Phonology 10 (1993) 209–241

*Units in the analysis of signs**

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1 Introduction

1.1 Goals

The assumption that there is a common set of linguistic principles underlying both spoken language and sign language phonology, which forms part of the human language capacity, is shared by most phonologists working on sign language. See Sandler (1993a) for an extensive discussion of these issues. But even though this assumption is reasonable, since both spoken and signed languages are products of the same human brain and fulfil the same function, it is not clear that theories of representation which have been proposed for spoken languages can be directly applied to the structure of sign languages. Such representations have been developed on the basis of the spoken language modality only. They are often so close to the phonetics of spoken languages that we cannot rule out the possibility that non-trivial aspects of them are modality-specific.[1] Therefore, rather than, for example, attempting to test various competing (spoken language-based) theories of syllable structure, we must first investigate the structure of sign language in its own right. This strategy need not be pushed too far, however. In developing a model of signs we can benefit from general principles which have proved successful in the study of spoken languages, especially if these principles do not seem to be directly based on 'spoken phonetics'.

In this article I will propose a model for the phonological representation of signs which is based on such general principles. These principles involve the claim that constituent structure for linguistic objects is HEADED and BINARY, and that one unit can be the head of successively more inclusive constituents. My goal will be to show that (a) well-established (although not always undisputed) empirical generalisations regarding the structure of monomorphemic signs (largely based on studies of American Sign Language) and (b) theoretical proposals regarding the hierarchical organisation of signs (in the spirit of feature geometry) can both be accommodated in a model which adopts a perspective on linguistic structure which is guided by these principles.

1.2 The basic insight

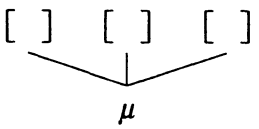
The insight that sign languages have a DUAL STRUCTURE, i.e. that basic signs can be further analysed in terms of a set of non-meaning-bearing

distinctive properties and rules manipulating these, is a fairly recent one. Stokoe (1960) proposed to decompose basic signs in American Sign Language (ASL) into three 'aspects' or parameters, which, like distinctive features, bear no meaning in isolation, i.e. by themselves they do not qualify as minimal meaning-bearing units or morphemes:

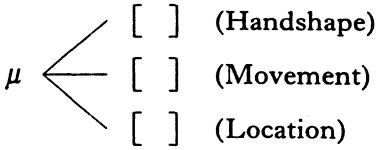
(1) a. Handshape
    b. Location of the hand
    c. Movement of the hand

Each of these three parameters, Stokoe argued, has a fixed number of values. To avoid underestimating the difference between spoken language and sign language, Stokoe referred to the parameters Handshape, Location and Movement as CHEREMES and to the study of their combinations as CHEROLOGY. Other researchers, however, including Stokoe himself in a later edition of his study (1978), used the terms PHONEME and PHONOLOGY. The idea then became prevalent that Handshape, Location and Movement are the formal analogues of the phonemes which make up morphemes in spoken languages. This claim was based on the insight that the three units seemed to constitute morphemes in the same way as phonemes in spoken languages constitute morphemes.[2] The main difference between spoken languages and sign languages was claimed to involve the presence of linear order among phonemes in the spoken language and its absence in sign language (μ = morpheme, [ ] = a phoneme or set of specifications representing a particular Handshape, Movement or Location):

(2) a. *spoken language*



b. *sign language*



Subsequent research has led to a somewhat different organisation of the relevant properties. One of the earliest changes is due to Battison (1978), who proposed to regard ORIENTATION (of the palm)[3] as a separate parameter; this has been accepted by most researchers.

In the next section, I will discuss a number of further developments of Stokoe's insights. These involve, on the one hand, the introduction of linear order and, on the other hand, further refinements of the parameters and the structural relations that hold between them. In §§3–5, I will present an alternative model of sign structure. §3 focuses on the feature content of signs, and argues that the structure of signs is essentially like that of a single feature tree, which in spoken language phonology is used to represent a single (possibly complex) segment. In §4 I consider the representation of the linear aspects of signs. Here my conclusion will be that signs have a 'reduced' form of syllable structure which does *not* have an analogue in the consonant–vowel distinction of spoken languages. This

point is further discussed in §5, where I argue that syllables in sign structure lack ONSETS at the phonological level.

My proposal is to some extent a reinterpretation and specific combination of claims and ideas that have been proposed in the literature, which I will refer to as I proceed; most of this literature deals with ASL. This reinterpretation follows from an attempt to base the model on principles of (recursive) headedness and binarity. At some points these principles force me to make decisions which lead to predictions which need to be further tested against new data.

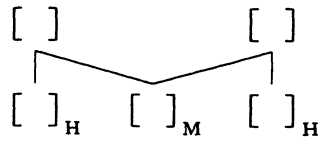
2 Developments of Stokoe's model

In this section I discuss a number of the major distinctions which any model of signs must be able to accommodate. Not all of these distinctions are uncontroversial and, moreover, not all aspects of the sign are represented in the present discussion. The following discussion, however, provides the basis for the construction of a (partial) model of signs.

2.1 Segmentation and sequentiality

The claim that the organisation of signs involves a number of simultaneous phonemes was questioned in Liddell (1982, 1984). He argued that signs involving a movement must be analysed as involving a starting point and end point, i.e. HOLDS (H), with a MOVEMENT (M) in between. A simplified representation of his proposal is given in (3):

(3)



Diagrams such as (3) are familiar from the early autosegmental literature, where, for example, the upper tier might represent tones and the lower tier all other features. In Liddell's model, the upper tier is referred to as the ARTICULATORY TIER. Handshape, orientation and place are represented on this tier. The lower tier is the SEGMENTAL TIER. Most of the features on this tier are relevant for M segments only, as they express various aspects of the movement part of the sign, e.g. the shape of the movement, whether the hand touches a body part during the movement, etc.

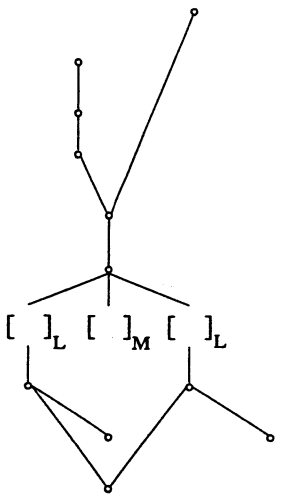
The movement unit can be either a PATH MOVEMENT, resulting from the hand moving from one location to another, or a LOCAL MOVEMENT, resulting from a change of handshape or orientation; this distinction is discussed in §2.2.1. Most of the arguments in favour of distinguishing between Hs and Ms come from signs with path movements. These arguments mainly rest on the claim that morphological rules of agreement or phonological rules of deletion or metathesis can only be formulated if

reference can be made to the beginning or end point of signs. These arguments, then, present evidence for the need to make reference to the H units, which represent these points. The arguments for the M unit are of a somewhat different form. In this case the main point is that there can be distinctive types of Ms. The features needed to express such distinctions (involving the shape of the movement or whether or not there is contact with a place during the movement) must be stated somewhere, and the claim is that they are stated as part of, or associated to, units which are on a par with Hs. Distinctions among movements are discussed in §2.2.2–3.

Further developments of this model can be found in Liddell & Johnson (1986, 1989) and Liddell (1990). Liddell (1990) suggests that *all* features (which were grouped in the articulatory bundle in the earlier model) can be represented on independent tiers. This means that if a property, e.g. place, is constant for the whole sign, it is specified only once, with association lines linking it to all H and M units while, at the same time, a property such as handshape may change and be represented as in (3).

Adopting, with important differences,[4] Liddell's proposal for sequential ordering, Sandler (1986, 1987, 1989) introduces an autosegmental model which incorporates the proposal for a geometrical organisation of autosegmental tiers in spoken languages (Clements 1985; Sagey 1986; McCarthy 1988). The application of geometrical phonology specifically involves a proposal that the HANDSHAPE and PALM ORIENTATION nodes are grouped together under a common node, HAND CONFIGURATION. This node associates to the sequentially ordered units, to which PLACE also associates. Hand Configuration and Place are not grouped together on any tier (except the skeletal tier to which all features or feature groups associate). The following diagram represents Sandler's claims, but suppresses some of the details in the structures she actually proposes (cf. Sandler 1989: 46, 102):

(4)



Palm orientation

Position

Fingers

Handshape

Hand configuration

ROOT

ROOT

Setting

Place

As can be seen in (4), Sandler proposes to analyse Handshape in terms of parameters involving nodes specifying which fingers are selected and a node Position, which refers to the relation between the fingers and the thumb.[5] I will refer to Position as APERTURE, since the main dimension involves the degree of opening between the selected finger(s) and the thumb.

Sandler's arguments for the grouping and further subdivision of the nodes Finger and Aperture/Position and the dependency relation between them will be discussed in §3. Another aspect of (4) that will be further discussed below is the distinction between Place and Setting.

Sandler motivates the use of autosegmental tiers for Hand Configuration and Place by pointing out that these aspects of signs have a 'once-per-morpheme' distribution, i.e. they are like prosodies (in a Firthian sense) whose domain is the morpheme. Sandler assumes that if these units are represented on autosegmental tiers, they are expected to have the entire morpheme within their domain, i.e. to have wide scope. It is important to realise, however, that an autosegmental treatment of such properties does not automatically entail wide scope. Although the autosegmental model allows the expression of wide scope, it is not the case that features which are autosegmental *necessarily* spread over a whole domain.[6]

Let us now discuss Sandler's claim that Hand Configuration and Place have a prosodic character. I will argue that the constraints that are involved here are *not* directly applicable to the morpheme, but rather to a phonological unit, the nature of which will be discussed in §5. The apparent appropriateness of using the morpheme as a domain will disappear once we realise that there is another constraint on the phonological structure of morphemes, which is that monomorphemic signs tend to consist of just one such unit, just as some spoken languages tend to have mainly monosyllabic morphemes. Brentari (1990), in fact, argues that the constraints indeed apply to a unit that she labels syllable, thus implying that the situation in ASL is exactly parallel to what we find in such spoken languages. The position that the syllable is a relevant category for ASL (or sign languages in general) goes back at least to Chinchor (1978), and has been defended by various other researchers. My own conclusion will not be in disagreement with this position, but my conception of the syllable in sign language will be different from what these researchers have proposed.

If we claim that Hand Configuration is a constant, we must address the fact that there are many monomorphemic signs which involve what at first sight may be called a 'changing' Hand Configuration. For example, the Sign Language of the Netherlands (SLN) signs in (5), exemplified in Fig. 1, appear to form counterevidence to the claim that Hand Configuration is prosodic:

(5) a. FREEZE, NICE, GO-OUT, ACCEPT, etc. (change in Aperture)
b. SATISFIED, DIFFICULT, BEGIN, etc. (change in Palm Orientation)

Such signs are not counterexamples, however, if we make the claim more precise. We saw above that the Hand Configuration node contains three

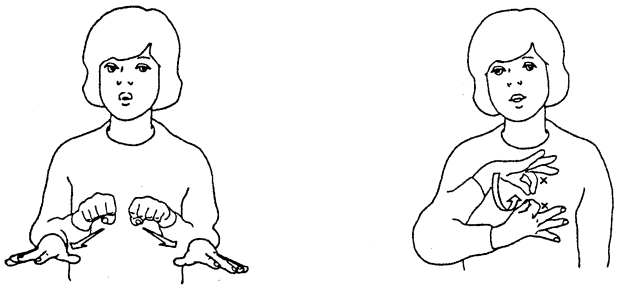


Figure 1
SLN FREEZE (left) and SATISFIED (right)

places of information: (Selected) Fingers, Aperture (Sandler's Position node) and Palm Orientation. The signs in (5a) and (5b) are characterised by changes in Aperture and Palm Orientation, respectively. What remains constant in all these signs is the value for the Selected Fingers parameter;[7] this was first observed in Mandel (1981). The change during the signs lies *not* in the selection of the fingers, but rather in the relation between the thumb and the other selected fingers, which goes from non-contact to contact, i.e. from open to closed (or *vice versa*), or in the orientation of the palm.[8]

Sandler represents change in Aperture or Palm Orientation in terms of branching nodes. The Aperture node, dominating two features, say [open] and [close], is interpreted as an aperture change, as is Palm Orientation (cf. note 7). In both cases, then, the beginning and end point of the change is a well-formed and independently occurring Hand Configuration, but, crucially, morpheme-internal transitions from one Hand Configuration to another are limited to cases which can be represented in terms of a branching Aperture or Palm Orientation node.[9]

The only Hand Configuration-internal node, then, that may *not* branch in Sandler's model is the Selected Fingers node. If we were to have a morpheme-internal change in Selected Fingers, Sandler would assume that *two* completely distinct Hand Configurations are involved. Her model does not exclude such a state of affairs, but since two Hand Configurations involve greater complexity than one, the model explains the unmarked status of morphemes which have no change in Selected Fingers. An example is the ASL word JOB, which consist of a sequence of a 'J'-handshape and a 'B'-handshape. Such a form is based on the fingerspelling system and it is generally recognised that it deviates from the normal pattern (Ronnie Wilbur personal communication).

Accepting the empirical basis for the prosodic status of Selected Fingers, we should note that Sandler's model does not offer a principled explanation for why the Selected Fingers node is so 'special'. In any event, we may conclude that Selected Fingers is indeed different from Palm Orientation and Aperture, in that Selected Fingers is invariant. I

will return to this issue, suggesting that invariance may be a trait of heads, but first I turn to the second claim, i.e. that a monomorphemic sign has at most one Place.

The claim that each morpheme can have just one Place specification may seem surprising, in view of the fact that many signs involve a movement of the hand along a path. In this case too, the claim must therefore be made more precise. Following Kegl & Wilbur (1976) and Battison (1978), Sandler (1989) argues that we must distinguish between MAJOR PLACE distinctions (such as head, trunk, weak hand and neutral space) and minor distinctions, which she calls SETTINGS. Settings subcategorise major place, just as features like [anterior] subcategorise the Coronal node in spoken language models. If a path movement occurs, this is typically the result of specifying two settings, one for each of the two Location units. Major Place, however, is represented as associated to both Location units of the sign; cf. (4). Thus, by separating Setting from Major Place, it can be maintained that each sign has a single Major Place specification even if there is a path movement.[10] It would seem that the prosodic status of Place is adequately *represented* in Sandler's model, but not strictly speaking explained (cf. note 6).

I will assume that the two constraints just discussed are 'real', even though there are signs which appear to violate them. Such signs frequently come from fingerspelling (cf. ASL JOB above) or represent (diachronic) compounds of which the composing morphemes simply had two different handshapes or places. In spoken languages, too, hidden or frozen compounds often violate valid phonotactic constraints. From a synchronic point of view, such forms violate common constraints on the phonological shape of morphemes. They can be represented, but their representation is more complex than that of lexical items which adhere to the two constraints.

To conclude this section, I discuss briefly the status of Location and Movement units. In what sense is it appropriate to refer to these units as *segments*? In autosegmental models of spoken language, segments in the sense of Chomsky & Halle (1968) have ceased to exist. Autosegmental phonology has developed from a model in which some features were placed on independent tiers, leaving the remaining ones on a 'segmental tier', to a model in which all features are granted this status (cf. note 6). It seems to me that such a generalised autosegmental model *must* provide a tier which has anchor points for all features. The reason for this is simply that without such a tier there is no way of representing how features on different tiers must be 'linearised'. I will adopt the familiar term SKELETAL TIER for the sequence of anchor points, since the tier containing these points serves the same purpose as the skeletal tier in spoken language models. The necessity of a skeleton is primarily, but not exclusively, motivated by its coordinating role in the linearisation of phonological 'content'.

The L and M segments in Sandler's model (and their equivalents in other models) have been compared to C and V units in spoken language

models, perhaps most explicitly in Perlmutter (1992), but the need for a skeleton is not dependent on the validity of this comparison. Even if we were to decide that the L/M distinction is unnecessary, e.g. by abandoning M as a primitive (a position that I will discuss in §4), it would still be the case that the remaining units (which would no longer need a categorical label) must fulfil the same coordinating function as skeletal units in autosegmental models of spoken language. Wilbur (1993), who argues against segments in the representation of signs, therefore also postulates 'skeletal units' which coordinate the features on the autosegmental tiers. As in spoken language models, if phonological and morphological rules make reference to the skeletal units, this lends further support to the skeleton, but such rules are not crucial in the motivation for a skeleton. The existence of such independent motivation may, however, help in deciding whether the skeleton is merely a part of the phonetic interpretation or belongs to the phonology proper.

We might refer to these units (both in models of spoken and signed language) as segments, but it will perhaps be less confusing if we simply use the term skeletal units. The term segment could also be used for other units which are not features, e.g. the node that groups features for Selected Fingers and Aperture, but this again can only lead to confusion, since such class nodes (Clements 1985) do not correspond to segments in the traditional sense of the word. In §3, I will (re)introduce the term segment for the feature tree which represents the featural content of signs.

2.2 Types of movements

2.2.1 *Local movements and path movements.* The preceding discussion has made clear that we can distinguish various types of 'activity', e.g. path movement (involving one place and two settings) and, in addition, aperture and orientation change (cf. Wilbur 1987 for a discussion of this three-way distinction). I adopt Liddell's term local movement for the latter two (e.g. Liddell 1990), to give (6):[11]

(6) a. Path movement
    b. Local movement
        i. Aperture change
        ii. Orientation change

In cases of combination there is typically complete synchronisation of the starting and end points of the activities involved. Hence it is untypical to execute an aperture change at the starting or end point of a sign which has a path movement, although such cases are not completely absent. In SLN PURSE, for example, there is a closing aperture change at the end of a path (Els van der Kooij personal communication). In this two-handed sign the index finger and thumb are selected, to form an 'L'-handshape. The index fingers and thumbs of the two hands are in contact. Both hands move away from each other and at the end of the movement the selected fingers are

closed, i.e. the two hands are now in what we might call a closed 'Q'-handshape. Thus a rectangular figure is described.

The model I propose will not exclude such signs, but it will account for the fact that complete synchronisation is more typical. It will be clear, in any event, that such differences in synchronisation, and indeed the notion of synchronisation itself, requires a skeletal tier, which cannot be purely phonetic if linearisation can be contrastive.

2.2.2 *Secondary movements.* There is a further type of 'activity', usually referred to as SECONDARY MOVEMENT, as opposed to path and local movement, which are PRIMARY (cf. Stack 1988). The characteristic trait of secondary movements is a rapidly repeated activity, which can be executed during a path movement or while the hand is motionless, i.e. not moving along a path (cf. Wilbur 1987).

According to Sandler (1987, 1989), Stack (1988) and Liddell (1990), nearly all of these secondary movements can be analysed as ITERATED versions of local movements. Liddell excludes wiggling and circling from this treatment (cf. (7)), while Sandler (this volume) claims that only circling is not derived from a local movement. Stack (1988) argues that circling is derived from a path movement.

Following Liddell (1990) I will refer to the feature that distinguishes secondary movement from primary movement (whether local or path movement) in terms of a feature [oscillated]; Sandler uses the label [trill]. Secondary movements can be superimposed on signs with and without a path movement. This seems unproblematical for secondary movements which are derived from local movements like aperture and palm orientation change, since these form aspects of the sign which are independent of path movement. However, it is less clear how secondary path movement can be imposed on a primary path movement. I will make a formal proposal in §3.3.

The complete inventory and analysis of secondary movements is a matter of debate. Liddell (1990) and Stack (1988) provide the inventory in (7) for ASL. The secondary movements marked with an asterisk are lacking in Liddell's list; Stack provides non-iterated (primary) versions for these secondary movements, which are not included; a dash indicates theoretical options for which I have found no example in the cited sources:

(7)		without path movement	with path movement
a.	i. hooking	ANALYSE	CRAWL
	ii. flattening	STICKY	GOSSIP
	iii. releasing	SHIRK-RESPONSIBILITY	HATE (all of them)
	iv. squeezing*	ORANGE	—
	v. wiggling	COLOR	LONG-AGO
	vi. rubbing	DIRT	SPRINKLE-AROUND
b.	i. twisting	TREE	WAY-FAR-AWAY
	ii. nodding	YES	CRACK
	iii. pivoting*	WHERE	—

c.	i. circling	COFFEE	TRAVEL
	ii. swinging*	DRAW	SING

(7a.i–iv) can be analysed as [oscillated] versions of independently occurring aperture changes. Stack proposes that wiggling can also be analysed as a repeated counterpart of the local aperture change in ASL BEAUTIFUL, which has an articulation in which the fingers are folded one by one, starting with the pinky. It is not the case, however, that wiggling is an oscillation of this ordered folding. Wilbur (1993) and Sandler (this volume) propose to incorporate wiggling differently, as a 'default' realisation of [trill]. It may be that there is *one* secondary activity which functions as the default option. Corina (1990a) makes the interesting suggestion that wiggling and flattening are the same. Both can be (at least partly) identified as the same local movement (i.e. bending of the knuckles adjacent to the palm) and the difference can be attributed to whether or not the fingers are spread.

However, a problem for the proposal to derive all secondary movements involving finger activity from corresponding local aperture changes, with wiggling as a default option, is that wiggling may not be the only case in which no aperture change is involved. Secondary movements like rubbing and scissoring (not mentioned in either Liddell's or Stack's list) do not involve an aperture change and yet they cannot be classified with the (b) or (c) category either (Irene Greftegreff personal communication).

I will leave this issue for further research and continue to refer this node as Aperture. In §3.3 I will adopt the proposal to analyse the (a)-types as aperture changes plus the extra feature [oscillated].

Liddell presents evidence for morphological relations for the derived status of the (a)-type of secondary movements. ASL DOUBT has a non-repeated local movement of the fingers (i.e. Aperture change) from 'V'-hand to 'V'-hand/hooked fingers, while DOUBTFUL has repeated 'hooking'. The analysis is supported by the fact that the beginning and end handshapes in DOUBTFUL are identical to those of the sign for DOUBT.

Type (7b.i) can be analysed as a Palm Orientation change plus [oscillated]. Stack also includes nodding and pivoting in the (c) group, with local counterparts involving a single movement at the wrist (in a forward/backward or sideways direction). I will suggest in §3.3 that nodding and pivoting are [oscillated] versions of a dimension which is formally distinct from Palm Orientation, HAND POSITION (cf. note 8), but this does not affect the observation that these secondary movements have a non-iterated counterpart.

This leaves us with the type in (7c). Stack (1988) classifies circling in a single category with swinging. Both, she argues, are secondary versions of path movements. In §3.3 I will present an analysis of these secondary movements which is also dependent on the use of the feature [oscillated].[12]

2.2.3 *Further distinctions.* A complete discussion of the manual aspects of signs should address two further dimensions of variation, *viz.*

path movement types and the distinction between one and two-handed signs.

The inventory and analysis of path movements is a complicated issue and I will not attempt to offer a comprehensive discussion here. The point of departure is the simple path ab, where 'a' and 'b' represent Setting values. Many more complicated types can be analysed as concatenations of simple path movements, leading to a distinction between unidirectional path movements (ab) and bidirectional path movements (ab+ba). The latter can presumably be expressed as (inverted) reduplications of the skeleton. Bidirectional paths must be distinguished from non-inverted reduplications, which lead to a repeated unidirectional path movement (ab+ab) (cf. Padden & Perlmutter 1987 for a brief but insightful discussion of these differences).[13]

Another aspect of path movement involves the SHAPE of the movement. Path movements can follow a straight line or a curved (or arced) line (cf. note 11). This distinction is primitive in the sense that it does not seem likely that we can derive one from the other and it therefore will play an important role in the discussion of the need to recognise M units on the skeleton. I will return to this distinction in §3.3.

The second distinction, which I will discuss only briefly, involves the fact that many signs use both hands rather than just one. Here we must make the further distinction between two-handed signs in which the non-preference hand can be seen as a (major) place and those in which both hands have equal status. Padden & Perlmutter (1987) use the terms strong and weak hand rather than preference and non-preference hand. The preference hand will normally be the strong hand, but this is not essential. I propose to refer to signs in which the weak hand is a place as UNBALANCED, while the other type is BALANCED. The distinction between the two was first discussed extensively in Battison (1978). The idea that in the former case the weak hand is a place can be attributed to Stokoe (1960), and an explicit defence and exploration of the consequences of this view are found in Sandler (to appear a). In such cases we predict that unbalanced signs are always produced in neutral space, if we assume that the non-preference hand fills the place specification (cf. Perlmutter 1991). This prediction appears to be correct. There are hardly any unbalanced signs in which both hands are positioned at, for example, the head. In balanced signs, then, both hands fulfil the same function (i.e. neither is the place). The shape, orientation and movement of both hands is either identical (parallel) or symmetrical. What must be absolutely identical in balanced signs is the handshape, i.e. the selection of fingers and the aperture specification.

2.3 Summary and preview

In the preceding sections I have reviewed the major aspects of the phonological organisation of signs and of the theoretical proposals relevant in the context of this article.

We have seen that Stokoe's original idea, which was that all aspects of the sign are phonologically unordered, has been replaced by the theory (a) that these aspects can be interpreted as autosegmental tiers and (b) that there is linear order on at least one of these tiers, the skeletal tier.

Sandler, in particular, has proposed that the autosegmental tiers can be grouped, applying insights from geometrical phonology. She also draws attention to the fact that there are severe limitations on what may change during the articulation of monomorphemic signs. The constraints she discusses are interpreted as syllable structure constraints by Perlmutter (1992). The essential observation is that the selected fingers *and* the choice of major place are typically invariant.

Several issues concerning movements have been discussed. A distinction was drawn between primary path movements and primary local movements, and secondary movements were introduced. The feature [oscillated] was argued to be motivated for secondary movements by the fact that a fair number of these movements can be analysed as repeated versions of local movements. We mentioned various types of path movements, stressing the primitive nature of the distinction between straight and arced path movements.

The last major issue was the distinction between one-handed and two-handed signs. In the latter category two types were distinguished: balanced and unbalanced.

In the following sections I will propose a (partial) model for the phonological representation of signs which builds on the models of previous researchers, but differs from all of them. The differences lie in the consistent application of a head–dependent relation wherever units can be said to form constituents. My claim is that a head–dependent labelling forms the basis for explaining how particular nodes behave with respect to being able to branch or to spread (§3). An important difference between my proposal and, for example, Sandler's will be that the movement units will be removed from the inventory of primitives (§3.2). In §4 I will recognise the skeleton, but argue that there is only one type of unit occurring there (equivalent to L in Sandler's model).

3 Signs as single segments

3.1 Background

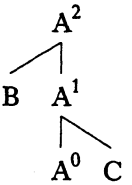
I start with a brief discussion of the notions constituent structure, headedness and binarity. My goal is to show the reader that the proposed structure of signs is entirely in line with well-documented and widely accepted views on the structure of representations in other domains and modalities (e.g. theories of morphological, syntactic and phonological structure in spoken languages, as well as morphological and syntactic work on sign languages). The point I wish to make is that these views can be fruitfully applied to the structure of signs.

A prevalent view of the structure of morphosyntactic and phonological representations is that all units (except those that are considered primitive) are exhaustively analysed in terms of sub-units which collectively determine all of their properties. Units, then, can be characterised in terms of an 'IS A' relation; each unit X IS A concatenation of a number of smaller units. Let us call this the CONSTITUENCY PRINCIPLE. Such a view of the organisation of complex structures can be properly expressed in terms of rewrite rules, graphically displayed as trees.

Particular subsets of the set of possible tree structures are often argued to most appropriately express syntactic constituent structure. Firstly, it has been proposed that the node label of a constituent must be categorically identical to the labelling of one of its daughters – specifically, the daughter that is obligatory and lexical. I refer to this as the HEADEDNESS PRINCIPLE. Secondly, it has been argued that linguistic representations involve binary branching nodes, either as the upper limit or as the only possibility (thus excluding non-branching nodes). This is the BINARITY PRINCIPLE. A combination of these claims leads to the exclusive use of binary headed tree structures.[14]

Virtually all work in generative syntax argues, directly or indirectly, for the headedness principle, and some also espouses the binarity principle (e.g. Kayne 1984). A further widely accepted aspect of syntactic constituent structure is that one unit 'may function as head of successively more inclusive constructions' (Anderson & Ewen 1987: 95); I will refer to this as recursive headedness.

(8)



The relation that holds between heads and dependents may differ, according to how close the structural relation is. Structural closeness (which can be measured in terms of the number of nodes intervening on the path going from one node to another) expresses the claim that the relation between A^0 and C in (8) is more 'intimate' (there is only one intervening node, A^1) than that between A^0 and B (which has two intervening nodes, A^1 and A^2). In syntax, the closest dependent is a unit which is 'directly selected' by the head (or for which the head is subcategorised). The presence of the node C may be obligatory, whereas the more remote dependent B is typically optional. (For further discussion of the relation between constituent structure and the head–dependent relation, as well as recursive headedness, see Anderson & Ewen 1987: 85–96; cf. also Halle & Vergnaud 1987: 8–9.)

Anderson & Ewen (1987), in particular, argue that the phonology of spoken languages can be analysed in terms of (recursive) headedness, with

a strong preference for binary structures. These principles have been widely adopted in other phonological models of spoken language. In metrical theory, binary headed structure has been postulated for foot structure (cf. Kager 1989; Hayes 1991). One level down, proposals have been made for assigning a binary headed constituent structure to the syllable (cf. Anderson & Ewen 1987; Kaye *et al.* 1990). Anderson & Ewen (1987: 96ff) explicitly claim that vowels are heads both of rhymes and of syllables.

A well-known problem arises when notions like head and dependent are applied to different modules (phonology and syntax) and, perhaps more so, to different modalities (spoken language and sign language). A characteristic trait of the head–dependent asymmetry, in both syntax and phonology, is that heads determine how the whole constituent combines at higher levels of structure. In syntax this means that heads determine the (categorial) properties of the whole constituent (i.e. a noun is the head of a noun phrase). In phonology, headedness often corresponds to the notion of 'prominence'. The head of a syllable is the most sonorous segment, the head of a foot is the stressed syllable, and so on for the higher levels of prosodic organisation. As in syntax, it is the presence of the heads rather than the dependents which is taken into account at higher levels of prosodic organisation.

Since I will conclude that monomorphemic sings essentially have a 'monosegmental' structure, I consider here in more detail the dependency interpretation of segmental structure, again referring to Anderson & Ewen (1987) for an extensive discussion of the matter.

In segmental structure, head features are more prominent: they make a greater contribution to the phonetic interpretation of a segment than dependent features. In Dependency Phonology, vowels consist of components such as [low] and [front]. In a combination of these two components either of the two may be the head. If [low] is the head, and [front] the dependent, the vowel is a low front vowel [æ], but if the relation is reversed, a mid front vowel [e] or [ɛ] is the result (cf. Anderson & Ewen 1987; van der Hulst 1989, 1993).

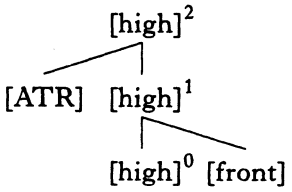
Intrasegmentally, a head–dependent relation is also postulated between groups of components (called GESTURES), for example between the set of place components and the set of manner components which is relevant for a particular segment type. Van der Hulst (1993) argues that the manner group is the head and the place group the dependent. The argument for this is the fact that the manner properties of segments are more important for the distribution of segment types in the higher syllabic organisation. Briefly, manner properties determine a segment's distribution to a much greater extent than its place properties do. This is typical of the properties of heads.[15]

Another relevant trait of the head–dependent asymmetry in spoken language segmental structure is that dependent properties can spread independently, whereas head properties cannot (van der Hulst 1993). Thus, when head properties are involved in a spreading process *all* features

which are dependent on the head spread as well. Since place properties can easily spread on their own (as in the numerous instances of nasals assimilating for place to neighbouring stops), this forms an independent argument for taking place to be the dependent group. This point is also supported in much work on feature geometry, in so far as the notion of dependency is adopted. In fact, dependency (formally expressed as the inverse of dominance; see Ewen to appear) is introduced in many cases to explain why certain features cannot spread independently (cf. McCarthy 1988). It is not immediately obvious how this diagnostic for headedness would apply to syntax, but there are many examples of syntactic (movement) operations or principles which crucially differentiate between heads and non-heads. It may ultimately turn out that the differences between syntax and phonology are caused by the fact that the modules, at least partially, make use of different types of operations to express relations between structural positions (i.e. movement *vs.* spreading).

Finally, van der Hulst (1993) argues that the notion of recursive headedness is relevant intrasegmentally within both the manner and the place groupings. This is based on the observation that not all components which have been identified as dependents show the same capacity to spread. For instance, the property [ATR] is much more likely to be involved in vowel harmony than components like [front] and [round], as is evidenced by the much wider distribution of tongue root harmony. To explain this, [ATR] can be represented as a structurally less close dependent than [front]/[round]. Van der Hulst (1993) argues that a high front [ATR] [i] vowel is represented as in (9), where the property [high] (representing the aperture or sonority dimension) forms the head:

(9)



The use of recursive headedness can be extended to other place components, and also to manner components. There is thus reason for believing that some version of X-bar theory is relevant in the realm of feature phonology.

One final point that should be made here is that the structures used to represent the featural organisation are usually not taken to express the relation of linear precedence, even in cases in which components are phonetically linearised on the surface (as in prenasalised stops, for example). Linear order is either phonetically absent or predictable from general principles. However, the suppression of linear order is not a specific property of feature trees. The crucial point is whether the linear precedence relation is predictable or not and, at higher levels of or-

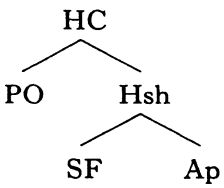
ganisation, whether constituency is assumed to be basic, so that linear order can be derived (cf. Anderson 1987).

Bearing these ideas in mind, let us investigate how a connection can be established between the headedness principle, recursiveness of headship, binarity and certain empirical observations regarding the structure of basic, i.e. monomorphemic, signs, in particular those discussed in §1.

3.2 The feature structure of signs

Our first task is to establish how the aspects Selected Fingers, Palm Orientation, Aperture and Place are structurally related. A grouping of the first three is proposed by Sandler (1989) (cf. (4)). This grouping has the properties of (10). I have replaced Sandler's dependency relation between Selected Fingers and Aperture by a sisterhood relation. Below, I will reintroduce her insight that Aperture is dependent on Selected Fingers:

(10)

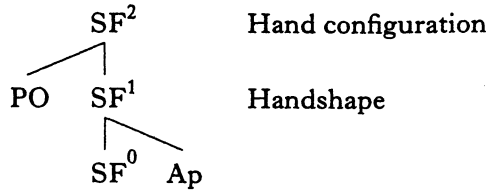


The proposal to group Palm Orientation (PO), Selected Fingers (SF) and Aperture (Ap) under a node Hand Configuration (HC) is supported by assimilation facts, which show that assimilation either involves the whole Hand Configuration or Palm Orientation only. There is no independent spreading of either Selected Fingers, Aperture or Handshape (Hsh). See Sandler (1987, 1989) for an extensive demonstration of this.[16] Her findings suggest that Palm Orientation is indeed the more remote dependent, assuming, as above, that more remote dependents spread more easily than closer dependents, and that heads do not spread independently of their dependents.

We have to establish which node is the head in (10). Palm Orientation is not a candidate, since it spreads independently. The choice, then, is between Selected Fingers and Aperture. A cue for viewing Aperture as the dependent comes from the fact that this node shares a property with Palm Orientation for which dependent status has already been established: just like Palm Orientation, Aperture may involve a change. For Selected Fingers there are no *changes* of this type, i.e. Selected Fingers represents a constant invariant property in monomorphemic signs (cf. §2). This observation puts Palm Orientation and Aperture in the same class and sets Selected Fingers apart. Hence the Selected Fingers node is the *only* node within Hand Configuration which specifies an invariant property. I tentatively propose that invariance is a trait of heads. In morphosyntax, too, heads are structurally simple as compared with their complements and specifiers.

These considerations and the arguments for grouping and dependency lead us to propose the following structure for Hand Configuration, which takes Selected Fingers as its (recursive) head:

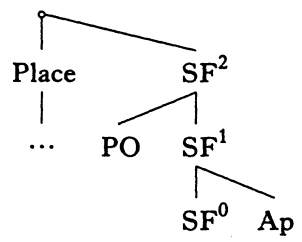
(11)



In this view, Selected Fingers must be characterised as a non-branching node, whereas the dependent nodes are allowed to branch.[17]

We now have to establish the relation between Hand Configuration (SF^2) and Place. More specifically, we have to determine which of these two is the head. The diagnostic for dependent status of Hand Configuration has in fact already been mentioned: Hand Configuration can spread. Sandler (1993b) claims that Place does not spread, unless total assimilation is involved. This evidence leads me to propose that (12) represents the structure of (monomorphemic) signs:

(12)



I now turn to a discussion of the internal structure of the Place node.

3.3 Against movement as a primitive unit

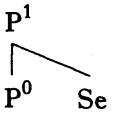
In our analysis, local movements (i.e. Aperture and Palm Orientation changes) do not involve a movement primitive. Rather, the activity results from the fact that there are two specifications for Aperture or Palm Orientation. I will now make a similar proposal for path movement. The obvious challenge for a movementless theory is to deal with properties which were formerly attributed to the M units. Among other things, these properties include various aspects of the shape of path movements (arc *vs.* straight path, wiggling, circling, etc.; cf. above) and whether or not the hand makes contact with the location during the movement.

Sandler (1989) represents the onset and the offset of a path movement as 'settings' which are associated to the Location units. The use of two settings to specify the onset and offset of path movements paves the way

for doing away with movement as a primitive. The presence of two settings, after all, necessitates a path movement.[18]

How, then, do we implement the idea of eliminating M and how do we express the properties which advocates of M-units attribute to these units? As a first approximation let us say that the Place node can have a dependent which I label SETTING (Se), using the term in essentially the same way as Sandler (1989):

(13)



Minimally, we need Setting features that specify the extreme points on three axes (cf. Stokoe 1960):

(14) a. ipsilateral/contralateral
b. forward/backward
c. upward/downward

The features representing the values on these axes can be interpreted as dynamic values like 'upward/downward', as suggested in Greftegreff (1992), rather than as static points. The presence of just one feature under Setting implies a movement, i.e. the *presence* of the Setting node (rather than its branching character) implies a path movement.

Assuming the dynamic interpretation, we must find a way of representing the Setting value of pathless signs. To specify just the Major Place is not sufficient in those cases; pathless signs select a particular setting within the Major Place. To represent pathless signs, I will assume that a single Setting feature is specified on the P^0 node, which receives a static interpretation (with the proviso that this static interpretation is a *target* that does not have to be actually reached under all circumstances). If we regard the dynamic interpretation as somehow 'weaker' than the static interpretation, we can say that the difference involved is a manifestation of the head–dependent status of the features: features in dependent position receive a weaker interpretation than (the same) features in head position. In van der Hulst (1989, 1993), I make the same claim regarding the interpretation of features in models of spoken language.[19]

As part of answering the question of how distinctive properties of movements can be accounted for in a theory that does not recognise movement as a primitive unit I now turn to a discussion of the representation of secondary movements.

For secondary movements which can be reduced to aperture or orientation change, I simply adopt the position of Liddell (1990) and Sandler (1989, this volume), and represent these by a single feature [oscillated], assigned to the Aperture or Palm Orientation node. The

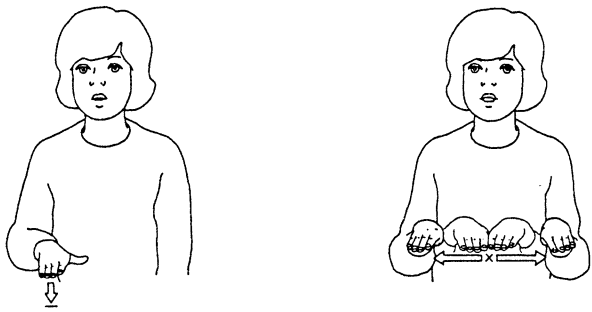
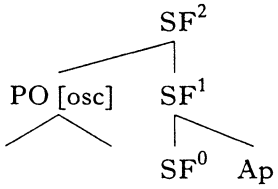


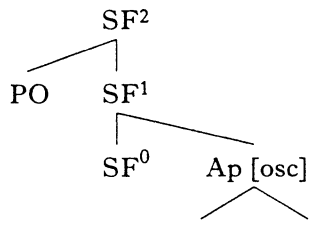
Figure 2
SLN CHILD (left) and BED (right)

phonetic interpretation of this feature is 'uncounted repeated local movement'. If neither Palm Orientation nor Aperture is branching, and [oscillated] is still assigned, the interpretation is wiggling (as proposed in Wilbur 1993 and Sandler this volume). Depending on whether or not the sign in question has a path movement, all these oscillated local movements will be executed on a path or *in situ*. (15) gives the representations of various types of secondary movements. In (15a, b) [oscillated] is specified on a branching node, whereas in (15c) neither Palm Orientation nor Aperture branches.

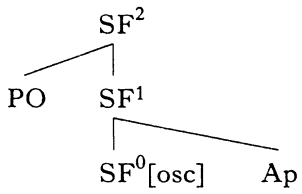
(15) a. *twisting*



b. *flattening*



c. *wiggling*

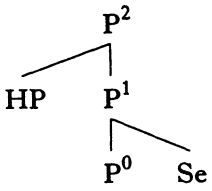


Two other secondary movements, nodding and pivoting, result from backward–forward and sideways activity at the wrist, respectively. In fact, nodding and pivoting can be seen as reduced versions of path movements. As in any movement, the palm or surface or a side of the hand 'faces' the

direction of the movement. I will refer to these possibilities, illustrated in Fig. 2, as FRONTAL and LATERAL position, respectively.

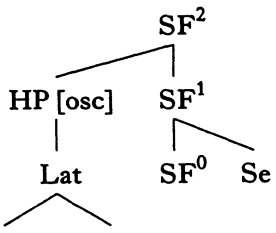
To accommodate this distinction, I propose a node, dependent on Place, which I will call Hand Position, which takes the nodes Frontal and Lateral as daughters. Each of these has two values, specifying the direction of lateral or frontal 'movement': for Lateral the values are pinky-side and thumb-side, whereas for Frontal they are backward and forward:[20]

(16)

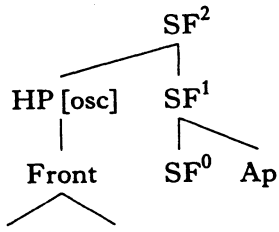


Any sign must have a specification for Hand Position. A branching node Lateral or Frontal under Hand Position, then, represents a local movement, pivot and nod. [oscillated] versions of these represent the secondary movements pivoting and nodding. Stack (1988) provides examples of all the logically possible cases. Again these secondary movements can occur on a path or *in situ*.

(17) a. *pivoting*



b. *nodding*



This account predicts the absence of the local movements nod and pivot as well as their secondary counterparts nodding and pivoting on a 'lateral' and 'frontal' path movement, respectively. A sign cannot, after all, be both Lateral and Frontal. While this seems correct for the local versions, one is inclined to reject it in the case of secondary movements: nodding on a lateral path movement or pivoting on a frontal path movement both seem easy to articulate.

The solution to this problem is that 'nodding' and 'pivoting' on lateral and frontal path movements can be interpreted as 'swinging', to which we now turn.

For swinging and circling, the two secondary movements that remain to be dealt with, I suggest that the dependent Setting node can also be marked as [oscillated]. Whether or not the sign is marked as [arc] (the location of the marking will be discussed below) will determine whether a movement is circling (with arc) or swinging (without arc). Swinging will

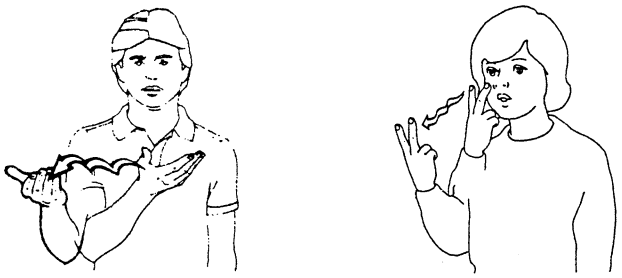
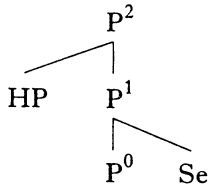


Figure 3
ASL THING (left) and SLN LOOK-FOR (right)

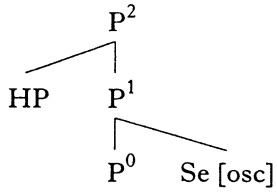
be frontal if the path movement is lateral and *vice versa* (Fig. 3). If there is no Setting node, i.e. no path movement, [oscillated] will be assigned to the P^0 node and this will give circling or swinging *in situ*.

This generates the following possibilities, reckoning with the presence or absence of a path movement and the fact that the sign is marked for the presence or absence of [arc]; I leave values for Hand Position, P^0 and Setting unspecified:

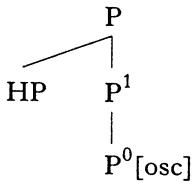
(18)



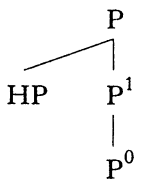
Marked with [arc]:
arced path movement
Not marked with [arc]:
straight path movement



Marked with [arc]:
circling on path movement
Not marked with [arc]: swinging
on straight path movement



Marked with [arc]:
circling in situ
Not marked with [arc]:
swinging in situ



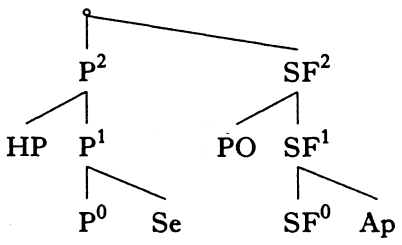
Marked with [arc]:
no movement
Not marked with [arc]:
no movement

We can now make the prediction that circling and swinging can occur on one path type only, e.g. we exclude the possibility of a contrast between

circling occurring on an arced path and circling occurring on a straight path. The presence or absence of [arc] is manifested in the secondary movement (circling or swinging) and can therefore not be used again for a specification of the primary path. As relevant minimal pairs do not seem to exist, the prediction appears to be correct.

The model we have proposed in the preceding discussion for the structure of monomorphemic signs is summarised in (19):

(19)

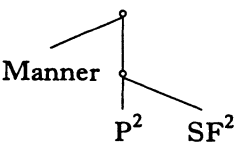


Any node may be marked for [oscillated]. Since no more than one node is marked in this way in any sign, some procedure for assigning it to a specific node must be developed, assuming that the feature is underlyingly attached to the root node. This problem is explicitly addressed in Sandler (this volume).

Representing path movements in terms of a branching P^1 node provides a basis for the claim (cf. Corina 1990b; Brentari 1990) that the 'sonority' (i.e. visual saliency) of path movements is greater than that of local movements, and lends support to the decision that Place is the head. The greater sonority of path movement is an instance of the greater impact that (properties of) heads have on the phonetic realisation of units.

We have shown how secondary movements are represented without the use of M skeletal positions. Let us now turn to the question of where features like [arc] are specified. Besides [arc], there are other features which are necessary to represent properties of movement, like the size of the movement and its 'speed'. I will assume, in the spirit of Ahn (1990) and Wilbur (1993), that a separate node will be necessary for such 'shape, size and speed' distinctions, and perhaps also properties like CONTACT, so that the representation of the monomorphemic signs will be as in (20):

(20)



Following Ahn (1990) and Wilbur (1993) I have labelled this node 'Manner'.

3.4 Summary

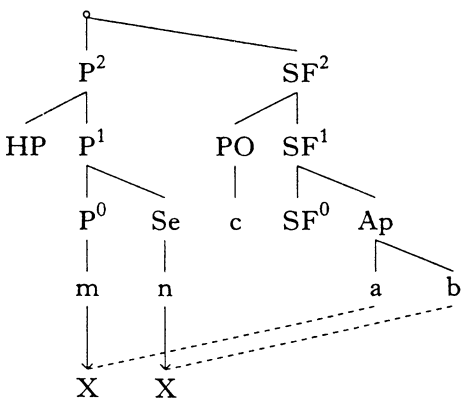
A structure like (19) or (20) is formally parallel to the structure of a single segment in spoken language, if we take the term 'segment' to represent a single feature tree. Most phonologists today accept the idea that phonological features for spoken languages are organised in a tree structure which replaces the 'unordered bundle' of Chomsky & Halle (1968). Phonological features can be grouped into classes, thus expressing the fact that these features are closely connected, as reflected in phonological processes. The formal similarity between (19) or (20) and single spoken segments *as represented* in current models is quite obvious. If Stokoe had made his proposal today, it seems quite likely that the parameters Handshape and Place would *not* be identified with phonemes or 'segments', but rather with CLASS NODES (cf. Corina 1990a, b, who makes this comparison explicit) or Dependency Phonology-style GESTURES (as I do here).

In §2.1 I argued that an autosegmental model must make use of a skeleton. In the next section I will therefore provide the necessary complement to the proposal made so far, which has not made any mention of the skeleton and its precise role.

4 The sequential structure of signs

Let us say that the terminal nodes of a sign tree such as that in (19) are aligned to a SKELETON:

(21)



('m' and 'n' represent settings, 'a', 'b' and 'c' values of other nodes.) This mode of association is rather different from what it usually proposed in models of spoken language, where root nodes associate to skeletal positions. The proposal advanced here is more in the spirit of the model proposed in Hayes (1990). Features are grouped, but at the same time

individual features rather than class nodes are associated to the skeletal units.

I propose that whether the skeleton is monopositional or bipositional depends on the presence of the Setting node, i.e. P^0 (which also dominates a setting feature) *and* the dependent Setting node both project one X position on the skeletal tier, indicated by the arrowed associated lines. Hence, if no Setting node is present (i.e. if the sign is pathless) there is only one X. As a matter of principle, the Setting value under P^0 projects the first X. Since the two settings have a different structural status in the feature tree we need not assume that P^0 and Setting are linearly ordered in the segmental tree.

Only signs with path movement, then, are bipositional on the skeleton. For signs having a local movement only, just a single X is present. This has the following consequence. Since opening and closing aperture changes are distinctive possibilities for Aperture, we must assume that the linear ordering is encoded in the feature tree (perhaps in the form of headedness, with the added proviso that heads precede dependents, or *vice versa*). The same holds for the Palm Orientation node in case of a Palm Orientation change. This limited amount of linear structure *in the segmental tree* seems appropriate, because the distinction between the bipositional and monopositional skeleton will provide us with a basis for a difference with respect to how secondary movements are distributed over the time span of signs with and without a path movement. We turn to this difference below.[21]

(21) shows that in order to represent the coordination of the starting and end point of path movements and orientation or aperture change, the values of the relevant branching nodes are associated with the Xs on the skeleton. If the nodes are not branching, association is superfluous. What is specified under non-branching nodes simply holds for the whole timespan of the monomorphemic sign.

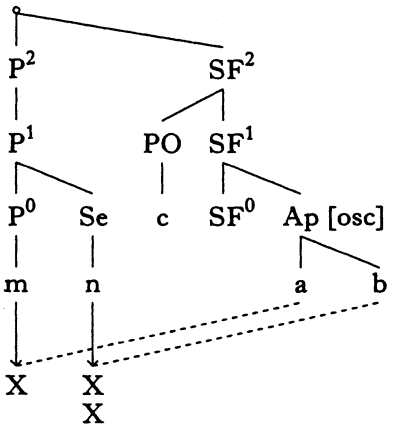
Notice that if one-to-one association is the unmarked situation (which is also claimed for association in the representation of spoken language phonology; cf. van de Weijer 1992), we predict that the onset and offset of different contours will normally be fully synchronised. We also allow, however, for the possibility that an aperture change occurs at the starting or end point of a path (the latter occurs in SLN PURSE, discussed above).

Let us now address the precise phonetic realisation of [oscillated]. Sandler (this volume) and Perlmutter (1992) provide accounts of the interaction of lengthening and secondary movement. In ASL, there is a phenomenon of phrase-final lengthening, referred to as HOLD (cf. Liddell 1990). Under phrase-final lengthening, secondary movements behave differently in signs with and without path movement (Perlmutter 1992). In a pathless sign, the secondary movement is maintained during the extra length resulting from the hold. In signs with a path, the hand is kept still during the hold timespan, i.e. the timespan of the secondary movement is not affected. How can we account for this fact in our model?

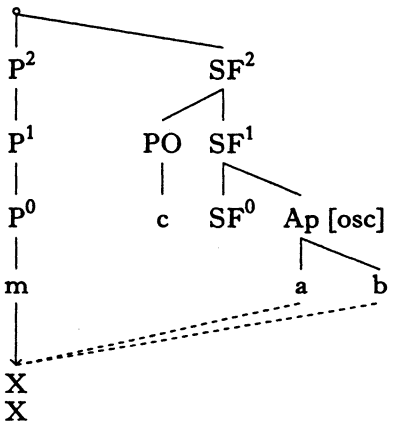
I propose to represent hold as 'beat addition', i.e. as a form of

prominence expressed on the skeleton. We can now simply say that iteration is realised *between* the two timing points if there are two. If the sign is pathless, however, iteration *must* be executed *in situ*, i.e. on the single X-slot that corresponds to a pathless sign. It is clear that this simple rule of phonetic interpretation makes the correct predictions concerning the behaviour of secondary movements under 'hold conditions'. For signs with a path, the extra duration which results from adding a beat to the second skeletal point has no effect on the time span between the Xs. But in a pathless sign, the extra duration goes to the skeletal unit which carries the secondary movement to begin with:

(22) a. *Path movement*



b. *No path movement*



Sandler (this volume) points out that the difference between signs with and without path movement only shows up if 'lengthening' is a result of

the phrasal hold phenomenon. Under morphological lengthening for Intensive aspect, both sign types behave in the same way: during the extra length secondary movement is not present. This suggests that morphological lengthening must be expressed as addition of Xs on the base line of the skeleton.

The skeleton adopted here bears a strong resemblance to the linear tier proposed in the models of Liddell & Johnson, Sandler and Perlmutter. The main difference is that the skeleton in this model does not differentiate between two types of units. This results from not recognising Movement as a distinctive unit. The locus for features which mark different types of path movements has been identified as forming part of the segmental tree in the form of a Manner node. The way in which these features as well as secondary movements are realised in the sign is a matter of phonetic interpretation.

Unlike Perlmutter (1992), I do not make use of a level of moraic structure. Perlmutter uses the mora level to allow a rule of mora addition for expressing the hold phenomenon. A disadvantage of this proposal is that it does not appear to be the case that the mora is a distinctive phonological unit, i.e. Perlmutter does not provide examples of a lexical contrast between monomoraic and bimoraic signs. In my model, phrase-final lengthening is expressed on the skeleton, which has a derived status and does not play a role in lexical contrast (except in cases like PURSE, which may be very limited). See Sandler (this volume) for a critical discussion of Perlmutter's moraic account.

5 Syllables

In this section, I discuss the relevance of the notion syllable in sign language (cf. e.g. Coulter 1982; Edmondson 1985, 1990; Wilbur 1990, 1993). I adopt the traditional view that syllables in spoken languages consist of two parts: an onset and a rhyme. Rhymes are heads, because only their properties are relevant in the higher prosodic organisation. Onsets are phonologically distinctive 'transitions' between rhymes.

It has been argued for spoken languages that the featural content of both simple and complex onsets essentially has a 'monosegmental' character; Hirst (1985), for example, argues for a 'single segment hypothesis' for complex onsets. In terms of feature geometry, Hirst's claim is that onsets have just one feature tree, but two positions on the skeleton. This proposal reduces complex onsets to the category of complex segments. It is now widely accepted that complex segments like prenasalised obstruents or affricates are represented in terms of a single feature tree in which certain features cooccur which require phonetic linearisation. Lombardi (1990), for example, argues that affricates are the phonetic results of feature trees containing the features [stop] and [continuant]. Van de Weijer (in preparation) extends this approach to other types of complex segments. Hirst's proposal can be interpreted along similar lines, although he does

not address the issue of the skeleton explicitly. If we find complex onsets, the amount of linearisation is simply more 'dramatic', such that two X units must be provided to accommodate the linearisation. This could be a result of the fact that the incompatibilities concern, let us say, major class features, i.e. in case a tree contains both the features [obstruent] and [sonorant].

Is a similar approach toward branching rhymes possible? We do in fact encounter phenomena which could be interpreted in a similar way. Goldsmith (1990), for example, argues that many languages do not allow an independent point of articulation in the second rhyme position, i.e. the coda. We could perhaps interpret this as a result of the fact that a branching rhyme, like a branching onset, is essentially monosegmental (with respect to its feature content), but bipositional on the skeleton. Goldsmith attributes the absence of a point of articulation for the coda to the fact that the syllable licenses just a single point, which is expressed in the onset. I suggest that the explanation lies in the fact that the rhyme head, the vowel, expresses the place of articulation of the rhyme (i.e. of the vowel), and that onsets and rhymes may each have a point of articulation. To pursue this further would go beyond the scope of this article, but we can simply establish that our proposal for the representation of signs differs from the syllabic organisation of spoken languages in that sign syllables consist of one feature tree and a corresponding monopositional or bipositional skeleton, whereas spoken language syllables have two such packages, i.e. two feature trees, each with a monopositional or bipositional skeleton.

I claim that the main difference between spoken and signed languages is that the latter lack (at the phonological level) the onset package. The rhymes of sign languages, like those in many spoken languages, can be bipositional on the skeleton, but are monosegmental with regard to their feature content.

Of course, there *are* transitions between sign rhymes, i.e. movements from one sign to another. Such movements, which must be sharply distinguished from path movements (which result from a branching P^1 node), could be referred to as 'onsets', but unlike onsets in spoken languages, they do not have distinctive properties.[22] The functional explanation for this could be that the array of possible distinct rhymes in sign languages is much greater than in spoken languages, so that there is no 'need' for different kinds of transitions. The fact that these 'onsets' in sign language lack distinctive properties places them outside the realm of phonology. We may observe that the extent to which spoken language onsets form a necessary part of the phonological representation is limited. At higher levels of prosodic organisation onsets are ignored. It would seem therefore that it is the presence rather than the absence of onsets which creates problems. Given that onsets are missing at the phonological level, we can conclude that monomorphemic signs are typically monosyllabic (mono- or bipositional), even though they are monosegmental with respect to feature content.

A notable difference between the view on syllable structure presented here and one that is common in the literature on ASL (most explicitly in Perlmutter 1992) is that our model does not provide a basis for analogues involving consonants and vowels on the one hand and location and movement on the other.

6 Conclusions

The proposal made in this article unifies various lines of research, both in sign and spoken phonology. It combines aspects of various models proposed for sign structure which earlier seemed incompatible, preserving a number of important generalisations:

(i) The single occurrence of Major Place and Selected Fingers per monomorphemic sign is formally explained by (a) singling out these nodes as heads in the segmental structure and (b) positing a monosyllabic structure for monomorphemic signs. (We must bear in mind here that the syllable has a rhyme only.)

(ii) The spreading asymmetry between Hand Configuration and Place has a principled basis. Hand Configuration is a dependent, and dependents can spread 'independently'.

(iii) If the distinction between closer and more remote dependents applies, only the latter can spread independently. This explains the difference in spreading behaviour between Aperture and Palm Orientation.

(iv) Following Hayes (1993), Stack (1988), Nagahara (1988) and Wilbur (1993), Movement is eliminated as a primitive. The perceptual salience of path movements (compared to local movement) has a structural basis. The former are properties of the head node. Moreover, only path movements determine a bipositional skeleton.

(v) The skeleton, even though no distinction between H (or equivalents) and M is made, allows a treatment of most phenomena that motivated Liddell's original plea for linearity.

(vi) Distinctive properties of path movements are expressed under a segmental node 'Manner', following Ahn (1990) and Wilbur (1993).

(vii) Following Sandler (1989), Liddell (1990) and Stack (1988), we have proposed a unified notion of secondary movement, including wiggling, circling and swinging. All are represented as derived from primary activities (i.e. local movement or path movement) plus a feature [oscillated].

(viii) This feature is a property of the root, following a proposal in Sandler (this volume).

(ix) The statement of linear order is largely separated from the specification of the 'content' of signs. This combines claims regarding simultaneity and linearity of signs in a principled way, along lines which are similar to the proposal in Wilbur (1993).

(x) The separation of feature tree and skeleton allows for marked and unmarked coordination of path movement and local movement.

(xi) The realisation of [oscillated] in signs both with and without path movement under hold conditions is adequately represented by viewing hold as a form of beat addition on the skeleton. Beat addition, thus conceived, captures Perlmutter's notion of mora addition.

NOTES

* This paper began as a comment on a paper presented by Wendy Sandler at a workshop on sign language held at Krems, July 1992. Thanks to her support and helpful suggestions that comment developed into the present article. I also owe much to discussions with Rob Goedemans and especially Els van der Kooij and Marja Wiggers, students in the Department of General Linguistics in Leiden. Anne Mills, Berend Hoff and Ronnie Wilbur provided me with useful comments on an earlier version. I also thank Irene Greftegreff for written comments and personal discussion. I am grateful for the comments of three *Phonology* reviewers. I would also like to emphasise that omissions in my reference to other work reflects nothing but my relative newness to this lively field of inquiry.

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[1] Edmondson (1985) is notable for emphasising that the application of non-linear phonological models to the structure of signs requires that we free such models from modality-specific aspects.

[2] The claim that Stokoe's aspects are in themselves meaningless has been called into question. This position makes it theoretically accidental that in most sign languages, for example, signs within the semantic field 'think' (i.e. THINK, UNDERSTAND, FORGET, REMEMBER, SMART, etc.) have the head as their place specification. The question is whether this fact should lead to granting a independent morphological status to one of the cheremes, or perhaps to all of them. My thesis will be here that it should not, and that the observed phenomenon falls under the rubric of 'form symbolism', the sign language counterpart of sound symbolism. This phenomenon (and iconicity in general) is more pervasive in sign language, because many more things have a form than a 'sound'. See Brennan (1990) for an extensive discussion of form symbolism (and iconicity) and its role in lexical innovation.

[3] In certain transcription systems (e.g. KOMVA 1988 and HamNoSys 1989) a distinction is made between Palm Orientation and Finger Orientation. The latter functions independently to make a distinction between, for example, the finger pointing forward or sideways, both with the Palm down. In this paper I will consistently use the term Palm Orientation. In many cases Finger Orientation is predictable from the place specification or a specification that I will call Hand Position. I leave open, however, the possibility that we must recognise a node ORIENTATION, dominating both Palm and Finger Orientation.

[4] Sandler replaces H by Location. Here I do not discuss the distinction between the notions Hold and Location: see Sandler (1989). Perlmutter (1992) replaces Sandler's L by Position.

[5] Cf. Sandler (to appear b) for a formal proposal of the open–close features and Liddell (1990) for criticism of Sandler's theory of handshape changes.

The notion selected finger roughly applies to fingers which are in some sense 'foregrounded'. The relevant distinctions are made in terms of a set of 'basic hands' in HamNoSys (1989).

[6] In early versions of autosegmental phonology *only* wide-scope features were 'autosegmentalised'; others were not. In later developments, however, the correlation between autosegmental status and wide scope was abandoned. Rather, features are autosegmental in character. Hence, autosegmental status no longer leads to the once-per-domain expectation.

[7] Whatever the make-up of this unit, no 'contours' are allowed. In this paper I am not concerned with the details of the sets of features under each node. I am

(pain)fully aware of the fact that ultimately we will not be able to decide on the correct grouping of features if we are not explicit about what it is that is being grouped; cf. notes 8 and 10.

[8] In the examples given here, orientation changes result from a 'twisting' movement which is executed by rotation of the lower arm. There are other movements which involve forward/backward or sideways bending at the wrist. The first activity results in what Liddell (1990) calls 'nodding' and the second, discussed in Stack (1988), in what she calls 'pivoting'. In §3, I will propose that these parameters must be represented separately from 'twisting', i.e. not under the same node as Palm Orientation.

[9] This suggests an analogy between such changes and complex segments like affricates and prenasalised stops. At present, given that serious doubts have arisen with respect to the proper representation of complex segments (cf. Goldsmith 1990) such analogies are difficult to evaluate.

It has been claimed (e.g. in Wilbur 1987 and Stack 1988) that no signs in ASL have both an Aperture and a Palm Orientation change. I am not sure that this restriction is general, but I will not pursue this issue here.

[10] The claim that path movements occur within a single major place cannot be fully evaluated if we do not commit ourselves to a list of major place specifications. Otherwise, we will be unable to decide whether a particular movement violates the constraint.

[11] Signs involving a path movement can involve a straight path or a curved path. This distinction may be distinctive (SLN TO SAY/TO MEAN). I deal with this difference in §3. Sandler uses the term hand-internal movement for local movement.

[12] There are a number of slightly distinct types of secondary movements which are either distinct from swinging and circling or just allophonic variants (and sometimes perhaps just different terms), e.g. zigzagging, waving (forms of swinging) and arc-sequencing (a form of circling). At the phonological level it will perhaps be sufficient to recognise just two major types.

[13] One path type which I have not discussed is the '7'-shape path (as in ASL CHICAGO, SLN APPOINTMENT). I refer to Supalla (1982), among others, for a more complete discussion of path types.

[14] Binarity can be derived from other principles, such as locality conditions on government relations holding between heads and their dependents: cf. Kaye *et al.* (1990).

[15] The grouping of manner features is not generally accepted. Cf. Clements (1985) and McCarthy (1988).

[16] Heleen Bos (personal communication) pointed out to me that assimilation of handshape only may take place. Pronouns may assimilate for handshape to a neighbouring sign, but not for orientation. Corina (1993) also discusses such cases. Cf. Sandler (to appear a: n. 3) for some discussion of such facts.

[17] This may seem peculiar, in view of the claim made in Dresher & van der Hulst (1992) that one of the manifestations of the head–dependent asymmetry is that heads allow a greater complexity than dependents. It is important to realise, however, that this manifestation of the asymmetry is found in cases where the same type of element (for example syllables) may occur in head or dependent position. In such cases the head position allows a greater variety and more complex structures than the dependent position. Selected Fingers, Palm Orientation and Aperture are *not* units of the same type.

[18] A similar proposal is made by Hayes (1993), Stack (1988), Nagahara (1988) and Wilbur (1993). An issue that I will not deal with here is whether signs with movement must always involve two settings. If they do, this would exclude distinctions like LML, LM and ML, for which Perlmutter (1992) provides examples.

[19] An alternative would be to adopt the static interpretation for Setting values throughout. In that case, a pathless sign could be represented with a single

Setting value under the strict dependent node. Signs with a path movement would have a branching Setting node, and if the movement is diagonal the Setting node would be 'extra' complex. In this alternative, Setting is like Palm Orientation and Aperture: if the node branches there is an activity (i.e. path movement, Palm Orientation change, Aperture change). Here I will not make a choice between these alternatives.

[20] The values of the node Hand Position may change the 'finger orientation', which is not to say that all cases of finger orientation differences can be represented in terms of these features.

[21] An alternative to the Manner node in (20) would be to associate 'manner properties' with the node which dominated the skeletal positions (i.e. the 'syllable' node; cf. §5).

[22] In the literature on ASL it is often stated that every sign *must* have some movement (e.g. Perlmutter 1992; Stack 1988), i.e. either a local or path movement. This constraint is not, however, applicable to lexical representations. Stack, for example, explicitly states that signs which have no movement get a path movement inserted. This path movement precedes the two-slot skeleton that she proposes for signs and would thus qualify as the phonetic onset that is discussed here.

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