Phonological Theories Meet Sign Language: Two Theories of the Two Hands

Harry van der Hulst
Holland Institute of Generative Linguistics (HIL)
University of Leiden

Wendy Sandler
The University of Haifa

Abstract. We explore two models of the nonpreference hand in sign language phonology. These models are fully developed by the authors elsewhere. Here, we compare and contrast the models, paying special attention to the relationship between the models and the theories behind them. In the process, we address questions of broad theoretical interest: (1) Does the existence of two anatomically similar articulators in sign languages require a phonological model that is fundamentally different from models of spoken language? (2) In what ways does the particular phonological theory adopted shape the investigation and its results? The model of Sandler (1989, 1994a) is motivated by theories of Feature Geometry (e.g., Clements 1985), while that of van der Hulst (1993, to appear) is motivated by principles of Dependency Phonology. These theories are not mutually exclusive, but each approaches the issue of phonological structure from a somewhat different perspective. We show that each model of the nonpreference hand has certain advantages over the other in accounting for the sign language data, and that the two models have independent theoretical and empirical consequences as well. In each model, the presence of two similar articulators leads to structural differences between signed and spoken languages, but in neither case do these differences violate general principles of phonological structure. That is, each phonological theory can accommodate the facts in a principled way. We find that each model serves to explain somewhat different properties of the aspects of sign language phonology examined. The particular phenomena that we analyze do not conclusively select one phonological theory over the other, but we do not see this as a shortcoming of the investigation. On the contrary, our results indicate that adopting different theories for sound reasons can expand our understanding of phonological phenomena, while at the same time shedding light on the scope and explanatory power of the theories.

1. Introduction.

A large and growing body of research has demonstrated that the sign languages of the deaf have a phonological level of structure, and that this

phonology bears certain nontrivial similarities to the phonology of spoken language (see Corina and Sandler 1993 for an overview). One substantive difference between the articulatory systems of languages in different modalities is the existence of two anatomically similar articulatory elements in sign language: the two hands. Spoken language has no equivalent in its articulatory system.

The ultimate goal of the enterprise is to attempt to arrive at modality-independent phonological universals. Therefore, investigation of the behavior of the two hands in the phonology of sign language is a challenging place to look. Does this modality-specific property require a phonological model of sign language that is different in principled ways from models of spoken language?

The exploration is organized in the following way. In section 2, the empirical problem is presented. Two types of two-handed signs are discussed. In one type, the nonpreference hand -- henceforth called the weak hand, after Padden and Perlmutter (1987) -- functions as a place of articulation for the preference (strong) hand. In the other type of two-handed sign, both hands appear to play the same role, both performing the same action as an articulator at some place. The problem is that despite its dual role, the nonpreference hand is physiologically unitary, and in some ways it functions as a single entity regardless of its phonological role.

Each of the authors in earlier work approaches the problem of sign language phonology by asking the question, what properties are likely to be universal regardless of modality? Section 3 is devoted to Sandler's (1989, 1994a) feature-class approach (the G (Geometry) model). The basic theoretical premise is that phonological features are not randomly glommed together, but are rather organized into classes, as evidenced by their behavior in phonological processes (following, e.g., Clements 1985). While the features themselves will be different in spoken and signed languages, their organization into classes is taken as a reasonable candidate for a language universal. In her model, the weak hand has two independent representations: as a duplicate hand configuration, duplicating the features of the strong (preference) hand, or as a place of articulation with other places like the head or the trunk. It is shown how this representation correctly predicts the phonological patterning of the weak hand according to its two roles.

Section 4 lays out the main aspects of van der Hulst's (1993, to appear) Dependency (D) model. The theoretical premise here is that structural properties such as headedness are expected to characterize phonology. Heads and dependents regardless of component or modality are assumed to have particular properties, and the weak hand is shown to manifest properties of dependents. In the D model, the weak hand has the same basic structural representation regardless of role, and not two different representations, as in the G model.

Each model relies to some extent on the assumption that there is a relationship between complexity and markedness which ought to be reflected in the phonological representation. In each model, then, the weak hand is underspecified to some extent. In the D model, the degree of underspecification is the main indicator of the role of the weak hand in a given sign. This way of distinguishing the two roles is exploited to explain the behavior of the weak hand in the phonological process of Weak Drop.

In section 5, we examine shortcomings of each model. Of particular interest is the question of whether the shortcomings result from the theoretical perspectives adopted, or whether they are a function of the specific analyses of the weak hand.

In the last section, some predictions and consequences of each model are described. As might be expected, the G model predicts that the weak hand will pattern with its parent class for any constraint or process affecting that class. We offer examples showing that such predictions are correct. The predictions made by the D model involve properties of a more relational nature, as a result of the head-dependency relation inherent in the theory on which it is based. Predictions of this sort are also shown to be borne out. In this way, the investigations highlight strengths of each theoretical approach.

2. Characteristics and behavior of the weak hand.[1]

2.1. Structure. A sign is formed by moving the hand, in some specified shape, from one location to another. For example, the sign SICK is formed by moving the hand, middle finger extended, from a point in front of the head to contact with the forehead. In this sign, the place of articulation is the head. Another common place of articulation is the trunk. A third common place of articulation is the weak hand. For example, the sign TOUCH is like SICK, except that the place of articulation is the weak hand.

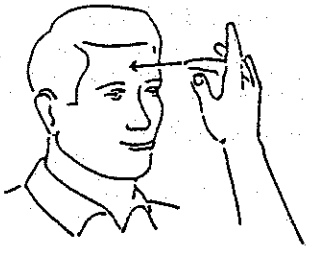


Figure 1. SICK

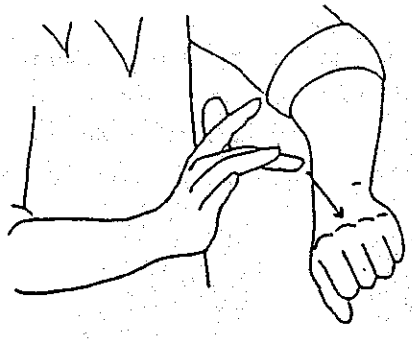


Figure 2. TOUCH

In TOUCH, then, the weak hand acts as a place of articulation, like the head in SICK. In some signs, the weak hand is involved but not as a place of articulation. Rather, it acts in the same way as the strong hand, articulating movements with respect to some place of articulation. An example of a two-handed sign of this second type is THRILL.

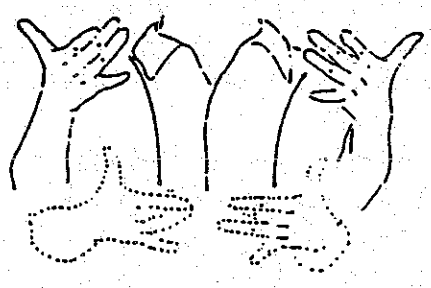


Figure 3. THRILL

Throughout this part of the exposition, we shall call TOUCH-type signs 2P signs (signs in which the weak hand (h2) is a Place of articulation), and THRILL-type signs 2E signs (signs in which h2 is an Echo of the strong hand). There are certain formational constraints on the weak hand in each type of two-handed sign. These were first formulated in Battison (1978):

(1) Symmetry Condition: If both hands move independently during articulation of a sign, then both hands must be specified for the same handshape and the same movement (simultaneously or in alternation), and specification for orientation must be symmetrical or identical.

(2) Dominance Condition: If the two hands do not share the same specification for handshape, then the specification of the passive handshape must belong to a restricted set: "A,S,B,5,G,C,O"

Sandler (1991, 1994b, to appear), presents an analysis of hand configuration which reduces this set of shapes to three: "G (1), 5, and A," pictured in (4). The ASL literature provides evidence from language acquisition and other domains for considering this set unmarked.

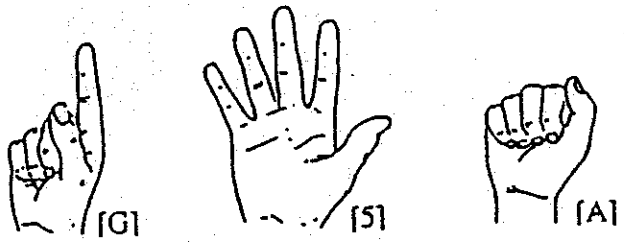


Figure 4. Unmarked Shapes

The dominance condition allows any handshape on h1, but if h2 is specified for a different shape than h1, this specification can only be one of the unmarked shapes. So, TOUCH (figure 2) is okay, because h2 is in an unmarked configuration. But there cannot be a sign similar to TOUCH, except that h2 is in a marked "X" (curved G) configuration, for example.

The conditions proposed by Battison allow h2 to be characterized by a marked handshape when it functions as an empty articulator, and then it must be identical to h1. An example of this is THRILL, pictured in (3).

Battison's conditions leave open the possibility that h2 may also have the same handshape as h1 in signs in which the weak hand acts as a place. In fact, in that case the weak hand may have a marked handshape, i.e., a handshape outside the unmarked set, and this is indeed the case in some signs, for example in the sign SIT.

It seems reasonable to assume that any sign that utilizes two articulators is more complex motorically than signs utilizing only one, and that this relative complexity will be reflected in the representation system adopted. Battison's constraints on two-handed signs are seen as limitations on the overall complexity of such signs (Brentari and Goldsmith 1993).

The symmetry condition notes that in signs in which the two hands move independendently, h2 may differ from h1 in very particular ways. The handshape must be identical. But the orientations may be either identical or symmetrical, and the movement pattern may be either identical or alternating. In addition to these observations, we add that the settings -- i.e, the particular area within a place of articulation -- may either be symmetrical or asymmetrical.

In the sign DIE, the two hands are in the same configuration and each moves. The movement is a change in orientation from palm-up to palm-down for the dominant hand, and from palm-down to palm-up for the nondominant hand. This contrasts, for example, with the sign BOOK, in which the two hands begin with the palms together, and the hands rotate outward so that each ends up palm-up. The example is from van der Hulst (1993, to appear), who collapses the observations described above to the following generalization: articulations of the two hands in signs in which both move (E2 signs) are either the same or opposite. In the sign COAT, the two hands contact the body, each on the side ipsilateral to it. In the sign ARMY, the two hands contact the body on one side: the side ipsilateral to the preference hand (contralateral to the nonpreference hand). There can be no specifications along either of these parameters that is other than the same or the opposite. For example, there is no E2 sign in which h1 has a palm-up orientation and h2 has an orientation of palm facing the body.

In the class of signs in which h2 does not move, the class we refer to as 2P (h2 = place of articulation) signs, neither the handshape nor the orientation of h2 is predictable on the basis of h1. They may be the same,

opposite, or just different, with the constraint that h2 is restricted to one of a few handshapes. Regardless of whether the weak hand articulates the same shape, place, and movement as the strong hand, or whether it functions as a place of articulation for the strong hand, then, the form of the weak hand is more restricted than that of the strong hand. Formational properties of the weak hand in each type of two-handed sign are listed in Appendix 1.

2.2. Processes. It is shown in Sandler (1994a) that morphophonological and phonological processes affect the weak hand differently, depending on whether it is functioning as an echo articulator or as a place of articulation. Here, we discuss the following processes that distinguish the two roles of h2: hand configuration assimilation, place "spread" or placing, empty root copy, weak drop, weak freeze, and multiple exhaustive inflection.

2.2.1. Hand configuration assimilation. In many ASL compounds, the hand configuration of the second member spreads regressively, and the hand configuration of the first member deletes (Sandler 1987a, 1989, 1994).[2] The surface form of the compound has a single hand configuration, the one that underlyingly characterized the second member of the compound. When the hand configuration that spreads characterizes an E2 sign, then both hands spread. In other words, if the second member of the compound is a two-handed sign in which h2 is an echo of h1, then the surface hand configuration of the whole compound after assimilation is also two-handed. If we wish to represent this process as the spreading of a single structural element, this implies that the two hands of an E2 sign form a class, i.e., are dominated by a single node (following Clements 1985, Sagey 1986). An example is the compound MIND+DROP=FAINT.

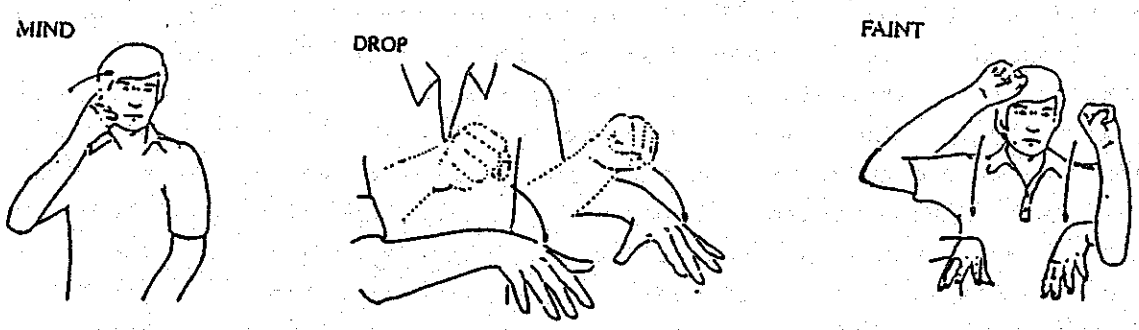


Figure 5. MIND+DROP=FAINT. Assimilation of both hands in an E2 sign.

If the second sign in a compound is two-handed, but h2 is a place, then h2 does not assimilate with h1.

2.2.2. Regressive h2-Placing. Another process that affects compounds occurs where the first sign is one-handed and the second is a two-handed 2P sign -- one in which h2 is a place of articulation. In these compounds, h2 appears in the signing space at the beginning of the compound (Liddell and Johnson 1986, Sandler 1989, 1994a). To explain in other words: the weak hand is a place of articulation in the second sign in these compounds. It is raised into the signing space when the first member is articulated on some other place of articulation. An example is BLACK+NAME=BAD REPUTATION. The illustration shows the two sign types and the compound, but unfortunately does not show the temporal ordering.

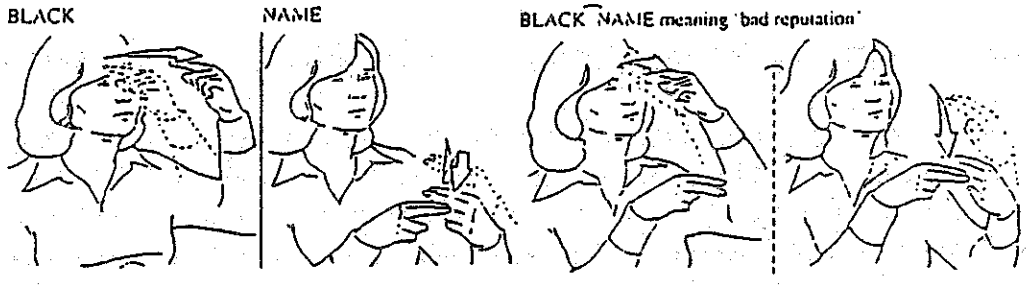


Figure 6. BLACK+NAME=BAD REPUTATION. Illustration c Ursula Bellugi.

This process is very productive, but is restricted to signs in which h2 is a place only. This process is called placing in Sandler (1994a).

2.2.3. E2 Copy. What does happen to compounds in which the second hand is two-handed, but is an echo articulator rather than a place? In such signs, different changes may occur. Either total regressive assimilation of hand configuration may occur, as described above and shown in Figure 5, or the first sign retains its own configuration, but adds h2 to become an E2 sign itself. That is, the first sign takes from the second member the characteristic of being a two-handed echo sign, but does not assimilate the features from the second sign.

An example is SLEEP+CLOTHES=NIGHTGOWN. In the compound, NIGHTGOWN, the first member becomes an E2 sign. That is, the weak hand, not involved in the base of SLEEP at all, behaves just like the dominant hand in the compound. The structural condition for the application of this rule is that the first sign in the compound be one-handed, and the second be E2.

It is not enough to say that the second sign must be two-handed; two-handed 2P signs do not undergo the process. Here again, a distinction between the two sign types is required.

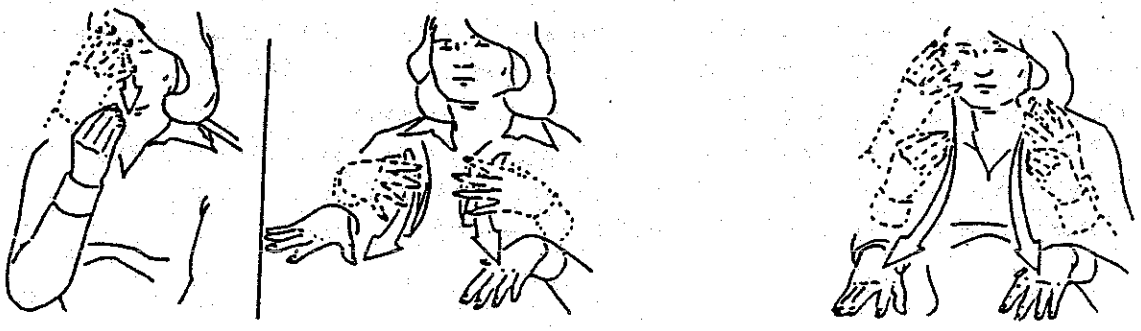


Figure 7. SLEEP+CLOTHES=NIGHT-GOWN. Illustration c Ursula Bellugi

2.2.4. Weak Drop. A phonological process that deletes the weak hand from a sign is described in Padden and Perlmutter (1987, henceforth P&P). P&P call this process Weak Drop. While P&P do not distinguish between the two functions for the weak hand that is described here, this process appears to make the distinction, since it only applies productively to the weak hand in E2 signs. Though h2 of 2P signs may delete sometimes, its deletion there is more constrained, and is generally not as acceptable (Battison 1974, Carol Padden, p.c.). This means that any E2 sign, such as DROP, has a one-handed variant. But one-handed variants of 2P signs like TOUCH (figure 2) would be odd or difficult to interpret. Therefore, h2-place deletion seems to require independent conditions for application. We will see that each of the models discussed here has a different explanation for these facts.

2.2.5. Weak Freeze. Another process affecting h2 is discussed in P&P: Weak Freeze. Under Weak Freeze, h2 remains in the signal but does not move. That is, h2 assumes its specified configuration and is raised into the signing space (rather than being left uninvolved alongside the body), but it does not articulate the specific locations and the movement that h1 does. The conditions under which the rule applies are as yet unclear, and may simply be sytlistic. P&P suggest that uncounted, rapidly repeated ("trilled") movement is a necessary condition for the application of Weak Freeze. This movement may be lexical or it may be derived. The rule is irrelevant to the majority of 2P signs, in which h2 does not move anyway, and therefore cannot be frozen. But in any case an adequate model of two-handed signs should be able to represent Weak Freeze.

2.2.6. The behavior of h2 under multiple exhaustive inflection. In the h2-place sign INFLUENCE, the first location articulated by h1 is on the back of h2. h1 then moves outward, toward the referent of the object of the verb. In its uninflected form, h2 does not move in this sign. Under multiple exhaustive inflection ('influence each of many'), however, h2 does move. In this form of INFLUENCE, the underlying outward path movement and the opening hand movement of h1 are iterated several times by h1 only, while **both hands** move along a horizontal arc-shaped path. Due to the fact that h2-P does move under multiple exhaustive in 2P signs, Brentari (1990) aruges that h2 should have a unified representation regardless of function. She argues that in these inflections, h2-P appears similar to h2-E because the two hands move together.

This similarity is only apparent, however. In fact, the nondominant hand in 2P signs does not behave the same as it does in E2 signs under this inflection. Although the two hands move in the same horizontal arc path in a 2P sign like INFLUENCE, they do not move together in the same way as E2 hands do. Rather, in 2P signs, the dominant hand repeatedly rearticulates the basic movement (outward and opening, for INFLUENCE) along the horizontal arc path, while the nondominant hand moves only in a smooth horizontal arc, without any outward or opening movement. That is, h2 manifests the inflectional horizontal arc movement, but not the lexical path movement and not the lexical hand internal (opening) movement.

This contrasts clearly with the formationally similar but E2 sign, BAWL-OUT. In the multiple exhaustive form of BAWL-OUT the movement of both hands is identical, both moving outward repeatedly, both opening repeatedly, while simultaneously moving along a horizontal arc path. In E2 signs, then, both h1 and h2 execute the reiterated lexical path and internal movements as well as the inflectional horizontal arc movement. In 2P signs, though, only h1 iterates the opening movement and the outward path movement, while both hands travel along a horizontal arc.

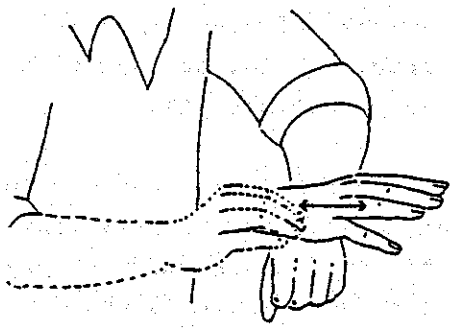


Figure 8. INFLUENCE (2P)

Figure 9. BAWL-OUT (E2)

2.3. Summary. We have seen that the morphology and phonology of ASL support a distinction between the two roles of the weak hand. The processes described show a systematic difference between 2P and E2 signs as summarized in Appendix 2. In the next two sections, we will see how the two models under discussion attempt to account for these phenomena.

3. The G model.

The overall model of sign language structure assumed for the G model of the weak hand is that of Sandler (1989). In this model, there is a timing tier consisting of sequentially organized locations and movements (Ls and Ms), and there are classes of features that are autosegmentally associated to the LM tier: hand confirgurations and places of articulation. While there is phonological and morphological evidence that locations and movements are sequentially ordered (e.g., Newkirk 1981, Liddell 1984, Liddell and Johnson 1985, 1989, Sandler 1987b, 1989, 1993a), morpheme structure constraints require that a single hand configuration and a single place of articulation is realized simultaneously on each morpheme (Battison 1978, Sandler 1989). Adopting an autosegmental representation (Goldsmith 1976), this temporal relationship is captured in Sandler's model by multiple association of the single hand configuration and the single place of articulation to the Ls and Ms on the LM tier.

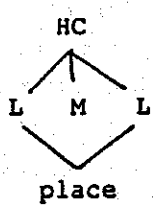


Figure 10. Multiple association to the timing tier.

If figure 10 were a representation of the sign SICK, for example, then the HC node would dominate handshape features specifying the middle finger in an extended position, the place of articulation would be the head, the first location would be specified for a setting a short distance in front of the forehead, and the last location would be specified for contact with the forehead. The movement in this sign is a plain, straight path movement.

Since signed and spoken language are the product of the same human brain and subserve the same communicative function, certain common organizational properties are expected to be found. Following the Feature Geometry theory of Clements (1985), Sandler seeks to express in the representation the way in which features divide themselves into classes in the forms and rule system of American Sign Language. In Feature Geometry theories, features are dominated by class nodes. The phonology may make reference to individual features, or to whole classes of features. In place

assimilation in spoken language, for example, the whole place node is affected. Here, we show only the major groupings for the G model of sign language; in a full representation, features of each category, hierarchically organized into subclasses, are associated to each of the elements shown in 10 (Sandler 1987a,b, 1989, 1993a,b,c, 1994a,b, to appear).

We have seen that the weak hand functions sometimes as a copy of hand configuration (h1), and sometimes as a place of articulation. The G theory of h2 represents this bifurcation in a straightforward way. In E2 signs, the weak hand is associated to the same features as the strong hand -- it is dominated by the HC node together with the strong hand. In 2P signs, the weak hand is represented as a feature of place, just as the head is represented as a place feature for the sign SICK.

E2 signs, in which h2 shares its configuration with h1 and articulates the same locations and movements, are represented with two HC root nodes, associated to the same HC node. Each root node dominates the same hierarchy of class nodes, including handshape and orientation classes (not shown in 11). Each dual class node dominates a single feature, since each hand is characterized by the same feature. This representation reflects Battison's Symmetry Condition.

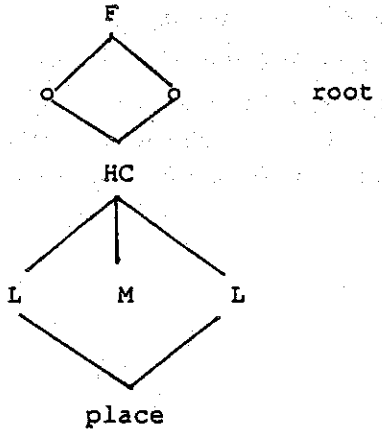


Figure 11. An E2 sign in the G model.

Via association to the HC node, each hand is associated to the same locations and movements. Two properties of the weak hand are captured by this representation: (1) two-handed E2 signs are more complex than one-handed signs, since they have additional HC root and class nodes, and (2) the weak hand representation is underspecified, sharing features of the strong hand.

The G model attempts to capture generalizations related to the organization of features into classes. We have seen that the weak hand patterns with the strong hand in E2 signs, in the processes of hand

configuration assimilation, spread of two-handedness, weak drop, weak freeze, and multiple exhaustive inflection. Representing h2 as subordinte to the HC node correctly predicts that whatever h1 does, h2 will also do in such signs. If the HC node assmilates from an E2 sign, for example, both hands will spread. This accounts for the hand configuration facts illustrated in figure 5.

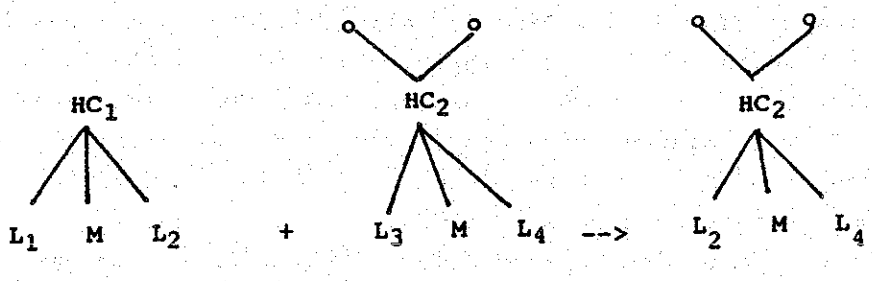


Figure 12. Hand configuration (E2) assimilation under compounding.

The representation in 11 accounts for the behavior of the weak hand in the multiple exhaustive inflection as well: both hands reiterate the path movement as well as the hand internal movement if there is one (BAWL-OUT), while moving along a horizontal arc path. The details of this pattern are beyond the scope of this paper. However, if h2 is linked to all the same features as h1 as well as to the same locations and movements, as the model shown in figure 11 requires, then h2 will necessarily do as h1 does.

As for 2P signs, they look like any other sign specified for place. In the figure below, the place is [h2]. In a sign like SICK, the place feature would be [head].

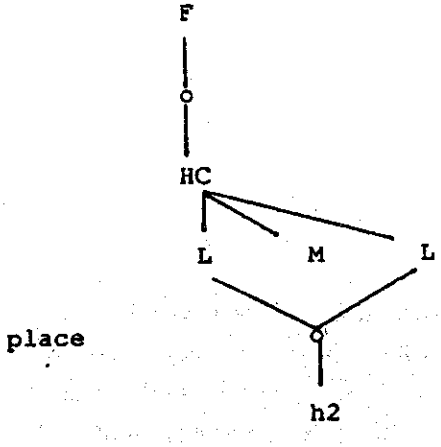


Figure 13. A 2P sign in the G model.

2P, i.e., h2 in its role as place of articulation, "spreads" regressively in compounds in a particular way. The weak hand appears in the signing space at the beginning of the compound, but it neither

articulates with the strong hand nor does it serve as a place of articulation; it simply appears. This process is represented in the G model by circling the information that spreads and bracketing its domain.

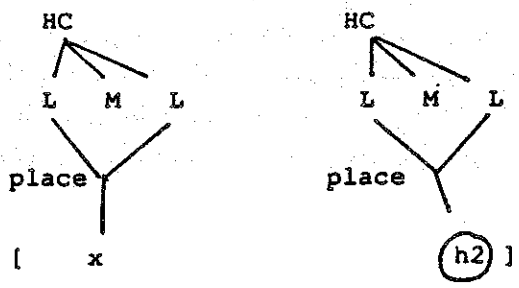


Figure 14. Placing.

The only apparent difference between h2 and other places of articulation is that h2 may be somewhat more complex, since handshape and orientation are not fully predictable. Specification of h2-P notwithstanding, h2 is still restricted in this role: it can only assume one of a very small number of basic handshapes.[3,4] A componential dependency model of handshapes (Sandler 1994b, to appear) develops the position that the unmarked handshapes are the least complex, i.e., the least specified. Unfortunately, the details of this representation cannot be described here due to space constraints. In any case, the fact that only the least-specified shapes are available to the weak hand in 2P signs reflects Battison's dominance condition.

In Weak Drop, the nondominant hand is deleted from the sign, in E2 signs. This is represented in 15 as delinking the root node of h2 from the HC and from all of its class nodes. The class nodes above the roots dominate handshape and orientation features.

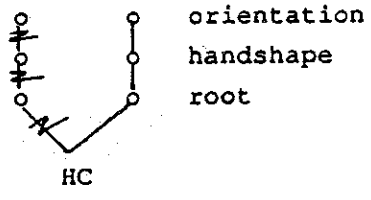


Figure 15. Weak Drop

It is a convention of the formalism that if a node is delinked, all of the nodes it dominates are deleted with it. Why then is it suggested in 15 that the lower nodes be explicitly delinked by this rule rather than disembody them by the usual convention? The reasons for this treatment are empirical and modality specific. The empirical reason for delinking each class node is that Weak Drop must be distinguished from Weak Freeze. Weak Freeze is represented by delinking the h2 root node from the HC node,

as in figure 16. The modality specific justification is simply that articulators are perceivable in the sign language channel, while they are not directly perceivable in spoken language. Sign language utilizes the distinction between actual articulation and presence of an articulator in the signal, as we have also seen in the placing process.

In the model adopted here, the dynamic aspects of path movement are represented as a sequence of locations and movements. In order to block h2 from articulating that sequence but still leave it in the signal, it must be delinked from the LM tier, "freezing" it, but must remain associated to its own features specifications.

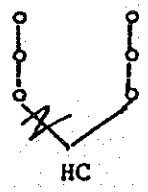


Figure 16. Weak Freeze

Leaving h2 linked to its own feature specifications for handshape and orientation, while breaking its transitive link with the LM tier, allows the configuration of h2 to be specified, while freezing its movement. Notice that both of these rules require access to the structure of the schema in Figure 11. See Sandler (1994a) for further justification of the distinction between the two kinds of delinking.

The opposite of Weak Drop is the process seen in the compound SLEEP+DRESS=NIGHTGOWN in which the first sign assimilates two-handedness from the second sign to produce two E2 morphemes in the compound. This is expressed by a rule of empty root copy. (Feature classes of HC are left out of the representation for simplicity.)

Figure 17. Empty root copy

The output of this rule is an E2 sign. Note that the application of this rule is triggered by the adjacent E2 sign.

Pointing out that in both empty root copy and in placing (shown in Figure 14), the weak hand spreads regressively, van der Hulst (to appear) collapses these two processes. This will be discussed and compared with the G model treatment in section 4.

Summary. The G model represents weak hand features in E2 signs as a

subclass of the hand configuration category. In 2P signs, weak hand features are represented as dominated by the place category. This representation, guided by the theoretical position that the grouping of features into classes is a language universal, captures structural generalizations such as the symmetry condition, and makes h2 features accessible to phonological rules according to class membership.

The fact that the weak hand is less specified than the strong hand in each of its roles is reflected in the model in two different ways. In E2 signs, h2 has no features of its own. Rather, it shares the features of the strong hand. In 2P signs, the set of handshapes available to the weak hand is only the unmarked set, those represented in the model of Sandler (1994a, to appear) as least complex.

What makes this model different from models of spoken language is the fact that a single articulatory element has two distinct representations.[5] Generally, spoken language vocal organs are not capable of doubling as articulators and places of articulations. An exception is the velum, which is an articulator in nasal sounds, but is a place of articulation in velar sounds, and indeed the two roles merit different representations in models of spoken language. Nevertheless, we see the roles of the weak hand in sign language to be significantly different, in that the weak hand is a complex articulatory element (as opposed to a single feature such as nasal or velar) and one that is very pervasive in the lexicon. Therefore, the dual role of this articulatory element appears to represent a genuine difference between signed and spoken language, and this difference ought to be reflected in any phonological model.

4. The D model.

In constructing a model of sign structure, van der Hulst (1993) begins with somewhat different assumptions about what is likely to be universal in phonological organization. He adopts a central tenet of dependency phonology (Anderson and Ewen 1987, van der Hulst 1989), namely, that phonological constituents are in a head-dependent relationship. While this view does not reject the feature class theory of Clements for example, the emphasis is on the relational nature of head-dependent structures. Heads and their dependents are assumed to have certain types of properties throughout the phonology. At the intuitive level, heads are stronger in some sense than their dependents. The head of a foot is the stressed syllable; the head feature-type component makes a greater contribution to the phonetic form than the dependent. In addition, heads are less restricted in content than dependents (Dresher and van der Hulst 1994). Finally, as in the feature geometry theory of Clements and others, dependents in this theory may spread alone, while heads may only spread if they take along their dependents as well.

In this framework, the D model proposes that place is the head of the

sign unit, that hand configuration (h1 in one-handed signs) is a dependent of place. The primary motivation for this is that HC shows one of the basic characteristics of dependent units, i.e., the capability to spread. We have seen in Section 2.2.2. that the HC unit may spread in compounds. No comparable process of place spreading appears to occur (we have shown that Placing is not the same as true spreading). Another indication that the place unit is somehow central may be derived from the order in which children acquire the components of signs. Children first get the place of articulation right (in combination with the movement) and only later the specific handshapes.

The whole structure is argued to constitute a sign syllable. In all two-handed signs, the basic structure of one-handed signs is duplicated and associated as a dependent syllable. The dominant place and hand configuration are suggested to be the head syllable in the sign "foot", while the nondominant hand and the place it is a dependent of are the weak syllable. The weak hand in E2 signs, called balanced signs in the D model, is unspecified for any features, getting all of its features redundantly from h1. In 2P signs, called unbalanced signs, the weak hand is specified for features, but only from a subset of the features that may characterize the strong hand. In this way, the representation reflects a distinction between the two roles of h2, but the distinction is intentionally minimal. In addition, the distinction becomes opaque in signs like SIT, in which the two hands have the same configuration, but h2 is a place. This problem is alleviated by another aspect of the representation, explained below.

In figure 18, we give van der Hulst's representation for one-handed signs, and figure 19 shows how two-handed signs are represented. The two types of two-handed signs differ in whether or not information is specified for h2. In the case of unbalanced signs, unmarked information is underspecified. The unmarked place of articulation is the neutral space in front of the signer, and it is left entirely unspecified. Only the unmarked handshapes 1, 5, or A may be specified for SF2 (= Selected Fingers, corresponding to hand configuration).

The internal structure of the SF1/HC node is essentially that motivated in Sandler (1989) moulded to an X-bar like organization. Place too has an X-bar like organization. For motivation of the specific details, we refer to van der Hulst (1993). The terminal modes of the "feature tree" are associated to the two points in the syllable skeleton. In two-handed signs, all feature information of both feature trees is associated to the same skeleton. Thus it is specified that the two hands are temporally coordinated. The use of the term "foot" should not conceal that the structure in 19 is a truly modality specific one, since it expresses no linear order between the two hands. In this sense, the sign "foot" is fundamentally different from feet in spoken languages.

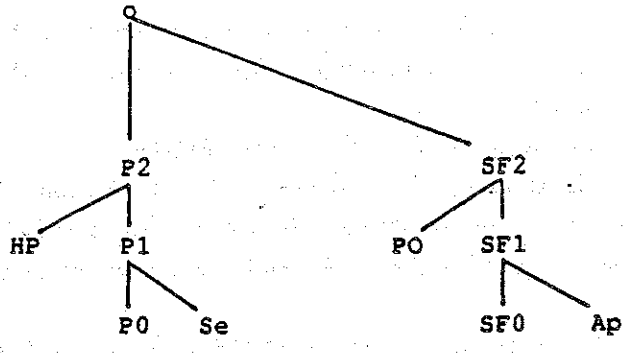


Figure 18. The representation of one-handed signs

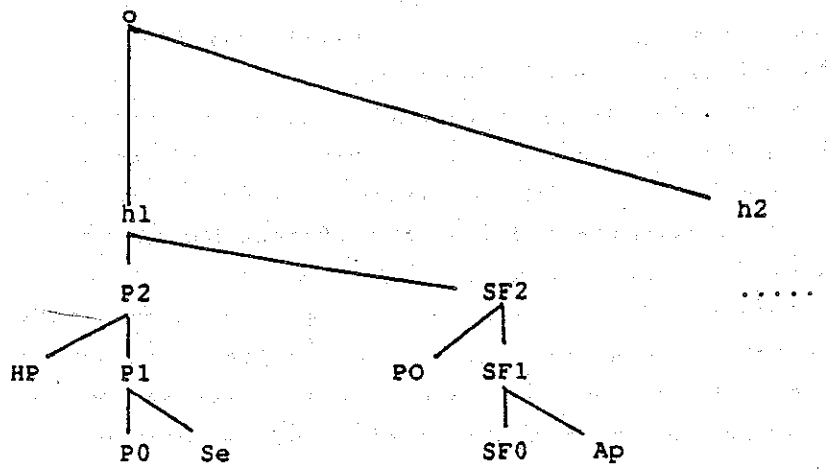


Figure 19. The representation of two-handed signs
h1 = strong hand
h2 = weak hand
P = Place
HP = Hand Position
Se = Setting
SF = Selected Fingers (Hand Configuration)
PO = Palm Orientation
Ap = Aperture

The intuition behind the structure in figure 19 is that the weak hand is either poorly specified (like the weak syllable in a foot is often reduced

to simple CV combination with a schwa vowel) or completely unspecified, and thus harmonic with the strong syllable. Unbalanced signs represent the former case, balanced signs the latter.

Thus, h2 in both types of two-handed signs shows the typical characteristics of dependents in head-dependent relations. It either has weak capabilities for expressing contrast or lacks contrast altogether. Van der Hulst's model, then, claims to capture what balanced and unbalanced signs have in common.

It now remains to be shown how the D model can explain that both types of two-handed signs appear to behave differently vis à vis the processes that we have discussed in section 2. Van der Hulst (to appear) does not address all the processes that we have seen in that section. We will summarize here his treatment of Weak Drop and spreading in compounds, concluding with an argument that he uses from historical change.

Recall that Weak Drop (WD) involves the phenomenon that two-handed signs may be realized with the strong hand only. If the weak hand in unbalanced and balanced signs has a totally different structural position, it is expected that WD will differentiate between them.

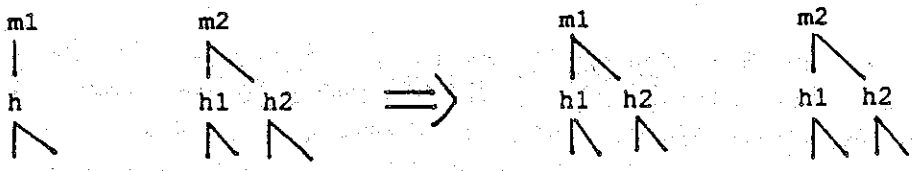
Sandler argues that WD only occurs in balanced signs, and not in unbalanced signs. This observation conforms to what is reported in Battison (1974), who observes that WD is possible in non-alternating balanced signs only. In unbalanced signs with different handshapes, deletion generally does not occur. However, deletion may occur in such signs where the weak hand is characterized by a B shape -- importantly, one of the least marked shapes. In unbalanced signs with identical handshapes, WD sometimes occurs in conversation, but then "there always seemed to be the need to 'ghost' the deleted hand by contacting another part of the body or another object."

The fact, however, that WD sometimes does apply to the weak hand in unbalanced signs can be taken as an argument in support of a uniform representation of the weak hand. Moreover, Weak Drop does not apply to all balanced signs, but rather (in its regular application) cuts through the class of balanced signs by excluding alternating signs. Arguing that alternating signs are represented with a feature [alternating] specified on the weak hand node, van der Hulst therefore capitalizes on the idea put forward in Brentari (1990), that it is plausible to say that WD can only freely target a weak hand node that is completely unspecified, i.e., only non-alternating balanced signs. That the amount of information carried by the weak hand plays a role in WD is also suggested in Battison (1974). The weak hand in unbalanced signs carries independent information, and therefore resists unrecoverable deletion. Yet at least in the case of one of the least marked handshapes (B), WD may also apply to such signs.

We now turn to van der Hulst's treatment of regressive h2 placing (cf. section 2.2.2.) and E2 Copy (cf. section 2.2.3.). Sandler's point is that placing can only affect a weak hand which is a place, whereas E2 copy can

only apply if the trigger sign is one in which the weak hand is an echo. Van der Hulst points out that the two processes can be collapsed into one: the weak hand node of the trigger (i.e., the second) sign in a compound spreads leftward. If this weak hand node is completely unspecified, it spreads as such. In that case, the empty node will be interpreted as a copy of the strong hand of the target (i.e., the first) sign. Thus the apparent differences between placing and E2 copy are an effect of the difference between spreading a node that has content and an empty node ("m" stands for morpheme in figure 20):

a. Placing



b. E2 Copy

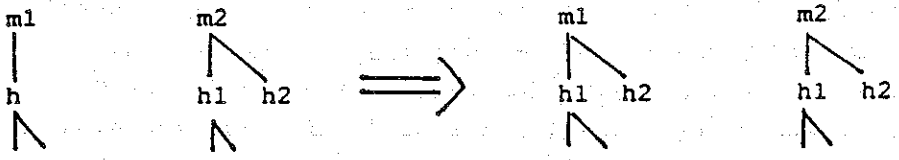


Figure 20. Placing and E2 Copy as one process

An additional point can be made on the basis of weak hand spreading. In van der Hulst (1993), it is argued that one of the arguments for representing Place as a head was the non-spreading character of this category. If this constraint on what may spread holds, we should not be inclined to analyze weak hand "spreading" as place spreading per se. As Sandler points out, this Placing process has different phonetic properties from those of normal spreading.

Finally, we turn to the argument from historical change. Frischberg (1975) and others report on diachronic changes in the phonology of signs. She shows that many changes involve a drift to greater symmetry. This is shown by the fact that the weak hand in unbalanced signs sometimes changes such that its shape becomes identical to that of the strong hand. Even more interesting is the fact that there are cases in which unbalanced signs (which may first have undergone the handshape change just mentioned) change further, to become balanced, two-handed signs, i.e., signs in which each hand also executes the same movement. In the D model, the chain of changes just described involves the gradual loss of information on the weak hand node.

Summary. The D model expresses the theoretical position that phonological elements universally stand in head-dependent relationships. While the model is capable of expressing differences between E2 (balanced) and 2P (unbalanced) signs, this difference is minimized in favor of what is seen as the more general head-dependent relation between the two hands regardless of role.

As is the case with the G model, the D model also shows that the existence of two anatomically similar articulatory elements results in modality-specific phonological structure, although the D structure is fundamentally different from the G structure. In the D model, there are two structurally identical trees, one for each hand.

5. Strengths and (especially) weaknesses of each model.

As we pointed out in section 1, the challenge presented by the weak hand is that it is one articulatory element but it has two phonological roles. In section 4, we have shown that the weak hand sometimes acts like a unified entity regardless of role. The G model emphasizes the differences in the two roles, while the D model emphasizes similar properties for the weak hand regardless of role. Both are correct in significant ways. As shown in section 3, the weak hand manifests two distinct patterns in terms of basic structure as well as behavior in the phonology and morphology. The independent representations and class memberships proposed in the G model fully account for these facts. Section 4 showed that the weak hand sometimes behaves in a unified way regardless of role, and that in each role it exhibits properties of a dependent vis à vis the strong hand. The unified representation of the weak hand as a dependent captures this generalization. As might be expected, the strength of each model is also its weakness, however, since the perfect model must be able to explain all the properties of the weak hand in a coherent and elegant way.

5.1. Weaknesses of the G model. All cases in which the weak hand exhibits unified behavior regardless of role are problematic for the G model. The fact that Weak Drop affects the weak hand as an echo across the board, and only sometimes affects the weak hand as a place supports the model, but only on the assumption expressed in section 3 that the loss of the weak hand involves two distinct processes depending on sign type (E2 or 2P). However, it is still a fact that weak drop may affect the weak hand in either role, even if the conditions differ in ways that are as yet not fully understood. The G model makes this behavior appear coincidental, which seems suspicious. An approach such as the D model account, according to which the ability of the weak hand to drop depends on the degree of specification and not on role appears more explanatory. Though it is not yet confirmed, it has the added advantage of being empirically testable.

Similarly, the historical change in which unbalanced signs become balanced signs is incoherent in the G model. (See Brentari 1992 for a

critique.) If it is the case that this diachronic process occurs in two stages -- first hand configuration uniformity and then movement-location uniformity -- then expression of these changes in the G model would involve entirely different mechanisms, which seems undesirable. However, it must be added that this process is extremely marginal, only having been documented for three or four signs, and therefore presents less of a problem.

A generalization goes unexplained in the G model because the two representations of the weak hand are absolutely distinct: E2 signs may never have the weak hand specified as a place of articulation. This generalization, clearly a result of the fact that the weak hand cannot fulfill both roles at once, appears coincidental in the model, which we see as a weakness.

As we have seen, there are two processes involving the regressive "spread" of the weak hand in compounds, which are expressly unrelated in the G model and analysis: placing and empty root copy. This is also somewhat problematic for the G model, since it is generally desirable to express commonality between two phonetically similar processes affecting the same articulator.

Finally, we turn to another aspect of the G model which may be seen as a weakness: the ways in which restrictions on the weak hand are expressed. It has been noted that the weak hand is in some sense more restricted than the strong hand, regardless of role. In the G model, each role is represented with its own restrictions: h2 must share features with h1 in E2 signs, and h2 must be represented (by stipulation) with maximally simple handshapes in 2P signs. Since the particular types of restrictions on the weak hand are different in each of its roles, Sandler takes the position that it is entirely natural for these restrictions to be expressed in different ways. Contrarily, it could be argued that since the same articulator is always somehow restricted regardless of role, this ought to be accounted for in a principled and uniform way. The latter position is taken by van der Hulst.

5.2. Weakness of the D model. Let us gaze upon the other side of the coin. Van der Hulst (1993b) acknowledges that a model in which the weak hand is not represented as a place misses the generalization that unbalanced signs have no other place of articulation. To avoid this, it is suggested that such signs specify [h2] under the place node, while representing the features of h2 elsewhere in the structure, as dependents of the weak syllable node. This solution is seen as ad hoc, and results in an anomalous and redundant representation.

Particularly problematic for the D model is the observed asymmetry of h2-P and h2-E with respect to path movement. The fact that h2-P generally does not move while h2-E always moves with h1 cannot be encoded in the model. As a result, phonological operations affecting movement of HC such

as Weak Freeze or any reduplicative process such as aspectual inflections, would incorrectly apply to h2 when it is a place of articulation. One way to avoid this is by stipulating that such processes do not apply to the weak hand where it is also specified under the head place node. Such stipulation, like the representation itself, uses the specification of h2 under the head place node as a diacritic rather than as an element of structure.

It could be argued, however, that the absence of movement for the weak hand in unbalanced signs is a manifestiation of having a completely unmarked place unit. This unit in van der Hulst's model expresses both location and movement: movement results from specifying a branching setting node, dominating two place settings. If the weak hand does not have such complexity, the absence of movement may be seen as following from that. However, it is still unclear how processes such as the multiple exhaustive could distinguish between the two types of h2, nor how processes that relocate place only (such as the dual inflection mentioned in section 6.1) can select h2-P only.

While collapsing the two regressive weak spread processes, as shown in section 4, has the advantage of unifying two similar processes applying to the weak hand, the model and analysis present problems of interpretation. In the case of placing, the weak hand "spreads" leftwards with its features. In the case of empty root copy, it is the property of two-handedness that spreads, and not the features of the weak hand.

Empty root copy copies the two-handedness of the second sign, and empty nodes of the weak hand automatically copy those of the strong hand in the first sign. That is, the expression of this spreading process in the D model is a notational variant of empty root copy expressed in the G model. This is fine, since each formulation gets the desired interpretation in a straightforward way. However, placing, expressed in the D model as essentially the same process, cannot be interpreted in the same way. The D representation of placing does not express the fact that in this process, the weak hand of the second member of the compound spreads with its features, and does not get its features from the first member of the compound. If the empty root copy rule were interpreted in the same way as the placing rule, that is, as spreading the weak hand with its features, then this would wrongly imply total hand configuration assimilation, which is a distinct process. In fact, total hand configuration assimilation can apply together with placing in the same compound, as it does in OVERSLEEP.

The interpretation intended by van der Hulst for the first two is as follows: the weak hand in placing does not take the features of the strong hand of morpheme 1 because the weak hand is not empty. Yet the uniform representation for the weak hand still impedes straightforward distinctions among the effects of the rules of placing, empty root copy, and hand configuration assimilation, at this stage of the model's development.

6. Consequences.

Each model makes predictions that find empirical support. Once again we must conclude that each model is "right", and the theories behind them justified on the basis of these sign language data. And again it is of interest what sorts of predictions are made by each approach, since the types of generalizations accounted for are determined in part by the particular theories adopted.

6.1. G-Consequences. By dividing up the phonological space according to class membership, the G model makes the right predictions about structural constraints as well as about behavior of other members of the purported classes.

A structural constraint stated in Perlmutter (1991) is accounted for by the G model. Two-handed signs in which the weak hand does not move (2P or unbalanced signs) are never articulated elsewhere on the body. This contrasts with signs in which both hands move (E2 or balanced signs), in which case both hands may make contact with the body (as in THRILL). In the G model, the former class of signs is represented as 2P signs, specifying the weak hand as a place of articulation. This accounts for the fact that there may be no other place of articulation in such signs. The G model represents the latter class of two-handed signs, in which both hands move, as E2 signs, in which both hands are specified for the same hand configuration features and are associated to the same location and movement elements. If the location dominates a place node specified for some body location, then both hands articulate that location.

By representing the weak hand as a place of articulation in 2P signs, the model makes another general prediction, namely, that the weak hand will class with other places of articulation. This is indeed the case. Other places of articulation exhibit the same Placing and other movement effects as the weak hand, to the extent possible. For example, in the multiple exhaustive inflection, the head place of articulation may move in a horizontal arc like the weak hand place does. Also, all places of articulation are placed in two distinct locations under the dual inflection. These and other examples are described in detail in Sandler (1994a) and are summarized in Appendix 2.

These consequences are due to the type of theory adopted, in which feature classes are directly represented in phonological structure, making them discretely identifiable in statement of constraints, and discretely accessible to phonological processes.

6.2. D-Consequences. Due to its focus on relational aspects of phonological structure, the D model makes predictions of a relational nature. Specifically, heads are predicted to be in some sense stronger, and dependents relatively weaker.

By representing the weak hand as the weak syllable of a foot, the prediction is made that some stress-like distinction should appear in the phonology. This prediction is borne out in alternating signs under emphatic stress. For example, in the balanced ASL sign (to) BICYCLE, the two hands, shaped as fists, move in alternating fashion, forming circles one after the other in the neutral space in front of the signer. Under emphatic stress (e.g., in a sentence like 'He bicycled with great difficulty uphill'), the strong hand undergoes the emphatic movement pattern (a slow-neutral-fast elliptical pattern), while the weak hand is unaffected (David Corina, p.c.). While it is still a problem that the model cannot perspicuously reflect the failure of the weak hand in unbalanced signs to be affected by movement changes, we find that the head-dependent structure offers a satisfying explanation for these stress facts in balanced signs.

The D model represents two-handed signs as having two places in addition to two hands. Dependency phonology theory predicts that the dependent place should in some sense be weaker than the head place. A common expression of this head-dependent relation is in the domain of markedness, as we have seen: dependent elements are less marked. We have found evidence to support this prediction as well. In Israeli Sign Language, an inflection for iterated or habitual activity involves alternating circular movement. That is, if the base sign is one-handed, the inflection makes it a balanced two-handed sign, with alternating circular movement. Under this inflection, the strong hand articulates its movement on or near the specified place of articulation. However, the weak hand often articulates its movement in unmarked neutral space, and not on or near the specified place. So here we see the reflex of the stress effects of ASL described above: the dependent place may be weaker than the head place (in this case, unmarked).

7. Summary and Conclusions.

In this article we have discussed a number of phenomena which show that two basic types of two-handed signs can be distinguished. We then turned to the question as to whether these two types deserve formal representations that are different in a principled way. Two models were compared, each representing one of the two possible opposite answers. One model, the G model, is theoretically rooted in the Feature Geometry approach to segmental structure. The other model, the D model, is based on principles of Dependency Phonology.

Our goal here has been to outline how each model arrives at a particular representation of both types of two-handed signs (given the basic architectural principles of the different approaches), and how processes that bear on the issue are dealt with.

We believe that it is too early to decide for one of the approaches. Both remain to be worked out fully and, moreover, there are still other proposals for two-handed signs that must be considered, such as that found in Brentari (1990) and Brentari and Goldsmith (1993), which shares a number of properties with van der Hulst's model, and that of Perlmutter (1991, 1994), which does not grant the weak hand any independent status in either balanced or unbalanced signs.

At present, it is fair to say that the choice for a particular approach is partly determined by the theoretical framework that one adopts.

A central observation that has emerged is that the weak hand in two-handed signs is limited in a variety of ways. In the context of the theme of the conference represented in this volume, we can say that the weak hand shows a dramatic decrease in contrast potential vis à vis the strong hand.

In an approach to language structure that heavily relies on the head-dependency relation, it is entirely straightforward to look upon two-handed signs in the way that is suggested by the D model. The crucial argument here appeals to what Anderson (1975) calls structural analogy, which embodies the idea that the architecture of language structure will make use of a uniform set of abstract concepts such as the head-dependent relation. Anderson refers to this point in order to defend the application of certain concepts, familiar from syntax, to phonology. Van der Hulst applies the same point to argue that there is no good reason for assuming that the sign modality and the spoken modality differ in their abstract architecture, as long as we are not forced into developing modality-specific constructs.

If we assume that the two hands enter into a head-dependent relation in which the strong hand is the head, the limitation on the weak hand's possibilties is entirely in line with the general asymmetry between heads and dependents. Dresher and van der Hulst (1994) discuss a number of examples which illustrate recurrent phenomena in spoken languages in which the number of contrasts is reduced in dependent positions.

On the other hand, if one adopts a theory in which feature groupings are seen as a basic, potentially universal organizing principle of phonology, this leads to the claim that it is this principle, rather than head-dependent relations, that plays a fundamental role in the representation of two-handed signs. As we have seen, this position is developed in the G model. Applying principles of Feature Geometry, Sandler argues that the sign language data motivate totally different repesentations for the weak hand in each two-handed sign type. As the weak hand belongs to two independent classes of features, it is reasonable, in this view, that it will be subject to two independent kinds of restrictions.

We believe that this type of investigation justifies both the exploration of different models with respect to the same problems, as well as attemtps to understand models other than our own.

APPENDIX 1. CHARACTERISTICS OF THE WEAK HAND (H2) IN UNDERIVED MORPHEMES (from Sandler 1994a)

h2-Echo articulator *	h2-Place of articulation
selected finger specification same as h1	may have different SF spec.
finger position specification same as h1	may have different FP spec. if different, restricted to a small subset of those available to h1
orientation same as h1	orientation not predictable from that of h1
internal movement same as h1	no internal movement
path movement same as h1	generally no path movement
place of articulation same as for h1	no other POA in sign

* All characteristics of h2-E except handshape (selected fingers and position) may be either the same or the opposite in E2 signs. Handshape must be the same.

APPENDIX 2. PROCESSES AFFECTING H2-E, H2-P, H1, AND OTHER PLACES OF ARTICULATION * (from Sandler 1994a)

	Weak drop	Weak freeze	Root copy trigger	Charac. adj. Placing	
h2-E	+	+	+	+	-
h2-P	-	-	-	-	+
h1	0	0	0	+	-
other places	0	0	0	-	+

Multiple Exhaustive

	i. path redup	ii. internal mov redup.	iii. horiz arc
h2-E	+	+	+
h2-P	-	-	+
h1	+	+	+
other places	0	0	+

Dual

	i. path redup	ii. internal mov redup	iii. locus change
h2-E	+	+	+
h2-P	-	-	+
h1	+	+	+
other places	0	0	+

* Participation or non-participation of h1 and of places of articulation other than h2-P are indicated with plus or minus only where they are plausibly capable of manifesting the relevant phenomenon. Zero marks nonparticipation where participation would be phonetically unlikely or impossible.

Notes

1. The present description is intended to give enough information to facilitate evaluation of the two theories under examination. The reader is referred to the following sources for a more complete understanding of the weak hand and its behavior: Stokoe (1960 (1978)), Battison (1978), Liddell and Johnson (1985), Sandler (1989, 1994a), Brentari (1990), Brentari and Goldsmith (1993), Perlmutter (1991, 1994), Blevins (1993), and Rozelle (1992). The G model is contrasted with some of these other treatments in Sandler (1994a).

2. The orientation of the hand may spread alone, but if handshape spreads then orientation must assimilate as well. On the basis of these phenomena, and following the Feature Geometry approach of Clements (1985), Sandler (1987a, 1989, 1993c) proposes that the hand configuration class is comprised of the subclasses of handshape and orientation, and that orientation is hierarchically subordinate to handshape.

3. A model of handshapes in a Dependency Phonology framework (Sandler 1994b, to appear) reveals the unmarked shapes that may occur on the weak hand in 2P signs to be the least complex formally.

4. Another restriction on the weak hand as place of articulation is that it may not be characterized by internal movement (change of handshape or change of orientation) (Perlmutter 1991, Sandler 1994a).

5. McCarthy (1989, 1991) proposes that laryngeal articulations should be represented in two distinct ways depending on the language: either as features of the laryngeal class or as features of the pharyngeal place class. Blevins (1993) suggests that the dual representation for the weak hand in sign language is similar. However, we believe that the sign language situation is different, because the dual representation is not a matter of language-specific parametrization. Rather, the weak hand sems to have the same two roles within each sign language. In addition, it has been suggested that the parametrization proposed for laryngeals in McCarthy is undesirable and unnecessary (Sandler 1994c), and that the behavior of laryngeals can be captured in a model that allows only one possible representation for this class.

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