Prosodic Constraints in American Sign Language

Author(s): Diane Brentari

Proceedings of the Twentieth Annual Meeting of the Berkeley Linguistics Society: General Session Dedicated to the Contributions of Charles J. Fillmore (1994), pp. 103-112

Please see “How to cite” in the online sidebar for full citation information.

Please contact BLS regarding any further use of this work. BLS retains copyright for both print and screen forms of the publication. BLS may be contacted via <http://linguistics.berkeley.edu/bls/>.

The Annual Proceedings of the Berkeley Linguistics Society is published online via [eLanguage](#), the Linguistic Society of America's digital publishing platform.

Prosodic Constraints in American Sign Language
 Diane Brentari
 University of California - Davis

0. Introduction.

One of the central questions in the current literature on formal models of signed language phonology can be stated as the following: To what degree can models constructed for spoken language phonology accommodate signed languages? Do features, segments, timing units and syllables in signed languages function the same as their spoken language counterparts? With respect to syntax, this issue is largely irrelevant since the formal constituents have little or nothing to do with the peripheral systems in which they are expressed. A noun phrase is a noun phrase regardless of whether it is signed or spoken. If signed languages are to contribute significantly to theories of general linguistics, we expect a number of contributions to be in the area of phonology, since it is here that systems of perception and production have a prominent role.

In this paper, I present two sets of forms that raise questions about the way that the relationship between simultaneous and sequential structure in spoken language models has been adopted by sign language research. The evidence that I will present here will argue that while sequential structure plays an important role in prosodic organization in sign, the set of constraints on simultaneous structure is more robust in signed languages than in spoken languages. There is a view about sign language structure that, except for different segment and feature labels, the phonological units of signed languages are completely explicable using spoken language formalism. This is Perlmutter's (1992, 1993) view. Position segments behave like consonants, movement segments like vowels, handshapes behave like tones, and the syllable contains an internal structure completely explicable through current formalism using a moraic account (Hayes 1989) or a modified form of CV phonology (Clements and Keyser 1983). I argue against this view here. The two types of languages do share a great deal about their prosodic constraints, as we will see, but there are also important differences. It is important to feed information about these differences back into general theories of phonological structure.

This paper addresses: 1) how visual sonority in ASL interacts with timing units and weight units in the formation of syllables, 2) how these units are used in ASL to construct prosodic templates, and 3) how these templates are used both to target forms eligible for morphological processes and to constrain surface outputs of phonological forms. First, I will show how sequential timing units are used in setting a maximum on length of words, using the lexicalization of fingerspelled forms to argue that the longest monomorphemic words in ASL are disyllabic, a view which has also been argued for in Perlmutter (1992, 1993). Then I will show that the process of reduplication requires that simultaneous weight units be counted in order to identify potential input structures. The set of forms picked out for reduplication provides evidence that signed languages exploit simultaneous structure to a relatively greater degree than do spoken languages. Accounts of ASL phonology which allow simultaneous structure to play a role can be seen in my early work, and Uyechi (1994) has also proposed simultaneous prosodic templates for the minimal monomorphemic words in ASL using a similar type of argumentation.

The assumptions made in this paper are the following. First, the sonority hierarchy in (1) is assumed, which incorporates the findings made elsewhere by myself and others (Brentari 1993a, Sandler 1993, Perlmutter 1992, Corina 1990).

All of the units given in (1) can function as well-formed syllables, except partial handshape change, which has been argued to be ill-formed when occurring with no other dynamic unit (Corina 1990). Second, I assume a pressure on forms in ASL to be monosyllabic whenever possible; this was first noted in Coulter (1982). Third, features are organized into four class nodes that function as independent tiers -- movement, place of articulation, hand/arm configuration, and non-manual behaviors. Fourth, any path movement feature on the movement tier or any branching structure on any one of the tiers of place, hand/arm configuration or non-manual behaviors will have a weight unit assigned to it. These weight units have been shown elsewhere to contain the minimum amount of sonorous material to function as an independent syllable. In (2) I have listed the criteria I have developed for counting syllables in ASL (Brentari 1994), although for these analyses we only need a crude measure -- (2a) is all we need.

(1) Sonority Hierarchy in ASL (Δ =change)

mvt > full hs Δ /non-manual Δ > orient. Δ > p.o.a Δ > secondary mvt > partial hs Δ

(2) Criteria for counting the number of syllables in surface forms.

- a. The number of sequential phonological dynamic units in a string equals the number of syllables in that string.
 - i. When several shorter dynamic units co-occur with a single dynamic element of longer duration, the longer unit is the one to which the syllable refers.
 - ii. When two or more dynamic units are cotemporaneous, it counts as one syllable.
- b. If a structure is a well-formed syllable as an independent word, it must be counted as a syllable word-internally.

1.0 Lexicalization of Fingerspelled forms in ASL¹

Fingerspelling in ASL, which is the representation of English words in handshapes that depict written letters, serves many purposes. Fingerspelled forms are a part of the language, and as such should conform to constraints proposed for the phonological grammar. Fingerspelling is used when there is no ASL sign for a concept, such as in most proper names used outside of a local community of signers (for example, the town of Stockton, CA, has a sign for the name of the town, but outside of the inhabitants of the local area, no one would recognize it and so it is fingerspelled most of the time), but fingerspelling serves other functions as well. Often fingerspelled forms are used to introduce a term, the sign for the term is then given, and subsequently the sign is used. Fingerspelled forms may also be used to assign emphasis to a word that has an ASL lexical item. (For example, it would be appropriate to fingerspell the word 'home' in the following sentence if the signer is tired and is anxious to leave: WE-TWO GO H-O-M-E!). The context of the fingerspelled forms analyzed in this paper demonstrate yet another use: In specific academic disciplines, fingerspelled forms are sometimes preferred over a coined sign because they may refer to domains of knowledge whose center is

outside the Deaf community, or because they refer to a discipline-specific term that may have not undergone broad discussion within the Deaf community.

Fingerspelled forms of the discipline-specific type just described go through a rapidly occurring lexicalization process, which I will henceforth refer to as local lexicalization, whereby a fingerspelled form comes to stand not for each letter in the English word, but for the concept the word conveys; this process fixes the shape of the fingerspelled form for the duration of a single discourse. This process typically occurs over the course of just three productions. When the form appears for the first time, each letter shape is distinctly formed. By the third production however these fingerspelled forms conform closely to constraints proposed for other well-formed native signs and have achieved a stable state in which the forms will remain for the rest of the discourse. There are also fully lexicalized fingerspelled forms in ASL, such as BACK, BANK, EARLY, EASY, JOB, YES, which have been discussed elsewhere in the literature (Battison 1978, Brentari 1990b) and will not be discussed here since we no longer have access to the process of lexicalization for these forms.

A subset of the forms used for this analyses is given in (3). The formal representation of the lexicalization process I will describe is given in (4) for the form M-O-R-P-H-E-M-E. These forms are taken from a course videotape for the book Linguistics of American Sign Language (Valli & Lucas 1992); Clayton Valli is a pre-lingually deaf, fluent ASL signer, who has produced a videotape that is a summary of the contents of the written text of the book intended for linguistics students who are more comfortable with ASL than with English. Each form in the corpus was signed at least three times and as many as twelve times; however the forms were in transition only during the first three forms; after that the forms were the same during each production.

Let us explore the phonological constraints exerted during the local lexicalization process. Of the four tiers of movement, handshape, place and nonmanual behavior, these constraints take place within the handshape tier alone. They are summarized in (5); we will look at each in turn. All of these constraints can be considered processes of resyllabification.

(3) A subset of locally lexicalized fingerspelled forms from the corpus ($\emptyset$ =epenthetic dynamic element; #=word boundary)

# ltrs	1st/2nd production	3rd production	#syllables
6	S-Y-M-B-O-L	S-I-L	2
6	S-Y-N-T-A-X	S-Y- $\emptyset$ -T-X	2
8	C-U-P-B-O-A-R-D	C-P-D	2
8	L-O-C-A-T-I-O-N	[L-I]-O- $\emptyset$ -C-N	2
8	M-O-R-P-H-E-M-E	M-O- $\emptyset$ -H-E	2
9	P-H-O-N-O-L-O-G-Y	P-H-G-Y	2
10	M-O-R-P-H-O-L-O-G-Y	M[wig]P-G-Y	2
10	L-I-N-G-U-I-S-T-I-C	L-I-N-G-I-C	2
10	C-L-A-S-S-I-F-I-E-R	C-L-[I-A]-E-R	2
11	O-R-I-E-N-T-A-T-I-O-N	O-[R-I]- $\emptyset$ -C-N	2
12	I-N-C-O-R-P-O-R-A-T-I-O-N	I-N-C-O#	2
		P-[wig]-C-N	2
12	M-E-T-A-L-I-N-G-U-I-S-T-I-C	M-E- $\emptyset$ -T-A#	2
		L-I-N-G-I-C	2

(4) Resyllabification of M-O-R-P-H-E-M-E -> M-H-E (*=weight unit)

- (5) Resyllabification in locally lexicalized fingerspelled forms
- A. Disyllabic constraint on phonological words enforced
 - B. Alignment of dynamic units into disyllabic structure
 - C. Syllable peaks are chosen according to two criteria:
 - a. word final position as a site of attraction
 - b. the sonority hierarchy
 - i. wrist nod/ wrist retraction
 - ii. full handshape aperture change
 - D. Merger occurs along the following dimensions
 - a. handshape symmetry
 - b. handshapes containing the same aperture setting are reduced
 - c. long sequences of different aperture settings merge to a single instance of finger wiggling

The disyllabic constraint on phonological words is enforced in all the forms analyzed, and the use of changes in selected fingers as an index of the number of syllables argued for elsewhere in the literature (Perlmutter 1992, 1993; Brentari 1990b) is dropped. Instead, the dynamic units that involve aperture change in handshape, wrist movement, and orientation change are used to construct syllables. All forms between 6-11 original letters are reduced to two syllables in the lexicalized form, given the criteria in (2). The disyllabic constraint on lexical items has been argued in monomorphemic forms in Perlmutter (1992). Forms longer than 11 letters are then broken into two phonological words; this break is signaled by a longer pause between the last letter of the first word and the first letter of the second, plus the movement or handshape between the first and second words take on the properties of an inter-word epenthetic movement. We can determine this unit is epenthetic because the handshape change is more abrupt than word-internal handshape changes, and when this handshape co-occurs with a movement, it is more abruptly articulated with respect to the duration of the movement (Brentari, Poizner, and Kegl 1994). These epenthetic dynamic units occur word internally without the extended pause in the lexicalized forms of L-O-C-A-T-I-O-N between the 'O' and the 'C' and in S-Y-N-T-A-X between the 'Y' and the 'T.'

If a long word is to be reduced to two dynamic elements from 6 syllables in a form such as M-O-R-P-H-E-M-E in (4), how does the phonological grammar accomplish this? I propose the processes in (5B-D). Weight units, shown in (4) as '*' are aligned to a disyllabic template according to sonority considerations and the word-final site of attraction. Selected finger groups of the same aperture setting are then merged according to principles of symmetry and reduction. The sonority hierarchy proposed in (1) has been shown to operate in constructing syllable peaks in monomorphemic forms (Perlmutter 1992); all of the asterisks represent dynamic units that can function a well-formed syllables; that is, they are all higher on the sonority scale than 'partial handshape change.' This work suggests that word-final

position is a site of attraction for dynamic units in the lexicalization process in the way described by Mohanan (1993), for codas in the way that they attract processes of weakening and neutralization in spoken languages.

The distinctive aperture settings are 'fully open,' 'flat open,' 'curved open,' 'curved closed,' 'flat closed' and 'fully closed.' These distinctions can be demonstrated with the 'B' handshape. In the sign 'HI' the aperture setting is fully open; in the first handshape in BOY the aperture setting is 'flat open' and second handshape is flat closed; in CUP the aperture setting is curved open; in NUMBER it is curved closed, and in PASSPORT it is fully closed (Ann 1993, Uyechi 1994, Johnson 1994). A partial handshape change is a change of just one aperture setting; a full handshape change is a change of two aperture settings, and it has been argued that a single partial handshape change is not sonorous enough to be a well-formed syllable (Corina 1990). In M-O-R-P-H-E-M-E, the 'M' to 'O' is a partial handshape change, and so this change is ignored for purposes of syllabification, even on the first production of the form. The change from 'O' to 'R' contains a full handshape change; the change from 'R' to 'P' has a wrist nod; 'P' to 'H' has an orientation change. 'H' to 'E' has a full handshape change; 'E' to 'M' has an orientation change; and finally, 'M' to 'E' has a wrist retraction. There are six syllables in all in the first production. By the third production of this form, the full handshape change, wrist nod, and orientation change produced in the M-O-R-P-H are produced in one smooth movement, and the full handshape change, orientation change and wrist retraction produced in the H-E-M-E are produced likewise in one smooth movement. This is a typical example of the principles listed in (5B-C). The word-final dynamic unit will be included if it meets the sonority requirement, while other dynamic may be deleted. For example, the 'S' to 'F' handshape change in C-L-A-S-S-I-F-I-E-R is deleted, but the 'E' to 'R' handshape change is not, even though both are full handshape changes. In word-final position, there are also routinized sequences of those handshapes frequently used in such forms. One such sequence that appears in the corpus -- I-O-N becomes 'I' (often articulated with another letter due to merger, which will be discussed below), 'O', 'C', 'N', increasing the sonority value in the last dynamic unit by inserting a 'C' to insure a well-formed syllable between word-final 'O' and 'N'. This change from 'O' to 'N' is a partial, rather than full handshape change without the inserted 'C.'

Let us now take a few examples of the principles listed in (5D). It is clear from the M-O-R-P-H-E-M-E example that handshapes depicting some letters are eliminated, and some undergo handshape merger. The first principle is handshape symmetry. If there are handshapes with the index finger and middle finger selected (e.g., L, R, D, U, etc.), and the word contains an 'I' or 'Y' handshape which has a pinkie finger selected, these forms will be articulated simultaneously, even if they are not adjacent in the English word. The word L-O-C-A-T-I-O-N illustrates this. The 'I' is 4 letters removed from the 'L', but they are produced simultaneously in the lexicalized form. The second principle in (5D) states that adjacent handshapes which realize a partial aperture change or no aperture change will be reduced or deleted. We see this in O-R-I-E-N-T-A-T-I-O-N. The E-N-T-A-T are all produced with partial handshape changes, and by the third production of this form these are deleted. Finally, long sequences of handshapes that differ in aperture setting in word-internal position are reduced to a single instance of finger wiggling, as in the third productions of C-U-P-B-O-A-R-D, M-O-R-P-H-O-L-O-G-Y, and in the second phonological word of I-N-C-O-R-P-O-R-A-T-I-O-N.

What these forms tell us can be summed up in the following points. First, there are sequential constraints on these forms, but syllables are not formed in these

lexicalized fingerspelled words on the basis of the selected finger groups, as we might expect from the criteria developed elsewhere in the literature (Brentari 1990b; Perlmutter 1992, 1993); rather, syllables are constructed on the basis of the dynamic units of the form. Second, the alignment of the dynamic elements suggests that the principle of ALIGNMENT argued for in Optimality Theory is at work in these forms in ASL (Prince and Smolensky 1993). Third, the lexicalized forms can be described by a canonical definition of borrowing, even though the borrowing from English to ASL occurs across modalities. We see this by looking at the possible candidates for this phenomenon shown in a recent paper by Kiparsky (1993) in addressing lexical diffusion. The fact that the lexicalized fingerspelled forms occur item by item, over a very short period of time, add new words to ASL's vocabulary, and use handshapes not found in other ASL lexical items, such as the forms produced by the merger of two forms 'L' and 'T' together, establishes this point clearly.

2.0 Prosodic templates and reduplicated forms

In this section I would like to briefly discuss one way that looking at the simultaneous weight units of signs is important in constructing a morphological template for reduplication in noun-verb pairs in ASL. Reduplication has been cast in the Hold-Movement and in the Hand Tier model in segmental terms, roughly as in (6). Although the form in (6) is an LML sign SIT, the forms that undergo reduplication can consist of other segment sequences as well -- that is, single Movement segments (e.g., the pair AIRPLANE and FLY), a Movement segment and a Location (e.g., WINDOW and CLOSE-WINDOW), or a single handshape change (e.g., STAPLER and STAPLE), represented in earlier versions of the Hand Tier model as single Locations.

(6) Reduplication in the Hand Tier model (Sandler 1989) (the lower case letters represent entire feature matrices; L and M stand for Location and Movement, respectively)

The problem that arises from this segmental format is twofold: first, there is no uniform class of segmental sequences that can pick out the forms eligible for reduplication; and, second, the emphasis is on the segmental units and not what is contained in the feature bundles. It is in the feature bundles that the true structural generalization can be found. The first work on noun-verb pairs (Supalla and Newport 1978) contains an appendix of 105 noun-verb pairs. The noun verb pairs are specifically described in Supalla and Newport (1978) as 1) related in meaning, 2) containing a verb that expresses the activity performed with or on the object named by the noun. There are 37 signs in the corpus that are either bi-directional (e.g., ERASE/ERASER, TYPE/TYPEWRITER) or repeated or continuous unidirectional forms (e.g., SMOKE / CIGARETTE, COMB (as noun and verb)). These 37 forms do not employ reduplication; they do not copy anything from the stem onto the noun form, but only apply restrained movement to the existing movement of the stem to form the noun. All 68 of the forms that do undergo

reduplication of the stem to form the noun form contain one and only one dynamic parameter; that is, one simultaneous weight unit. The representation using simultaneous weight units to capture this generalization is given in (7). The sets of forms to which this process applies are given in (8).

(7) Input structure using simultaneous weight units

(8) Noun /verb pairs (from Supalla and Newport 1978)

(The verb form is the first one, the noun is second)

Reduplicated Movement

SIT/CHAIR
 GO-BY-PLANE/AIRPLANE
 GO-BY-BOAT/BOAT
 GO-BY-ROCKET/ROCKET
 GO-BY-TRAIN/TRAIN
 GO-TO-BED/BED
 PUT-ON-BRACELET/BRACELET
 CLIP-FINGERNAILS/CLIPPER
 PUT-ON-COAT/COAT
 PRESS-DOORBELL/DOORBELL
 PULL-DRAWER/DRAWER
 PUT-ON-EARRING/EARRING
 PUT-ON-GAS MASK/GAS MASK
 CLOSE-GATE/GATE
 PUT-ON-GOGGLES/GOGGLES
 HANG-UP/HANGER
 SCREW-ON-JAR LID/JAR LID
 FLICK-LIGHTER/LIGHTER
 THUMP-MELON/MELON
 SQUEEZE-PLIERS/PLIERS
 PUT-ON-RING/RING
 CUT/SCISSORS
 PUT-ON-SOCK/sock
 PUT-ON-TAPE/TAPE
 OPEN-UMBRELLA/UMBRELLA
 BLOW-WHISTLE/WHISTLE
 ZIP-UP/ZIPPER

CALL/NAME

HIT-WITH-HAMMER/HAMMER
 GO-BY-FLYING-SAUCE/FLYING-SAUCE
 GO-BY-SHIP/SHIP
 PUT-ON-BACKPACK/BACKPACK
 COVER-WITH-BLANKET/BLANKET
 PUT-ON-BROOCH/BROOCH
 PUT-ON-CLOTHESPIN/CLOTHESPIN
 OPEN-DOOR/DOOR
 TURN-DOORKNOB/DOORKNOB
 PUT-ON-DRESS/DRESS
 PUT-ON-EARPHONES/EARPHONES
 ADD-GAS-TO-TANK/GAS
 SHIFT-GEARS/GEARSHIFT
 SHOOT/GUN
 PUT-ON-HAT/HAT
 PUT-ON-HEARING-AID/HEARING-AID
 STRIKE-MATCH/MATCH
 TAKE-PILL/PILL
 PLUG-IN/PLUG
 PUT-ON-SCARF/SCARF
 TURN-SCREW/SCREWDRIVER
 PUT-ON-SUSPENDERS/SUSPENDERS
 TELEPHONE/TELEPHONE
 OPEN-WALLET/WALLET
 CLOSE-WINDOW/WINDOW

Reduplicated Handshape

SNAP-PHOTOGRAPH/CAMERA

STAPLE/STAPLER

Most of them are forms which contain a movement and no handshape change; a few contain a handshape change and no movement (e.g., SNAP-A-PICTURE (verb) vs. CAMERA (noun)). Some nominals are not formed in this way, and these are exceptions to the semantic criterion described in Supalla and Newport (1978); these are the activity nouns, such as those discussed in Padden and Perlmutter (1987) -- e.g., ACT / ACTING, CHAT / CHATTING and apply another formational process.² However, whatever the form, if it undergoes reduplication, it contains just one mora. Consider the forms in (9). The nouns are all reduplicated forms, and they all are monomoraic.

(9) Forms not meeting Supalla and Newport's semantic criteria, but which undergo reduplication to form their nominal.

a.	noun	verb	noun	verb
	SUPPORT	SUPPORT	APPLICATION	APPLY
	DEBT	OWE	ASSISTANT	ASSIST
b.	nouns only			
	CHURCH	COUGH	CUP	
	COLD	DOCTOR	NURSE	

The 68 forms from Supalla and Newport that undergo reduplication, plus the forms in (9) are forms that contain one and only one weight unit. A segmental representation can not capture this. These forms span the range of segmental representations proposed; only by counting the number or simultaneously occurring weight units can we capture the appropriate generalization. Furthermore, Perlmutter (1992, 1993) has proposed that moras in ASL are primarily units of timing. Implicit in the proposal is the claim that the phonological grammar in ASL is not sensitive to the number of weight units in a syllable, but rather, just as in spoken languages, after a specified threshold of sonority has been reached by a given feature bundle, a single mora is constructed on the timing tier. This set of reduplicated forms shows that moraic units are not counted on the basis of some threshold of sonority, but instead maintain their individual identity as simultaneously occurring weight units that are visible to the morphology.

3.0 Conclusion

These two sets of forms have demonstrated that both sequential and simultaneous constraints operate on sign structure. The sequential constraints, such as those seen in the lexicalized fingerspelled forms, look very similar to those found in spoken languages. The simultaneous constraints found in the reduplicated forms are less common in spoken languages, yet these are important for sign. This separation of timing units from weight units is necessary if we are to understand sign structure.

To conclude, we have seen two sets of forms that are not monosyllabic -- lexicalized fingerspelled forms and reduplicated forms. The lexicalized fingerspelled forms conform to the constraints of monomorphemic forms: namely, they must not exceed two syllables in length. The reduplicated forms are disyllabic as well, but exhibit a different kind of constraint, one that scans input forms for the number of weight units contained in the input structure. These two sets of forms show that by uncovering the violations of the tendency towards monosyllabicity and describing these exceptions in terms of simultaneous and sequential structure,

we may be able to make better predictions about where polysyllabic words in ASL will occur.

FOOTNOTES

¹This section is part of a longer joint project on fingerspelling done in collaboration with Robert Johnson of Gallaudet University.

²Another possible source of exceptions to this generalization come from nouns whose stems are adjectival forms -- OLD / AGE; POOR / POVERTY. However, in consulting native informants, these forms do not undergo reduplication.

REFERENCES

- Ann, Jean. 1993. Ease of articulation of handshapes. Paper presented at the Workshop on Sign Language Phonology and Morphology. Amsterdam, Netherlands.
- Battison, Robbin. 1978. Lexical borrowing in American Sign Language. Silver Spring, MD: Linstok Press.
- Brentari, Diane. 1994. Prosodic Structure in American Sign Language. in preparation.
- Brentari, Diane. 1993a. Establishing a sonority Hierarchy in American Sign Language: The use of simultaneous structure in phonology. *Phonology* 10(2). 281-306.
- Brentari, Diane. 1993b. Secondary movement and sonority: Formal representation and phonetic realization. Paper presented at the Workshop on morphology and phonology of signed languages. Amsterdam, The Netherlands.
- Brentari, Diane. 1990a. Theoretical Foundations of American Sign Language. Chicago, IL: University of Chicago dissertation.
- Brentari, Diane. 1990b. Licensing in ASL handshape change. *Sign Language Research: Theoretical Issues*, edited by Ceil Lucas, 57-68. Washington, DC: Gallaudet University Press
- Brentari, Diane, Howard Poizner, and Judy Kegl. 1994. Aphasic and Parkinsonian signing: Differences in phonological disruption. *Brain and Language*. (in press.)
- Clements, G. Nick, and Jay Keyser. 1983. C-V Phonology. A generative theory of the syllable. Cambridge, MA: MIT Press.
- Corina, David. 1990. Reassessing the role of sonority in syllable structure: Evidence from a visual gestural language. *CLS* 26(20).33-44. Chicago: Chicago Linguistic Society.
- Coulter, Geoffrey. 1982. On the nature of ASL as a monosyllabic language. Paper presented at the annual meeting of the Linguistic Society of America. San Diego, CA.
- Hayes, Bruce. 1989. Compensatory lengthening in moraic phonology. *Linguistic Inquiry* 20.253-306.
- Johnson, Robert E. 1994. Handshape features in American Sign Language. Washington, DC: Gallaudet University. ms.
- Kiparsky, Paul. 1993. The phonological basis of sound change. Paper presented at the Stanford Workshop on Sound Change.

- Liddell, Scott. 1990. Structures for representing handshape and local movement at the phonemic Level. *Theoretical issues in sign language research*, vol. 2, edited by Susan Fischer and Patricia Siple, 37-65. Chicago: University of Chicago Press.
- Liddell, Scott and Robert Johnson. 1989. American Sign Language: The phonological base. *Sign Language Studies* 64.197-277.
- Mohanan, K.P. 1993. Fields of attraction in phonology. *The Last Phonological Rule*, edited by John Goldsmith, 61-116. Chicago: University of Chicago Press.
- Padden, Carol. and David Perlmutter. 1987. American Sign Language and the architecture of phonological theory. *Natural Language and Linguistic Theory* 5.335-375.
- Perlmutter, David M. 1993. Sonority and Syllable Structure in American Sign Language. *Phonetics and Phonology*, vol. 3: *Current Issues in American Sign Language Phonology*, edited by Geoffrey Coulter, 227-262. New York: Academic Press.
- Perlmutter, David M. 1992. Sonority and syllable structure in American Sign Language. *Linguistic Inquiry* 23(3).407-442.
- Prince, Alan. and Paul Smolensky. 1993. *Optimality Theory*. ms
- Sandler, Wendy. 1993. A sonority cycle in American Sign Language. *Phonology* 10(2).243-279.
- Sandler, Wendy. 1989. *Phonological representation of the sign*. Dordrecht: Foris.
- Stack, Kelly. 1988. *Tiers and syllable structure: Evidence from phonotactics*. Los Angeles, CA: University of California ms.
- Supalla, Ted. and Elissa Newport. 1978. How Many Seats in a Chair? The derivation of nouns and verbs in American Sign Language. In P. Siple (ed) *Understanding Language Through Sign Language Research*, edited by Patricia Siple, 91-133. New York: Academic Press.
- Uyechi, Linda. 1994. Wiggling and circling as movement in American Sign Language. Paper presented at the annual meeting of the Linguistic Society of America.
- Valli, Clayton and Ceil Lucas. 1992. *The Linguistic Structure of American Sign Language*. Washington, DC: Gallaudet University Press.