

# A Formal Analysis of Phonological Contrast in Sign Language Handshapes

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In this paper we analyze issues concerning the representation of handshape in sign languages. We address these issues by utilizing recently developed tools available in the areas of *phonological contrast* and *feature distribution*. In particular, we explain the degree to which iconic elements of handshape interact with the feature system of sign language handshapes in different components of the lexicon. We then discuss similarities and differences between signed languages and spoken languages and the implications for a theory of features that might adequately capture phenomena in both communication modalities. Although cross-linguistic data have been collected and analyzed in this regard, we focus on data from American Sign Language in this work.

## 1 Introduction

In this paper, we discuss the issues surrounding contrast types and their distribution throughout the lexicon of American Sign Language (ASL), comparing them to similar distributional patterns in spoken languages. In employing recent work on feature contrast and distribution, we seek to explain the different historical, morphological and phonological pressures on the two types of languages, and how these pressures result in apparent differences between. We will provide examples of these differing pressures, focusing particularly on how iconicity and morphology influence the phonology.

This paper will be organized in the following way. After presenting introductory material on the phenomenon of handshape (Section 1.1) and on tools employed from theories of feature contrast and distribution (Section 1.2), we will describe some sign language data that is representative of a general problem concerning the types of contrast and how it influences the number of features in the phonological representation (Section 2). The data shows differences in the way that features from the class of handshape properties known as *joint configuration* are used across the three components of the lexicon (foreign, core and spatial). Evidence will be presented showing not only that features behave differently across the lexicon, but also that the link between iconicity, morphology and phonology is an important factor in analyzing these feature distributions. Then, in Section 3 we analyze the data using Optimality Theory, showing that different constraint rankings can account for both the differences in contrast type across the lexicon and the interaction of iconicity, morphology and phonology. Finally, in Section 4 we summarize our results and discuss the implications for a theory of representation adequate for both signed and spoken languages.

## 1.1 Handshape in the lexicon











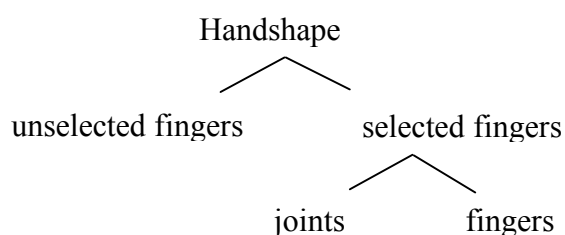
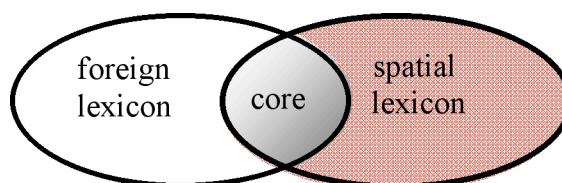
Handshape in sign languages has a distinction between the *selected fingers* that move or contact the body during articulation and those that do not (i.e., *unselected*). The selected fingers node has two primary groups of features, joints and fingers. *Finger features* refer to which of the fingers are active in a handshape: e.g., , , , , , . The flexion or extension of the joints of those fingers are represented by *joint features*; for example, , , ,  all use the same four selected fingers (ignoring the thumb for now), but each has a different joint configuration. In this paper we focus primarily on the joint features of the representation.




Figure 1. The separation of joint and finger features in sign language phonology (cf. Brentari 1998).





As in many spoken languages, words in sign languages (i.e., signs) have multiple origins and uses, resulting in a lexicon divided into components according to both historical (diachronic) factors and contemporary (synchronic) morphological and phonological behavior. A *core-periphery* model has been proposed for spoken Japanese to account for this behavior (Itô and Mester, 1995a,b), in which sounds behave differently in the various sub-components of the lexicon. A similar model has been proposed for ASL (Brentari and Padden 2001) that has consequences for the representation of handshape, since handshapes (rather than sounds) have different statuses in the three components of a sign language lexicon.

Figure 2. The core, foreign and spatial components of the sign language lexicon



In the *core lexicon*, handshapes are purely phonological and combine with other elements to form stems; crucially handshapes do not carry morphological status in this component. In the *foreign lexicon* handshapes can be morphological and often exhibit forms that have a relationship with the surrounding spoken language. The forms from this component discussed in this paper contain a letter of the manual alphabet—e.g., 'V' ()', 'K' ()', 'C' (). The *spatial lexicon* primarily includes *classifier constructions*. Classifier constructions (or classifier predicates) are polymorphemic verbal complexes with a verbal root—the movement—and affixes that involve place of articulation and handshape. These often carry iconic visual information about the size and shape of the object.

An example of the same joint alternation (/) across all three parts of the lexicon is given in examples (1)-(3). (1) contains a core form—e.g., SEE; (2) contains two foreign forms—e.g., (2a) VERB and (2b) KITCHEN; (3a) and (3b) are examples of two different types of classifier handshape-affixes. Classifiers that represent an entire class of objects are called

*whole entity* classifiers—e.g., (3a) 'vehicle-fall-on-its-side' (the thumb is extended), while those that represent the limbs of the body are called *body part classifiers*—e.g., (3b) 'person-climb-over-fence'. The relevant sign in each example is in boldface.<sup>1</sup>

(1) Core component

\_\_\_\_\_ raised eyebrow \_\_\_\_\_ (see Figure 6)  
 STUDENT YOUR COURSE **LET'S SEE** (✎/✎) HOW MANY  
 "Let's see how many students are in your course"

(2) Foreign component

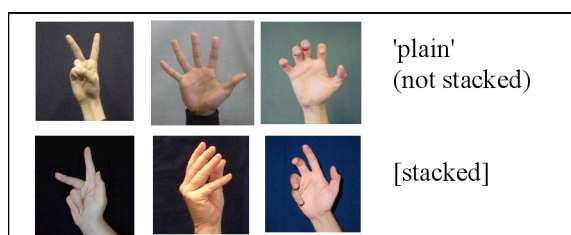
- a. \_\_\_\_\_ raised eyebrows \_\_\_\_\_ (see Figure 7)  
**VERB** (✎/✎) MORPHOLOGY INDEX-3 FAVORITE  
 "He's crazy about verb morphology."  
 b. \_\_\_\_\_ raised eyebrows \_\_\_\_\_  
**KITCHEN** (✎/✎) MY NEW APARTMENT SMALL  
 "The kitchen in my new apartment is small."

(3) Spatial component

- a. \_\_\_\_\_ raised eyebrows \_\_\_\_\_ (see Figures 8)  
 BICYCLE, **'vehicle-fall-on-its-side'** (✎/✎) with thumb extended  
 "The bicycle fell on its side." [whole entity classifier]  
 b. \_\_\_\_\_ raised eyebrows \_\_\_\_\_  
 SKIRT **'person-climb-over-fence'** (✎/✎) NOT EASY  
 "If I am wearing a skirt, climbing over the fence isn't easy." [body part classifier]

The handshape indicated as (✎) has [+stacked] fingers, a specific type of joint configuration. In the [+stacked] configuration, beginning with extended index finger and moving toward the pinkie, each successive selected finger of a handshape becomes increasingly flexed (Johnson 1990). In other words, the fingers are progressively spread apart from each other in a plane perpendicular to the palm. Examples of [stacked] handshapes are given in Figure 3. From the data we presented, we will discover what status and distribution the feature [stacked] has in the three parts of the lexicon, thus providing a methodology for investigating other features.

Figure 3. Examples of [stacked] and plain handshapes



<sup>1</sup> We cannot provide an overview of all types of classifier constructions in sign languages in the space here, but see Benedicto & Brentari (2004) for an overview.

## 1.2 Theories of phonological contrast and their application to sign languages

Every theory of phonological representation has had to deal with the concept of **phonological contrast** (e.g., Trubetzkoy 1939, Bloomfield 1933, Harris 1951, Jakobson, et al. 1957, Chomsky and Halle 1968, Archangeli 1988a,b; Steriade 1995). For our analysis we employ more recent work regarding contrast (Avery and Idsardi 2001, Clements 2001, Dresner 2003) and feature distribution (Goldsmith 1995).

Clements (2001) proposed a typology of contrast types—*distinctive*, *active*, and *prominent*—as described in (4). Clements' approach acknowledges the unique properties of each type of feature and allows a feature to have more than one type of status.

### (4) Phonological contrast types

- a. Distinctive: The presence/absence of this type of feature in a pair of segments creates a minimal pair. E.g., [voice] in English obstruents in a pair, such as '[z]oo'/'[S]ue'.
- b. Active: This type of feature is used in a phonological constraint. E.g., [voice] in German obstruents in word-final position, in a case such as 'ra/d/' > 'ra[t]', (Eng: 'advice'). A constraint prohibits voiced obstruents in codas: \*CODA<sub>[+voice]</sub>
- c. Prominent (a subtype of active): This type of feature qualifies as an autosegmental tier because it is: (a) involved in a particular type of phonological operation (such as spreading), (b) used productively for morphological purposes, (c) a participant in long distance effects, where a segment affects a non-contiguous segment, or (d) involved in many-to-one association (Goldsmith 1976).<sup>2</sup> E.g., [high] in Japanese palatalization used to mean 'unreliable' (Hamano 1998), as in cases of awkward or irregular movement, such as 'p<sup>1</sup>oko-p<sup>1</sup>oko' (Jap: 'jumping around in an uncontrolled manner') from 'poko-poko' (Jap: 'up and down movement').

Distinctive and active features have received most of the attention in theories of phonology. Distinctive features have been part of the debates concerning mental representation, while active features have been part of the debates concerning predictability and redundancy (e.g. how features should be captured via a language-particular constraint ranking or rule system).<sup>3</sup> Meanwhile, prominent features have received less attention in the recent literature as features. This could be because autosegmental phonology provided an adequate solution for representing these features both in the representation and in the rule/constraint system, especially considering that only a relatively small set of features in spoken languages are autosegmental (e.g., tone, nasality, and vowel quality in vowel harmony).

In addition to employing different contrast types in our analysis of handshape, we also consider different kinds of feature **distributions**. Goldsmith (1995) describes five distributional patterns of contrast that can hold between a feature and a phonological system;

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<sup>2</sup>Only the first two criteria are helpful for sign languages because long-distance effects have not been observed in these languages, and many-to-one association is observed almost everywhere throughout the system and so would not reveal anything new. 'Many-to-one' association occurs, for example, when one handshape has more than one place of articulation—e.g. ASL compounds—or when one location has more than one handshape—e.g., in disyllabic signs (e.g., DESTROY, BACKGROUND in ASL. These many-to-one relationships exist for all combinations of parameters.

<sup>3</sup>In particular, underspecification theory (Archangeli, 1988a,b, Steriade 1995) has discussed this issue at length. Underspecification Theory (Archangeli, 1988a,b, Steriade 1995 and references contained therein), while helpful, is insufficient to explain the possible distribution types described below because all parts of the lexicon are treated alike in this theory.

these are shown in (5). Like the constraint types, these are not mutually exclusive categories and features can participate in more than one of these distributions within a given language.

- (5) Distributions of spoken language features within a phonological system
- a. Distinctive: the opposition usually creates a minimal pair (e.g. [voice] in English)<sup>4</sup>
  - b. Modest asymmetry case: the alternation is allophonic in one part of the lexicon, but distinctive in another (e.g., [±labial] in the Japanese periphery)
  - c. Not yet integrated semi-contrasts: a general change has taken place in the system but a few remnants remain (e.g., [tense]/[lax] in Florentine Italian mid-vowels)
  - d. Barely contrastive: almost completely determined by the system (e.g., [retroflex] in English)
  - e. Allophonic: completely determined by the system (e.g., [aspiration] in English)

Of the different types of distribution (5a) and (5e) are the efficient workers in the phonological workplace, (albeit in different ways) and most work on spoken language phonology has focused on them. In the case of distinctive distribution (5a), it is the *representation system* that is working; a feature such as [voice] in English is represented primarily in the lexicon (i.e., in the mental representation of a form). For example, the voiceless obstruents /p, t, k/ are distinct from the voiced ones /b, d, g/ because the feature [voice] is in the representation in the latter forms. In the case of allophonic distribution, concerned with active features, (5e), it is the *rule system* that is working; a feature such as aspiration in English is typically not in the lexicon. Instead, there is a rule that selects a set of well-defined forms to which the feature is added. This is exactly what happens in the case of aspiration in English— /p, t, k/ > [p<sup>h</sup>, t<sup>h</sup>, k<sup>h</sup>] at the beginning of words when followed by a vowel.

Cases (5b)-(5d) are the in-between cases; they all deal with varying degrees of 'asymmetry' between rules/constraints and some type of representation (morphological or phonological). Autosegmental tiers were one of the first phenomena in this groups, so it is no surprise that Goldsmith is very aware of these cases. Modest asymmetry cases, (5b), are determined largely by representation, but there is a sizable set of forms that is handled by a rule. These are similar to the case we will deal with from sign languages in this paper. One example from spoken Japanese used by Itô and Mester (1995a,b) illustrates how features can have different statuses in different parts of the lexicon. The distribution of [h] and [f], shown in (6) shows that in the *core* (which includes the Yamoto, Sino-Japanese, and Mimetic components) [h] and [f] are allophones of /h/, while in the *periphery* (Foreign component) /h/ and /f/ are phonemic. This is illustrated by the fact that in the core [f] does not appear before any vowels except 'u' (i.e., \*[fa], \*[fe], \*[fi], \*[fo]), where [h] appears instead; in other words, they are in complementary distribution. In the periphery, however, both [h] and [f] appear more or less everywhere, showing that these two sounds—or, more specifically, these two opposing values of the feature [labial]—are distinctive in the periphery.<sup>5</sup>

- (6) Distribution of [h] and [f] in Japanese:
- a. core distribution (Yamoto, Sino-Japanese, and Mimetic components)
    - \*[fa], \*[fe], \*[fi], \*[fo], **[fu]**
    - [ha], [he], [hi], [ho] ∅
  - b. foreign distribution (borrowings)

<sup>4</sup> Even distinctive contrasts do not hold absolutely everywhere. For example, the voicing contrast in English is true for obstruents (stops and fricatives), but suspended in onset clusters and syllable codas.

<sup>5</sup> Interestingly, [hu] is still disallowed in the periphery.

[fa], [fe], [fi], [fo], [fu]  
 [ha], [he], [hi], [ho] ø

In the not yet integrated semi-contrasts, (5c), the feature in question is largely allophonic, but a small pocket of forms with contrast remains. For example, all vowels are redundantly [tense] in Italian except in Florentine Italian which holds onto a mid vowel contrast /e/-/ɛ/ and /o/-/ɔ/ associated to specific Latin historical source. Barely contrastive cases, (5d), are determined largely by rule, but not completely; in the case of English [-retroflex] a redundancy rule makes all sounds [-retroflex], except for /r/ which needs [+retroflex] to distinguish it from /l/.

The asymmetry examples in (5b) and (5c) are particularly important because they show that variable behavior in the phonological system may be due not only to phonological factors, but also different components of the lexicon due to historical or morphological reasons. In the Florentine Italian case, the distribution is due to an historical remnant of Late Latin (Marotta 1985, van der Leer 2006), and in the Japanese case it is due to recent foreign borrowings into the language.

We argue that the *types of contrast* in (4) and the *distributional patterns of contrast* in (5) come together to explain some aspects of sign language phonology that heretofore have been left unaccounted for.


## 2 Data from Signed Languages

Using the categories of distribution for spoken languages described in (5), examples of the distribution of joints structures of handshape are given in (7). Phonologists working on sign languages know that minimal pairs—i.e., the cases in (7a)—are scarce. Work by Liddell & Johnson (1989), Sandler (1989) Brentari (1998) and van der Kooij (2002) demonstrates clearly that distinctive contrasts exist, but there are far fewer minimal pairs in signed languages than in spoken languages. This is also true for operations that are purely allophonic—i.e., the cases in (7e). In ASL both selected fingers and joints participate in phonological processes such as handshape assimilation in compounds in ASL (Liddell & Johnson 1986, Sandler 1989), but almost all rules/constraints are optional. To our knowledge the example of handshape change is the only example of purely allophonic alternation. Comparing the spoken language examples like those in (5) with sign language examples such as in (7), the number of cases in spoken languages in categories (5a) and (5e) is very high, and as Goldsmith 1995 notes, these have received the lion's share of attention in the spoken language literature. In sign languages, however, fewer cases exist at these extreme ends (7a) and (7e) and more cases are asymmetry cases (7b-7d), analogous to cases (5b-5d) in spoken languages. All are examples of joint contrasts, not because selected fingers examples do not exist, but because we are focusing on joint contrasts in this paper (See Eccarius (2008) for further details).

### (7) Distributions of handshape elements

- a. distinctive contrast: the opposition creates a minimal pair  
 The feature [spread] in the SCREWDRIVER (✋) vs. MEANING (✋)
- b. Modest asymmetry case: the alternation is allophonic in one part of the lexicon, but distinctive in another.  
 The feature [stacked] handshapes; for example, 'V' (✋) vs. 'K'/'P' (✋). These handshapes are allophonic in the core, but distinctive in the foreign component.
- c. Not yet integrated semi-contrasts: a general move has taken place in the system but a

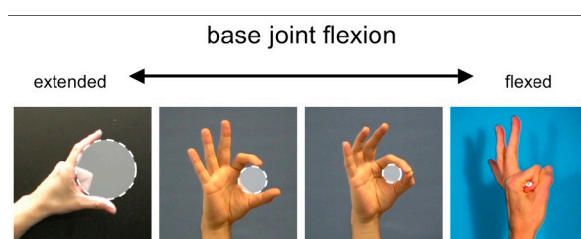
few remnants remain. We found no examples of this.

- d. Barely contrastive: almost completely determined by the system.  
The feature [flexed] at the metacarpal (knuckle) joint is largely predicable (Crasborn 2001), but there are a few cases in B-handshape forms where the metacarpal joint must be bent, such as ASL SUN (  )
- e. Allophonic: determined completely by the system.  
The feature [flexed] in the context of handshape change; the value of one handshape is predictable from the value of the lexically specified handshape

One type of asymmetry case—the one described in (7b)—is very prevalent in sign languages, and in the next section we describe one example in depth— [+stacked] handshapes (a joint configuration). It is slightly more complicated than the description in (7b) would indicate, because not only does it involve distinctive and active contrasts by virtue of the distinctive and allophonic distribution mentioned, but it also involves a prominent (morphological) contrast with an iconic origin.

Visuo-spatial iconicity plays a role in many of the asymmetry cases, because some (though not all) prominent/ morphological features in the spatial lexicon are iconic in their origins. Consider the use of a different joint feature, [flexed], at the base (knuckle) joint, as shown in Figure 4 (cf. Eccarius 2008:41)

Figure 4. Iconic use of the base (knuckle) joint to show size.



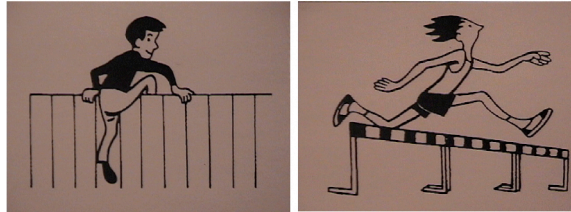
Although size can be varied continuously, the base joint (+contact) represents only four categories of size. When signers are discussing objects that are flat and round (without reference to a specific range), they will use only these discrete categories (Emmorey & Herzig 2003), making this both an *iconic* and *meaningful* use of the feature. In the case of [flexed] the feature is also both *morphological* because it is discrete and productive, and *phonological* because it has a particular set of interactions with the feature [flexed].



## 2.1 Distribution of the Feature [Stacked]







In this section we consider the contrast type and distribution exemplified in the specific feature [stacked]. We analyzed data from three native, adult users of American Sign Language (ASL) for this analysis. Archival sources—i.e., dictionaries, (Stokoe, et al. 1965; Valli, 2005)—were used to determine the distribution of the stacked configuration in core and foreign components forms, but for classifier constructions, new data were collected. These took the form of articulatory interviews involving grammaticality judgments and elicited descriptions of picture stimuli (from Zwitserlood 2002). We concentrated on data from two pictures that we felt had a strongest chance of eliciting a stacked configuration due to the leg

positions of the characters involved, given in Figure 5. The [stacked] configuration can potentially be used to iconically represent the position of the legs.<sup>6</sup>

Figure 5. Stimulus items for eliciting [stacked] classifier handshapes (from Zwitserlood 2002).



As stated earlier, in the [+stacked] configuration, the fingers are progressively spread apart from each other in a plane perpendicular to the palm (Johnson 1990). Although the stacked feature is attested in four-fingered handshapes as well as in handshapes with the index and middle fingers selected, here, we limit our discussion to the two-finger cases (e.g.  vs. .

The stacked joint configuration in  was found in all components of the ASL lexicon. For example, the stacked configuration () is found in the foreign component in the fingerspelled letters 'K' and 'P' vs. the [-stacked] 'V' () , as well as in initialized signs using those letters (e.g. KITCHEN) to distinguish it from 'V' (e.g., VANILLA). In this case [+stacked] is used distinctively. The stacked hand is also used as a variant of initialized 'V' () in specific phonetic contexts (e.g. VERB), as well as in the core component, where [+stacked] can be seen in signs such as BORROW, TWICE and SEE, as a variant of , again in specific contexts. In this case it is used as an active feature with an allophonic distribution. The classifier data also yielded stacked handshapes: two of the three informants used the [+stacked] configuration to represent both a boy climbing over a fence and the person hurdling. We also observed that a [+stacked] variant of a  whole entity classifier can be used, when, for example, a bicycle is lying on its side.

These results suggest the following generalizations:

- **Feature status:** The [+stacked] feature has different statuses in the different lexical subcomponents: *distinctive* in the foreign component, *prominent* in the classifier component, and *allophonic* in all three components, thereby exemplifying all of Clement's contrast types.
- **Feature distribution:** [+stacked] is captured by the (5b) 'modest asymmetry' case of Goldsmith (1995), because it is distributed differently in the three lexical components.
- **Iconicity:** Joint iconicity plays a role in the spatial component (for separated legs in body part classifiers), and potentially in the foreign component as well (for the arrangement of lines in the written letter 'K'). Moreover joint iconicity is employed differently in different types of classifiers—body part (yes) vs. whole entity (no).

This type of distribution is common in sign languages; features have multiple uses in systematic ways throughout the lexicon, and a large number of prominent features in the classifier system have iconic origins. The idea of the 'multi-functional feature' has led to inconsistencies in the number of features included in phonological representations; the

<sup>6</sup> Data from other languages were also collected for cross-linguistic comparison (see Eccarius 2008, Brentari & Eccarius in press), but because of space issues, we do not include those analyses here. Despite the iconic potential for using the stacked feature, not all sign languages exploit this type of iconicity in the 'by-legs' classifier.



number of features included in the system is dependent on whether only distinctive features are represented, or whether prominent and active features are included as well. Liddell & Johnson (1989) Brentari (1998) have included all types, while Sandler (1989) and van der Hulst (1993, 1995) have attempted to rid the representation of all except distinctive features in core forms.

Since iconicity is distributed in particular ways throughout the lexicon, we now turn to the problem of how to integrate iconicity into the representation of features in sign languages.

### 3 Analysis

A sketch of our analysis using Optimality Theory is as follows. In Optimality Theory there are MARKEDNESS Constraints; simplifying a little (but not too much) these are fundamentally 'Ease of Articulation' and 'Ease of Perception' effects. In other words, for spoken languages, some combination of features is preferred or dispreferred because of pressures due to their aerodynamics, mobility of articulatory structures (vocal folds, tongue, velum, lips), and ease of perceiving auditory properties. Sign languages have MARKEDNESS constraints too, so combinations of features are preferred or dispreferred based on the mobility of articulatory structures (joints and muscles of the hands, arms, body) or the ease of perception of visual properties. Optimality Theory also has two types of FAITHFULNESS Constraints. One type prohibits changes either to an input form from the language itself or to some type of external input, such as forms from another language in the case of borrowing (i.e., faithfulness to the borrowed input). Perlmutter (2006) commented that iconicity might be considered a form of borrowing. (he called this "The Loan Hypothesis")<sup>7</sup>, and Eccarius (2008) built upon this idea by proposed that, as a type of borrowing, various types of iconicity could be formulated as FAITHFULNESS Constraints to the visuo-spatial input. In addition, there is another type pressure on all languages expressed in more recent versions of Optimality Theory by Flemming (2002) in Dispersion Theory. According to Flemming there are universal constraints creating as many contrasts as possible along given dimensions; the constraints are called MAXIMIZECONTRAST constraints. For example, a language such as like French with 12 vowels might rank MAXIMIZECONTRAST constraints concerning formant frequencies or [±nasal] higher than a language with just 5 vowels, such as Japanese or Italian. We have formulated an analysis of [stacked] using one constraint of each type just described; these are given in (8)<sup>8</sup>:



(8) Constraints used in this analysis

- a. MARKEDNESS (+ORIENTATION): This context-sensitive markedness constraint is based on the idea of minimal effort. It insures the use of a [+stacked] configuration anytime there are two orientations of the hand being articulated at the same time, and one of them happens to be midsagittal plane (e.g., TWICE, SEE, EXTRACT, SALAD).
- b. MAXIMIZECONTRAST (MAXJOINTS): This constraint insures that the maximum number of distinctions in joint configuration is maintained. In the case of these [stacked]




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<sup>7</sup> This idea has also been proposed by Geraci (personal communication).

<sup>8</sup> These constraints and their motivation are simplified somewhat for purposes of exposition here. In addition to these constraints for joints there are also constraints on selected fingers, which we will not describe here in the interest of space. See Eccarius (2008) for full details.

examples, there is the [+stacked]  and the [-stacked]  potential contrast.

- C. FAITHFULNESS IN ICONIC BORROWING (FAITH:ARRANGEMENT): This constraint insures that if there is a visual arrangement of the appendages (e.g., in the legs), the handshape should be faithful to (or include) that arrangement in its configuration.

The tableaux in (9)-(11) will demonstrate these constraints at work. The tableau in (9) shows how these constraints work in the core component of the lexicon, using the example SEE, which can potentially exhibit the two forms in Figure 6 (with or without the [stacked] feature). In the figures of this section the preferred form has the black border around it. Iconicity, we would claim, plays no part in the joint configuration of this handshape, hence FAITH:ARR is the lowest ranked constraint.<sup>9</sup> The context sensitive MARK:+ORI constraint is at work because the more frequent form is the [+stacked] form; therefore, all candidates including  violate this constraint. With regard to the MAXCONTRAST Constraint, neither the  or  alone in the system is optimal because a contrastive distinction is lost (as indicated by single check marks for Candidates (b) and (c) vs. double check marks for Candidate (a) where a contrast between the two would exist). The fact that a distinctive contrast between the two forms does not exist in the core indicates that the context sensitive constraint MARK:+ORI, and not the MAXCONTRAST constraint, determines the winner.

(9) Tableau for the core form SEE










	SEE  — SEE 	MARK:+ORI	MAXJOINTS	FAITH:ARR
a.	 — 	*	✓✓	
b. 	—  —		✓	
c.	—  —	*	✓	

Figure 6. The 2 potential forms of SEE in ASL: [-stacked] (left), and [+stacked] (right), which is the more common form.



The tableaux in (10) demonstrates how the constraints are ranked in the foreign component. Here there is a distinctive difference between  and  in some locations, but this distinction is neutralized in many places of articulation. For example, VANILLA vs. KITCHEN, which are both signed in 'neutral' space and therefore do not meet the structural description of MARK:+ORI, exhibit the distinctive contrast. The tableau in (10) shows how the constraints work for the form VERB, which does meet the structural description of MARK:+ORI. As with SEE, there are two potential forms, one with and without the [stacked]

<sup>9</sup> The location, movement, and even the choice of two fingers may be historical remnants iconic, but not the joint configuration.

configuration (see Figure 7).<sup>10</sup> Again the [+stacked] form wins, (it is the preferred form), so MARK:+ORI must be ranked higher than MAXJOINTS, indicating that the distinction is neutralized. The FAITH:ARR constraint is no longer completely inactive, since one could argue that the [±stacked] form of the two fingers are (or once were) iconically representing the graphical ‘appendages’ of the 'V' and 'K', but it does not determine the winner.<sup>11</sup>

(10)

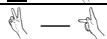







	<u>VERB</u> <sub>h</sub> — <u>KXX</u> <sub>h</sub>	MARK:+ORI	MAXJOINTS	FAITH:ARR
a.		*	✓✓	
b.			✓	*
c.		*	✓	

Figure 7. The 2 potential forms of VERB in ASL: [-stacked] (left), and [+stacked] (right) , which is the more common form.



The tableaux in (11) and (12) show how the constraints work in the spatial component where iconicity becomes an important factor. The tableau in (11) shows the ranking for a whole entity classifier 'vehicle-leaning-on-its-side' (e.g. a bike), which again also has two variants —one with and one without the [stacked] configuration. The handshape itself is morphological (referring to the class 'vehicles') and the selected fingers show a distinctive contrast ('vehicles' uses the thumb' but 'upright being' does not), but the [stacked] configuration is neither distinctive nor iconic. The ranking in this case is the same as the ranking in the core lexicon, there is no minimal pair between +thumb and +thumb and MARK:+ORI decides the winning candidate.<sup>12</sup> The two potential variants are given in Figure 8 (the [+stacked] one is preferred).

(11) Tableau for the whole entity classifier 'vehicle-leaning-on-its-side'

	'vehicle' <sub>h+th</sub> — 'vehicle' <sub>h+th</sub>	MARK:+ORI	MAXJOINTS	FAITH:ARR
a.		*	✓✓	
b.			✓	
c.		*	✓	

<sup>10</sup> There is an accidental gap here, which is why we used 'KXX' in the tableau, but if there were an initialized 'K' format this location, we would predict that the contrast between the two forms would neutralize.

<sup>11</sup> The FAITH:ARR Constraint may also influence the choice of selected fingers, but we are focusing on joint configuration here, so we because of space we refer the reader to Eccarius (2008).

<sup>12</sup> This is one reason why the group of whole entity classifiers is considered most similar to items in the core lexicon.

Figure 8. The 2 potential forms of the whole entity classifier predicate 'vehicle-leaning-on-its-side'in ASL: [-stacked] (left) and [+stacked] (right), which is the more common form.

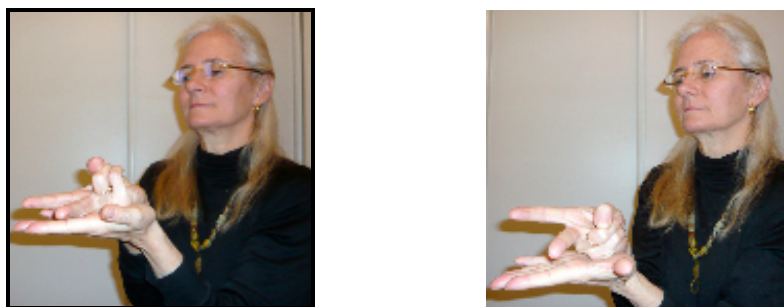


The tableau in (12) shows the ranking for the body part classifier predicates 'sunbathe-flat-on-one's-back' (☞) vs. 'sunbathe-with-legs-straddled' (☞). So far in the core and foreign component, each pair of forms has had just one meaning associated with it. In the body part classifier, however, there is a difference in meaning and form. In the case of 'sunbathe-flat-on-one's-back', only the [-stacked] form is acceptable since the [+stacked] form would indicate legs in a position other than what is intended, and vice versa. Because both potential meanings are preserved, Candidate A (containing the preserved contrast) is the winner.

(12)

	'sunbathe <sub>☞</sub> ' — 'sunbathe <sub>☞</sub> '	FAITH:ARR	MARK:+ORI	MAXCONTRAST
a. ☞	☞ — ☞			✓✓
b.	☞ — ☞	*		✓
c.	☞ — ☞	*	*	✓

Figure 9. The 2 forms of the body part classifier 'sunbathe' in ASL: [-stacked] (left) 'flat-on-one's back ' vs. [+stacked] (right), which would mean 'legs-straddled'.



These tableaux demonstrate three important points relevant to the goals of this project. First, the [stacked] feature is interpreted as an 'asymmetry' case in terms of contrast type and feature distribution, because is used differently among the three components of a sign language lexicon. As shown, a prominent contrast is present only in body part classifiers (where there is a difference in meaning), a distinctive contrast is apparent only in the foreign forms, and the feature is active throughout the lexicon. Secondly, these tableaux show how iconicity interacts with these other constraints, both within the spatial component and across the other lexical components as well. Thirdly, models that consider only the core vocabulary relevant for building a phonological feature inventory would not include [stacked] in the inventory at all because it is not distinctive in the core, and such analyses would be missing an important factor in sign language grammars.

We would predict that this analysis would generalize to many other features in a sign language phonological system.

## 4 Conclusion

Although sign languages and spoken languages utilize the same kinds of contrasts in their phonological systems (i.e. distinctive, active and prominent), they differ in how the contrasts are distributed across their lexicons; sign languages would appear to have a larger number of asymmetry cases than spoken languages, and fewer distinctive and purely allophonic feature distributions.

We would argue that the explanation for the distributional differences between modalities is ultimately two-fold. First, *iconicity* is an important factor responsible for the small number of distinctive minimal pairs in sign language lexicons. The use of prominent~morphological~iconic features makes many more features 'autosegmental' in sign languages as compared to spoken languages. Van der Kooij (2002) has proposed that iconicity can be handled by a set of phonetic implementation rules, but we have shown that no single solution will work since each lexical component uses features in a different way, both in terms of type of feature (distinctive, active, prominent) and in terms of distribution (distinctive, allophonic, asymmetrical). In addition, the historical iconic motivation for some movements and locations in some forms in the core lexicon creates a sparsely populated grid of lexical items (van der Kooij 2002, van der Hulst and van der Kooij 2006), thus creating few explicit examples of distinctive contrasts.<sup>13</sup> We would argue that in order to understand phonology in sign languages one needs to understand how conventionalization takes place and affects the grammar in these languages.

Secondly, at the other end of the spectrum we would argue that the small number of purely allophonic examples is due to the greater *articulatory independence* in sign languages with respect to spoken languages. Because of the confined space and the limited number of articulators in the vocal tract in spoken languages, most movements of one part of the tongue—e.g. the tongue tip—effect movements of other parts of the tongue, as well as the length of the vocal tract. In the absence of antagonist moves to the contrary, phonological 'gestures' in speech have a constellation of concomitant, phonetically motivated and potentially allophonic consequences. Some such phonetic consequences exist in sign languages, too--the anatomy of the hand definitely effects the frequency of certain types of handshapes over others, as Ann (1993, 2006) and Greftegreff (1993) have shown. Allophonic flexion of the knuckles (Crasborn 2001) and the closing of the fist and extension of the wrist (Mandel 1979, Brentari 1998) are two further examples. However, in general, articulation is slower in sign language and the articulators of the body arms and hands in sign languages are capable of greater articulatory independence than spoken language articulators. Since sign languages are freer to control the movements of the hands and body, phonological elements have fewer allophonic consequences dictated by the entire articulatory system.

Sign languages are excellent language cases for studying both the effects of contrast types throughout a system and how the system changes in historical time, precisely because we can see evidence of both historical change and synchronic variation. Optimality Theory affords us with a potential way of representing this variation, allowing features to participate in

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<sup>13</sup> Movements or locations may be neutralized to some extent, but they will not be neutralized to as great a degree as in spoken languages (see Johnson & Liddell 1984 for movement changes and see van der Hulst and van der Kooij 2006 for changes in location).

FAITHFULNESS and MARKEDNESS constraints, which make the role of distinctive, active, and prominent contrasts more transparent in the system.

## Acknowledgements

This work was supported in part by NSF grants to Brentari (BCS 0112391 and BCS0547554) and by a Purdue Research Foundation Grant to Eccarius.

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