1 Temporal Aspects and ASL Phonology

WENDY SANDLER

1.1 Introduction

For over twenty years, sign language researchers have worked productively within the ground-breaking paradigm offered by William Stokoe's *Sign Language Structure* (1960). The internal structure of the sign is presented in Stokoe's work as simultaneously realized phonemes of location, handshape, and movement. Recently, evidence has been mounting to support the view of sign structure as having sequentially ordered elements. If these elements are phonologically significant, such a structure would be much more like that of spoken language than was previously assumed.

We begin with the assumption, supported by a large body of research, that sign languages share with all other languages universal organizing principles. In this view, identifiable structural differences between spoken languages and signed languages can be attributed to modality effects alone. The clearer and more precise our identification of the similarities and differences between languages in the two modalities, then, the deeper our understanding of language universals.

The phonological level of analysis is potentially instructive for addressing the questions of the structural relationship between signed and spoken languages and modality effects. This is because the phonology is in part determined by the physiological capabilities and limitations of the articulators, while at the same time it entails an abstract system of rules.

In this light, the following questions become pressing: What are the phonologically significant elements of sign language? How sequential are they? How does the structure of the sign, seen now as comprising at least some sequential segments, compare with the structure of the spoken word?

The work contained in this chapter is part of ongoing research attempting to characterize the phonological form of American Sign Language. The frame-

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work is called the hand tier model of ASL (for reasons that will become clear), and the corner of the grammar dealt with here is part of the system of temporal-aspect marking. Specifically, I will focus on two temporal aspects: habitual and durational. I chose these two because they are apparently very common for most signers and because they are formationally distinct from one another, thus avoiding the problems of individual and regional variation, yet they bear certain formal similarities to one another that have until now been reported in descriptive rather than formal terms (e.g., Klima and Bellugi 1979).

Section 1.2 briefly discusses simultaneous and sequential properties of ASL. Section 1.3 gives a sketch of the theory of autosegmental phonology, focusing primarily on the work of Goldsmith (1976) and McCarthy (1979, 1981). An overview of the hand tier (HT) model is presented in section 1.4, and section 1.5 is an analysis of the temporal morphology described above. Section 1.6 compares the HT model with the movement hold model of Liddell and Johnson (e.g., 1985). The last section returns to the question of language universals.

1.2 Simultaneous and Sequential Segments

The Stokoe model of ASL sign structure (1960, 1978) identifies categories of meaningless units that combine to form signs. These categories—handshape (dez), location (tab) and movement (sig)—are seen as *simultaneously* executed in simple signs. The sign LOOK-AT, for example, is represented in Stokoe notation in (1.1).

(1.1) LOOK-AT $\underset{\cap}{}\mathrm{V}^{\perp}$

The symbol $\underset{\cap}{}$ represents the head location, V is the handshape, and $\perp$ means movement away from the signer. That the symbols are written in linear sequence is not intended to reflect any temporal order. A more accurate representation of the Stokoe view of sign structure would stack the symbols as in (1.2).

(1.2) LOOK-AT $\begin{matrix}\underset{\cap}{}\\ \mathrm{V}\\ \downarrow\end{matrix}$

Minimal pairs differing in any one simultaneously occurring phoneme category, or *chereme* in Stokoe's terminology, provide support for the categories proposed in the model (Battison 1978). For example, CHINESE and SOUR, shown in Stokoe notation in (1.3) and (1.4), differ only in location or tab.

(1.3) CHINESE $\cap\mathrm{G}^{\ddot{\alpha}}$

(1.4) SOUR $\cup\mathrm{G}^{\ddot{\alpha}}$

If sign language phonology has no significant linear structure, this would represent a fundamental distinction between signed and spoken languages, since linearity is a universal property of spoken language phonology. For example, each of the two English minimal pairs "pin" and "bin," and "pin" and "pit," differ only in one *linearly* sequenced phoneme. This distinction between signed and spoken languages would entail a difference in the forms of rules in the two language systems and would imply a corresponding difference in the kinds of cognitive operations involved in using them.

Recently, however, researchers have begun to suggest that, like spoken languages, ASL has phonologically significant linear structure. Newkirk (1981) shows that such phenomena as movement dynamics for continuous aspect and multiple marking on verbs can be represented only by dividing signs into sequential segments. In particular, he shows that the continuative form consists of a sequence of tense, slow, and neutral manners of movement. Newkirk also demonstrates that the horizontal arc that marks "multiple object" may be suffixed to the verb stem, constituting a linear operation rather than a simultaneous one. Supalla and Newport (1978) refer to morphologically distinct "manner of movement" alternations on temporally distinct parts of signs. Action verbs that entail a spatial end point, for example, are characterized by a "hold" manner of movement on the *end* of the sign; those that have no spatial end point are executed with "continuous" movement at the end. Padden (1981, 1983), Meier (1982), and others state explicitly that verb agreement for subject, object, and other arguments is marked on the beginning or ending of verb signs. Liddell (1984a) shows that temporally distinct parts of signs delete when compounds are formed. Liddell (1984a) and Liddell and Johnson (1989, 1986) proposed the first model of ASL phonology with explicitly represented sequential and autosegmental elements. Using data from Newport (1981), Sandler (1986) shows that some sequential elements delete and suggests that others coalesce to form complex verbs of motion. Negative incorporation (Woodward 1974) is analyzed as a process involving suffixation in Sandler (1989). In their work on syllable structure, Wilbur (this volume) and Coulter (this volume) provide additional support for the claim that signs have significant internal temporal structure.

As I show in section 1.5, a unified account of temporal aspect inflections also requires temporal segmentation of sign structure. Before describing the HT model and the way it accounts for this type of data, I will present a brief overview of the basic tenets and machinery of autosegmental phonology.

1.3 Autosegmental Phonology

First developed as a formal theory by Goldsmith (1976), autosegmental phonology offers a principled treatment of phonological entities that do not map uniquely onto discrete segments of words. These entities have temporal structure of their own, and their association to consonants and vowels is governed by universal conventions and language-specific rules. Since phonological elements may be characterized by a degree of temporal autonomy from one another, they are referred to as "autosegments."

One of the strongest forms of evidence supporting the theory is the phenomenon of stability, shown in Goldsmith (1976) to characterize the tones of tone languages. This property of autosegments was defined as the preservation of the tone of a segment even when the segment itself deletes or is changed to a segment type that cannot bear tone. A rule for tone stability is difficult to formulate in a traditional segmental framework, and any such rule would fail to capture the generalization that stability exemplifies. The solution is to represent a separate autonomous tonal tier, which is associated to tone-bearing units (vowels, in the example to follow), according to the proposed universal well-formedness condition shown in (1.5).

(1.5) Well-formedness condition
(i) All vowels are associated with at least one tone; all tones are associated with at least one vowel.
(ii) Association lines may not cross.

An example from Lomongo, as presented in Kenstowicz and Kisseberth (1979), provides a clear illustration of the theory. The example begins with an underlying representation of two verbs, their tones associated to each vowel by association lines:

(1.6)

ba-as-a	ba-is-a
H L L	H H L
'they search'	'they hide'

A rule of vowel deletion deletes the first of two adjacent vowels, giving the following representation, with unassociated tones where the vowels used to be:

(1.7)

b -as-a	b -is-a
H L L	H H L

The unassociated tones link or *spread* to the nearest tone-bearing unit (TBU):

(1.8)

b -as-a	b -is-a
H L L	H H L

This derives the correct surface form: *bâsà, bísà*. HL is realized on the surface as a contour tone with falling pitch, and HH surfaces as a high tone.

The postulation of autonomous tiers that are related by conventions and rules of association and spreading makes it possible to account for effects such as the one illustrated above in a perspicuous and theoretically coherent way that was not possible in the earlier strict linear matrix model (Chomsky and Halle 1968). Since the appearance of autosegmental phonology (Goldsmith 1976), the framework has been extended to account for many other phonological effects.

One of the developments to emerge from this line of research is the proposal, developed by McCarthy (1979, 1981) in his work on Semitic languages, that there is an abstract skeleton or timing tier to which phonological features are associated. McCarthy extends the notion of autosegmental tiers to capture generalizations in Semitic phonology and morphology that had previously been difficult to characterize formally.

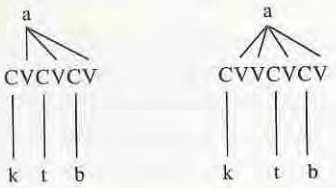
Semitic roots are traditionally represented as a series of consonants (usually three). The vowel melodies—that is, the phonological content of the vowels, as well as the length of consonants and vowels, which are largely predictable in the verbal morphology—had to be listed individually for each *binyan* (derivational class; plural, *binyanim*). Examples of binyanim of the root *k-t-b* in standard Arabic appear below. The semantic range of the root involves writing, as is reflected in the glosses. (There are many other systematically related forms accounted for in McCarthy's work. Those below are chosen for expository purposes.)

(1.9)
(i) kataba 'he wrote'
(ii) kaataba 'he corresponded'
(iii) kutib 'was written'
(iv) kattaba 'he caused to write'

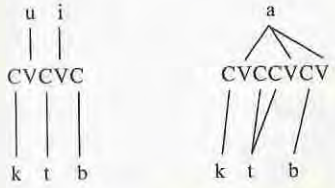
The consonantal constituents of all these related forms are *k, t, b* in that order, and the single vocalic constituent of (i), (ii), and (iv) is *a*. To account for gemination of segments, McCarthy proposed that *templates* consisting of abstract CV timing units or skeletons represent morphological class, and that the consonantal and vocalic *melodies*, respectively (i.e., in the example above, phonological feature matrices of *k, t, b, a*, etc.), be represented on separate tiers and associated autosegmentally to the CV patterns. Each tier—the consonantal melody tier, the vocalic melody tier, and the abstract CV tier—is seen as representing a separate morpheme. The framework per-

spicuously reflects the *nonconcatenative* nature of the morphological operations involved. The proposal that each morpheme be represented on a separate autosegmental tier has become known as the morphemic tier hypothesis (MTH). The MTH has the desired effect of preventing the crossing of association lines in just the desired configurations. The templates and associations for the forms listed above are shown in (1.10). To account for these associations, McCarthy (1979, 1981) proposes universal association conventions involving left-to-right mapping and spreading and a language-specific rule that applies to derive (1.10d).

(1.10) (a) kataba (b) kaataba



(c) kutib (d) kattaba



McCarthy provides strong evidence that the geminate vowel and consonant in (1.10b) and 1.10d), respectively, for example, are instantiations of the same phonological material extended over two timing slots. Indeed, without this claim it is impossible to state the generalization that these are all forms of the same root. In McCarthy's analysis, a very small number of universal association conventions and language-specific rules accounts for a large and complex set of derivational relations, of which (1.10) is a small subset. In the interest of brevity, I refer readers to McCarthy (1979, 1981) for explicit statement of the proposed conventions and rules.

Current phonological theory, then, makes the following claims, among others, about the form of phonological representations and rules: the lexical entries of a language consist of sequential timing units and associated features; some phonological elements, represented on their own tiers, may characterize more than one timing unit; phonological rules consist of associating, spreading, or delinking on defined tiers; languages may have morphological operations that are linear or nonlinear. The following sections examine American Sign Language phonology in light of these claims.

1.4 The Hand Tier Model of ASL Phonology

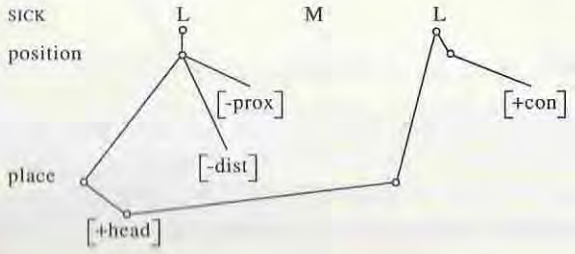
We have seen that spoken languages are now understood to be characterized by structure that has both linear and nonlinear properties. The evidence for simultaneous (nonlinear) and for sequential (linear) structure of ASL described in section 1.2 suggests that the same is true of American Sign Language. This leads us to ask the following questions: What are the phonologically significant categories and features of sublexical ASL sign units? What formal relationship do they have to each other? The hand tier (HT) model of ASL phonology is a formal framework within which these questions are addressed. What follows here is a brief overview. Unfortunately, there is not yet an International Phonetic Alphabet for sign languages, and as in spoken language, full phonological representations of each form are lengthy and complex. Therefore the representations in the following sections are partial, selectively representing elements essential for interpretation and relevant to the discussion. For complete representations, as well as detailed motivation and discussion of the model, consult Sandler (1989).

I propose that the skeletal tier of ASL phonology consists of sequences of abstract skeletal units linked to location (L) and movement (M) features.

1.4.1 Locations

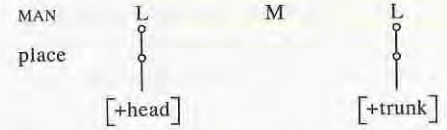
Location features are divided into classes of position, manner, and place. The position features, such as [ipsilateral] and [proximal], are interpreted with respect to the specified place feature. The manner feature characterizing locations is [tense]. Place features more or less correspond to what other researchers have called major body areas (Battison 1978; Kegl and Wilbur 1976); [head], [neck], [shoulder], [trunk], [arm], and [hand]. The place feature is uniform in a simple sign, constituting *place harmony*, represented in the same way as vowel harmony in spoken language, by double association. In (1.11) place harmony is shown in the partial representation of the sign SICK.

(1.11) SICK



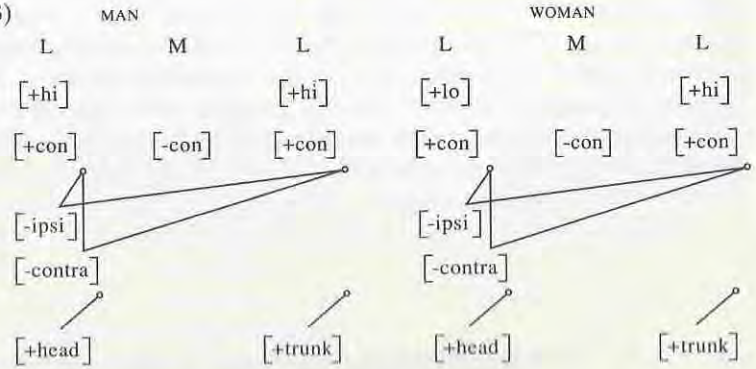
The internal structure of feature classes seen in (1.11) follows Clements (1985); (1.11) illustrates how features of position and place classes link through the class nodes to the L skeletal slot. This hierarchical structure is beyond the scope of the present investigation and will not be discussed further here, nor will all structural relationships among tiers appear in all representations (but see Sandler 1989 for motivation and elaboration). Example (1.11) is intended to illustrate the relationship of place to the skeletal tier. The feature [+head] characterizes both locations: the sign begins at a position a medial distance from the head ([-proximal], -distal])[1] and ends at a position that is in contact with the head ([+contact]). Many compound signs and signs that are diachronically descended from compounds are revealed by the HT representation to be structurally distinct from simple signs, since they often do not exhibit place harmony, as we see in the partial representation of MAN in (1.12).

(1.12)



The characterization of location as a major category and specification of the features proposed in the HT model reflect structural relationships among signs in the lexicon. For example, the minimal pair MAN and WOMAN differ only in one location feature in the first location of each sign. The first location of the sign MAN is at a high position on the [head] place of articulation, while the first location of the sign WOMAN is at a low position on the [head] place.

(1.13)

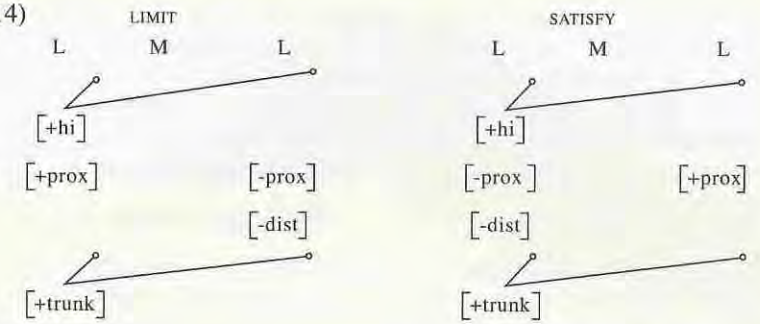


In the partial representation in (1.13), the features [-ipsi, -contra], interpreted as mid with respect to the [head] place, are doubly associated to the two Ls of each sign, eliminating redundancy in the representation.

1. The terms *proximal* and *distal* are from Liddell and Johnson (1985).

Other structural similarities among signs are also apparent given this model. In the pairs ALL-RIGHT/SOME, WHAT/ONCE, LIMIT/SATISFY, the beginning and ending position features are the reverse of each other while all other features are identical, as shown in the partial representation in (1.14).

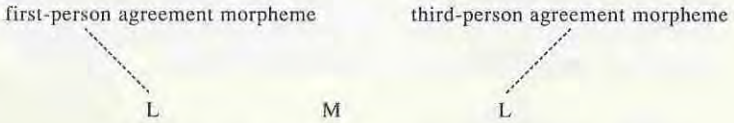
(1.14)



There is a class of sign pairs that have the same structural relationship as LIMIT/SATISFY and that are derivationally related as well: ALIKE/DIFFERENT, NARROW/WIDE, BORROW/LEND, IMPROVE/DETERIORATE, and so forth. In all these pairs of opposites, beginning and ending location features are switched and everything else is the same. The semantic and structural relationship between members of these pairs suggests that the derivational rule involved must have access to elements that are inherently location features. These structural lexical relationships support the claim that location has phonological significance.

Other morphological rules require access to location features as well. Subject and object agreement morphemes are described as floating features of location that associate to designated L slots by rule, as shown schematically in (1.15).

(1.15) Verb agreement



In the lexicon, the agreement morphemes are specified with location features, such as [+con, -hi, -lo, -ipsi, -contra, +trunk] for first person. (See Liddell and Johnson 1985 and Sandler 1990 for more examples of the phonological form of agreement loci.)

A phonological operation that crucially refers to location features is metathesis (Wilbur 1979; Liddell and Johnson 1989; Johnson 1987). In HT termi-

nology, metathesis of position features occurs in signs in which both Ls are specified for [+contact] and exhibit place harmony. The context of the rule must also refer to location features, since a location that is closer to the underlying second location of the target sign conditions the reversal.[2]

A rule that intensifies verbs and forms resultative (become X) of predicate adjectives also operates only on locations. The forms may be derived by inserting a parafix of L skeletal slots, as shown schematically in (1.16). The feature specifications of the lexical locations, symbolized by F below, spread to the affixed L skeletal slots, forming geminates. When affixed to the verb ZOOM-OFF, the intensive is formed; and when affixed to the predicate adjective SICK, the resultative is formed. The dotted line indicates linking of features of locations.

(1.16) L slot parafixation

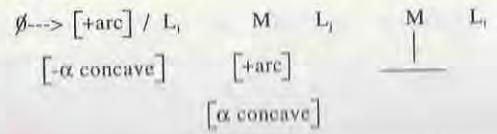
We have seen that features that are crucial to representation of distinctions in the lexicon, and to formulation of phonological and morphological rules, are inherently features of location. This is seen as evidence that location is a major segment category in ASL.

1.4.2 Movement

The movement features linked to the M slot on the skeletal tier are those characterizing path movement, defined as movement from one location to another. Internal movement is represented as features of hand configuration, as described below.

Movement feature classes are those of shape, manner, and position. The default shape of movement is straight, so that only the shape [+arc] need be specified underlyingly. Signs with circular movement, such as SORRY, are represented as a sequence of two arcs with complementary values for concavity. The value for concavity of the first arc is lexically specified for such signs, and that of the second is filled in by a redundancy rule:

(1.17) Alpha concave rule



2. Precise, formal statement of the metathesis rule awaits formalization of relative height and laterality relationships *among* place specifications.

In this representation, circular movement signs are seen as forming a class with bidirectional signs, which are formally identical, except that the movements of the latter are straight rather than arc.

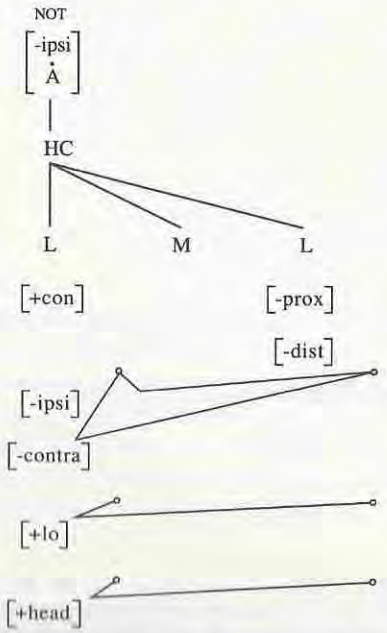
(1.18) Bidirectional sign form $L_i\ M\ L_j\ M\ L_i$

The issue of the representation of circular movement is discussed further in the proposed treatment of durational aspect in section 1.5. The manner feature [tense] may characterize movements, as may the position feature [contact]. Morphological evidence for movement as a major category of ASL phonology and morphology is offered in section 1.5.

1.4.3 Hand Configuration

The hand tier model is so named because in this framework hand configuration is represented on an independent tier. The proposal that hand configuration is autonomous with respect to the LM tier is motivated by two of its properties: (1) a single hand configuration generally characterizes all sequential elements of a sign, and (2) in compounds, hand configurations exhibit stability. A partial representation of the simple sign NOT in the HT framework illustrates the first property:[3]

(1.19)

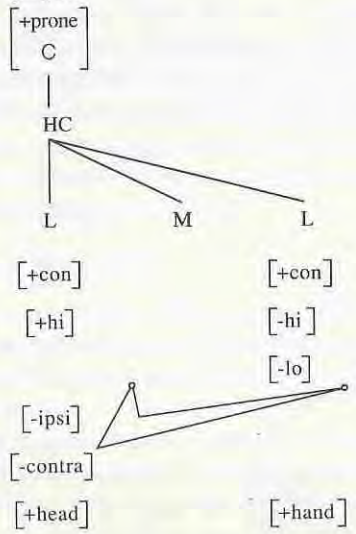


3. In Sandler (1987, 1989) a hierarchical model of hand configuration is proposed, specifying handshape and orientation as the major feature classes. Handshape is further subdivided into

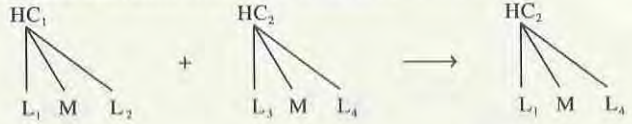
The hand configuration characterized by the A-dot handshape with contralateral palm orientation [-ipsi] is maintained throughout the sign. This property of one hand configuration per sign is typical of the majority of simple signs in the lexicon.

Hand configuration in the compound HUSBAND is partially represented in (1.20). We also see in (1.20) that HUSBAND is a compound in that it does not exhibit place harmony as simple signs do. The schematic derivation in (1.20b) illustrates the property of stability in the following way: in forming the compound, the location to which the hand configuration of the first sign is associated is deleted, while the hand configuration does not delete but rather remains in the signal and spreads leftward to associate to a new L. In this compound, the first hand configuration deletes. The feature [+prone] specifies palm orientation, and the C symbolizes the handshape.

(1.20) (a) HUSBAND



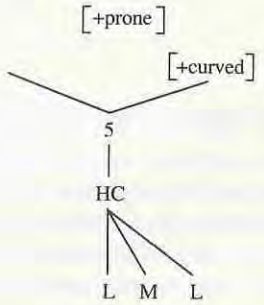
(b) Schematic derivation of HUSBAND from MALE + MARRY



selected finger features and position features. The issue of the internal hierarchical structure of hand configuration is peripheral to the analysis of temporal aspects dealt with here and is therefore not addressed in this chapter.

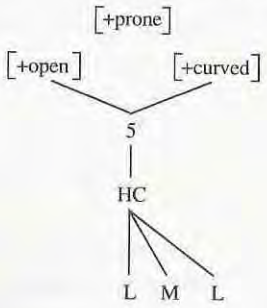
The HT model represents internal movement as contour features of a single HC element, as shown for the sign FREEZE in (1.21a).[4]

(1.21) (a) FREEZE



A redundancy rule fills in the value for the leftmost branch as [+open], resulting in the following surface form:

(b) Surface hand configuration for FREEZE

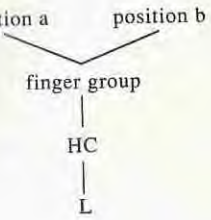


In the partial representations above, we see that the internal movement is indicated by two feature specifications associated to a single handshape node. This representation is interpreted as a *temporal sequence*, an interpretation that follows analyses of contour tones (e.g., Goldsmith 1976) and contour segments such as affricates (e.g., Steriade 1982). Signs characterized by internal movement but no path movement are represented with a contour hand configuration associated to a single location, as shown schematically in (1.22).[5]

4. Orientation-internal movement (Sandler 1987, 1989) is not dealt with here.

5. When signs such as BORED, represented here as location-only with internal movement, are inflected for intensive, the orientation change occurs after *gemination* of the location—that is, after the hand is suspended momentarily without movement in its initial orientation (Scott

(1.22)



Corina (1986) independently proposes that such forms are single-segment signs.

The HT model seeks to capture the generalization that a single basic hand configuration characterizes any given simple sign. This interpretation is based on the observation that whether or not there is internal movement in a sign, the finger group involved remains constant (see Mandel 1981). In FREEZE, the finger group that executes the sign—all four fingers plus the thumb—remains constant. Only the position of the fingers changes, from open to curved. This generalization appears to hold for the vast majority of ASL signs, excluding fingerspelled loans, discussed below. Another generalization captured by the representation and proposed redundancy rules is that in signs with changing handshape, the position of one of the two shapes is redundant. Together these generalizations constitute the handshape sequence constraint, or HSC (Sandler 1989).

(1.23) Handshape sequence constraint (HSC)
In monomorphemic signs with handshape internal movement,
(i) the initial and final shapes are specified for the same selected fingers, and
(ii) the first shape may be [+closed] if the second shape is [+open]. Otherwise the first shape is [+open].

That the same basic handshape generally characterizes all sequential elements of simple signs suggests that hand configuration is a distinct and temporally autonomous phonological element in ASL.

Morphological evidence for the independent status of HC comes from the classifier system (Supalla 1982), in which hand configuration alone represents a classifier morpheme. Gee and Kegl (1982) and Shepard-Kegl (1985) claim much more pervasive morphological status for hand configuration in the ASL

Liddell, pers. comm.). Sandler (n.d.) proposes a solution to this problem that involves linearization and level ordering.

lexicon. According to the morphemic tier hypothesis, hand configuration must be represented on a separate tier wherever it functions as a morpheme. Thus it appears that there is morphological evidence in addition to phonological motivation for representing hand configuration on its own tier.

Now that I have outlined the HT framework, I present further support for it by analyzing two aspectual inflections in ASL.

1.5 The Temporal Aspects Habitual and Durational

The ASL literature has provided descriptions of a number of modulations of verbal signs for temporal aspect (see especially Fischer 1973; Klima and Bellugi 1979). I will examine two here: aspects described as habitual and as durational. It at first appears as if the rules for deriving these two forms are trivial: reduplicate, and reduplicate in a circle. But as Newkirk (1981) notes and Liddell and Johnson (1985) demonstrate, simple commands like these will yield the wrong results. Detailed formalization of the rules will give the correct surface forms and reveal significant elements of sign structure.

1.5.1 Habitual

A simple reduplication rule would suffice to produce the habitual forms, with the important addition of an M-epenthesis rule, inserting a transitional movement between the two reduplications. Without M-epenthesis, reduplication would result in two adjacent locations that are in two different points in space or on the body, with no intervening movement—a physical impossibility.

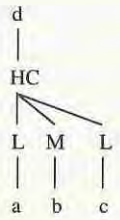
Newkirk (1981) points out that a linking movement is added in some reduplicated forms. This is evident from the distinction between bidirectional signs, with $L_1ML_2ML_1$ structure, and monodirectional signs with L_1ML_2 structure. In the first case no linking movement is inserted, since the hand winds up in its original position before reduplication. In the second, an epenthetic straight movement is inserted. An M-epenthesis rule is proposed in (1.24).

(1.24) M-epenthesis

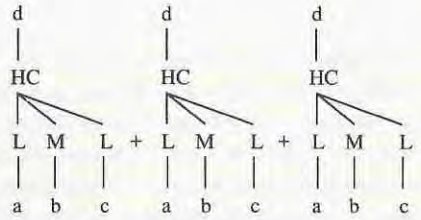
$$[\varnothing] \rightarrow M \;/\; L_i\_\_L_j \quad \text{where } L_i \neq L_j$$

Hand configuration spreads bidirectionally onto the epenthetic M. Assuming a model of reduplication that follows Marantz (1982), reduplicating the skeletal structure and the melodic elements and associating from left to right, habitual aspect is formed in the following way. The lower-case letters symbolize the features associated to each slot.

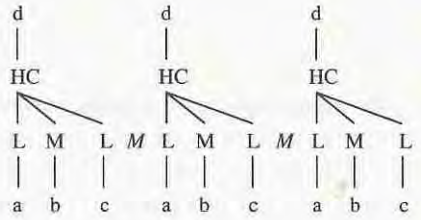
(1.25) Input



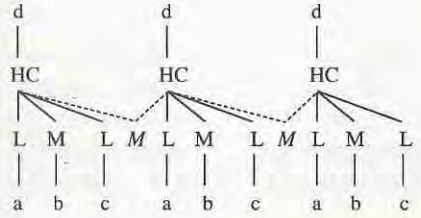
Reduplication



M-epenthesis

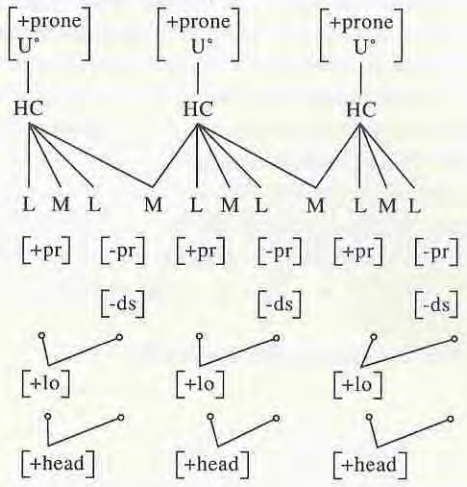


HC spread



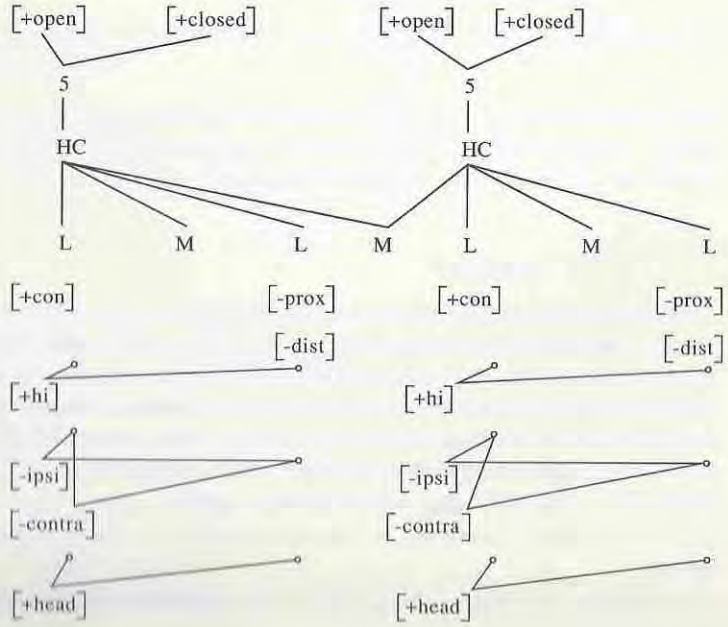
The default value [-arc], interpreted as straight, is inserted for the epenthetic M by a late rule. Let us take the verb LOOK-AT as an example. Assuming a first-person subject locus and a neutral second-person object locus, the verb LOOK-AT, derived for habitual aspect, has the form in (1.26). The abbreviations pr and ds stand for proximal and distal. The symbol U· represents a handshape with index and middle fingers extended and spread, corresponding to a V shape in other representation systems.

(1.26) LOOK-AT habitual



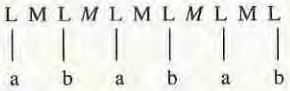
In signs with internal movement, such as MEMORIZE, the hand returns to the left-branching position during the epenthetic M. This results from phonetic implementation of the form partially represented in (1.27).

(1.27) MEMORIZE, habitual

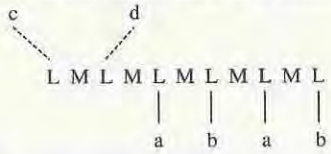


In signs that take agreement, such as LOOK-AT, rule order is required in order to arrive at the correct surface form: verb agreement must take place before reduplication. The verb agreement rule (1.15) must be stated in terms of specified locations. Specifically, the subject agreement locus is generally associated to the first L and the object agreement locus to the second. If reduplication were to apply to the citation form before verb agreement, the non-occurring form shown in (1.28b) could be derived:

(1.28) a. Reduplication

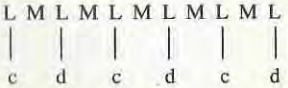


b. Third person to third person subject-object agreement



If agreement applies before reduplication, however, the agreement loci are reduplicated, yielding the correct surface form:

c.



An analysis involving *sequentially* associated agreement morphemes accounts for the correct direction of movement in the derived form. This is seen as supporting the proposed LML sequential structure.

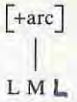
1.5.2 Durational

The impressionistic description "circular reduplication" does not suffice to produce durational forms. Specifically, without a more detailed formal treatment, there are three logical problems with such a description: it does not specify the direction of the circle; it does not predict that on the last iteration only half a circle is executed (Newkirk 1981); and it does not specify the concavity or convexity of the first half-circle (arc). For the sign LOOK-AT durational, then, the following ungrammatical outputs must be ruled out: (a) Sideways circles; (b) convex + concave pattern; (c) full circle on the last iteration.

Problem (a) is solved by assuming the durational is the same basic process as the habitual: reduplication with M epenthesis and HC spread. Specifically, direction of movement is determined by the location specifications as shown for LOOK-AT and MEMORIZE in the previous section. Problem (b) is solved by rules of arc association and shape assignment, to be discussed directly. Problem (c) is solved by this analysis as well, as I will show after discussing arc association and shape assignment.

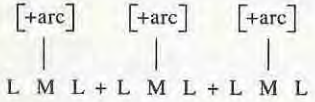
There is a durational morpheme consisting of [arc] that, when combined with a word by morphological rule, associates to the only segment that can be specified for that feature, the M segment. Since a conflicting value of [-arc] would be assigned only by a late default rule, there is no feature clash when [+arc] is associated to M.

(1.29) Arc linking (durational)



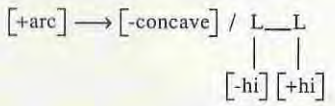
In the most parsimonious treatment, the durational morpheme rule precedes reduplication. The arc then characterizes every iteration of the underlying M.

(1.30)



Problem (b) is solved by positing an arc shape rule, in which [−concave] is interpreted as convex:

(1.31) Arc shape rule

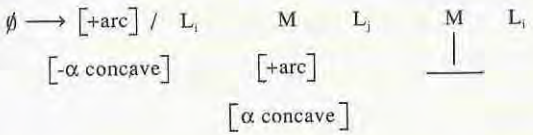


That is, if the first location is lower than the second, then the arc is convex. An example is ENCOURAGE, which is underlyingly specified for [-hi, -lo] for the first location, and [+hi] for the second location. ENCOURAGE, durational, is specified by the arc shape rule for [+convex] on the first M. In a sign in which the first location is higher than or the same height as the second location, the default value of [+concave] is filled in by redundancy rule shown in (1.32).

(1.32) [+concave] default rule
[+arc] → [+concave]

Another rule applying at this level of the morphology and ordered after all other rules already discussed is the independently required alpha concave rule shown in (1.17) and repeated here.

(1.33) Alpha concave rule

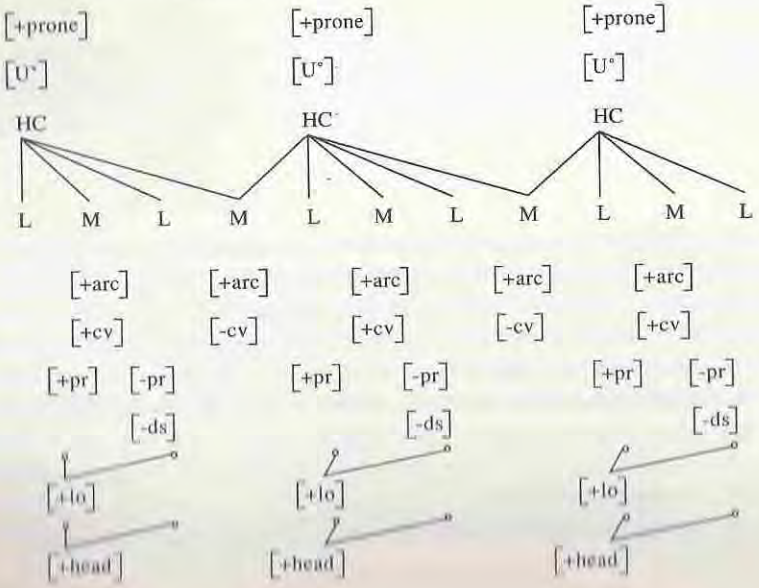


To derive the durational aspect, then, the following rules apply.

Morphology	Phonology
1. [arc]durational	1. arc linking
	2. arc shape
	3. reduplication
	4. M-epenthesis
	5. alpha concave
	6. bidirectional HC spread

Derived for durational aspect, LOOK-AT has the form in (1.34). The abbreviation *cv* stands for [concave].

(1.34) LOOK-AT durational



No epenthetic M is inserted at the end, since the conditions for M-epenthesis are not met. We see, then, that problem (c), the problem of representing only an arc and not a full circle at the end, is solved as well.

Certain hypotheses about ASL phonological structure are supported by the preceding analysis. For example, that the underlying (or earlier derived) location specifications determine the direction of movement in both habitual and durational argues for the existence of distinct, sequentially ordered location elements in signs. The discussion of verb agreement in inflected signs further supports this claim, since the direction of circles changes as a result of different agreement loci. In addition, crucial reference to the movement segment in deriving the durational form for Ms is seen as evidence for a movement category. The existence of a large number of other aspectual modulations involving circular reduplications (Klima and Bellugi 1979) provides additional support for phonological movements.

A number of important similarities to spoken language phonology are also revealed by the model and analysis presented here. Sequentially ordered skeletal units and autosegmental associations are shown to characterize American Sign Language, as they do spoken languages. In addition, this analysis proposes that there are partially specified morphemes in the lexicon that are associated to Ls or Ms nonlinearly by morphological rule. Specifically, verb agreement loci link to Ls, and the durational morpheme [+arc] links to Ms. This is similar to morphological forms and processes in Semitic languages, in which certain vowel combinations correspond to particular forms of verbs when associated to the appropriate template (McCarthy 1979, 1981). Finally, as in spoken language phonology, the formal relationship between underlying forms and derived forms is revealed by the particular representations postulated and the application of ordered rules. The relationship between the two aspects, habitual and durational, is also made clear in the present analysis: they differ only in the absence or presence of arc feature specification.

Liddell and Johnson (e.g., 1989, this volume) make certain proposals similar to some of those made here. In particular, they propose sequential segments and autosegmental relationships. Liddell and Johnson also suggest that verb-agreement features are inserted in segmental feature bundles and offer a sequential analysis of habitual aspect formation.[6] These proposals and the

6. Liddell and Johnson (1985) propose the following transformational rule for deriving habitual aspect:

(a) Habitual aspect rule: 1 2 3 → 1 2 3 → 1 2 3 → 1 2 3 . . .
(for HMH signs) str str str

Under a transformation analysis of this sort, a different rule is required for each input form, a problem that does not exist under the model of reduplication adopted here (Marantz 1982). Liddell and Johnson apply hold deletion to the derived form, yielding the following string:

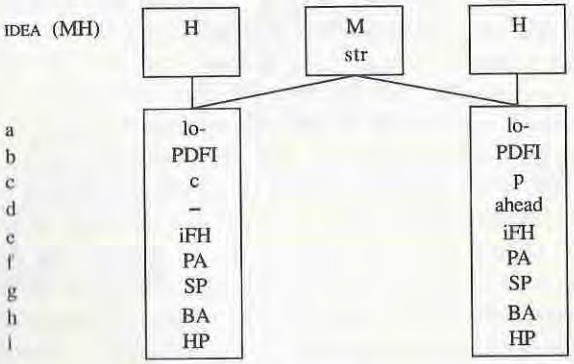
(b) H M M M M M M M H

model that reflects them represent an important advance in sign phonology research and inspired many facets of the hand tier model. As I noted earlier, there are substantial differences as well. In the next section I examine some of the differences.

1.6 HT versus MH

In the movement hold model of Liddell and Johnson, the major class segments are proposed to be hold (H) and movement (M), which the authors consider analogous to consonants and to vowels. Ms and Hs are represented on a separate autosegmental tier from bundles of articulatory features. The feature bundles contain specifications for hand configuration, location, facing, orientation, and plane. The representation of the sign IDEA in the movement hold (MH) model is shown as follows in Liddell and Johnson (1985).

(1.35) IDEA (MH)



Line (a) represents the handshape: 1o- means all but pinky closed, thumb opposed and closed, (b) = fingerpad contact, (c) = proximity, where c means contact and p means proximal, (d) = spatial relation, from contact to ahead of location, (e) = major body area location, ipsilateral side of forehead, (f) place of articulation = palm facing location, on (g) SP = surface plane, (h) BA = base of hand, on (i) HP = horizontal plane.

As with any representation system, the system illustrated in (1.35) reflects a number of central assumptions about the structure of the entity it represents. First, it is noteworthy that the features that characterize holds and movements

If most of the proposed holds turn out, upon empirical investigation, to be derived and not underlying, as I assume in my analysis, then no rule deleting holds is necessary, and such strings as (b) are not derived.

are nearly identical. Movements may have specifications represented outside the feature bundles, such as *str* (= straight), while there are no features that characterize only holds, defined only as the absence of movement. The implication is that there is a single segment type, [+segment], which must have a value for the binary feature [+/−move]. Since holds often delete (Liddell and Johnson 1989), the surface signal often consists of a series of segments that are of the same major category: movement. The analogy in spoken language would be a model in which the two major segment types are distinguished only by the feature [+/−sonorant]. Adjacent segments would have identical feature matrices but would contrast only in terms of a plus or minus value for sonority. Such a model can of course be rejected on empirical grounds. I suggest that there is a functional explanation why such a model could not reflect spoken language phonology: a language in which adjacent segments have identical classes of articulations and sounds would not be intelligible, since there would not be enough variation in the signal to make the distinctions perceivable. It seems reasonable to expect major segment categories in a signed language to be similarly distinct.

Some phonological questions arise as well. No phonological test has been proposed to determine that GOOD has the structure HMH, while SIT has the structure MH (Liddell and Johnson 1985). Apparently, phonetic measurement using slow-motion videotape was used (Liddell 1984a) to make this determination. In addition, the rule of H deletion proposed by Liddell and Johnson (1985, 1986) seems to have all the earmarks of a low-level phonetic process, since it apparently applies at word boundaries where there is neither body contact nor a phrase boundary. In spoken language, consonants and vowels present the two broadest natural classes of phonological elements and are referred to as classes in phonological rules. No phonological evidence, such as the necessity of positing a hold segment to state morpheme structure constraints or to account for classes of phonological alternations, has as yet been provided to support the proposal that holds have major phonological significance. A question involving learnability spans both the phonetic and the phonological domains: If holds are generally deleted, how does the language learner discover them? It appears that the near identity of holds and movements, the frequent deletion of holds, and the dearth of phonological evidence for holds present significant problems for the proposal that holds constitute a major phonological category of ASL.

In contrast with the MH model, the hand tier model examined here proposes that the major categories in question are movement and location and that with the exception of [tense] and [contact] the two have distinct feature specifications. Note that only two features vary from H_1 to H_2 in the MH representation of IDEA; the rest are identical in all segments of the sign. Those features are of proximity and spatial relation to the place of articulation and are defined

as *location* position features in the hand tier model. Evidence from minimal pairs in the lexicon, from derivationally related pairs differing in location features only, and from the central phonological process of location agreement has been offered to support the claim that locations are a major phonological category. The question of lexical holds and their interaction with phrasal and sentence-level prosody is worthy of extensive examination. Where lexical holds can be shown to exist, they are represented in the HT model as geminate Ls, as was shown earlier for morphologically introduced holds and is repeated here (F = features).

(1.36) A hold

Slow movements, such as the movement observed in continuative aspect,[7] are also represented as geminates in the HT representation, lending unity to the representation system and predicting that ASL prosody can refer to long segments of either major category.

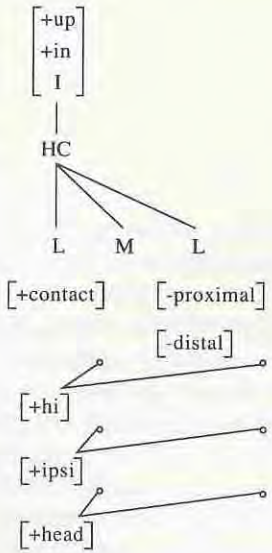
(1.37) A slow movement

Also in contrast with the MH model, which redundantly represents the major body area in each matrix, the representation of place harmony in the hand tier model seeks to capture the generalization that only one major body area is permitted in simple signs (Battison 1978; Kegl and Wilbur 1976).

Another major difference between the two models is the representation of hand configuration and hand-internal movement. In the movement hold model, hand configuration is listed with features of location and the other features in the matrices associated to the Hs and Ms. In most signs, in which hand configuration is constant, the same handshape specification is listed in each matrix, as we saw in the representation of IDEA in (1.35). Again ignoring features and associations of hand configuration not relevant to the present discussion, IDEA is partially represented in the HT framework in (1.38), in which the features [+up, +in] specify palm orientation.

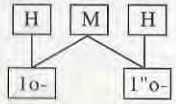
7. Sandler (1989) proposes an analysis of continuative aspect by association to a morphological template.

(1.38) IDEA (HT)



In signs with changing handshape, the movement hold model lists each shape independently under the first and last segment of the sign. For example, (1.39) extracts the handshape features from the representation of the sign ASK in Liddell and Johnson (1985). The handshape is index extended (other fingers closed) at the beginning of the sign and index hooked (other fingers closed) at the end of the sign.

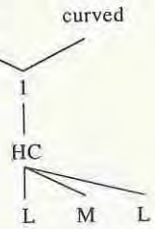
(1.39) ASK (MH)



Liddell and Johnson claim that the relationship between the initial and final handshapes is not predictable because of the existence of sequences such as S-O, 'so what,' and S-H, 'throw.' They claim there is no way to predict that S will be followed by O in one case and by H in the other, a point I will return to directly.

As we have seen, the HT model represents hand configuration as a single autosegment in simple signs, multiply associated to the Ls and Ms. In signs with changing handshape, referred to as handshape-internal movement, the different finger positions are represented as branching or contour features associated to a single hand configuration autosegment, as in (1.40).

(1.40) ASK (HT)



The sequence S-H that Liddell and Johnson claim characterizes the sign THROW would not be predicted by the HSC, since S involves all four fingers plus the thumb, while H involves only the index and middle fingers. However, this apparent counterexample is only apparent. In the HT model, the sign THROW is represented with a single finger group and branching position features, just as is the case with ASK. This is because the model encodes the observation that the index and middle fingers of the final H handshape are already slightly uncurled and restrained by the thumb at the *beginning* of the sign. This involvement of selected fingers at the beginning and end of signs with handshape-internal movement is a general property of such signs. Thus, THROW is represented as consisting of the sequence "closed H–open H."

The HT model eliminates redundancy in the representation and in so doing seeks to capture significant generalizations about the function of hand configuration that characterizes the whole sign. Also, representation of handshape-internal movement as a contour associated to a basic finger group reflects the HSC, stated in (1.23).

Numbers are excluded from this generalization. As with many spoken languages, the number system of ASL is characterized by exceptional phonological properties. Similarly, the class of signs that are borrowings from fingerspelling—such as the S-O example of Liddell and Johnson—is excluded from the generalization stated in the HSC. Such exclusion is seen in other languages, in which borrowings are not subject to the same constraints as are native lexical items (e.g., *kn*ish, *shl*emiel in English from Yiddish). Fingerspelled borrowings, I claim, are similarly exempt from the morpheme structure constraint on hand configuration in ASL. They are also exempt from certain morphological operations such as verb agreement. It is significant that a number of fingerspelled loans have regularized by analogy with native signs (Battison 1978). A well-known example is #NO, which has changed from the fingerspelled version in which N and O are executed by different finger groups and in which the finger position for N is not encountered in native signs. The synchronic borrowed form involves a single finger group (thumb, index, and middle fingers), and typical open-closed internal movement. That is, #NO now conforms to the HSC. Interestingly, the sign has a verbal variant, SAY-NO-TO, which is subject to regular verb-agreement morphology. Other examples of regularized borrowed forms are discussed in Battison (1978), Mandel (1981), and Sandler (1989).

Exceptional forms are represented in the HT model as characterized by two hand configurations. By distinguishing between single hand configuration signs and double hand configuration signs, the representation reveals a class of exceptions. This is seen as providing further support for the generalization embodied in the HSC.

In contrast, according to the movement hold representation the generalizations regarding handshape sequences appear to be coincidental, and any sequence of shapes, including the ill-formed *5-3, for example, is wrongly predicted to occur in a regular sign of the language.

We have seen that the major differences between the hand tier model and the movement hold model lie in the phonological significance of locations versus holds and the behavior of hand configuration. The two models make different claims and concomitant predictions about these categories, which future research will test.

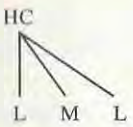
Let us now return to the question of language universals raised in the introduction to this chapter.

1.7 Conclusion

I suggested in the introduction that any property or process that could be shown to be unique to sign languages may be attributable to modality effects, and the rest to more general principles of linguistic organization. Given current phonological theory, none of what has been dealt with here is outside the domain of general principles. Specifically, it is proposed that ASL phonology is characterized by sequential units, autosegmental relationships, hierarchical feature structure, morpheme structure constraints, and distinct morphological and phonological alternations accounted for by formal, ordered rules. All these properties are predicted by phonological theory to exist in any natural language. The existence of morphemes that associate autosegmentally to the skeleton, such as the [arc] durational morpheme, is attested in many diverse spoken languages, as exemplified by Semitic, discussed in section 1.3. In fact, as Padden and Perlmutter (1984, 1987) claim, there does not appear to be any significant formal distinction between the phonology of signed and spoken languages, apart from the specific lists of features that characterize each.

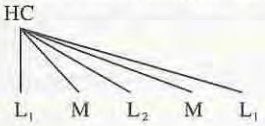
There are, however, certain properties of ASL that, though compatible with current theory, seem unfamiliar in comparison with spoken languages. An example that is apparent from the material covered in this chapter is the canonical word structure:

(1.41)



Under the present analysis, there cannot be any L clusters, since it is not physically possible to articulate a sequence of distinct locations without movement in between. Future research will determine whether M clusters occur in morphologically complex forms (such as in the classifier plus verb of motion system analyzed by Supalla 1982 and Newport 1981). But in simple forms, any sequence LL or MM is analyzed as a geminate. In uninflected forms longer than LML, such as bidirectional or circular signs, we find partial reduplication, in that the last L has the same feature content as the first L.

(1.42) Schematic form of bidirectional and circular signs



With the exception of compounds, even morphologically complex signs are generally no longer than (1.41) or (1.42). What seems at first glance to be particularly incongruous about this limit on sign length is that ASL is morphologically complex. This apparent incongruity is less surprising when compared with the morphology of other languages with nonconcatenative morphology, such as Semitic languages. As in nonconcatenative spoken language, ASL morphological operations are nonlinear and do not result in a greater number of sequential segments. However, ASL is still somewhat simpler in its linear structure than Arabic verbs, for example, which contain surface sequences such as CVCVVCVC (McCarthy 1981) and which may also involve linear affixation of nonroot elements.

A possible explanation is offered in Bellugi and Fischer (1972) and Klima and Bellugi (1979). The researchers found that ASL signs take about 50 percent longer to produce than English words, but that similar *propositions* in the two languages are about the same length. Klima and Bellugi suggest that "cognitive pressures underlying language might well create an optimal production rate for propositions, regardless of language mode. Under such cognitive pressure, a relatively slowly articulated language of signs might well exploit the possibilities of simultaneous elaboration of meaning which exist in the visual-spatial mode" (1979, 194).

In this chapter, one process of "simultaneous elaboration" is represented formally in the form of arc linking to form durational aspect and is shown

to be formally identical to processes in spoken languages such as Semitic languages.

This investigation of sequential and simultaneous properties of ASL has sought to examine those properties within a rigorous framework and to begin to make meaningful comparisons between the phonological structure of signed and spoken languages. That autosegmental phonology makes the right predictions about the structure of American Sign Language provides additional support for the theory.