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Phonology, phonetics and the nondominant hand

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Many studies have shown that the phonology of sign language has much in common with that of spoken language, including the existence of meaningless phonological features and feature classes, phonological constraints, rules of assimilation, and more. At the same time, the phonetics of the two language modalities is shaped in part by articulators with very different anatomical and physiological characteristics. For these reasons, sign language offers an interesting vantage point from which to view the relation between phonetics and phonology. In this chapter, the behavior of the nondominant hand in the phonology and the prosody of sign language is analyzed. This articulator, anatomically identical to another articulator in the system (the dominant hand), has no parallel in spoken language, yet it plays a significant role in aspects of phonological organization that are similar in the two modalities.

1. Introduction

Natural sign languages have been found to be similar to spoken languages in significant ways at all levels of structure, despite the radically different physical channel of transmission: the hands, face, and body and vision, instead of the vocal tract and audition (Sandler and Lillo-Martin 2006). Because the physical system underlying the phonetics and phonology of sign language is beyond any doubt qualitatively different from that of spoken language, it is at once surprising and intriguing that similarities have been found at the phonological level of structure. I wish to make two related claims: (1) There is a phonological level of linguistic organization common to signed and spoken language (2) phonological organization does not derive from phonetics alone. This is clearly a complex issue with important implications, and it has been approached from various perspectives in the sign language literature (e.g., Brentari 1998; Crasborn 2001; Sandler 1989; Sandler and Lillo-Martin 2006; Uyechi 1996). The present investigation proposes to examine it in a

restricted way, but one that is potentially especially revealing – namely, from the point of view of the nondominant hand, an articulatory element with no parallel in spoken language.

The nondominant hand (henceforth, h2) is anatomically identical to the primary articulator of sign language, the dominant hand. A priori, one might anticipate that each hand could participate equally to provide meaning in sign language utterances, the way they do in some kinds of co-speech gesture (Enfield 2004; McNeill 1992). For example, each hand might be configured to represent a different entity iconically, and together, they could convey the spatial relation between the entities. As in gesture, the shapes and relations of the hands might also be metaphorically extended, representing the interaction of events or concepts. If a system like this were to exist in sign language, it would mean that each hand assumes some kind of meaningful word-like status.

Stokoe's (1960) demonstration that the handshapes of American Sign Language are like phonemes, formationally significant but meaningless, provides a diametrically different characterization of h2. Like the dominant hand, h2 is shown to function not as a word or morpheme, but as an articulator, assuming different shapes and articulating different locations and movements – themselves also meaningless – in a phonological system. Stokoe's work served to bring sign language into the arena of general linguistic investigation. In so doing, it opened the door to new and important questions.

For example, once the hands are thought of as articulators in a phonological system, the nondominant hand appears to be anomalous when compared to the spoken language articulatory system, because it is an anatomical copy of the dominant hand. Spoken language has no such dual articulator. The primary articulator of spoken language, the tongue, is unitary, as are all other elements in the articulatory apparatus of the medium. One might expect sign languages to exploit the articulatory potential of the nondominant hand, promoting it to equal or near equal status to that of the dominant hand in the phonology. Contrarily, the system might bear only one dominant articulator, the dominant hand or h1, relegating h2 to a subordinate role in the phonology.

Yet another possibility is that the biology of language, having a perfectly good articulator at its disposal, will not let h2 off the phonological hook so easily, and will instead exploit it for a function that is phonological but different from that of h1 – for augmenting the rhythmic properties of prosody, for example.

In this chapter, the behavior of the nondominant hand in the phonology, morphology, and prosody of sign language is singled out. This articulator, uniquely available to the sign modality, reveals linguistic properties at each of these levels of organization that are independent of modality. This state of affairs is argued here to be incompatible with a theory in which phonetics and phonology are one and the same, and incompatible as well with a theory in which all of phonology is directly derived from phonetics.

Distinguishing between phonetics and phonology has proved to be a challenging enterprise (see, e.g., Kingston and Beckman 1990) and the present paper does not aim to resolve the issue. Instead the goal is to demonstrate that there is phonology in sign language that is recognizably similar to spoken language phonology, despite the fact that the articulators are not comparable in any meaningful sense. As the articulators and their properties mold the phonetic system, it follows that the phonetic systems cannot be the same in the two modalities. And if it can be shown that phonological organization is similar in specific areas of spoken and signed languages where the phonetics is different, we must conclude that the phonology does not derive from the phonetics alone.

For the sake of the discussion, I make the following general assumptions about phonetics and phonology. First, phonetic processes are gradient while phonological processes are discrete and categorical (e.g., Cohn 1993). Second, phonetic processes are mandated mainly by physical production mechanisms while phonological processes are also linked to higher levels of grammatical structure, such as the lexicon and the syntax. Most of the attention in the present study is given to structure and processes related to the nondominant hand that are phonological in the sense just described.

The exposition begins with the lexicon, where h2 plays a clearly subordinate and restricted phonological role (§1), then proceeds to classifier constructions, in which h2 has the status of a morpheme and does not conform to the same restrictions (§2). In §3, I review research demonstrating that the nondominant hand plays a systematic role in the demarcation of prosodic constituents. The point of the overview is to show that a single phonetic articulator is recruited by a diverse range of subsystems in the grammar of sign language in ways that that clearly have no parallel in the phonetics of spoken language. The claim that there are significant phonological similarities in the two modalities despite the different phonetic foundation will rely mainly on two of these levels, lexical and prosodic. It's at these two levels

that the linguistic behavior of h2 has been most clearly worked out, and can best exemplify the specific claims that I wish to make here. The data come from two sign languages: American Sign Language (ASL) and Israeli Sign Language (ISL).

2. The phonology of the nondominant hand in the lexicon

There is a broad consensus that there is only one primary articulator in the lexical phonology of sign language, the dominant hand (Brentari 1990, 1998; Brentari and Goldsmith 1993; Perlmutter 1991; Sandler 1989, 1993a; van der Hulst 1996; van Gign, Kita and van der Hulst in press).[1] This means that the nondominant hand plays only a minor role in lexical representations. It represents a meaningless phonological element, and its shape and behavior are so strictly constrained as to make it largely redundant.

The formational elements in sign language words are subject to phonological constraints, among them constraints on the nondominant hand. The constraints I am about to describe have been attributed to various domains, such as the 'sign' or the morpheme. I am attributing them here to the lexeme. What is relevant for our purposes is that these constraints hold within the lexicon, and that together they characterize the typical sign language word. One constraint on structure is monosyllabicity: most sign language words have only one movement; that is, they are monosyllabic (Coulter 1982; Sandler 1993c).[2] The Selected Finger Constraint (Mandel 1981) requires a maximum of one specification for selected fingers (on the dominant hand) in a lexeme. This means that a handshape is defined in terms of the fingers that are selected in its articulation. The handshape  selects the index finger and thumb; the shape  selects the index and middle finger, etc. Among the constraints on lexemes are two that have special relevance here, as they restrict the specification of the nondominant hand: the Dominance Condition and the Symmetry Condition (Battison 1978). These constraints are paraphrased below.

The Dominance Condition
If the hands of a two-handed lexeme do not share the same specification for handshape, then one hand must be passive while the active hand articulates the movement, and the specification of the passive handshape is restricted to be one of a small set:[3]   

The Symmetry Condition
If both hands move independently, then both hands must be specified for the same handshape and the same movement (whether performed simultaneously or in alternation), and the specifications for location and orientation must be either identical or mirror-image.

Lexemes are further constrained by specification for a single major body area (Battison 1978), called place of articulation in the model used here. Places of articulation include the head, trunk, and nondominant hand (h2). Normally, h1 moves from one setting to another (e.g., high to low, contralateral to ipsilateral, or proximal to distal) with respect to the place. The Dominance Condition is relevant for lexemes in which only one hand, h1, articulates, and h2 is a place of articulation (Sandler 1989, 1993a). An example of a sign in which h2 is a place of articulation is (ISL) AT-THAT-MOMENT, pictured in Figure 1b. Figure 1a is a schematic representation of such signs. In this schematic example, HC stands for the category of Hand Configuration; Ls are location positions and M is a movement position on a skeletal tier. In the sign, the dominant hand is configured in a particular shape and orientation, represented in a complex feature hierarchy (Sandler 1987, 1989). In the schema here, an icon is used for simplicity. The hand moves from one location to another, on or near a single major body area, such as the head, the trunk, or in the present example, the nondominant hand, labeled [h2] in the schematic representation. The single major body area is labeled 'Place', for place of articulation. Location features specify further refinenements of the place category, such as [proximal], [high], [contact], etc., called settings. In the sign pictured, the dominant hand moves from the first location, a point above the nondominant palm ([proximal]), to the second location, contact with the palm.

The Symmetry Condition refers to lexemes in which h2 is essentially a copy of the dominant hand, h1. In such signs, h2 is simply represented as a member of the Hand Configuration class (Sandler 1989, 1993a). An example is (ISL) CAT, shown in Figure 2b. In this sign, the head is the place of articulation and the settings are [ipsilateral] to the signing hand, [low] (i.e., side of mouth area) for both locations, [contact] for the first location and [proximal] for the second location. The change in setting describes the path traversed by the hands. Signs in which h2 functions like a copy of h1 may be represented as in Figure 2a. The h2 node is associated to the same feature complex as h1, abbreviated here by the handshape icon  , and articulates the same locations and movement.

In both types of two-handed words, the nondominant hand is underspecified. In the dominance type (Figure 1), the hand must either have one of only a few unmarked handshapes, or it is redundantly marked for the same shape as h1. In the example, the h2 handshape is the unmarked shape,  . The notion of markedness assumed here is that of Jakobson (1968), and underspecification is seen as a device for expressing relative markedness: the less specified, the less marked (see Sandler 1995, 1996 for a treatment of handshapes in this framework). In the symmetrical type (Figure 2), h2's shape, and the locations and motion it articulates, are all completely unspecified, assuming those of h1 by default.[4]

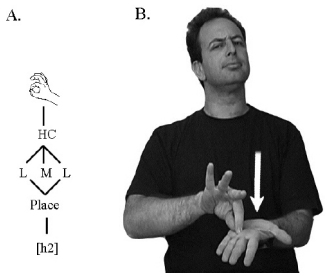

Figure 1. A) Partial schematic representation of sign with h2 as a place of articulation: AT-THAT-MOMENT (ISL). B) Illustration of the sign.

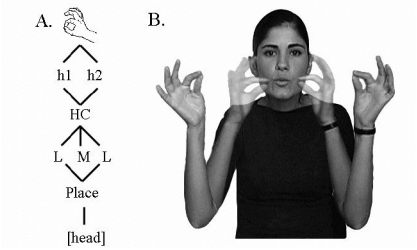

Figure 2. A) Partial schematic representation of sign with two symmetrical articulators: CAT (ISL). B) Illustration of the sign.

Furthermore, in the phonology and morphology of ASL, h2 patterns with h1 in symmetrical signs, and with the place of articulation class in the other type of two-handed sign (Sandler 1989, 1993a). For example, the place constraint applies to h2 in dominance (Figure 1) type signs: if h2 is the place of articulation, then no other place of articulation may be specified in the lexeme (Perlmutter 1991), just as there may be no other place besides the head in the sign in Figure 2. Similarly, in symmetrical signs (Figure 2 type), h1 and h2 behave identically under assimilation of hand configuration in compounds.

In order to understand the behavior of the hands in sign language phonology, let's look at assimilation in ASL compounds. The form of lexicalized compounds is often reduced, in part by total regressive assimilation of the Hand Configuration (Liddell and Johnson 1986; Sandler 1987, 1989). If the second base sign happens to be a symmetrical two-handed sign, i.e., if h2 is part of the HC class, then both hands assimilate. Figure 3 shows the com-

pound MIND+DROP, which means FAINT. Figure 4 shows (schematically) how the rule works (see Sandler 1987; Sandler and Lillo-Martin 2006 for full representations).

In this lexical phonological rule, the entire hand configuration is involved, and it spreads discretely to the beginning of the compound and no further. It is to be distinguished from post-lexical coarticulatory (phonetic) processes, which are gradient and/or non-categorical. For example, Corina (1993) describes coarticulation between words that adds a single finger from the handshape of one sign to the handshape of an adjacent sign. Coarticulation of this sort between signs is not categorical, since only part of the shape assimilates. It is non-structure preserving in the sense that it may create shapes that don't exist in the handshape inventory. I note that no instrumental measurement of the sign language phenomena under discussion has been undertaken. Thus, claims about gradience and discreteness rely on human judgment. This shortcoming is not quite as dire as it may seem, however, for the following reasons: (1) unlike the articulators of speech, sign language articulators are large and slow relative to speech articulators; (2) sign language articulators are directly observable by the eye; and (3) all relevant phenomena have been scrutinized on videotape many times in slow motion ranging from 30% of normal speed down to frame-by-frame viewing.[5] The fact that this method can distinguish between non-categorical handshape coarticulation between words and categorical handshape assimilation in compounds encourages us to accept results achieved this way, at least until a better method can be satisfactorily implemented.

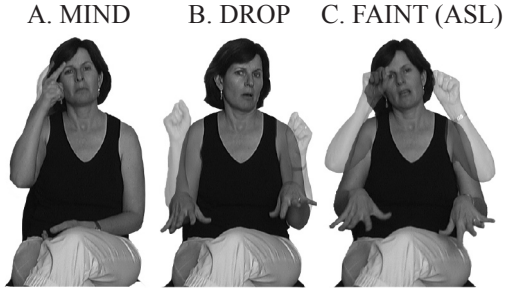

Figure 3. ASL lexicalized compound with Hand Configuration assimilation.

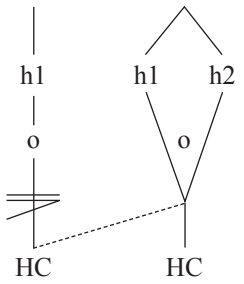

Figure 4. Total HC assimilation in a symmetrical two-handed compound.

Because the total HC assimilation rule in compound words is lexical, structure preserving, and categorical. rather than post-lexical, non-structure preserving, and non-categorical, it is presented here as an example of a phonological rule.[6] Phonology in both modalities, then, recognizes the category 'word' and is affected by discrete assimilation rules. Furthermore, regardless of modality, phonology systematically affects whole classes of features (e.g., Clements 1985). In the kind of assimilation presented here, the whole hand configuration class, including the selected fingers, their position, and the orientation of the hands, assimilates.[7] Yet despite these phonological similarities, the phonetic articulatory systems of the two modalities have nothing in common that meets the eye or ear. The specific shape taken by coarticulation in each system is determined by the physical nature and dynamic properties of the articulators. But the fact that HC assimilation is categorical and linked to a higher level of structure – the word – makes it phonological. These phonological properties don't derive from the phonetics, and they are present in both modalities.

Returning to the nondominant hand in lexical signs, we may describe its role as largely redundant. It is underspecified, and it behaves like h1 in symmetrical signs or like a place of articulation in dominance signs. Of the sign languages that have been studied, vanishingly few minimal pairs have been attested in which the presence or absence of h2 is contrastive. In fact, h2 is so redundant that it can often be omitted, by a process called Weak Drop (for ASL, Brentari 1998; Padden and Perlmutter 1987; for Sign Language of the Netherlands, van der Kooij 2002; for ISL, Levy 2001). Specific phonological analyses vary, but there is a consensus on the following claim: although phonetically there are two manual articulators, there is phonologically only one major articulator in lexical signs: h1, the dominant hand (see the references at the beginning of this section).

It is likely that a combination of motoric, perceptual, and cognitive factors underlies the dramatic subordination of h2 to h1 within lexemes in the sign language lexicon. Discovering what these factors are and how they interact is worthy of future research. But whatever they are, the end result is a lexicon in which the form of two-handed words is severely restricted and the specification of the nondominant hand is largely redundant.

The question of why h2 appears at all in lexical words is worthy of attention. Part of the answer is surely phonetic: the nondominant hand is there, and it is subject to motor patterns that are dictated by bimanual coordination. Yet due to phonological constraints, its role within the lexicon is minimal. Keeping in mind that these constraints hold only on words, an explanation

suggests itself: the redundant properties of h2 in lexical words are significant in sign language processing. It is reasonable to speculate that the redundancy itself signals to the child acquiring sign language or to the addressee that a two-handed articulation so formed has the status of a lexeme or lexical word. Words may be distinguished by such constraints from other linguistic elements in sign language, such as classifier constructions, to which we turn now.

3. The nondominant hand as a meaningful element: Classifiers

I have said that h2 plays only a minor role in the representation of lexemes. This does not mean, however, that h2 is insignificant throughout the lexicon. In all established sign languages studied to date, an elaborate system of classifier constructions exists, in which h2 has a more independent status. These structures, often invoked to express events of motion and location, spatial relations among concrete referents, or the handling of objects (Supalla 1982, 1986), involve a set of handshapes that function as classifiers. Classifier handshapes typically classify referents in terms of semantic category (e.g., HUMAN, SMALL ANIMAL, VEHICLE, etc.), size and shape (SMALL-ROUND-OBJECT, FLAT-OBJECT, etc.), or the dimensions of the handler of an object (and by extension, of the object being handled). These combine with different paths and manners of movement, and with locations. In this system, each hand, instead of being a phonological element, may represent a morpheme by its configuration.

Classifier constructions are most clearly reminiscent of the contribution of gesture in the formation of sign languages. For example, like iconic gestures (McNeill 1992), the hands can take on the shape of objects being described and can mimic their relative locations and the kinds of motion they undergo. Also as in gestures (Enfield 2004), the nondominant hand in classifier constructions can serve as the ground for the dominant hand, the figure (Supalla 1982). Yet these structures are not pantomimic analogs. Rather, they are comprised of a finite list of handshapes and movements, they are rule-governed (Supalla 1982, 1986), and they pose a challenge for the child acquiring sign language (Slobin et al. 2003; Supalla 1982, 1986). Nevertheless, linguists often treat the system separately from the rest of the language, because of the formal structure of classifier constructions, which is quite different from that of lexical words. To begin with, each of the main components – handshape, location, movement – usually has meaningful morphological status.

This is in direct contrast with ordinary words of sign languages, in which each of these categories is strictly phonological, and, by definition, meaningless. When the morphemes combine, they do not create lexemes, but rather expressions that translate as full sentences, such as 'A small animal is sitting on a log,' or 'A vehicle drove over a hill.'

Distributional and prosodic properties of classifier constructions provide more reasons for regarding them as distinct from lexemes or words (Sandler and Lillo-Martin 2006). Although a classifier construction might span only one syllable, giving it the appearance of a word (Brentari 1995), a single classifier might also span several prosodic constituents (such as intonational phrases) without re-articulation of the handshape (Aronoff et al. 2003). The handshape remains constant across a sequence of movements traversing several locations and representing a chain of events in which the classifier's referent participates. An event in which a car, for example, drives uphill, turns right, then left, then parks along an incline is likely to be represented in this way. In this respect, too, classifier constructions are unlike lexical words. The individual morphemes in the classifier subsystem, each a minimal pairing of form and meaning that recombines productively with other morphemes in the system, must be assumed to be independently listed in the lexicon, like other morphemes. But crucially, each is a bound morpheme and cannot constitute a word by itself. Their meanings, their phonological forms, and their prosodic properties suggest that the morphemes of the classifier system are combined post-lexically (Sandler and Lillo-Martin 2006).

Of special interest to us here is a particular anomaly of this subsystem that provides additional evidence for the claim that the Symmetry and Dominance conditions on the nondominant hand are lexical and phonological and not imposed by the phonetics. In classifier constructions, the nondominant hand (h2) can function as an independent classifier (Supalla 1982), and as such can freely break the phonological constraints that are strictly enforced on h2 in words.

In Figure 5, h2 is configured as an AIRPLANE classifier, and the dominant hand as an UPRIGHT-HUMAN. It is taken from an ISL utterance meaning, 'a person approaches an airplane'. In this figure, the dominant, moving hand has one handshape, and the nondominant, static hand has a different handshape,  , and one that is marked. In a lexical word, this combination of configurations in an otherwise similar structure would be ruled out by the Dominance Condition.

The Symmetry Condition is violated in classifier constructions as well. In discourse context, Figure 6 means something like 'a person proceeds for-

ward, dragging a dog squirming behind' in ASL.[8] One hand represents an upright human and the other a legged-creature – a different configuration on each hand, each hand moving in a different shaped path. The structure is not a possible word of ASL or ISL, ruled out by the Symmetry Condition.

Figure 5. ISL classifier construction: 'a person approaches an airplane'.

Figure 6. ASL classifier construction: 'a person proceeds forward, dragging a dog squirming behind'.

Configured and functioning as a classifier, the nondominant hand can exhibit a great deal of independence in the discourse. For example, it can remain in the signing space throughout a discourse segment to background the referent it represents (see Brentari and Crossley (2002) for references). Miller (1994) describes discourse-regulation devices such as placing a classifier to mark a location and directing a non-classifier with respect to it.

This discussion does not mean to imply that there is no relation between lexical words and classifier constructions. A considerable number of words in any sign language lexicon are believed to have originated as classifier constructions and to have become lexicalized. An example is ISL WRITE, shown in Figure 7.

Figure 7. ISL lexical word: WRITE.

Presumably, WRITE originated as a classifier construction in which the dominant hand, h1, is configured as the handler of a small manipulable object, and h2 represents a flat object, the piece of paper being written on.

As with any other words and unlike the classifier constructions from which it evolved, each of the formational categories in WRITE (handshape, location, movement) is meaningless (Stokoe 1960), and the form behaves in all phonological and morphological respects like a word.[9] However, the grammar treats words differently from classifier constructions.

Sign language classifier constructions are in some respects unique to the sign modality (Schembri 2003). However, even this system bears grammatical and functional similarities to verbal classifiers of some spoken languages, such as Cayuga and Digueño (Aronoff et al. 2003), and it would be a mistake to deduce that sign language morphology is modality specific. On the contrary, other more familiar lexical morphological processes such as verb agreement, temporal aspect inflection, and derivational processes are widely found in these languages as well, and with more familiar formal instantiation, templatic as well as affixal (e.g., Aronoff, Meir and Sandler, 2005; Padden 1988).

Classifier constructions have been introduced into the present discussion for two reasons. First, they underscore the possibility that the redundancy of h2 in words plays a role in the system, namely, to mark words as words, distinct from classifier constructions that are formed at the post-lexical level. Second, they show that the constraints on h2 in words are not phonetic, as they are freely violated in classifier constructions. Instead, they are related to a higher level of linguistic structure – the morphosyntactic word – and are therefore phonological.

4. A grammatical role for h2: the delineation of prosodic constituents

The next question to be addressed is this: does the phonological redundancy of h2 in words mean that the nondominant hand plays no grammatical role in the phonology of sign languages? Interestingly, the answer is ‘no’.

An investigation of the prosodic structure of Israeli Sign Language conducted in large part with Marina Nespor (Nespor and Sandler 1999; Sandler 1999b) revealed that h2 functions as a delineator of boundaries of two prosodic constituents: the phonological word and the phonological phrase. A brief review of those results will demonstrate how this phonetic element is recruited by the prosodic phonology.

Throughout the following discussion, Nespor and Vogel's (1986) theory of prosodic phonology is assumed. The prosodic hierarchy shown below is the same as theirs, except that here their clitic group category is subsumed by the next higher category, phonological word (as explained below).

Prosodic hierarchy (following Nespor and Vogel 1986)
mora < syllable < foot < phonological word < phonological phrase < intonational phrase < phonological utterance

In our study, 30 Hebrew sentences were created with the purpose of determining whether prosodic constituents and intonation exist in ISL, and if so what their properties are. Based on patterns known from spoken languages, the target stimuli were designed to elicit simple, declarative sentences; longer, more complex strings like sentences with relative clauses or sentential complements; yes-no questions; and wh-questions. Three trained native signer consultants were asked to read each sentence, internalize it, put the paper aside, and sign the sentence in natural ISL to another native signer seated by the camera. All 90 sentences (30 x 3 signers) were recorded on videotape and subsequently glossed with the help of a native signer consultant, one sentence per coding sheet. Each observable facial articulator (eyebrows, eyelids, cheeks, nose, and mouth) was listed down the lefthand side of the sheet, as were head and body. In addition, rhythmic and prominence properties of the hands, such as size, speed, number of iterations, pauses and holds were also listed. Coding consisted of describing the action of each articulator on its line, and drawing a line tracing its scope vis à vis the glossed text at the top of the page. All coding was done by a research assistant together with a native signer consultant, by viewing the data on videotape repeatedly, in slow motion, and recording the activity of hands, face, and body next to the relevant coding category listed beneath the gloss. The extent of each articulation was indicated by drawing a solid line opposite the articulator label under the words in the gloss that were characterized by it (see above references for a sample).

The coding revealed that the sentences were divided rhythmically by the hands and head into prosodic constituents, specifically, phonological words, phonological phrases and intonational phrases, and that the scope of the facial expression adhered to that rhythm (in particular, changing dramatically at intonational phrase boundaries).[10] After noticing that the nondominant hand often behaves differently in connected signing than might be predicted from the citation form of signs, we tracked and coded its behavior as well

by adding a line for h2 on the coding sheet and describing its behavior there, drawing a line for each exemplar to show the scope of the behavior as with the other categories. We now turn to results of the prosody study that are relevant to the nondominant hand.

4.1. The phonological word

By phonological word I mean a morphosyntactic word plus any surrounding words (typically function words) that are part of the same stress group. The category is similar to that defined in Nespor and Vogel (1986), but different in one respect: the category 'phonological word' is collapsed with the category 'clitic group'. Thus, for our purposes, *Mary's*, in an English sentence like *Mary's on the phone*, is a single phonological word, formed from the two morphosyntactic words, *Mary* and *is.* The formation of phonological words from more than one morphosyntactic word is typically achieved by reducing a function word and assigning it weak stress, relative to the adjacent content word to which it is grammatically related. Thus, the process makes reference to the lexical category of the words and the grammatical relation between them.

In Israeli Sign Language (ISL), if a symmetrical sign is followed by a pronoun in the prominent (final) position of a phonological phrase, the pronoun can cliticize to its host through coalescence to form a single phonological word. The nondominant hand articulates only the host sign, while the dominant hand smoothly articulates the host and the clitic pronoun in the same time span. Figure 8 is extracted from a sentence meaning 'The shop around the corner went bankrupt'. Use of the deictic sign THERE is a typical sign language device, locating a concrete noun in space at first mention, establishing a locus for potential spatial referencing later in the discourse.

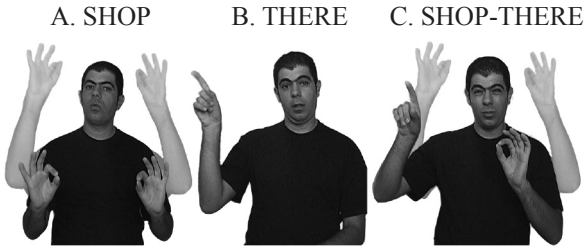

Figure 8. ISL SHOP, THERE, and the cliticized form SHOP-THERE.

In 8a, the sign SHOP is a symmetrical two-handed sign and the deictic pronoun THERE 8b is one-handed, normally signed with the dominant hand. In the cliticized phonological word, the dominant hand signs only half of the sign SHOP, and then changes hand configuration to that of the sign THERE, while moving forward to complete that sign – a coalescence process shown in 8c.

What is of interest here is the behavior of h2. As the dominant hand coalesces, blending two signs, the nondominant hand simply completes the host sign, SHOP, over the same temporal span. The nondominant hand articulates a single syllable (i.e., one movement), and the dominant hand also articulates a single movement, though with a sequence of two different handshapes. In a noncliticized version of these two words, two movements (syllables) would be required to sign SHOP and then THERE. Under coalescence, the cliticized THERE loses its syllabicity, a phenomenon found also in spoken language clitics, e.g., in English aux contraction (Selkirk 1984). In the ISL case specifically, the effect is to create a monosyllable over the domain of the phonological word. The process occurs not only with THERE, but also with both personal and possessive pronouns. It does not occur between two content words, which indicates that the process has access to the grammatical distinction between the two kinds of words.

The effect is to make the cliticized form more like a typical word in its phonological form (Sandler 1999a, 1999b), since sign language words are typically monosyllabic (Coulter 1982). In this process, then, h2 serves to mark the boundaries of the phonological word. As a post-lexical phenomenon, coalescence is non-structure preserving – it violates the Symmetry Condition which requires two active hands to be symmetrical in shape, movement, and location.[11] But as a phonological process, it is discrete. The nondominant hand demarcates precisely the boundary of the host plus clitic, and no more.

4.2. The phonological phrase

The next level up in the prosodic hierarchy is the phonological phrase, projected from the heads of syntactic phrases such as NPs, VPs, and AdjPs (see Nespor and Vogel 1986, for a formal definition and explanation). Though not always isomorphic with the syntactic boundaries of those phrases, phonological phrases are linked to them and, like intonational phrases, they are linked to the syntax. The algorithm below for forming phonological phrases is adapted from Nespor and Vogel's:

> The domain of a phonological phrase consists of a …lexical head X, and all [phonological words] on its non-recursive side up to the [phonological word] that contains another head outside of the maximal projection of X.

The phonological phrase constituent is identifiable by minor rhythmic breaks. For example, the square brackets divide the following sentence into phonological phrases that would be likely to occur at a normal to slow rate of speech: *[The very tall] [construction worker] [carefully walked] [under the ladder]*. If the phrases are shorter, under certain circumstances, Nespor and Vogel show that phrases may be restructured together, becoming non-isomorphic with the individual syntactic phrases projected from each lexical head, e.g., [He ate] [a hearty lunch] versus [He ate lunch], the latter restructured from [He ate] [lunch]. Restructured or no, under normal circumstances, prosodic constituency does not disrupt syntactic constituency, so that the following divisions are impossible: **[The very] [tall construction] [worker walked under] [the ladder]*. Instead, prosodic constituency may be thought of as interpreting the syntax.

Phonological evidence for the existence of this prosodic constituent is found in external sandhi rules whose application is restricted to the domain of the phonological phrase. An example is French liaison (Nespor and Vogel 1986; Selkirk 1986). The underlying final consonant, normally deleted, is pronounced before vowel-initial words if the two words are in the same phonological phrase. Liaison does not apply between words across a phonological phrase boundary.[12] In the sentence, *Les enfants [sont^allés] φ à l'école.* taken from Nespor and Vogel (1986), there is liaison (signified by the symbol ^) between *sont* and *allés* within a phonological phrase; i.e., the [t] of *sont* is pronounced. But there is no liaison between *allés* and *à* (i.e., the final consonant of *allés* is *not* pronounced) because a phonological phrase boundary (φ) intervenes.

ISL utterances are also divided into phonological phrases. Final phonological phrase boundaries are marked phonetically by holds, reiterations of the last sign, or pauses (Nespor and Sandler 1999; Sandler 1999b). The sentence below is divided into two intonational phrases (each marked with an I index), the first containing three phonological phrases, and the second containing two phonological phrases.[13]

> [I-TELL HIM]$_{\varphi}$ [BAKE CAKE]$_{\varphi}$ [TASTY]$_{\varphi}$]$_{I}$ [[ONE FOR ME]$_{\varphi}$ [ONE FOR SISTER]$_{\varphi}$]$_{I}$
> 'I told him to bake a tasty cake, one for me and one for my sister'.

Confirmation for the existence of the phonological phrase constituent was found in an external sandhi rule involving h2, called Nondominant Hand Spread (NHS). Unlike French liason, this sandhi rule does not involve sequential segments. Rather, the spread of the nondominant hand from the triggering two-handed sign is simultaneous with the signing of other words by the dominant hand. An example is the phrase, BAKE CAKE from the sentence above.

Figure 9 illustrates NHS in this sentence. In it, the nondominant hand from the sign BAKE spreads to the end of the phonological phrase by remaining in the same configuration as in the source sign, BAKE, throughout the next sign, CAKE, which is a one-handed sign. The end of the phonological phrase is marked by a hold – holding the hand in position at the end of the last sign. Precisely at the onset of the next phonological phrase, $[\text{TASTY}]_{\varphi}$, the sandhi stops, and the hand assumes a neutral shape. The illustration shows the signs BAKE^CAKE in Figures 9b and 9c with NHS. Figure 9a shows the sign HIM in the phonological phrase that precedes BAKE^CAKE, and Figure 9c shows the sign TASTY in the phonological phrase that follows it.

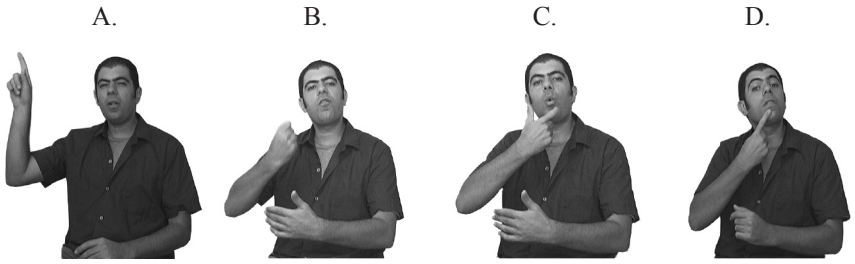

Figure 9. A. HIM; B. BAKE; C. CAKE; D. TASTY. Nondominant Hand Spread in the phonological phrase, $[\text{BAKE CAKE}]_{\varphi}$ blocked from spreading across the boundary either to $[\text{HIM}]_{\varphi}$ in the preceding phrase, or to $[\text{TASTY}]_{\varphi}$ in the following phrase.

In our corpus, the spread of h2 is only to the edge of the phonological phrase, as seen clearly in this example. Importantly, two other conceivable explanations for the blocking of NHS spread are ruled out here. If there were a two-handed sign in the following phrase, the presence of a specified h2 there might conceivably be blamed for the fact that NHS stops where it does. However, the sign in the phrase that follows the one with NHS, TASTY, is one-handed, so it is not implicated. The other conceivable explanation is the presence of a higher (and stronger) constituent boundary, that of the Intona-

tion Phrase. This possibility is also ruled out in the present example, because, according to both syntactic and prosodic criteria established in the Nespor and Sandler (1999) study, the IP boundary occurs after the next phonological phrase, $[\text{TASTY}]_{\varphi}]_{I}$. In our corpus, there were no exceptions to the blocking effect of the phonological phrase boundary. Furthermore, the spread is discrete and not gradient. Repeated slow motion viewings revealed that NHS extends clearly to the edge (right, left, or both) of the prosodic constituent. From this behavior, together with the fact that phonological phrases are linked to syntactic phrases, it appears that NHS is a phonological process, and not a phonetic process of coarticulation.[14] As a post-lexical process, it is, like coalescence, non-structure preserving: the result of NHS is the presence of two places of articulation during the production of one sign (here, the sign 'CAKE'). At the lexical level, only one place of articulation is licensed (Battison 1978).

I've suggested that h2 participates in signs, despite its redundancy, partly because of the physiology of the system, which includes motoric organization of bimanual coordination. The behavior of h2 in the 'cake' sentence (Ex. 9) is a good example of this. The signer's nondominant hand is present in the signing space, in a neutral configuration and location, even when it is participating neither in a two-handed sign nor in Nondominant Hand Spread. The neutral configuration for this particular signer is one in which the index finger is slightly prominent and the rest of the fingers are loosely curled.[15] The transition from the handshape of BAKE to this neutral configuration, assumed precisely at the onset of the next phonological phrase, difficult to convey in still pictures, is striking on the videotape.

5. Conclusion

We've now traced the nondominant hand in a full circle through the grammatical system of sign language. In the lexical words of sign languages, there is only one major articulator, the dominant hand, and the nondominant hand plays a subordinate and largely redundant role in which its handshape, place of articulation, and movement are severely restricted. The prosodic system exploits this seemingly redundant element to demarcate prosodic constituents at different levels of the prosodic hierarchy, as we have seen. A meaningful role for the nondominant hand is seen in the classifier subsystem, where it has the status of a morpheme and enjoys almost as much articulatory freedom as the dominant hand.[16] At the discourse level, a level that was

touched on briefly in §2, h2 can be quite useful in rhetorical devices of sign languages, tracking referents and backgrounding portions of the discourse while the dominant hand simultaneously continues to 'talk', using lexical words in syntactic constructions.

It should be quite clear by now that the nondominant hand is a phonetic articulator utterly unique to sign language, that there is no corresponding element in spoken languages. At the two extremes of the grammar – the classifier subsystem and the discourse level – the nondominant hand is an equipotential articulator, representing entities and concepts like its physiological twin, the dominant hand. No individual phonological element in spoken languages functions systematically and cross-linguistically as a full morpheme. In addition to the modality specific range of functions performed by h2 in sign language grammar, the physical and dynamic properties of this articulator are also obviously different from those of any spoken language articulator. Insofar as such properties form an integral part of phonetic systems, we must say that the phonetics of h2 is unlike those of any articulator in spoken language. We will return to this point below.

The linguistic roles that h2 plays, however, do have direct counterparts in spoken language. Let's first consider words in the lexicon. Just as spoken words have structural constraints, so do signs. In most signed words, h2 must either be an articulator that is symmetrical with h1, or it must be a place of articulation in which handshape is underspecified. Spoken words are constrained differently, e.g., in terms of the number and types of consonants that may appear initially and finally. While the specific constraints are different, the fact that phonological elements and their co-occurrence are constrained within words is well known from spoken languages. Presumably, this kind of predictability about the shape of a linguistic entity has acquisition and processing advantages in both modalities.

Another way in which sign language phonology behaves like that of spoken language despite very different phonetics is in signaling prosodic constituents. In many languages, assimilation rules that cross word boundaries, external sandhi rules, have been shown to respect particular prosodic constituent edges. One can think of this merging of words that stops at the boundary of a prosodic constituent as a way of binding together words within that constituent. In spoken languages, where linear structure is prominent, sandhi normally occurs between adjacent segments. In sign languages, in which structure at all levels is more simultaneous, sandhi can merge more than just adjacent segments; it can merge whole stretches of words.[17] This is the effect of coalescence and of NHS. The seemingly redundant articulator of sign

language, the nondominant hand, can unite a host and clitic, and it can spread simultaneously across whole words within a phonological phrase, with the effect of binding together the words in the constituent. The phonetics of external sandhi processes is starkly different in the two modalities – affecting adjacent sequential segments in spoken language, and simultaneously affecting an entire word or more than one word within a prosodic constituent in sign language – but the phonological role is arguably quite similar.

This investigation, considering only one element in the structure of sign language, reveals both universal and modality-specific properties. The specific feature pool and classes, and the details of phonological processes are not universal; they differ in the two modalities. Furthermore, spoken languages tend to have sequential organizing properties and phonological processes that affect sequentially arranged elements, while sign languages have a good deal more nonlinear or simultaneous structure and processes.[18]

But there are also significant properties that this brief investigation of the nondominant hand in sign language shows to be universal. The existence of features, feature classes, and processes that systematically change underlying form are linguistic universals. For example, in the model assumed here, h2 may either be represented as a member of the HC class or of the Place of Articulation class, and in each case it behaves like other members of its class in the morphophonology.[19] This indicates that languages universally organize features into classes (in the sense of Clements 1985), regardless of modality. In addition, the very fact that the surface forms of signs can differ systematically and discretely from the underlying forms, i.e., that there are phonological rules, is also universal. The present investigation has demonstrated three such rules involving h2: assimilation in compounds, coalescence and Nondominant Hand Spread. Concomitantly, we see that when words are strung together in sentences, constraints on canonical word form are relaxed. In other words, there is a distinction between lexical and post-lexical levels in both modalities.

We have also seen that the existence of underspecified or default forms is a universal property of language. The nondominant hand must share the specification of h1 in symmetrical signs; it gets its specifications by default. In signs in which h2 is a place of articulation, it may only be specified for one of a few unmarked handshapes, another form of underspecification (Sandler 1995, 1996; van der Kooij 2002).

Finally, the segmentation of the language stream into prosodic constituents that are linked to morphosyntactic constituents is universal. These constituents are marked by cues related to rhythm and prominence, and their

cohesion is often reinforced by sandhi rules that may not cross the prosodic constituent boundary.[20] The present discussion points to two such phenomena, both of them sandhi-type rules instantiated by the nondominant hand. Coalescence characterizes the phonological word constituent (host+clitic), while Nondominant Hand Spread characterizes the phonological phrase.

This investigation has three interrelated messages to convey about phonology, phonetics, and the relation between them. First, we've seen evidence that at least some phonological restrictions of sign language do not derive directly from the phonetics of that system. In the classifier subsystem and for rhetorical effect, the Symmetry and Dominance conditions are freely violated in the same language, as we saw in §2 and §3. These constraints must not be dictated solely by phonetics, but answer instead to a higher authority: the morphosyntactic entity, 'lexeme.' Second, significant aspects of phonology were shown to be common to languages in two phonetically different modalities, implying dissociation between phonetics and phonology in a different way. For example, assimilations within prosodic constituents delimit the scope of a prosodic domain that is linked to syntactic structure in both modalities – but the phonetic means recruited by spoken and signed language to achieve this end are unrelated. Third, in both modalities, there is a linguistic component, phonology, that is characterized by a relation to higher levels of grammatical structure. The sign language examples of this relation discussed here were (a) constraints in the lexicon that don't hold post-lexically (§1, §2), and (b) processes that characterize prosodic constituents linked to morphosyntax (§3).

The investigation reported here does not imply that there is no relation between phonetics and phonology, of course. Instead, it may help us be more explicit about what the relation might be. We might begin by drawing a distinction between inherent phonetic properties and phonetic organizing principles. While the former are distinct in spoken and signed language, the latter may share common ground.

Insofar as the physical and dynamic properties of specific articulators are integral to phonetics, effects that are directly related to these properties are expected to be different in the two modalities. And indeed, we see that certain assimilatory processes are instantiated simultaneously by two anatomically independent but identical articulators in sign language – an impossibility for spoken language. Both the articulatory behaviors and the physical apparatus behind them are so different in spoken and signed language that any attempt to derive the specific assimilatory behaviors found in each modality via the same mechanism seems doomed.

However, the organizing principles of phonetics may derive from a common base, a possibility with potentially interesting theoretical consequences. Cheek (2001) argues that handshape coarticulation in ASL – which she distinguishes from the handshape assimilation found in compounds – bears the following similarities to coarticulation in speech: it is gradient; it is affected by rate; and it is explained by principles of economy. A similar possibility worth investigating was raised by an anonymous reviewer: that general principles underlying rhythmic motor behavior influence assimilatory effects within prosodic constituents in both modalities. Furthermore, the claim that certain principles unify phonetics and phonology (e.g., Flemming 2001; Ohala 1990), may well be valid across modalities. For example, it is likely that phonetic coarticulation is the source of the phonological sandhi rules in both French and ISL. The present study implies that the articulatory path from one to the other cannot be the same, but the organizing principles behind them may be shared.

In sum, this investigation has highlighted some architectural similarities in the phonology and prosody of spoken and signed languages. It has done so by documenting the behavior of the nondominant hand in sign language, an articulator with no phonetic counterpart in speech.

Notes

1. The models of the nondominant hand presented in the works referred to here vary. However, there is a general consensus that the nondominant hand is not an independent articulator in the phonology of sign language.
2. A syllable is defined as one movement, either (a) along a path, (b) internally through handshape or orientation change, or (c) the two simultaneously.
3. Battison's set of unmarked shapes was larger than the one shown here. The set I assume here abstracts away from small differences in the degree of closure and spread between the fingers which are either phonologically predictable or noncontrastive (Sandler 1995, 1996).
4. In the case of symmetrical two-handed signs, the representation reflects the least marked possibility for two-handed signs: one in which only one handshape is represented.
5. So far only Cheek (2001) has done instrumental studies of coarticulation between words. See discussion in §4.
6. Not all post-lexical rules are phonetic. However, rules and constraints associated with the lexicon and word formation are assumed here to be phonological and not phonetic. See Cohn (1993) for discussion.

7. The hand configuration assimilation rule supports an additional claim about ASL phonology, namely, hierarchical representation of feature classes, in which handshape dominates orientation. The representation is motivated by the fact that orientation in compounds may assimilate alone, but if handshape assimilates, orientation must assimilate as well (Sandler 1987, 1989). Such a representation is similar in principled ways to the representation of feature classes proposed to characterize spoken language phonology (Clements 1985). This requirement breaks down post-lexically: handshape may coarticulate without orientation at that level (Corina 1993; Sandler 1993b), providing further evidence for a distinction between lexical and post-lexical levels.
8. There are some differences between the classifier systems of ASL and ISL (Aronoff et al. 2003), but they are not relevant to the analysis presented here.
9. Another difference between classifier constructions and their verbal word counterparts is that the latter may undergo aspectual inflection, while classifier constructions may not (Sandler and Lillo-Martin 2006).
10. We concluded from this and other kinds of analysis that facial expression corresponds to intonation in sign language (Nespor and Sandler 1999; Sandler 1999b; developed in Sandler and Lillo-Martin 2006).
11. This lexical-post-lexical distinction relies on Kiparsky (1982, 2000).
12. According to Selkirk (1972), the prosodic behavior of liaison is most consistent in informal registers.
13. In our data, the cues to a phonological phrase boundary – hold, reiteration or pause – were in complementary distribution, suggesting that they perform the same function, but we cannot yet predict under which conditions each will occur. The reader is referred to Nespor and Sandler (1999) for discussion of the intonational phrase markers.
14. NHS is optional, and other factors confound the tally, so that the number of clean examples in our data, though exceptionless, is small (9). However, if phonological phrase boundaries that coincide with intonational phrase boundaries are not ruled out, and are instead tallied together with the spreads that coincide only with the lower phonological phrase boundary alone, then the number of spreads that are stopped by some prosodic boundary increases greatly, reinforcing the claim that the process is discrete.
15. The neutral location for the nondominant hand in running signing is close to and in front of the body (coincidentally at a location near that specified for the sign BAKE).
16. As a 'secondary classifier', h2 depicts the ground, while the dominant hand depicts the figure (Supalla 1982). For this reason, and probably due also to motoric constraints, the dominant hand typically moves and changes configuration more than the nondominant hand in classifier sequences.

17. Simultaneity at all levels of structure is described in detail, and both the reasons and the implications connected with this kind of structuring examined, in Sandler and Lillo-Martin (2006).
18. In addition to widespread 'simultaneous' structure, there is also significant sequential structure in sign language phonology and morphology. See Liddell (1984), Liddell and Johnson (1989), Sandler (1989; Sandler 1993c), and Sandler and Lillo-Martin (2006) for specific arguments and analyses.
19. Detailed arguments for this model and for the representation of h2 either as a member of the HC class or as a member of the place of articulation class are presented in Sandler (1993a). For alternative analyses in which h2 is represented in a unitary way regardless of sign type, see van der Hulst (1996) and Brentari (1998). The models are compared in Sandler and Lillo-Martin (2006).
20. As is the case with the other properties mentioned here, the bulk of the evidence for such constituents is presented elsewhere (Nespor and Sandler 1999; Sandler 1999a, 1999b).

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