Formal Symmetry in American Sign Language
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Formal Symmetry in American Sign Language*

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1 Introduction

Our primary goal in this paper is to account for a puzzling alternation found in the class of two-handed signs in American Sign Language. To account for the data we present an analysis of two-handed signs, based on a formal interpretation of *symmetry* and grounded in a geometry-based model of sign (Uyechi 1996).

Battison (1978) was the first to recognize that symmetry is a crucial property for analyzing two-handed signs. As a result, he introduced a three way typology that routinely serves as a basis for discussions about the phonological representation of two-handed signs (e.g., Sandler 1989, 1993, Blevins 1993, Brentari and Goldsmith 1993, Brentari 1995). However, Battison's interpretation of symmetry is informal and not discriminating enough to account for the puzzling variation that we discuss in this paper. A review of related typologies (Sandler 1993, van der Hulst 1996) reveals similar problems.

In formalizing the notion of symmetry we extend Battison's typology beyond a three class system to a continuum in which Type 1 signs (maximally symmetric) serve as one endpoint of the continuum and Type 3 signs (maximally nonsymmetric) serve as the other endpoint. This new approach accounts for the puzzling properties of two-handed signs while formally capturing Battison's original observations on the crucial role that symmetry plays in the linguistic functioning of two active articulators.

2 Previous Analyses of Two-Handed Signs

Battison (1978) identifies three classes of signs using the Symmetry and Dominance Conditions, given in (1).

(1) I. **Symmetry Condition** (Battison 1978:35)

a. If both hands of a sign move independently during its articulation, then

b. both hands must be specified for the same location, the same handshape, the same movement (whether performed simultaneously or in alternation), and the specification for orientation must be either symmetrical or identical.

II. **Dominance Condition** (Battison 1978:35)

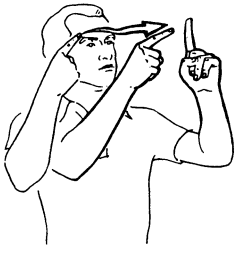
a. If the hands of a two-handed sign do not share the same specification for handshape (i.e., they are different), then
b. one hand must be passive while the active hand articulates the movement, and
c. the specification of the passive hand is restricted to be one of a small set: A, S, B, 5, G, C, O.

Battison uses these conditions to differentiate between Type 1, Type 2, and Type 3 signs. A Type 1 sign obeys the Symmetry condition. This means that both hands have the same handshape and perform the same movement. This is illustrated by the sign ALIKE in (2a). In this sign, the index fingers of both hands are extended while the remaining fingers are curled under the thumb. The fingertips of the index fingers point away from the signer and the palms of the hands face down. To articulate the sign the hands move towards each other until the sides of the index fingers touch.

A Type 2 sign obeys neither the Symmetry condition nor the Dominance condition. It is articulated with the hands in the same handshape; one hand is static while the other hand moves. For example, to articulate GOAL, (2b), the hands are in the same handshape as for (2a). One hand is held static with the index finger pointing upward while the other hand moves towards it with the tip of the index finger pointed towards the tip of the static index finger.

A Type 3 sign obeys the Dominance condition. It is articulated with the hands in different handshapes; one hand is static while the other hand moves, as illustrated by DISCUSS in (2c). One hand is held static with the palm facing upward and the fingers and thumb extended to form a flat surface. The moving hand is held with the index finger extended and the palm facing the signer. To articulate the sign the hand moves up and down so that the side of the index finger touches the open palm of the static hand.

(2) a. ALIKE
Type 1
Both hands active.
Same HS, LOC, OR, "MOV".



b. GOAL
Type 2
One hand passive.
Same handshape.

c. DISCUSS
Type 3
One hand passive.
Diff. handshapes.

More recent typologies are variations of Battison's approach.[1] Sandler (1993) argues convincingly that the non-dominant, or static hand, acts either as a place of articulation (2P signs), or an active articulator (2E signs), essentially recasting Type 1 signs as 2E signs and Types 2 and 3 signs as 2P signs. In Sandler's model, the two sets of signs have distinct representations. Echoing Sandler's account, van der Hulst (1996) refers to Type 1 signs as "balanced", and Type 2 and 3 signs as "unbalanced". He offers a head-dependency analysis in which the phonological representations of the two types of signs are more similar.

3 Problems with these Typologies

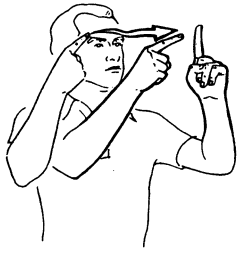
In this paper we are concerned with just one problematic aspect of the typologies introduced in the previous section[2]: they fail to provide insight into the puzzle described below, namely why some Type 2 signs have Type 1 pronunciations and other Type 2 signs do not.[3]

3.1 Puzzle: Type 2 signs with a Type 1 alternation

On any interpretation, both of the signs in (3) fall into the same category; either Type 2 (Battison 1978), unbalanced (van der Hulst 1993) or 2E (Sandler 1993). In each case, the sign is articulated with the hands in the same handshape while one hand is static. For both signs, the index fingers of both hands are extended while the remaining fingers are curled against the palms with the thumbs folded on top. To articulate (3a), the palms of the hands face their respective sides while the tips of the index fingers point away from the signer's body. The bottom hand is static while the top hand moves from above and ends in contact with the bottom hand. (3b) is described above (as (2b)).

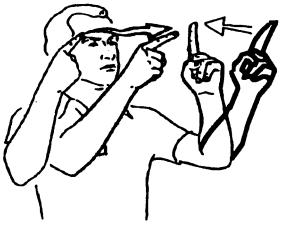
(3)

a. RIGHT/CORRECT



b. GOAL

However, as shown in (4a), (3a) also has a Type 1 pronunciation; it can be articulated with both hands moving toward each other. In contrast, (3b) does not have a Type 1 pronunciation. As shown in (4b), the pronunciation of this sign with both hands moving is unacceptable.



(4) a. RIGHT/CORRECT$_{Type1}$ b. *GOAL$_{Type1}$

The Type 1 alternation of only some Type 2 signs is a property of two-handed signs that must be accounted for, but current analyses lack the explanatory power to account for it. In each case both signs in (3) are members of the same class (Type 2, unbalanced, 2E) and, therefore, structurally undifferentiated. Thus the Type 2/Type 1 alternation described above is a puzzle for these analyses.

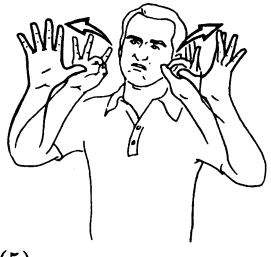
We propose that the first step towards understanding the underlying structure of the two-handed sign is not to focus on the difference between the active and static hands but rather to formalize the symmetric properties of the whole gesture. To that end we present a completely formal re-interpretation of the symmetry of two-handed signs. The result is the introduction of a binary symmetry feature for each component of the sign and the recognition of a symmetry continuum that leads to an explanatory account of the Type 2/Type 1 alternation. To do this we adopt a geometry-based model of signs (Uyechi 1996) that both captures their spatial properties and is appropriate for formalizing their symmetries.

3.2 Uyechi's Geometry-based Model

Stokoe (1960) identified three main components of a lexical sign: handshape, location and movement. Battison (1978) introduced a fourth parameter, hand orientation. More recently, Stack (1988), Hayes (1993), and Uyechi (1996) argue that of the four parameters, only handshape, location and orientation are phonological primitives. On this analysis, movement is not a primitive. Rather, it is derived from changes in the other three parameters, as illustrated by the signs in (5).

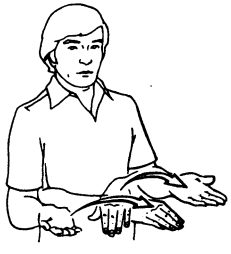
(5a) is an example of a change in handshape. For this sign the hands are held on either side of the head with the tips of the middle finger and thumb initially in contact with each other and the other fingers extended. To articulate the sign, the middle finger and thumb open up so that at the end of the gesture they, too, are extended. (5b) is an example of a change in location, and is described above as (2a). (5c) is an example of a change in orientation. To articulate it the hands start in a position in which one palm

faces up and the other down. The hands then rotate 180 degrees so that each palm faces the other way. All movements articulated in monomorphemic lexicalized signs can be represented by these three transitions: change in location, change in handshape, and change in orientation (Uyechi 1996). It is this analysis of phonological primitives that we take as our starting point.



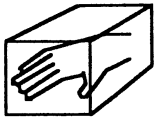
(5) a. AWFUL
Change in Handshape

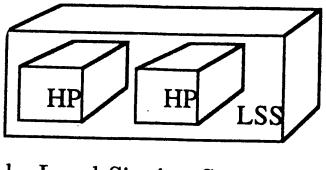
b. ALIKE
Change in Location

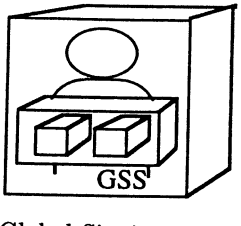


c. DIE
Change in Orientation

The geometry-based model is based on a three-dimensional rectangular representation of signing space. The hands are represented as hand prisms, (6a), embedded in rectangular prisms of signing space that correspond to distinct morphological levels. A monomorphemic sign is articulated in local signing space, (6b), which is in turn embedded in global signing space, (6c). Morphologically complex signs are specified for positions in both local and global signing space.[4] Of interest here is the representation of monomorphemic signs, so the discussion will focus on the relation between the hand prisms and local signing space.

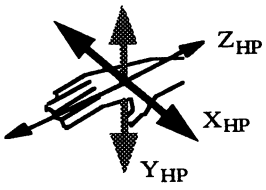


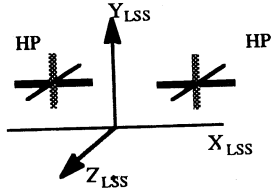




(6) a. Hand Prism b. Local Signing Space c. Global Signing Space

The dimensions of the hand prisms, local signing space, and global signing space can also be represented in terms of the axes which define them. For example, the hand prism in (6a) is represented by its axes in (7a). (7b) illustrates the axial representation of two hands in local signing space.





(7) a. Hand Prisms b. Hand Prisms in Local Signing Space

The position of LSS does not change during the articulation of a monomorphemic sign, rather, it carves out the relevant part of signing space, (8), within which the hand prisms move. Thus, the planes of LSS serve as references for determining the relative posture of the hands.

(8) Local Signing Space

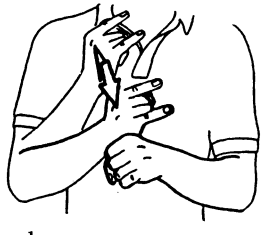
Using this model we can formalize symmetry for each of the components of a sign, namely handshape, location, orientation, and "movement".

4 Formalizing Symmetry

The formal interpretation of symmetry for handshape, orientation, location, and movement is based on the geometry-based model. In each case, the symmetry of each component of the sign can be captured by a binary feature.

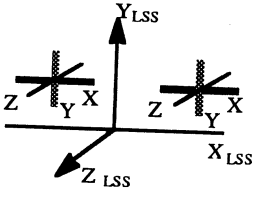
Handshape. Although not discussed in detail here, handshape in the geometry-based model is captured formally in terms of *specified fingers*, the *joint positions* of the fingers and thumb, and the relation of the thumb to the fingers. Handshape is symmetric if those characteristics of the hands are identical. By this metric, (9a) has symmetric handshape, but (9b) does not. (9a), ALIKE, is described above as (2a). WHISKEY, (9b), is articulated with the fingers and thumb of the static hand closed in a fist. The index and pinky fingers of the active hand are extended while the other fingers are curled and tucked under the thumb. Both hands are held so the palms face to the sides. To articulate the sign the active hand moves in a straight line towards the static hand, touches it, and then repeats the movement.

(9) a. ALIKE
HS: +SYM

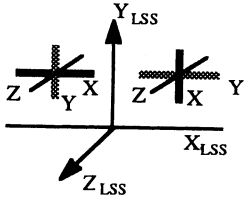


b. WHISKEY
HS: −SYM

Orientation. As argued in Toole and Uyechi (1995), a sign is articulated with symmetric orientation if the corresponding axes of the hands are parallel at the beginning and end points of the sign, where by "corresponding axes" we mean both X-axes, both Y-axes, and both Z-axes of the hand prisms. In (10a) all three axes are parallel to each other during the articulation of ALIKE. In contrast, in (10b) only the Z-axes are parallel during the articulation of GOAL; the X and Y-axes are perpendicular to each other. Hence, (10a) is articulated with symmetric orientation, but (10b) is not.

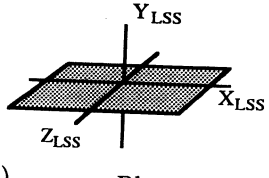


(10) a. ALIKE
OR: +SYM

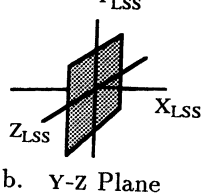


b. GOAL
OR: −SYM

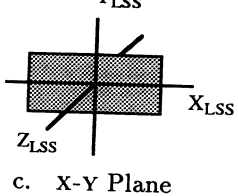
Reference Planes. To discuss the symmetry of location and movement requires the identification of reference planes in signing space. The planes defined by the axes of local signing space provide the formal reference planes, (11). For the sake of convenience we refer to (11a) as the *base plane*, (11b) as the *center plane*, and (11c) as the *local plane*.



(11) a. X-Z Plane
Base



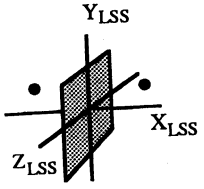
b. Y-Z Plane
Center



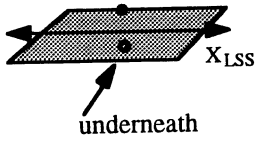
c. X-Y Plane
Local

Location. Given the reference planes identified above, the symmetry of the location of the hands is determined by the relative position of the origins of the hand prisms, where the "origin" is the point at which the X, Y, and Z-axes intersect each other. If, at the beginning or the end of the sign, the origin of one hand prism is a reflection of the origin of the other hand prism about a reference plane, then location is symmetric.

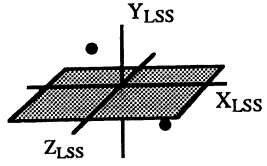
For example, to articulate ALIKE the origins of the hand prisms are reflected about the center plane throughout the articulation of the sign, (12a), so location is symmetric. To articulate RIGHT the origins of the hand prisms are reflected about the base plane at the end of the sign, (12b), so its location is also symmetric. In contrast, even at the points where the hands are closest during the articulation of DISCUSS, the origins of the hand prisms are skewed with respect to the base plane, (12c), and are not reflected about any of the other reference planes, so location is not symmetric.



(12) a. ALIKE
LOC: +SYM

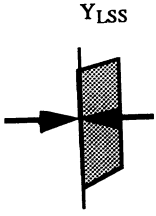


b. RIGHT
LOC: +SYM

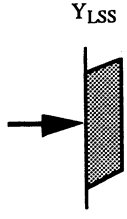


c. DISCUSS
LOC: −SYM

Movement. A movement is symmetric if the transition, a change in handshape, change in location, or change in orientation, is symmetric about a reference plane. For example, both signs in (13) are articulated with a change in location. The movement vectors for the sign ALIKE are reflected about the center plane, (13a). In contrast, only one hand moves during the articulation of GOAL so the vectors are not reflected about any of the planes of reference, (13b). Hence (13a) is articulated with symmetric movement but (13b) is not.



(13) a. ALIKE
"MOV": +SYM



The dark arrows represent the transitions of the hands.

b. GOAL
"MOV": −SYM

4.1 The Symmetry Continuum

With these formal definitions of symmetry for each component of the sign, a sign's symmetry can now be determined in terms of a cluster of binary features, where + is symmetric and − is not. We summarize the symmetry of relevant signs in (14), organized in a table so that the signs reflect a continuum of symmetry. On the leftmost side of the table all components of the sign are symmetric; on the rightmost side of the table no component of the sign is symmetric. We refer to the former as "maximally symmetric", and the latter as "maximally nonsymmetric".

(14)

	Maximally Symmetric				Maximally Nonsymmetric
	[Type 1] [2E]	[Type 2] [	[Type 3] ← 2P →	[Type 2]	[Type 3]]
	a. ALIKE	b. RIGHT	c. WHISKEY	d. GOAL	e. DISCUSS
OR	+	+	+	−	−
LOC	+	+	+	−	−
HS	+	+	−	+	−
"mov"	+	−	−	−	−

With Battison and Sandler's classes of signs mapped onto the table, a problem with Battison's Type 2 and Type 3 categories, and Sandler's 2P signs is immediately apparent. Whereas the Type 1 class picks out signs that are completely symmetric, neither Battison's Type 2 and Type 3 categories nor Sandler's 2P classification pick out natural classes of signs. For example, (14c) and (14e) are both Type 3 signs, yet WHISKEY has two symmetric parameters while DISCUSS has none. Similarly, (14b) and (14d) are both Type 2 signs, yet RIGHT has three symmetric components but GOAL has only one. It is this second pair of signs that provides insight into the puzzling alternation described in Section 3.1.

Whereas neither Battison nor Sandler's classifications can account for this observation, the symmetry features reveal an obvious and quantifiable difference between these signs. Recall that RIGHT has a Type 1 pronunciation but GOAL does not. The decomposition of RIGHT in (14b) reveals that all of its basic parameters, handshape, location, and orientation, are symmetric. In contrast, for GOAL, (14d), only handshape is symmetric. We propose that the symmetry of the change in location only follows with maximal symmetry of the primitive parameters. To capture this interpretation we propose the principle in (15).[5]

(15) If HS, OR, and LOC are [+SYM], and change in location is [−SYM], then the sign has an alternation in which change in location is [+SYM].

In sum, our approach to the symmetry of two-handed signs which led us to the symmetry features and Symmetry Continuum provides specific advantages over previous approaches: (i) it captures the status of each parameter in terms of a formal definition of symmetry, revealing the range of symmetry that two-handed signs have, and (ii) it provides an explanation to the puzzling Type 2/Type 1 alternation.

5 Consequences of the Analysis

Internal to sign language analysis our results are straightforward. They provide greater insight into the internal structure of signs while accounting for a previously unexplained puzzle. However, our proposal appears at first a bit less appealing when we compare it to spoken language phonology.

Specifically, distinctive features are commonly associated with *segments.* And, as noted above, the symmetry feature is associated with the sign gesture. Yet a large number of proposals in sign language phonology (e.g., Sandler 1989, Wilbur 1990, Perlmutter 1992, Brentari and Goldsmith 1993, Blevins 1993, van der Hulst 1993) support the idea that there is roughly a one-to-one mapping of the sign gesture to the syllable. If that is the case, then our proposal appears problematic because it implies that we are proposing a set of distinctive features that associate with the *syllable* rather than the segment.

In light of the fact that there are proposals in spoken language phonology to associate features with the syllable (summarized in Blevins 1995), our proposal may appear less problematic. But those proposals are restricted to a few languages in a few specific cases. In contrast, we are dealing with a widespread phenomenon. A survey of sign languages in the Netherlands, Germany, Quebec, Britain, and Hong Kong indicates that they have two-handed signs that exhibit symmetric properties similar to ASL (Linguistics 369, Linguistics Institute, University of New Mexico 1995). Indeed, a sign language without symmetric characteristics of two-handed signs has not yet been reported. Thus, we are introducing the possibility of rampant feature-syllable association for sign languages. This poses a significant difference from the phonological organization of spoken language.

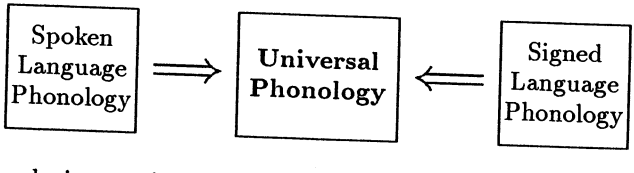
This leads us to consider at least three alternatives. First, we could maintain the view that distinctive features associate with segments and conclude that previous formulations of sign syllables are incorrect. Second, we might accept previous formulations of sign syllables and conclude that this analysis lends support to the (few) arguments in spoken language phonology that some features associate with syllables. Or we could consider the possibility that the underlying phonological structure of the sign differs from the underlying structure of the spoken word in significant ways.

We favor the latter alternative. The first two alternatives are consistent with what we refer to as the "transfer-and-test" approach to sign language phonology, schematized in (16). This is an approach based on the premise that what we know about spoken language phonology is equivalent to our knowledge about universal phonology. In turn, because a universal theory of phonology should hold for all natural languages, it follows that theoretical models of spoken language phonology should apply to sign languages. Thus the "transfer-and-test" approach encourages the search for a one-to-one mapping of spoken language constructs and their principles onto sign language phenomena.

(16) "Transfer-and-Test"

But the two types of natural language are fundamentally different, so we believe that the discovery of a distinct class of natural languages provides the unprecedented opportunity to reinforce a theory of universal phonology with independent evidence. To that end, we advocate the approach in (17), where the relation between universal phonology and signed language phonology is turned around. Distinct theories of both signed and spoken language phonology are formulated in modality-specific frameworks and contribute independent evidence to a modality-independent theory of universal phonology. The expectation is that – at some level of organization – we will find common principles that bridge the signed and spoken modes.

(17) *Preferred Approach*: Independent Evidence



In conclusion, rather than dwell on the segment-like or syllable-like structure of two-handed signs, we prefer to withhold judgment until we have the opportunity to fully explore the ramifications of the symmetry feature and the Symmetry Continuum for ASL as well as other signed languages. We approach this task with the firm belief that mode-insensitive phonological principles exist – but with a healthy skepticism that what we discover through signed languages need not be just as we've found it in spoken languages.

Endnotes:

*The research reported in this paper was supported in part by an Australian Federation of University Women Fellowship to Janine Toole. The authors also wish to acknowledge their colleagues at the Fifth International Conference on Theoretical Issues in Sign Language Research in Montreal September 1996 where the ideas in this paper first started taking shape: Onno Crasborn, Kelly Stack, and Lorna Rozelle. We would also like to thank Diane Brentari for bringing us all together (if even unwittingly) at the 1995 Linguistics Institute in Albequerque, New Mexico.

[1] Reiterating Battison's original typology, Brentari (1995) argues for the stability of the Type 2 classification based on two trends in historical change: (i) some signs with Type 3 characteristics become Type 2 signs, and (ii) some signs with Type 1 characteristics become Type 2 signs.

[2]We discuss other problematic aspects of the Battison typology in Toole and Uyechi 1995.

[3]For the sake of convenience we use Battison's terminology to refer to the sets of two-handed signs. Although we ultimately argue against it, the typology provides a convenient shorthand for the descriptive properties of the signs.

[4]At an even higher level of representation, discourse is represented as instances of global signing space embedded in a discourse signing space.

[5]Note that an alternative interpretation is that RIGHT is inherently a symmetric (two-handed) sign that undergoes a process of Weak Freeze (Padden and Perlmutter 1987). We suspect, in fact, that the alternation has this alternative interpretation because the other signs that we have identified with this alternation (e.g., MOST, GHOST, THIN, RESIDENTIAL-SCHOOL, WORLD) are also articulated with changes in location that are symmetric with respect to the base plane. We contrast this with the absence of alternations for (Type 1) signs whose transitions are symmetric with respect to the center plane (e.g., WITH, FAIR, BREAK, DIFFERENT). Differences between the symmetries of the reference planes are explored in Uyechi (1995). Resolution of these alternatives is a topic of our ongoing work.

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(Pictures from: Humphries, Padden, and O'Rourke (1980), illustrated by Frank A. Paul.)