a single family with many deaf members, and the signing of children, we find telling clues presented in Sect. 4 that presage the onset of phonology in ABSL. We suggest there that it is not necessarily (or not only) the size of the message set that gives rise to duality, but other factors as well—factors which figure prominently in computational simulations of language evolution: conventionalization, and the automaticity and redundancy that come with it (Kirby 1999; Smith et al. 2003; de Boer 2001). The conclusion (Sect. 5) considers implications of these findings for spoken language.

[5] Israeli Sign Language is about as young as ABSL, but the size and heterogeneity of the ISL community and its linguistic history, as well as the circumstances of the emergence and use of ISL, are very different, and these may account for the differences in form, regularity, and systematicity that we find between ISL and ABSL (see Meir et al. 2010a, 2010b).

1 Duality of patterning in established sign languages

The single most influential finding in sign language studies was Stokoe's (1960) discovery that American Sign Language (ASL) has phonology, which he called *cherology* (from Classical Greek [xeir] 'hand') because the signs are produced with the hands. His work focused mainly on minimal pairs, showing that each of the major categories of handshape, location, and movement contains a finite list of features, and that substituting one for another in a given category could result in a change in meaning, just as features of traditional consonant and vowel phonemes in spoken languages do. The reason that Stokoe's slim volume, *Sign Language Structure*, was so influential is that it demonstrated for the first time that signs are not holistic icons, as most people had believed, but rather are comprised of meaningless building blocks which can recombine to form a potentially large vocabulary, as is the case with the sounds that make words of spoken languages.

Once the floodgate was opened, research on various aspects of sign language structure surged through, investigating the morphology, syntax, and, of special interest to us here, phonology of ASL and other sign languages. In the subsequent sections, we sketch some of the main findings in sign language phonology, to demonstrate that it makes sense to talk of duality in visual languages.[6]

In the subsections that follow, aspects of the phonological structure of sign languages are presented, as are constraints on that structure. We note that these structural properties seem to characterize many sign languages that have been studied. Two factors contribute to these similarities. One is the fact that phonological constraints and structures are phonetically grounded, and the other is that all sign languages are relatively new compared to spoken languages. We suggest that certain phonetic tendencies become more strictly enforced as phonological organization emerges, explaining why they are found in many sign languages. We'd expect to find more language-particular phonological properties with more research on different sign languages, and to see others emerge as sign languages age.

1.1 Minimal pairs

To say that there is a phonological level of structure means that there are discrete and meaningless formational elements that work together in a system (like Morse code dots and dashes). The existence of minimal pairs—meaningful words distinguished by such elements drawn from a finite list—is strong evidence for a system of this kind. In spoken languages, distinctions between words are made by sounds that are divided at the highest level into the categories of consonants and vowels. In sign languages, the major categories of phonological organization are Hand Configuration, Location, and Movement, each with its own hierarchy of features. Most of the phonological properties we illustrate here with examples from Israeli Sign Language (ISL) and ASL have been found to characterize several established sign languages. Figures 1–3 illustrate minimal pairs along the handshape, location, and movement parameters.

[6] A detailed, though not exhaustive, recent overview of sign language phonological research appears in Sandler 2011and Lillo-Martin (2006: unit 3). See also Brentari (to appear).

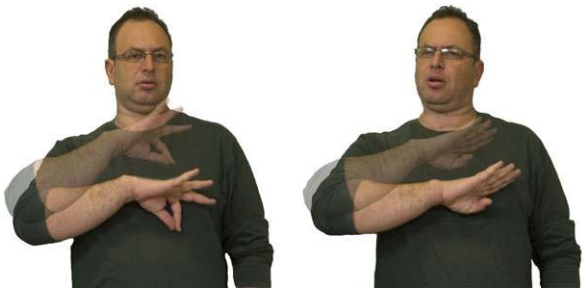


Fig. 1 ISL minimal pair distinguished by Hand Configuration features: PROFIT, RESTRAINT

Fig. 2 ISL minimal pair distinguished by Location features: SEND, SCOLD

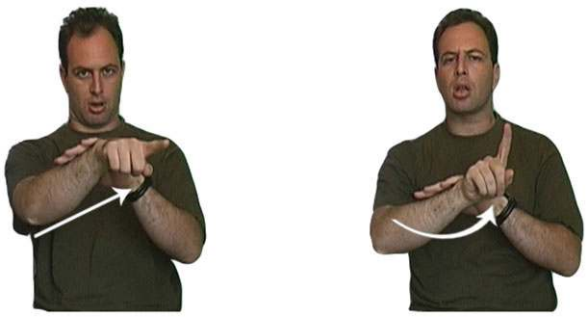


Fig. 3 ISL minimal pair distinguished by Movement features: ESCAPE, BETRAY

For PROFIT, the Hand Configuration is  , and for RESTRAINT, it is  . All other aspects of the two signs are the same. The signs SEND and SCOLD have the same Hand Configurations and Movements, but are distinguished by Location: near the signer's torso for SEND, and near the face for SCOLD. The features that distinguish these handshapes and locations are hierarchically organized by class (see Fig. 15). The signs ESCAPE, BETRAY are distinguished by the shape of the path movement, straight for ESCAPE, and arced for BETRAY. COMPARE and VACILLATE are distinguished by features of orientation, a subcategory of Hand Configuration. The three sign languages whose phonologies have been most extensively

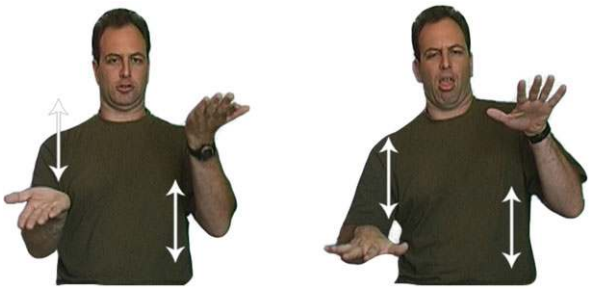


Fig. 4 ISL minimal pair distinguished by Orientation features: COMPARE, VACILLATE

studied (ASL, ISL, and SLN—Sign Language of the Netherlands) all have minimal pairs distinguished by features belonging to these categories.

While minimal pairs in spoken languages are defined in terms of the linear position of a given phoneme (***p****in/****b****in; p****i****n/p****e****n, pi****n****/pi****t***), the sign language units have a somewhat more simultaneous organization. Nevertheless, there are good arguments for a degree of linear structure in signs as well, which we can't discuss fully here for lack of space.[7]

1.2 Phonological constraints on lexical structure

One of the characteristics of organization at the level of meaningless formational units is the fact that the elements of the system are constrained in terms of the ways in which they may co-occur. Some of these constraints are language-specific, and others are general. For example, the way in which sounds are ordered on either side of a syllable peak is nearly universally determined primarily by the relative sonority of the sounds. Sonority rises before the peak and falls following it (*pr*, not *rp* syllable-initially, but *rp* and not *pr* syllable finally). Yet the number of consonants that may occur in a cluster in each position and the permissible sonority distance between them are both language-specific. Here we review several constraints on the phonological form of signs that characterize the three sign languages that have been the object of detailed phonological investigation: ASL, ISL and SLN. These languages are not related as far as we know, so we assume the constraints are very general across established sign languages, much like the sonority cycle (Clements 1990) in spoken languages.

The handshape is made up primarily of the selected fingers (e.g., index only; four fingers; etc.) and their positions (e.g., open, closed, curved, etc.).[8] For example, each of the handshapes in Fig. 5a have all fingers selected, while those in 5b select only the index finger. In each case, the selected fingers may be configured in one of several positions, some of them shown here.

[7] See Sandler and Lillo-Martin (2006), Chap. 9 for a treatment of the sequential aspects of sign language structure.

[8] Much of the discussion that follows relies on details of the Hand Tier model (Sandler 1989; Sandler and Lillo-Martin 2006). Other models that differ in various ways have been proposed (e.g., Liddell and Johnson 1989; van der Hulst 1993, 1996; Brentari 1998; van der Kooij 2002). All demonstrate duality of patterning in sign languages (ASL, ISL, SLN), as they rely on the systematic distribution and behavior of meaningless formational units.

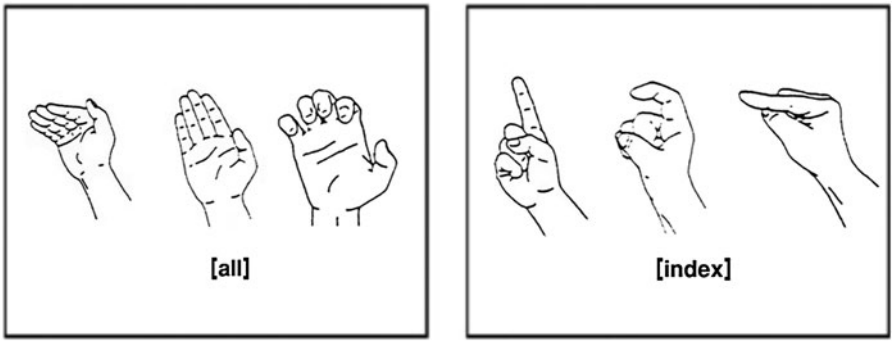


Fig. 5 (**a**) Handshapes that select all fingers, specified for different finger positions. (**b**) Handshapes that select the index finger, specified for different finger positions

One constraint on the structure of simplex signs that has been proposed requires there to be only one group of selected fingers in a sign (Mandel 1981). For example, a sign may be specified for the index and middle fingers (in a 'V' for victory shape), or it may be specified for all five fingers in an open hand shape.[9] But within the sign, the finger selection cannot change from one group to another—only one group of fingers is allowed per sign. The simplex sign in Fig. 6, which selects the index finger and thumb, is well-formed, but the one in Fig. 7, with two different groups of selected fingers, is ill-formed. The position of these fingers can change, from closed to open, for example, or from open to curved. Yet even if the position of the fingers changes, the same fingers are still selected.[10]

Mandel points out further that the contrast between the different positions of the selected and unselected fingers have the effect of foregrounding the selected fingers. One might think of this as a kind of phonetic enhancement (Stevens and Keyser 1989). The specified fingers may be open, closed, curved or bent, while unspecified fingers are either open or closed.[11] The Unselected Fingers Redundancy Rule (Corina 1993) states that "If specified fingers are closed, unspecified fingers are open; otherwise unspecified fingers are closed."

All sign language lexicons contain both one-handed and two-handed signs. Two robust constraints on two-handed mono-morphemic signs are the Dominance Condition, and the Symmetry Condition (Battison 1978). The Dominance Condition holds for two-handed signs in which the dominant hand moves and the nondominant hand functions as a place of articulation. In such signs, the nondominant hand may either have the same shape as the dominant hand, or, if different, it must have one of

[9]This constraint is strictly observed on the form of the morpheme, and holds for most kinds of morphologically complex signs as well.

[10]The fact that selected fingers can change their position within a sign but the choice of selected fingers is fixed is one of the motivations for a model in which the fingers and their position are represented as two different feature classes in a hierarchical relation with one another: the selected fingers node dominates the finger position node (Sandler 1989, 1996).

[11]Eccarius (2002) argues for a third group of fingers, called secondary selected fingers, based primarily on certain handshapes in sign languages of Asia in which selected fingers may not all be in the same position.

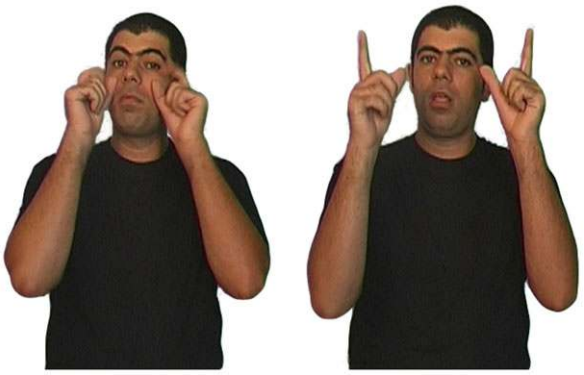


Fig. 6 (**a**, **b**). The ISL sign WAKE-UP with index selected, moving from closed position (in contact with the thumb) to open position

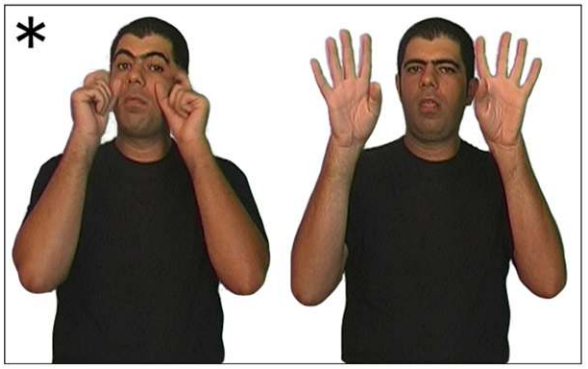


Fig. 7 Ill-formed sign, with two different selected finger specifications

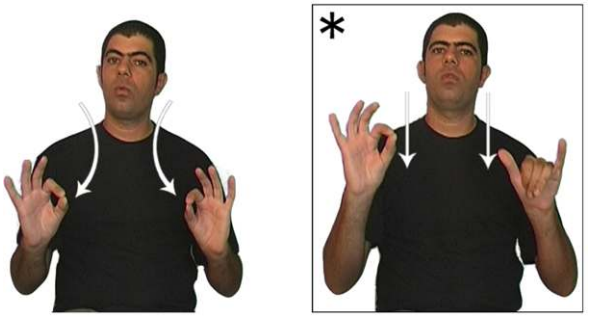


Fig. 8 (**a**) According to the Symmetry Condition, ISL SHOP is well-formed. (**b**) Ill-formed sign: both hands move, but in different configurations

a set of unmarked shapes. The Symmetry Condition holds for signs in which both hands move. In these signs, both hands must have the same configuration and move symmetrically,[12] as exemplified in Fig. 8a by a sign in ISL, a language which also im-

[12]We subsume under the term 'symmetrically' forms in which the two hands move in identical fashion, as mirror images of each other, or identically but in alternation. See for example Brentari and Goldsmith (1993), Sandler (1993b, 2005), van der Hulst (1996) for various treatments of the behavior and representation of the nondominant hand in sign languages, and Crasborn (2011) for an overview of this topic.

poses this constraint. Figure 8b shows an ill-formed sign that violates the Symmetry Condition.

The domain of most of the constraints described is the simplex lexical sign, supporting the claim that the constraints are phonological rather than merely motoric (phonetic). They can be violated when more than one morpheme is combined, even if combined in a single, still 'pronounceable' syllable.[13,14] For example, the two hands need not obey the symmetry condition in complex classifier constructions, in which each hand is a separate morpheme (see Aronoff et al. 2003 for an example), and the selected fingers constraint does not hold in compounds, comprised of two morphemes, even if they are monosyllabic. They can also be violated in signs adapted from fingerspelling (Battison 1978; see also Brentari and Padden 2001 on core and peripheral phonology in sign languages).

1.3 Assimilation of phonological elements

Phonological alternations provide crucial evidence for a phonological level of structure, since they make reference to formational properties of sublexical elements that bear no meaning. The pattern of assimilation in lexical compounds in ASL and ISL indicates that this is a (morpho-)phonological process rather than simple coarticulation resulting from motoric factors. Specifically, the compounds reduce by truncation (deletion of sequential segments, Liddell and Johnson 1986), and the hand configuration of the second member of the compounds is assimilated regressively by the first member of the compound (Sandler 1987; Sandler and Lillo-Martin 2006). This assimilation may be partial or total. Partial assimilation involves assimilation of the orientation alone, while total assimilation includes both the handshape and the orientation. Some compounds, like OVERSLEEP in ASL, whose component parts are shown in Fig. 9, allow either partial assimilation (Fig. 10a) or total assimilation (Fig. 10b).

Assimilation of handshape without orientation is not attested in any of the set of lexicalized compounds studied.[15] For this reason, Sandler (1987, 1989) following Clements (1985) for spoken language, argues for a hierarchical representation of these feature classes, with orientation dominated by handshape. The same pattern is found in ISL (Sandler and Lillo-Martin 2006). The important point is that handshape-only assimilation, i.e., without orientation, is perfectly possible physically, but is not

[13] Exceptions are the selected and unselected finger constraints whose domain is the syllable.

[14] For treatments of the syllable in sign languages see Wilbur (1993), Brentari (1990, 1998), Perlmutter (1992), Sandler (1999, 2008). A discussion of factors distinguishing the syllable, the morpheme, and the word in ASL is found in Brentari (1990), Sandler and Lillo-Martin (2006), and Sandler (2008).

[15] This investigation of hand configuration assimilation relied on a list of lexicalized compound signs elicited at the Salk Institute for Biological Studies and kindly made available to the investigator by Ursula Bellugi. The compounds studied are lexicalized, but we do not consider this fact to make the assimilation phenomena irrelevant for the phonology. On the contrary, since the pattern is robust, we see it as indicative of phonological structure, much as lexicalized plurals such as *knives, wives, halves, leaves,* etc. (cf. *fifes, reefs, staffs*, etc.), are not random, involving instead an alternation between voiceless labiodental fricatives and their voiced counterparts.

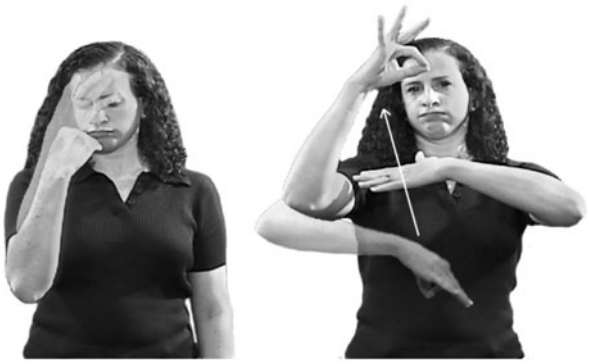


Fig. 9 SLEEP and SUNRISE, the constituents of the lexical ASL compound OVERSLEEP. (**a**) Partial assimilation, (**b**) total assimilation

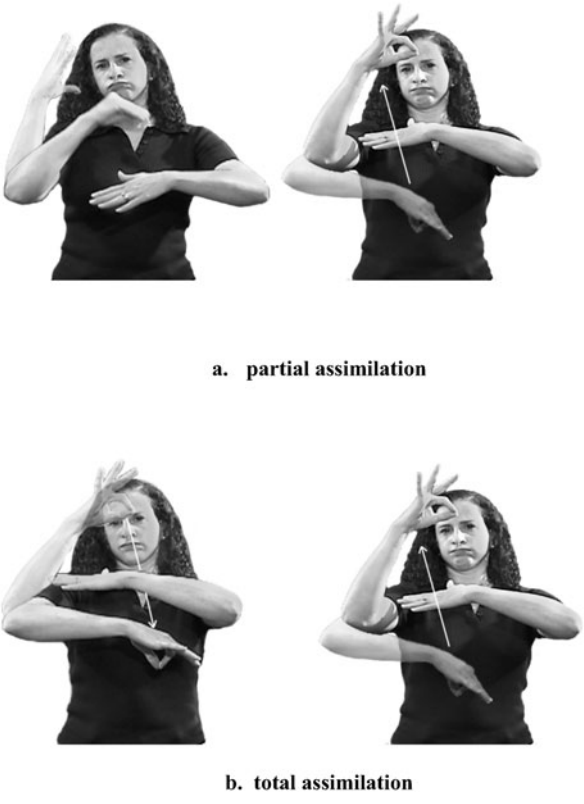


Fig. 10 Attested assimilation in ASL lexical compounds. (**a**) Partial assimilation on the first constituent of the compound: orientation. (**b**) Total assimilation on first constituent: handshape as well as orientation

attested. This tells us that the constraint on assimilation is not motorically required, but rather a fact about the organization of sublexical meaningless units.

The important generalization here is that in partial and total assimilation, formational elements are discretely and systematically manipulated, without reference to meaning. In fact, the meaning of the members of the compound can be obscured by these processes.

Taken together, the existence of minimal pairs, formally motivated constraints on the organization of meaningless elements, and discrete assimilation of such elements provides evidence that these elements are part of a level of structural organization that is not governed by meaning.[16] But does the omnipresence of phonology in established languages necessarily imply that you can't have language without it?

2 Al Sayyid Bedouin Sign Language

For the past several years, we have had the privilege of observing a language which has arisen in a Bedouin village in the south of Israel. It is a new language, one that arose under normal communicative pressures in relative isolation from any possible language model, and that functions like any other language.

The Al-Sayyid Bedouin group was founded about 200 years ago in the Negev region of present-day Israel. According to folkore, the first settler in the area migrated there from Egypt and was a *fallaah*, 'peasant', not a Bedouin. Today, his descendants live as Bedouin and are regarded as Bedouin. The group is now in its seventh generation and numbers about 4,000 members — all of whom reside together in a single community exclusive of outsiders. Consanguineous marriage has been the norm in the group since its third generation. Such marriage patterns are common among Bedouins in the area and lead to very strong group-internal bonds and group-external exclusion. It is indicative that the Al-Sayyid still view themselves as a single large family, and all bear the family name Al-Sayyid, though now divided into subfamilies.

In the fifth generation since the founding of the community (about 75 years ago), four deaf siblings were born into the community. In the next two generations, deafness spread in many other families as well. The number of deaf individuals in the community today is estimated at about 120–150. The particular distribution of deafness in the community, typical of recessive congenital deafness (Lane et al. 2000), has had socio-linguistic implications: deaf members of the community are integrated into its social structure and are not shunned or stigmatized, and a sign language developed in the community as a means of communication, used by both deaf members of the community and a significant portion of its hearing members (Kisch 2000). The sign language, Al-Sayyid Bedouin Sign Language (ABSL), is passed from one generation of signers to the next in a natural social setting. Thus, the Al-Sayyid community presents a highly unusual situation of a language that developed de novo in a stable community.[17]

This rare social setting provides many deaf children born into the community with direct access to linguistic input from the earliest age. In more typical communities, over 90% of deaf children are born to hearing families living in hearing environments, and many are not exposed to sign language models until they reach school. Some schools for deaf children in several countries expose children

[16] Phonological processes in sign languages have been shown to observe a lexical-postlexical distinction (Padden and Perlmutter 1987; Sandler 1999), further evidence for phonology.

[17] ABSL, though rare, is not the only extant village sign language. See Meir et al. (2010a) for an overview of emerging sign languages.

to native sign language models, either by design, through hiring deaf teachers and including sign language in the school curriculum, or by accident, by co-mingling native signing children from deaf families with children from hearing families. The policy of other schools is to restrict children's input to sign systems contrived to accompany spoken language and mimic its structure, and in these situations deaf children do not have access to a real sign language model. Finally, deaf children raised orally have no sign input at all. Many deaf people who were raised without exposure to a sign language eventually do join the deaf community and learn sign language later in life, so that the overall sociolinguistic picture has led some researchers to suggest that sign languages are in a constant state of recreolization (Fischer 1978).

This is not the situation with Al-Sayyid. In this community, sign language seems to be everywhere, and deaf people of all ages enjoy effortless and natural communication, with deaf and hearing people alike. Functionally, there can be little doubt that ABSL is a genuine language, and we have identified linguistic patterns that provide a scaffold for this communal language (Sandler et al. 2005; Aronoff et al. 2008), outlined in Sect. 3.

But if the remarkable sociolinguistic setting of this group and the ease of linguistic interaction among them led us originally to expect a veritable explosion of grammar, beginning, perhaps, with the development of a phonological system, we had some surprises in store for us.

2.1 No evidence for dual patterning in ABSL

It is certainly not obvious *a priori* that a sign language should have a phonological level of structure, and, though it is hard to believe now almost 50 years later, Stokoe was initially ridiculed for his claim that ASL does. Considering the fact that many signs are iconically motivated, it was assumed, tacitly or explicitly, that signs are holistic gestural pictures of what they represent ("merely developments of ordinary gestures", in the words of Bloomfield 1933:144). But as the brief survey in Sect. 2 shows, this is not the case. Even these languages with a considerable potential for creating words with a transparent correspondence between form and meaning develop a level of form that has no meaning. This discovery gives added force to Hockett's proposal that duality of pattering is a basic design feature of human language. It also makes Jackendoff's (1999) model of language evolution in which phonology emerges before syntactic structure relevant to this investigation, since duality is not restricted to the oral/aural modality.

Yet, when we first began examining videotapes of vocabulary items of ABSL as signed by signers of all ages across the village, we were struck by what seemed like imprecision and variation in the production of signs—more than we have come to expect from experience with other, more established sign languages. This was our first clue that the articulatory level was not organized into a system. It is a challenge to show that something does not exist, but it is a challenge that we enthusiastically undertake, in our search for a satisfying answer to the question of why this fledgling language looks different from its more established sisters.

2.2 Stimuli, corpus and subjects

Three different picture naming tasks were administered on three different occasions to partially overlapping groups of subjects. The elicitation materials were different for each task, but they were of the same general nature: pictures of concrete objects. There were a total of 23 subjects, and together they named 128 pictures. The original purpose of the elicitation was the compilation of a dictionary of ABSL. We soon learned that our goal was more difficult to achieve than we had anticipated.

In the naïve expectation that vocabulary would be similar across a small, insular community, we aimed to get a larger list of vocabulary items by using partly different stimuli for different groups of signers. What we did not expect was the wide range of variation that we found, both lexical and formational. The data were elicited in the field. For these reasons, the sample was too small to allow for useful statistical analysis. For example, if, in a group of seven signers, three used the same basic sign, and of those, two used a compound in which only one sign was the same for the three signers, it is difficult to provide a meaningful statistical measure of variation across the three. Instead, the results we report here are generalizations observed in our video recordings collected through fieldwork, with detailed examples, and informed by our experience with other sign languages. In our research program, we proceed from these generalizations to other kinds of inquiry, such as the quantified study in the Sign Language Research lab at the University of Haifa by Assaf Israel (Israel 2009), comparing sublexical variation in three sign languages, to be summarized in Sect. 2.5.

2.3 Aiming for an iconic prototype

Fortunately, we have a good idea of the traces we would expect phonology to leave if it were indeed present in ABSL, and the traces are absent. First of all, we have encountered no minimal pairs in our study of the language to date. While we can't deny the logical possibility that minimal pairs are there but evading us, we find it striking that none have surfaced so far, in over 150 words of elicited vocabulary (in this study and Israel's study)—hundreds of elicited sentences, and numerous narratives and conversations. Second, while constraints on the form of a sign are not absent, they are not strictly enforced. We interpret this as an indication that these constraints, shared as they are by established sign languages that have been studied, are articulatorily grounded, and become more strictly enforced as phonological organization emerges. Overall, it is as if the signers are aiming for an iconic and holistic prototype, with details of formation taking a back seat.

Let us take as a first example the sign for an everyday object, LEMON. In a simple picture naming task, signers signed LEMON with different handshapes, orientations, and internal movements. For instance, one signer produces the sign in the space in front of the signer's torso with a rubbing movement of the index finger, middle finger, and thumb. Another signer uses all five fingers throughout the closing movement, and his sign has a different orientation than that of the one just described, palm down instead of to the side. Examples of two of the different handshapes that occurred for this sign are shown in Fig. 11.

A third signer uses three fingers, but the location is next to the mouth instead of in neutral space in front of the signers. Several other versions occur in the data. We

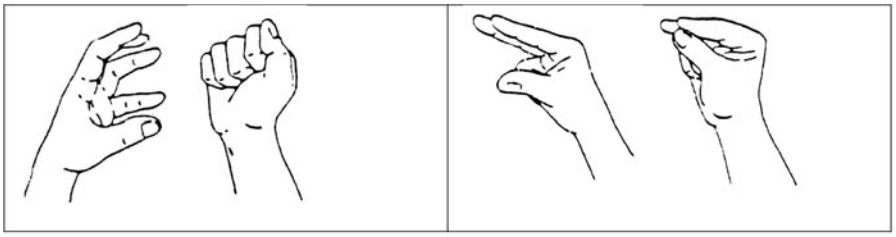


Fig. 11 Two different closing handshapes produced for LEMON in ABSL. (**a**, **b**) All five fingers selected. (**c**, **d**) Three fingers selected

Fig. 12 Some handshapes for TEA

were struck by the amount and types of variation we found in our data, variation that we would not expect in the established sign languages with which we are familiar. In ABSL signs we see variation in the group of fingers selected, the orientation of the hand, and the location—all potentially contrastive in other sign languages. There is more than one way to squeeze a lemon, and that is the guiding force. The two handshapes shown here are contrastive in other sign languages. For example, they distinguish SAY-NO-TO from CATCH in ASL, and the open shapes (fully open versions of the two handshapes on the left in each box in Fig. 10) distinguish AWKWARD from BALANCE or WEIGH in ASL.

The sign TEA was signed with three different handshapes across eight signers with the same sign for TEA. These are shown in Fig. 12. At first glance, the signs looked identical: the location is in front of the mouth, the palm orientation is comfortably toward the contralateral side, and the movement is a rotation of the hand at the wrist toward the mouth. But closer observation reveals differences in the position of the selected fingers (index and thumb), and in the position of the other, unselected fingers. The point is to hold a teacup by its handle, and not to use a particular form.

In DOG, major body areas that are contrastive places of articulation in other sign languages vary freely in ABSL. Figure 13 shows the head and the torso (or neutral space) as variants. Orientation, considered a feature class dominated by the Hand Configuration category (Sandler 1987), can also be contrastive in established sign languages, as Fig. 4 above demonstrated. In ABSL, we find unexpected variation in orientation as well. The sign SCORPION is shown in Fig. 14a with a palm out orientation rotating to palm down, and in Fig. 14b with palm up, rotating to palm in.

The sign for DOG, for which only two variants are shown in Fig. 13, is a good example of the kind of formational variation we encountered in this language. Of eleven signers, ten used the same lexical item, representing the barking mouth of a dog with the hand or hands. One signer represented a dog's ears and paws, this exception proving the rule that DOG was the same lexical item for the other subjects.

Fig. 13 Head and torso are not contrastive places of articulation in ABSL variants of DOG (**a**, **b**)

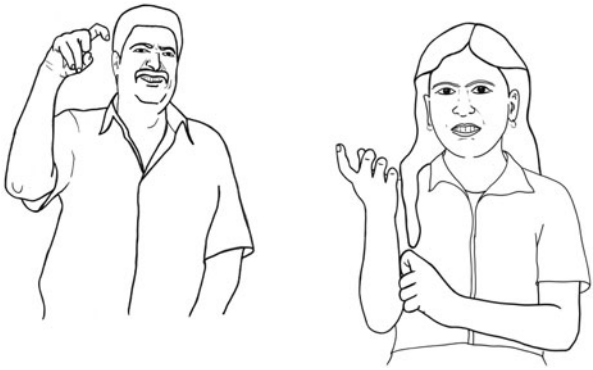


Fig. 14 Two different orientations attested for the sign: SCORPION

Ten out of eleven is an unusually high consensus on a lexical item, and DOG therefore gives us a good opportunity to observe phonetic variation. While the sign is iconically motivated, it is still lexicalized, in the sense that it conventionally selects a particular aspect of dogginess to represent: barking.[18] Iconic signs are still conventional, of course. The sign is iconic in ISL as well, but represents the running paws. In ASL the sign is conventionalized but not iconic; it is derived from a lexicalized finger-spelled borrowing (Battison 1978), synchronically resembling a finger snap.

Across the exemplars of DOG in ABSL, there was a great deal of variation. The sign typically involved a repeated curving movement of the fingers, from laxly extended to curved. Yet one signer selected only three fingers; one closed the fingers (in an 'O' shape); some used two hands facing one another and some two hands facing outward. Some selected the head (the mouth) as the place of articulation (as shown in Fig. 13a), and some the space near the torso (shown in 13b). Compare with Fig. 2 above showing the ISL contrast between SEND and SCOLD made by substituting the same two major locations as the two noncontrastive variants of DOG in ABSL. One used bending at the wrist instead of curving of the fingers, and another moved his two hands outward in a short path movement away from the body. The variation in

[18] Dogs are not beloved pets in the Al-Sayyid village. Rather, they are feared, and are chained near livestock to fend off intruders. It is no wonder, then, that the most salient feature of a dog there is its barking mouth.

Table 1 Variation in the sign DOG

	hand shape	orientation	# hands	location	movement	# movements
Signer B		Outward/ downward	1	Torso (low)	Closing (thumb restraint)	2
Signer A		Contralateral sideways	1	Torso (high)	Curving	1
Signer M		Contralateral sideways	1	Torso (mid)	Closing	2
Signer S		Outward	2	Torso (mid)	Clawing	2
Signer I		Contralateral sideways	1	Head (side of mouth)	Curving	3
Signer Mh		Contralateral sideways	1	Head (center of mouth)	Clawing	1
Signer R		Facing each Other (contralateral sideways)	2	Torso (mid)	Curving	3
Signer F		Facing each Other (contralateral sideways)	2	Torso (mid)	Curving	2
Signer Sm		Outward	1	Torso (mid)	Nodding (wrist)	1
Signer Z		Outward	2	Head (near mouth)	Path Movement forward	2

this sign is shown in Table 1. In the table, two handshape illustrations in an example indicate a change of handshape.

On the face of things, one might be tempted to suggest that it just so happens that these particular features are not contrastive in this language while other heretofore unattested features are contrastive. But we stress that this is unlikely, because differences in pronunciation such as those we exemplify here involve major feature categories such as selected fingers and major body area, and not only finer grained features within such categories such as finger position and different settings within the body areas. Figure 15 shows partial feature hierarchies proposed for hand configuration and location based on American Sign Language according to the model on which we have been relying (Sandler 1989). Feature classes and their organization are shown here, while the terminal features they dominate are left out for simplicity.

For example, while most ABSL signers select all fingers for DOG, one, signer A, selects only 3. Major body area, another high level distinction, varies from head to

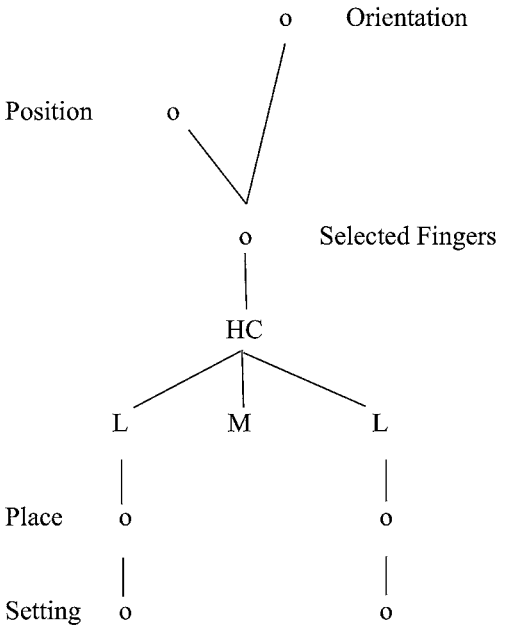


Fig. 15 Hierarchies of feature classes for Hand Configuration and Location (following Sandler 1989)

torso to nondominant hand. The type of movement varies from hand internal movement (of the fingers or wrist, another variation not typically found in citation forms) to path movement, in subject Z. If the language does not exploit these broader categories to make distinctions, it seems unlikely that it will exploit finer distinctions. By looking for contrasts at higher levels of the hierarchy—comparable, for example, to a contrast between voiced and voiceless states of the glottis or nasal and oral sounds rather than finer distinctions such as between coronal and palatal places of articulation—we are giving ABSL, a newly developing language, the benefit of the doubt, assuming that early contrasts would be at broader rather than finer levels of articulation (see Sandler and Lillo-Martin 2006 for detailed feature hierarchies). Even at the broader levels, we find non-contrastive variation and no minimal pairs. Many finer variations are also found here, such as whether the orientation of the hand/s is outward or sideward, whether the fingers curve, claw, or close, whether or not there is thumb restraint, and whether the internal movement involves the fingers (most subjects) or the wrist, in the nodding movement of subject Sm. In established sign languages, most of these differences, whether 'broad' or 'fine', are typically either contrastive or invariant in citation forms for reasons of well-formedness.

Note also that the variation is unsystematic; the signs are produced in isolation and the variation we see has no apparent allophonic motivation. That is, there is no articulatory reason for selecting one of these handshapes or locations over the other in these citation forms. Instead, it appears that signers are approximating a conceptual prototype, articulating within the constraints of iconicity and not the constraints of a formal transmission system, even in everyday signs such as these.

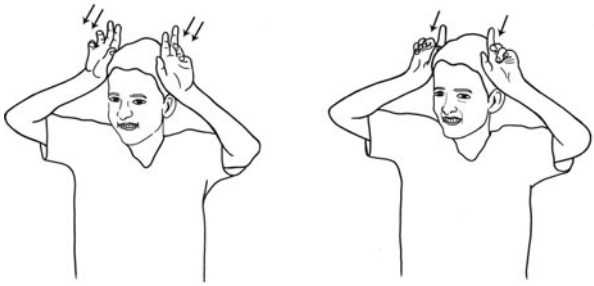


Fig. 16 Violation of the Selected Finger Constraint. ABSL simplex sign: DONKEY; finger selection switched mid-sign

2.4 Constraints

In addition to variation in the fingers selected like those in the examples of LEMON in Fig. 11, ABSL sign productions are anomalous in another way as well. As explained, in established sign languages, the same fingers must be involved in a sign, obeying the Selected Finger Constraint (Mandel 1981). In other words, if the sign begins with two fingers extended and proceeds to a bending movement for example, that movement should involve only those two fingers throughout. We see that this constraint on the phonological form of signs does not always hold in ABSL. In Fig. 16, we see an example of the sign DONKEY in which the signer begins by a bending movement of two fingers in an H shape  , and ends with a bending movement of the index finger only  .

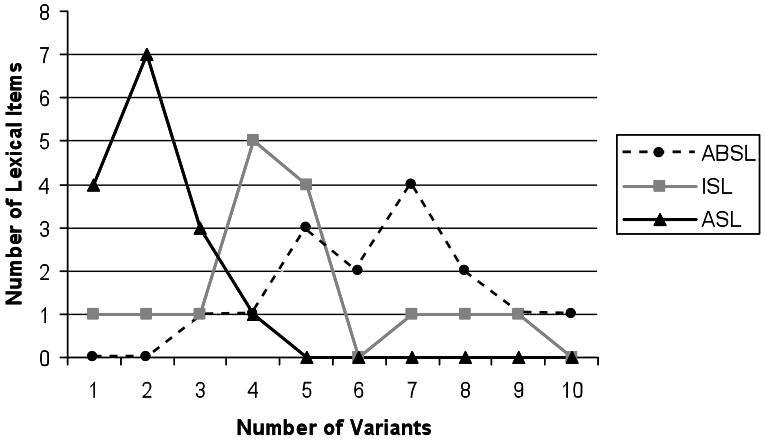
Our data show that satisfaction of other constraints that appear ubiquitous in more established sign languages such as the symmetry condition and the unselected finger constraint is also fuzzier in ABSL. Once again, we have little reason to believe that we are just looking in the wrong place, that this particular language has fancier constraints instead of these. The constraints mentioned are common across unrelated sign languages; they are presumably motivated articulatorily and become more and more strictly enforced as the elements become discretely identified and organized into a system—a stage that ABSL has not yet reached.

2.5 Quantifying variance

Influential linguistic theories are based on the notion of an ideal speaker/hearer in a homogeneous speech community, and do not regard variation as interesting or informative (Chomsky and Halle 1968). This view leads to the expectation that variation across the community is irrelevant for underlying representation (and for stating phonological alternations).

Sociolinguistic theory (Labov 1994) and exemplar theory (Johnson 1997; Bybee 2001; Pierrehumbert 2001) show that much can be learned from studying language

Table 2 Variation at the sublexical level in three sign languages (from Israel 2009)



variation across a community. Theorists are able to make significant predictions about language change and synchronic alternations as well by sampling and quantifying performance data. Our findings suggest to us that detailed investigation of variance is necessary in order to fully understand the ABSL data.

A preliminary study of this kind has been undertaken in the Haifa lab (Israel 2009; Israel and Sandler 2010, to appear). In this study, comparing a vocabulary list of 15 items signed by 10 signers in ABSL, ISL, and ASL, all three languages showed more variation than anticipated, but ABSL showed significantly more than the others, when variation along all articulatory categories for all tokens are combined.

In general, ABSL showed the most variation; ISL was next; and ASL showed the least amount of variation in sign production, leading Israel to suggest that social factors such as language age and size of the community contribute to convergence on phonological categories in a language. Taking the category of hand configuration as an example, ABSL varied more than the other two sign languages in each of the subclasses of finger selection: flexion, spreading, aperture, thumb position, unselected finger position, and orientation. With the exception of thumb position, the differences were not statistically significant in this small study. However, for most phonological subcategories of the major categories of hand configuration, location, and movement, the pattern was consistent: ABSL > ISL > ASL.

When tokens were compared on a global measure of variation—that is, with variation in any category counted as a different variant of the sign—then the differences were clear. ASL has the lowest amount of variation (2.07 variants per lexical item), ISL follows with a higher level of variation (4.67 variants per lexical item), and ABSL has the highest amount of variation (6.47 variants per lexical item). An analysis of variance (ANOVA) found these cross-linguistic differences to be statistically significant ($p < 0.0001$). The combined results are shown in Table 2. The table shows that ASL is most consistent: four out of fifteen lexical items have a single variant, and seven have two variants. ABSL does not have a single lexical item with fewer than three variants for all signers, and most have more. The results are even more striking

when characteristics of the subjects are taken into consideration. Most of the ABSL signers came from the same household, while the ASL signers were from different parts of the United States.[19] And yet, the signs of the ASL group showed the least amount of variation.

In sum, we find three kinds of evidence for the claim that this new language has not yet converged on a set of abstract, meaningless phonological categories. The first red flag we noticed is a dearth of minimal pairs in our data so far. However, it has been observed that there may be fewer minimal pairs in sign languages than in spoken languages generally (van der Kooij 2002), so that this criterion alone is not decisive. The second form of evidence is in the more glaring violation of general sign language formational constraints than we expected from familiarity with more established sign languages. The third observation that led us to question the existence of a phonological system is the amount of variation in sign production across signers. A quantificational comparison across ASL, ISL, and ABSL revealed that there is indeed significantly more variation in ABSL, and that some of this variation (such as selection of one vs. two fingers and articulation on different major body areas) crosses categorical boundaries that are clearly contrastive in more established sign languages.

If we have convinced readers that ABSL does not yet have a clearly defined phonological system, we hope the investigation has not cast doubt on the characterization of ABSL as a real language. In the following section, we present evidence that we believe to be incontrovertible for our claim that ABSL is indeed a language. This demonstration is meant to stave off any suggestions that, if ABSL lacks phonological organization, that is because it also lacks other characteristics of a full-fledged language.

3 ABSL is a language: functional and linguistic evidence

First of all, ABSL acts like a language. We have documented conversations and narratives on subjects as removed from the here and now as personal histories, a folk immunization for scorpion bites, a dream (reported second-hand), and a tribal legend, recounted remarkably by a first generation signer, and as nuanced as advice about the best way for a wife to cajole her husband. Conversations appear effortless and linguistic interaction satisfying to interlocutors. Group plans are made and carried out, instructions given and implemented, gossip is exchanged. The language works.

Al-Sayyid signers have metalinguistic awareness as well. They compare the sign language proficiency of different people in the village; young signers can distinguish between ABSL and ISL, translate signs of ABSL into ISL and the opposite; and signers have no problem performing the tasks with which we present them.

Second, there is linguistic evidence. While certain structures that we have come to expect in sign languages are not found in ABSL, there is grammatical regularity in

[19] On nearly all measures, ABSL came out with the most variation, ASL with the least, and ISL in between. The differences in variation between languages became statistically significant when variation in any category was counted as variation between whole tokens. See Israel (2009) for analysis and discussion.

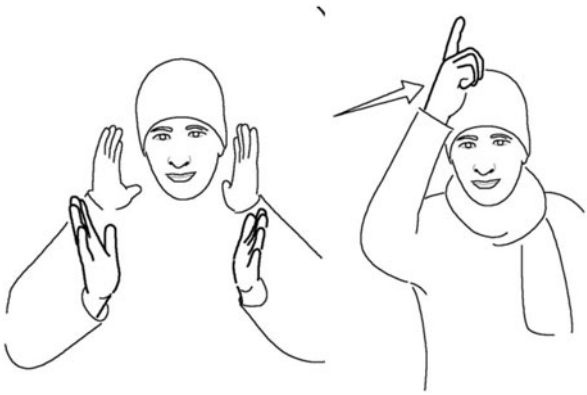


Fig. 17 PRAY-THERE, 'Jerusalem'. An example of a place name compound

the language at the syntactic, morphological, and prosodic levels, to which we now turn.

ABSL syntax within clauses is highly regular (Sandler et al. 2005). In a study of second generation signers, we found that the constituent order is quite rigidly SOV and the order of elements within phrases is head-modifier. These relations necessarily imply hierarchical structure, as subject, object, and verb belong to a clause, object and verb to a verb phrase, and noun and modifier to a noun phrase. The clause-internal order of constituents in ABSL contrasts with pragmatically-induced foregrounding, in which different orders may occur, for example, the patient argument introduced before the agent argument (Padden et al. 2010). The distinction between the clause internal order and the pragmatically-determined inter-clausal order is evidence that ABSL has developed a syntactic level as an independent level of linguistic organization.

In ABSL, space is used to indicate real world locations, such as the location of a hospital, health clinic, school, etc. Signers also use pronominal pointing signs toward locations of people's homes as a way of referring to the people.

The language has developed a particular type of compounding or affixation to specify the size and shape of objects. For example, TELEVISION + 'small rectangular object' refers to a remote control device; WRITE + 'long thin object' refers to a pen. We will have more to say about these interesting forms in Sect. 4.1. There is also a compounding system for referring to place names in the area, by first articulating a sign that represents some physical characteristic associated with people of the region and then a pointing sign, with the two movements fluidly connected (Aronoff et al. 2008; Meir et al. 2010). Examples are KAFFIYEH-THERE, 'Palestinian Authority'; LONG-BEARD-THERE, 'Lebanon'; WIDE-HAT-THERE, 'America'; PRAY-THERE 'Jerusalem'. The last example is shown in Fig. 17.

Prosodic organization is also evident in ABSL. Even the first generation of signers used rhythmic cues to signal the ends of utterances. Young second generation signers use cues of manual rhythm, body posture, and facial expression to organize their discourse into utterances and phrases, to express dependencies between clauses, and to convey illocutionary force, as in questions (Sandler et al. 2008, in press; see references regarding prosody in sign language in note 2).

4 The birth of a design feature

Our claim is that ABSL as a language does not yet have a fully developed phonological system. However, a fine-grained examination of the sign productions in Al-Sayyid uncovers a blueprint for its development. Pinpointing the kernels of phonology in this way may be informative for the evolution of phonology more generally, an idea to which we return in the conclusion. Examples we will present here come from a closer look at handshapes in conventionalized word productions of one signer; alternations triggered by two productive word formation processes; and from the signing of members of a single family, promoting the notion of the *familylect*, developed in Sect. 4.3. We will also see that young signers with deaf parents are contributing to the formal development of the language. Our findings suggest that alongside Hockett's requirement of a significantly large vocabulary, a key ingredient in creating a phonological system is conventionalization.

4.1 The emergence of categories

Our larger study on which this article is based relies mainly on 128 elicited items produced by 23 signers in response to pictures. In these elicitations, a large number of handshapes were recorded, pictured in Table 3. Many of these are uncommon or infrequent in the inventories of familiar sign languages, and would therefore not be expected to be included in the phoneme inventory of a new sign language. Further investigation suggests that they are not. It appears that these shapes occur randomly as signers seek to create visual images of items for which they have no conventionalized sign.[20]

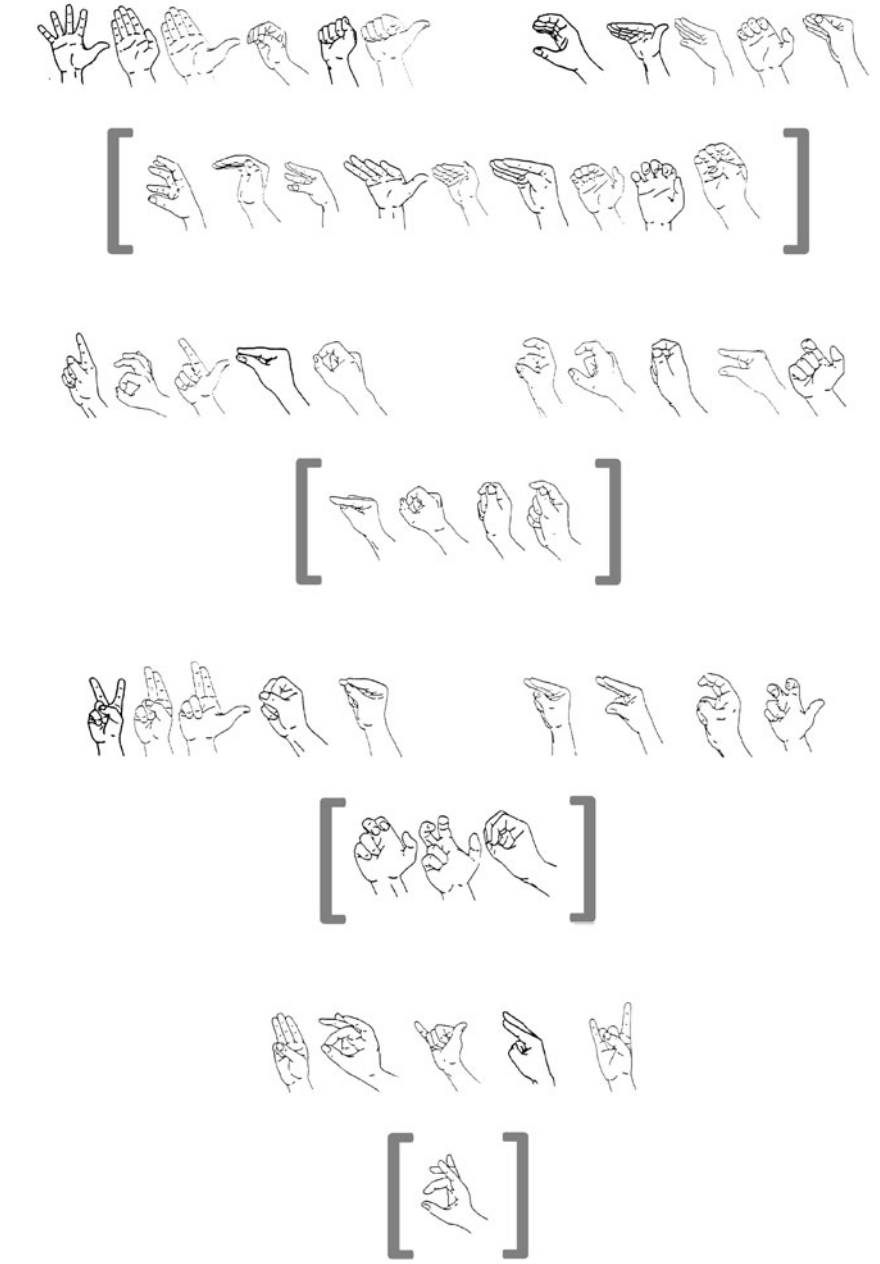
We followed up by looking more closely at a list of signs produced by one signer asked to translate from a list of Hebrew words. We were confident that this signer would be able to read and understand a long list of words, as she possesses a degree of literacy that is very rare among deaf people in the village. Since this signer can read Hebrew, it was clear to her from the written list precisely which concept was required. Of 387 signs (translations of 218 words; many of them were compounds whose handshapes were counted individually), 297 had a handshape with all fingers and thumb selected: 194 in an extended position 'B' and 103 in a lax position, both shown in Fig. 18.

These two shapes are not likely to be contrastive in a more conventionalized system (in which only a clearly curved C shape would contrast with B), so we will consider them one category in the present discussion: an all-five-fingers-extended handshape.

What can we learn from this? Two hypotheses present themselves. The first is that the shape found most often is an unspecified one in the handshape space of which the two in Fig. 18 are phonetic variants. The second hypothesis is that this

[20]For a discussion and representation of markedness in ASL handshapes, see Battison (1978) and Sandler (1996) and references cited there. Note that marked handshapes are more common in bound classifier morphemes of established sign languages than when they function as meaningless phonological units in the lexicon (see Supalla 1986 (ASL) and Duncan 2005 (Taiwan SL) for classifier handshape examples).

Table 3 Handshapes observed in ABSL. For each pair of lines, the second line (in brackets) contains shapes that differ only slightly from those in the line above, included for completeness. The top pair of lines shows shapes with all five fingers; the second pair shows one finger and one finger plus thumb shapes; the third pair of lines shows shapes with two fingers and two fingers plus thumb. Each top line is grouped such that the shapes on the left are the less marked (open or closed) while the shapes on the right are the more marked (curved or bent). The finger combinations in the last pair of lines are considered most highly marked in other sign languages. Handshape illustrations are from the Hamburg Sign Language Notation System (HamNoSys)



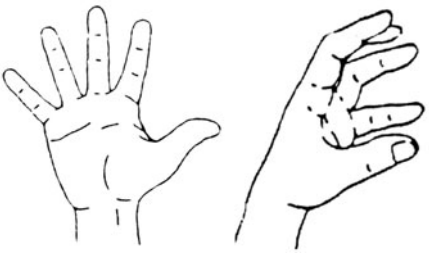


Fig. 18 Tense and lax versions of the five-finger-extended handshape characterizing 74% of signs from the word list of a young second generation signer

Fig. 19 The second most common handshape in the list is maximally distinct from the first

open, five-finger shape is the first that will be recruited in an emerging phonemic system. When we consider the second most common handshape, we see evidence for the latter hypothesis, which was suggested to us by Björn Lindblom (p.c. December, 2008). Eighty (80) signs in the signer's list were characterized by a handshape with the index finger only extended, shown in Fig. 19, a shape that is maximally distinct from that with all five digits selected (Klima and Bellugi 1979). Only ten signs of the list were characterized by other handshapes. In vowel inventories of spoken languages, the articulatory/perceptual distance between vowels can be predicted by the number of vowels in the inventory. The fewer the number of vowels, the more distant from one another in articulation/perception space. A two-vowel system will have the maximally distinct vowels [i, a] and a three-vowel system will consist of [i, a, u] (Liljencrants and Lindblom 1972; Lindblom 1983). In the ABSL case, the first handshape is articulatorily the simplest (Ann 1993), and the second is maximally distinct from it. The other ten handshapes, occurring in much smaller numbers of signs, (from 21 signs to only one sign) included both unmarked and marked shapes, but did not include any of the highly marked shapes found in the picture naming study.[21]

We have not yet found evidence that the shapes in Figs. 17 and 18 are used contrastively in ABSL, but the hypothesis that they are the beginning of a system gives us a promising point at which to begin looking for regularity and other indications

[21]The question of why the translation task elicited this particular distribution of handshapes while the picture naming task elicited a much broader range is still unanswered. A possibility to pursue is that this distribution reveals a division between an emerging stable lexicon accessed in the translation task and a more imagistic representation strategy accessed through picture naming.

of formal organization. In fact, handshapes in which the index finger only is selected are the first ones that we have observed undergoing systematic permutations, as we explain in the next two sections.

4.2 A size and shape specifier morpheme[22]

A common way of creating new lexical items is through compounding, and ABSL makes productive use of this option. In picture naming tasks, ABSL signers often produce two or more nominal signs together. We found that a particular kind of sign denoting the size and shape of the object, which we call a size and shape specifier, is commonly used in these constructions. We hypothesize that these forms are actually affixes rather than members of compounds because they do not occur alone; they are drawn from a small list of possible forms; and they are typically (but not uniformly) in final position. However, the discussion does not hinge on this labeling. The examples WRITE+LONG-THIN-OBJECT specifier for PENCIL, and TV + FLAT-SQUARE-OBJECT specifier for REMOTE-CONTROL-DEVICE, are shown in Fig. 20. In the specifier one hand represents the size and shape of the object (in these examples, index finger only for a long, thin object; two fingers for an object of medium width; and the whole hand for an oblong object) and the other hand contacts the wrist, usually indicating the relative length of the object. Typically, the hand contacting the wrist is in a pointing, one-finger-extended configuration in this affix, so that the two hands have different shapes. While the specific signs in Fig. 20 are not invariant across the community, the word formation process that involves adding a size and shape sign to a referential sign is very widely attested in ABSL (Meir et al. 2010b).[23]

In the examples in Fig. 20, the hand that points to the classifier shape in each of the pictures on the right assimilates the shape of the classifier itself, here, one finger for PENCIL and the whole hand for REMOTE-CONTROL-DEVICE. Also attested but not shown here was SCOOP + LONG-THICKER-OBJECT specifier = SPOON, in which a two-fingers-extended handshape was assimilated from SCOOP to the specifier.

The assimilation found in these affixed forms is not purely motoric in its motivation, since we do not see it in other nonsymmetrical two-handed signs where instead we find that the nondominant hand is overwhelmingly in a lax five-finger-extended shape, regardless of the shape of the dominant hand. It is intriguing that the handshape that assimilates is more typically in an extended index finger configuration. This is one of the two handshapes hypothesized above to form the beginning of a phonological system in ABSL, and, by assimilating in the few instances of assimilation we have found, we see it behaving systematically as a formal element. The index finger can be interpreted as a pointing gesture, indicating on the other hand the length of the

[22] While the specifiers in question function as classifiers, they are not to be confused with the classifiers found in classifier constructions in many sign languages (see papers in the Emmorey 2003 volume), for they are different in both form and function. In ABSL the forms seem to be suffixal, instantiating a sequential type of morphological complexity that is rare in sign languages (see Aronoff et al. 2005).

[23] This process is not attested in ASL or ISL, but a similar though not identical kind of form is reported for another village sign language, Adamarobe Sign Language in Ghana (Nyst 2007).

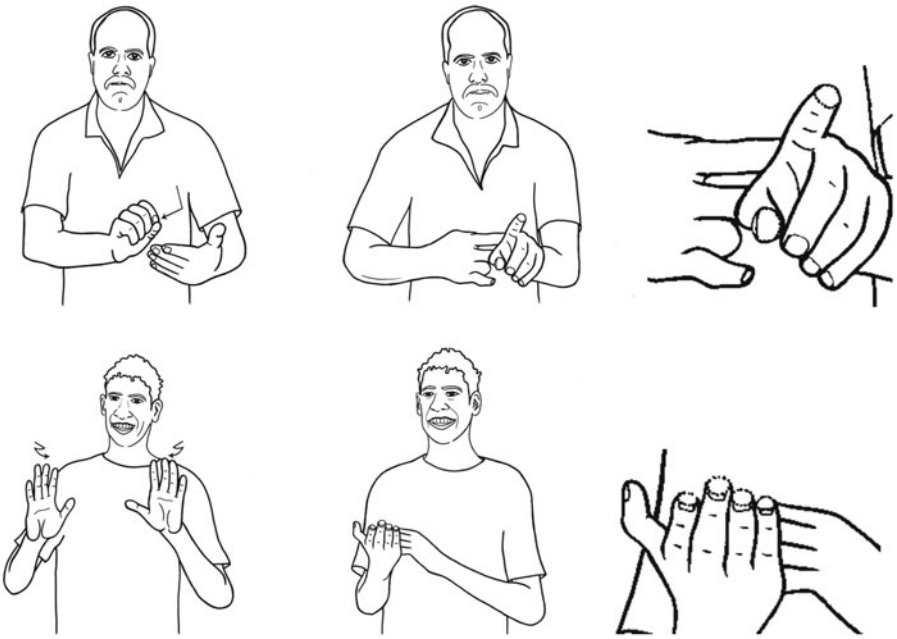


Fig. 20 Assimilation of handshape to that of the other hand in a productive morphological process. (**a**) 'WRITE + LONG THIN OBJECT' = PENCIL. (**b**) 'TELEVISION + RECTANGULAR OBJECT' = REMOTE-CONTROL

object being represented. When it assimilates, its shape is no longer iconic or deictic; instead, it takes on the shape of the dominant hand, behaving as a meaningless formal unit in this process.

That conventionalization is involved is supported by the fact that these examples of assimilation occur in a productive process of specifier affix formation (though the complex words themselves are mostly not conventionalized). Nor do we find handshape assimilation in compounds that are more randomly formed by idiosyncratically stringing together two, three, or four signs (Meir et al. 2010a). The mechanism that adds an affix to specify classes of objects according to size and shape is conventionalized, commonly appearing in our data. This creates a degree of redundancy in form, in the sense that the pointing finger handshape is 'expected' in specifier affixes. We suggest that it is this redundancy, and the automaticity that goes with it, that pave the way for formal elements to organize themselves without reference to meaning.

4.3 Assimilation in a compound and the familylect

Where we see variation in lexical items across the community (Sect. 2.2), we often see uniformity within households that have a number of fluent signers (which may include hearing siblings). For example, the sign for KETTLE, a very common everyday object, is signed in a variety of ways. Three examples are shown in Fig. 21. These productions are not examples of phonetic variance, but of different lexical items.

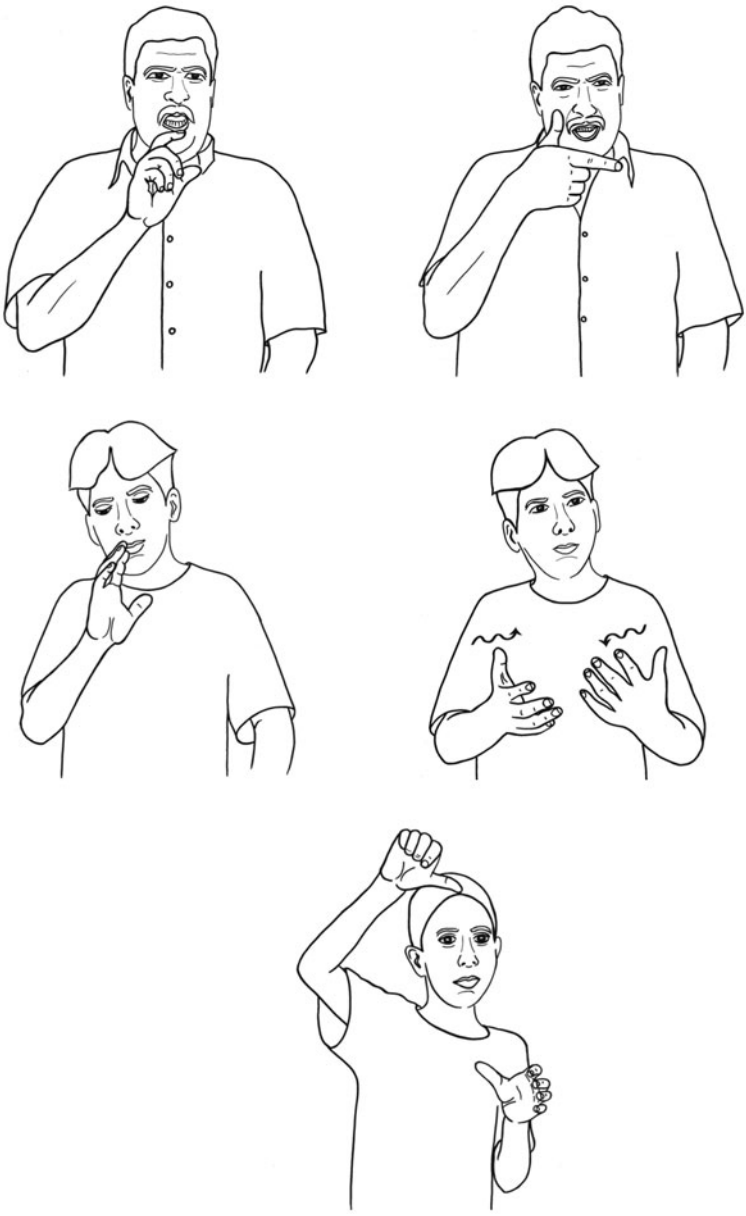


Fig. 21 (**a**–**c**) Some different signs for KETTLE across the village. The first two examples are compounds; the third is simplex

However, this kind of lexical variation disguises an important generalization, which we find when we look closer.

Within families with more than one deaf family member that we investigated, a single form is used. Figure 22 a, b shows the versions of two families for this con-

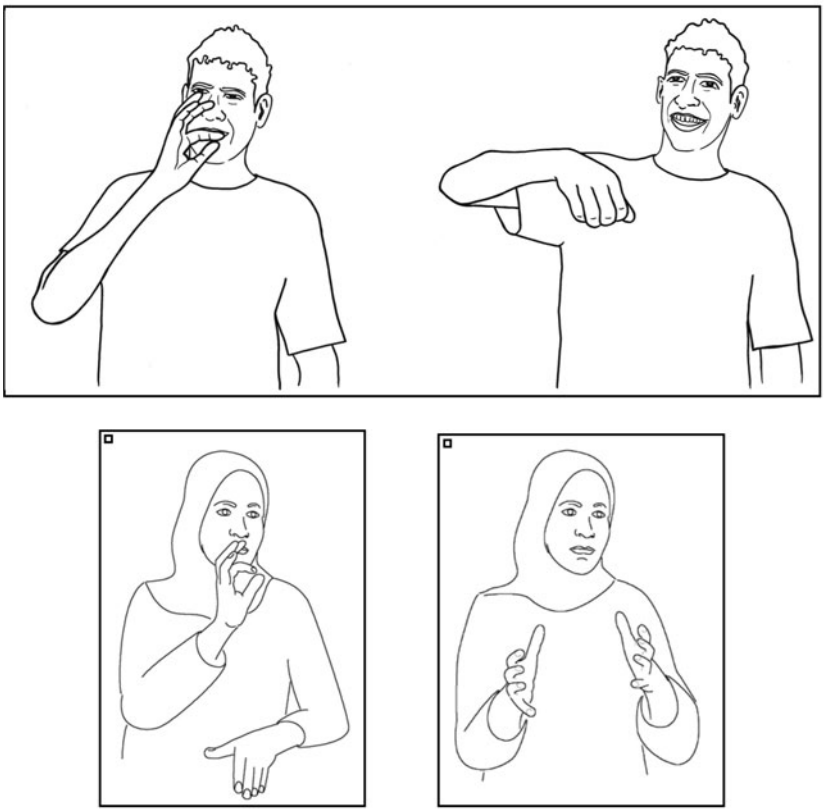


Fig. 22 Familylects. Two different compounds for KETTLE from two different families, uniform across the members of each family

cept. One version of KETTLE (22a) is signed identically for the two deaf brothers and their hearing close-aged sibling in one family. A different version (22b) is signed identically for all five videotaped deaf members of a different family. This lexical uniformity within families is striking compared to the variation found across signers in this small village. It is likely that all the different versions would be intelligible across the community, due to iconicity, context, or the existence of synonymy in the signers' mental lexicons—possibly all of the above. Yet within the family, one choice prevails. This sort of familial consensus seems natural (we all remember family words, sometimes originating as novel pronunciations by small children and persisting), and it may have played a role in the emergence of ancestral languages within small communities of humans. We refer to the language of each family as a *familylect*, and return to this notion in the conclusion.

In the familylect of one family with many deaf members, we find a clue to how conventionalization can lead to duality. The family members include a deaf mother and five deaf children out of eight, a family in which all eight children are fluent signers. (The deaf mother has five deaf siblings herself.) The example we present is the sign for EGG, which is a compound made up of CHICKEN + SMALL-OVAL-

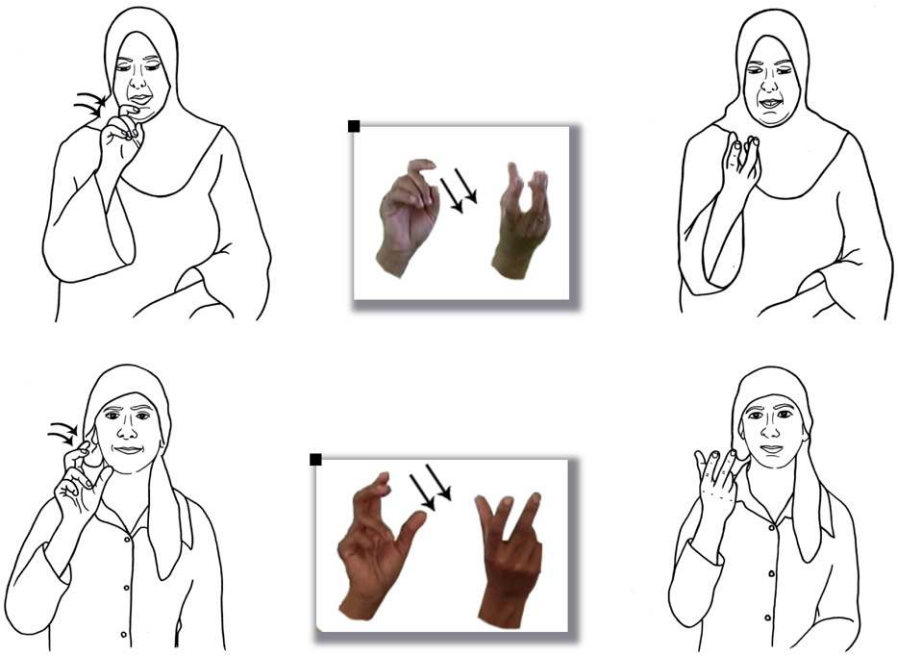


Fig. 23 (**a**) Two handshapes for the compound CHICKEN + 'oval object' = EGG, standard form. (**b**) Consistent assimilation of handshape in first constituent of EGG within a familylect

OBJECT classifier. CHICKEN, a sign that is quite standard across the village, is produced with the index finger in a curved shape and the hand bending at the wrist twice, apparently motivated by the beak of a chicken pecking for food. The sign for SMALL-OVAL-OBJECT is produced with three spread fingers, the palm oriented up. The hands for the basic compound are shown in Fig. 23a.

In the familylect exemplified by the signer in 23b, assimilation occurs. The finger selection for the second sign assimilates regressively to the first sign, CHICKEN. Figure 23b shows the hands for CHICKEN signed in a familylect. A deaf mother and three of her deaf daughters whom we recorded all signed CHICKEN with the same assimilated form.

There are three reasons for believing that this is a phonological alternation, and not mere motoric coarticulation. First, assimilation does not occur in other villagers' sign for EGG. Second, it is confined to this family and occurs in EGG for all four members of the family that we videotaped. Third, it is not gradient, in the sense that all three fingers are selected and are in the same curved, spread position in both members of the compound. The assimilated form is counter-iconic, no longer conveying a narrow, pointed shape. Iconicity gives way to arbitrariness in the emergence of a formal system (Frishberg 1975). The handshape undergoing assimilation is one in which the index finger only is selected, the same finger selection characteristic found in the frequently occurring handshape described above (though differing in finger position), suggesting, albeit tentatively, that the index finger shape has some formal status in the emerging system.

While handshape assimilation in conventionalized compounds is well known in established sign languages, it typically observes a feature hierarchy in which the shape of the fingers dominates the orientation of the hand (see Fig. 15). This constraint is observed in ASL and ISL at least, but in the ABSL example, the constraint is violated: handshape assimilates, but orientation does not. A possible interpretation of this is that the categories of handshape and orientation are emerging, but they are not (yet?) hierarchically organized with respect to each other.

In any motor activity, actions may overlap and otherwise affect other actions in the same motor schema, and the articulations of language are no exception (Browman and Goldstein 1989). But systematic alternations of categories of elements in the same class of environments point to phonological organization, characterized by such properties as discreteness rather than gradience (Hayes 1999).[24]

The handshape assimilation shown here is another example of what happens when a sign becomes fully conventionalized. The meaningful, holistic icon is no longer the target. Instead, the sign is represented as a formal entity, made up of meaningless parts. As in any language, assimilation provides an important clue to the existence and nature of those meaningless formational elements, and, in the case at hand, a clue to the emergence of phonology.

4.4 Children with deaf parents select form over meaning

In some young signers, we begin to see the hint of a dual system, and here again conventionalization is implicated. In particular, in third generation signers with a deaf parent, certain indications that the signs are losing iconicity and gaining articulatory regularity have caught our eye. The examples come from children in a rare linguistic environment in the village. Because the gene for deafness, though recessive, is so widely distributed in the community, some families with one deaf parent have several deaf children. The first two examples we bring here are from such children.

The first example is the sign for TREE. There were a variety of responses among signers to the picture of a tree, most of them complex descriptions, conveying the trunk and then the leaves and then something about the nature of the tree, such as whether it is a date palm or some other kind. But the youngest person we videotaped, aged 5 at the time, signed TREE in a very different way. There was only one sign, consisting of one reduplicated syllable, in which the two hands move together, observing the symmetry condition described above—a well-formed sign by any phonological criteria. In addition, the sign defies iconicity, as the two hands move toward and then away from one another—a phenomenon created not by the wind, but by the symmetry condition on meaningless formational elements. This situation in which articulatory symmetry overrides iconicity is seen in the ASL sign for TAPE-RECORDER. If the sign were faithful to iconicity, the fingers would circle in the same direction, moving the tape from reel to reel. But in the ASL sign, the two index fingers circle in opposite directions. If the reels actually moved in this way, the tape would break. Articulatory symmetry trumps iconicity in a system with duality of patterning.[25]

[24] But see Ernestus (2011) for discussion of gradience in phonological processes.

[25] The signing of young signers in deaf households changed in the direction of duality in the movement category as well. While the signs of the older signers often occurred with no lexical movement—

Fig. 24 (**a**) BOY, signed by an older deaf man in the village. (**b**) BOY signed consistently with countericonic orientation signed by daughter of a deaf man

The second example is the sign for BOY signed by another third generation signer, herself hearing but with a deaf father. That the origin of the iconic sign is the penis can be seen by the way it is typically signed, shown in Fig. 24a as signed by an older signer. The daughter changes the orientation to one that is articulatorily easier, a contralateral orientation that is easier to produce with the side-to-side wrist movement in this sign. Her sign (24b) does not require movement from neutral position at the elbow and shoulder joints as the orientation of the older signers' more iconic version does. Articulatory ease once again trumps iconicity. The sign BOY was required by numerous responses to a sentence elicitation task, and respective productions of father and daughter were consistent throughout the task.

In these examples, it is the fact that the signs are so conventionalized and familiar in these native signers that gives rise to duality. Iconicity is dormant; the hands are not required to represent a visual image as an iconic whole; and the formational elements are free to organize themselves into an independent system.

A connection between arbitrariness and phonology was first noticed in a study of the history of ASL signs. In a comparison of ASL signs since 1913, Frishberg (1975) showed that signs tended to become less iconic and more arbitrary over time. Interestingly, the arbitrariness of the signs was accompanied by more regularity in their formation, both within and across signs (the latter leading to phonology, as we explain). For example, signs that involved movement of parts of the body such as the head or shoulder came to be produced by the hands only over time, thereby limiting the number of primary articulators to one—the hands—comparable to the primary role of the tongue in spoken language (Perlmutter 1991; Sandler 1993a, 1993b). Two-handed signs in ASL tended to become more symmetrical over time in both handshape and movement, constraining the form of discrete articulatory elements (Frishberg 1975). ISL signs have moved in the same direction (Meir and Sandler 2008). What this indicates is that there is a relationship between arbitrariness and phonology. In other words, the diachronic change toward arbitrariness was not random from a formational

phonologically anomalous in those more established sign languages that have been studied—third generation signers in deaf households produced forms that epenthesized lexical movement, counter-iconically (Sandler 2011b).

point of view. As signs became more arbitrary, they did not remain unconstrained in form. Rather, with increased arbitrariness came more systematic imposition of formal constraints of the sort that are characteristic of phonology.

Changes such as these, discovered so far in small numbers in ABSL, should eventually result in the establishment of a finite list of discrete articulatory elements, constraints on their combination, and systematic formal alternations—in duality of patterning.

5 Conclusion

Al-Sayyid Bedouin Sign Language is a natural language that freely and comfortably fulfills the communicative needs of a community. It is a language with robust word order restrictions and some prosodic complexity, but little syntactically marked complexity; one that shows the beginnings of morphological complexity through an affixation process and compounding. ABSL shows much lexical variation and a degree of sublexical variation that leads us to believe it does not yet have a phonological level of structure, that it is a language without duality of patterning.

This raises many questions in the context of contemporary thinking about language. How do these findings mesh with Hockett's observation that duality of patterning is a basic design feature of human language? What are the implications for linguistic theories proposing that phonological organization is part of our innate linguistic endowment? What bearing do these findings have on theories of language evolution that have arisen in recent years? What do we learn about a role for social factors in the formal substance of language?

Hockett himself hypothesized that combinatory organization at the level of the signal came last, only after the size of the set of holistic signals became unmanageable. Our work confirms that language is possible without such combination at the outset, although the kernels of a phonological system are beginning to present themselves. This implies that universal properties of language, or at least a property such as duality/phonology, can be *inevitable* without being somehow prespecified in our species.

Our work also suggests that it is not only the cognitive load of a large vocabulary that triggers the development of phonology, but other factors as well, notably conventionalization, and the concomitant weakening of a one-to-one correspondence between form and meaning. This claim is compatible with the well-documented phenomenon of phonetic reduction in redundant material. The word *nine* in the adage *A stitch in time saves nine* is far more reduced in structure than the same word in the unpredictable context, *The next number is nine* (Lieberman 1963). Similarly, Gahl (2008) has shown that frequent words like *time* are shorter than their infrequent homophones, in this case *thyme*. It also sits well with a body of evidence in Exemplar Theory showing that words occurring with high frequency are more likely to undergo various kinds of reduction than less frequent words with similar phonological properties. A syllable is lost in frequent words with unstressed schwa+sonorant sequences like *every, camera* but not in lower frequency words like *mammary, artillery*, and final [t, d] are more likely to be deleted in frequent words like *and, just* than in less

frequent words (Bybee 2001). In all cases it is redundancy that fosters departure from the canonical form of the word. In a new language, we argue that conventionalization is the mother of redundancy in the signal, and the redundancy in turn takes the burden off faithfulness to the canonical, in our case, iconic, form. Formal reorganization then becomes possible.

The study puts forward the notion of the familylect, arising, we argue, from conventionalization within families that have rich sign language interaction. An additional motivation for the emergence of a familylect is sociological. Labov's work (1994, 2001) has provided robust and widespread evidence for the importance of correlations between phonetic/phonological speech characteristics and membership in a social group. Docherty and Foulkes (2000:111), investigating the social distribution of preaspiration of voiceless stops in Tyneside English, explain the phenomenon this way: "... it seems that speakers not only produce lexical items in sufficiently distinct form that their message can be successfully conveyed to listeners, but in doing so are simultaneously *using the same vocal apparatus to signal aspects of their social identity* [emphasis ours]." Substitute 'manual' for 'vocal', and we see another explanation for familylects in ABSL.

Research has shown that deaf children exposed to irregular models tend to impose more regular structure on their language productions (Singleton and Newport 2004; Senghas et al. 2005), a phenomenon that is sometimes attributed to creolization. The nature of the processes behind "creolization" is a hotly debated issue. Even Bickerton, champion of the theory that creole grammar springs forth from the language bioprogram in the brains of children, attaches a great deal of importance to social factors in this process (Bickerton 1984), and there are certainly creolists who argue that adults make important contributions to creolization (see McWhorter 2005 for discussion). Fortunately, we need not leap into that fray, since the input here is a naturally occurring language in a community, and not a pidgin or a late-acquired language. In any case, we find evidence for regularization in older, second generation adults (familylect lexical consensus, for example, in KETTLE, and assimilation in the lexical compound, EGG) as well as in third generation children. Recall that the first generation of deaf people in Al-Sayyid consisted of four siblings, none of whom were parents of the older second-generation signers to whose signing we attribute familylect features. While the explanation for the emergence of phonological form will certainly come partly from the proclivities of the child's mind, it must also have other sources.

We propose that conventionalization among signers, and the automaticity and redundancy that go with it, underlie the emergence of a meaningless formal level of structure in the language of a community. As a particular sign becomes conventionalized, attention to the form–meaning correspondence is reduced, and the formational elements themselves self-organize, under cognitive and motoric pressures for ease of articulation, formal symmetry, and the like. An element that is automatically and conventionally part of some sign may become redundant in the sense that the meaning of the sign does not directly rely on it, and it can then become vulnerable to permutation under formal organizational pressures such as ease of articulation.

In the familylect's conventionalized compound, EGG, the 'beakiness' of a handshape that looks like a bird's beak no longer contributes to its meaning, and production of the sign becomes automatic for the signers. In this case, we might hypothesize

that the number of fingers selected for the first part of the sign becomes redundant through this conventionalization, and subject to assimilation for reasons such as ease of articulation. In productively formed classifier affixes, a gesture pointing to the articulating hand is no longer a pointing gesture, and the hand involved in the articulation of the sign is free to assimilate to the shape of the other hand, creating a more symmetrical structure. When a sign is conventional and automatic, and the iconic relation between the form and the meaning are no longer prominent, the modality-universal well-formedness requirements are imposed, even when they contradict the meaning originally contributed by iconicity. Fingertips of the two hands wave toward and away from each other because such movement is symmetrical, and not because leaves blow in opposite directions.

It seems reasonable to adopt, as Pinker and Jackendoff (2005) do, Hockett's suggestion that the need to create a large vocabulary contributes to the emergence of duality. At the same time, laboratory experiments suggest that humans may have a propensity to create duality even with a very small vocabulary of symbols (Del Giudice et al. 2010). In any case, it is likely that more than one kind of pressure is responsible for the phenomenon. We propose that conventionalization together with automaticity and redundancy propel the self organization of the system as well.[26]

In a paper about the evolution of language, Jackendoff (1999) hypothesizes that a phonological level of structure must have preceded hierarchical syntax, on the assumption that a large vocabulary must have come first, and that a large vocabulary requires phonological compositionality. Apparently, it is not the case that phonology must precede syntax, at least for a sign language. But could spoken languages have arisen without duality?

The aural/oral modality does not lend itself to iconicity to the same extent that the visual/corporeal modality does. In fact, the ability to transparently represent correspondence between the sound of a word and its meaning is so limited in the aural/oral medium that de Saussure (1916) proposed arbitrariness in the sound-meaning relation as a fundamental characteristic of language. Some languages, like Japanese (Hamano 1994) and Kambera (Klamer 2002), do have extensive subsystems of mimetics or expressives—sequences of sounds that evoke particular physical sensations and events, such as quick movement or rolling—so it is conceivable that a certain amount of communication could take place through an iconic acoustically conveyed system. But even if early words were arbitrarily related to their meanings, it is possible that they were initially holistic syllables, only later becoming variegated into different combinations of consonants and vowels (MacNeilage and Davis 2000, 2005). It is certainly conceivable that early humans were able to store a much larger number of distinct holistic signals than vervet monkeys, and might have created syntactic combinations with those.

The research reported here resonates with current work in phonological theory that speaks to the issue of innateness in phonology. For example, Blevins (2004) provides persuasive evidence that most properties of the synchronic phonology of any

[26]Thanks to Louis Goldstein for his thoughtful comments on this work, among them, pointing out the likelihood that a phenomenon as robust as duality of patterning must have more than one source.

language result from the interaction of physical, cognitive, and social forces in its history rather than from properties that are intrinsic to the language faculty. As ABSL has virtually no history, it is not surprising on this view that it has little in the way of phonology. Alternatively, Berent (to appear) brings together evidence from a number of disciplines and types of data (including sign language) to argue for a specialized "phonological mind". Interestingly, Berent interprets the appearance of the kernels of phonology in ABSL (including those reported in Sect. 4 here) as supportive of her theory. We take the position that basic properties of human language in both modalities self-organize from a complex array of interacting human propensities and various pressures, including propensities that may be specific to language (see Sandler 2010).

We cannot know for sure whether early spoken words were iconic or holistic or both, and whether early spoken language was devoid of duality at the outset. But Al-Sayyid Bedouin Sign Language shows that such a language is humanly possible.

Acknowledgements This research was supported by National Institutes of Health grants DC6473 and R01-DC6473, U.S.–Israel Binational Science Foundation grant 200-372, and Israel Science Foundation grant 5433/04. Our thanks to Debbie Menashe and to Meir Etedgi for illustrations of ABSL signs.

References

Anderson, Stephen R. 2002. *Doolittle's delusion: Animal communication, linguistics, and the uniqueness of human language*. New Haven: Yale University Press.

Ann, Jean. 1993. A linguistic investigation of the relationship between physiology and handshape. PhD dissertation, University of Arizona, Tucson.

Aronoff, Mark, Irit Meir, Carol Padden, and Wendy Sandler. 2003. Classifier constructions and morphology in two sign languages. In *Perspectives on classifier constructions in sign languages*, ed. Karen Emmorey, 53–85. Mahwah: Lawrence Erlbaum Associates.

Aronoff, Mark, Irit Meir, and Wendy Sandler. 2005. The paradox of sign language morphology. *Language* 81: 301–344.

Aronoff, Mark, Irit Meir, Carol Padden, and Wendy Sandler. 2008. The roots of linguistic organization in a new language. In *Holophrasis, compositionality and protolanguage. Special issue of interaction studies*, eds. Derek Bickerton and Michael Arbib, 133–149.

Battison, Robbin. 1978. *Lexical borrowing in American Sign Language*. Silver Spring: Linstok Press.

Berent, Iris. To appear. *The phonological mind*. Cambridge: Cambridge University Press.

Bickerton, Derek. 1984. The language bioprogram hypothesis. *Behavioral and Brain Sciences* 7: 173–221.

Blevins, Juliette. 2004. *Evolutionary phonology*. Cambridge: Cambridge University Press.

Bloomfield, Leonard. 1933. *Language*. New York: Holt.

Brentari, Diane. 1990. Theoretical foundations of American Sign Language phonology. PhD dissertation, University of Chicago.

Brentari, Diane. 1998. *A prosodic model of sign language phonology*. Cambridge: MIT Press.

Brentari, Diane. 2002. Modality differences in phonology and morphophonemics. In *Modality and structure in signed and spoken language*, eds. Richard P. Meier, Kearsy Cormier, and David Quinto-Pozos, 35–64. Cambridge: Cambridge University Press.

Brentari, Diane. To appear. Sign language phonology. In *Handbook of phonological theory*, eds. John Goldsmith, Jason Riggle, and Alan Yu. New York: Blackwell.

Brentari, Diane, and John Goldsmith. 1993. Secondary licensing and the nondominant hand in ASL phonology. In *Phonetics and phonology 3: Current issues in ASL Phonology*, ed. Geoffrey Coulter, 19–41. San Diego: Academic Press.

Brentari, Diane, and Carol Padden. 2001. Native and foreign vocabulary in American Sign Language: A lexicon with multiple origins. In *Foreign vocabulary in sign languages*, ed. Diane Brentari, 87–120. Mahwah: Lawrence Erlbaum Associates.

Browman, Catherine, and Louis Goldstein. 1989. Articulatory gestures as phonological units. *Phonology* 6: 201–251.

Bybee, Joan L.. 2001. *Phonology and language use*. Cambridge: Cambridge University Press.
Chomsky, Noam, and Morris Halle. 1968. *The sound pattern of English*. New York: Harper and Row.
Clements, George N. 1985. The geometry of phonological features. In *Phonology yearbook 2*, 225–252.
Clements, George N. 1990. The role of the sonority cycle in core syllabification. In *Papers in laboratory phonology 1: Between the grammar and physics of speech*, eds. John Kingston and Mary Beckman, 283–333. New York: Cambridge University Press.
Corina, David. 1993. To branch or not to branch: Underspecification in ASL handshape contours. In *Current issues in ASL phonology*, ed. Geoffrey Coulter, 63–95. New York: Academic Press.
Crasborn, Onno. 2011. The other hand in sign language phonology. In *Blackwell companion to phonology*, eds. Marc van Oostendorp, Colin Ewen, Keren Rice, and Elizabeth Hume, 223–240. Oxford: Wiley-Blackwell.
Dediu, Dan, and Robert Ladd. 2007. Linguistic tone is related to the population frequency of the adaptive haplogroups of two brain size genes, ASPM and Microcephalin. *Proceedings of the Natural Academy of Sciences* 104: 10944–10949.
Dobrin, Lise. 1998. The morphosyntactic reality of phonological form. In *Yearbook of morphology 1997*, eds. Geert Booij and Jaap van Marl, 59–81. Amsterdam: Kluwer Academic Publishers.
Docherty, Gerard, and Paul Foulkes. 2000. Speaker, speech, and knowledge of sounds. In *Phonological knowledge: Conceptual and empirical issues*, eds. Noel Burton-Roberts, Philip Carr, and Gerard Docherty, 105–130. New York: Oxford University Press.
de Boer, Bart. 2001. *The origins of vowel systems*. Oxford: Oxford University Press.
de Saussure, Ferdinand. 1916. *Cours de linguistique générale*, eds. Charles Bally and Albert Sechehaye with the collaboration of Albert Riedlinger. Lausanne: Payot.
Del Giudice, Alex, Simon Kirby, and Carol Padden. 2010. Recreating duality of patterning in the laboratory: A new experimental paradigm for studying the emergence of sublexical structure. In *Proceedings of the 8th international conference (EVOLANG 8)*, eds. Andrew D.M. Smith, Marieke Schouwstra, Bart de Boer, and Kenny Smith. Utrecht University, The Netherlands.
Duncan, Susan. 2005. Gesture in signing: A case study from Taiwan Sign Language. *Language and Linguistics* 6: 279–318.
Gahl, Susanne. 2008. Time and thyme are not homophones: The effect of Lemma Frequency on word durations in spontaneous speech. *Language* 84: 474–496.
Goldin-Meadow, Susan, Carolyn Mylander, and Cynthia Butcher. 1995. The resilience of combinatorial structure at the word level: Morphology in self-styled gesture systems. *Cognition* 56: 195–262.
Eccarius, Petra. 2002. Finding common ground: A comparison of Handshape across multiple sign languages. MA thesis, Purdue University.
Emmorey, Karen, ed. 2003. *Perspectives on classifier constructions in sign languages*. Mahwah: Lawrence Erlbaum Associates.
Ernestus, Mirjam. 2011. Gradience and categoricality in phonological theory. In *Blackwell companion to phonology*, eds. Marc van Oostendorp, Colin Ewen, Elizabeth Hume, and Keren Rice, 2115–2136. Oxford: Blackwell.
Fischer, Susan. 1978. Sign language and Creoles. In *Understanding language through sign language research*, ed. Patricia Siple, 309–331. London: Academic Press.
Frishberg, Nancy. 1975. Arbitrariness and iconicity: Historical change in American Sign Language. *Language* 51: 696–719.
Hamano, Shoko. 1994. Palatalization in Japanese sound symbolism. In *Sound symbolism*, eds. Leanne Hinton, Johanna Nichols, and John J. Ohala, 148–157. Cambridge: Cambridge University Press.
Hayes, Bruce. 1999. Phonetically driven phonology: The role of optimality theory and inductive grounding. In *Functionalism and formalism in linguistics*, eds. Michael Darnell, Edith Moravscik, Frederick Newmeyer, Michael Noonan, and Kathleen Wheatley, 243–285. Amsterdam: John Benjamins.
Hockett, Charles. 1960. The origin of speech. *Scientific American* 203: 89–96.
Israel, Assaf. 2009. Sublexical variation in three sign languages. MA thesis, University of Haifa.
Israel, Assaf, and Wendy Sandler. 2010. Observing the birth of phonology. In *Proceedings of the 8th international conference on the evolution of language (EVOLANG 8)*, eds. Andrew D.M. Smith, Marieke Schouwstra, Bart de Boer, and Kenny Smith. 14–17 April 2010, Utrecht University, The Netherlands.
Israel, Assaf, and Wendy Sandler. To appear. Phonological category resolution: A study of handshapes in younger and older sign languages. In *Formational units in sign language*, eds. Rachel Channon and Harry van der Hulst. Nijmegen: Ishara Press.
Jackendoff, Ray. 1999. Possible stages in the evolution of the language capacity. *Trends in Cognitive Sciences* 3: 272–279.

Johnson, Keith. 1997. Speech perception without speaker normalization: An exemplar model. In *Talker variability in speech processing*, eds. Keith Johnson and John Mullennix, 145–165. San Diego: Academic Press.

Kirby, Simon. 1999. *Function, selection and innateness: The emergence of language universals*. Oxford: Oxford University Press.

Kisch, Shifra. 2000. Deaf discourse: Social construction of deafness in a Bedouin community in the Negev. Tel Aviv University MA thesis, Tel Aviv.

Klamer, Marian. 2002. Semantically motivated lexical patterns: A study of Dutch and Kambera expressives. *Language* 78: 258–286.

Klima, Edward S., and Ursula Bellugi. 1979. *The signs of language*. Cambridge: Harvard University Press.

Labov, William. 1994. *Principles of linguistic change. Volume 1: Internal factors*. Oxford: Blackwell.

Labov, William. 2001. *Principles of linguistic change. Volume II: Social factors*. Oxford: Blackwell.

Lane, Harlane, Richard C. Pillard, and Mary French. 2000. Origins of the American deaf-world: Assimilating and differentiating societies and their relation to genetic patterning. *Sign Language Studies* 1: 17–44.

Liddell, Scott K., and Robert E. Johnson. 1986. American Sign Language compound formation processes, lexicalization, phonological remnants. *Natural Language and Linguistic Theory* 8: 445–513.

Liddell, Scott K., and Robert E. Johnson. 1989. American Sign Language: The phonological base. *Sign Language Studies* 64: 195–277

Lieberman, Philip. 1963. Some effects of semantic and grammatical context on the production and perception of speech. *Language and Speech* 6: 172–187.

Liljencrants, Johan, and Björn Lindblom. 1972. Numerical simulation of vowel quality systems: The role of perceptual contrast. *Language* 48: 839–862.

Lindblom, Björn. 1983. Economy of speech gestures. In *The production of speech*, ed. Peter F. MacNeilage, 217–245. New York: Springer.

MacNeilage, Peter F., and Barbara L. Davis. 2000. On the origin of the internal structure of word forms. *Science* 288: 527–531.

MacNeilage, Peter F., and Barbara L. Davis. 2005. The frame/content theory of the evolution of speech: A comparison with a gestural-origins alternative. *Interaction Studies* 6: 173–199.

Mandel, Mark. 1981. Phonotactics and morphophonology in ASL. PhD dissertation, University of California, Berkeley.

Martinet, André. 1960. *Éléments de linguistique générale*. Paris: Armand Colin.

McWhorter, John. 2005. *Defining Creole*. New York: Oxford University Press.

Meier, Richard. 2002. Why different, why the same? Explaining effects and non-effects of modality upon linguistic structure in sign and speech. In *Modality and structure in signed and spoken languages*, eds. Richard P. Meier, Kearsy Cormier, and David Quinto-Pozos, 1–26. Cambridge: Cambridge University Press.

Meir, Irit, and Wendy Sandler. 2008. *A language in space: The story of Israeli Sign Language*. New York: Lawrence Erlbaum Associates/Taylor Francis.

Meir, Irit, Wendy Sandler, Carol Padden, and Mark Aronoff. 2010a. Emerging sign languages. In *Oxford handbook of deaf studies, language, and education*, Vol. 2, eds. Marc Marschark and Patricia Spencer, 267–280. Oxford: Oxford University Press.

Meir, Irit, Mark Aronoff, Wendy Sandler, and Carol Padden. 2010b. Sign languages and compounding. In *Compounding*, eds. Sergio Scalise and Irene Vogel. Amsterdam: John Benjamins.

Nyst, Victoria. 2007. A descriptive analysis of Adamrobe Sign Language (Ghana). PhD dissertation, University of Amsterdam.

Padden, Carol, and David M. Perlmutter. 1987. American Sign Language and the architecture of phonological theory. *Natural Language and Linguistic Theory* 5: 335–375

Padden, Carol, Irit Meir, Wendy Sandler, and Mark Aronoff. 2010. Against all expectations: Encoding subjects and objects in a new language. In *Hypothesis A/Hypothesis B: Linguistic explorations in honor of David M. Perlmutter*, eds. Donna Gerdts, John Moore, and Maria Polinsky, 383–400. Cambridge: MIT Press.

Perlmutter, David. 1991. Feature geometry in a language with two active articulators. Ms., LSA Summer Institute, Santa Cruz.

Perlmutter, David. 1992. Sonority and syllable structure in American Sign Language. *Linguistic Inquiry* 23: 407–442.

Pierrehumbert, Janet. 2001. Exemplar dynamics: Word frequency, lenition and contrast. In *Frequency and the emergence of linguistic structure*, eds. Joan Bybee, and Paul Hopper, 137–157. Amsterdam: John Benjamins.

Pinker, Steven, and Ray Jackendoff. 2005. The faculty of language: What's special about it? *Cognition* 95: 201–236.

Robinson, Stuart. 2006. The phoneme inventory of the Aita dialect of Rotakas. *Oceanic Linguistics* 45: 206–209.

Sandler, Wendy. 1987. Assimilation and feature hierarchy in ASL. In *Chicago Linguistics Society parasession on autosegmental phonology*, eds. Anne Bosch, Barbara Need, and Eric Schiller, 266–278. Chicago: Chicago Linguistic Society.

Sandler, Wendy. 1989. *Phonological representation of the sign: Linearity and nonlinearity in American Sign Language*. Dordrecht: Foris.

Sandler, Wendy. 1993a. A sonority cycle in American Sign Language. *Phonology* 10: 209–241.

Sandler, Wendy. 1993b. Hand in hand: The roles of the nondominant hand in sign language phonology. *The Linguistic Review* 10: 337–390.

Sandler, Wendy. 1996. Representing handshapes. In *International review of sign linguistics*, eds. William Edmondson and Ronnie B. Wilbur, 115–158. Mahwah: Lawrence Erlbaum Associates.

Sandler, Wendy. 1999. Cliticization and prosodic words in a sign language. In *Studies on the phonological word*, eds. Tracy Alan Hall and Ursula Kleinhenz, 223–254. Amsterdam: Benjamins.

Sandler, Wendy. 2005. Phonology, phonetics and the nondominant hand. In *Papers in laboratory phonology: Varieties of phonological competence*, eds. Louis Goldstein, Douglas Whalen, and Catherine Best, 185–212. Berlin: Mouton de Gruyter.

Sandler, Wendy. 2008. The sign language syllable: Hand and mouth in the evolution of language. In *Ontogeny and phylogeny of syllable organization*, eds. Barbara Davies and Kristine Zajdo. Mahwah: Lawrence Erlbaum Associates.

Sandler, Wendy. 2010. The uniformity and diversity of language: Evidence from sign language. Response to Evans and Levinson. *Lingua* 120: 2727–2732.

Sandler, Wendy. 2011a. Prosody and syntax in sign language. *Transactions of the Philological Society* 108: 298–328.

Sandler, Wendy. 2011b. The phonology of movement in sign language. In *Blackwell companion to phonology*, eds. Marc van Oostendorp, Colin Ewen, Keren Rice, and Elizabeth Hume, 577–603. Oxford: Wiley-Blackwell.

Sandler, Wendy. To appear. The visual prosody of sign language. In *Sign language: An international handbook*, eds. Roland Pfau, Markus Steinbach, and Bencie Woll. Berlin: Mouton de Gruyter.

Sandler, Wendy, and Diane Lillo-Martin. 2006. *Sign language and linguistic universals*. Cambridge: Cambridge University Press.

Sandler, Wendy, Irit Meir, Carol Padden, and Mark Aronoff. 2005. The emergence of grammar: Systematic study in a new language. *Proceedings of the National Academy of Sciences* 102: 2661–2665.

Sandler, Wendy, Irit Meir, Svetlana Dachkovsky, Mark Aronoff, and Carol Padden. 2008. Prosody and linguistic complexity in an emerging language. In *The evolution of language*, eds. Andrew D.M. Smith, Kenny Smith, and Ramon Ferrer i Cancho, 489–490. World Scientific: Singapore.

Sandler, Wendy, Irit Meir, Svetlana Dachkovsky, Mark Aronoff, and Carol Padden. To appear. The emergence of complexity in prosody and syntax. *Lingua*.

Senghas, Anne, Richard Senghas, and Jenny Pyers. 2005. The emergence of Nicaraguan Sign Language: Questions of development, acquisition, and evolution. In *Biology and language revisited: From neurogenesis to psychogenesis*, eds. Jonas Langer, Sue Taylor Parker, and Constance Mibrath, 287–306. Mahwah: Lawrence Erlbaum Associates.

Singleton, Jenny, and Elissa L. Newport. 2004. When learners surpass their models: The acquisition of American Sign Language from inconsistent input. *Cognitive Psychology* 49: 370–407.

Smith, Kenny, Simon Kirby, and Henry Brighton. 2003. Iterative learning: A framework for the emergence of language. *Artificial Life* 9: 371–386.

Stevens, Kenneth N., and Samuel J. Keyser. 1989. Primary features and their enhancement in consonants. *Language* 65: 81–106.

Stokoe, William. 1960. Sign language structure: An outline of the visual communications systems. In *Studies in linguistics, occasional papers 8*, Buffalo: University of Buffalo.

Supalla, Ted. 1986. The classifier system in American Sign Language. In *Noun classification and categorization*, ed. Collette Craig, 118–214. Amsterdam: Benjamins.

van der Hulst, Harry. 1993. Units in the analysis of signs. *Phonology* 10: 209–242.

van der Hulst, Harry. 1996. On the other hand. *Lingua* 98: 121–143.

van der Kooij, Els. 2002. Phonological categories in Sign Language of the Netherlands: The role of phonetic implementation and iconicity. PhD dissertation, University of Leiden. Published by LOT.

Wilbur, Ronnie B. 1993. Syllables and segments: hold the movements and move the holds! In *Current issues in ASL phonology*, ed. Geoffrey Coulter, 135–168. New York: Academic Press.

Wilbur, Ronnie B. 2000. Phonological and prosodic layering of nonmanuals in American Sign Language. In *The signs of language revisited: Festschrift for Ursula Bellugi and Edward Klima*, eds. Lane Harlan and Karen Emmorey, 213–241. Hillsdale, NJ: Lawrence Erlbaum.

Zwicky, Arnold M., and Geoffrey K. Pullum. 1986. The principle of phonology-free syntax: introductory remarks. In *Interfaces*, ed. Arnold M. Zwicky, 63–91. Columbus: Ohio State University.