American Sign Language: The Phonological Base

Scott K. Liddell and Robert E. Johnson

Abstract

This paper has the ambitious goal of outlining the phonological structures and processes we have analyzed in American Sign Language (ASL). In order to do this we have divided the paper into five parts. In section 1 we detail the types of sequential phenomena found in the production of individual signs, allowing us to argue that ASL signs are composed of sequences of phonological segments, just as are words in spoken languages. Section 2 provides the details of a segmental phonetic transcription system. Using the descriptions made available by the transcription system, Section 3 briefly discusses both paradigmatic and syntagmatic contrast in ASL signs. Section 4 deals with the various types of phonological processes at work in the language, processes remarkable in their similarity to phonological processes found in spoken languages. We conclude the paper with an overview of the major types of phonological effects of ASL's rich system of morphological processes.

We realize that the majority of readers will come to this paper with neither sign language proficiency nor a knowledge of sign language structure. As a result, many will encounter reference to ASL signs without knowing their form. Although we have been unable to illustrate all the examples, we hope we have provided sufficient illustrations to make the paper more accessible.

1. Sequential Phenomena in Sign Formation

1.1 Background

The fact that all spoken languages combine meaningless elements to form meaningful symbols is regarded as one of the defining features of human language. Stokoe (1960) demonstrated that ASL signs may also be viewed as compositional rather than holistic and thereby provided the first structural evidence that ASL should be regarded as a language rather than merely a gesture system. His pioneering work has had a profound effect on all subsequent research into ASL structure.

He proposed that a sign consists of three parts which combine simultaneously: the tab (location of the sign), the dez (handshape), and the sig (the movement). Influenced by the American structuralists, Stokoe referred to these three aspects of a sign as "cheremes." He regarded cheremes as meaningless elements which combined to form all the signs in the language, in a manner analogous to that of spoken language phonemes.

The Stokoe model has been adopted almost universally by sign language researchers. The most recent treatments of the model hold signs to be temporally unitary phenomena, composed of some number of simultaneously occurring gestural

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primes. According to this view of sign structure, the entire set of gestures comprising a sign is seen to be analogous to the set of articulatory primes that comprise a single segment in spoken language (Studdert-Kennedy and Lane 1980; Klima and Bellugi 1979:85–194).

Differences among signs are described by the substitution of primes within the simultaneous bundle. Thus, the difference between the signs MOTHER (an Open "5" hand touches the chin twice with the thumb) and FATHER (an Open "5" hand touches the forehead twice with the thumb) is described as a difference in location in the bundles of otherwise identical primes. Analogously, the difference between [p] and [t] is commonly described as a difference in the place of articulation primes in bundles of otherwise identical primes. Because of this view, sign languages have been seen to be unusual in that meaning is attached to such simultaneous bundles rather than to sequences of such bundles as it is in spoken languages.

In this model of sign structure (as in the model of spoken language segment structure), however, the claim that signs are simultaneous bundles of primes is not a claim that there are no sequential events within signs. It is a claim that within signs sequential organization is phonologically unimportant. Thus, while Stokoe and more recent workers recognize sequence within signs, they typically hold it to be phonologically insignificant (Stokoe 1960, Battison 1978). This is similar to the recognition that the onset-closure sequence present in the stops [p] and [t] is phonologically insignificant.

Liddell (1984a) argues that an adequate description of many phenomena in ASL requires the recognition of sequences of primes, and demonstrates that such sequences are capable of signaling contrast among signs. Below we will describe several descriptively important sequences of primes, and then return to the issue of contrast.

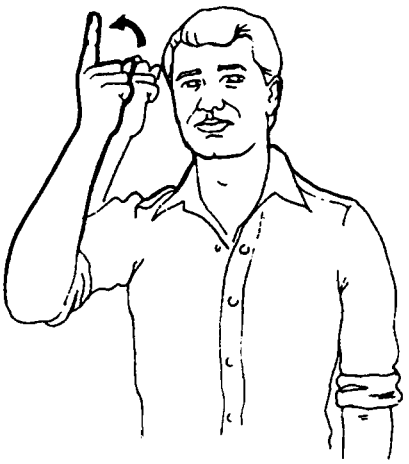


Figure 1. UNDERSTAND

1.2 Handshapes

A significant number of signs in the ASL lexicon are produced with changes in handshape. For example, UNDERSTAND begins with an S handshape but ends with a 1 handshape.

This handshape change is described by Stokoe et al. (1965) as a unitary movement they call an "opening movement" wherein a handshape changes from a "Closed" handshape to an "Open" handshape. Table 1 presents a sampling of signs which all begin

Table 1. Signs with Initial S Handshape Changing to Second Shape

Sign	Initial Handshape	Final Handshape
UNDERSTAND	S	1
THROW	S	H
TWELVE	S	V
SO-WHAT	S	O
FINGERSPELL-TO	S	4
GAMBLE	S	5

with an S handshape, but end with different handshapes.

Many other sequences of two handshapes occur in ASL signs. A smaller number of signs are produced with a sequence of three handshapes. In SHOCKED the handshape sequence is S-C-S. In THINK-SAME-THOUGHT the sequence is S-1-S. In GOVERNMENT the sequence is 1-Bent 1-1.

1.3 Locations

It is quite common for the hand to move from one location to another location during the production of a single sign. Such relocations occur frequently in simple signs and are especially common in compound signs, almost all of which move from one location to another.

The sign PARENTS is such a compound sign, derived from the signs MOTHER and FATHER. It begins at the chin (the location of MOTHER) and then moves to the forehead (the location for FATHER). Table 2 lists several examples of signs in which the location of the hand changes.

Compounds are marked with a "(C)." Because Stokoe's sign schema permits a sign to have only one location, his notations treat

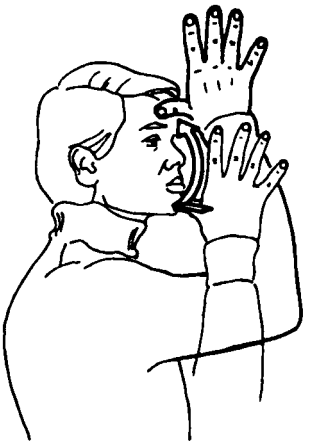


Figure 2. PARENTS

relocations in simple signs as complexes of movements. Thus, for example, NAVY might be said to be located at the left side of the waist and then to move to the right and make contact. The actual location at the right side of the waist would not be specified. Compounds are treated as linked notations of two complete signs, each of which has its own location.

Numerous verbs in ASL are marked for subject and object agreement and typically move from one location to another. Table 3 shows the locations involved with two verbs

Table 2. Initial and Final Locations of Some Common Signs

	Sign	Initial Location	Final Location
	SANTA-CLAUS	chin	chest
	GOOD	chin	base hand
	NAVY	left side of waist	right side of waist
	KING	left side of chest	right side of waist
	INDIAN	nose	side of forehead
	AHEM	chin	chest
(C)	PARENTS	chin	forehead
(C)	SON	forehead	forearm
(C)	PALE	chest	face
(C)	BROTHER	forehead	base hand
(C)	PROMISE	chin	base hand

Table 3. Initial and Final Locations for Two Agreement Verbs

Verb	Subj.	Obj.	Initial Loc.	Final Loc.
TELL	—	1st person	chin	chest
TELL	—	3rd person(a)	chin	place(a)
GIVE	1st person	3rd person(b)	chest	place(b)
GIVE	3rd person(a)	3rd person(b)	place(a)	place(b)
GIVE	3rd person(b)	1st person	place(b)	chest

marked for agreement. TELL always begins in contact with the chin, and then moves to a location which reflects agreement with its object. GIVE agrees with both its subject and object. Its initial and final locations are determined by the subject and object agreement morphemes which are inserted into the verb stem. Subject and object marking is not capable of being represented in Stokoe's notation system. We will discuss this in more detail in section 1.6.

1.4 Movements

Stokoe's original observations demonstrated that some signs require movements to be carried out in sequence. He describes CHICAGO as being made with a rightward movement followed by a downward movement; WHEN with a circular movement followed by a contacting movement; YEAR with a circular movement followed by a contacting movement; and ALSO with a contact movement followed by a rightward movement, then another contacting movement.

Supalla and Newport (1978) demonstrate that very finely detailed differences in movement could distinguish some nouns from related verbs. Whereas Stokoe et al. (1965) reports the existence of a single sign meaning both "sit" and "chair," Supalla and Newport claim that SIT and CHAIR are separate signs. They find that for more than 100 such noun-verb pairs, the pattern of movement of the noun differs in predictable ways from that of the verb. They distinguish these formational differences in terms of three "manners of movement." They describe the movement of the sign SIT as a single, unidirectional movement with a "hold manner" and that of CHAIR as a repeated, unidirectional movement with "restrained manner."

Figure 3a. WHEN

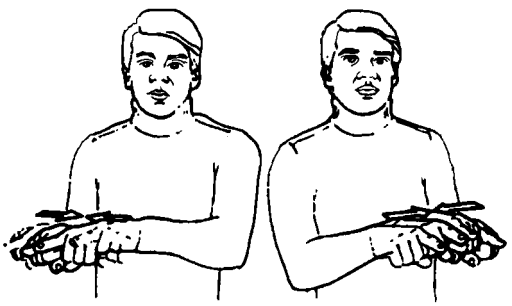


Figure 3b. ALSO

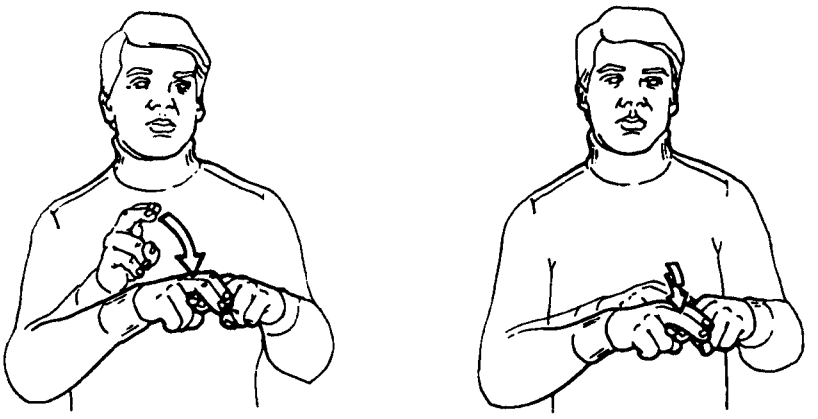


Figure 4. The movement differences between SIT and CHAIR.

Their manners of movement demonstrate a significant type of sequentiality in the formation of signs. The sign SIT begins with a motion toward the base hand and ends with the two hands in contact, but not moving. A sign ending with the hands immobile is said to have "hold manner" at the end of the sign. In their view such motionless periods are as important in providing contrast as are the periods of movement. They note (1978:96) that one of the possible implications of their findings is that signs may have sequential internal segments rather than a simultaneous bundle of features.[1]

1.5 Local Movements

Local movements are small repeated movements of the fingers and wrist which accompany the major movements of the hand. For example, LONG-AGO is produced with a "5" hand configuration which moves backward to a hold at a point just over the shoulder. During the backward movement itself the fingers wiggle, but the final hold is produced without finger wiggling.

Thus LONG-AGO contains the sequence: local movement, no local movement. In other signs, such as JUMP-FOR-JOY the wiggling is restricted to the middle of the sign where the active hand does not contact the base hand. This produces the sequence: no local movement, local movement, no local movement.

1.6 Nonmanual Signals

Many nonmanual signals involve no sequentiality. For example, the combination of raised eyebrows and backward head tilt which accompanies topics (Liddell, 1977) is

Figure 5. LONG-AGO

purely configurational, with no internal changes. Some nonmanual signals, however, are produced by sequencing nonmanual activities. Some such nonmanual signals occur as part of lexical items and others occur as part of morphological processes. A lexical item which requires a sequence of nonmanual activities is GIVE-IN. During the initial part of its production the lips are closed but during the final part of its production the lips are open. ALL-GONE, on the other hand, begins with the lips apart and the tongue slightly protruding and ends with the lips closed.

Sequences of nonmanual activities are also important as part of morphological processes. Liddell (1984b) describes a sequence of nonmanual activities required as part of the inflection for unrealized-inceptive aspect. When this inflection is applied to a verb, specific, predictable changes occur in both the manual and nonmanual portions of the sign. The sequence of nonmanual behaviors associated with this inflection require the signer to inhale through the mouth while rotating the trunk, and then to hold the resulting configuration during the final portion of the sign.

1.7 Contrast in ASL

We have illustrated several types of sequentiality in ASL signing, including sequences of handshapes, locations, nonmanual signals, local movements, and movements and holds. The simultaneous model of sign structure is not able to represent these sequential details in an effective way. This alone argues for a descriptive device which is able to represent important aspects of ASL sequence.

Specifically, given that signs have sequential structure, that sequence can be shown to correspond to phonological segments responsible for sequential contrast of the sort found in spoken languages. The identification of physical sequence in the linguistic signal provides the evidence needed to argue that signs are composed of sequenced, abstract, linguistic segments. Support for the existence of such linguistic segments comes, in part, from a demonstration that ASL, like spoken languages, contains pairs of signs distinguished only by differences in sign-internal sequence.

It has become traditional in treatments of ASL structure to illustrate "minimal pairs" of signs as a demonstration of phonological contrast. However, because the simultaneous model of sign structure dictates that signs are composed of a single, simultaneous bundle of gestural features, such pairs of signs are able to demonstrate only simultaneous contrast of the sort found within segments in spoken languages. Thus, staying for the moment with the notion that signs are simultaneous, most "minimal pairs" of signs identified in the literature on ASL exhibit contrasts analogous to the differences between [p], [t], and [b]. They are distinctions of one feature within a single, co-occurrent bundle of features.

By contrast, in spoken language analysis, the notion of "minimal pair" has typically been used to demonstrate sequential contrast. Thus, a minimal pair is usually considered to be two words, contrastive in meaning, which are identical in all segments except one, in which they differ by only one feature. The kinds of ASL sequential details we have identified above provide this kind of evidence for sequential contrast.

THANK-YOU and BULLSHIT are minimal pairs in this sense. Both begin with identical holds produced at the chin and move to holds produced at a location about six inches out and slightly below the chin. In both signs, the orientation of the hand remains constant, with the palm toward the face and the wrist toward the ground. Thus, from the perspective of movement, location, and

Table 4. Sequential Contrast Between Minimal Pairs THANK-YOU and BULLSHIT.

	THANK-YOU		
	first part	*middle part*	*last part*
movement	hold	move out	hold
location	chin	transitional	out from chin
orientation	palm to chin	transitional	palm to chin
hand configuration	B	transitional	B
		BULLSHIT	
movement	hold	move out	hold
location	chin	transitional	out from chin
orientation	palm to chin	transitional	palm to chin
hand configuration	B	transitional	S

orientation the signs have identical sequences. They differ only in hand configuration sequence. Specifically, during the production of the sign THANK-YOU, the hand configuration begins and ends as a "B." In the sign BULLSHIT, however, it begins as a "B" and ends as an "S." In Table 4 the parts of THANK-YOU and BULLSHIT are aligned.

Although true minimal pairs such as these are not abundant in ASL, there are similar pairs that demonstrate sequential contrast in each of the major descriptive parameters of signs. Together they demonstrate that segments function to signal contrast in ASL in much the same manner as in spoken languages, and suggest that the description of segments is central to an adequate phonological analysis of ASL signs. In addition, the value of a segmental description in the analysis of the phonological and morphological processes of ASL will become more apparent as we proceed.

2. A Phonetic Transcription System for ASL

At first glance, it may seem inappropriate to use "phonology," "phonetics," and other seemingly vocally-based terms in referring to details of sign language and its organization. As we mentioned earlier, Stokoe's work explicitly avoids this difficulty by positing terminology such as "chereme" and "cherology," which are specific to sign language. Battison (1974) demonstrates that sign language descriptions contain a sublexical level of analysis that appears in certain ways to be organizationally and functionally equivalent to the level of phonology in spoken languages. He argues convincingly that standard phonological terminology refers appropriately to those levels. A part of what we will be demonstrating in this paper is that an analysis of the patterns of organization of sign language signals yields levels of analysis quite similar to those known to exist in spoken language phonologies.

It is a matter of historical accident that, during the period of development of modern linguistic terminology, all languages known to linguists were spoken languages. Even so, for the most part, phonological terminology refers to the patterns of organization of linguistic signals, rather than to the signals themselves. Thus, the vocal reference of the *phone-* stem in words such as

phoneme is largely unnecessary. We use phonological terminology in referring to the organization of sign languages, with the understanding that the terminology here, as in studies of other languages, refers to general principles of organization probably found in all languages rather than to the specific vocal gestures of spoken languages.

2.1 Goals of Transcription

A transcription system for a language or set of languages should meet the dual goals of at once providing for the accurate representation of the detail of the "facts" of a language and assuring that those representations are useful in characterizing the organization of the facts.

We have attempted to devise a system that provides a linkage between the abstract and concrete aspects of phonological systems without committing overwhelmingly to either. Clearly, an adequate system of transcription must have elements of both. On the concrete end, a transcription must account for all the linguistically interesting details of the production of the signal. For our purposes, such phonetic transcription will be roughly equivalent in its concreteness to the "systematic phonetic representations" of standard generative phonology (Chomsky and Halle 1968). While such representations must account for a great deal of detail, they exclude (a) linguistically nondistinctive differences such as the difference between apical and laminal [s] in English; (b) sequential detail within phonologically functional units, e.g., elimination of onset and closure information from the description of English stop consonants; (c) detail stemming from universal physiological conditions; (d) detail stemming from individual physiological conditions, e.g., absolute voice pitch; and (e) traditionally nonlinguistic detail such as rate, loudness, and affect marking features.

On the abstract end, an adequate notation system must provide descriptive devices that permit a plausible linkage between the detailed surface representation and the underlying forms of the individual lexical items that are present in it. Thus, a single set of descriptive devices should at once be capable of characterizing each of the following: (a) the phonological shape (underlying form) of lexical items; (b) the phonological aspects of the morphology; (c) phonological processes; and (d) the surface forms of signs in running signed productions (at the level of concreteness specified above). To the extent that a system of notation succeeds in achieving this balance, it provides phonetic motivation for phonological features and phonetic plausibility for the abstract structures and processes of the phonological component.

That the system be usable is a second, more pragmatic goal which has influenced the current form of our notation system. Thus, while sign notations will ultimately be reducible to matrices of binary phonological features, most of the notations presented here contain taxonomic entries that represent bundles of such features. The use of such taxonomic entries is primarily a matter of clerical and typographical convenience, reducing the number of symbols required to transcribe a sign.

2.2 Overview of Sign Structure

2.2.1 Describing Segments. The segment is the central element in our view of the structure of signs. Thus, the representation of segments is the essential task of our notation system. In our system, each segment is represented individually and signs (and discourse strings) are represented as strings of segments.[2]

Segments in sign languages are composed of two major components. One

describes the *posture* of the hand; the other describes its *activity*. A description of the posture of the hand is concerned with where it is, how it is oriented, how its own movable parts are configured, and so on. The features that describe these details are collectively called *articulatory features*. We refer to the combination of articulatory features needed to specify a given posture of the hand as an "articulatory bundle."

The articulatory bundle contains four major clusters of features. The first represents the *hand configuration*, i.e., the state of the fingers and thumb. The second cluster represents *point of contact*, which specifies the primary location with respect to which the hand is located, the part of the hand that points to or contacts that location, and the spatial relationship between that hand part and that location. The third cluster represents *facing*, which is composed of sets of features specifying a second location, and features indicating the part of the hand which faces that location. The fourth cluster of features in the articulatory bundle, *orientation*, contains features specifying a plane toward which a part of the hand faces. Orientation features distinguish THING (a sequence of movements made with the palm up) from CHILDREN (like THING but with the palm down). The four clusters, all taken together, describe the posture of the hand at a particular point in the production of a sign. They do not describe the activity of the hand.

The features that specify the activity of the hand during the production of the segment are grouped into a separate segmental feature bundle. They describe whether or not the hand is moving, and, if so, in what manner. The elemental work of this class of features is to distinguish movements from holds. *Movements* are defined as periods of time during which some aspect of the articulation is in transition. *Holds* are defined as periods of time during which all aspects of the articulation bundle are in a steady state.

While the descriptive work of the segmental features is to detail the movement of the articulators, they function within signed strings to divide the flow of gestures into segments. By definition, then, the features that distinguish movements from holds also define the segmental structure of larger units such as signs, which we represent as strings of juxtaposed segments. This is not unlike the manner in which the major class features of generative phonology function. In spoken language phonology, major class features specify phonetic details of segments such as spontaneous voicing, interruption of the airstream, and syllabicity. These same feature values distinguish consonants from vowels and therefore also function to specify the manner in which the flow of speech is divided.

The remaining features in the segmental bundle specify the finer detail of segments such as contour of movement, simultaneous local movement of the fingers, and precise timing information such as length. We will discuss these features in detail below.

We have presented the articulatory bundles and segmental bundles separately, and in fact they function independently from each other in the specification of entire segments. The articulatory features combine to describe postural states. By definition, movement segments are those during which there is a change in state in some complex of articulatory features, and hold segments are those during which no such change occurs. Because they involve a steady state, a single matrix of features will be sufficient to describe holds. This matrix will contain both the segmental bundle of features including the specification of fine detail of the segment and the articulatory bundle of features describing the postural

state present during the production of the hold segment.

Movement segments, however, present another problem. During a movement the hand changes from one posture to another. Thus, because our articulatory features represent states, our system requires the specification of an initial and final bundle of articulatory features to indicate the changes during the production of the segment. Movement segments contain one bundle of segmental features containing the specification of the segment type and the fine details of the movement and two bundles of articulatory features, the first of which specifies the postural state at the inception of the movement and the second of which specifies the postural state of the hand at the conclusion of the movement. Hold segments contain one articulatory bundle; movement segments contain two articulatory bundles.

Both hold and movement segments may be represented by matrices of features, but following the discussion above the matrices will be different. The hold segment would correspond to be a straightforward and traditional feature matrix as in Figure 6, while the movement segment will have one set of segmental specifications and two sets of articulatory specifications, as in Figure 7.

An apparent alternative solution to the use of two kinds of matrices might be to use

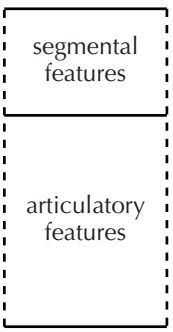


Figure 6. A hold matrix.

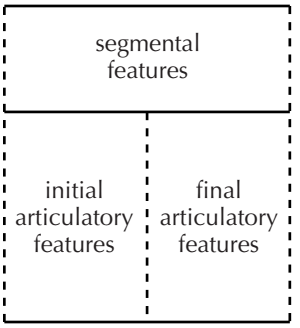


Figure 7. A movement matrix.

only hold matrices, let them define segmental structure, and have movement take place as a result of transitions from one state to the next. As we present more detailed descriptions of signs it will become apparent that independent movement features are necessary. This is because the fine details of movement production are features of the movement itself, not of either of the individual articulatory bundles. For example, when the hand moves on a path from one location to another, that path may take any of three contours. It may move in a straight line, on an arc, or on an indirect path with a sharp change of direction in the middle. These differences in path are contrastive and therefore must be recorded. They are not a feature of the initial articulatory posture nor of the final articulatory posture nor of both at once. They are a feature of the period of time during which the hand is changing from the initial posture to the final posture. Thus, they are details of the movement itself and must be specified independently of the articulatory information. Considerations presented below will confirm this claim of independence of the segmental and articulatory bundles of features.

2.2.2 Non-Manual Behaviors. The segmental structure of signs also bears on the representation of the non-manual behaviors

that have linguistic function in ASL. At times, non-manual behaviors clearly have functions that are independent of the segment. Examples of such non-manual behaviors are those that have syntactic function and those that have clear morphological status. Others appear to be tied to specific segments within specific signs (Liddell 1984a). In both cases, although possibly independent in function, the behaviors are timed to the production of segments, and need to be specified in the transcription system. The exact nature of this specification will be taken up later.

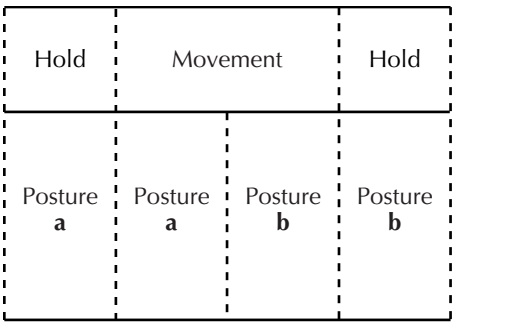


Figure 8. Representation of feature matrix for sign GOOD.

2.2.3 Describing Sequences of Segments. In the view of sign structure presented here, individual signs and larger constructions are all composed of sequences of segments. Thus, a sign or a piece of discourse may be represented as a sequence of hold and movement matrices, each composed of the appropriate number of segmental and articulatory bundles. The sign GOOD, for example, is composed of three segments: a hold, a movement, and a hold (see Figure 26b). The first hold occurs with the finger pads of a flat hand in contact with the chin. For convenience, we will call this complex of articulatory information "posture a." From this hold, the hand moves outward and downward to a final hold, which occurs in space about a foot in front of the sternum with the same flat hand configuration oriented so that the palm of the hand is facing (roughly) upward and the tips of the fingers are pointing outward at about a forty-five degree angle. We can call this complex of articulatory information "posture b." In our matrix format we can represent this sign as in Figure 8.

Notice that in the representation of GOOD the initial articulatory specification of the movement segment is the same as the articulatory specification of the first hold segment. Similarly, the final articulatory specification of the movement segment is the same as the articulatory specification of the second hold segment. An initial posture of any segment in a string is identical to the final posture of the preceding segment. This is true by definition because a given line of transcription represents a sequence of behaviors of a single articulator, which can only start a gesture from the posture in which it terminated the preceding gesture. From this perspective it is unnecessary to record every articulatory bundle of information because (within signs) two articulatory bundles that share a common segmental boundary must be identical.

This observation stands as additional evidence for the independence of the articulatory features from the segmental features. It also recommends the use of an autosegmental representation which permits the attachment of single clusters of features of one sort to single clusters of features of another sort (Goldsmith 1976, McCarthy 1979), as in Figure 9.

Autosegmental representations of the sort presented in Figure 9, in addition to enhancing clerical economy, provide additional support for the earlier suggestion that the articulatory bundle of features is autonomous in function from the segmental

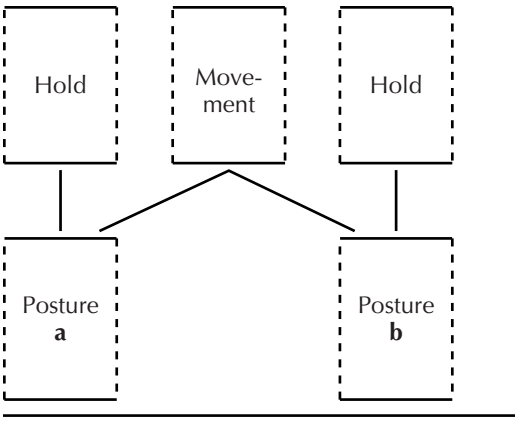


Figure 9. Representation of autosegmental attachment of feature bundles of the sign GOOD.

bundle of features. It is also quite likely that certain of the clusters of features within the articulatory bundle itself enjoy a similar kind of autonomy, particularly at the lower levels of the phonology where the independent postural and movement components must be finely timed to one another. Similarly, there may be more autonomous tiers of feature clusters at the level of the phonology that controls the production of fast speech, in which muscular activities and postures are reinterpreted and produced as perceptually and productively similar (though linguistically different) muscular behaviors. Autosegmental analyses of these phenomena may prove to be worthwhile. For our purposes, however, it is sufficient to use only the articulatory and segmental tiers, together with a tier for non-manual behaviors.

A number of the combinations of segments that may occur in ASL signs are presented in Figure 10.

2.2.4 Describing Signs Requiring Two Hands. As we indicated above, many signs make use of both hands as articulators. From a phonetic perspective, each hand is independent of the other. Moreover, the hands may carry different phonetic information at a given moment. For example, one may be moving while the other is not. One may be in one location or orientation or hand configuration while the other hand is specified differently for one or more of these details. As one might expect, there appear to be fairly strong conditions on the nature and extent of the simultaneous articulation of two segments (Battison 1974, 1978), so the two hands are not completely independent phonologically. While a notation system may ultimately be able to eliminate certain aspects of the information that is predictable from such constraints on simultaneous articulations, it is useful at early stages of analysis to be able to represent each hand in its full phonetic configuration.

From the perspective of the segmental notation system described above, there is no difference between the productions of one hand and those of the other. Given this and their phonetic independence, each hand must be represented as a separate string of segmental notations, and the segments of one hand must be attached (for timing purposes) to the co-occurrent segments of the other hand.

The first difficulty encountered in the representation of the behaviors of both hands is that right and left are not absolute in signing. First, left-handed and right-handed signers sign mirror images of the same sign sequence with no change in meaning. A notation system should describe both the left-handed, left-dominant and the right-handed, right-dominant versions identically. Secondly, certain constructions treat spatial locations on the right and the left as absolute. A notation system must be able to distinguish right from left under these conditions. Third, certain constructions allow a signer to meaningfully alternate between right-dominant and left-dominant signing. The notation system must be able to describe this sort of alternation.

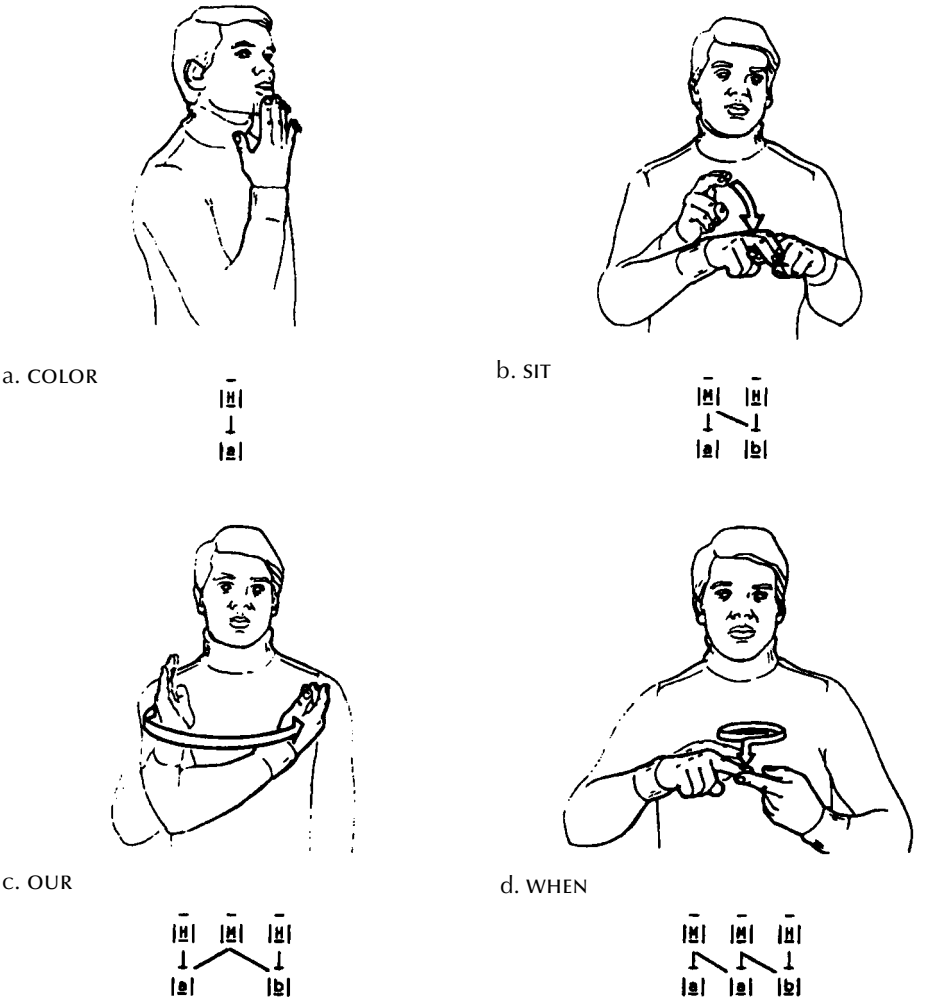
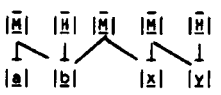


Figure 10. Signs illustrating common segment combinations.

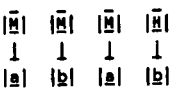
Padden and Perlmutter (1984) introduce the terms "strong" and "weak" to describe the active hand and the hand it acts upon. Adopting those terms for our notation system will permit signs to be specified in a single way although signed in mirror image by right- and left-handed signers. We have chosen to use two vertically stacked strings of segments for two-handed signing. The top line represents the strong hand and the bottom line represents the weak hand. In such cases, the strong hand is understood to be the dominant hand of the signer. Particular transcriptions of running sign will need to be marked for the dominance of the signer. When a signer shifts from expected-dominance signing to opposite-dominance signing the strong label will be shifted to the bottom line and the weak to the top line. In those instances when each hand is actually operating independently, the top line will be right for right-dominant signers or left for left-dominant signers.

It appears that the strong hand segments function as the central organizing elements for the timing of strings of co-occurrent

e. CONGRESS



f. CHAIR



g. JUMP

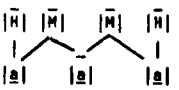


FIGURE 10 (continued). Signs illustrating common segment combinations.

segments. Therefore, the segments of the weak hand must be attached to those of the strong hand. Several combinations of strong and weak hands within signs and our conventions for attaching them are presented in Figures 11–13.

2.3 Detailed Description of Segmental Bundles

Segmental feature bundles specify the detail of movements and holds. Each such cluster defines one segment in the string of gestures in the transcription of a running signed production. Ultimately, the segmental bundle will contain numerous binary features. At present it contains five slots for the entry of taxonomic symbols representing clusters of features. The five types of entries within the segmental bundle are laid out as shown in Figure 14.

2.3.1 Major Classes of Segments. There are two major classes of segments in ASL: holds and movements. As described above, a movement (M) segment is characterized by a change in one or more of its articulatory features and hold (H) segments are not. Notice that not all movement segments involve movement from one location to another. The change in articulatory specification may occur in the hand configuration

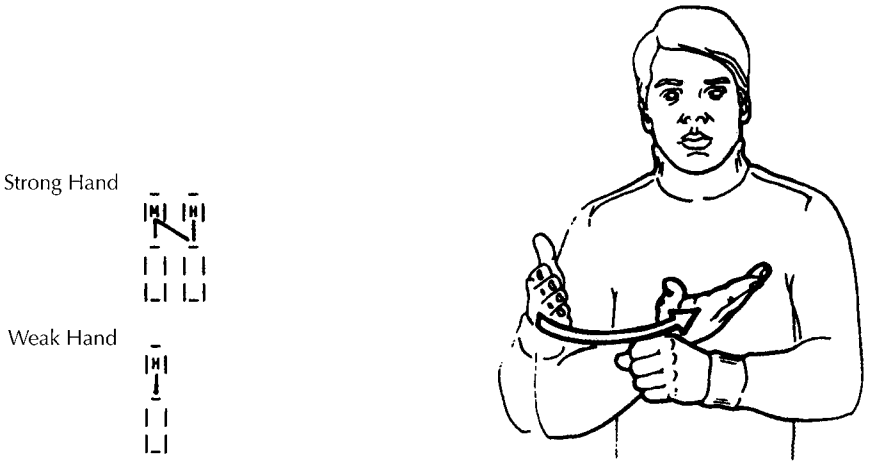


Figure 11. FIRED, a two-handed sign in which the strong hand moves with respect to the weak hand.

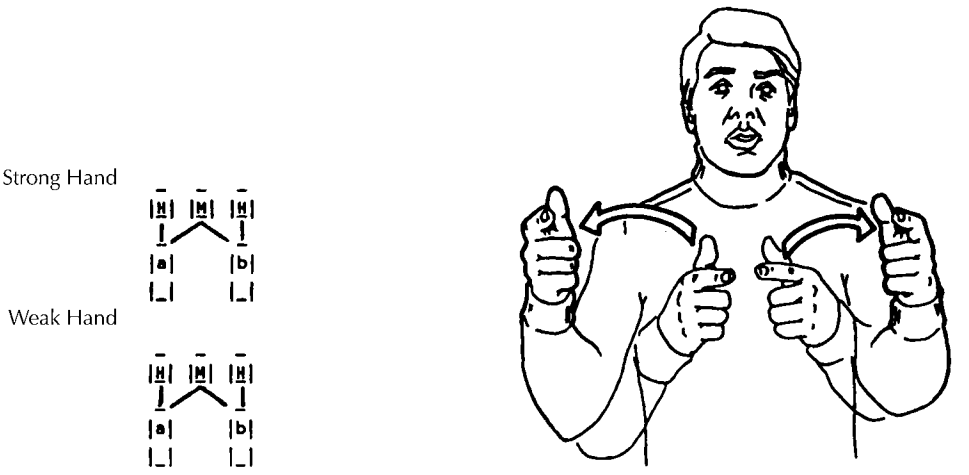


Figure 12. LARGE, a two-handed sign in which two hands move independently, simultaneously, and symmetrically.

(UNDERSTAND), the orientation (START), or other clusters of the specification. Such nonpath movements do not appear to have a phonological status different from that of path movements (those in which there is a change in the point of contact specification) and so need not be distinguished by a special feature.

2.3.2 Contours of Movement. Those movement segments that move on a path between two locations may do so on one of several contours. *Straight* [str] movements traverse a direct, straight path between two points (GOOD). There are two types of indirect contour paths: *round* [rnd] and *seven* [7]. The seven contour describes an indirect path that is sharply angled (CHICAGO). The round contour describes an indirect path that is smooth. Arcs (OUR) and circles (FACE) both describe *round* paths but are distinguished by the fact that an arc begins at one

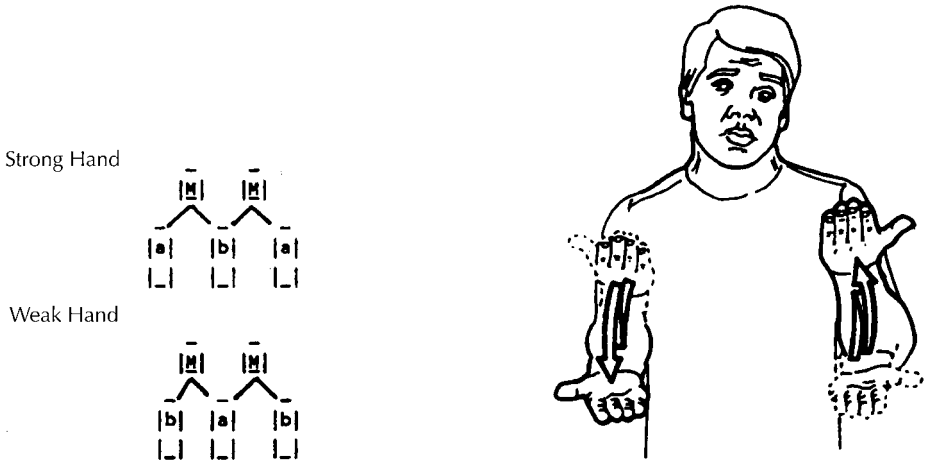


Figure 13. MAYBE, a two-handed sign in which the strong and weak hands perform independent movements but in temporal alternation.

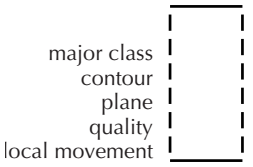


Figure 14. Organization of segmental features.

location and ends at another whereas a circle begins at a point, traverses a round path, and ends at its beginning point.

2.3.3 Contour Planes. When a path movement is not straight, it is necessary to specify an additional piece of information, which functions to orient the path. The entries indicate the plane upon which the hand travels as it moves between points. We currently record five planes. The *horizontal plane* [HP] is the plane parallel to the floor (OUR). The *vertical plane* [VP] is that plane parallel to the front of the torso (RAINBOW). The *surface plane* [SP] is the plane parallel to the surface at a location on the body or hand (FACE). The *midline plane* [MP] is a plane that intersects the surface plane along the midsaggital line of the body (BLOUSE, SIGN), or the plane through the long midline of the bones of the arm or the hand (BASKET). We currently use the designation *oblique plane* [OP] to represent the plane that is horizontal from side to side but angled up and away from the body.

2.3.4 Quality Features. Quality features describe fine details of a segment. Among these are the temporal qualities *prolonged* [long], *shortened* [short], and *accelerating* [acc], and the nontemporal qualities *tense* [tns], *reduced path* [sm], and *enlarged path* [lg]. The quality feature *contacting* [contact] indicates that the hand makes contact with the other hand or a body location during the course of the movement. It describes brushing movements, in which the hand travels between points on two sides of a location, making brief contact with that location as it passes. It is also useful in describing the movement in which the hand moves to a location, makes brief contact, and rebounds to a point near that location.

2.3.5 Local Movements. The major classes of segments (H and M) reflect activity of the hand taken as a whole. It is common for signs simultaneously to exhibit movement

at the finger, wrist or elbow joints. Such movements are overlaid on the actual segmental activity, occurring together sometimes with H segments and sometimes with M segments. Thus, they are secondary, though linguistically significant activities. Each of the local movements is characterized by rapid, uncountable repetition. All may occur in H segments. At least wiggling, twisting, nodding, and hooking may occur in M segments.[3]

Wiggling [wg] represents repeated, sequentially alternating retraction at the first joint of all fingers extended at the first joint (COLOR). *Hooking* [hk] involves repeated, simultaneous retraction at the second and third joints of all fingers that are extended at the first joint and retracted at the second and third joints ("hooked" hand configurations) (WORM). *Flattening* [fl] is repeated, simultaneous retraction at the first joint of all fingers that are extended at the second and third joints and retracted at the first joint ("flat" hand configurations) (STICKY).[4] *Twisting* [tw] describes repeated, alternating rotations of the wrist (WHERE). *Nodding* [nod] is a repeated retraction and extension of the wrist joint (YES).[5] *Releasing* [rel] involves rapid, repeated opening of fingers that have thumb restraint (SHIRK-RESPONSIBILITY). *Rubbing* [rub] is repeated, back and forth rubbing of the thumb and the finger pads (DIRT). *Circling* is a repeated, uncountable local circling about a central point simultaneously with either an H or M. It requires the specification of a plane.

2.4 Detailed Description of Articulatory Bundles

Each articulatory bundle is composed of eight entries, each representing a complex of features. The entries cluster into four possibly autonomous groupings, described above as hand configuration (HC), point of contact (POC), facing (FA), and orientation (OR). They are organized as shown in Figure 15.

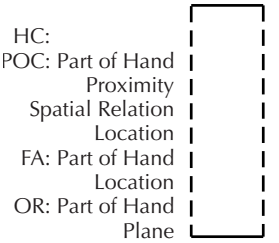


Figure 15. Organization of articulatory bundle.

2.4.1 Hand Configuration. We have found more than 150 HCs in ASL lexical signs. Many more occur in the surface forms of running sign. A system of thirteen mostly binary features will distinguish all HCs we know to exist in sign languages. The taxonomic symbols we use as HC entries in our notations are capable of describing all the HCs of ASL and many more. They translate to features in a very straightforward way.

The HC entry is organized according to the following schema (see Figure 16).

While most HC use only the hand, others use the entire hand and forearm as a unit (ALL-DAY). Following Stokoe (1960), the symbol indicates the presence of such forearm involvement in the HC. If / is absent, the HC is assumed to use only the hand itself.

The HC description we have developed differs from most other approaches in that it notes finger configuration and thumb configuration separately. The portion of the HC

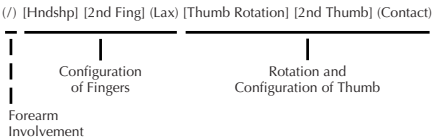


Figure 16. Organization of handshape features.

notation concerned with finger configuration contains slots for three symbols. The first is *handshape*, which indicates the state of extension and retraction of the four fingers. The symbols presented in Table 5 represent those combinations of open and closed fingers we know to occur in ASL signing.

Each of the four fingers is independently capable of being in one of four basic configurations: *open* (proximal joint (PJ) and distal joint (DJ) extended); *closed* (PJ and DJ flexed); *hooked* (PJ extended, DJ flexed); *flattened* (PJ flexed, DJ extended). The taxonomic symbols presented here function primarily to indicate which fingers are open and which are closed. The slot labeled [2*nd Fing*] in the schema contains diacritics for the hooking and flattening of those fingers ordinarily extended in a given handshape. Hooked is indicated by [″]; flattened is indicated by [^]. Thus, the symbol 1″ indicates that the index is extended at the proximal joint and flexed at the distal joints and the symbol B^ indicates that all four fingers are flexed at the proximal joints and extended at the distal joints.

The diacritic for *lax* [~] indicates an additional modification to the finger configuration. It relaxes (slightly reverses) the prominent muscle action at both the proximal and distal joints. If the joint is extended lax will flex it slightly, although not enough to be fully flexed. Similarly, if the joint is flexed, lax will extend it slightly, although not enough to be perceived as fully extended. Thus, the effect of laxing is that the finger remains as specified but not rigidly so. Lax tends to affect all four fingers but has no effect on the configuration of the thumb.

All details of thumb configuration are specified in the final cluster of symbols. The primary value for the thumb is thumb rotation. The proximal joint of the thumb (near the wrist) is capable of rotating about ninety degrees on its axis. When the thumb is relaxed and roughly adjacent to the plane created by the palm of the hand, it is in its *unopposed* [u] rotation. When the thumb is unopposed, its friction pad faces across the palm, and is capable of contacting the radial

Table 5. Symbols for Taxonomic Description of Major Finger Combination

Symbol	Configuration
A	Four fingers closed (pads contact palm)
S	Four fingers closed (tips contact palm)
1	All but index closed
!	All but middle closed
l	All but pinky closed
Y	All but pinky closed; pinky spread
=	All but pinky and index closed; unspread
>	All but pinky and index closed; pinky and index spread
H	All but index and middle closed; unspread
V	All but index and middle closed; spread
K	Ring and pinky closed; index open; middle partly open
D	Index open; all others partly open
R	Ring and pinky closed; index and middle crossed
r	Ring and pinky closed; middle open; index partly open and crossed under middle
W	All but pinky open and unspread
6	All but pinky open and spread
7	All but ring open and spread
8	All but middle open and spread
F	All but index open and unspread
9	All but index open and spread
B	All four fingers open and unspread
4	All four fingers open and spread
T	All fingers closed; thumb under index
N	All fingers closed; thumb under middle
M	All fingers closed; thumb under ring

side of the middle joint of any (flattened) finger or the radial side of the palm. Typically, if the thumb is touching the palm, it is in unopposed position.

The thumb may also be rotated so that its friction pad faces the palmar surface. This is its *opposed* [o] rotation, in which the tip of the thumb may easily contact the tip of any of the fingers. The opposed thumb typically cannot touch the palm of the hand except at the base of the little finger. It often contacts the fingers at the tip, pad, or nail, and if the fingers are closed may contact the back of the penultimate finger bones.

Both opposed and unopposed thumbs must also be specified for one of four values of secondary extension and flexion, indicated in the [2*nd Thumb*] slot. The proximal joint of the thumb is near the wrist and along with the two more distal joints operates to define the same four values of extension and flexion available to the fingers. Because the thumb features are descriptive rather than taxonomic, however, open and closed must be indicated. An *open* thumb is one in which the proximal and distal joints are both extended. Thus the symbol Bu will indicate a handshape with all fingers extended and unspread and a thumb that is on the plane created by the palm and extended at about ninety degrees outward from the radial side of the hand. The symbol Bo will designate the same finger configuration with the thumb extended at a ninety degree angle from the palmar surface. Leaving the PJ extended and flexing the DJ provides the *hooked* [“] thumb configuration. In *flat* [^] thumb configurations the PJ is flexed and the DJ is extended. In the [^] configuration the degree of flexion of the middle joint is typically adjusted to bring the thumb pad into contact with either a finger pad (for [o^] thumbs) or the middle joint of the first finger flexed at the PJ (for [u^] thumbs). When the [u^] thumb is not in contact with a finger it is in pad contact with the radial side of the palm. The *closed* [-] configuration flexes both the PJ and the DJ. The symbol Bu- indicates the B fingers with the thumb flexed and in contact with the palm. Ho- indicates a hand configuration in which the index and middle fingers are extended and the thumb is closed over the ring and little fingers.

In many hand configurations the thumb contacts one or more of the fingers. The specifications for this are the final entry in the hand configuration schema. There are four kinds of contact: *tip* contact [c]; thumb *pad* contact [p], in which the thumb pad contacts either the finger pad or the radial side of the finger; *finger restrained* contact [f], in which the thumb pad contacts the finger nail; and *thumb restraint* [t], in which the finger pad contacts the thumb nail. These symbols combine to describe every hand configuration we know to exist in ASL. A selection of them is presented in tabular form in Appendix A.

2.4.2 Point of Contact. The Point of Contact (POC) cluster contains slots for four symbols. These are: *location*, analogous in function to place of articulation in that it identifies a place on the passive articulator; *handpart*, the part of the hand that is located there; *proximity*, how near the handpart is to the location; and the *spatial relationship* between the handpart and the location.

Three different kinds of location specification may be entered in the location slot. Some signs are made with reference to a location on the body, some are made in the signing space surrounding the front of the head and torso, and some are made at a specific place on the weak hand.

Body Locations are those places where lexically distinctive signs may be made on the head, neck, torso, upper legs, or arms (exclusive of the hands). We have found that the accurate description of ASL requires

Table 6. The Twenty Major Body Locations

BH	back of head	CN	chin
TH	top of head	NK	neck
FH	forehead	SH	shoulder
SF	side of forehead	ST	sternum
NS	nose	CH	chest
CK	cheek	TR	trunk
ER	ear	UA	upper arm
MO	mouth	FA	forearm
LP	lip	AB	abdomen
JW	jaw	LG	leg

many more phonetically distinctive body locations than proposed in earlier treatments of sign notation. The entries describing body location are composed according to the following schema:

(%) (i) location (t or b)

The slot labeled location is filled by one of the twenty major body locations shown in Table 6.

Diacritic symbols may be added to each of the major body location descriptions in order to specify other locations near them. The diacritic [%] indicates that the location specified is on the side of the body contralateral to the signing hand. If this slot is empty the location is assumed to be ipsilateral.

Most of the major locations specified above are surrounded by a set of corresponding locations that may be described by adding two diacritics to the basic location symbol. The first is *ipsilateral* [i], indicating that the hand is at a location slightly toward the outside of the body from the major location. The second indicates a location in the *top* [t] portion or *bottom* [b] portion of the major location. Combining these entries provides the locations represented in Figures 17, 18, and 19. Appendix B presents examples of lexical signs made at each of the locations we know to be distinctive in ASL.

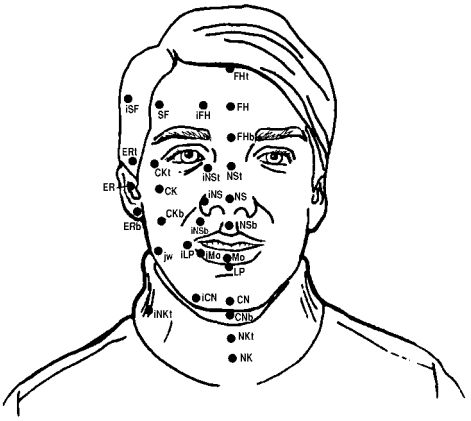


Figure 17. Articulatory locations on the head and neck.

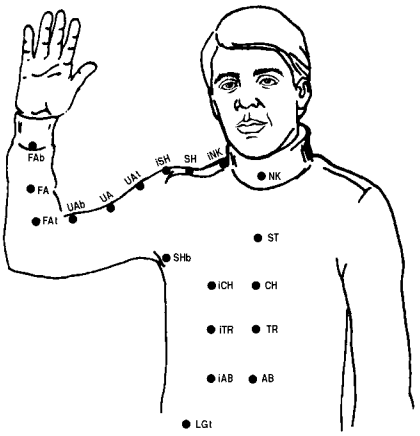


Figure 18. Articulatory locations on the torso.

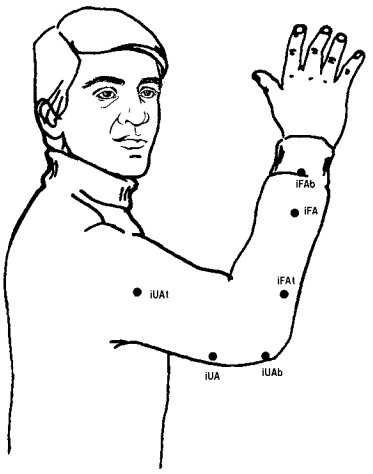


Figure 19. Articulatory locations on the arms.

Signs may also be produced at locations in the signing space surrounding the front of the body and head. Such *spatial locations* are described by a combination of a diacritic indicating a distance forward from the body on a perpendicular line, a symbol indicating the extent of ipsilateral offset from the midline, and the symbol for a major central body location:

Proximity—Ipsilateral Offset—Central Location

We currently distinguish four degrees of forward distance for spatial locations: *proximal* [p], indicating a location within a few inches of the body location; *medial* [m], a position roughly an elbow's length from the body location; *distal* [d], a comfortable arm's length from the body; and *extended* [e], a full arm's length from the body location.

The side-to-side dimension appears to require two degrees of ipsilateral offset. The first of these is roughly in line with the breast and the second is roughly in line with the outside edge of the shoulder. In order to avoid confusion with the set of finer distinctions among ipsilateral offset for the body locations, we refer to the degrees of ipsilateral offset for spatial signs with the numbers [0] (no offset), [1], and [2], respectively.

The last symbol indicates the height of the spatial location. It is chosen from among the major body location symbols that refer to points along the midline of the body (TH, FH, NS, MO, CN, NK, ST, CH, TR, AB). Thus, each spatial location is represented by a complex of three symbols. For example, the symbol m-0-TR describes a location about an elbow's length directly in front of the solar-plexis. The symbol m-1-TR indicates a location at the same height and distance forward, but on the breastline. Similarly, the symbol d-2-FH describes a location about an arm's length forward and a shoulder's width to the ipsilateral side of the center of the forehead. Appendix C presents selected signs produced at different spatial locations.

Most signs appear to locate on points like those described above. However, one important class of signs makes use of locations created by vectors radiating from midline locations. We have found use for seven such vectors. These vectors ([L3] [L2] [L1] [0] [R1] [R2] [R3]) and the locations they create around their intersection with the lines representing degrees of distance from the body are presented in Figure 20. One such semicircular system of locations may exist at each contrastive height along the

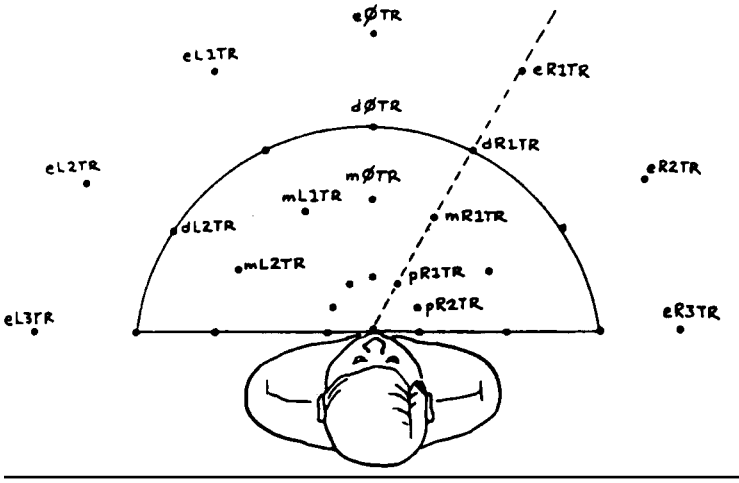


Figure 20. Spatial vectors used by agreement verbs.

midline. The vector specification substitutes in the spatial location schema for the ipsilateral offset number.

Thus, m-R1-TR specifies a location at TR height, about an elbow's length out from the center line on an approximately thirty degree right vector. Although the addition of a second set of location specifications may appear to be excessive, the behavior of predicates inflected for subject and object agreement and the behavior of locative predicates require it. We will return to this issue in more detail below.

For many signs, the location of the strong hand is a point on the weak hand (FIRED). The schema describing *weak hand locations* is composed of two symbols: one indicating a major part of the hand (hand, fingers, forearm, thumb, etc.), and the other indicating a zone in that major hand part (inside, back, radial edge, etc.). The specifications for locations on the weak hand and examples we have found in ASL appear in Appendix D.

The *handpart* slot of the POC complex will contain a handpart specification constructed in the same way as those described above. Whereas the handpart specifications exemplified in Appendix D specify weak hand locations, the handpart slot proper indicates which part of the strong hand makes reference to or contacts the location of the POC. An inventory of strong hand handparts we know to occur in ASL is presented in Appendix E. Combining handpart and location in POC, we would find that the first segment of the sign GOOD, for example, contacts the LP location with the fingerpads of the strong hand. The POC of this segment will contain PDFI in the handpart slot and LP in the location slot. In the final segment of the sign STOP, the handpart is UL and the location is PA.

The *proximity* slot of the POC cluster specifies whether the handpart is in *contact* [c] with the location or, if not in contact, then its distance from the location. It appears that three distance specifications (proximal [p], medial [m], and distal [d]) are sufficient.

The spatial relationship slot of the POC cluster describes the direction at which the handpart is offset from the location. In brushing signs the hand moves between points on two sides of a location, making brief contact as it passes the location. For example, in the sign FALSE the handpart is the RAFI of a 1o- (index extended) hand configuration. The location is NS, the tip of the nose. The hand begins at a point proximal and to the ipsilateral side of the nose and moves to point proximal and to the contralateral side of the nose, briefly contacting it as it passes (Figure 21).

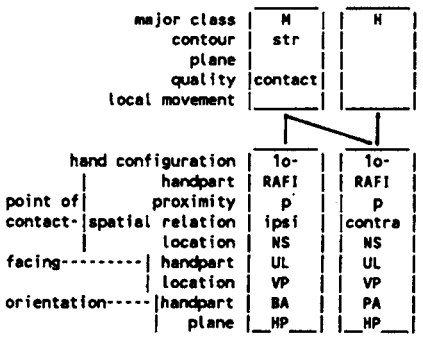


Figure 21. FALSE

We use two sets of spatial relationship symbols. One set refers to locations on the body or in space and the other set refers to locations on the weak hand. Those for body and spatial locations are the absolute directions over, under, behind (toward body from spatial location), ahead, contra, and ipsi. Because the weak hand can move, the spatial relations specified with respect to weak hand locations are relative to parts of the hand. The set includes: tipward [toti], baseward [toba], toward ulnar side [toul], toward radial side [tora], palmward [topa], and backward [tobk]. An articulatory bundle specified c in the proximity slot may be left unspecified in the spatial relation slot.

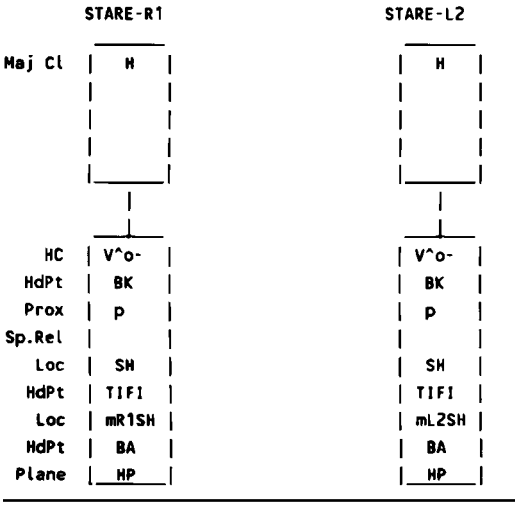


Figure 22. STARE: Two different third person objects

2.4.3 Describing Hand Orientation. The POC entries in the notation simply place a part of the hand at a location. At any location it is possible for the hand to assume countless orientations. The orientation of the hand is important in ASL signs, for both lexical contrast and morphological functioning. It appears that signs make use of two dimensions functioning together to orient the hand. The first of these is *facing*, which "points" a part of the hand at a location. The second is *orientation* proper which usually indicates which part of the hand is pointing toward the ground. The facing cluster is composed of two entries: one for a handpart and one for a location. The orientation cluster is also composed of two entries: one for a handpart (other than that used in facing) and one for a plane (usually HP). The sign STARE exemplifies the interaction of facing and orientation. In citation form it is produced as a hold with the hand located near and in front of the shoulder, with a V^o-hand configuration. If the third person object is associated with the vector R1, the tips of the fingers point directly forward toward R1 and the base of the hand points toward the ground. If the object is associated with the vector L2, the hand remains in front of the shoulder, and the base continues to point to the ground, but the tips point to the object agreement location, in this case mL2SH.[6] Numerous object agreement inflections may be achieved by altering the facing complex of STARE, independently from POC and orientation.

3. MORPHEME STRUCTURE CONSTRAINTS

Upon recording a corpus of connected signs using the system described above, it becomes clear that certain phonetic details of the segmental strings are predictable. For example, some details of phonetic representations recur as consistent patterns in the lexicon. These may be stated as *morpheme structure constraints* (MSC) on the combinations of features and segments permissible in novel lexical forms.

Battison (1974, 1978) identifies several MSCs in ASL, based on the notations present in Stokoe et al. (1965). As a result, they are stated largely in terms of a simultaneous model of sign structure. Nonetheless, he identifies both simultaneous and sequential conditions on the structure of ASL signs. For

example, he observes that the hand configuration R may contact locations in only a relatively limited number of ways (1978:38). This observation can be restated explicitly as a segmental MSC: If the hand configuration of a segment is specified as Ro-, then the hand part specification in POC will be one of the following: TIFI (DONUT), PDFI (RESTAURANT), BAFI (CIGAR), BA (ROCKET).[7] Segmental MSCs such as this will constrain the inventory of segments that may be utilized in forming novel morphemes.

Similarly, Battison noted that in signs in which the hand configuration changes, only a limited number of sequences occur. One such sequential MSC states that if two segments of a sign contain different hand configuration specifications and the final hand configuration is 1o-, then the first hand configuration will be 1″o-f (UNDERSTAND). Similar sequential constraints appear to pertain to the following final/initial pairs of hand configurations: Ho-/Ho″-f (BEAT), Vo-/Vo″-f (TWELVE). Such constraints describe the preferential structure of lexical items but do not operate as phonological processes across word boundaries. For example, in the clause EXTREMELY-FOND-OF ## NAME "I am extremely fond of that name," the Ho-hand configuration of the final sign NAME does not predict a H″o-f hand configuration for the preceding sign. EXTREMELY-FOND-OF retains its So-hand configuration, resulting in the sequence So-Ho-. The sequence H″o-f Howould be ungrammatical for this clause. Many other constraints such as these appear to exist in the lexicon, and will ultimately describe the extensive harmonic sequencing observable in ASL signs.

Battison also identifies another, more unusual sort of MSC, which specifies cooccurrence relationships between the two hands (1974). Spoken languages have little need for specifying the possibilities of cooccurrence among the independent articulators, although constraints on the feature [round] and constraints describing coarticulated implosives are probably similar in function. In ASL it is possible to have fully specified strong and weak hands performing identical activities (LARGE) or mirror image activities (MAYBE), or completely different activities (FIRED). Moreover, there are minimal contrasts among one-handed and two-handed signs (LIKE; INTERESTING), so the weak hand is not completely predictable, and must be specified. Battison's Dominance Condition specifies rather rigid limitations on differences between the hands. He points out that if the two hands have different hand configurations then the hand configuration of the weak hand must be chosen from a very limited set of easily discriminable hand configurations, while the hand configuration of the strong hand is much less constrained. The refinement of MSCs of this type promises to be a rich area of research in the segmental phonology of ASL.

4. Phonological Processes

The phonological strings contain still another sort of predictable detail, traceable to *phonological processes*, producing alternations among surface forms. These processes are typically described by a complex of phonological rules, each of which may alter some detail of the representation of a form or add nonlexical phonological information to a string. The combined action of these processes ultimately derives the surface representation of the string.

4.1 Movement Epenthesis

Phonological processes proper influence the phonetic shape of phonological strings. Many of the phonological processes known to occur in spoken languages appear also in ASL. The most easily described is a process which inserts a movement between concatenated

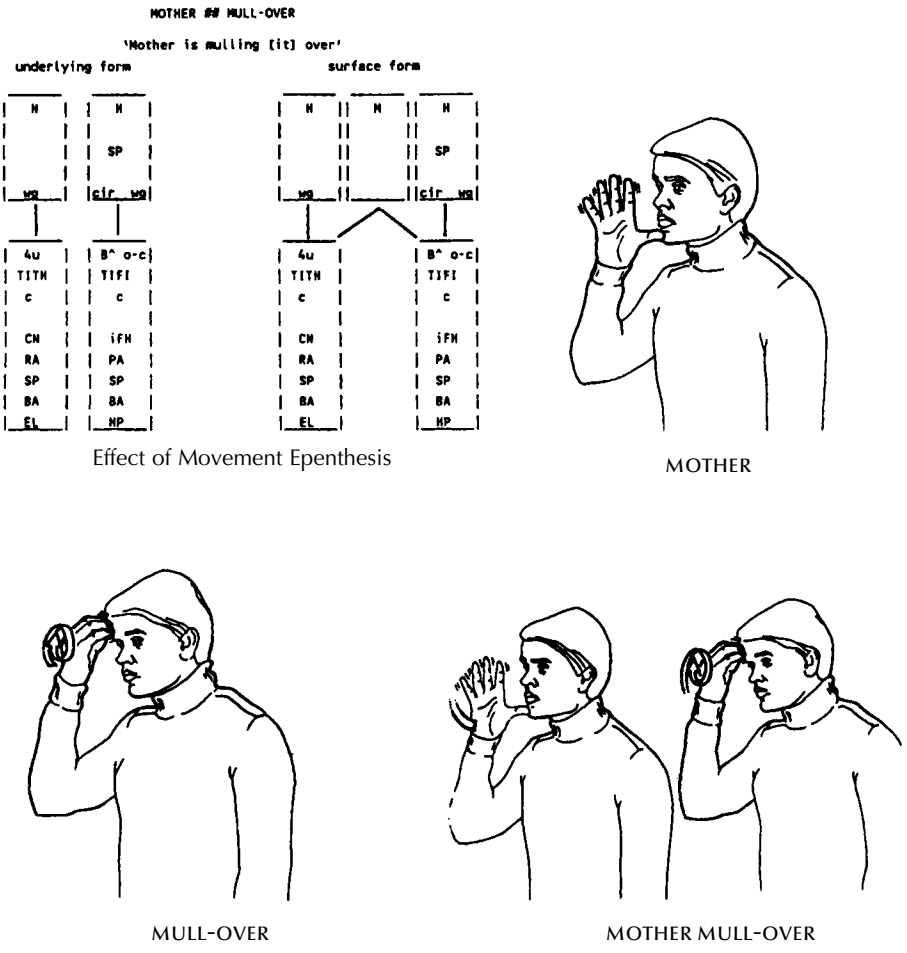


Figure 23. The effect of M Epenthesis in the string MOTHER MULL-OVER.

segments, the second of which begins with an initial articulatory bundle different from the final articulatory bundle of the preceding segment. For the most part, this process applies at the boundary between signs and enjoys the relatively straightforward function of moving the hand from the articulatory posture that ends one sign to the articulatory posture that begins the next. In the case of MOTHER MULL-OVER the Movement Epenthesis Rule inserts an M segment between the last segment of MOTHER and the first segment of MULL-OVER.

Although it may seem to be unnecessary to propose a rule describing a process so predictable, pervasive, and physiologically motivated, the M segment introduced into strings by the M Epenthesis Rule functions as a critical part of the environment that feeds another phonological process.

4.2 Hold Deletion

That process is Hold Deletion, which, with certain exceptions, eliminates hold segments occurring between movement segments. The surface form of the phrase GOOD ## IDEA "good idea" demonstrates the application of the H Deletion Rule.

Because the sign GOOD ends with a segment articulated in a different way from the

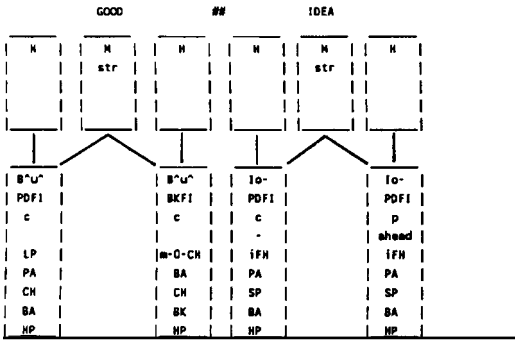


Figure 24. Underlying form of GOOD IDEA.

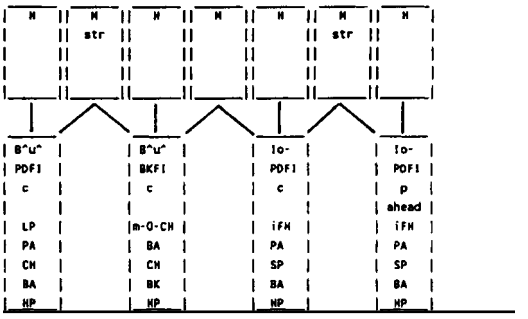
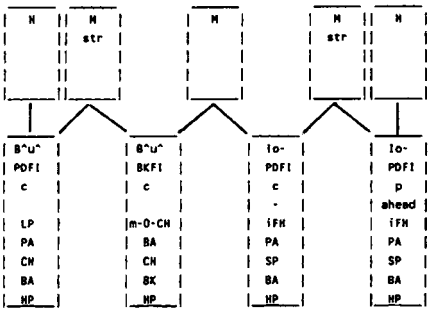


Figure 25. GOOD IDEA (Movement Epenthesis applied)



Final form of GOOD IDEA (Hold Deletion applied)

GOOD

IDEA

GOOD IDEA

Figure 26. The effect of M Epenthesis in the string GOOD IDEA.

initial segment of IDEA, the M Epenthesis Rule will insert a segmental bundle, specified as M, between the two signs. This has the effect of moving the hand from the area immediately in front of the chest to a location in contact with the side of the forehead and simultaneously changing the other articulatory specifications from those describing an open hand oriented with its back to the HP to those of a hand with only the little finger extended and oriented with the tip of the little finger upward.

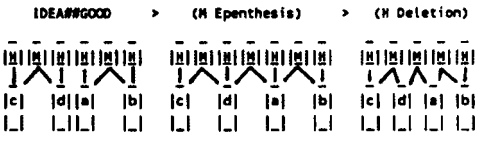


Figure 27. M Epenthesis and H Deletion.

Whereas the isolated signs GOOD and IDEA end and begin with substantial holds, when juxtaposed in this phrase the final H of GOOD and the initial H of IDEA are deleted. The critical environment for the application of this rule seems to be the M segments that surround each H segment.[8]

The surface form of the clause IDEA # # GOOD "The idea is good" is also affected by the H Deletion rule, which again causes only the inter-M holds to be deleted [Figure 27].

Certain conditions prohibit application of the H Deletion Rule. Holds that are lengthened, either by the presence of local movement or by morphological processes such as the one which produces a lengthened H at the beginning of emphatic forms, tend not to delete. Moreover, it appears that the application of H Deletion is variable by context. Although the extent and exact nature of the variation is not yet clear, it appears that H segments that do not contact the body or the other hand are generally deleted in inter-M contexts (as long as they are not lengthened), whereas those that do contact another body part are variably deleted. The following combinations result (+ indicates body contact) [Figure 28].

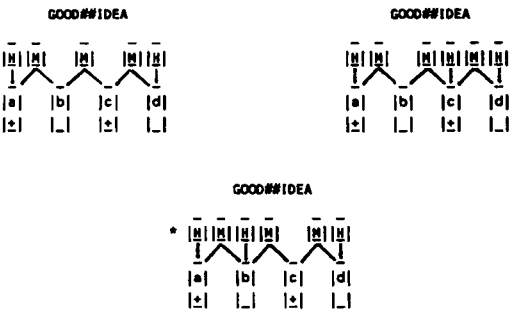


Figure 28. Possible and disallowed application of H Deletion.

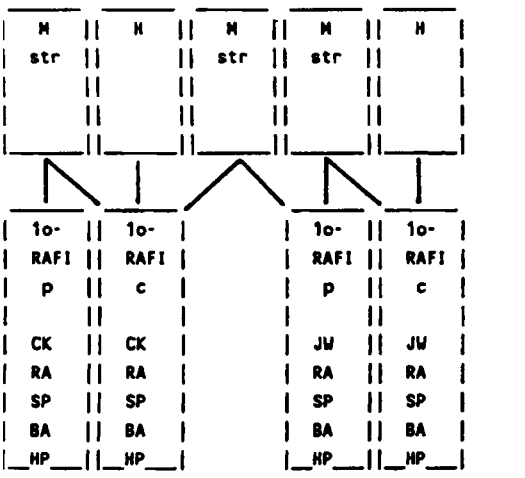


Figure 29a. DEAF

Figure 29b. DEAF

4.3 Metathesis

A number of signs exchange an initial sequence of segments with a sequence of final segments in certain contexts that appear to be purely phonological. The sign DEAF is typical of such metathesizing signs.

In this form of the sign the index finger first moves to contact the cheek and

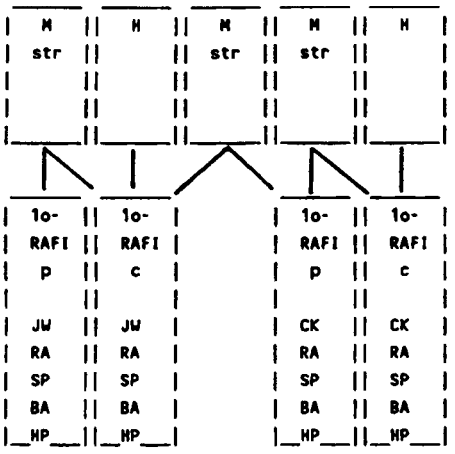


Figure 30a. DEAF (after metathesis).

Figure 30b. DEAF (after metathesis).

then moves to contact the jaw. This form of the sign typically occurs immediately following signs produced in the higher facial areas. Thus, it would be likely to occur in the clause FATHER ## DEAF "Father is deaf," since FATHER is produced with contact at iFH. However, if DEAF is immediately preceded by a sign in the lower facial regions (and perhaps other lower areas), the initial two segments are exchanged with the final two segments. In the clause MOTHER ## DEAF "Mother is deaf," the sign MOTHER produced at the chin causes DEAF to be produced as in Figure 30.

The sign WE further illuminates the metathesis process. There are two forms of WE; one has a segmental structure like that of DEAF, the other has an H M H sequence, with an arc M. WE_1 metathesizes but WE_2 does not (Figure 31).[9]

The signs CONGRESS, FLOWER, RESTAURANT, DEAF, HONEYMOON, NAVY, TWINS, BACHELOR, PARENTS, HOME, and HEAD have all been observed to undergo metathesis. All these signs have the same basic segmental structure as DEAF, i.e., a movement to a hold at one location followed by a movement to a hold at another location. Because no sign with another segmental structure has been observed to metathesize, application of the phonological rule appears to require this underlying segmental structure. However not all signs with this underlying segmental structure may metathesize. BODY, KING, CHRIST, INDIAN, BLOUSE, THANKSGIVING, CHILDREN, and THING all have the appropriate segmental structure but may not metathesize. Most of these share the characteristic that their two contacts are in markedly different locations on the body. The last two do not make contact with the body. These tentatively appear to be additional phonological constraints on the application of the rule.

These observations carry two important implications for the general theory of the structure of signs we are proposing here. The first is that we have some justification for treating signs with this segmental structure as having two lexical parts. Specifically, we propose that the underlying form of such signs contains two unconnected M H sequences, which are subject to metathesis and which (whether or not metathesis has applied) are connected by the M Epenthesis Rule, as represented in Figure 32.[10] Signs such as WE_2 have a unitary lexical form

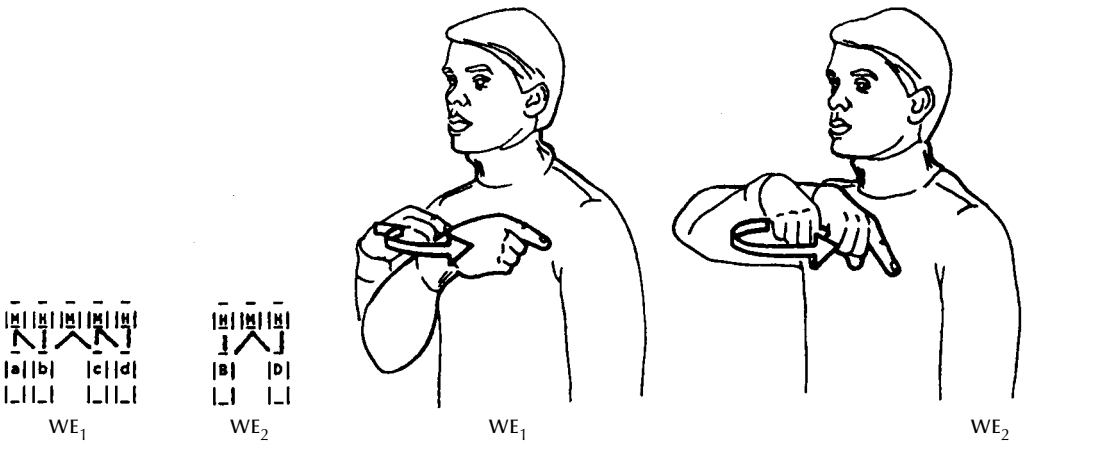


Figure 31. Alternate forms of WE.

H M H, which may not be permuted by metathesis and in which the segmental information in the M must be specified as an arc.

The second important implication of these observations suggests that a complete feature analysis of locations will provide insights into the nature of phonological processes. First it is probable that some feature or set of features unites the sets of locations between which metathesis may occur and distinguishes those which are saliently distant enough to prohibit metathesis. Moreover, the conditioning of the Metathesis Rule by prior signs will depend on a feature analysis that recognizes that certain locations are more to the left or right or below or above certain other locations. Only features that carry this sort of information may condition the appropriate application of the Metathesis Rule. Such featural information will account for the fact that signs made on the stomach, the chest, or the chin may all provide the condition that selects initial occurrence of the lowermost sequence of DEAF.

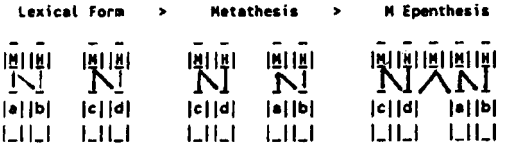


Figure 32. Relationship between metathesis and epenthesis.

4.4 Gemination

Although such occurrences are rather rare in ASL, it sometimes happens that the terminal segment of one sign is identical to the initial segment of the following sign. In the sentence,

SPAGHETTI$_{3A}$, MOTHER REPULSED-BY$_{3A}$
"Mother really hates spaghetti"

the final segment of MOTHER (the form of MOTHER without local movement) and the initial segment of REPULSED-BY are identical holds. The result is a single long hold. An epenthetic movement away from the chin or a hold of normal length is ungrammatical.

4.5 Assimilation

There are numerous instances of assimilation in ASL. For example, the hand configuration of the sign ME typically assimilates to that of a contiguous predicate in the same

Figure 33. Phonological assimilation of handshape features in the string ME GULP.

clause. Thus, whereas the underlying form of ME contains a 1o- hand configuration, in the string

MOTHER$_{3A}$STARE-AT$_{1}$. ME GULP.
"Mother was staring at me and I was nervous about what was to come"

ME assumes the 9o-c hand configuration of GULP. The extent to which signs other than ME assimilate to the hand configuration of another sign, although not yet thoroughly investigated, appears to be considerably more limited.

Assimilation of the hand configuration of the weak hand to that of the strong hand in two-handed signs is quite common. For most signers it appears to be variable, probably controlled by formality and fast-signing constraints. Thus, it is common that in signs in which the strong and weak hand configurations are different in formal signing, the weak hand configuration will be fully assimilated to the strong hand configuration in casual or fast signing.

We have observed numerous other examples of assimilation in ASL. Among these are the assimilation of orientation and facing features of the weak hand to those of the strong hand; assimilation of features specifying location in POC of an initial segment of one sign to the location features of the final segment of the preceding sign; assimilation of location features of the final segment of a sign to the location of the initial segment of a following sign; two-handed signs becoming one-handed as a result of assimilation to a one-handed sign in the same string; one-handed signs assimilating to two-handed signs. These processes await more detailed description.

4.6 Reduction

Frishberg (1975) notes a number of historical trends in ASL which she identifies as "displacement." Each of these involves the diachronic relocation of certain signs to areas either less central to the face (and thereby less likely to obscure important facial signals) or to areas more central to the lower head and upper body regions of the signing space (and thereby more readily perceptible).

Although such forms appear to be lexicalized at their new locations, the phonological processes that originally must have moved them are still active in contemporary ASL. The rules which account for them

appear to be variably selected by casual signing, and, like vowel reduction rules in spoken languages, have the effect of neutralizing contrasts of location. Thus, many signs that are produced with contact at the SFH location in formal signing may be produced in casual signing at the CK location. Similarly, signs produced at the CK location (including those moved from the SFH location) may be produced at the JW location. These same signs also appear at times without contact in the area immediately in front of the iNK location. The first segment of the sign KNOW-THAT is produced formally at the SFH location but may occur in casual signing at any of the other locations described above.

In a somewhat similar manner, signs produced at a location proximal to, but not in contact with FH or NS in citation form (KNOW-NOTHING, DOUBT) and signs produced with contact at the mouth (GLASS) may be produced at the CH location. Signs that do have underlying contact at the FH or NS locations are not subject to the effects of this rule (FATHER, BLIND). Similar rules exist to reduce peripheral locations on the torso to more centralized locations.

It appears also that there are rules that reduce the distance between the locations of two-location signs in casual signing. The M M M H sequence of the type isolated by the metathesis rule (CONGRESS, HOME) is commonly reduced by such a rule, and it appears that many other segment sequences also undergo a similar reduction process (GOOD, GIVE, etc.). Similarly, the size of the first (round) movement in M M H sequences such as YEAR, WHEN, POLITICS, and QUESTION is often reduced in casual signing.

4.7 Perseveration and Anticipation

Typically, signed strings contain both one-handed and two-handed signs. When a one-handed sign follows a two-handed sign, although the weak hand is not required, in casual and fast signing it commonly either perseverates features of the former sign or anticipates features of the following sign, or both, rather than returning to a resting position. Although these processes and other very late phonological processes such as reduction have the relatively trivial phonological function of speeding and smoothing the phonetic string, they apply very broadly. Thus, because they apply to most forms produced in comfortable signing, these processes commonly have a substantial impact on the underlying form of lexicalized compounds and other lexical entries that result from the lexicalization of productively produced forms.

5. Morphological Processes

Another sort of predictable detail originates in the morphology, where *morphological processes* create words. Across languages, words are formed by attaching lexical forms to one another and by moving, reproducing, deleting from, adding to, and altering the phonological information carried by lexical forms. Although both morphological processes and phonological processes may add, delete, alter, or move phonological details, they differ in that phonological processes do not account for meaning changes whereas morphological processes do.

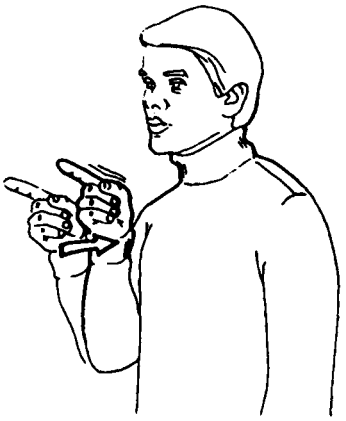
Below we will describe a small selection of ASL morphological processes that illustrate the diverse phonological effects which result from their application. We have divided these processes into two broad categories. In the first, meaningful feature bundles (morphemes) are inserted into one or more segments of a root with incomplete articulatory feature bundles. This insertion results in a phonologically fully specified stem. In the second major category, the

morphological processes operate on a completely formed stem either by removing some of its phonological features and inserting them in a segmental frame, by modifying them through reduplication, or, rarely, by attaching an affix.

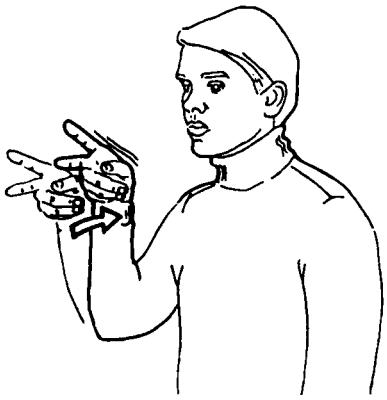
5.1 Processes that Insert Features in Roots

For many ASL signs, we posit lexical forms of roots with empty spaces (or "cells") in their underlying feature specifications. A number of ASL morphological processes "fill out" such incompletely specified roots with morphemes which consist of the small bits of phonological information used to fill the empty cells in the root. The three signs in Figure 34 are representative of a large class of such signs, built from roots specified for all their features except hand configuration.

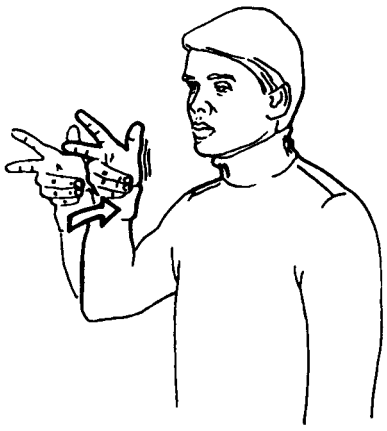
These three signs are identical except for their hand configuration. FIRST-PLACE is produced with a 1o- hand configuration, SECOND-PLACE has a Vo- hand configuration, and THIRD-PLACE has a Vu hand configuration. Signs meaning FOURTH-PLACE through NINTH-PLACE can be formed by using other hand configurations. In numerous other signs the same hand configurations convey equivalent meanings of numerosity.



FIRST-PLACE



SECOND-PLACE



THIRD-PLACE

Figure 34. Substitutability of numeral morphemes into a phonologically incomplete root morpheme.

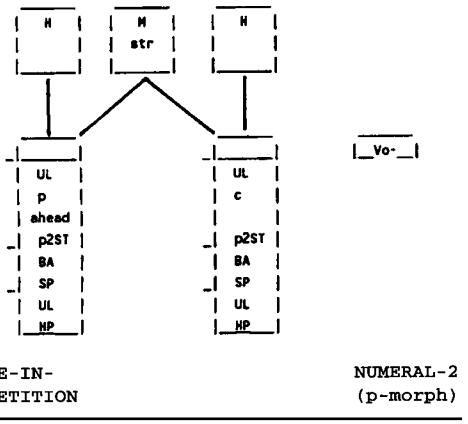


Figure 35. The two bound morphemes required for "first place," "second place," etc.

We contend that these signs (and others with numeral hand configurations) contain at least two morphemes: the root morpheme, a numeral classifier which means "place in a competition," and the numeral morpheme. The two morphemes in SECOND-PLACE and their phonological relationship to one another are sketched in Figure 35. The root, PLACE-IN-COMPETITION, is composed of three segments and two incompletely specified articulatory feature bundles. A numeral morpheme is required to complete the phonological representation of the stem SECOND-PLACE.

We refer to roots such as PLACE-IN-COMPETITION as "Incomplete S-morphs," since their phonological representation is segmental, but incomplete (Johnson and Liddell 1984). The numeral morpheme is referred to as a "P-morph" since it only provides paradigmatic contrast (i.e., it contains no segmental information). It can be inserted into a root consisting of one or more segments and its features simply spread according to autosegmental principles. We have identified more than thirty different incomplete S-morphs which, like PLACE-IN-COMPETITION, require the insertion of a numeral morpheme.[11]

A second major category of incomplete S-morph contains verb roots with unspecified location information. The completed form of the verb stem of such signs contains location (vector) specifications received through the insertion of subject and/or object agreement morphemes. Two such verbs, ASK and TELL, are illustrated in Figure 36.

The initial location for TELL is the chin. Its final location, however, is determined by the insertion of an object agreement morpheme. In Figure 37, TELL agrees in location with the 3rd person object already indexed on the signer's left.[12] ASK is structured so as to allow both object agreement and subject agreement morphemes to be inserted.

The subject agreement morpheme pictured on the left in Figure 38 is determined by the person and location of the subject

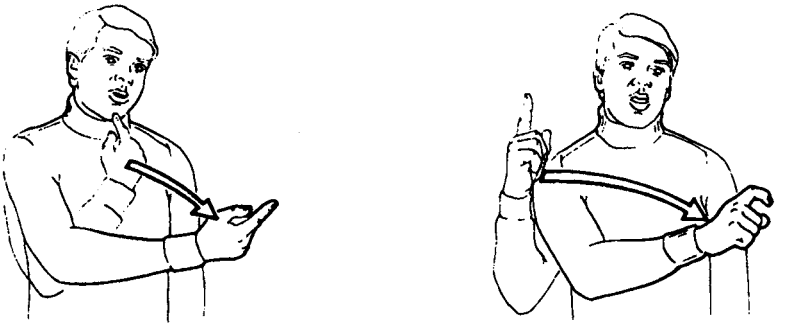


Figure 36. An object agreement verb (TELL) and a subject-object agreement verb (ASK).

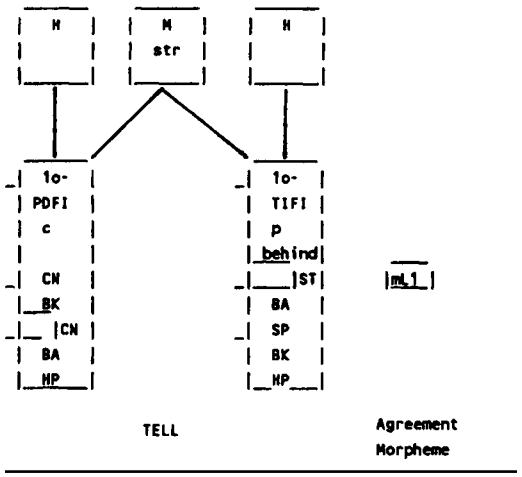


Figure 37. The shape of TELL with an object agreement morpheme.

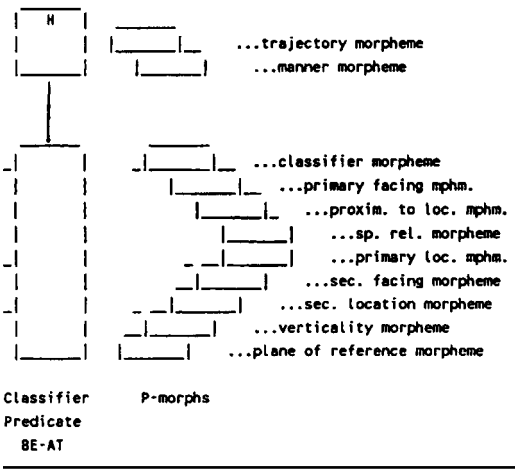


Figure 39. The composition of a classifier predicate.

nominal, and is inserted into specific places in the two feature bundles. The object agreement morpheme is determined by the person and location of the object and is similarly inserted into both articulatory bundles. Thus, the completed verb stem 3a-ASK-3b is composed of three morphemes: one root and two agreement morphemes.

In the examples of feature insertion discussed so far, the root contains only a small number of empty cells. Many other signs are built from roots that are specified only for segment type, and contain empty cells for all other segment features and all articulatory features. This class of signs has been referred to as "classifier predicates" by Liddell (1977), and "verbs of motion and location" by Supalla (1978), who first proposed the idea of movement roots in the analysis of these signs. Morphological processes insert a number of morphemes in appropriate cells to derive a polysynthetic predicate stem.

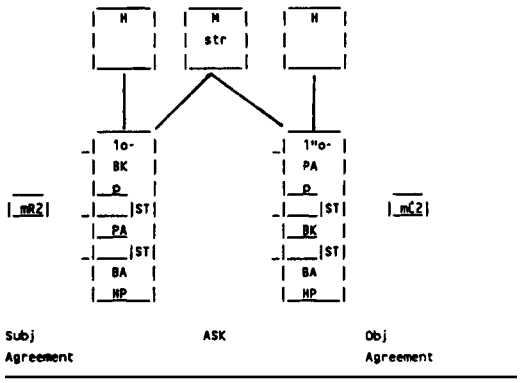


Figure 38. The shape of ASK with subject and object agreement morphemes.

The type of information which can be inserted into such movement roots has been investigated in depth by Supalla (1978). We will not provide additional analysis here, but simply observe that this category of predicate is highly productive in ASL and is responsible for a significant number of the signs observed in ASL discourse.

5.2 Processes that Operate on Fully Specified Stems

The processes we describe below all operate on fully specified stems. Such stems can either come directly from the lexicon as completely specified s-morphs, or become fully specified through processes like those described above.

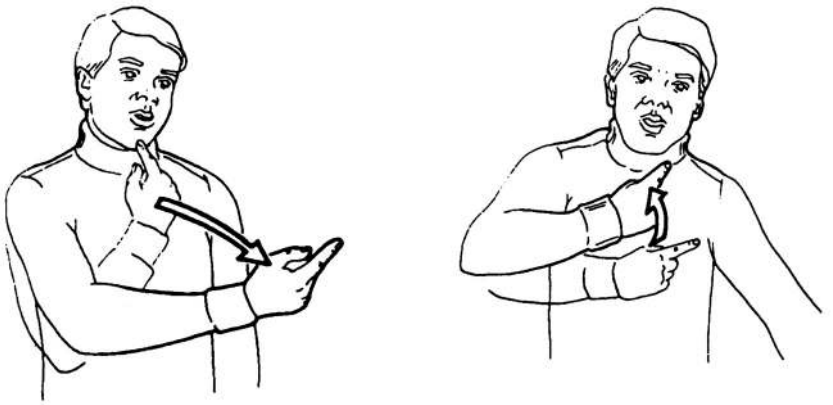


Figure 40. TELL and its unrealized-inceptive form.

5.2.1 Frames. Many ASL inflections have an unusual characteristic. Regardless of the syllable structure of the uninflected stem (the input to the process), the syllable structure of the inflected form (the output) is completely uniform. For example, Liddell (1984b) describes the verb inflection for unrealized-inceptive aspect. The input to the inflection could be a verb with a single segment, two segments, or even three segments. The inflected verbs, however, uniformly have the shape M H.

In this analysis the inflected verb is not strictly a modification of the verb stem, but rather results from feeding a small piece of articulatory information from the verb stem into a segmental structure referred to as an "inflectional frame." Figure 41 shows the shape of the uninflected verb stem TELL, and its form when inflected for the unrealized-inceptive (U-I) aspect.

For verb stems in the same verb class as TELL, the initial feature bundle of the stem is identical to the final feature bundle of the U-I form of the verb. Further, all of their U-I forms have the form M H, and all have the same location features in the initial feature bundle. The inflectional frame is the phonological structure provided by the inflection itself. This frame is not prefixed or suffixed onto the stem, but rather, serves as the phonological framework used to construct the inflected sign. The frame has a partially specified initial feature bundle, but no final bundle of features. For verbs like TELL, which begin in contact with the body, the initial bundle of articulatory features is removed from the stem and inserted into final position in the frame. The remainder of the phonological information from the verb stem does not appear in the inflected form.[13] The resulting sign begins at the location specified by the inflectional frame and moves to what

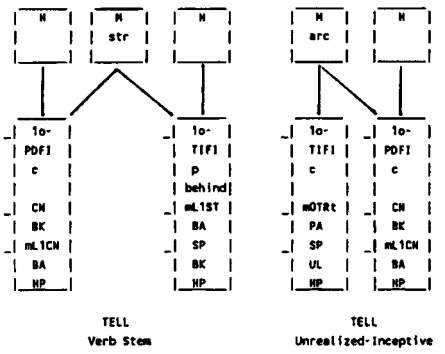


Figure 41. The stem TELL and its unrealized-inceptive form.

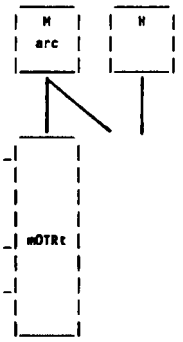


Figure 42. Unrealized-Inceptive Frame.

was the original location specified in the stem.

Many details have been left out of our description of this inflection. In fact, three such frames (i.e., three allomorphs) are needed to account for the U-I data. A fuller account can be found in Liddell (1984b). There are a number of other ASL inflections which will naturally lend themselves to an analysis utilizing inflectional frames.

5.2.2 Reduplication. Reduplication is common in ASL. Habitual aspect and iterative aspect are each marked in ASL by a different type of reduplication rule.[14] Figure 43 illustrates the form of the verb LOOK along with its habitual and iterative forms.

For purposes of our discussion, we will use the verb stem ASK, described earlier, and its habitual and iterative forms. The shape of

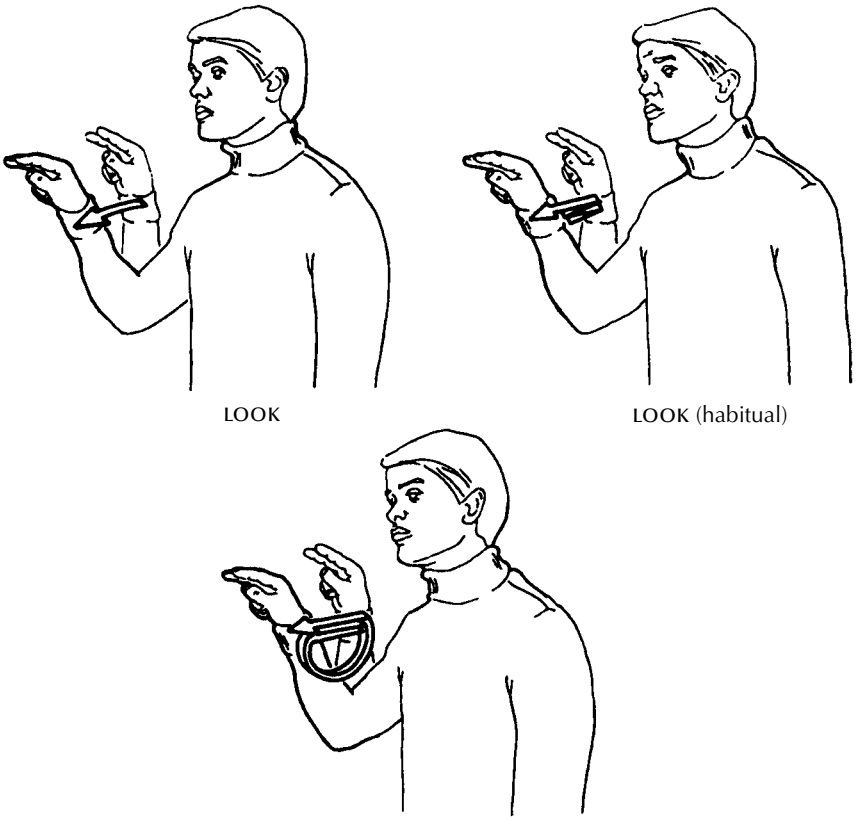


Figure 43. The habitual and iterative forms of LOOK.

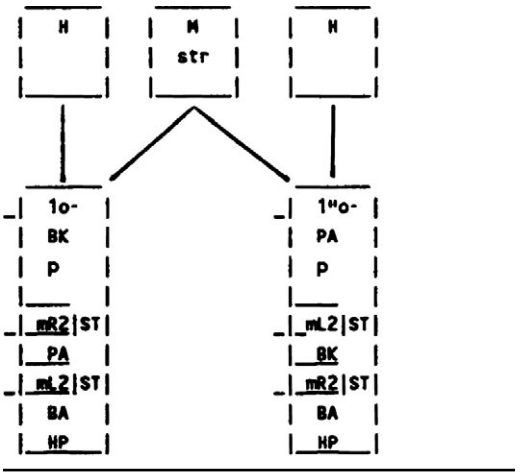


Figure 44. ASK

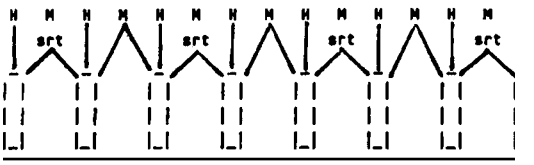


Figure 45. Habitual form after application of M Epenthesis.

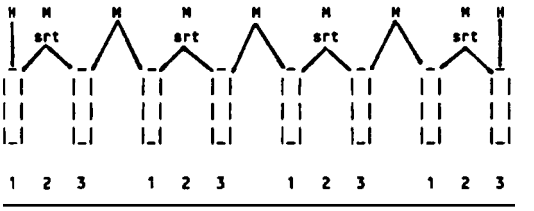


Figure 46. Surface form of ASK (habitual aspect).

the movement of these forms is the same as that seen in Figure 44. The verb stem ASK is an incomplete S-morph. It has phonological cells which are filled with subject and object agreement morphemes.

After the subject and object agreement morphemes are inserted, the phonological structure of the stem is complete. Habitual aspect is then marked for the verb ASK through the application of a reduplication rule like the following:

Habitual Aspect Rule:
(for H M H signs)

1 2 3 → 1 2 3 1 2 3 1 2 3 1 2 3
srt srt srt srt

The rule produces four copies of the verb stem and shortens each of the movements (srt).[15] The application of this rule creates the environment for the M Epenthesis Rule described under phonological processes above.

The circled Ms are inserted between the final H of one repetition and the initial H of the next by the M Epenthesis Rule. Because none of those Hs are attached to articulatory bundles specified for body contact, the H Deletion Rule applies. It deletes every H except for the first and the last, producing the structure in Figure 45.

The epenthetic Ms and the feature bundles attach as shown in Figure 46. This produces what, for ASL, is a relatively long word consisting of nine segments.

A different and slightly more complicated reduplication rule could have applied, producing the iterative aspect.

Iterative Rule:

1 2 3 → 1 2 3 M 1 2 3 M 1 2 3
Long arc Long arc Long

The application of this rule to ASK will produce the following structure (see Figure 47).

In this case the M Epenthesis Rule will not apply because the reduplication rule itself has already inserted a particular type of M

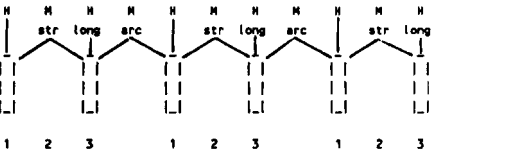


Figure 47. Result of application of iterative rule to ASK.

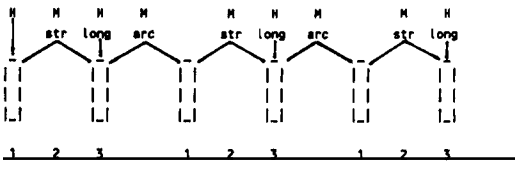


Figure 48. ASK (Iterative form) after H deletion is applied.

(with the feature "arc") between each repetition of the stem. The rule has also marked some of the Hs with the feature [long], which prohibits application of the H Deletion Rule. The H Deletion Rule may apply to unlengthened Hs, however. Its application produces the structure in Figure 48.

The application of the Iterative Rule has also produced a rather long ASL sign, though its structure is significantly different from that produced by the Habitual Aspect Rule.

We will now summarize the morphological and phonological processes which have interacted to form these two forms of ASK. Each began as a phonologically incomplete stem. The stem was made complete through a morphological rule which inserts agreement morphemes into the stem. The completed stem then underwent one of the reduplication rules, which produced an aspectual inflection. The application of either of the reduplicative rules creates the environment for the application of one or more phonological rules. The phonological rules then apply to produce the correct surface form.

It has been common practice in the past to refer to signs which have undergone reduplication process as being marked by the phonological feature [+ redup] (Fischer and Gough, 1978; Supalla and Newport, 1978; Klima and Bellugi, 1979; Padden and Perlmutter, 1984). It should be clear from the two reduplication rules we have examined that such an approach is not adequate. The two reduplicated forms do not differ from their stems by the single phonological feature [+/- redup]. They have undergone a reduplicative process which copies phonological segments, adds phonological features, and triggers the application of phonological rules.

5.2.3 Affixation. Across spoken languages, one of the most common phonological means for marking the application of a morphological process is the affixation of one or more segments to a stem. This also occurs in ASL, but it is uncommon. The one clear case is a nominalizing suffix having the structure M H. When suffixed to the verb TEACH, it produces a word meaning "teacher," and, when suffixed to the noun LAW, it produces "lawyer." This is the only ASL morpheme we know of which clearly has the status of an affix. Most ASL morphological activity involves filling in cells in phonologically incomplete segments, or operations on phonologically complete stems, which either modify them through the use of frames, or through some type of reduplicative process.

6. CONCLUSION

Early in this paper we suggested that, although the terminology of modern phonology would appear to eliminate signed languages from phonological analysis, the concepts that underlie the terminology are sufficiently broad to permit its application to the levels of organization of sign language. Our discussion of the phonetic, phonological, and morphological structures of ASL has been aimed at demonstrating the often surprising degree to which both the levels of organization and the processes and structures of ASL parallel those found in spoken languages. Thus, it should now be possible to refer to the phonetic structure, the morpheme

structure conditions, or the phonological processes of sign languages and be confident that what is being described is analogous to similar phenomena in spoken languages. This potential for comparison permits an expansion of our knowledge about language universals, and should encourage the description of some of the dozens of independent sign languages of the world.

More importantly, the unique lexical structures and morphological processes we have identified and described add to our knowledge of the variety of forms of human language.

REFERENCES

Battison, R. 1974. Phonological deletion in American Sign Language. *Sign Language Studies* 5:1–19.

——. 1978. *Lexical Borrowing in American Sign Language.* Silver Spring, MD: Linstok Press.

Chomsky, N. & M. Halle. 1968. *The Sound Pattern of English.* New York, NY: Harper and Row.

Fischer, S. & B. Gough. 1978. Verbs in American Sign Language. *Sign Language Studies* 18:17–48.

Frishberg, N. 1975. Arbitrariness and iconicity: Historical change in American Sign Language. *Lg.* 51:676–710.

Goldsmith, J. 1976. Autosegmental phonology. MIT dissertation.

Johnson, R. & S. Liddell. 1984. Structural diversity in the American Sign Language lexicon. In *Papers from the Parassession on Lexical Semantics,* Testen, Mishra, & Drogo, (eds.). Chicago, IL: Chicago Linguistic Society. 173–186.

Klima, E. & U. Bellugi. 1979. *The Signs of Language.* Cambridge, MA: Harvard University Press.

Liddell, S. 1977. An investigation into the syntactic structure of American Sign Language. UCSD dissertation.

——. 1984a. THINK and BELIEVE: Sequentiality in American Sign Language signs. *Lg.* 60:372–399.

——. 1984b. Unrealized inceptive aspect in American Sign Language: Feature insertion in syllabic frames. In *Papers from the Twentieth Regional Meeting of the Chicago Linguistic Society*, Drogo, Mishra, & Testen, (eds.). Chicago, IL: Chicago Linguistic Society. 257–270.

Liddell, S, C. Ramsey, F. Powell, & D. Corina. 1984. Numeral incorporation and numeral classifiers in American Sign Language. Gallaudet University, ms.

McCarthy, J. 1979. Formal problems in Semitic phonology and morphology. MIT dissertation.

Padden, C. & D. Perlmutter. 1984. American Sign Language and the architecture of grammatical theory, ms.

Stokoe, W., Jr. 1960. *Sign Language structure: An outline of the visual communication Systems of the American Deaf* (Studies in linguistics: occasional papers 8) Buffalo, NY: University of Buffalo. [Rev. ed., Silver Spring, MD: Linstok Press, 1978].

——, D. Casterline, & C. Croneberg. 1965. A *Dictionary of American Sign Language on Linguistic Principles.* Washington, DC: Gallaudet College Press. [Rev. ed., Silver Spring, MD: Linstok Press, 1976.]

Studdert-Kennedy, M. & H. Lane. 1980. Clues from the differences between signed and spoken language. In *Signed and Spoken Language: Biological constraints on linguistic form,* Bellugi & Studdert-Kennedy, (eds.). Weinheim: Verlag Chemie. 29–39.

Supalla, T. 1978. Morphology of verbs of motion and location in American Sign Language. In *Papers from the Second National Symposium on Sign Language Research and Teaching.* Caccamise & Hicks, (eds.). Silver Spring, MD: NAD. 27–45.

—— & E. Newport. 1978. How many seats in a chair? The derivation of nouns and verbs in American Sign Language. In *Understanding Language Through Sign Language Research*, Siple, (ed.). New York: Academic Press. 91–132.

AUTHOR NOTE

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Notes

1. It might be possible to argue that in many cases, the hold at the end of a sign is simply the physiological result of making contact with the body. It is not difficult to demonstrate that this is not so. The sign KNOW moves toward the forehead, makes contact, then stops briefly in contact with the forehead. It can be described as ending with hold manner. Liddell (1984a) reports the occurrence of a noncontacting form of the sign in which the hand approaches but does not touch the forehead and in which the sign still ends with hold manner.
2. In actuality, discourse strings must be represented as several simultaneous strings: one for each hand, since each produces segments, and one for each linguistically independent complex of torso, head, and facial behaviors. For the moment we are focusing on segments and strings of segments produced by a single hand.
3. Earlier work treated these as features of hand configuration (Liddell, 1984a). There is evidence for their independence from hand configuration, however, in the fact that certain of the local movements function as the sole manual markers of inflectional morphemes attached to signs which have plain (i.e., nonmoving) hand configurations in their uninflected forms.
4. It may be that a single feature such as "contracting" unifies both hooking and flattening.
5. For certain hand configurations and under certain discourse conditions it is possible to achieve twisting and nodding with the elbow joint rather than the wrist joint. For example, the sign WHERE is typically performed by twisting the wrist but by changing the hand configuration to one with a straight, rigid wrist the twisting can be transferred to the elbow. Similarly, YES which normally nods at the wrist may nod at the elbow in its emphatic form.
6. This sign also inflects for subject agreement. In fact, the example shown in Fig. 22 is the appropriate one for a first person subject, but we will not deal with this issue here.
7. Recently introduced signs for representing English words whose spellings begin with r use three other hand parts in POC: PA (RELAX), UL (RIGHT), RAFI (REALLY), but the use of such introduced signs is highly constrained.
8. A treatment whereby lexical forms of such signs contain terminal M segments and H segments are inserted finally would also have to propose that the initial H segments were also inserted by phonological process. This is not an appealing solution, however, since there exist signs with initial M segments that are not preceded by H segments, even in isolation (WHEN). We know of no principled way to predict which signs would add an H and which would not. Moreover, a number of signs consist of only a hold in isolation but are deleted between Ms. The underlying M solution would clearly not work for such signs since they have no M. The alternative proposal would amount to a claim that they have no segmental structure in their underlying forms which appears to introduce unnecessary complication to a theory of lexical structure of ASL.
9. The feature bundles in these two signs share many features. That is, feature bundle "b" is closely related to feature bundle "B." Likewise, feature bundle "d" is very similar to feature bundle "D."
10. Hold Deletion may optionally apply to the first hold of this string, yielding an M M M H surface form. In addition, although the derivation is presented in ordered form, M Epenthesis and Metathesis appear to be unordered with respect to each other.
11. Many of these are analyzed in detail in Liddell, Ramsey, Powell, and Corina (1984).
12. In ASL discourse any nominal may be assigned a grammatical association with a spatial location or vector. The process of assigning this association has been called "indexing" and the location or vector associated with the nominal has been called its "index." While ASL pronouns may make reference to a nominal by pointing at its index, verbs such as TELL and ASK agree with their subject and object nominals through the insertion of agreement morphemes. The agreement morphemes are morphs, the phonological form of which is a specification determined by the location of the index of a nominal.
13. We hesitate to talk about "deletion" here since this constructive process may take place within the lexicon. If so, then the process merely copies (reads, selects) specific information from the lexical entry of the stem and there is nothing to delete.
14. The data on these aspects are from Klima and Bellugi (1979), who first described them.
15. The actual number of repetitions can vary. For example, it could easily be produced with three rather than four repetitions.