

A Sonority Cycle in American Sign Language

Author(s): Wendy Sandler

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# *A sonority cycle in American Sign Language\**

Wendy Sandler  
University of Haifa

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## 1 Introduction

It is generally accepted that there are three major categories of phonological elements in the signs of sign language: (i) the shape of the hand, (ii) the location of the hand on or near the body and (iii) the movement of the hand – either (a) movement of the fingers or palm at a single location or (b) movement of the whole hand along a path from one location to another. It has further been argued that each of these categories consists of hierarchically organised classes of features (Sandler 1987b, 1989a).

A controversial issue in sign language phonology concerns the organisation of these categories and classes in relation to one another. The pioneering work of Stokoe (1960 [1978]) proposes that the phonological categories of American Sign Language (ASL) signs are executed simultaneously, rather than linearly as is the case in spoken language. That paradigm dominated sign language research until Liddell (1984a), which argues for the existence of sequential segments in ASL. The current literature generally acknowledges the significance of both simultaneous and linear properties in ASL, but there is much spirited disagreement about the phonological significance of each of these properties, their representation and their realisation (e.g. Sandler 1986, 1987b, 1989a; Edmondson 1985; Liddell 1990; Brentari 1990; Wilbur 1993; van der Hulst this volume).

A number of investigators have claimed that there are two different major category types that are sequentially organised in sign language (e.g. Liddell 1984a; Sandler 1987b, 1989a; Liddell & Johnson 1989; Perlmutter 1992). If this is the case, then it is reasonable to expect to find a fundamental kind of contrast between the two category types for articulatory and perceptual reasons (Sandler 1986, 1989a). That is, one would expect there to be meaningful parallels between the consonants and vowels of spoken language and the two segment types in sign language. It would further be expected that the existence of two distinct, sequentially organised categories would exhibit patterns that emphasise the optimal sequential relationship between them. In other words, one would expect to find an analogue to the sonority contrasts found in spoken language syllables.

In this paper, I develop a line of research supporting the view that there is significant linear structure to signs. I will argue that the locations and movements of sign language form a sonority cycle (in the sense of Clements 1990) in the typical sign, and that this cycle tends to be preserved and even created where one does not exist underlyingly, throughout the morphology and phonology of the language. A Sonority Distance Maximisation Principle is proposed, which is argued to be active throughout the phonology of the language: in organising morphological templates and nucleus projection, and in determining how features align and spread under lengthening processes.

I adopt the position expressed by other researchers that movement is the most sonorous part of the ASL syllable (e.g. Coulter 1982; Wilbur 1993; Brentari 1990; Perlmutter 1989, 1992, 1993), and that it constitutes the nucleus. The proposed representation and analysis account for the similarities among path movement, internal movement and secondary or trilled movement, and between oscillating secondary movement and non-oscillating secondary movement. A formal expression of movement that generalises over path movement and hand-internal or local movement is proposed. This representation facilitates formulation of a simple algorithm for nucleus projection.

I begin the exposition in §2 with an overview of some necessary background assumptions. It is hoped that this section will help make the main discussion accessible, especially for those who are not familiar with sign language research. Some arguments for linear organisation are presented there, and the organisation of the location and movement categories is described. §3 demonstrates that the typical sign language morpheme is of the form LML, comparable to CVC, and inherently manifesting an optimal sonority cycle. The structure of the sign syllable is discussed in §4, where a sonority hierarchy and nucleus projection rule are proposed.

§5 presents empirical data which support the sonority cycle theory. A morphological process, Intensive aspect, which lengthens signs at the edges, is described. It is shown that this lengthening affects static elements only. The set of movement elements in signs, previously represented and treated as a disjoint set, is shown to behave as a class under Intensive lengthening: movement of any sort always occurs at the centre of the sign, and never lengthens under this morphological edge-lengthening process.

An analysis of this process, within the broader context of the syllable and sonority in ASL, is offered in §6. The notion of a sonority cycle is extended to American Sign Language, and a Sonority Distance Maximisation Principle (SDMP) is argued to account for the fact that the sonority cycle is preserved derivationally.

A consequence of the sonority cycle proposal is discussed in §7. It is suggested that the SDMP can account for the survival of [contact] locations in compounds under reduction.

The treatment of trilled internal movement under lengthening is

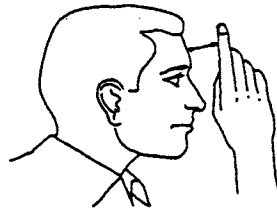
contrasted with analyses of similar phenomena in Liddell (1990) and in Perlmutter (1992, 1993) in §8.

## **2 Background: the sequencing and content of locations and movements**

The theory of sign language structure adopted here is sometimes referred to as the Hand Tier theory (Sandler 1987b, 1989a). The model follows Stokoe (1960) in positing three major phonological categories: Hand Configuration (HC), Location (L) and Movement (M).<sup>1</sup> Sandler (1987a, b, 1989a) argues for particular feature content for each category, and for a hierarchical organisation of those features. For our purposes here, the content of the categories will be presented, and their organisation discussed, only where relevant to the topic at hand. The complex category of hand configuration, discussed at length elsewhere within the same theoretical framework in Sandler (1987a, b, 1989a, 1993a, b, to appear a, b) will be given little attention here.

There are two points to focus on in this section. One is the fact that two major categories are sequentially ordered. The other is that these two major categories are of fundamentally different types. This discussion will lead to an analogy with consonants and vowels of spoken language, and from there to the sonority cycle.

Consider the sign INTELLIGENT, illustrated in Fig. 1. This sign is characterised by the canonical LML form. The first location is in contact with the side of the forehead, ipsilateral to the signing hand. This is followed by a straight movement, and a second location, a short distance in front of the first. As is typical of the vast majority of monomorphemic signs, there is a single hand configuration throughout. In addition to the observation that HC tends to remain constant, there is evidence from spreading that all HC features stand in an autosegmental relation to the Ls and Ms (Sandler 1986, 1987a, b, 1989a, 1993a). Schematically, then, the

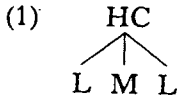


*Figure 1*

### **ASL INTELLIGENT**

Illustrations of the signs in Figs. 1 and 3–5 are from *A basic course in manual communication*, National Association of the Deaf, Communication Skills Program (1973), Silver Spring, MD.

major feature categories are related to each other in the manner shown in (1):



## 2.1 Arguments for linearity

Locations and movements, then, follow one another in a sequence. It should be pointed out that there is no argument against the observation that signs have beginnings and ends. Rather, the relevant question involves the phonological status of those beginnings and ends. The alternative to a sequential segment analysis is to propose that each sign consists of a single location, movement and hand configuration, with some sort of direction feature determining the relation between the beginning and end of the sign (e.g. Stokoe 1960; Brentari 1990).<sup>2</sup>

The case for sequential segments is that all of the features that are temporally aligned with a posited linear segment behave as a unit in the phonology. Some of the evidence for phonologically significant linear sequencing is listed below. Not all authors who propose sequential units agree on their identity. For coherence, I adopt the terminology of the model assumed here.

(i) Verb agreement is marked on the beginning and/or ending location of a sign (Padden 1981, 1988; Meier 1982). Statement of verb agreement rules must therefore refer to initial or final locational segments.

(ii) Beginning and ending locations in a certain class of signs may undergo environmentally conditioned metathesis (Johnson 1986; Liddell & Johnson 1989). Linear adjacency of a metathesising segment to a segment in the preceding sign is required for the rule to apply. Schematically:  $Lx M Ly \rightarrow Ly M Lx / Ly' \#\# \text{---}$ .

(iii) Morphological processes involve affixation of features to an individual movement segment (Sandler 1989a, 1990). This process does not affect the surrounding locations, and therefore must be able to single out the movement segments.

(iv) Some morphological templates are comprised of linear segment positions. Even more importantly, discrete initial or final segments of base signs systematically align themselves with these partially specified linear templates (Liddell 1984b; Sandler 1987b, 1989a, b, 1993a; Corina & Sandler this volume).

(v) In compounds, identifiable segments of the base signs are deleted (Liddell 1984a; Liddell & Johnson 1986; Sandler 1987b, 1989a). This is illustrated in §7.

(vi) Some (though few) minimal and near-minimal pairs are distinguished by individual segments in the same linear position (Sandler 1989a, 1993b). That is, there are pairs like  $Lx My Lz / Lw My Lz$  that correspond to spoken language *bin/pin*.

(vii) Spoonerism-type (*dear old queen* → *queer old dean*) sign errors exist which switch only one of two locations in the same positions in each sign (Sandler 1989a).

(viii) Individual locations may be lengthened under morphological inflection (Sandler 1987b, 1989a, b, 1993a and here) and phrase-finally (Perlmutter 1992, 1993).

**2.2 Locations**

Assuming that there is indeed significant ordering of location and movement units, the next question we turn to is the content and internal organisation of these units. We begin with locations, and focus only on those aspects of location quality that are relevant to the study at hand.

As in INTELLIGENT (Fig. 1), most signs involve a path movement from one location to another. Monomorphemic native signs are located at one major body area, or PLACE OF ARTICULATION, such as the head, the trunk or the non-dominant hand. Generally speaking, the difference between the two locations is in one ARTICULATION SETTING feature only, i.e. a feature of height, of laterality, of proximity or of contact. INTELLIGENT has as its major body area, or place of articulation, the head. The hand moves from a setting that is high, ipsilateral to the dominant (signing) hand, and in contact with this location, to a second setting that is a proximal distance away from the high, ipsilateral, head location. That is, the feature [contact] characterises the first L, and the feature [proximal] characterises the second. (2) shows a partial representation of the locations of INTELLIGENT.<sup>3,4</sup> In (2) and all representations in this article, descriptive labels are sometimes used instead of real features (argued for elsewhere) for simplicity. Such labels are enclosed in quotation marks.

(2) INTELLIGENT

selected finger: ['index']

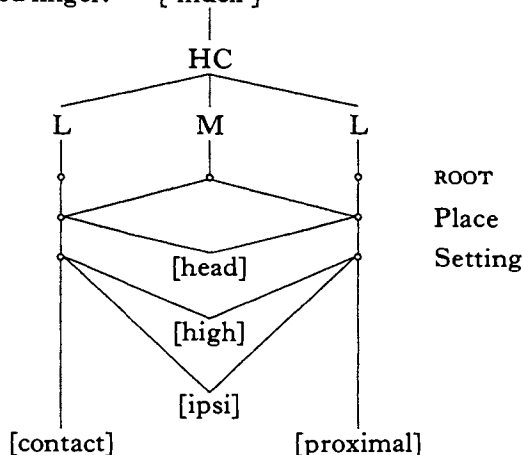




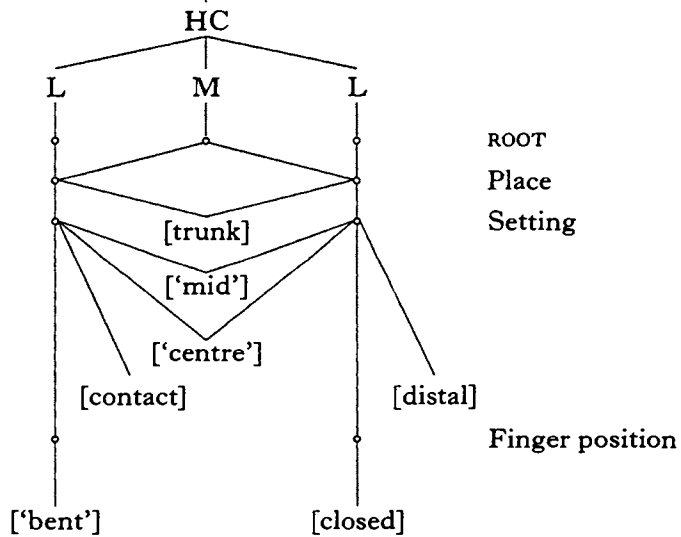
Figure 2  
ASL LIKE

In INTELLIGENT, the selected finger is the index finger. Other hand configuration features – finger position and palm orientation features – are omitted from (2), for simplicity.

Of particular interest to the present investigation are signs with hand configurations that involve two finger positions in sequence. Change of finger position will be referred to here as HAND-INTERNAL MOVEMENT (IM).<sup>5</sup> An example of a sign with IM is the sign LIKE, pictured in Fig. 2. Phonetically, the first finger position is temporally aligned with the first location in LML signs, and the second finger position is temporally aligned with the second location.<sup>6,7</sup>

(3) LIKE

selected finger: ['middle']



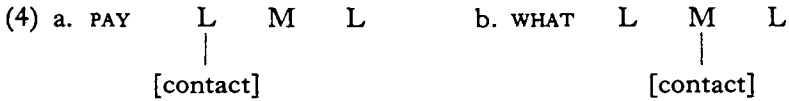
In §6, the phonetic segmentation of location features shown in (3) will be

given phonological support from lengthening phenomena in which place, setting and finger position features spread together.

**2.3 Movement**

The features of the path movement between two locations is often determined entirely by the locations. That is, path movement is often a plain straight movement of the hand from L1 to L2. This has prompted some investigators to propose that Ms are entirely redundant and should be eliminated from the underlying representation (Stack 1988; Hayes 1993; Wilbur 1993; van der Hulst 1992, this volume; Uyechi 1992). However, there are two good reasons for maintaining movements.<sup>8</sup>

One is that they must often get their own non-redundant specifications. An example is when the movement has an arc shape, represented by the feature [arc]. In addition to underlying arcs, some morphological processes require association of an arc to the base (Sandler 1989a, 1990). A movement feature that distinguishes derivationally related nouns from verbs is [restrained] (Supalla & Newport 1978). In addition, movement must sometimes be specified for [contact]. In the formationally similar signs PAY and WHAT, for example, PAY is characterised by contact on the first L, while WHAT is characterised by contact on the M, resulting in what is sometimes referred to as brushing.



The second important reason for including movements in the model is that movement is required for a sign to be well-formed (Chinchor 1978; Perlmutter 1989, 1992, 1993; Brentari 1990). It would be odd indeed if the only syllable position that is required for well-formed syllables were redundant. It will be shown in the next sections that the existence of a segment between the two locations allows a perspicuous representation of movement segments as dynamic elements, and consequently, makes them identifiable as syllable nuclei.

Consider a hypothetical spoken language with similar properties. The spoken language counterpart to a sign in which there are few independent movement features would be a spoken word of the form CVC, in which the quality of the vowel is often entirely determined by the surrounding consonants. To complete the analogy, the language would have in its inventory some vowels whose quality is partially specified, like the arc or contacting movement specifications of ASL. Finally, a CC string without an intervening V would be ill-formed in the language. The issue is not whether such a spoken language actually exists. Rather, the question is whether the existence of such a language would prompt phonologists to eliminate the vowel position from syllable templates. Since the language



does have specified vowels, and since reference to vowels is required to state syllable and morpheme structure constraints, I believe the vowel position would stay. The same should be true of the movement position in sign language.

Notice that the root node of the M segment is associated to the place nodes of the L segments. This type of double association to specify movement features that are determined by the surrounding segments follows Liddell & Johnson (1985, 1989). It will be shown in §4 that such a representation is a perspicuous characterisation of the dynamic quality of such segments, precisely the quality that makes them syllable nuclei.

### 3 Morpheme shapes: toward a unified representation of movement

Most ASL morphemes have one of only three shapes: LML, LMLML and L. We have seen examples of LML signs, with and without internal movement: *LIKE* and *INTELLIGENT*, respectively. The vast majority of signs, according to the present theory, have this canonical LML shape. In addition to the prevalence of this canonical shape in the lexicon, synchronic and diachronic processes tend to create signs of the same LML shape (Chinchor 1978; Sandler 1987b, 1989a; Corina & Sandler this volume).

The LMLML group of signs requires three locations. Here, the specification of the third location is predictable: it is the same as that of the first location. These signs are called bidirectional: they start at some location, move to some other location and return to the first location. All that need be listed in the lexicon are the feature specifications of the first two locations and their order, the feature specifications of M, and the skeleton LMLML. The inclusion of slots for M segments in the representation allows a unified representation of bidirectional signs and another type of signs, circular signs. In circular signs, the hand starts at one location, moves in an arc to a second location and returns via another arc to the first location, forming a circle. In the present model, circular signs have precisely the same type of representation as bidirectional signs, with the addition of the feature [arc] to the movement segment. Phonological and morphological arguments that circles are in fact two arcs with different values for concavity appear in Sandler (1989a, 1990).

We have seen two types of LML signs. Both have path movement, and one has internal movement as well (*LIKE*). In addition, there are signs that have IM with no path movement. An example is the sign *UNDERSTAND*, pictured in Fig. 3. The hand remains in place at the forehead, and the selected index finger changes from a closed position to an open position. Such signs are represented as LML signs as well.<sup>9</sup> Signs like *UNDERSTAND* have the same temporal structure as signs with path movement (such as *INTELLIGENT* or *LIKE*); the distribution of features across that structure is

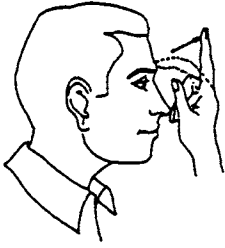


Figure 3  
ASL UNDERSTAND



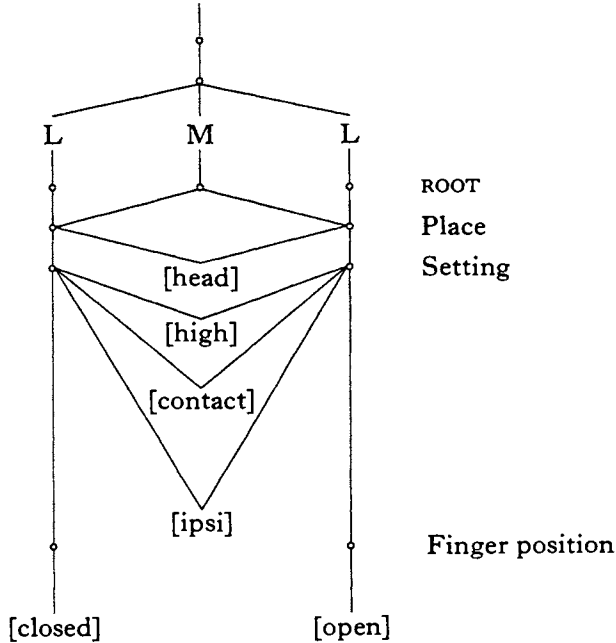
Figure 4  
ASL COLOR

Illustration from T. Humphries, C. Padden & T. J. O'Rourke (1980), *A basic course in American Sign Language*, T. J. Publishers, Inc., 817 Silver Spring Avenue, Silver Spring, MD 20910, U.S.A.

different, however. The beginning and ending location segments are at the same place and setting in UNDERSTAND; locations are distinguished only by finger position features. The representation of UNDERSTAND at the relevant level of the lexicon is shown in (5):

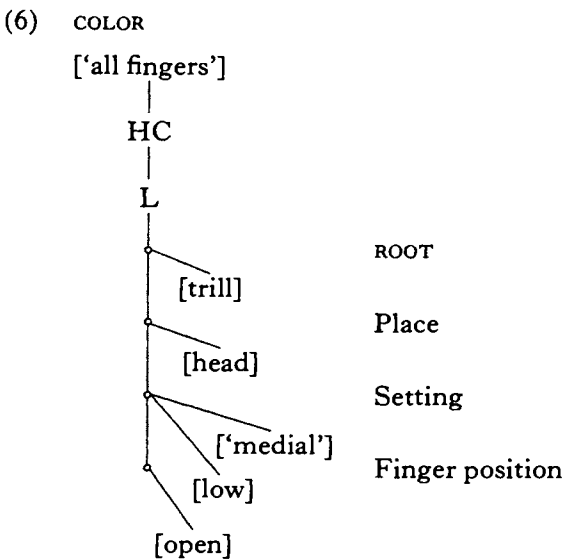
(5) UNDERSTAND

selected finger: ['index']



The last major morphological template is L. This is reserved exclusively for signs that have neither two locations nor two finger positions.<sup>10</sup> The only signs of this type are signs in which the only movement is wiggling of the fingers, such as *COLOR*, illustrated in Fig. 4.

Signs with finger wiggling and no path movement, like *COLOR*, are structurally different from other signs. All other types involve either a sequence of location features or a sequence of hand configuration features, or both. Conversely, there is no coherent way in which signs with finger wiggling and no path movement can be described as a sequence of discrete features. The representation of signs with wiggle and with no path movement is shown in (6). The feature standing for wiggle in (6) is [trill].



In addition to wiggle, there are two other sign types in which movement internal to the hand (i.e. not path movement) is rapidly repeated: handshape change signs, such as *LIKE*, and orientation change signs. In the present model, [trill] characterises all signs with rapidly repeated hand-internal movement, or trilled internal movement (TIM).<sup>11</sup> Trilled handshape or orientation change signs are referred to as TIM-1 signs; wiggle signs are referred to as TIM-2 signs. TIM is discussed at length in the next section.

Four major categories of movement have emerged from this discussion: path movement from one location to another, and three basic types of internal movement: handshape internal movement, orientation internal movement and trilled internal movement. Trilled internal movement can occur on its own (wiggle – TIM-2), or it can combine with handshape IM or orientation IM (TIM-1). In addition, all types of internal movement can cooccur with path movement in a sign, though they need not. This

results in eleven possible lexical movement patterns, all of which are attested in ASL.

According to the model adopted here, ten of these eleven movement types have the form LML, similar to a spoken language CVC form. This observation is central to the sonority cycle analysis presented in §6. Only signs with the wiggle sort of trilled internal movement and no path movement (like *COLOR*; Fig. 4) are represented as monosegmental L signs, with no M segment (6). We shall see in §6 that even these signs have a formal characteristic that classes this type of movement together with all other movements, namely a branching root node. More important, it will be shown that even these signs exhibit a sonority cycle as soon as other segment slots are added.

## 4 Syllables and sonority

Locations and movements tend to be temporally organised in such a way as to keep the movement at the centre of the sign. In this section, I will argue that this optimal LML form is a sign syllable with the most sonorous element at the centre, analogous to CVC.

The ASL literature offers a rather baffling array of theories about syllable structure in the language (e.g. Chinchor 1978; Coulter 1982; Edmondson 1986, 1990; Wilbur 1987, 1993; Sandler 1987b, 1989a; Corina 1990; Perlmutter 1989, 1992, 1993; Brentari 1990; Brentari & Goldsmith 1993). A unifying thread in the work on ASL syllables is the observation that some kind of movement is necessary for a well-formed sign, just as a vowel or, in its absence, some other sonorous element, is necessary for a well-formed syllable in spoken language (Corina & Sandler this volume). Some signs, and even some monomorphemic signs, have more than one movement, but at least one seems to be required.<sup>12</sup>

It has also been noted that movement is perceptually salient, just as vowels are perceptually salient in spoken language (e.g. Brentari 1990; Perlmutter 1992, 1993). In vision, motion enhances perception, both for purposes of noticing an object's presence and for purposes of discriminating the form of the object (e.g. Sekuler & Blake 1985).<sup>13</sup> Here, I adopt the position that visual salience plays a role in sign language that is similar to that of auditory salience in spoken language, i.e. that it is analogous to sonority. I further assume that movement is necessary for syllabicity.

### 4.1 Nucleus projection

Movement means change of state. In the present proposal, the movement segments are represented as doubly associated to the features of the surrounding locations. Specifically, movements have branching root nodes. It is this branching root node, signifying dynamic change of

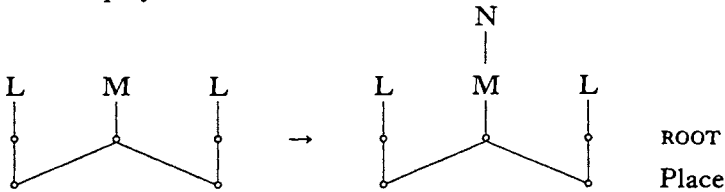
state within the movement portion of the sign, which triggers nucleus projection:

(7) *Nucleus projection*

Project a nucleus over a segment with a branching root node.

Generalising as it does over signs with and without path movement, (7) is a simple way of syllabifying derivationally, obviating the need to associate strings to syllables underlyingly.

(8) *Nucleus projection*



The nucleus projection rule implies that there is only one M per syllable. Thus, bidirectional signs and circular signs (LMLML) are bisyllabic, though they are monomorphemic. In §6, examples of monosyllabic bimorphemic forms will be discussed.

We have made two central claims about the structure of signs: (i) signs are characterised by linear sequences of location and movement segments and (ii) movement is necessary for syllabicity. We have also seen that a typical syllable includes both movements and locations. Nearly all proposals for sonority hierarchies make the claim that movements are the most sonorous elements in a sign. Taken together, these findings suggest that there is a rise–fall sonority sequence within such syllables, going from the less sonorous L to the sonorous M and back to the less sonorous L. The model and analysis proposed here will show that a constant sonority cycle characterises both signs with path movement and signs without path movement, and will suggest that the pressure for a sonority cycle is also active derivationally.

#### 4.2 A sonority hierarchy

Keeping in mind that motion enhances perception, I propose a sonority scale according to which the amount of movement within a sign is directly correlated with the degree of sonority.<sup>14</sup> At this point, the scale is dictated by the purely phonetic consideration of relative amount of movement.

(9) *An ASL phonetic sonority hierarchy*

1: contacting L < 2: plain L < 3: L with TIM < 4: contacting M < 5: non-path M with IM < 6: path M < 7: path M with IM < 8: path M with TIM

At the two extremes of this phonetic scale are contacting Ls and trilled

path Ms. Ls that are in contact with the body are analogous to obstruents; they preclude any movement and are therefore the least sonorous. Trilled Ms involve both path movement and trilled internal movement, and are therefore the most sonorous. The minimum requirement for a well-formed sign appears to be trilled L, indicating that the minimum sonority value for a well-formed syllable is 3 on this scale. Attributing more sonority to path movement (6) than to internal movement (5) is arbitrary at this point, since each involves a single change of state (but see Brentari this volume for arguments in favour of this relation).

Movements of various types may cooccur simultaneously, as we have seen, but they may not occur in a sequence in the same syllable, by definition. Furthermore, it is a physical impossibility for two different locations to occur in a sign with no intervening movement. Therefore, the usual sequencing tests for relative sonority that exist in spoken language are much more limited in sign language. Support is presented in the sections that follow for two aspects of the proposed hierarchy: (i) trilling adds sonority and (ii) contacting Ls are lowest on the scale.

We now look at empirical data showing that, under Intensive aspect lengthening, all seven types of movement pattern the same way: Movement, no matter what kind, constitutes the temporal CENTRE of the sign, and only the static elements that precede and follow it are lengthened. This finding supports the particular sequential model and sonority cycle proposed here, and refutes simultaneous theories of phonological and sonority patterning.

## **5 The Intensive form: morphological edge-lengthening**

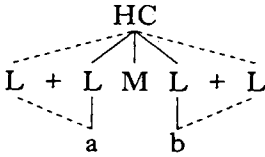
One way of forming the Intensive aspect in ASL involves lengthening the beginning and the ending of the sign. Phonetically, this means holding the hand static at the beginning and the end. The movement part of the sign is not affected by the lengthening. In the intensive form of INTELLIGENT (base form illustrated in Fig. 1), for example, the hand is held static for a moment in contact with the forehead, then moves to the setting a short distance in front of the forehead, where it is held static again. This differs from the base form in that the first and second locations of the base form are geminated for Intensive.

A formal treatment of this process entails affixing an L...L parafix to the base, and spreading the L features and the HC features. In this model, then, Ls and Ms are skeletal slots that stand for segment order within a sign, and represent timing as well (McCarthy 1979, 1981). In (10), the symbols *a* and *b* stand for all features of each L, respectively.

This rule, proposed in Sandler (1987b, 1989a), is evidence for discrete and sequential location segments, as suggested in (viii) of §2.1, since all and only the features phonetically cooccurring at each location spread to the added slots.

In signs with internal movement, the first and second finger positions

(10) *Edge lengthening for Intensive*

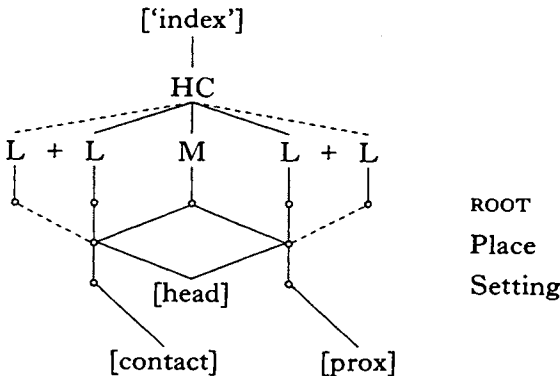


(or palm orientations) lengthen together with the location features. LIKE (Fig. 2) is signed in the following way under Intensive inflection: (i) the hand is held static in its first shape (middle finger bent) and at its first articulation setting (in contact with the trunk), (ii) then moves in a straight path and (iii) then reaches the second shape (middle finger closed to thumb) and the second setting (a medial distance in front of the trunk), where it is held static again. Each discrete finger position is geminated together with each discrete articulation setting, while the transition between them, like the path movement, is not affected by the lengthening.

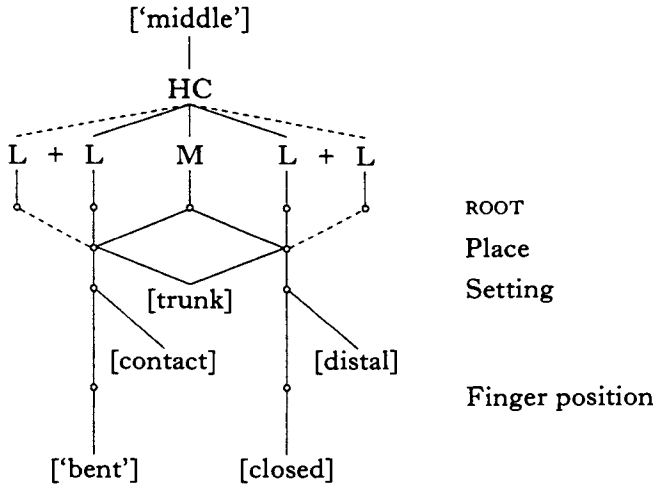
For clarity, I show the effect of lengthening plain LML signs, LML signs with path and internal movement and LML signs with internal movement but no path movement (from Sandler 1989b, 1993a). (11a) is a partial representation of the effect of Intensive lengthening on the sign INTELLIGENT, illustrated in Fig. 1; (11b) is LIKE, illustrated in Fig. 2; and (11c) is UNDERSTAND, illustrated in Fig. 3.<sup>15</sup>

Central to the sonority cycle analysis argued for here is the behaviour of L signs with wiggle (like COLOR) under lengthening for Intensive. Crucially, these signs pattern like the signs with LML structure, in that the fingers are ‘frozen’ at the edges: wiggling occurs only at the centre of the sign, and only the static features geminate.

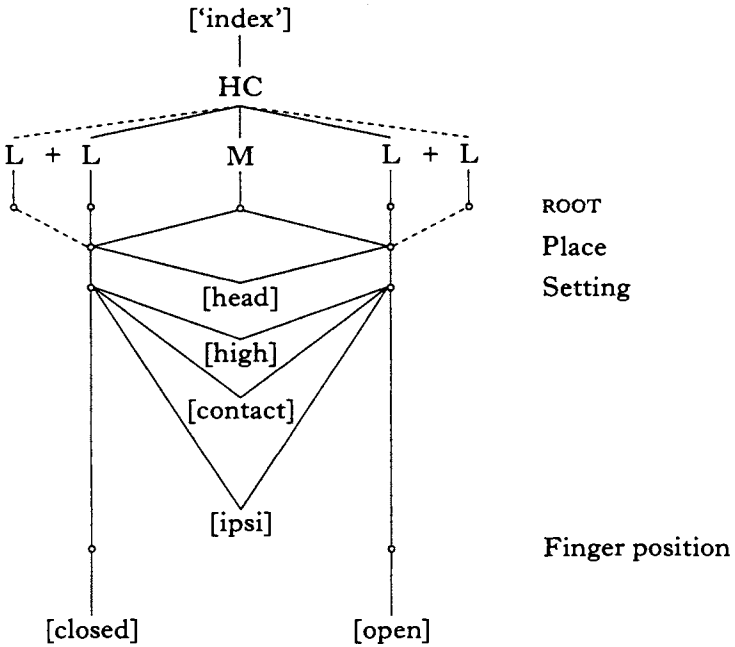
(11) a. INTELLIGENT, Intensive



b. LIKE, Intensive



c. UNDERSTAND, Intensive



**5.1 TIM under lengthening: a unified phenomenon**

Here, as in earlier work, I include as one class rapidly repeated handshape or orientation change, as well as finger wiggling (Sandler 1987b, 1989a),



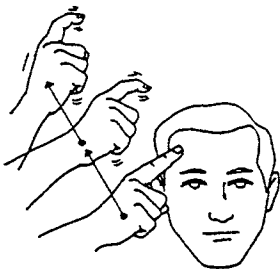
referring to all as trilled internal movement (TIM).<sup>16</sup> As mentioned in the previous section, I further subdivide TIM into two types: TIM-1, rapidly repeated handshape or orientation change, and TIM-2, wiggle. Recall as well that both TIM-1 and TIM-2 occur in signs with path movement, as well as in signs without path movement. Figure 5 illustrates the sign DREAM, a TIM-1 sign with path movement. This means that there is a rapidly repeated oscillation between two finger positions during the path movement.

TIM-1 (rapidly repeated handshape change) may also occur in a sign with no path movement, such as MISCHIEVOUS (Fig. 6). In this sign, the hand remains in contact with the ipsilateral side of the forehead, and the selected index and middle fingers repeatedly change from an open to a curved position.

The sign COLOR, illustrated in Fig. 4, is a TIM-2 (wiggle) sign without path movement. TIM-2 (wiggle) may also occur in a sign with path movement, such as GO-UP-IN-FLAMES or LONG-AGO. In LONG-AGO, the hand, all fingers extended and spread, moves backwards from a point in front and to the side of the head to a point over the shoulder on the same (ipsilateral) side of the body. During this path movement, the fingers wiggle. In both types of TIM signs – TIM-1, oscillation between two discrete finger positions or palm orientations, and TIM-2, finger wiggling – the trilling cooccurs temporally with path movement, if there is path movement in the sign.

Liddell (1990) observes that in signs with finger wiggling, the fingers do not wiggle on ‘hold’ segments. Hold segments correspond roughly to lengthened Ls in the present model, with the important difference that for Liddell these static units are underlying and not derived. Perlmutter (1992, 1993) makes the related observation that wiggle occurs on the movement segment where there is one.

If we view finger wiggle as part of the same phenomenon as handshape or orientation oscillation, as do Sandler (1987b, 1989a), Stack (1988) and



*Figure 5*  
ASL DREAM



*Figure 6*  
ASL MISCHIEVOUS  
Illustration © Ursula Bellugi, The Salk  
Institute for Biological Studies, La Jolla,  
CA 92037, U.S.A.

Liddell (1990), then we can generalise the behaviour of trilling under lengthening over TIM-1 and TIM-2: in neither sign type does trilling characterise the lengthened portion of the sign. Under initial and final lengthening, a TIM-1 sign like DREAM (Fig. 5) is executed by geminating the first finger position and the last finger position as well as the first and last location settings. Precisely the same elements are lengthened in a plain (non-trilled) IM sign, as shown in (11b) above. The trilled portion of the sign, however, occurs during the path movement part, and does not spread under lengthening.

In the case of a TIM-2 (wiggle) sign, TIM also cooccurs only with the path M, but instead of having two different finger positions at the lengthened edges, a single position gets geminated there. If the finger position is open, the usual case for wiggle signs, then the lengthened position at each edge will be open. That is, the sequence will be: geminate open finger position at place and setting  $x$  → finger wiggling during path movement → geminate open finger position at place and setting  $y$ . In an LML sign like LONG-AGO, then, the finger wiggling cooccurs temporally with the path movement, neither of which is affected by lengthening.

The fact that wiggle and oscillation (i.e. rapidly repeated IM) behave in the same way under lengthening motivates a unified representation of these two types of hand-internal movement. The feature [trill] serves that purpose. Signs that have a sequence of finger position or orientation features and [trill] involve oscillation between the two features. Signs with [trill] but no sequence of finger position or orientation features are interpreted as random wiggling of the fingers.<sup>17</sup>

The fact that only location features spread, and neither path movement nor TIM features do, supports the claim that TIM is temporally aligned with the M segments in signs with Ms.

The interesting data are the TIM signs with no Ms (L-wiggle signs like COLOR). In these signs, [trill] must be associated with the L, since that is the only segment in the sign. Of special interest to the present discussion is the fact that all features of a TIM-2 sign without path movement lengthen under Intensive, *except* the trill. In other words, the following sequence occurs: geminate open finger position at place and setting  $x$  → finger wiggling still at  $x$  → geminate open finger position still at place and setting  $x$ .

The facts that need to be accounted for, then, are these:

(12) *Temporal patterning of TIM under lengthening*

- a. In LML signs of both TIM-1 and TIM-2 types, [trill] patterns temporally with the M, and does not lengthen under Intensive.
- b. In L signs of the TIM-2 type, i.e. trilled signs with no path movement, all L features lengthen rightward and leftward, *except* the trilling, which does not lengthen.

(12a) is explained by the fact that [trill] is associated to the movement segment, and only the edge locations spread. But how can (12b) be

explained? That is, why is it that all features associated to a segment spread, except one? I will argue that [trill] is associated to the sign in such a way as to maximise sonority distances within the sign syllable, and that [trill] does not spread under lengthening for the same reason.

The idea that there is a relationship between secondary movement and sonority is proposed and investigated in other current work (Corina 1990; Perlmutter 1992, 1993; Brentari this volume). The next section supports the claim that such a relationship exists, and makes an explicit new proposal about its nature.

## 6 Sonority distance maximisation

It emerged from the discussion of edge-lengthening that TIM is somehow aligned with the movement segment of a sign where one exists, and not with segments that have no movement, namely locations, in such signs. This will be accounted for by proposing that (i) TIM is represented by the feature [trill], which characterises wiggle as well as oscillating handshape or orientation, (ii) [trill] is floating underlyingly and (iii) the association and behaviour of [trill] conform to a sonority cycle.

It has long been known (e.g. Sievers 1881; de Saussure 1916) that spoken language syllables observe a sonority sequencing principle according to which sonority rises from the onset to the nucleus and falls from the nucleus to the coda (see Clements 1990 for a recent examination of the 'sonority cycle'). The nucleus, usually a vowel, is the most sonorous element in the syllable. The simplest closed syllables are CVC, a simple sonority cycle. In more complex syllables, initial consonant clusters rise in sonority, and syllable-final consonant clusters fall in sonority. Cross-linguistically, this determines that [pr] may be an initial cluster while [rp] may not, and that the reverse is true in coda position. Clements (1990 and the references cited there) also points out that there is generally a difference in the degree of sonority distance in onsets *vs.* codas, such that distance between consonants in an onset is generally greater, i.e. 'maximised' to a greater extent, than the distance between coda consonants.

The temporal realisation of TIM in ASL suggests that it associates to segments in such a way as to maximise sonority distances in the syllable. In addition, it refrains from spreading under lengthening in order to preserve the cycle in LML signs, and to create a cycle in L signs. I assume that the following principle determines this behaviour of [trill]:

### (13) *Sonority Distance Maximisation Principle (SDMP)*

Wherever possible, ASL syllables maximise sonority distances from onset to nucleus, and from nucleus to coda.

An immediate consequence of having such a principle in the grammar is that it eliminates the need to order Ls and Ms in the lexicon. Following principles set out in McCarthy (1989), only the Ls must be listed in their

order, and the position of the M is then determined by the SDMP. A lexical entry will be of the form  $L_i L_j, M$ .<sup>18</sup>

Let us turn to the implications of the SDMP for [trill] association. Given that there are so few segments in an ASL syllable (generally at most LML), distances within the sonority cycle can be maximised simply by achieving the largest possible sonority distance between L and M initially, and between M and L finally, in the syllable. Let us take as a clear example an LML sign in which the Ls are contacting, i.e. 1 on the scale. If such a sign were listed in the lexicon with the floating feature [trill], then [trill] would have to choose what it associates with: (a) to one L or the other, (b) to all segments of the sign or (c) just to the M. The (a) option would result in a sonority cycle of 3–6–1; the (b) option 3–8–3 and the (c) option 1–7–1. The SDMP dictates the (c) option.

If there is no M in the sign, then [trill] associates to the L, making it more sonorous than a plain L, and deriving a well-formed syllable. Perlmutter (1989, 1992, 1993) has suggested that an L with TIM is analogous to a syllabic consonant.

So far it could be argued that deriving the association of [trill] via the SDMP has only a marginal theoretical advantage over associating [trill] in underlying form, which is essentially the approach of Liddell (1990) and Perlmutter (1992, 1993). I will now show that an analysis entailing the SDMP has the added advantage of explaining why [trill] never spreads in morphological lengthening processes, regardless of whether it is associated to the M or to the L in signs without an M.

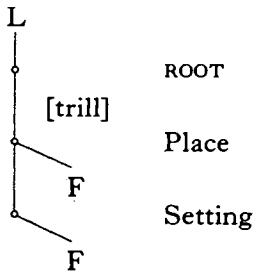
If it is associated to the M, then [trill] does not spread because it is not on the edge; only the features aligned with the initial L (onset) or the final L (coda) spread. In the case of L signs with no M, the SDMP prevents [trill] from spreading. L signs arguably have no onset or coda, only a nucleus, established as such at an earlier stage of the derivation, when [trill] first associated to the L, creating a well-formed syllable. When additional slots are added at the beginning and the end under intensive inflection, the SDMP explains why [trill] does not spread to these slots. If [trill] did spread, there would be no sonority cycle, rather, the sign would have a sonority 'sequence' of 3–3–3. If [trill] does not spread, then a sonority cycle of 1–3–1 (if the L is contacting) is derived. In other words, the added slots are derivationally endowed with the status of onset and coda, and a sonority cycle is *created* according to the SDMP. This analysis suggests that there is perceptual pressure in signed as in spoken language for a sonority cycle.

### 6.1 Nucleus creation: association of [trill] to the root

Structurally, TIM is prevented from spreading by its association to the root node, since spreading is proposed to operate at the place node, as shown in (11). In this model, the root node plays a role in sonority effects. The branching root node of M segments is suggested to be a formal representation of change of state, i.e. of the dynamic character of that part

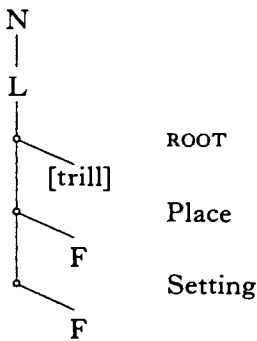
of the sign. It is for this reason that the nucleus is projected over the segment with the branching root node. The feature [trill] is suggested to be dominated by the root node, on the reasoning, discussed below, that it is a type of sonority feature, indicating a particular kind of change of state. If we make this assumption, then signs with only one L segment can become syllabic after [trill] association according to the SDMP: the L will then have a branching root. (14) shows the underlying representation of a sign with finger wiggle but no path movement. It is not a well-formed syllable, because no nucleus can be projected according to the nucleus projection rule stated in (7).

(14) *Underlying representation of a sign like COLOR*



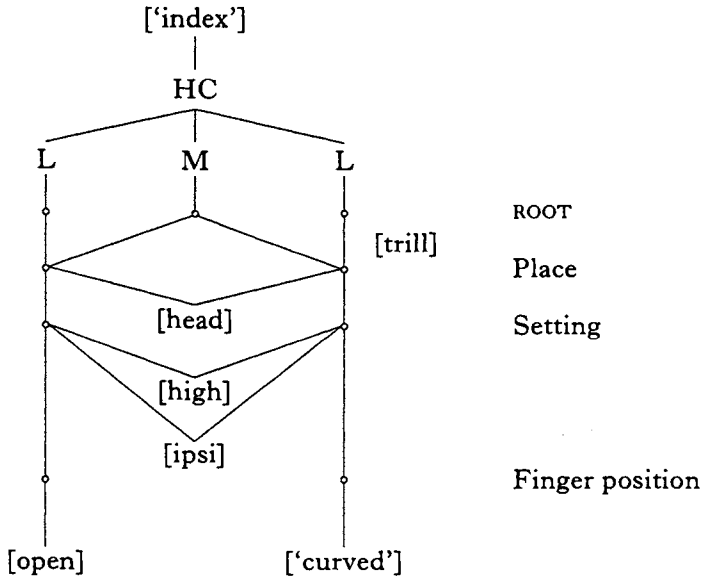
Finding no M segment, [trill] associates to the L segment, at the root. This gives the sign a branching root node, enabling nucleus projection to take place, as in (15):

(15) *After [trill] association and nucleus projection*

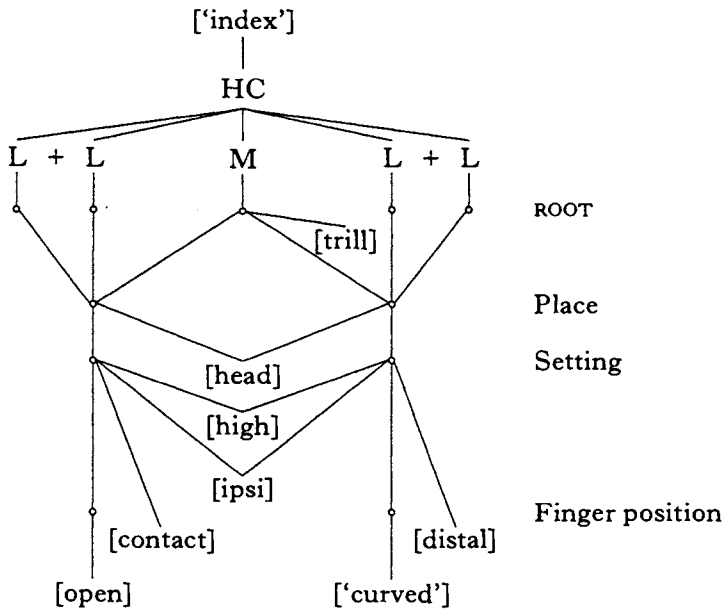


It has been argued that certain features in spoken language are in a sense part of the root, since these features only spread if all features dominated by the root spread, i.e. if the whole segment spreads (e.g. McCarthy 1988). Those features are [consonantal] and [sonorant]. In a recent paper, Kaisse (1992) has demonstrated that [consonantal] may spread, which leaves only the feature [sonorant] constituting the root. There, Kaisse refers to a suggestion by Harry van der Hulst that associating [sonorant] to the root,

(16) a. Underlying representation of DREAM



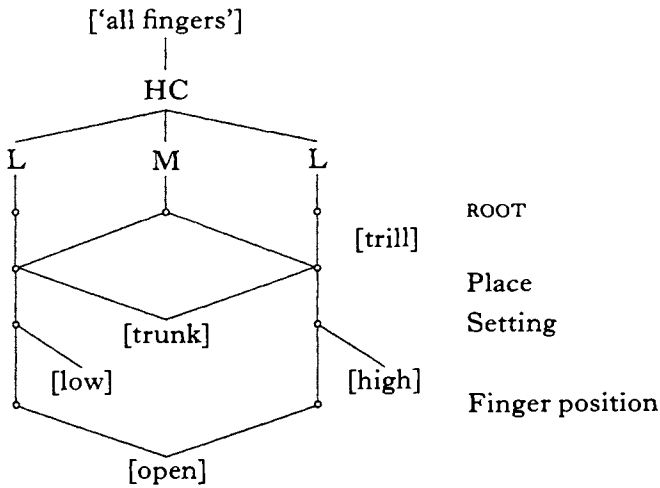
b. After [trill] association and edge lengthening



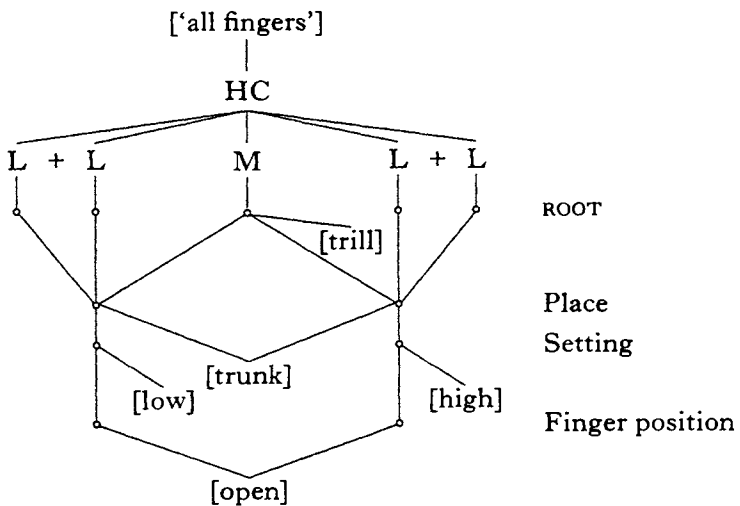
the highest level in the feature hierarchy, makes this property accessible to syllabification. Van der Hulst (1993) encodes this relationship into his model of spoken language phonological structure. I am suggesting that [trill], while not directly analogous with the feature [sonorant], may have certain properties in common with it.

The double association of M segments, and the association of [trill] to the root node according to the SDMP, makes it possible to unify all movements formally: movements have branching root nodes. This is seen

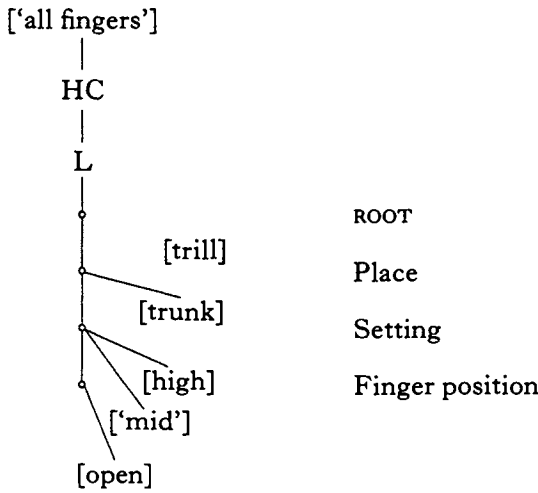
(17) a. *Underlying representation of GO-UP-IN-FLAMES*



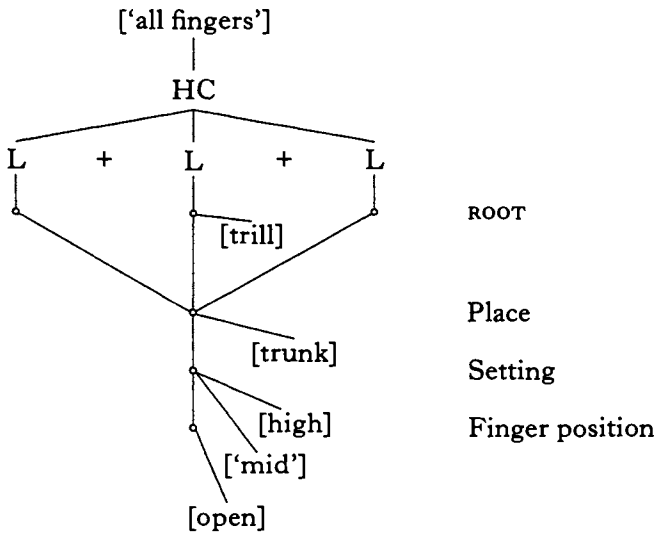
b. *After [trill] association and edge lengthening*



(18) a. Underlying representation of FINE



b. After [trill] association and edge lengthening



as an advance over previous models, which represent path movement, internal movement and trilled internal movement as a disjoint set.

The representations in (16)–(18) are partial, including only essential features for showing the temporal properties of [trill] under spreading. (16) is DREAM, (17) is an LML sign with finger wiggling, such as LONG-AGO or GO-UP-IN-FLAMES, and (18) is a sign such as the variant of FINE, which has the same form as COLOR, i.e. L plus TIM-2 or wiggle. (FINE is chosen because it is semantically more likely to undergo Intensive inflection than COLOR.) The (a) representations are at a stage of the derivation before



[trill] association, and the (b) representations are surface forms, after both [trill] association and lengthening.

## 6.2 Summary

It has been argued that the behaviour of trilled internal movement provides evidence for a sonority cycle in ASL. It associates to the most sonorous segment in the sign, where there is more than one segment, creating maximum sonority distances within the syllable. Where there is only one (non-sonorous) segment, it attaches to it, making the segment sonorous enough to constitute a syllable nucleus. Under lengthening, TIM never spreads, whether it is underlyingly surrounded by other segments or not. All of these phenomena are explained by the SDMP. The account is seen as preferred over those in which trill (or secondary movement) features are underlyingly associated to elements of the sign (Liddell 1990; Perlmutter 1992, 1993).

## 7 A consequence

In this section, I will argue that proposing an SDMP that is active in the phonology has an additional advantage: it explains the survival of contacting Ls in reduced compounds. Ls that make contact on the body are claimed in (9) to be the least sonorous segments in the ASL inventory. This designation is based on the phonetic fact that contact of the signing hand or hands with the body inhibits movement. Where there is a choice, it appears that these contacting Ls survive at the derived edges of compounds, in favour of more sonorous non-contacting Ls, maximising the sonority cycle in the derived forms.

### 7.1 Expansion and reduction to LML

A sizeable number of morphological processes in ASL conspire to conform to a basic LML template, either by expanding or by reducing the base signs (Chinchor 1978; Sandler 1987b, 1989a; Corina & Sandler this volume). For example, two linear affixation processes of ASL have been described in the literature, each of which involves shortening the base: Unrealised Inceptive (Liddell 1984b) and Negative Incorporation (Woodward 1974; Sandler 1989a, 1993). Within the present framework, the processes are described schematically for most forms as:  $LML + L \rightarrow LML$ . The derived form has certain features of one L prespecified by the morphology, while the other L in the derived form has the features of one L of the base. These processes (referred to in (iv) of §2.1) produce bimorphemic, monosyllabic forms.

In addition, the circular appearance of temporal aspect morphology has been argued to be best accounted for by positing an LML template with

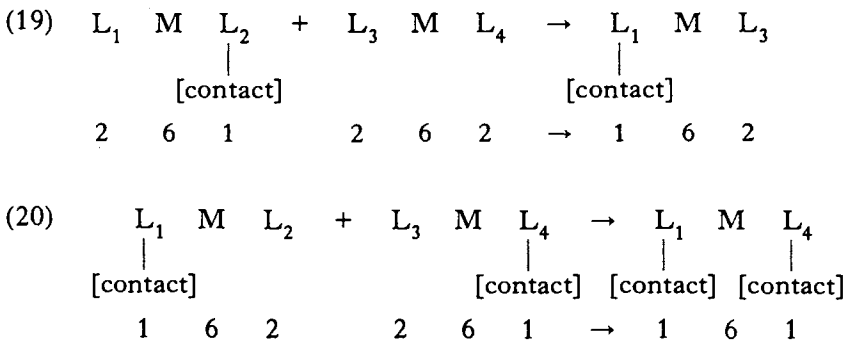
an [arc] associated to the M, which is then reduplicated (Sandler 1989a, 1990). When signs that are shorter than LML – i.e. L signs with wiggle – undergo inflection for a ‘circular’ temporal aspect, these are expanded by the addition of a path movement to fill an LML template. An example is DIRTY, an L-wiggle sign, which expands to LML+arc under Characteristic Adjective inflection:  $L \rightarrow LML$ .

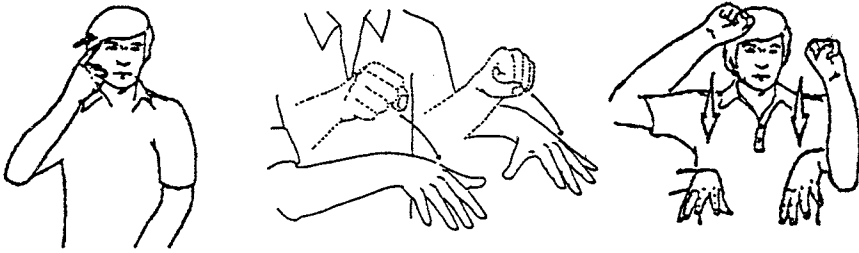
A unified analysis of these processes has yet to be undertaken. For our purposes, it is sufficient to note that there appears to be pressure within the language for signs to conform to the canonical LML template, a template with a single, simple sonority cycle. This is compatible with the finding of Coulter (1982) that ASL signs tend to be monosyllabic.

**7.2 Reduction in compounds and the SDMP**

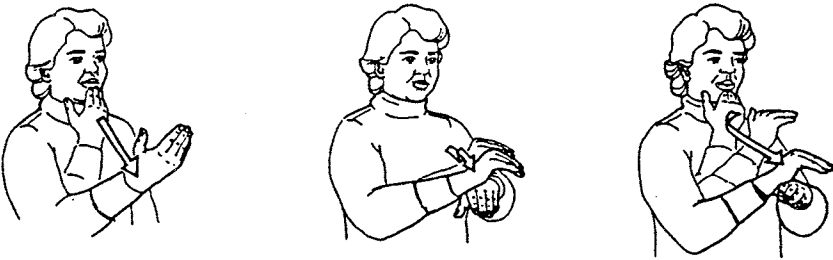
Another process that reduces forms to LML is compounding. A number of investigators have observed that compounding often results in reduction of the bases of the members (Klima & Bellugi 1979; Liddell & Johnson 1986; Sandler 1987b, 1989a; Brentari this volume). In the present framework, many reductions, especially in lexicalised compounds, are viewed as conforming to this tendency to reduce the two base signs, generally of the form LML+LML, to a compound of the form LML. In the process, some of the material of each sign is deleted. In particular, the HC features of the second member of the compound spread to characterise the whole compound, while Ls of either member may delete.<sup>19</sup>

It has been observed that Ls that are specified [+contact] tend *not* to delete in this process (Liddell & Johnson 1986; Sandler 1989a; Brentari 1990). A detailed segmental description of a large corpus of reduced compounds and of the base forms, necessary for a full analysis, is not yet available. However, examples that have been cited in the literature indicate that the following types of compound reductions are typical. (19) is an illustration and a schematic representation of MIND+DROP = FAINT (Fig. 7). (20) shows GOOD-NIGHT (Fig. 8), in which each base sign has one contact. The base form of NIGHT is reduplicated; the reduplicated part is omitted from the representation for simplicity. Sonority values are listed under each segment:





*Figure 7*  
ASL MIND (left), DROP (centre) and the compound FAINT (right)  
Illustration supplied by Geoffrey Coulter



*Figure 8*  
ASL GOOD (left), NIGHT (centre) and the compound GOOD-NIGHT (right)  
Illustrations from S. K. Liddell & R. E. Johnson (1986), American Sign  
Language compound formation processes, lexicalization and phonological  
remnants. *NLLT* 4. 445-513.

In both examples, the surface compounds are bimorphemic and monosyllabic. (19) and (20) are *not*, of course, the only conceivable ways in which such forms could reduce to LML. Alternatively, the non-contacting Ls of the bases could survive. Such signs would be ‘pronounceable’ and well-formed phonotactically. However, the reported data indicate that this does not occur. Notice that it is not the sequential position of the L that determines its survival, but rather whether or not it is marked for [contact].

If contact Ls are the least sonorous segment type, like obstruents, as the hierarchy in (9) posits, then their survival at the expense of plain, more sonorous Ls, under pressure to reduce the string to LML, can be explained by the SDMP: the least sonorous Ls occur at the edges, maximising the sonority distance between them and the M nucleus.

## **8 Comparison with the hold and moraic accounts**

The present investigation of the behaviour of TIM under lengthening was prompted in part by observations and insights of Liddell (1990) and Perlmutter (1992, 1993). Liddell (1990) observes that secondary movement does not occur on hold segments. In the course of Perlmutter's examination of ASL syllables, he provides an account of the behaviour of secondary movement under phrase-final lengthening, in which the fact that secondary movement occurs on syllable nuclei is pointed out.

### **8.1 The Move-Hold account**

Liddell (1990) is responsible for the observation that wiggle does not occur on the hold part of a sign of the form MH (movement-hold). He proposes that all so-called secondary movement (a larger set than TIM) features are underlyingly part of the segmental tier itself, somehow belonging to an M or an H (hold), rather than autosegmentally associated to it like the other features. He proposes four secondary movement features: oscillating handshape, oscillating orientation (here, both TIM-1), wiggling (TIM-2) and circling (see note 16).

The major difference between Liddell's treatment of movement and the present one is that all timing properties and cooccurrences of movements are posited as underlying in Liddell's analysis. Arguments against underlying holds appear in Sandler (1986, 1989a), Brentari (1990), Perlmutter (1992, 1993) and Wilbur (1993), and I shall not repeat them here. It has been shown in the preceding analysis that a more principled account of the temporal realisation of trill is possible, one that is based on syllable structure and sonority considerations. In addition, the present account reduces Liddell's four secondary movement features to a single feature, [trill].

### **8.2 Wiggle and sonority in the moraic account**

Perlmutter (1992, 1993) examines the implications of a sequential segment model of ASL signs for syllable structure, proposing that movements (Ms) are more sonorous than positions (Ps, corresponding in content to locations in the Hand Tier model). In addition, he explores the relation between secondary movement (wiggling and circling) and sonority, observing that secondary movement is associated to syllable nuclei: path movement where there is one, otherwise positions. The present study is informed by these insights. The theory and analyses presented in this article differ from those of Perlmutter in a number of significant ways, however. The following subsections compare the two treatments and models in the following ways: motivation of sonority contrasts, possible syllable shapes, and formal distinction of the two lengthening phenomena described. The possibility that there are distinct sonority patterns at the syllable level and at the phrasal level emerges from the comparison.

8.2.1 *Motivating the sonority cycle.* Perlmutter (1992, 1993) highlights the existence of sonority contrasts in signs with path movement, by adopting a linear model and by attributing sonority and syllable peak status to movement segments. The present study motivates these contrasts by positing a Sonority Distance Maximisation Principle, which is claimed to play an active role in the phonology. Advantages of this approach are mainly three: (i) the present account explains *why* trills cooccur with other movements, namely to maximise sonority peaks, and offers a unified representation of this cooccurrence; (ii) it explains the failure of [trill] to spread under Intensive lengthening even in L-wiggle signs; and (iii) it has the consequence of explaining the compound reduction facts described in §7.

8.2.2 *The inventory of syllable types and the preferred rise–fall cycle.* The present model also collapses several syllable types represented distinctly in the moraic model. The moraic model posits five syllable shapes, PMP, MP, PM, M and P, and a concomitant variety of possible sonority sequences. The present model reduces this inventory to two, L and LML, and the vast majority of signs are analysed as having an LML shape (see notes 10 and 21). It is noteworthy that this proposed inventory reinforces the claim made here that ASL signs favour a rise–fall sonority *cycle*.

While there is not enough space here to describe all the differences between the two models of sign types, one difference should be highlighted, since it is directly relevant to the lengthening data described by both authors. That is the representation of what is referred to here as TIM-1 signs, signs in which handshape or orientation oscillates between two discrete values.

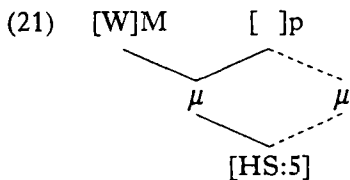
The moraic model distinguishes these signs from signs with internal movement (i.e. two handshape or orientation values) but no rapid repetition. DREAM (Fig. 5) is described in Perlmutter (1992, 1993) as consisting of a single handshape and the secondary movement feature [bending]. According to his account, the fact that, under Intensive, the first [open] handshape lengthens at the beginning of the sign and the second handshape [curved] lengthens at the end (cf. Liddell 1990) is not predicted, since no discrete shapes would be represented. In the present account, TIM-1 signs are represented as ordinary IM signs plus [trill]. The independent finger positions are aligned with the L segments, and the [trill] is associated to the M. This representation reflects the structural similarity of plain IM and TIM-1 signs, and correctly predicts which finger positions will be lengthened in both sign types (see (16)).

8.2.3 *The representation of two types of lengthening.* Another major difference between the two treatments is in the structural analysis of lengthening phenomena. Perlmutter intentionally avoids any representation that involves internal feature structure, for simplicity. Considering the morphological lengthening process reported here, however, we see that the feature bundle approach of Perlmutter creates a problem for

distinguishing phrase-final lengthening from Intensive lengthening. In particular, the representation proposed in Perlmutter's study can express the phrase-final lengthening process he describes, but makes the wrong predictions about the morphological lengthening discussed here. We now look at the empirical difference between these two processes, and find a formal expression of the difference within the structural model proposed here.

Perlmutter observes that under phrase-final lengthening (PFL), there is an asymmetry in the lengthening of wiggle, depending on whether wiggle characterises a PMP (= LML) sign or a P (= L) sign. Wiggle does not lengthen phrase-finally in the former sign type, but it does in the latter. In other words, in a sign like COLOR or FINE, the fingers continue to wiggle on the lengthened end of the sign. Under Intensive inflection, it will be recalled, they do not. TIM patterns differently under PFL, a phrase-level phenomenon, than under the morphological process of Intensive inflection, where TIM does not lengthen in either type of sign.

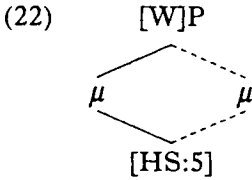
This behaviour of wiggle under PFL leads Perlmutter to propose an analysis in which the secondary movement feature [wiggle] and handshape features link to the prosodic structure in two different ways: secondary movement features are linked via association to segments, while handshape features are directly linked to prosodic structure, in particular to morae.<sup>20</sup> The representation of a sign with wiggle and path movement like LONG-AGO or GO-UP-IN-FLAMES in that model is shown in (21).<sup>21</sup> M and P are movement and position category labels with no timing properties, W stands for wiggle and  $\mu$  represents a moraic level. Phrase-final lengthening is accounted for in this model by a rule of mora insertion.<sup>22</sup>



This representation is argued to account for the lengthening of the P but not of the wiggle in a sign like GO-UP-IN-FLAMES, since association of the M segment with its wiggle feature to the inserted mora would purportedly violate the line-crossing constraint (Goldsmith 1976). As we have seen in morphological lengthening, it is also the case in PFL that handshape features in signs with or without IM do lengthen. Since handshape features (including changing handshapes; note 20) are linked independently to the morae in the moraic account, they can lengthen without crossing association lines.

It is crucial to the account that PFL spreads the root node, giving the correct result for PFL. We shall see, however, that the lengthening process in the Intensive forms must spread material at a lower level in the feature hierarchy, as shown in the previous section.

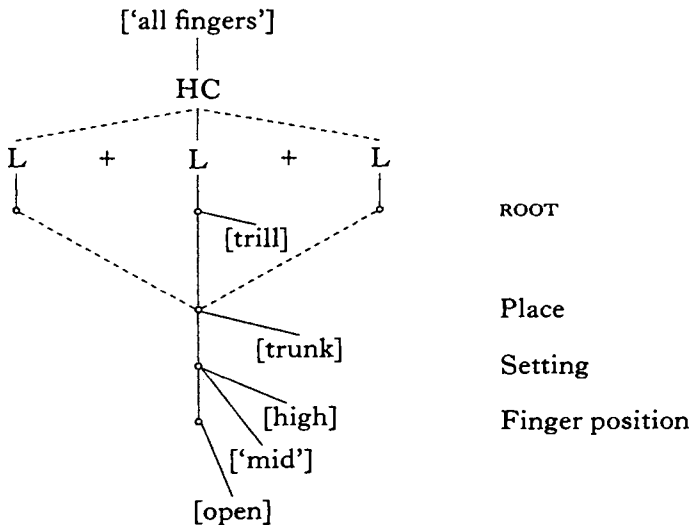
In a sign without path movement, such as COLOR or GERMANY (a P-syllable in the moraic model terminology), in which wiggle is a feature of P, wiggle spreads with the P under PFL:



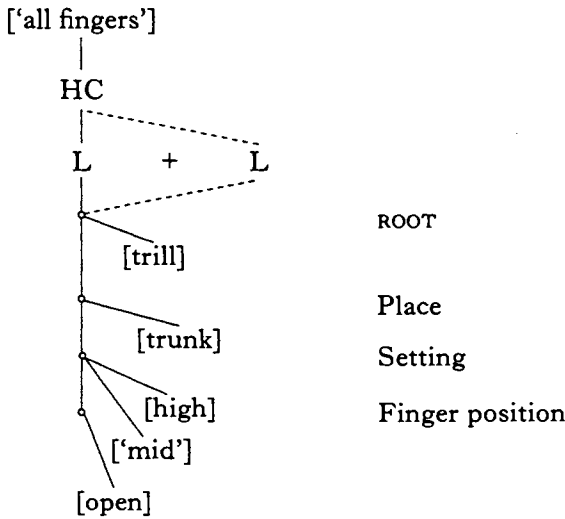
Taken together with the analysis of PFL in which all features of P spread together, the representation of wiggle predicts that wiggle must spread if P spreads. This is the case for PFL, but the structure and analysis proposed are not sufficiently elaborated to account for the morphological lengthening facts dealt with in §§5–6 of this paper. In particular, they predict that wiggle will always lengthen with the final segment of a sign. As we have seen in the morphological lengthening process of intensive aspect, this is not the case. P-features (location features in the Hand Tier model) lengthen in FINE Intensive, while wiggle does *not*.

In the account of the morphological process of Intensive aspect formation argued for here, the place node spreads, as in (11) and (16)–(18). Intensive lengthening for the L sign FINE is repeated in (23a) for convenience. The formal representation proposed here also makes it possible to express PFL, and to distinguish it from morphological lengthening. The model argued for in this article expresses PFL for a sign like COLOR, FINE or GERMANY, as spreading of the whole root node to the added L, shown in (23b):

(23) a. *Intensive edge lengthening of FINE*



b. *Phrase-final lengthening of FINE*



By positing that trill is associated directly to the root, as I do here, two interrelated possibilities are brought to our attention. First, the representation draws a parallel with spoken language, in which the feature [sonorant] has been argued to be part of the root node. In ASL, the [trill] feature, which is seen as adding sonority, is attached to the root. Second, it follows that the sonorous feature [trill] does not spread unless the entire segment spreads, as in PFL.

8.2.4 *Syllable-level vs. phrase-level sonority shape.* The two analyses of different lengthening phenomena reveal an interesting asymmetry between syllable-level sonority shape and phrase-level sonority shape. The behaviour of [trill] at the syllable level reported here reinforces the view that ASL syllables observe a rise-fall sonority cycle. The PFL phenomenon described by Perlmutter indicates that this cycle can be violated by higher, phrase-level considerations, flattening out the cycle at the right-most edge. The elaborated formal representation proposed here makes it possible to express this asymmetry. The possibility that this flattening may interact with intonational patterns is left to future research.

## 9 Summary and conclusions

The primary aim of the present investigation is to support the claim that the two segment types proposed to exist in sign language are organised in sign syllables in such a way as to constitute a sonority cycle. It is argued that signs tend to conform to a single, LML syllable shape, comparable to CVC. A Sonority Distance Maximisation Principle is proposed, to explain the association and behaviour of rapidly repeated hand-internal move-



ment, represented by the feature [trill]. [trill] associates in such a way as to *maximise* the sonority cycle, and it fails to spread under morphological lengthening so as to *maintain* the maximal cycle in LML signs. The same principle also explains the *creation* of a sonority cycle in L signs, when additional segment slots are added under lengthening. The SDMP is argued to have the desirable consequence of providing an explanation for the survival of contacting Ls at the edges of reduced compounds.

The analysis and its formal instantiation unify signs with plain internal movement and signs with trilled internal movement, in such a way as to account for the lengthening of finger positions but not of the intervening movement (path, internal and/or trilled). It also formally unifies trilled movements that are oscillations between two finger positions or orientations with those that are non-discrete finger wiggling, explaining the identical patterning of trills in both sign types. Finally, the formal structure introduced here makes it possible to discern differences between the sonority shape of syllables and of phrases.

In the course of the exposition, it has also been demonstrated that ASL signs have both linear and non-linear structural properties, hierarchically organised phonological features and morphological and phonological rules.

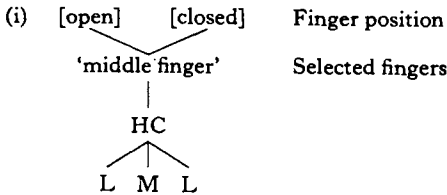
## NOTES

- \* I am grateful to Harry van der Hulst for discussions of and comments on the material dealt with in this paper, to Keren Rice for detailed comments and to Carol Padden for insightful discussions of the lengthening phenomena. I also thank David Perlmutter and the *Phonology* reviewers for comments. This article is based on a paper presented at the first Holland Institute of Generative Linguistics Phonology conference (HILP! 1) in January 1993. Thanks are due to participants of that conference for their comments and questions.

Illustrations of the signs INTELLIGENT, LIKE, UNDERSTAND, COLOR and DREAM are from *A basic course in manual communication*, National Association of the Deaf Communication Skills Program (T. J. O'Rourke, Director) (1973), Silver Spring, MD: National Association of the Deaf. The illustration MIND + DROP = FAINT was supplied by Geoffrey Coulter. The sources of other illustrations are cited near the illustrations in the text.

- [1] These categories went by the names of TAB (tabulator), DEZ (designator) and SIG (signifier), respectively, in Stokoe's work.
- [2] See Wilbur (1993) for a theory of ASL phonology involving linearity without segmentation.
- [3] (2) differs from Sandler (1987b, 1989a). In the earlier model, place and setting were represented as sisters. The revision follows the convention of feature geometry (e.g. Clements 1985; Sagey 1986) that features that are refinements of more general classes are represented as subordinate to them.
- [4] I follow the theories of Clements (1985) and Sagey (1986) in positing a root node at the highest level of the feature hierarchy, that 'holds together' all features of a segment. Some other characteristics of the root are explained in §6.
- [5] Such signs are sometimes referred to as signs with local movement or signs with handshape change. Note that signs with orientation change are also called IM signs by some investigators (including myself), since they seem to behave the same as signs with finger position change. For simplicity, I will only be dealing with handshape change IM, and not with orientation change IM.
- [6] A number of phonological and morphological phenomena require finger position

to be part of the autosegmentally represented HC category underlyingly, rather than part of the location category, elaborated in Sandler (1987a, b, 1989, 1993a). For those reasons, signs with IM – two finger positions or two palm orientations – are underlyingly represented as contours, associated to the HC class, and through HC to the LM tier, as shown here for the sign LIKE:



However, certain later morphological processes affect the position features independently, and, crucially, together with location features. These phenomena motivate the linearisation of finger position features under L segments within the lexical phonology (Sandler 1989b, 1993a). This underlying representation is linearised to the representation shown in (3).

- [7] The particular hierarchical relationship between the setting and finger position classes is motivated by a late assimilation rule reported in Corina & Sagey (1989), in which finger position assimilates without location features, across word boundaries.
- [8] The morphology of Israeli Sign Language offers a third good reason for positing a movement element in a universal model of sign language structure. To form the Intensive in this language, the movement segment is lengthened. This contrasts with another process in the same language, Continuative aspect, which lengthens location (Sandler 1993c).
- [9] This representation contrasts with my earlier work, and with the model proposed by Perlmutter (1992, 1993), in which all signs with no path movement are represented with no M segment. The representation adopted here for such signs is similar in segment structure to that of Liddell & Johnson (1989). A discussion of the range of facts motivating this change is beyond the scope of this study.
- [10] It is argued in Brentari (1990) that there is another L-type sign. Signs such as THINK and HAVE involve movement to contact with a location on the body. In the signing stream, there is no clear first location, and therefore no underlying first L. Brentari claims that an initial movement is epenthesised. I adopt this view, but make the added claim that an initial location is epenthesised as well.

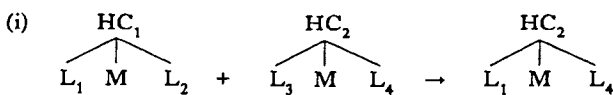
In citation form, as well as utterance-initially, these signs do have specific, non-random, initial locations, that are redundantly determined by the second location and the orientation of the hand. It has been suggested to me by Keren Rice that this is similar to a situation in which a glide is inserted syllable-initially, and its quality is determined by the following vowel. This redundant specification of an L can be seen in other parts of the grammar in which an underspecified location is added by the morphology to the beginning or end of a sign (Sandler 1989a). Therefore, THINK-type signs are seen here as LML in structure.

- [11] The term 'trill' was first used in Padden & Perlmutter (1987) for a somewhat larger set of rapidly repeated movements.
- [12] There are certain exceptions in derived forms. One is protracted aspect (noted also in Brentari 1990 and Perlmutter 1992, 1993), which involves holding the hand static for a long time with no movement. Another is a root used in the classifier and verbs of motion system, meaning 'be located at' (Supalla 1982). At present, I am exploring the possibility that changes in facial expression or gaze, which accompany such derived forms, may be the dynamic elements that serve as syllable nuclei.

Brentari *et al.* (1993) report articulatory evidence that the purportedly epenthesised Ms in signs like THINK and SICK (see note 10) are qualitatively

different from non-phonological transitional Ms between signs. Such evidence points to the phonological necessity of epenthesis Ms where they do not exist underlyingly.

- [13] It was suggested by a *Phonology* reviewer that a more detailed discussion of the relation between visual perception and motion is necessary to strengthen the claim that movement is salient in sign language. It is certainly true that such a study is required in order to develop a comprehensive biological-linguistic theory of sign language. At the same time, it should be noted that numerous constraints and rules of syllable structure have been stated for spoken language, although a clear acoustic or perceptual correlate to sonority in spoken language has proved elusive.
- [14] A *Phonology* reviewer took exception to the use of the term 'sonority' for sign language: 'It strikes me as being glottocentric to extend the term... that clearly has to do with sound in a cavalier fashion to sign', and suggested instead 'salience hierarchy' or 'perceptibility hierarchy'. The spoken language terms are used here analogically. I view as an empirical question the extent to which the notions onset, nucleus, coda, sonority and syllable have the same character in signed as in spoken language.
- [15] The representation of (11c) is different from that proposed in earlier work. See note 9.
- [16] Some of these movements are called secondary movement by some researchers. For Liddell (1990) and for Brentari (1990, this volume), secondary movement includes rapidly repeated handshape or orientation change, wiggling, circling and path movement. Perlmutter (1992, 1993) includes only wiggle and circling as secondary movement. I do not include circling here as a type of TIM. In some signs, there are alternants, such that circling is achieved either by rotation at the wrist or by displacement of the whole hand in space, creating a path movement, an alternation that does not exist with TIMs. Also, though it is generally the case that two types of TIM do not cooccur in a sign, circling cooccurs with wiggle in the sign MULL-OVER. I suspect that circling does not behave like TIM or IM under lengthening. However, since I do not have the relevant data, I leave the correct classification of circling to future research.
- [17] This representation for wiggle signs resulted from a discussion of the issue with Harry van der Hulst. In earlier versions of the Hand Tier model (Sandler 1989a), wiggle signs were unified with oscillation signs by the feature [tense]. That version differed from the present one in two ways: (i) [tense] was associated to the HC node and (ii) wiggle signs were represented with a [wiggle] feature in addition to [tense].
- [18] This consequence was pointed out to me by Keren Rice.
- [19] This asynchronous behaviour of HC *vis-à-vis* the LM tier provided motivation for the autosegmental representation of HC which characterises the HT model (Sandler 1989a). Below is a schematic representation of a typical deletion of this type:



- [20] Perlmutter (1992, 1993) represents handshape as an autosegment, and handshape changes as a contour, similar to the HT representation (discussed in detail in Sandler 1987a, b, 1989a). Temporal alignment of the two finger positions in signs with handshape change is accomplished differently in the two models, however. In the HT treatment, the finger position features are delinked from the hand configuration node, and linearised under locations in advance of the lengthening and certain other morphological processes, dealt with in Sandler (1989b, 1993a). In the moraic analysis, the two branches of the contour are underlyingly linked to morae.
- [21] The structure of GO-UP-IN-FLAMES is assumed to be MP in the moraic model,

while it is represented in the Hand Tier model as LML. Since the hands must obligatorily begin at waist level regardless of the location of the preceding sign, it is not clear to me why the moraic model represents the sign without an initial P. Other syllable shapes argued for in the moraic model – PM and M – are viewed in the Hand Tier model as LML syllables with underspecified locations, whose features are filled in by agreement morphology (Sandler 1987a, 1989b). The MP signs of the moraic model are analysed in the HT theory as LML (PMP) signs as well (see note 10).

- [22] As its name suggests, Perlmutter's moraic theory represents all length distinctions with morae, and does not include skeletal slots. The HT model is skeletal, with L and M slots standing for sequential positions as well as timing units. Skeletal slots are motivated by a range of processes (see, for example, §2.1 of this article). In spoken language, the main motivation for morae is an onset–rhyme asymmetry for weight-related phenomena. This sort of evidence appears to be lacking in ASL phonology. In all cases that I am aware of, the mora is a notational variant of the skeletal slot in sign language.

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