

On the internal and external organization of sign language segments: some modality-specific properties

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1. Introduction¹

In this article, we focus on the notion of *segment* in the study of sign languages. After a brief review of the notion of segment in spoken languages in section 2, we discuss what, in our view, might be a useful interpretation of the concept of 'segment' in the context of sign languages (section 3). We focus on the question how this interpretation relates to other phonological units, specifically notions such as *complex segment* and *syllable*. We will discuss two types of sign models that have previously been proposed in the sign language literature: *segmental models* (section 3.1) and *syllabic models* (section 3.3). We will then provide our own analysis of the sign as a *single segment* in section 4. When it comes to the issue of syllabic structure, we suggest that, to the extent that this level of analysis encodes linear order (as it does in spoken language, according to the most common view), the representation of movement as involving the specification of two 'timing points' could qualify as syllabic organization. If this is the case, it follows that, in sign language, syllabic structure is intrasegmental, as opposed to being suprasegmental in spoken languages, because movement is represented in our model as branching of subsegmental nodes. A different, reasonable interpretation of such branching structures would invoke the notion of *contour* or *complex segment* (as used for affricates, prenasalized stops or consonants with multiple articulation in spoken languages). A distinguishing property of such entities, in contrast with syllabic constituents, is the lack of distinctive (as opposed to phonetic) linear order. The issue of linearization is the topic of section 5. Linear order in syllables and complex segments in spoken language is discussed in 5.1. Based on a review of a large set of signs we then discuss the need for underlying (i.e. distinctive) linearization in signs in section 5.2, concluding that the choice of linear order between the timing points of move-

¹ We would like to thank two anonymous reviewers and the editors of this volume for their very useful comments.

ment representations is not 'free'. In the majority of cases, linear order can be predicted as a default case, whereas other cases appear to be largely semantically motivated. In our final section, we will discuss the consequences of our findings regarding linear order in signs for the syllable/complex segment ambiguity noted above.

Let us note that, although an important goal of analyzing languages may be to understand them in their own right, we believe that a consideration of certain conceptual issues regarding a potential common organization of languages in different modalities is also important. This is especially relevant in light of the hypothesis that all human languages (or rather their underlying grammars) originate from the same language-specific (and species-specific) capacity.

All example signs are from *Nederlandse Gebarentaal* (NGT - Sign Language used by the Deaf community in the Netherlands).

2. The notion of segment in spoken languages

The notion of segment in the phonology of spoken language differs from theory to theory and, within generative phonology, has changed considerably since SPE (Chomsky and Halle 1968). We will not attempt to give a historical overview here (cf. van der Hulst, in press). In essence, segments represent 'vertical slices' of the speech stream (Goldsmith 1976). In SPE, vertical slicing was exhaustive. No phonological properties of words had scope over more than one segment. With the introduction of autosegmental phonology, certain 'features', called autosegments, comparable to Firth's (1948) prosodies or Harris' (1944) long components, were allowed to exist on a separate horizontal tier and thus to extend over a stretch of units that represented the 'rest of the segments'. In radical forms of autosegmental theory, all features have their own tier, and what is left of the old segment is a (skeletal) position. A further, independent change has been to impose a hierarchical organization on the set of features (or on the tiers that these features occupy).

Furthermore, it was argued that certain properties (such as *length*) could be regarded as the interpretation of multiple linking, whereas others (such as *syllabicity* and *stress*) could be interpreted as nodes in the syllabic and foot structure. The structural representation of properties that were once thought to be exponents of distinctive features can, and have been extended to major class properties (such as *consonantality* and *sonorance*). This, however, requires a departure from the widespread assumption in generative phonology that syllable structure is a derived property. Given a linear arrangement of

segments (or skeletal position *cum* associated features), syllabification can be applied as a 'test' on wellformedness. Seen as an early step in the phonological derivation, syllabification then also provides a structural organization of the segmental string that can be referred to by subsequent rules. Syllabification rules rely crucially on two factors: (a) linear precedence relations between the segments and (b) feature specification *in* those segments indicating their membership to so-called major classes (such as [$\pm$ consonant] and [$\pm$ sonorant]); reference to other segmental features such as place or laryngeal features are typically not called for in syllabification rules. An alternative view is possible, however, specifically one in which the syllabic grouping of segments itself is specified in the underlying representation (cf. Anderson 1987). Such a move allows for a structural encoding of consonantality and sonorancy (cf. Golston and van der Hulst 1999) and, at the same time, removes the need to specify underlying linear precedence relations (cf. also Haraguchi 2003). This latter point has obvious consequences for the discussion in this article and we will return to this issue toward the end of this article. First, we will give some background on the representation of signs and the use of notions like segment and phoneme in the earliest work.

3. The notion segment and syllable in the representation of signs

3.1. The emergence of segments

With reference to the manual aspect of signs, Stokoe (1960) distinguished three units, or rather types of units: the *handshape*, the *location* and the *movement* of the hand. For each of these units there is an array of possibilities or values: different handshapes, different locations, and different movements. Lexical contrasts in sign languages are typically made in terms of different choices at this level of representation. For example, the NGT signs HOLIDAY and TO LIVE are distinguished by their values for handshape (B-hand, all fingers extended vs. T-hand, thumb and index closed, all other fingers extended²); the movement and location values are the same for both signs:

² The handshapes B-hand and T-hand are names used in the KOMVA sign notation system (NSDSK 1988). This notation system is based on Stokoe's notation system for ASL (Stokoe 1960).

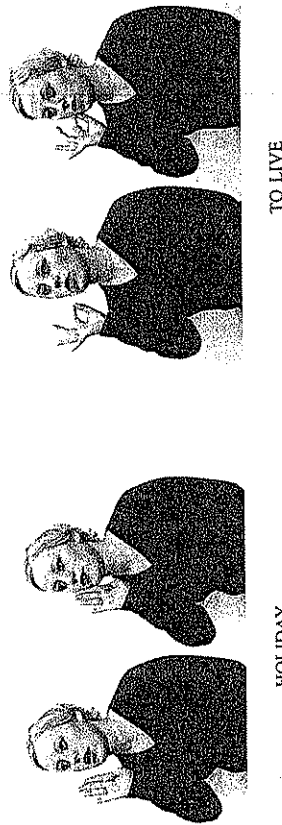
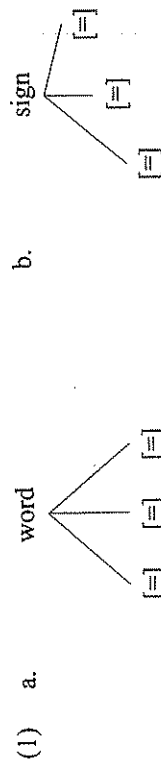


Figure 1

Stokoe (1960), who proposed the three unit types as basic building blocks of signs, called them *cheremes*, a term that was later superseded by the term *phoneme*. Since the phonemes of spoken languages occur in a sequential order, whereas the sign phonemes occur simultaneously, Stokoe concluded that the difference of sequentiality versus simultaneity represented an important modality-determined difference between the phonological organizations of words in spoken languages and signs in sign languages.

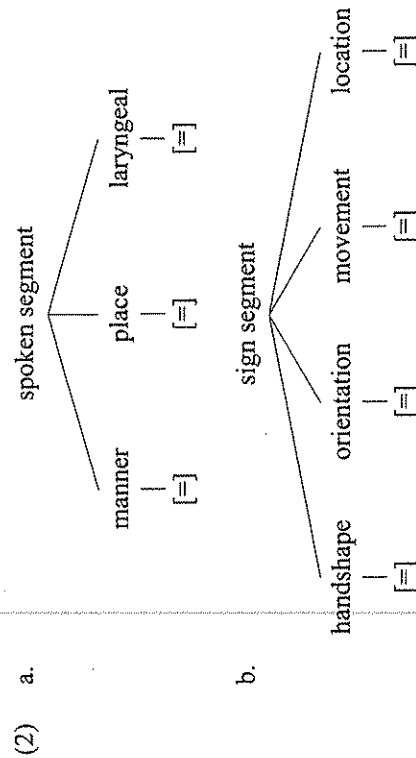
We must bear in mind that the values of the three cheremes/phonemes could actually be small sets of feature specifications. For example, the handshape does not just involve a choice of which fingers are extended (cf. above), but also involves a shape of these fingers (e.g. extended versus curved). Similar points can be made for movement and location. Subsequent research has, in fact, revealed an increase in the number of features that needs to be specified for each of the three units. We can therefore see the point of Stokoe's comparison between his three basic *units* and spoken language *phonemes*: both are feature bundles. In the latter case, a distinction can be made between various major classes (vowels, consonants, sonorants) and it would not be necessarily inappropriate to refer to the handshape, movement and location units as 'major classes' of sign phonemes. As a result, Stokoe's comparison can be represented as follows:



In (1a) we represent the features bundles ('[=]') of spoken language words on one 'tier' to indicate their linear order, whereas in (1b), the sign units are repre-

sented as being unordered (which we take to indicate simultaneity by default).

With subsequent developments in the subsegmental structure in spoken languages, a different kind of analogue emerges, however. If spoken language segments are viewed as simultaneous occurrences of so-called *class nodes* (such as *manner*, *place* and *laryngeal*; cf. Clements 1985), each potentially characterized in terms of more than one feature, segments by themselves show a remarkable relationship to Stokoe's conception of the signs as a whole; units such as handshape, orientation etc. in (2b) can be thought of as simultaneous class nodes:



We will return to the 'mono-segmental' view of signs (that we essentially subscribe to) below. First, we will look at some developments that took place after Stokoe made his original proposals. The developments that we focus on involve the recognition of linear organization within the sign. Certain regularities in sign languages seem to make reference to the beginning or the end of a sign, which seems to imply that the notion 'beginning' and 'end' must be part of the formal representation of signs. These regularities involve morphological rules or phonological changes in the form. The following sections contain representative examples.

a. The representation of verb agreement

In some verbs agreement with their arguments is marked on the beginning and/or end location (Padden 1983 for ASL, Bos 1993 for NGT). In the NGT verb TO VISIT, the subject is marked on the first location and the direct object on the second location. The pictures in Figure 2 illustrate the difference in the inflected forms I-VISIT-YOU and S/HE-VISIT-ME.



I-VISIT-YOU

S/HE-VISIT-ME

Figure 2

b. Reduction in sequential compounds

In compounds, beginning or end parts of one of the signs are deleted (Klima & Bellugi 1979). For example: the ASL compound *BLACK^NAME* (meaning 'bad reputation'), consisting of *BLACK* (1-hand over forehead) and *NAME* (with the N-hand repeatedly tapping on the weak N hand), the first position of the sign *BLACK* is deleted in the compound (as is the repeated movement of *NAME*).

c. Slips of the hand

Sign errors exist which switch only one of two locations in the same position in each sign (Sandler 1989).

d. Morphological lengthening

End locations may be lengthened under morphological inflection (Sandler 1989). Lengthening may also occur phrase-finally (Perlmutter 1992).

e. Minimal pairs

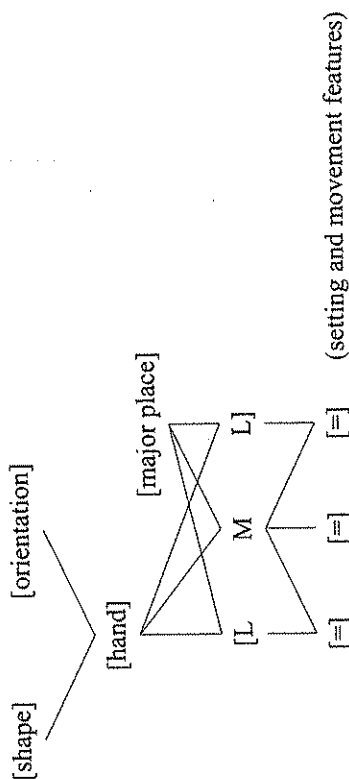
Some researchers have claimed that there are minimal pairs that are distinguished by linear order of the same specifications (Sandler 1989). For example, in the ASL-sign *GAMBLE* the hand opens from a fist to a 5-hand (all fingers extended and spread), whereas the fist opens to an H-hand (index and middle finger extended and spread) in the sign *THROW*. In other signs the same specifications occur in different linear orders. Some of these pairs in which both members appear to have opposite meanings are called reversible signs. We will come back to these later.

To allow the representation of the phonological and morphological phenomena involved, the notion 'beginning' and 'end' (that apparently needs to be referred to) must be formalized and doing that automatically entails recognition of a sequential structure in the phonological representation. A variety of

proposals can be found during the eighties and nineties (Newkirk 1981, Liddell & Johnson 1986, 1989, Sandler 1989, Perlmutter 1992), which all share the adoption of units that occur in some sequential order. Since, meanwhile, models of spoken phonology had developed a distinction between skeletal positions (terminals of a syllabic organization; cf. Clements and Keyser 1983) and hierarchically organized feature sets that associated to these positions, models for sign structure adopted this distinction and assumed a skeletal tier of some sort as a means to encode linear order of the associated feature structures. Two types of units were distinguished on this tier, corresponding to features that specify the beginning and end location of the signs and features that specify the (manner of) movement of the signs. The sequential skeletal units of the sign came to be referred to as *segments*, presumably by analogy to the use of this term in models of spoken language in which, indeed, segments were 'reduced' to skeletal positions (plus, implicitly, all features that associate to these positions).

It is important to see that although only the need for an initial and final *static 'segment'* (for initial and final location) was demonstrated, the segmental models all contain a second type of segment, i.e. a dynamic segment standing for movement. A schematic representation of skeletal segmental models is given in (3). L stands for 'location' (some models use H for 'hold' or P for 'position'), while M stands for 'movement'. Two independent developments (mainly due to Sandler 1989) that also emerge in this model must be mentioned here. Firstly, Sandler proposed that the general property of location be split up in a notion of *major place* and a notion of *setting*. The former indicates a relatively broad area in front of or on the body where the sign is articulated (e.g. the head or the chest or the weak hand), while the latter indicates the specific beginning and/or end location within this area. Secondly, Battison (1978) had proposed to add a fourth major building block, viz. orientation (of the hand). Sandler (1989) suggested to group orientation and handshake into one class node (basing herself on their potential joint behavior in phonological processes, viz. assimilation in sequential compound signs), following the analogical proposals for hierarchical grouping of feature sets in the study of spoken languages (cf. section 2):

(3) Skeletal segmental models



Features that describe the hand (its shape and its orientation) and 'major place' are associated, as autosegments, to both the L and the M segments, as proposed in Sandler (1989). This captured the empirical observations that the aspects of handshake and major place remain constant across the initial location, movement and final location of *monomorphemic* signs. Below, we will discuss this point further because, as we will see in section 3.2, certain aspects of the shape of the hand, as well as its orientation do not necessarily remain constant in signs. For example, in the sign JEALOUS, illustrated in Figure 4 below, the major place is the upper body. The setting changes from 'low' to 'high', resulting in an upward movement across the chest.

A further remark is in order. The features that characterize the M unit like 'straight', 'arc', 'tensed' or 'contacting movement' (Sandler 1996) are exclusive to this unit, but setting features are shared by L and M units, with the result that the M unit shows a contour going from the initial location to the final location. The reason for considering the theoretical existence of an M-segment (rather than seeing movement as a predictable interpolation between two settings) lies in the observation that the hand can move between two (identical) settings in different, and thus distinctive ways. The hand can, for example, follow a straight path or a curved path. In addition, it may describe little circles, or a series of arcs, and so on. Proponents of the segmental models that include an M-segment correctly observe that M must be part of the formal representation of signs in order to have distinctive properties.

Understandably, the LML skeleton quickly invoked analogues to CVC syllables in spoken language. As a result, the notions of segment (roughly the equivalent of the 'old' phoneme) and of syllable (as a linear sequence of segments) were now firmly established in the sign language literature.

3.2. Intermezzo: handshake change and orientation change

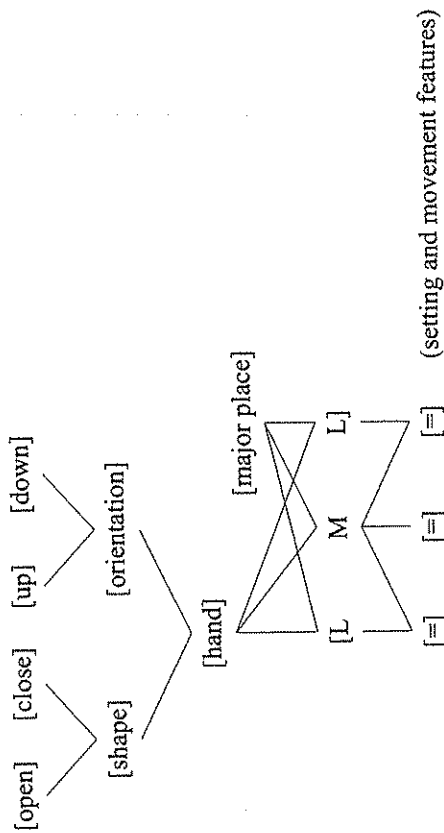
Many signs consist of a *path movement* (movement of the whole hand) only, while the handshake and its orientation do not change. For such signs, the model in (2) looks adequate. The dynamics is represented by having different settings for the initial and final L. However, apart from 'path' movement (also sometimes called 'global' movement), there can also be 'local' movement involving either rotation of the hand (called *orientation change*) or movement of the fingers or *hand-internal movement*. Hand-internal movements mainly consist of *aperture change* that involve making contact between the fingers and the thumb (closing) or the release of such contact (opening). One aspect of handshapes does not change during monomorphemic signs, viz. the *finger selection* (i.e., roughly, whether one finger is extended, two or all four) (Mandel 1981). These local movements can constitute the only movement in the sign when a path movement is absent, as in the NGT sign TO DO. Local movements can also be combined with path movements, as in the NGT sign DRY. These signs are shown in Figure 3.



Figure 3

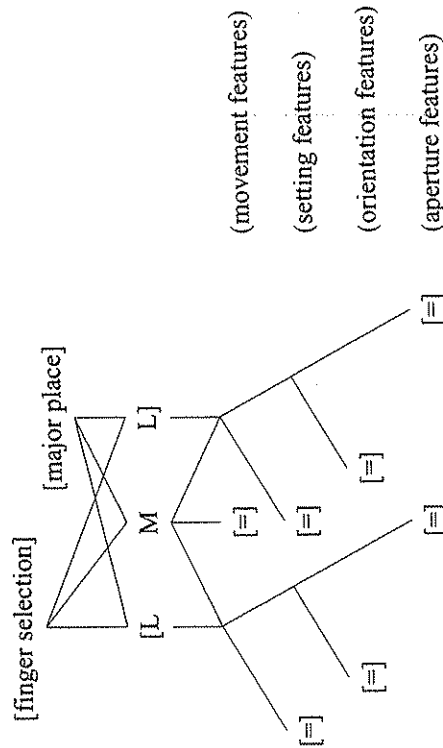
How can the dynamics of handshake and orientation be expressed in models like those in (2)? Conceivably, we could allow the handshake and orientation nodes to branch:

(4) Skeletal segmental models

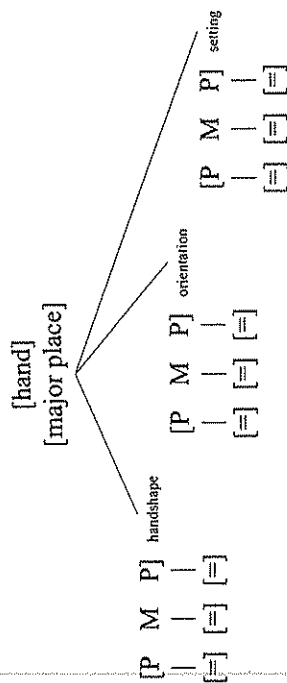


Another idea (which was essentially proposed in Sandler 1989) is to group features for aperture and orientation together with setting features:

(5) Skeletal segmental models



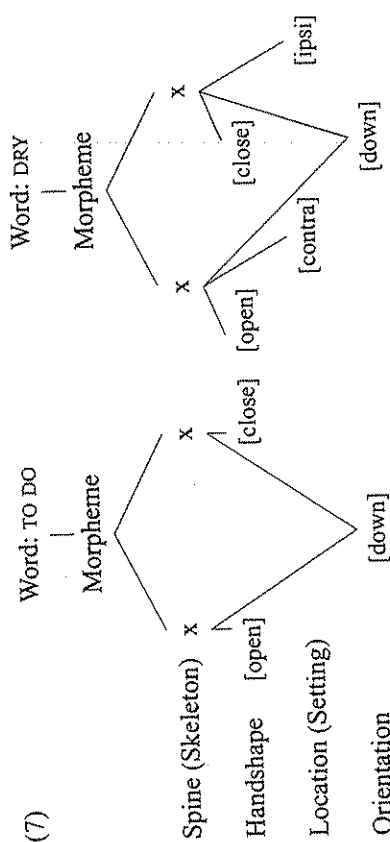
(9)



Although perhaps reasonable because of the analogical treatment of all three types of movement, there really seems to be no need for movement features in the case of handshape and orientation changes. In opening or closing hand-internal movement, there is only one way in which that change can be executed and the same holds for orientation changes. Changes in setting seem different in this respect because the hand, while moving, can describe different types of paths (straight, arc, zigzag, etc.). Thus, it would seem that only path movements call for featural distinctions. However, if we take the analogue between all three movements seriously, we might also, at this point, wonder whether there really is a need for M-units in the case of path movements. This is the subject of the next section.

3.3. Wilbur's non-segmental model

Wilbur (1993) discusses various uses of the term 'segment' in phonology (both in general and in models for signs) and reaches the conclusion that none of them really seems appropriate for signs. She proposes an alternative non-segmental model that only recognizes feature tiers (hierarchically arranged) and the notion of syllable. In (7) we reproduce a simplified version of her representation of the signs TO DO and DRY that were illustrated in Figure 3 above.



All changes (including location changes) are represented as simple sequences of values on the relevant tier. This proposal effectively eliminates the M unit and reduces the skeleton (called *spine* in Wilbur's model) to one type of unit, labeled 'x'. We will not commit ourselves as to whether Wilbur's spine does not, in some sense or other, capture the notion of segment. We take her more important point to be that skeletal units (whether we call them segments or not) come in only one variety. For the majority of signs, the content of the alleged M unit is indeed predictable if the features for the initial and final setting features are specified. The movement is simply the predictable interpolation between two points or states. Hayes (1993), who also reaches the conclusion that M units are superfluous, makes the general point that, in spoken phonology, we routinely encode 'dynamic' properties of segments by specifying only the beginning and end point (as in affricates or contour tones). Hence, he also proposes an M-less model, as did various other sign language researchers around the same time.

At this point, one might wonder how the notion 'syllable' fits into Wilbur's model. According to Wilbur, syllables are not part of the underlying structure of signs, but rather arise as a consequence of syllabification. She defines a syllable as "a unit of associated autosegmental tiers containing at least one sequence of distinctive articulatory features [...] and no more than two such sequences [...]". (Wilbur 1993: 150). The upper limit of two feature sequences per syllable is based on the empirical observation that monomorphemic signs do not seem to combine all three possible changes at the same time.

In the next section, we will discuss our own model, which follows Wilbur's rejection of the M-unit. At the same time, our model insists on the correspon-

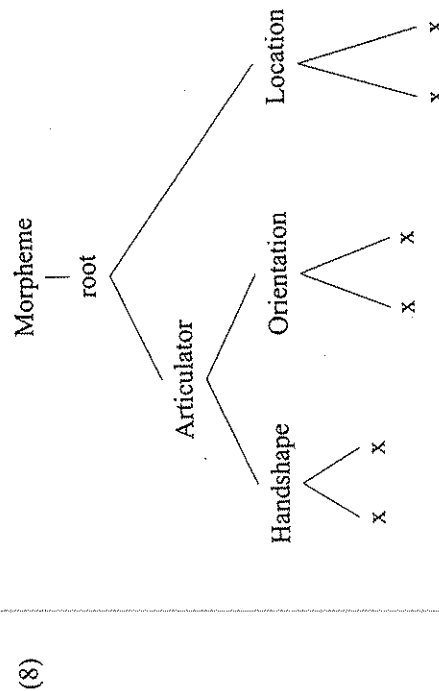
dence that was noted in (2) above between single segments (in spoken languages) and signs.

4. Signs as single segments

The monosegmental model that we propose continues the approach in van der Hulst (1993), which, since then, has been developed and extended in various publications. For a full discussion (and references) we refer to van der Kooij (2002).

As in Wilbur's syllabic model, we propose a unified representation of all types of movement in terms of transitions between states that are characterized by a-temporal features. That is, we adopt Wilbur's syllabic view of movement, representing movement as multiple feature specifications. In the model we propose, all tiers are hierarchically organized into a structure that captures the degree of coherence between features of different types. The model originally proposed in van der Hulst (1993) adds head-dependency relations to the hierarchical organization of tiers in order to provide a formal underpinning for the distinction between tiers that do and tiers that do not allow multiple specification. Here we will not discuss this aspect of our model.

As argued in van der Hulst (2000) and van der Kooij (2002), our model differs from Wilbur's in two ways. Firstly, we relate the root node to the morpheme node and, secondly, we represent separate spines for each sequence of features. As a result, our feature tree is represented with the leaves down:



The skeletal pairs are placed on different lines to emphasize the fact that they are not linearly ordered with respect to each other. The idea is here that only within each class node we find linear order of the two values. With respect to the question which aspect of the phonological structure links to the morpheme, we adopt the view expressed by (8) because, in our view, the phonological content of signs has the formal structure of a single segment, making the root node the overarching label for the whole structure, which is therefore the relevant unit to link to the morphemic level.

Our proposal to regard each branching structure as a skeleton in its own right (which deviates from our earlier views in which we had one skeleton like Wilbur 1993; cf. van der Hulst 1993) is based on the idea that this view is the most minimal one. This may, at first, strike the reader as untrue; isn't one skeleton more minimal than three? The point is, however, that (8) should really be taken as making the minimal claim that certain nodes in the structure are branching, or have two values. In addition, our claim is that admitting branching structures obviates the need for an additional skeleton that coordinates the first and second value on the different tiers. It is true that the beginning and end point of different movements are indeed synchronized. Perlmutter (1992) points out that we do not encounter signs in which, for example, an aperture change occurs at the end of a path movement. However, this kind of synchronization is fully predictable and hence does not need to be encoded in the phonological structure of signs.

Arriving at the conclusion that the sign has the structure of a single segment, we turn to a potential use for the notion of syllable. Here, we differ from Wilbur's interpretation of this notion. Rather than viewing the whole structure as a syllable if it contains at least one branching substructure (corresponding to a sequence of two values on some tier in Wilbur's model), we have proposed to regard the branching structures themselves as syllables (cf. van der Hulst 2000, van der Kooij 2002). The position that the branching configuration in (8) creates 'syllable structure' leads to the apparently odd claim that in sign phonology syllables are *inside* segments, rather than the other way around. If we maintain using the term 'segment' for the root node unit that dominates the different class nodes and we use the unit class node for aspects like handshake, location and so on, we end up with the paradoxical conclusion that in sign language the unit segment dominates the unit syllable, and, in fact, that one segment can contain several (simultaneous) syllables.

Despite the apparent oddness of reversing the dominance relationship between segment and syllable, we believe that the terms segment and syllable could be maintained in a coherent cross-modality manner if this idea is accepted. Phonological categorization of the phonetic substance proceeds in

two dimensions: the vertical (sequential) and the horizontal (simultaneous) one. Spoken language has long been looked at in terms of an absolute precedence of vertical slicing over horizontal slicing. The vertical slicing produces a *linear* sequence of segments (organized in a syllabic structure), which is then followed by a horizontal slicing of each individual segment into co-temporal features. As a consequence of the fact that vertical slicing (sequential syllable structure) has dominance over horizontal slicing (co-temporal feature structure), syllables come to dominate segments and, also, each feature has scope over just a single segment. As pointed out in Goldsmith (1976), spoken language may not entirely work this way. In some languages, certain aspects of the speech signal may be sliced off horizontally before vertical segmentation takes places. This allows so-called autosegments (or Firthian 'prosodies'), such as tone, nasality or vowel that take scope over a larger stretch of (the rest of the) segments.

We believe that Stokoe's original insight, viz. that properties of signs are simultaneous, responds to the fact that in sign language phonology, the horizontal slicing of the signal generally takes precedence over the vertical slicing, making the latter (i.e. the sequential syllable structure) subordinate to co-temporal feature structure. Hence, there is no contradiction in recognizing the fact that syllable structure, in the sense of sequentiality, is subordinated by segmental structure. A further consequence of this idea is that, indeed, signs are typically monosegmental (yet, segment-internally syllabic, or even polysyllabic).

At this point, it might be asked why the dominance relationship between vertical and horizontal slicing would be different in both modalities. In other words, what is it that gives rise to this modality effect? We submit, tentatively, that the reversed relation between syllable and segment is a result of the fact that in the visual channel perception is 'instantaneous', which then leaves little room for temporal effects. Conversely, we think that perception in the auditory channel proceeds in a predominantly temporal fashion, making horizontal, co-temporal divisions a secondary effect.

The claim (or rather: the empirical finding) that all signs have some type of movement implies that signs must be syllabic, which, if our reasoning is accepted, is no longer in conflict with the claim that signs are monosegmental. Monomorphemic signs are typically monosegmental and contain at least one syllable. We have seen that they are maximally bisyllabic, i.e. have only two simultaneous movement components (as in the sign DRY). This could be seen as a word minimality effect, comparable to similar effects in spoken language.

Of course, there are also signs that consist of two segments. This must be the case if a sign has two completely different handshapes (involving differ-

ent finger selections) or different 'major' locations. Typically, bisegmental signs are morphologically complex. In NGT we find bisegmental signs involving different finger selections that are frozen remnants of fingerspelled words (e.g. *SILLY* consisting of a sequence of the manual letters F and L, the initial letters of the Dutch word 'flauw', while rotating the hand). An example of a sign that has different 'major' locations is the frozen (hidden) compound *SANTA CLAUS*; the first part of the sign consists of a downward movement from the *chin* while the second part consists of an upward and downward movement in *space*. Bisegmental signs may also be visually motivated as the sign *MEMBERSHIP CARD*, which outlines the shape of a rectangle, shows. In this sign, both hands with index finger and thumb in open position first move sideward and then the index finger and thumb make a closing movement, contrary to what we might expect from the generalization that movement components are synchronized.

The different impact of changes in finger selection and major location, as opposed to that of changes in aperture, setting and orientation is derived in our approach from augmenting the structure with head-dependency relations. Class nodes for major location and finger selection are formally represented as heads, whereas the other, dynamic properties are dependents. For a more detailed discussion of these aspects of our model we refer to van der Hulst (2000), van der Kooij (2002) and earlier sources cited there.

Finally, a few words have to be said about path movements. Remember that one of the motivations for M-segments in other models was the fact that path movements can have different distinctive properties. Features that have been attributed to the M segment are few, however, and they often concern the whole articulation and not only the movement component of the sign. Movement features concern the tenseness of signs, contact of the hand with the specified place, and the shape of the movement (for instance a circular or arc-shape). We accept that there is a distinction between straight and arced or curved path movements, but we suggest that, while the natural movement of the hand may be curved (because of our anatomy), a straight movement may be the result of an overall 'tensed' articulation of signs (van der Kooij 2002). Thus, if we recognize a property 'tense' ('somewhere high up' in the sign's segmental structure), this feature could affect the execution of the path movement, as well as aspects of the handshake (for example, making a 'curved 5 hand' look like a 'claw hand'). In fact, it seems impossible to execute tensed movements with a non-tensed handshake, as in the sign *JEALOUS* (Figure 4).



JEALOUS

Figure 4

The only movement shape that would require independent specification is the *circular* shape. Circular movement can be realized by the whole hand, which in a segmental model would generate an M-segment. If the circular movement is made by rotation of the wrist or of the base-joint of the index finger, the movement would be hand-internal and no M-segment would be generated to support the feature [circular]. If the higher-up node that accommodates such properties as 'tense' (the 'Manner of movement' node) can also accommodate the overall shape of the movement, either path or local, there are no path movement features left that would necessitate a segmental M position.³

5. The issue of linearization

5.1. Syllables or complex segments?

In the preceding section, we proposed that certain dynamic properties of monomorphemic signs give rise to intrasegmental syllabic structure. Channon (2002), who also takes the position that monomorphemic signs are structurally monosegmental, compares the dynamic subsegmental properties to 'contact' segments in spoken language (like affricates or prenasalized consonants).

³ Sandler (1996) considers [contact] as one of the movement features. In the model proposed here (following van der Kooij 2002), contact is not a phonological feature. The contacting movement of the hand with a specific location is the (phonetic) consequence of certain location and setting specifications. For example, the specification of major location [chest] and setting [low], [high] results in a continuous contacting movement across the chest, as shown in the sign *JEALOUS* in Figure 4.

She does not use branching structure to indicate dynamic properties but instead uses 'dynamic features' like [opening] or [closing]. We do not appeal to dynamic features because they prohibit the expression of phonological processes. For example, in the NGT compound sign STREET LIGHT, illustrated in Figure 5, the order of POLE is reversed, and the closed initial state of the hand-internal opening movement of the sign LAMP is omitted. In a model with sequences of static features, the latter can be described as a reduction process (deletion of the initial static feature [close]), while the model that uses dynamic features would have to argue for a feature change (from the dynamic feature [opening] to the static feature [open]).

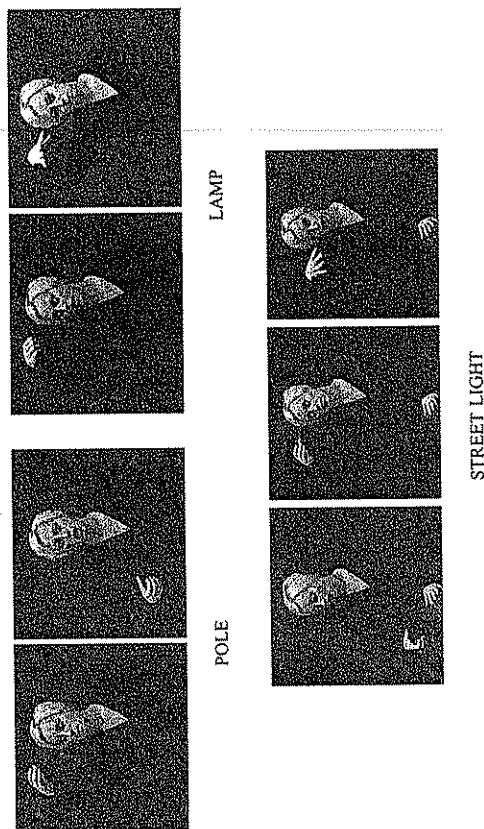
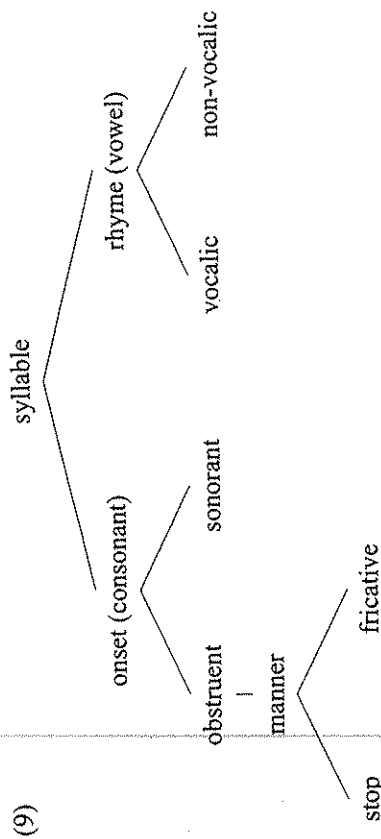


Figure 5

However, the question as to whether dynamic aspects of signs could be seen as analogues of intrasegmental complexities that are usually *not* thought of as involving syllabic structure in spoken languages is valid. In fact, when looking at the structure in (8), and comparing the nodes with class nodes as we did in (2), it seems perfectly reasonable to say that branching of class nodes in signs delivers complex segments, just like branching nodes in spoken language class nodes delivers complex or contour segments.

Let us ask, then, on what basis one might distinguish between syllabic complexity and segmental complexity. This is by no means an easy question and one that could easily be the topic of a separate article. In quite general terms, one might argue that prototypical syllables combine segments types that are as different as can be, viz. consonants and vowels. Assuming that

syllables consist of onsets and rhymes, each of these units can be complex by combining segment types that, within the range of these constituent types, again differ maximally. In the case of onsets, this means that obstruents and sonorants can be combined. For rhymes, matters are more controversial, but it could be argued that complex rhymes combine vocalic and non-vocalic sonorants (cf. van der Hulst, to appear). So-called complex segments simply seem to extend this pattern at the level of onset and rhyme heads:



Affricates, at least, combine 'segment types' that differ maximally within the range of obstruents. What is the motivation for referring to obstruent-sonorant sequences by way of complex syllable structure (i.e. as clusters) and to stop-fricative sequences by way of complex segmental structure (i.e. as complex segments)? We here leave aside many related issues, such as the question if there is an analogue of affricates on the rhymal side. Also, we obviously encounter additional types of 'segmental' complexity involving prenasalized consonants on the onset side and contour tones on the rhyme side of the syllable. There are also consonants with multiple articulations on the onset side. We cannot possibly discuss all these (and perhaps other) cases of alleged segmental complexity here.

One factor that comes might be a potential demarcation line between complex syllabic structure and complex segmental structure is *linearity*. It has been argued that the internal components of complex segments that appear in a linearized form in the phonetic surface do not need to be linearized phonologically, because the linear order is universally fixed and therefore not potentially distinctive. In the case of affricates, the universal order of the stop and fricative part is that the stop precedes the fricative.

Is it true, however, that syllabic complexity indeed involves underlying linearization? The truth of the matter is that the importance of linear order is not a necessary property of a syllabified string of segments. As pointed out in Anderson (1987), linear order of segments within syllables is largely predictable. $\{p, r\}$ as an onset will always be $p > r$, for example, and $\{a, m\}$ in a rhyme will always be $a > m$. Finally $\{\text{onset, rhyme}\}$ will always be $\text{onset} > \text{rhyme}$. In short, given the fact that segments are grouped into syllabic constituents, linear order is completely predictable.

The inevitable conclusion, then, seems to be that linear order is not a valid criterion to distinguish 'syllabic' complexity from 'segmental' complexity. Both types of parsing involve a vertical slicing of the speech signal, and in both cases the phonological representation does not need to encode the actual order of the 'points'. Does this mean that, in spoken languages, no principled distinction can be made between syllable structure and segmental structure and that the only tangible distinctions involve the hierarchical position where branching occurs? We believe that this conclusion is not warranted. There is a difference, however, between the points that result from syllabic parsing and the points that result from complex segment parsing. When we look at other properties of segments such as place and laryngeal features, we find that syllabic points can have their own values for these features, whereas the complex segments points cannot. The different parts of affricates cannot have different values for place or voicing, while the different points of a branching onset or branching rhyme can. From this it follows that syllabic points are anchors for other segmental properties, while 'subsegmental' points are not.

Turning back now to the structure of signs, we need to ask (again) as to whether the branching structures in sign correspond to syllabic structure or complex segment structure. If we adopt the latter view (as is done in Channon 2002), it follows that monomorphemic signs simply do not have a syllable structure analogue. Since other properties of signs (like finger selection and major place) have already been factored out, we cannot say whether the points that result from branching serve as anchors for other properties. Hence no criterion seems available to separate segmental (i.e. syllabic) points from subsegmental points. With the intuitive oddness of recognizing subsyllabic syllables (as was suggested above), we are left with the apparently 'obvious' conclusion that the branching structures correspond to complex segments. The truth of the matter is that we cannot decide the issue on any grounds that we can think of. We might add, at this point, that nothing hinges on making what is essentially a terminological decision. The 'real' proposal is the structure in (8), irrespective of how we label or call the nodes.

5.2. Linear order in signs

The discussion in the preceding section has brought to light a potential difference between spoken language constructs (syllables and segments) and sign language constructs, viz. that the former lack distinctive linear order while the latter have it. Indeed, we have assumed that the two points under each of the branching nodes in (8) must be linearly ordered so that, for example, we specify whether a hand shape is closing ([open] precedes [closed]) or opening ([closed] precedes [open]). In this section, we raise the question to what extent such linear information must really be specified in signs. In Wilbur's model linearization is necessarily present because she represents dynamic properties in terms of opposing value on a single tier. In our model, however, which employs branching structures for the same purpose, linear order is not necessarily implied. (Although this is beyond the scope of this article, the structural restriction that branching is binary can elegantly account for the fact that there is typically one transition per subsegmental unit. In other words, both local movement and path movements are typically simple transitions from one state to another.)

We therefore investigated the need for underlying linearization within the sign more closely. An important observation reported in the literature that seems to be relevant in this discussion is that in some signs movement direction varies. In the literature on ASL we find examples of what has been called *metathesis*. Liddell & Johnson (1989), for instance, point out that in the citation form of the ASL sign DEAF movement proceeds from ear to chin. In some instances, however, the order of settings is reversed. Liddell and Johnson suggest that this reversed order of settings is triggered by the sign that immediately precedes it. If the preceding sign is made in lower areas, the hand goes 'chin to ear'. Lucas (1995) shows that the locations of the preceding and following sign only play a modest role and that it is not completely clear what determines or triggers reversal of the initial and final positions. Examples of NGT-signs that have variants with reversed initial and final positions are TO CHECK and A LOT. These signs have a horizontal movement from side to side. Other signs, with vertical movements, seem to resist a reversed order. There are, however, examples of morphological contexts influencing the order of the positions even in vertical movements. Take, for example, the compound sign STREET LIGHT (POLE + LAMP) that was illustrated in Figure 5. The downward movement of POLE is reversed in the compound STREET LIGHT in order to smoothen and shorten the transition between the first and second part of the compound. There is therefore variation in the order of features in some subsegmental units.

5.2.1. Minimal pairs

An important argument for linearization at a phonological level would be the existence of minimal pairs consisting of the same feature content. In such pairs, the only thing that would differ would be the linear order of features in one of the subsegmental units. A hypothetical potential minimal pair would consist of the sign TO DO (as in Figure 3) and another sign with the 'reverse' hand-internal change, i.e. from close to open. Another minimal pair of this type would be the sign LATE, consisting of a movement of the whole hand from the contralateral side of the chest to the ipsilateral side of the chest, and another sign with the same handshape/orientation specification in which the hand moves from the ipsilateral side to the contralateral side of the chest. There are only very few sign pairs that are good candidates for this type of minimal pair. A review of the database SignPhon (a phonological-phonetic database containing over 3,000 lexical NGT signs) and of our knowledge of NGT signs resulted in the pairs of signs in (11):

- (11) MOTHER-TO LIE
BOTHER/INCONVENIENT-YUGOSLAVIA
TO GO TO SLEEP-TO WAKE UP
TO PAY TAX- TO GET FUNDING
TO GO UP-TO GO DOWN (ELEVATOR)
TOMORROW-YESTERDAY
EAST-WEST

Most pairs in (11), except for the first two, are examples of signs that have reversed movements *and* meanings. In sign production, such pairs are quite common. It seems that the direction of movement in these cases has a semantic flavor to it. In the next section we further discuss these semantically motivated directions of movement.

5.2.2. Preferred and motivated orders

A review of SignPhon reveals some further interesting patterns. We focused our study on two types of movement: simple path movement and changes in aperture. Our finding was that the order of feature values for these movements shows two patterns that need to be distinguished: *preferred (default) orders* and *motivated orders*.

We start with changes in aperture, which represent the most common type of hand-internal movement. The change can either involve opening or closing. For example, NICE has a closing handshape and AWAKE has an opening handshape:

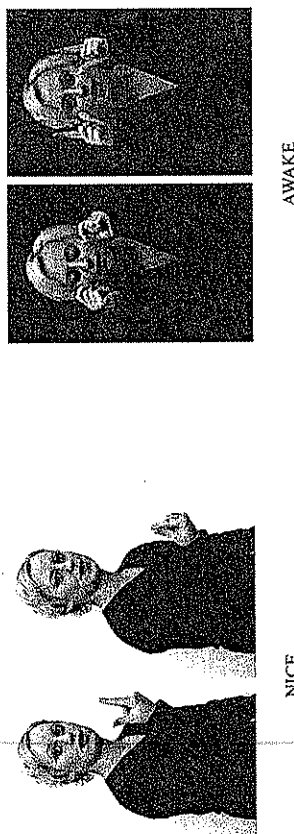


Figure 6

Since we proposed to represent these movements as transitions between two states, underlying linear ordering seems to be required in order to represent these movements in terms of the static features [open] and [close]. Of all signs with an aperture change ($n=277$), closing movement occurs twice as often as opening movement (180 vs. 97). Moreover, closing is neutral in meaning in most cases (e.g. NICE, SON, TO DO, DRY), whereas opening movement is often visually motivated (e.g. SHOOTING A PELLET, WAKING UP and FLOWER).

Turning to path movements, the direction of path movement in our model is also represented in terms of static features. For signs made in the space in front of the signer, the movement directions can be upward, downward, sideward from contralateral to ipsilateral (i.e. from left to right for a sign made with the right hand) and vice versa, and finally toward or away from the body. For signs on the head or body, the directions are limited to upward-downward and the two horizontal directions (contra-ward and ipsi-ward). These directions can be represented by the tentative feature pairs in (12):

- (12) downward/upward - [high]-[low]
 contralaterally/ipsilaterally - [contra]-[ipsi]
 forward/backward - [near]-[far]

Our survey of SignPhon again revealed clearly preferred directions of movement. From the distribution of movement in the *vertical dimension* (both in space and on the head and body) it is clear that downward movement is less marked than upward movement (289 vs. 53, only 16% upward). Moreover, of

these 53 signs with upward movement 90% are semantically motivated for direction. Iconic visual motivation accounts for 38 signs. Examples include UPWARD, BIG, TO PICK UP/TO FIND, SMOKE, (TO PUT ON) TROUSERS, ELEVATOR and ERECTION. Another 10 signs are in line with the metaphors that are active in ASL as well (Taub 2001). These metaphors are UP IS MORE, UP IS IMPROVEMENT and UP IS POWERFUL, as exemplified in the NGT signs PROFIT, TO PROMOTE, TO GROW and TO WIN. We may analyze these motivated directions as direction morphemes (cf. Brennan 2000). In that case, the signs at hand are morphologically complex. We may argue that underlying linearization in these signs is *morphologically* (and *semantically*) licensed. Downward is the unmarked direction, not only by its relative frequency, but also by the fact that it is semantically neutral, whereas upward is semantically motivated in a majority of the cases.

In the *horizontal-lateral dimension* the default direction is from the contralateral side to the ipsilateral side. Except for the sign WEST, which is clearly motivated by the visual image of West being left on the map, we found only three exceptions to this tendency (ISRAEL, TO LIE and OTHER). For signs with a lateral movement on the body, we observed various instances of variation in the direction of the lateral movement, even in the same discourse. For example, the sign TO INSPECT/EXAMINE, which has a lateral movement on the chest first touching the contralateral side, and then the ipsilateral side, occurred with the reversed order when it was followed by a pointing sign (index) toward the space in front of contralateral side of the body of the signer (as in the NGT sentence ALREADY EXAMINATION INDEX_{left} 'He already had his medical examination').

In the *horizontal-parallel dimension* the default direction is forward. And again, in most signs that have a backward movement the direction is semantically motivated or morphemic. Examples are DRAWER, TO PARK, BEHIND, TO ACCEPT, TO IMITATE, BACK.

Based on this survey of 3,000 signs, the following phonetic tendencies with respect to movement directions can be formulated. These tendencies are even stronger when we single out the signs with motivated directions by proposing a direction morpheme in these cases.

- (13) Unmarked directions of path movements are downward, toward the ipsilateral side (the side of the active hand), and forward (away from the body)

Summarizing, the need for underlying sequential structure is limited. The order of specified features either follows from a phonetic default pattern or is

iconically semantically motivated or morphologically determined. Elsewhere (e.g. van der Kooij 2002, van der Hulst and van der Kooij, to appear), we have argued for treating semantically-motivated form properties of signs in terms of *phonetic pre-specification*. This approach would allow a position that no linearization is needed in the phonological specification of signs.

6. Concluding remarks

In this article, we discussed a variety of models for the representation of monomorphemic signs. Starting with Stokoe's original simultaneous model, we saw how various researchers introduced linear structure in the form of sequences of two types of skeletal points. We argued against the adoption of such skeletal structures and proposed a return to the more simultaneous view in which the linear structure is 'tucked' away inside an essentially segmental structure. We then raised the conceptual question as to whether the intrasegmental linear structure should be regarded as syllabic structure or as a kind of complexity that is on a par with affricates in spoken languages. We concluded that it might not be possible to decide the matter on principled grounds. Then, we shifted our attention to the more substantive issue of linearity itself and offered some results of our inquiry into the 'functional load' of linearity in sign language. From a study of a corpus of signs from Sign Language of the Netherlands, we concluded that the linear order of branching structure is essentially predictable and that signs that go against the default have semantically determined linearizations. In line with our previous work, we suggested treating semantically motivated properties of signs in terms of *phonetic pre-specification*, i.e. the specification of phonetic properties of signs alongside phonological properties in the lexicon.

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Part 2

Nasality