A constraint-based analysis
of compound formation in the sign modality

1. Introduction

In this paper a new analysis of the phonological process of reduction and assimilation, prevalent in American Sign Language (ASL) compound formation, is presented. Phonological processes of compound formation are relatively well-researched in the sign language phonology literature. For example, it has been shown that the formation of compounds is a productive, grammatical process very similar to that found in many spoken languages (Klima & Bellugi 1979). Also, previous analyses have found that particular features of the root morphemes of the compound, features such as contact with the body, are resistant to deletion while others, such as shape of the hand, are much more malleable (Liddell & Johnson 1986; Sandler 1989). Using an Optimality Theoretic framework (Prince & Smolensky 1993), I re-interpret these observations as constraints and show that their appropriate rankings and interactions make accurate predictions about the forms of compounds which were missed by previous, rule-based analyses.

In the process of compound formation the root morphemes which make up the compound are phonologically altered in relatively consistent and predictable ways such that the resulting compound adheres to the phonological patterns of words in the lexicon. For example, the sign THINK (fig.0) can be said to consist of three segments, LML. The hand begins in a particular shape, at an initial location (L₁) a few centimeters from the forehead. Then a short path movement (M) takes the hand from this location to a final location (L₂) in contact with the forehead, all the while leaving the shape or configuration of the hand intact. The sign SELF can be represented similarly with segments also coming together to form this LML templatic shape. The compound resulting from the conflation of these two words also consists of an initial location, a path movement, and a second location, but unlike the signs THINK and SELF, it also exhibits a change between the hand shape of the first and second locations. It is then evident that some segments from each root morpheme were retained at least in part in the final compound, while others were lost. In addition, the thumb involved in the handshape of the sign SELF appears, or regressively assimilates, to THINK's handshape.
It is these phonological alternations which have often provided key, foundational evidence for the majority of the proposed theoretical frameworks for ASL phonology, including Liddell and Johnson's MH model (Liddell 1984; Liddell and Johnson 1985, 1986), Sandler's HT model (1987, 1989), Brentari's prosodic model (1998) and Uyechi's Visual Phonology (Uyechi 1993; 1996). Despite the focus that this phenomenon has received, our understanding of the phonological systematicity involved has not increased correspondingly. Analyses of the phenomenon often lack the capability to accurately predict which movements and locations will be retained in novel compound forms or lack generalizability to a larger set of compound types, including those which do not reduce as efficiently as does THINK^SELF. In part, this is because a typical approach has been to analyze compound forms in the hope that the results of the analysis will generalize to other morphological processes or similar domains of the lexicon. Yet, this approach has led to the creation of general rules which often require phenomenon-specific exceptions for where they fail to apply even in the domain of compound formation. Recently, more appealing alternative approaches such as that in Uyechi (1993) have analyzed compound formation processes by first examining the general pattern of the lexicon, deriving a set of properties specific to grammatical words, and then analyzing compound forms by examining their adherence to those properties. However, this rule based approach continues to rely on domain-specific application of rule blocking which leads to false predictions.

The constraint-based framework Optimality Theory (OT), on the other hand, provides a useful tool with which to formalize this recent type of approach. This is because these general observations made regarding the phonological system of ASL and other sign languages, observations such as the resistance to deletion of body contact or the restricted typology of handshape changes, can be analyzed as universal and violable constraints. These constraints' violability through their interactions can then be shown to make accurate predictions, such as for cases where reductions fail to occur.

I propose such an analysis in which the reduction and assimilation noted in compounds results from the interaction of four crucial constraints, all founded on observations made in previous analyses regarding the set of grammatical forms in the lexicon. As this new analysis partly relies on the theoretical foundations of preceding work, in the next section I summarize those observations as they pertain to this analysis of compound formation. I subsequently present a necessary set of the relevant data and then show that the phonological process of reduction prevalent in compound formation is analyzable as a process driven by a constraint MONOSYL which is violated by word forms that stray from a preferred templatic, monosyllabic shape. In cases where MONOSYL is violated, two more highly ranked constraints
play a role in blocking the reduction as well as determining which segments will be retained in the surface form of compounds: M\text{axContact}, a constraint on the deletion of segments which make contact with the body, and M\text{axHs}_\Delta, a constraint on the deletion of morpheme-internal handshape change within a lexeme. Similarly, I show that the total or partial assimilation of handshape is driven by either a constraint on phonologically licensed handshape changes over a syllable, S\text{pecFinger}, or the necessity to retain handshape changes from an input sign as required by M\text{axHs}_\Delta. The appropriate rankings and the interactions of these constraints accurately predict the surface forms of compounds which have not been accounted for by previous analyses. Finally, I will present some processes of compound formation not addressed by the current or previous analyses and suggest further areas of research required to achieve a comprehensive account of the phonological processes of compound formation.

2. Sign Language Phonology: A short overview of the relevant models

The field of sign language linguistics, now almost a half-century old, germinated from some basic observations of the sub-lexical components of signs (Stokoe 1960). These four originally proposed components were:

a) \textit{Handshape}: The configuration of the hand and fingers during articulation. Often referred to by the numbers and letters they represent in the language and the manual alphabet (fig.1).

b) \textit{Location}: The major body area in which the full sign is articulated. The majority of signs are confined to one general location on or near the head, the chest, the other arm or hand, or in neutral space.

c) \textit{Movement}: The manner in which the hand moves during articulation. The most common movement type is a \textit{path movement} in which the hand simply moves from one location to another, typically in a straight or arced path (fig.2). The second common type is an \textit{internal movement} in which the hand remains in one location, but a single change in handshape occurs (fig.3) or is reduplicated\textsuperscript{1}.

\textsuperscript{1} Some theoretical frameworks classify movement in repeated signs such as NIGHT in figure 5 as internal movement, others, as path movement. This distinction will be discussed further in section 3.
d) Orientation: The orientation of the palm, typically with respect to the body.

With the use of these 'phonemes', the ASL sign DEAF (fig.2) would be classified by the parameters presented in (1):

(1) HS: 1
L: Head/Cheek:Chin
M: (path) Arc/Downward
Or: Away

These four basic, and independently meaningless units, when combined, produce all signs in the lexicon of not only ASL but of all the established sign languages in the world. It was this simple observation, that signs are not holistic gestures, which instigated a minor revolution in the methodology of sign language research. Although many of the original formalisms were eventually modified or even abandoned, Stokoe's analysis was an essential step which led to several discoveries in the field, the majority of which revealed the important similarities and differences between the spoken and signed modalities and thereby increased our knowledge of the structures of natural human language.

Eventually, as the theoretical formalisms developed, more comprehensive methods for discussing and analyzing sign language phonological processes emerged. These methods were the result of several important observations. One was the sequential ordering of segments, which provided evidence that sign language may have a syllable-like timing unit similar to that of spoken language (Chinchor 1978; Newkirk 1998; Liddell 1984b). Another observation involved constraints on the non-dominant hand (Battison 1978), typically the left hand for a right-handed signer, which is an articulator that plays a role in two-handed signs either as a location for, or an articulating copy of the dominant articulator.

2.1 Phonological frameworks: The Move-Hold Model

In the formation of Liddell and Johnson's (L&J) theoretical model of sign language phonology, the Move-Hold (MH) model (Liddell 1984; L&J 1985;1986), the structural assumptions of Stokoe (1960) and Battison (1978), which divided signs into four independent features, were dissected and altered in
order to represent the sequentiality of combinations of segments. L&J observed that the basic structure of the sign could be decomposed into a series of Moves (M) and Holds (H). Each of these M and H segments are specified with at least nine features ranging from point of contact to hand configuration to body proximity.

For example, as we saw in the signs THINK and SELF, the sign DEAF (fig.2) would be represented as an H₁MH₂ series of segments. The first H₁ segment consists of the hand configuration '1' with outward orientation, contact by the index finger at the lower cheek, etc. The M segment, representing the movement, has many of the same features as the preceding H₁ segment since, for example, there is no hand shape change. However, the hand does not come into contact with the body during the movement so the “proximity to body” feature would differ. An additional movement type feature is attributed to the M segment types only. In the case of DEAF, this feature is 'arc' to represent the curved movement which takes the articulator from its first location to the second location, H₂. The H₂ segment also carries many of the same features as H₁. However, its point of contact has changed to the chin and its orientation has also shifted laterally.

The structural configuration of DEAF is represented as in figure 4. In this type of representation, each segment was linked to an array or 'bundle' of the nine features. Those segments and features were then linked together into groups of segments. With these segment groups derived for the MH model, L&J first formalized a notion of the sign language syllable by interpreting the H and M segments as playing roles equivalent to C's and Vs of spoken languages. In this system, syllable types could be of the forms HM, MH, or HMH. Within this model, the overwhelming majority of signs in ASL were shown to be monosyllabic, however a large class of these consisted of quick, repeated movements, such as seen in NIGHT (fig.5). These were classified as bisyllabic in this framework, consisting of the segments MH₁MH₁.

This formalism allowed the first detailed, rule-based analyses of phonological processes in ASL. Stokoe's framework had less to say about the evidence from morphological processes such as compound formation or aspectual marking, which involved the deletion or epenthesis of movements, or the deletion or reduplication of what were now considered syllables. Though many of the assumptions of the MH model became crucial in the
development of sign language phonology, many of its problems inspired new models to be developed.

One of the major issues of contention was the redundancy of the feature bundle representation. The vast majority of signs show little or no feature changes from segment to segment, yet the cumbersome representation required each feature to be specified. As a result, the model ignored evidence that subgroups of these features often changed in unison and there appeared to be a hierarchical relationship to some feature groups such that change in some feature X always accompanies a change of feature Y though a change of feature Y does not necessarily imply a change in feature X.

Another problem involved the choice of representational segments for individual signs. The phonetic reality of some H and M segments, which are expected to be surface representations, was called into question since little empirical evidence was involved in assigning such segments to individual signs. For example, the HMH shape of the sign DEAF is visually reinforced by the contact to the body at the beginning and end of the sign, providing some concrete, surface reality to the H segments. But it is less clear how to represent signs which occur in neutral space, whose H segments don't contact the body, such as DROP (fig.6). If an H segment is to be defined by some temporal pause as suggested, then DROP is likely to have the representation MH. Yet the rampant deletion of such pauses in natural speech or their absence even in some citation forms, especially in signs articulated in neutral space, have led some researchers to posit these H segments as underlying and appearing in the surface as articulated pauses only in specific contexts (Perlmutter 1989; Sandler 1989). Similarly, the MHMH type of representation used for reduplicated movements in signs such as NIGHT (fig.5) have little or no temporal pause in the first H segment. Perlmutter (1990) convincingly argues that the M segment of many of these reduplicated signs should not be represented in the underlying form but should instead be considered transitional movements appearing only in the surface form. Thus an alternative representation for the majority of these reduplicated forms is that of a geminate segment, a position taken in some of the models which were to follow.

2.2 Phonological frameworks: The Hand-Tier Model

Using the MH model as a starting point, Sandler (1987, 1989) developed a new system for representing signs. The Hand-Tier (HT) model, as it was to be named, retains assumptions of segmentation, the syllabic frame, as well as some of the nine basic features from the MH model.
However, it differs in some key assumptions.

First, H segments are replaced with a location segment, L. These segments are meant to represent the beginning and ending points of a sign. Thus a syllable or a sign such as THINK (fig.0) or DROP (fig.6), which involve a path movement, are represented by the templatic shape LML. Signs with internal movements such as UNDERSTAND (fig.3), for which the beginning and end location do not change, have the templatic shape L. Reduplicated signs such as NIGHT (fig.5) are represented as geminates of shape LL as suggested by Perlmutter (1990). In this model, all syllables are of the form LML or L making DROP and UNDERSTAND monosyllabic morphemes and NIGHT a bisyllabic morpheme.

Second, the HT model foregrounds Stokoe's original three features of Handshape, Orientation, and Movement but, borrowing elements of Auto-segmental phonology, reorganizes and reinstates them as categories on separate tiers of representation. These categories are further refined by the features developed for the HT model and borrowed from the MH model. This strategy of separating features into inter-related hierarchical bundles rather than in a single array, serves three purposes.

First, it represents the hierarchical relationship between some features. This is crucial for the features of Handshape and Orientation. Sandler (1989) found that in instances of progressive or regressive handshape assimilation, specifically in compound forms, if Handshape is assimilated then Orientation must also be assimilated. However, in some instances of assimilation, only orientation assimilates while the handshape does not. There is no physiological or phonetic reason for this dependency, as the orientation feature can be changed independently of the handshape and vice versa in other words of ASL. Sandler takes this as evidence for a hierarchical organization in words of ASL between these features subsequently applying it to the model.

Second, it avoids the redundancy suffered by the MH model such that the retention of particular features like handshape across a sign for which no handshape changes occur (a sign such as DEAF fig.2), does not require duplicate representation across segments. Rather, a single Hand Configuration can be linked to both the initial and final L segments. This method allows signs consisting of the two syllable types LML and L, to share a single schematic representation, differing only in their tier linking pattern. On the other hand, signs which exhibit a change only in one of these categories can be minimally represented exactly so. For example, the sign UNDERSTAND (fig.3), consists of an internal movement rather than a path movement. Internal movements are often characterized by a change in handshape. UNDERSTAND
consists of an initially 'closed 1' handshape followed by an 'open 1' handshape (as represented on the aperture tier in figure 7). The aperture tier, being a sub-component of the Hand Configuration tier, can represent this handshape change without the need for any additional segments, unlike the strategy required in the MH model. An added benefit of such a representation is that it incorporates the relative importance of the sign's features. For example, if a sign exhibits no change in aperture, then the aperture tier remains empty or unspecified. If, however, an aperture change is specified, it is its representation which can be said to be resistant to deletion in a phonological process such the reduction of compounds.

Third, this model accurately encapsulates the constrained typology of handshape changes in the ASL lexicon. The most common is a change in aperture as seen above. This change can be characterized as one between a closed fist or 'S' handshape to some more specified handshape such as the 'Y' or '1' handshapes (see fig.1) as typified by the change seen in UNDERSTAND (fig.3). Similarly, the handshape can change from an open hand or 'B' handshape to a more specified handshape such as 'Y' or '1', or from a specified handshape to an open or closed handshape. The only instances of syllable-internal handshape changes which do not follow this pattern of closed to specified, specified to closed, etc. are compound forms which sometimes allow handshape changes such as '1' to 'Y', in which a completely different set of fingers is used in each of the two contrasting handshapes. The former observation, that aperture is the most common type of handshape change, played a role in Mandel's (1981) development of a constraint on possible handshape changes which limits the number of 'selected fingers' in a word.

This notion of selected fingers comes from the general observation that, for each handshape in which the fingers are not joined in unison as in a fist or open hand, a very specific subset of the five fingers will be prominent. For example, in the '1' handshape, the index finger plays this prominent role, in the 'Y' handshape it is the pinky and thumb, and in the '8' handshape it is the middle finger and thumb. This is

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4 The representation in figure 7 is a simplified version of the full representation which would include, among other elements, a separate 'Place' tier and 'Feature' tier.
formalized in the HT model by representing, or specifying, any selected fingers as a linked feature in the Hand Configuration tier. In creating this representation, Sandler observed that compounds are the basic exception to Mandel's constraint, and this influenced the modification of this constraint, applying it to morphemes rather than words. The HT model's application of an aperture tier which is dominated by, but independent from, a hand configuration tier also helps capture this limited range of possible handshape changes attested.

The basic assumptions articulated in Sandler (1987, 1989) and further developed in Sandler and Lillo-Martin (2006) serve an analysis of compounds remarkably well. As I show in the next section, the syllabic template originating with the MH model and later modified by the HT model proves to be useful in predicting the forms of compounds which arise from signs of various syllabic shapes. Furthermore, the representational system of the HT model provides an accurate formalism with which to explain important generalizations of handshape change.

3 Compound Formation

Compounding is a prevalent word formation strategy in sign languages as it is in many spoken languages. This process involves two independent 'root' signs combining to form a new sign. Klima and Bellugi (1979) (K&B) and Bellugi and Newkirk (1981) showed that compound formation in ASL is a productive, grammatical process which establishes the compound as a lexical item independent of the root morphemes from which it is derived. To do this they provide evidence that:

a) a compound is an indivisible and un-interruptible unit
   • in English - Large Blackboard vs *Blacklargeboard
b) it can undergo grammatical operations that extend over single words but not over phrases
   • in English – Inflectional modulation of Adjective as in Darkroom, darkroomish, *darkishroom
c) a root sign of a compound cannot serve as a constituent in a syntactic construction’

(K&B1979:206)

K&B found that the articulation time for the compound forms showed a consistent decrease (i.e. the length of the compound was significantly shorter) compared to the non-compound phrase of the two morphemes from which it is derived. In order to test whether these reductions were due to a grammatical process, and not some kind of time pressure, they ran studies in which they either directed signers to sign each sentence slowly and carefully or had signers communicate across long distances, forcing the

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5 No clear English analogue exists to this phenomenon.
interlocutors to “shout,” which causes the signer to increase the length of the movement and slows the speed of the sign. The temporal differences between compounds and phrases persisted in both additional studies.

The relevant crucial findings of K&B, which closely resemble the process of “assimilation and fluidity” found in the diachronic changes of compounds by Frishberg (1975), suggested that the observed reduction of the root morphemes as they combine to form the compound is propelled by one or more of the following strategies:

(2) a) Reduction of a pause in the L segment
b) Shortening or loss of movement in one of the root signs
c) Deletion of a root morpheme’s reduplication (most commonly the first root sign)
d) Reduction in transitional movement between the two signs

Some of the strategies in (2) are prevalent in a prototypical compound form such as THINK^SELF→THINK-FOR-ONE’S-SELF presented in figure 8. In this compound we see that the second location of the first root THINK is the only segment maintained from that root. An additional, transitional movement is incorporated from this location and merged with the M segment of the second root, SELF, ending at the same final location as that root. The resulting compound is therefore reduced to the form LML. Although discussed in little detail in K&B (1979), though mentioned in the historical data by Frishberg (1975), in this compound we also notice partial regressive handshape assimilation where the selection of the thumb from the second root morpheme SELF appears in the first root morpheme THINK.

In the following sub-sections I will expound the orthographic representational system used in the analysis and apply it to further examples of compounds in ASL, thus presenting the descriptive generalizations

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6 Here I use terminology established a decade later by Sandler (1987, 1989) to summarize K&B’s results.
which have played a role in analysis of compound formation since L&J (1986).

3.1 A note regarding the orthographic representation used herein

In the analysis presented below I will apply the HT segment representation of syllabic frames (LML and L) along with my own system of subscripting to orthographically represent the processes involved. All root morphemes which play a role in the process of compound formation are monosyllabic LML or L shaped morphemes or bisyllabic geminates, LL. An LML shaped monosyllabic sign which is the first root morpheme of a compound will be represented as $L_1M_A L_2$. The first subscript 'I' represents the order of the segment in the input as well as the handshape which is associated with that segment. The subscript letter 'A' represents the movement and features associated with the M segment of the first sign. The bold type-face seen in the segment $L_2$ represents the feature of body contact linked to the segment. A second LML shaped root morpheme which joins with another LML shaped root to form the compound will be represented as $L_3M_B L_4$. A sign which is reduplicated, such as NIGHT (fig.5), would then be represented as $LL_4$ if it is the first root morpheme. Similarly, a sign consisting of an L syllable, such as UNDERSTAND, would be represented as $L_4$ if in first position. Here the underscore represents a handshape change.

With this system, the compound THINK-FOR-ONE’S-SELF will be represented as in (3):

(3) THINK-FOR-ONE’S-SELF representation:

<table>
<thead>
<tr>
<th>THINK</th>
<th>SELF</th>
<th>THINK^SELF</th>
</tr>
</thead>
<tbody>
<tr>
<td>$L_1M_A L_2$</td>
<td>$L_3M_B L_4$</td>
<td>$L_23M_{TB}L_4$</td>
</tr>
</tbody>
</table>

The subscripts '23' in the first segment of the compound ($L_{23}$) represent the appearance of the handshape from SELF’s first segment ($L_3$) to the second segment of the sign THINK ($L_2$). The subscripts 'TB' on the compound’s movement ($M_{TB}$) represent the merging of a transitional movement ($M_t$) from the first location, to the location in neutral space of SELF’s movement segment ($M_B$). Such merges are only possible if the path type and directionality features of the M segment in the input are shared by the transitional movement. To represent total assimilation of handshape an additional subscript '#' will be used. If the root morpheme has two handshapes, it is assumed that the handshape assimilated is 'closest' temporally (as ordered). For example, if handshape assimilation is regressive then it is the handshape of

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7 In such an instance, a following LML shaped sign would have the representation $L_2M_A L_3$. If the geminate appears in second position with an LML shaped sign in first, it would be represented as $LL_1$. 
the first segment of the second root morpheme which is assimilated. This assumption is made on the basis that no compound which violates it has been attested in ASL.

3.2 More examples of compounds

The compound THINK^SELF is prototypical in that it surfaces as a monosyllable by the HT definition. The majority of compounds, both those that have developed diachronically or those that are spontaneously created as needed, such as the sign GENETIC-ENGINEERING (appendix fig.A), enter the lexicon as monosyllables. In this way, they share a general feature of the lexicon. At the time of K&B's analysis, the notion of syllable for sign languages was less than a year old and a formal definition was not available until Liddell's (1984) proposal. The observations summarized in (2) were simply the best formalization available at the time to describe this process of reduction. However, not all compounds reduce as THINK^SELF does. An example of one such compound is presented in figure 9.

In accordance with K&B's observations in (2), BLACK^NAME→BAD-REPUTATION exhibits a loss of reduplication in the second root morpheme NAME (LL₃→L₃). It is not clear whether this sign exhibits partial handshape assimilation because the two signs' handshapes differ by only one selected finger. However, regressive assimilation of NAME's handshape may be blocked by the resulting compound's homophony to a variant of the word CHRISTIAN. The sign BLACK (L₁M₃L₂), made with the finger of the 'I' handshape brushing the forehead as it moves from the first location to the second, surfaces with no reductions to its underlying form. The resulting compound is thus bisyllabic having the surface form L₁M₃L₂+M₁+L₃.

(4) BAD-REPUTATION representation:

<table>
<thead>
<tr>
<th>BLACK</th>
<th>NAME</th>
<th>BAD-REPUTATION</th>
</tr>
</thead>
<tbody>
<tr>
<td>L₁M₃L₂</td>
<td>LL₃</td>
<td>L₁M₃L₂+M₁+L₃</td>
</tr>
</tbody>
</table>

I suggest that the reason for the lack of reduction is the resistance to deletion of the body contact feature of BLACK's M segment. This contact to parts of the body is an important feature in the phonological system of sign languages. One of the critical observations used by L&J (1986) in the form of a
compound-specific phonological rule is that segments which make contact with the body are preserved in the surface form of compounds. This observation also plays a critical role in the compound formation analysis in Uyechi (1993). However, by applying their rule only to contact of H segments with the head and body L&J do not appeal to the general importance of contact evident in M segments as well. Similarly contact with the non-dominant hand is also crucially retained in surface forms. With this limitation, the rules posited for the MH model or the HT model do not make any predictions for the surface form of compounds like SICK^SPREAD→EPIDEMIC (fig.11) or GOOD^ENOUGH→BARELY-ADEQUATE (appendix fig.E).

The compound MIND^DROP→FAINT (fig.10) presents a typical case of total regressive assimilation. Here, the initial handshape of the second root morpheme DROP (L3M3L4) regressively assimilates to the reduced sign MIND (L1M1L2→L2), a homophone\(^8\) of THINK previously seen in the compound THINK^SELF (fig.8). FAINT surfaces as a monosyllable represented as \(L_{23}M_{12}L_{4}\).

\[\begin{array}{ccc}
\text{MIND} & \text{DROP} & \text{FAINT} \\
L_{1}M_{1}L_{2} & L_{3}M_{3}L_{4} & L_{23}M_{12}L_{4}
\end{array}\]

To the best of my knowledge, previous research has not provided a complete explanatory or predictive account for the absence or appearance of assimilation in compounds. However, a generalization which lends itself well to an OT analysis can be made: Many of the compounds which exhibit assimilation like that seen in FAINT, are composed with a root morpheme that exhibits a handshape change. This change, which appears to be an information-heavy\(^9\) component of the root sign, is resistant to deletion and competes with the drive toward reduction to create surface forms such as these seen in FAINT. The importance of sign internal handshape changes has been noted previously as it played a role in

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\(^8\) It is not clear whether this should be treated as a homophone or as the same lexical item with respect to the compound.

\(^9\) By which I mean that the contrasting handshapes of the two locations provide a key perceptive clue to the meaning as the handshape change is a marked component of the sign.
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formulating the aperture tier in the HT model. Therefore, a constraint which is violated by the loss of such a handshape change will be proposed in the analysis presented here. However, not all assimilation is driven by root morpheme handshape change. A larger group of compounds, those similar to THINK^SELF (fig.8) or THINK^MARRY→BELIEVE (appendix fig 1), which may contain total or partial assimilation, are instead driven to assimilate by the previously discussed constraint first proposed in Mandel (1981). That constraint resists signs in which the handshape change within a word is complicated by the 'selection' of different sets of fingers in the initial and final handshapes.

The compound “EPIDEMIC”, like BAD-REPUTATION, also fails to surface as a monosyllable. In this compound, the sign SICK (LL₁), commonly a two-handed sign made with an 'open 8' handshape contacting the forehead and chest (first frame of fig.11), consists of a reduplicated movement similar to that seen in NAME. The sign SPREAD (L₂M₃L₃) begins with both hands in a closed, 'O' handshape in contact with one another and ending in an open handshape, apart, and further away from the body. The compound has the surface form L₁+M₁+L₂M₃L₃. I propose that the monosyllabic form here is blocked by a combination of constraints involving retention of both the handshape change and body contact of the sign SPREAD.

(5) EPIDEMIC representation:

<table>
<thead>
<tr>
<th>SICK</th>
<th>SPREAD</th>
<th>EPIDEMIC</th>
</tr>
</thead>
<tbody>
<tr>
<td>LL₁</td>
<td>L₂M₃L₃</td>
<td>L₁+M₁+L₂M₃L₃</td>
</tr>
</tbody>
</table>

One compound which has caused problems for a previous analysis is RESEMBLE (fig 12). The sign FACE (L₁M₃L₁), made with the '1' handshape beginning close to the face¹⁰ followed by a circular movement¹¹ which traces the outline of the face and returns the hand

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¹⁰ Some variants of the sign begin near the chin, others near the nose.

¹¹ The diameter of this movement is quite variable as the movement can be preformed at the knuckle joint, the wrist, or the elbow and is possibly dependent on phonetic, prosodic, or meta-linguistic factors. For more information, see the
to the same location it began, is reduced to a single segment L₁. A transitional movement takes the hand from this location to ALIKE's location in neutral space. The second morpheme, ALIKE (L₂ or LL₂)₁², surfaces in the compound with an optionally wiggled 'Y' handshape preformed simultaneously with the transitional movement. The resulting compound's monosyllabic form is L₁+M_{T(2)}+L₂₁³. This sign exhibits partial assimilation of the kind previously seen in THINK^SELF, proposed in this analysis to be driven by the lexically 'disallowed' contrasting finger selection of the '1' and 'Y' handshapes.

(6) RESEMBLE representation:

<table>
<thead>
<tr>
<th>FACE</th>
<th>SAME</th>
<th>RESEMBLE</th>
</tr>
</thead>
<tbody>
<tr>
<td>L₁M₁A₁L₁</td>
<td>(L)L₂</td>
<td>L₁+M_{T(2)}+L₂</td>
</tr>
</tbody>
</table>

In the next section I will present a summary of motivations, resulting from the data presented here and in previous literature, for the validity of four crucial constraints which play roles, not only in the phonological processes relevant to compound formation, but which shape the lexicon of ASL as well as other sign languages. I will then show how the interaction of these constraints account for surface forms of the vast majority of compounds analyzed in this and previous works.

4. A constraint-based approach to compound formation

It has been suggested that the variability found in surface forms described above might benefit from analysis via a constraint-based framework in which global tendencies are motivated by specific constraints while surface differences are modeled by the competition and ultimate violation of those constraints in specific phonological contexts (Brentari 1998; Sandler 1999; Sandler & Lillo-Martin 2006). Incorporating the relevant discoveries of preceding models, the following analysis attempts to simplify those observations using just such an approach.

4.1 Phonological constraints playing a role in shaping the lexicon

At least as early as Stokoe (1960) it has been noted that the majority of signs in the lexicon consist of a single path or internal movement. In the HT model these are represented by the templates


12 In one variant of this sign, made in neutral space in front of the body, there is only Internal Movement produced by a simple wiggle resulting from twisting the wrist back and forth in quick succession (L). A more common variant actually involves movement at the elbow which shakes the hand from left to right more closely resembling geminate forms such as NAME (LL).

13 The subscript (2) represents the optional wiggle sometimes apparent in the sign's movement.
LML and L, respectively. This preference for a single movement template appears to be a cross-linguistic phenomenon in the sign modality and it has supported one of the main arguments for assigning a syllable-like timing unit to this canonical shape (Chinchor 1978; Liddell 1984; Wilbur 1990; Brentari 1998:6; Sandler & Lillo-Martin 2006: 228-229). More notable is the fact that this LML shape, as defined in the HT model, is expressed in the surface form of even morphologically complex signs such as verbs with both aspectual and agreement markers. Although some of the most recently developed models, most notably Uyechi's (1993, 1996) visual phonology and Brentari's (1998) prosodic models, reject this template as a structural definition of the syllable or timing unit the alternatives they propose construct a surface equivalent generalization that the majority of signs can be grouped into this general “monosyllabic” class.

The universality of this phenomenon and its effects in grammatical processes such as compound formation, verb morphology, or negative incorporation (described in Woodward 1974) is strong evidence for its status as a markedness constraint in Optimality Theory (Sandler 1999; Sandler & Lillo-Martin 2006:231). In the following analysis I utilize exactly such a constraint to show that its appropriate ranking and interaction with other constraints drive the reductions noted in the historical data by Frishberg (1975) and modern data by K&B (1979) of compound surface forms. This constraint is defined as in (7).

(7) **MONOSYL**: words must consist of single syllables of the templatic shapes 'LML' or 'L' (defined by Sandler, 1989)

A second candidate for constraint status comes from the observation made in the preceding section, as well as much of the literature, that segments which feature contact with the body are always preserved in the surface forms of compounds. Beside being formulated in some fashion in all preceding models, this faithfulness constraint has already been proposed as playing an important role in Brentari's (1998) OT analysis of Weak Drop. Therefore, I will adopt a similar constraint, **MAXCONTACT** defined in (8).

(8) **MAXCONTACT**: A contact feature specified in the input must be present in the output

Originally proposed in Mandel (1981), the Selected Finger Constraint was posited to account for the relatively constrained typology of possible handshape changes within a word, as briefly discussed in the

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14 Weak Drop refers to the optional deletion of the non-dominant, or 'weak', articulator in some two-handed signs.  
15 In the HT model, a reduplicated sign such as NIGHT (LL) has a single associated contact feature linked to both L segments. Thus, if one segment is deleted, then the contact feature is not lost but simply linked with the surviving L.
previous section. Sandler (1989, 1999) proposes a modification to the original formulation of this constraint. Her proposed version limits the numbers of selected finger specifications within a morpheme rather than a word because violations of this constraint were present in some compound forms. However, evidence of handshape feature spreading discussed here, in conjunction with diachronic analysis as noted in Frishberg (1975), suggests that pressures from this constraint are exerted on compound forms as well, most commonly if they are reduced to a single syllable. I therefore reject Sandler's modification of Mandel's original constraint in place of my own, that only one set of selected fingers can be specified within a syllable, a luxury afforded by the basic assumption in OT that constraints are violable. I then propose that regressive assimilation is typically driven by this constraint since such assimilation only fails to appear in compounds within which the handshape of one root morpheme is an open or closed variant of the handshape of the other root morpheme. This constraint will be defined as in (9).

(9) \textit{SpecFinger}: Only one specification for a set of selected fingers is allowed in a syllable

Handshape changes in the root morphemes of a compound are preserved in surface forms. This observation has been integrated in most models; for example in the HT model it is a useful result of representing the linking of individual 'handshape' feature nodes to the movement tier. Despite this observation, Sandler (1989:176) attributes the blocking of reduction seen in the compound MIND\textasciitilde{}BLOW-UP\textasciitilde{}“BLOW-ONE'S-TOP” (see Appendix fig.B) to the directionality of the movement in the second root morpheme. Although movement directionality and relative height of the two root morphemes are likely to play a role in the phonological system, as there appears to be a universal tendency for compound morpheme order to begin high and end low in the signing space (Wallin 1981), this more simple constraint on preserving handshape-change in the sign BLOW-UP can similarly account for the resulting bisyllabic surface form of compounds like “BLOW-ONE'S-TOP”. This faithfulness constraint will be defined as in (10).

(10) \textit{MaxHS}: Segments in the input which include a handshape change must be present in the output.

In the following analysis I will assume that the more general faithfulness constraint \textit{Max} also plays a role in the phonological system of sign language preventing the indiscriminate deletion of segments of the input. For ease of exposition, I will also include a faithfulness constraint which specifically requires the underlying feature of handshape to appear in the output in order to simplify the definition of the constraint \textit{Max}, although only \textit{Max} plays a crucial role in the analysis. The \textit{MaxHS} constraint will allow
for an independent analysis of segment deletion and feature deletion such that it will clarify what violations are being counted in the tableau. These two constraints are defined as such:

(11) MAX: Segments present in the input forms must appear in the output
(12) MAXHs: The handshape feature present in segments of the input must not be modified in the output

4.2 The Analysis - Part I: Reduction and blocking with Monosyl, MaxContact, and MaxHsA

Our highly ranked constraint, Monosyl plays a crucial role in driving the reduction of word forms as exhibited in both diachronic (Frishberg 1975) and synchronic changes (K&B 1978; Bellugi & Newkirk 1981). The constraint is not only active in compound formation, but can also be seen in various morphological processes such as negative incorporation (as defined in Woodward 1974) and cliticization (as defined in Sandler, 1999) and is likely to play a role in driving the synchronic and diachronic reduction of morphologically complex verb forms. In Tableaux A the compound THINK^SELF→THINK-FOR-ONE'S-SELF (fig. 13), which presents a reduction of two LML morphemes into a single LML template, suffers a deletion of three segments from the input. This deletion is preferred over an unreduced form, candidate (b), in which the two independent morphemes appear unaltered in the output though joined by a transitional movement, or a partially reduced form (c), where only the first segment of the second root is deleted. This comparison provides evidence for the basic ranking Monosyl⇒Max, responsible for the reduction of the vast majority of compounds. This ranking represents the general tendency of complex morphological forms in the ASL lexicon to prefer deletion of segments in the input over multi-syllabic forms. Other compounds whose reduction can be analyzed as such are NOSE^STICK-IN→SNOOP, HEART^ATTACK→HEART-ATTACK, FACE^ALIKE→LOOK-LIKE (fig.12), EAT^NOON→LUNCH, and EARRING^YELLOW→GOLD.

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16 Two general types of candidates will be omitted from this analysis: The first are candidates which are physiologically impossible, requiring the articulator to appear in two distinct locations without an intermediate movement, the epenthetic M, segment is therefore assumed to be a necessary component which mediates two incongruous segments. The second are candidates where an entire root morpheme is deleted. See the discussion at the end of this section.
The preceding tableau lacks accurate detail as one further constraint is needed to determine which segments will be sacrificed for the sake of reduction. In the vast majority of signs, the crucial input segment which must appear in the output is one which makes contact somewhere on the body. Revisiting the compound THINK^SELF in Tableau B, where segments which make contact with the body are represented in bold, we analyze a new candidate (c). In this candidate, the contact segment of the sign THINK is deleted rather than the initial segment. This candidate fails to surface as the winning candidate due to a MAXCONTACT violation not incurred by candidate (a). Although no ranking argument can be made for MAXCONTACT here, it is a crucial constraint which determines the choice of retained segments. The root morpheme SELF has no segment which makes contact with the body. So as to not incur too many violations of the constraint MAX, the final L segment is retained. Candidate (d) represents the compound within which the first segment of the sign SELF (L3) is retained rather than the second. This candidate suffers an additional MAX violation because the movement segment M6 of the sign is deleted rather than merged with the necessary transitional movement M7. A candidate such as L2+M4L3, where the movement segment M6 is transposed with the location segment L3, cannot occur. This is because, though metathesis is a grammatical process of ASL, it crucially operates on entire LML syllables. Thus, if SELF were metathesized (L3M6L4 → L4M6L3) the directionality of the M segment must change, now moving the articulator toward the body rather than away. This feature would disallow the merge with the transitional movement.

The MAXCONTACT constraint actually plays a more important role than evident from the analysis of THINK^SELF. This is because a violation of MONOSYL is preferred over a violation of MAXCONTACT.
Evidence for the ranking $\text{MAXCONTACT} \gg \text{MONOSYL}$, and by transitivity $\text{MAXCONTACT} \gg \text{MAX}$, is available in the analysis of compounds with root morphemes that contact the body during a movement, such as $\text{BLACK} \wedge \text{NAME} \rightarrow \text{BAD-REPUTATION}$ (fig. 14). Only the second root morpheme of this compound reduces ($\text{LL}_3 \rightarrow \text{L}_3$) while the first compound surfaces intact. BAD-REPUTATION thus incurs a violation of $\text{MONOSYL}$ by surfacing as bisyllabic as shown in Tableaux C. Here, this bisyllabic winning candidate is compared to the reduced form, candidate (b), which has lost the contacting M segment.

![Figure 14: BLACK, NAME, and BLACK^NAME → BAD-REPUTATION](image)

<table>
<thead>
<tr>
<th>C: $\text{BLACK} \wedge \text{NAME}$</th>
<th>$\text{MAXCONTACT}$</th>
<th>$\text{MONOSYL}$</th>
<th>$\text{MAX}$</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\text{L}_1 \text{M}_A \text{L}_2 + \text{LL}_3$</td>
<td>$\ast$</td>
<td>$\ast$</td>
<td></td>
</tr>
<tr>
<td>a. $\rightarrow \text{L}_1 \text{M}_A \text{L}_2 + \text{M}_T + \text{L}_3$</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>b. $\text{L}_1 + \text{M}_T + \text{L}_3$</td>
<td>$\ast$</td>
<td>$\ast$</td>
<td>***</td>
</tr>
<tr>
<td>c. $\text{L}_1 \text{M}_A + \text{M}_T + \text{L}_3$</td>
<td></td>
<td>$\ast$</td>
<td>**!</td>
</tr>
</tbody>
</table>

The transitional movement necessary in candidate (a) could be hypothesized to surface as in candidate (c), sans an intermediate L segment, but unlike previously noted in TableauA's winning candidate, it cannot merge with the $\text{M}_A$ segment. This due to their incompatible directions: While $\text{M}_A$ moves the articulator perpendicular to the body's central plane, from left to right, $\text{M}_T$ must move parallel to the central plane, in a downward direction toward the non-dominant hand. The resulting form thus violates the $\text{MONOSYL}$ constraint as it fails to fit the appropriate syllabic template. Although both L&J and Sandler assume that this compound is actually bisyllabic due to the sharp change in direction between the two movements, Brentari (1998) disagrees, considering the surface form of this sign as consisting of an arc movement from $\text{L}_1$, brushing the forehead and curving down to meet the location $\text{L}_3$ on the non-dominant hand. By Brentari's account, this sign should thus be considered monosyllabic.

This current analysis could be modified to incorporate such a view by rejecting Sandler's representational hypothesis and allowing the conflation of BLACK's straight path movement $\text{M}_A$ to the transitional movement $\text{M}_T$ into a new path movement marked with the feature [arc] and thus resulting in a
monosyllabic form allowing candidate (c)\textsuperscript{17} to surface. In such an analysis, the victory of candidate (c) would be ensured regardless of the additional Max violation due to its satisfying of the Monosyl constraint. Further research is necessary to deduce the relative benefits or drawbacks of these representations. However, a few monomorphemic signs with movement shapes very similar to that of the compound BAD-REPUTATION do exist in the lexicon. But these signs, often place names like CHICAGO (fig.15), are considered to be exceptional members of the lexicon due to their bisyllabicity. Though it is unclear whether Brentari would agree, that they are so commonly considered bisyllabic provides some support for the analysis as presented above.

Another compound form that surfaces as bisyllabic is SICK\textsuperscript{\textasciicircum}SPREAD→EPIDEMIC (fig.16). While the first geminate morpheme SICK of this compound reduces to a single L segment, the second morpheme SPREAD does not because it contains an internal handshape change. As previously discussed, these changes are important elements of the sign and are resistant to deletion. Therefore, despite reducing SICK, the resulting compound still violates Monosyl.

In candidate (b) of Tableau D the first segment of the second root morpheme SPREAD (L\textsubscript{2}) is deleted. In this segment the two hands contact each other as can be seen in the third frame of figure 16. Therefore its deletion causes a violation of MaxContact. Furthermore, upon its deletion, the output sign would lose the handshape change specified in the input as the resulting shape change will be '8' (L\textsubscript{1})→'open' (L\textsubscript{3}) rather than 'closed O'→'open' as in the input. Therefore, this also constitutes a violation of MaxHs\Delta. A similar violation is incurred by candidate (c) in which the M\textsubscript{a} and final L\textsubscript{3} segment of the sign SPREAD are deleted (the final frame in figure 16). A violation of MaxHs\Delta here provides evidence for the ranking MaxHs\Delta\textsuperscript{>Monosyl}. The handshape change is represented here as an underlined segment, and indicates not only that a change occurs during the movement, but necessarily that the handshapes of the two

\textsuperscript{17} Or a very similar candidate of the form L\textsubscript{1b}M\textsubscript{a}L\textsubscript{N}.
segments surrounding it are pre-specified elements of the change in the input and cannot be altered in the output.

<table>
<thead>
<tr>
<th>D: SICK^SPREAD LL1+L2M4L3</th>
<th>MAXCONTACT</th>
<th>MAXHsΔ</th>
<th>MONOSYL</th>
<th>MAX</th>
</tr>
</thead>
<tbody>
<tr>
<td>a. L1 + M1+L2M4L3</td>
<td>*</td>
<td>*</td>
<td>*</td>
<td></td>
</tr>
<tr>
<td>b. L1M1L3</td>
<td>*!</td>
<td>*!</td>
<td>**</td>
<td></td>
</tr>
<tr>
<td>c. L1+M1+L2</td>
<td>*!</td>
<td>*</td>
<td>***</td>
<td></td>
</tr>
</tbody>
</table>

Although few of these compound types are attested, there exist several others which show the same blocking of this reduction, surfacing as bisyllabic by a similar analysis. These all have handshape changes in the root forms, most typically found in the second root; MIND^BLOW-UP→“BLOW-ONE’S-TOP” (see appendix fig.B), SLEEP^SOFT→ PILLOW, SLEEP^CLOTHES→PAJAMAS, THINK^ADD-TOGETHER→PRETEND, etc.

(13) BREAKFAST representation:

<table>
<thead>
<tr>
<th></th>
<th>EAT</th>
<th>MORNING</th>
<th>BREAKFAST</th>
</tr>
</thead>
<tbody>
<tr>
<td>LL1</td>
<td>L2M4L3</td>
<td>L1+M1+L2M4L3</td>
<td></td>
</tr>
</tbody>
</table>

Based on data interpreted by previous researchers the compound EAT^MORNING→BREAKFAST (fig.17) provides the first challenge to this analysis. Unlike the related signs EAT^NOON→LUNCH and EAT^NIGHT→DINNER, this compound has been noted to commonly surface as a bisyllabic sign. SPREAD, from our previously analyzed compound EPIDEMIC, remains unreduced by retaining it's contacting segment and handshape so as to avoid a violation of MAXCONTACT and MAXHsΔ. However, MORNING (fig.18) contains no handshape change or body contact18 yet surfaces unreduced in the compound

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18 This is not entirely accurate since the non-dominant hand does contact the inner elbow. However, in the HT model, contact of this type is treated differently than contact made by the dominant hand as its retention does not seem to be as crucial. See Brentari’s (1998) analysis of Weak Drop.
BREAKFAST. Tableau E shows how the interaction appears to make inaccurate predictions about the surface form.

There is reason to believe that this counter-example is not such a serious drawback. First, candidate (b) fails to appear because it is nearly equivalent to the compound EAT^NOON→LUNCH, which is likely to be a particularly confusing homophone (see appendix fig.E). This is because the final segment L3 of the compound BREAKFAST, made with the arm bent at the elbow and perpendicular to the ground (figs.18), differs from the second segment of the compound LUNCH only by the location of the non-dominant hand. Second, although candidate (a) is very likely to be the output surface form, candidate (c) is not disallowed. For example, in the video dictionary from which the images in figure 14 were captured (ASL video dictionary and Inflection guide, 2000), the last syllable of the citation form appears with a significantly reduced movement M when compared to the near 90 degree bend made by the citation form of the sign MORNING. Thus, even this sign tends toward the monosyllabic candidate (c). Evidence to further support this hypothesis can be found in the compound TOMORROW^MORNING→THE-NEXT-DAY as reported in Klima and Bellugi (1979, appendix fig.C). This compound, surfacing as a near minimal pair to BREAKFAST differing only in the handshape and location of the first segment, appears as a monosyllable of a form similar to candidate (c) in Tableau E. A detailed empirical analysis is required to verify the possible surface forms and the contexts in which both of these forms appear.

4.3 The Analysis - Part II: Handshape assimilation with MONOSYL, MAXHsΔ, and SPEC FINGER

As noted in Frishberg (1975), L&J (1985,1986), and Sandler (1989), the assimilation of handshape between roots of compounds is a common occurrence. However, the application of assimilation appears to be unpredictable, so much so that previous analysts have not been able to account for the variety of applications with a general phonological rule. Sandler's analysis applies Mandel's Select Finger Constraint, though modifies it to exclude compounds, to account for the most general type of assimilation in the lexicon. However, this constraint should be applied to compounds as it can explain a large variety of assimilations found in compounds that surface as monosyllables. Yet it is not enough to
explain the variation of assimilation in all compounds. Here I propose a first step toward a comprehensive analysis not yet achieved by a rule-based attempt. A basic constraint ranking will show that the need to minimize complexity of hand shape change in a syllable as well as retain handshape changes already present in the input often outranks the need for the underlying handshape to surface in the output.

In Tableau F, we revisit the compound THINK-FOR-ONES-SELF(fig.19) for a typical example of how assimilation is driven by a need to satisfy the \texttt{SPECFINGER} constraint. The compound here has sacrificed the handshape of the sign THINK, incurring a violation of \texttt{MAXHS}, by modifying it such that there is a more minimal change between the handshapes of its two L segments. We examine candidate (b) for which the first segment's handshape (L\textsubscript{2}) and last segment's handshape (L\textsubscript{4}) have been retained as they were in their root forms. This candidate violates our constraint \texttt{SPECFINGER} because there are two sets of selected fingers throughout the sign's syllable: The index finger in segment L\textsubscript{2} and the thumb in segment L\textsubscript{3}. This violation causes its failure to surface thus promoting the ranking \texttt{SPECFINGER}\textgreater\texttt{MAXHS}.

Although the compound THINK\textasciitl藝SELF only exhibits partial handshape assimilation, the majority of instances of total assimilation in compounds can also be analyzed in this way (e.g. KNOW\textasciitl藝STAY\rightarrow REMEMBER, THINK\textasciitl藝TOUCH → OBSESS, etc. though there are caveats as will be discussed in section 4.4)

<table>
<thead>
<tr>
<th>F: THINK\textasciitl藝SELF</th>
<th>\texttt{SPECFINGER}</th>
<th>\texttt{MAXHS}</th>
</tr>
</thead>
<tbody>
<tr>
<td>L\textsubscript{1}M\textsubscript{A}L\textsubscript{2}L\textsubscript{3}M\textsubscript{B}L\textsubscript{4}</td>
<td>\texttt{SPECFINGER}</td>
<td>\texttt{MAXHS}</td>
</tr>
<tr>
<td>a. \textasciitilde L\textsubscript{23}+M\textsubscript{TB}L\textsubscript{4}</td>
<td>*</td>
<td></td>
</tr>
<tr>
<td>b. L\textsubscript{2}+M\textsubscript{TB}L\textsubscript{4}</td>
<td>*!</td>
<td></td>
</tr>
</tbody>
</table>

The \texttt{SPECFINGER} constraint drives assimilation in the most common types of cases where compounds surface as monosyllables, yet total regressive assimilation can also be triggered as a result of a \texttt{MAXHS}\texttt{Δ}
violation. For example, in the compound MIND^DROP→FAINT (fig.20), the handshape change from the sign DROP is preserved at the cost of losing MIND's handshape. This is done by assimilating the handshape of the first segment of DROP to the reduced segment of MIND. An attempt to maintain MIND's handshape while reducing the compound to a monosyllable would create a loss of the handshape change of the input form of DROP, as demonstrated with candidate (b) of Tableau G. Keeping both handshapes, as in candidate (c), would require the compound to surface as bisyllabic, causing a violation of MONOSYL. Thus we have a direct argument for the rankings MONOSYL»MAXHS and MAXHS∆»MAXHS. These rankings suggest that reduction to a monosyllable and retention of underlying handshape changes are preferred over the retention of an input handshape. This prediction holds true in the analysis of a variety of other compounds such as KNOW^BRING→INFORM or THINK^HOLD→MEMORIZE.

<table>
<thead>
<tr>
<th></th>
<th>MONOSYL</th>
<th>MAXHS∆</th>
<th>MAX</th>
<th>MAXHS</th>
</tr>
</thead>
<tbody>
<tr>
<td>a.</td>
<td>L2M1L4L2+L3M4L4</td>
<td>***</td>
<td>*</td>
<td></td>
</tr>
<tr>
<td>b.</td>
<td>L2M1L4</td>
<td>*!</td>
<td>***</td>
<td>*</td>
</tr>
<tr>
<td>c.</td>
<td>L2+M1+L3M4L4</td>
<td>*!</td>
<td>*</td>
<td></td>
</tr>
</tbody>
</table>

Based on this new information, we can revisit Tableau D, expanded below as Tableau H, to examine why total regressive assimilation, such as that found in MIND^DROP, was not a viable solution for the compound EPIDEMIC (fig.21). We examine a new candidate (b) with total regressive assimilation similar to that of winning candidate (a) from Tableau G. In this candidate the '8' handshape (L1) from the first root morpheme SICK is replaced with the 'O' handshape from the first segment of the second morpheme SPREAD (L2). Now that the handshape change will be retained, satisfying MAXHS∆, an attempt to satisfy MONOSYL by deleting L2 fails because of the lost contact feature. We see in Tableau H
that, crucially, this new candidate violates $\text{MAXCONTACT}$.

<table>
<thead>
<tr>
<th>H: SICK$^\text{SPREAD}$</th>
<th>$\text{MAXHS}$</th>
<th>$\text{MAXCONTACT}$</th>
<th>$\text{MONOSYL}$</th>
<th>$\text{MAX}$</th>
<th>$\text{MAXHS}$</th>
</tr>
</thead>
<tbody>
<tr>
<td>LL$_1$L$_2$M$_3$L$_5$</td>
<td></td>
<td>*</td>
<td>*</td>
<td></td>
<td>**</td>
</tr>
<tr>
<td>a. $\Rightarrow$L$_4$M$_7$L$_2$M$_3$L$_5$</td>
<td></td>
<td>*</td>
<td>!</td>
<td>**</td>
<td></td>
</tr>
<tr>
<td>b. L$<em>{12}$M$</em>{17}$L$_3$</td>
<td></td>
<td>*</td>
<td>**</td>
<td>*</td>
<td></td>
</tr>
</tbody>
</table>

### 4.4 Borne and Unborne Predictions: Variation in the Lexicon

The argumentation above proposes that the appropriate rankings for these constraints are: $\text{MAXHS}$, $\text{MAXCONTACT}$, $\text{MONOSYL}$, $\text{MAX}$, $\text{MAXHS}$ and $\text{SPECFINGER}$, $\text{MAXHS}$. These rankings make accurate predictions for a set of compounds consisting of more forms than that of previous analyses. A large group of compound forms that no analysis has yet to account for is that which does not so easily conform to our $\text{SPECFINGER}$, $\text{MAXHS}$ ranking. As predicted by this analysis, many signs such as BLUE$^\text{SPOT}$$\rightarrow$BRUISE (Appx fig.D), EAT$^\text{MORNING}$$\rightarrow$BREAKFAST (fig.14), SURE$^\text{WORK}$$\rightarrow$SERIOUSLY, or SAY$^\text{TESTIFY}$$\rightarrow$VOW do not show assimilation because one of the two root morphemes consists of a handshape, an unmarked S (fist) or B (open-hand), which has no selected fingers. Therefore, this handshape plays the role of a closed or open alternate handshape to the other root morpheme's more complex handshape or finger selection. The resulting compound then does not violate the $\text{SPECFINGER}$ constraint which would otherwise drive the assimilation. However, as Sandler (1989) noted, there is large variability with respect to assimilation such that several compounds can surface with full, partial, or no assimilation even within the set of utterances of an individual signer. Some of these optionally assimilated compounds are presented in the following table 1.

<table>
<thead>
<tr>
<th>1. Optionally assimilating Cmpds</th>
<th>Handshape type</th>
<th>Violates $\text{SPECFINGER}$</th>
</tr>
</thead>
<tbody>
<tr>
<td>EARRING$^\text{YELLOW}$→GOLD</td>
<td>1 + Y</td>
<td>yes</td>
</tr>
<tr>
<td>FACE$^\text{LIKE}$$\rightarrow$RESEMBLE</td>
<td>1 + Y</td>
<td>yes</td>
</tr>
<tr>
<td>SLEEP$^\text{SUNRISE}$$\rightarrow$OVERSLEEP</td>
<td>Open(or B) + D</td>
<td>no</td>
</tr>
<tr>
<td>THINK$^\text{TOUCH}$$\rightarrow$OBSESS</td>
<td>1 + 8</td>
<td>yes</td>
</tr>
<tr>
<td>GIRL$^\text{SAME}$$\rightarrow$SISTER</td>
<td>S + L</td>
<td>no</td>
</tr>
<tr>
<td>RED$^\text{FLOW}$$\rightarrow$BLOOD</td>
<td>1 + 4</td>
<td>yes</td>
</tr>
</tbody>
</table>

A comprehensive analysis is necessary to accurately determine what constraints may be driving the
violation of SpecFinger, however my own observations show that those compounds which violate this constraint are more likely to surface with the predicted assimilation, and the unassimilated forms are sometimes noted as being formal or archaic. Output violations of SpecFinger, for the most part, are constrained to signs containing the 1-handshape in the first root morpheme. One possibility which could account for some of this data is that some highly ranked constraint governs the selection of the index finger, the selected finger in the '1' handshape. This constraint would outrank SpecFinger allowing the '1' handshape to surface with its violation. Also, for independent reasons, it has been claimed that this particular handshape belongs to the class of unmarked handshapes (Sandler & Lillo-Martin 2006) and this is evidence that this constraint should ignore all unmarked forms, as we might assume such forms lack finger specification. However, because it is still unclear whether phrasal phonological context affects the appearance or disappearance of assimilation in these forms, a detailed empirical analysis is also required to make any confident claims about the status of these compounds.

Throughout this analysis, candidates which exhibit the complete deletion of one its root morphemes have been ignored. This is mostly because such a surface form would be indistinguishable from the undeleted root morpheme. These forms are not attested in any synchronic analysis undertaken (Bellugi and Newkirk 1981) though a reason for this may be that they would be difficult for signers to differentiate unless they belonged to the signing community which took part in establishing them. However, Frishberg (1975) does note that such a deletion has occurred diachronically.

One example is that of the modern sign for BIRD (fig.23), which has lost the second root morpheme, glossed either as the noun WINGS or as the verb FLY. There are several reasons why this drastic reduction may have taken place: the general diachronic tendency for signs to move toward the central plane of the signing space, as Frishberg observed, or the semantic redundancy of representing an animal by two of its salient features rather than a single one. Frishberg herself suggests that “we can find numerous examples of signs in which it was formationally impossible to integrate the two parts of the compound into a single flowing lexical item” and as a result, a subset of those, such as the sign BIRD have lost one of its morphemes in the drive to reduce. The difficulty of integrating the two signs here may be due to their relative distance, however, as the present analysis suggests, the retention of a morpheme which makes contact with the body is preferred over the morpheme which does not.
Finally, another set of candidates also ignored in this analysis are those forms which would require the articulator to 'teleport' from one location to another without the intervening movement. An inviolable constraint which would drive the insertion of transitional movements to mediate segments of different locations could have been posited. Such a constraint could similarly block forms which would require the initial or final locations of movement to be at incongruous locations to the following or preceding morpheme. This constraint would have driven the epenthesis of the many transitional movements used at the expense of a violation of some constraint Dep which would be violated when segments not present in the input appeared in the output. I follow previous researchers such as Sandler in relegating the work of such a constraint to the physiology of the system.

However, it is crucial to examine these epenthetic movements in closer detail. Path and internal movements have played a major role in the literature as the crucial elements of the syllable or timing unit for sign languages by Perlmutter, Brentari, Sandler, and L&J. However, research has suggested that these epenthetic movements are markedly different than those lexically specified movements in their role as 'syllabic nuclei' (Brentari 1998; Brentari & Poizner 1994). For example, the SpecFinger constraint as defined in this analysis, does not always apply to syllables formed with a transitional movement as it would not apply between words in a phrase. A typology of similar segments, namely 'intrusive' vowels, has been attempted for spoken languages by Hall (2006). It is unclear whether epenthetic movement segments can be classified as intrusive based on the criteria proposed in that analysis as it relies on modality specific phenomena which lack clear sign language analogues. However, that such non-syllabic segments have been proposed for spoken languages lends credence to a sign language analogue, and vice versa. Although such an analysis is beyond the scope of this paper, its results are eagerly anticipated as they are likely to affect the current discussion.

5. Discussion of preceding analyses and areas of future work

Early analyses of compound formation such as can be found in Frishberg (1975), K&B (1979), and Bellugi and Newkirk (1981) lacked a well developed phonological framework with which to formalize the observations of compound formation which were being scrupulously recorded. Later, one of the key works which helped promote the necessary framework for such an analysis, L&J's MH model, involved a thorough investigation of compound formation (L&J 1986). In that analysis, the reductions noted were a result of two domain-specific rules and two more general rules. However, the domain-
specific rules were not exhaustive enough to make predictions for all possible compound forms while the more general rules were shown to be superfluous side-effects of the schematization system. Sandler (1987,1989) created a system which would do away with those general rules but her analysis of compounds, though making significant strides through the application of a selected finger constraint and the LML/L template, still relied on compound specific rules that could not account for the blocking of reductions in signs like EPIDEMIC or the assimilation of handshape as in FAINT which the current analysis accounts for as shown in Tableaux D, G, and E.

5.1 Most recent analyses

The two most recent attempts at an analysis of compound formation in ASL are those of Brentari (1998) and Uyechi (1993). Both of these approach the problem by drawing from observations made about the general importance of movements and changes within words. This approach results in analyses with the most predictive power. However, some of these predictions are inaccurate.

For example: in Brentari's analysis, a sign's syllable count is determined by the number of movement features associated with that sign. For theory-internal reasons, a sign with a single circular movement is deemed bisyllabic due to two associated features \{arc\} and \{trace\}. Reductions for compounds in her analysis would not predict that the sign FACE, consisting of a circular movement associated with these two features, would reduce to a single location. However, for the current OT analysis which relies on movement feature representations from the HT model, the compound FACE^ALIKE→RESEMBLE was easily derived in Tableau I.

<table>
<thead>
<tr>
<th>I: FACE^ALIKE^9 (L_1M_3L_1+(L)L_2)</th>
<th>MonoSyl</th>
<th>Max</th>
</tr>
</thead>
<tbody>
<tr>
<td>a. (\alpha L_{12}M_{12}3+L_2)</td>
<td>**(*)</td>
<td></td>
</tr>
<tr>
<td>b. (L_1M_3L_1+M_1+L_2)</td>
<td>*!</td>
<td></td>
</tr>
</tbody>
</table>

In Uyechi (1993) the analysis uses her own model of Visual Phonology (1996) which she refers to as a “transition-based model”. This label alludes to the importance of word-internal location changes and handshape changes, or 'transitions', which are captured quite well by her model. In it signs are represented as simple matrices, or cells, which consist of three features (Location, Handshape, or

\[19\] In this compound, the 'trilled' movement of the sign ALIKE can optionally appear in the output. This trill is most often incorporated in the epenthetic path movement. Movements of this type, when they appear during a path movement do not add to the syllable count.
A constraint-based analysis of compound formation

Orientation) and the transitions those features undergo in the sign. There are two change types: a Primary Change $\Delta$, which refers to prototypical changes exemplified in the path movement and orientation of DEAF (fig.2), or Secondary Change $\delta$, which refers to the shorter reduplicated or trilled changes seen in the movement of UNDERSTAND (fig.3). In this analysis a constraint on the number of changes allowed per cell is established to incorporate the observation that no signs in ASL exhibit a change in all three parameters: location, orientation, and handshape. This is claimed to be a strength of the model since it is a generalization missed by previous models which cannot account for the absence of such signs in their framework.

Uyechi first suggests that a general tendency for signs in the lexicon to be represented as single cells should be a crucial element of the model. This element would capture the mono-syllabicity of word forms, prevalent in the lexicon. Those few signs which other frameworks refer to as bisyllabic, such as the sign CHICAGO, are forms which must be represented as two independent cells (fig.24). This is because the first line of each cell, the Location parameter, includes a primary change, $\Delta$. Merging can only occur if both signs are single parameters and don't involve such change. These signs must then be schematized as two such cells and admitted in the lexicon as exceptional forms.

The crucial claim is that reduction in compound formation is driven by this general requirement for two cells of two independent signs to merge into one as a condition to entering the lexicon. With this assumption, she posits the reduction rule in (14):

\[
\begin{align*}
\text{(14)} & \quad \text{a) Secondary change reduces to primary change} \\
& \quad \text{b) Primary change reduces to a single param value (e.g. } [\text{NT}_{P1}, \text{NT}_{P2}]_{\text{LOC}} \rightarrow [\text{NT}_{P2}]_{\text{LOC}}) \\
& \quad \text{c) Body location is preserved.}
\end{align*}
\]

The reduced forms then undergo the process of merging in which the singleton elements of the individual cells combine to form changing elements in a single cell. Merging is blocked if either or both of the root morphemes maintain a specified element change after the reduction phase. This is a result of the same constraint which blocks merging in signs like CHICAGO which include two primary changes of the Location feature. Though this model could be extended, it currently fails to make any predictions regarding the handshape assimilation data. In addition, it fails to predict the blocking of reduction in compounds such as BLACK$^\text{name}$ → BAD-REPUTATION (fig.14) or GOOD$^\text{enough}$ → BARELY-
ADEQUATE (appendix fig.F) because the reduction and merging process, as described, would reduce BLACK to a single parameter value with contact at the forehead, thus predicting that the resulting sign could be reduced to a single cell with a straight path value from the forehead to the non-dominant hand.

The analysis presented here makes the accurate predictions missed by these previous analyses. Its strengths lie in the use of violable constraints which mirror observed tendencies in the lexicon. Where previous analyses could not neatly divide the set of compounds by way of rules into those which reduce to monosyllables, or those which exhibit assimilation, and those that don't, an appropriate ranking of the constraints MAXCONTACT, MAXHsΔ, SPECFINGER, and MONOSYL has covered the necessary ground. Furthermore, because the constraints used capture general observations about the lexicon, it is likely that they may provide useful in a future analysis of a different domain. Therefore once a complete analysis of compound formation has been achieved, a future step will be to explore the effects of these constraints in other word formation domains such as affixation and cliticization as described by Aronoff et al (2005) and Sandler (1999).

5.2 Compound formation's unanswered questions

One of the most problematic elements of any analysis of compound formation is the variable retention of reduplicated movements from the underlying form of the second root morphemes. If a reduplicated movement occurs in the first root of a compound it will be lost in the compound formation process. If, however, the reduplication occurs in the second root morpheme, it will only appear obligatorily if it is a two-handed sign and there is no body contact, otherwise, the reduplication is optional. L&J (1986) briefly and incorrectly address this as pertaining to only three compound forms without discussion, while Uyechi (1993) does not mention it at all, as it presents a critical obstacle for the analysis. However, both citation forms and forms in context of compounds with a reduplicated second morpheme variably appear with or without reduplication in the surface form. A short list of such compounds follows.

(15) Compounds with geminate second morphemes which may surface unreduced

TRUE\WORK→NO-KIDDING
EARRING\YELLOW→GOLD
RED\FLOW→BLOOD
THINK\ADD-ON→PRETEND
THINK\EXPECT→HOPE
THINK\MIX-UP→CONFUSED
SAY\APPLAUD→PRAISE
MONEY\EXCHANGE→BANK TELLER OR BUDGET
Klima and Bellugi (1979) propose that the observed asymmetry is a result of the late application of a rule which derives nouns from verbs. However, deverbal nouns can appear in root morphemes in the first position and as such are not reduplicated in the surface compound form. Frishberg (2002) suggests that related reduplication found in established compound forms should be analyzed as an instance of compensatory lengthening, where the final repetition compensates for the loss of a syllable present in an earlier form of the compound. This analysis is appealing and strengthened by its possible integrability with Perlmutter's (1989) moraic theory, which posits that syllables in ASL are bi-moraic and phenomena such as phrase-final lengthening results from the shifting of morae, which must be expressed in the surface form, to the end of phonological phrases. Still, a problem with this analysis is that the reduplication discussed in the diachronic and synchronic data refers to a complete copy of the remaining single syllable. It is therefore not clear how it should be directly applicable to the retention of a pre-existing sign-internal repetition. Yet, even if applicable to the forms in question, an explanation is required for both why such repetitions are optional and why an asymmetry exists between the first and second root morpheme.

Sandler (1989) delegates this phenomenon to asymmetry of the second root morpheme resulting from stress assignment as formulated by Klima and Bellugi. However, this notion of stress at that time had yet to be formalized in any empirically falsifiable way. Since then, attempts have been made to study stress patterns in ASL phrase structure (Wilbur 1999), but a conclusive study of lexical stress has still not been undertaken.

If we take into consideration the fact that assimilation in compound forms is overwhelmingly regressive, an asymmetry analysis is the most likely candidate as it implies that the second root morpheme is more resistant to alternations. One might propose a constraint preserving segments and features of the second root morpheme, preferring instead to alter the first morpheme in order to create a legal lexical form. That this repetition is only obligatory in roots which have no contact feature, such as WAITER, provides further evidence for a constraint-based analysis where a “second-root-morpheme-preserving” constraint interacts with our established $\text{MAXCONTACT}$ and $\text{MONOSYL}$ constraints. However, given that its optional appearance in other forms does not seem to be motivated by any other compound-internal contexts, the next step is to examine these compounds in larger phrasal contexts. Final reduplication which often appears in citation contexts often disappears in non-focus and non-phrase-final sentence contexts.
A final step toward a comprehensive analysis also must include a thorough investigation of the role of the non-dominant hand (h2). In MIND^DROP→FAINT, we saw an example of a two-handed sign DROP compounding with a one-handed sign. More specifically, DROP is a two-handed sign in which h2 acts as a mimicking articulator to the dominant hand. A somewhat typical result of such a combination, when involving regressive handshape assimilation as FAINT does, is the assimilation of h2’s features to the first sign. Another possible type of two-handed sign is one in which h2 plays the role of a body location rather than articulator. In this role, the non-dominant hand generally remains fixed as in the sign ENOUGH (appendix fig.F). When such signs are part of a compound, the non-dominant hand tends to anticipate by appearing during the articulation of the first root sign (see GOOD^ENOUGH fig.F), or persevere by appearing during the articulation of the final morpheme.

L&J (1986) observe that the position (first root or second root) of the two-handed root morpheme is crucial in determining the appearance and effects of h2 in the surface forms. Sandler (1989) suggests that the role of h2, whether as an articulator or a place of articulation, also plays a crucial role in determining the surface form of such compounds. Although the list of attested compounds with two-handed root morphemes is short, some generalizations can be observed. For example, two-handed root morphemes are much more likely to appear in second position, though this is just as likely a result of a tendency for compounds to begin high in the signing space and end low. Also, as previously mentioned, if h2 in the root form is not an articulator, it will persevere or anticipate depending on its position in the compound. If it behaves as an articulator, it will exhibit anticipation or perseveration most often if handshape is also assimilated. In order to carry out such an analysis, a comprehensive list of compounds consisting of h2 root morphemes must first be compiled. Such an undertaking would also be beneficial for collecting samples of modern compounds which may have entered the lexicon since the last time, over thirty years ago, that such an inventory was taken.

6. Conclusion

I have shown that utilizing the constraint-based framework of Optimality Theory in analyzing compound formation in ASL leads to a concise encapsulation of two large subproblems; the blocking of reduction and the application of assimilation. Using four key constraints; Monosyl, MaxContact, MaxHSa, and SpecFinger, the analysis shows that a large set of reduction effects in compounds and the blocking of the reductions can be explained via their interactions. Similarly, the ranking of those constraints also gives us the most concise explanation of assimilation in compounds to date. Though
more work is necessary to complete a comprehensive analysis, the work presented here shows that an OT analysis, generally ignored in the sign language literature, shows promise where previous models have fallen short.

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8. Bibliography


Appendix A: Additional Figures

Figure A: HEREDITY, CHANGE, and GENETIC ENGINEERING

Figure B: MIND BLOW-UP → BLOW-ONE'S-TOP (loose one's temper)

Figure C: TOMORROW, MORNING, and TOMORROW MORNING → THE NEXT DAY

Figure D: BLUE SPOT "a blue spot" and BLUE SPOT BRUISE
A constraint-based analysis of compound formation

Figure E: EAT NOON → LUNCH

Figure F: GOOD, ENOUGH, and GOOD^ENOUGH → BARELY-ADEQUATE

The sign GOOD

The sign ENOUGH

The compound GOOD ENOUGH meaning ‘just barely adequate’

Figure G: THINK, MARRY, and THINK^MARRY → BELIEVE

Drawing 1: Figure G: THINK, MARRY, and THINK^MARRY → BELIEVE

a. THINK
b. MARRY
c. BELIEVE
Appendix B: Compounds analyzed

KNOW\^BRING = INFORM
BLUE\^SPOT = BRUISE
BLACK\^NAME = BAD REPUTATION
HEART\^ATTACK = HEART ATTACK
SICK\^SPREAD = EPIDEMIC
BED\^SOFT = PILLOW or MATTRESS
EAT\^MORNING = BREAKFAST
FACE\^ALIKE = LOOK-LIKE
EAT\^NOON = LUNCH
EARRING\^YELLOW = GOLD
FACE\^STRONG = RESEMBLE
SLEEP\^SUNRISE = OVERSLEEP
SURE\^WORK = SERIOUSLY
HEREDIT\^CHANGE = GENETIC ENGINEERING
TRUE\^WORK = No-KIDDING
GIRL\^SAME = SISTER
RED\^FLOW = BLOOD
THINK\^ADD-ON = PRETEND
THINK\^FREEZE = SHOCKED
THINK\^MIX-UP = CONFUSED
SAY\^APPLAUD = PRAISE
TIME\^SAME = SIMULTANEOUS
SAY\^TESTIFY = VOW
NUDE\^ZOOM-OFF = STREAKER
CELEBRATE\^GIFT = ANNIVERSARY-GIFT
THINK\^ALIKE = AGREE
EAT\^EVENING = DINNER
GOOD\^ENOUGH = BARELY-ADEQUATE
FOOD\^BUY+ = GROCERY-SHOPPING
MIND\^BLOW-UP = BLOW-ONE'S-TOP
THINK\^SPECIFIC = GOAL
NOSE\^STICK-IN = SNOOP
MONEY\^EXCHANGE = BANK TELLER OR BUDGET
RED\^SLICE = TOMATO
EAT\^SLEEP = HOME
SLEEP\^DRESS = NIGHTGOWN/PJS
EARRING\^YELLOW = GOLD
SLEEP\^SUNRISE = OVERSLEEP
THINK\^TOUCH+ = OBSESS
TALK\^NAME = MENTION
GIRL\^SAME = SISTER
RED\^FLOW = BLOOD
KNOW\^STAY = REMEMBER
THINK\^SELF = THINK-FOR-ONE'S-SELF
BOY\^SAME = BROTHER
WOMAN\^MARRY = WIFE
MAN\^MARRY = HUSBAND
MIND\^DROP = FAINT
THINK\^HOLD = MEMORIZE
THINK\^EXPECT = HOPE
TOMMORROW\^MORNING = THE-NEXT-DAY
THINK\^MARRY = BELIVE