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The Parallel Structures Model of Feature Geometry*

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There are currently many competing feature theories and models of segment-internal representations. Despite differences in detail, however, the general proposals are fairly uniform, each making minor modifications to the feature set of SPE (Chomsky and Halle, 1968) and the geometry of Clements (1985) – with two notable exceptions. First, Clements (1991) proposed an innovative unification of consonant and vowel place features, which greatly economized the set of place features. Second, all proposals for sign language depart radically from spoken language proposals. In this paper, we propose a very different model of feature geometry, in which the insights of Clements (1991) are extended to other areas of the phonology, and structural and featural economy are exploited to the greatest extent possible. This model not only eliminates a large number of features from the grammar (including the major class features), but it provides a unified analysis for consonants, vowels, place, manner, tones, complex and contour segments in spoken and signed languages.

1. Background on features and feature geometry

It has long been established that the feature, not the segment, is the basic unit of phonological representation, and that features combine in a variety of ways to form speech sounds. Further, there are many proposals in the literature regarding not only the set of universal features, but also the ways in which they combine. This paper reviews some of the most common features found in the literature today and some of the proposals for their placement in segmental representations, and it proposes a new model of feature geometry in which parallel structures/features are used wherever possible. Under this proposal, economy plays a greater role in the organization of the phonology than is normally assumed.

In this section, we briefly review the most common major class, manner, place, laryngeal and tone features and representations, and we highlight a variety of unresolved issues that suggest that a new model of features and geometry is warranted. In Section 2, we propose a new set of manner, place and laryngeal features and representations for simple segments in spoken language. Section 3 discusses complex and contour segments

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in spoken language and suggests a limited and principled set of representations for them. Section 4 proposes a new way of looking at sign language segments, and shows that the basic features and representations assumed in this paper for spoken language may also be applied to signed languages. The conclusions are given in Section 5.

1.1 Major class features

According to *The Sound Patterns of English* (Chomsky and Halle 1968, pp. 301-302),

> Reduced to the most rudimentary terms, the behavior of the vocal tract in speech can be described as an alternation of closing and opening. During the closed phase the flow of air from the lungs is either impeded or stopped, and the pressure is built up in the vocal tract; during the open phase the air flows out freely. This skeleton of speech production provides the basis for the major class features, that is, the features that subdivide speech sounds into vowels, consonants, obstruents, sonorants, glides, and liquids.

Currently, the major class features are typically considered to be [±consonantal] and [±sonorant], minimally. The feature [±consonantal] is used to distinguish vowels and glides from consonants, and the feature [±sonorant] to distinguish vowels and sonorant consonants from obstruent consonants. Further, relative sonority is usually thought to be a direct result of specifications of particular major class features. The most sonorant speech sounds, vowels, are [+son] and [-cons], while the least sonorant, obstruents, are [-son] and [+cons]. Naturally, the nasals and liquids are [+son] and [+cons] since they are of intermediate sonority.

(1)

<table>
<tr><th rowspan="2"></th><th colspan="2">Features</th><th colspan="2" rowspan="2">Classes</th></tr>
<tr><th>[sonorant]</th><th>[consonantal]</th></tr>
<tr><td>stops & fricatives</td><td>-</td><td>+</td><td>obstruent</td><td rowspan="2">consonant</td></tr>
<tr><td>nasals & liquids</td><td>+</td><td>+</td><td rowspan="2">sonorant</td></tr>
<tr><td>vowels & glides</td><td>+</td><td>-</td><td>vowel</td></tr>
</table>

Following this claim that sonority is encoded in the major class features, Clements (1987) included a feature [±approximant] to distinguish among the nasals and liquids, and to create a natural way for liquids and glides to pattern together, as seen in (2). He also replaced the [±consonantal] feature with [±vocoid] so as to capture relative sonority via the relative number of major class feature 'plus' values.

(2)

	Features			**Classes**	
	[sonorant]	[approximant]	[vocoid]		
stops & fricatives	-	-	-	obstruent	consonant
nasals	+	-	-	sonorant	consonant
liquids	+	+	-	sonorant	consonant
vowels & glides	+	+	+	sonorant	vowel

Since the advent of feature geometry, one of the recurring questions has been how best to represent the major class features. While Sagey (1990) and others have proposed that they (and other stricture features) are associated directly with the root node, Schein and Steriade (1986) and McCarthy (1988) have proposed that the major class features are found *within* the root node. The major motivation for this is that the major class features do not behave as other features do. That is, they do not seem to spread or de-link independently, and while other features may be absent from a given segment or even absent from an entire language, the major class features seem always to be present. The consequence of this is the conclusion that every segment must be specified for each of the major class features, and that these features are an integral part of the root node.

1.1.1 Major class problems: Stipulations, privativity and manner

While this description of the major class features and their place in the feature geometry seems fairly straightforward and is almost universally accepted, it does not come without problems. First, why are the major class features so different from the other features? Why are they necessary for every segment? Why can they not spread or delink? The representational accounts that have been proposed to explain these behaviors are not particularly satisfying. That is, they assume that the major class features exist *as* *features* in order to differentiate among the major sonority classes, but they stipulate that the behavior of these *features* is different because they are associated directly with the root node. Could there be a better explanation? As we will see below, a better account might be to say that the major class features do not exist as features, thus they are not expected to act like features. We will propose below that the major sonority classes are defined structurally, not featurally.

A second problem with the major class features has to do with privativity. That is, if we take seriously the strong hypothesis that all features are privative, as is suggested by much of the current phonological research (e.g. Avery and Rice 1989, Mester and Itô 1989, Lombardi 1991, Goad 1994, Steriade 1995, Avery and Idsardi 2001, Ghini 2001, Grijzenhout 2001), then there are several problems with Clements' formulation of the major class features. For example, it cannot be the case that all segments are fully specified for the major class features. Assuming that [sonorant], [approximant] and [vocoid] are privative, then obstruents have no major class features, sonorants have one, liquids have two and vowels/glides have three. Further, if markedness is encoded at least partially via the relative number of associated features, then this conception implies that vowels are featurally the most marked segments, followed by liquids, nasals and finally obstruents. This seems counter-intuitive because one might argue that obstruents *and* vowels are the least marked segments from a featural perspective since all languages have them, but not all languages have sonorant consonants (Maddieson 1984). In addition, while returning to a privative version of the SPE feature [consonantal] improves the situation slightly in that consonants now have at least one major class feature and we gain a fairly straightforward markedness relationship among major classes, we now lose Clements' insight regarding the relationship between major class features and sonority.

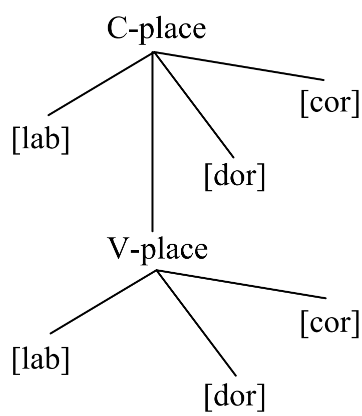
Finally, it is interesting to note that not all work on feature theory has unanimously agreed that the major class features are a class unto themselves. For instance, Clements (1985) and Sagey (1990) group them together with the manner/stricture features [±continuant], [±strident], [±lateral], and [±nasal]. This should not be surprising if we consider the quote from SPE above. That is, the manner/stricture features seem to define various degrees of openness of the vocal tract, exactly what the major class features were intended to do. This is an important point that will be returned to below.

1.2 Place of articulation

With the advent of the SPE, place features went from being defined by acoustic cues (e.g. Jakobson, Fant and Halle 1963), to being defined by articulators, with particular attention paid to the active articulators. Many revisions have been made to the set of place features since SPE. The most popular seems to be that of Clements (1991).

For Clements, [labial], [coronal] and [dorsal] can each be associated with either a consonant place (C-place) or vowel place (V-place) class node, and the V-place node is dependent on the C-place node. (3) illustrates this relationship (only relevant structures are shown).

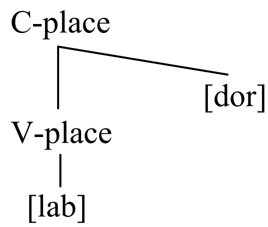
(3)



This organization helps to explain several place-related facts. First, the articulatory similarity between consonant and vowel place is captured and there is a reduction in the number of features in the inventory. Consonants and vowels made with an active lip articulation have the feature [labial]. Consonants and vowels made with the front half of the tongue have the feature [coronal], and consonants and vowels made with the tongue dorsum have the feature [dorsal].

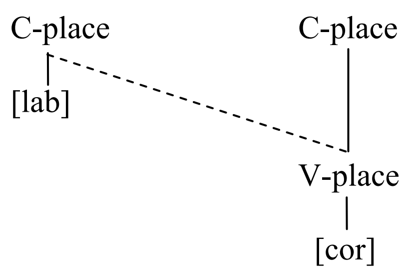
Second, the contrast between primary and secondary place articulations is straightforwardly accounted for using this model. Consonants with only a primary place have only a C-place node with a terminal feature. Vowels have both a C-place and a V-place node, but only a terminal feature on the V-place node. Consonants with secondary articulations have both a C-place and V-place terminal feature, as shown in (4).

(4) $[k^w]$



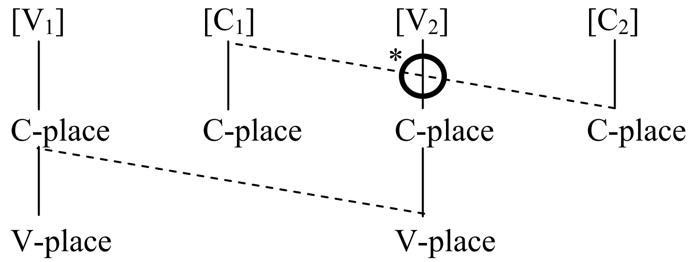
This representation also helps to explain how consonants can assimilate to adjacent vowels, as in palatalization, labialization and velarization.

(5) /pi/ $\rightarrow$ $[p^j i]$

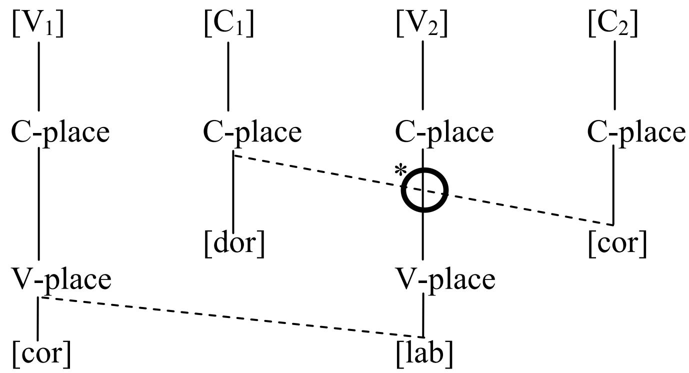


Finally, this representation also helps to explain harmony asymmetries. That is, while vowel place harmony is quite common cross-linguistically, consonant place harmony is quite rare. If all segments have a C-place, but only vowels typically have a V-place, then spreading a place node or individual place feature from one consonant to another consonant without the intervening vowel participating is prohibited because it would involve skipping an intervening node on the same tier (crossing of association lines). However, vowel place may spread across intervening consonants with impunity if the language does not allow secondary articulations.

(6)



(7)



One major place of articulation that is not usually discussed in the feature geometry literature is [pharyngeal] (a.k.a. [guttural] or [radical]). While it is well established that such a class exists, the exact nature of the features and the geometry involved is still unresolved. This will remain the case here, but will be returned to below.

1.2.1 Place problems: Active and passive articulators, and sub-articulators

Much of the literature on place features and place feature geometry stops there. Unfortunately, this leaves several interesting inventory facts unexplored. First, while it is widely acknowledged that coronal place can be further divided into an anterior and a posterior articulation, there is little discussion of what seems to be an incompatibility problem with the definitions of [coronal] and [±anterior]. That is, much of the post-SPE literature defines the major places via active articulator, so [coronal] sounds are those made with the front of the tongue (including the blade and the tip), but [±anterior] is a division of the passive articulator. [+anterior] currently refers to those sounds made at the teeth and/or alveolar ridge, while [-anterior] describes those made somewhere on the hard palate posterior to the alveolar ridge. Despite the fact that [coronal] is usually defined by the active articulator and [±anterior] is always defined by the passive articulator, the latter is represented as a dependent of the former. One wonders if there might be a better way to capture the need for both passive and active articulator features and potential dependencies between them.

Second, despite the fact that many phonologists acknowledge the need for a [±anterior] coronal division, few mention the fact that the labial, dorsal and pharyngeal places are also divided into more front articulations and more back articulations. For example, labials can be either bilabial or labio-dental and dorsals can be either velar or uvular. Again, we seem to need both an active articulator feature and a passive articulator feature. Further, not only does the posterior specification of the coronal seem to be the more marked (at least for consonants), but the posterior specification of each of the other major places is also marked. For example, uvular stops and fricatives are usually considered more marked than velar stops and fricatives in those languages which display a contrast, and epiglottals are usually considered more marked than pharyngeals. One wonders if there is a straightforward and economical way to capture this generalization that passive place can be divided into a more front articulation and a more back articulation and that the posterior articulations are more marked. At present, [±anterior] is reserved for coronals, and there is a proliferation of additional place features proposed for non-coronals (e.g. [dental], [uvular] and [epiglottal]).

Finally, to account for the fact that some languages distinguish between dental and alveolar sounds and others between retroflex and palatal sounds, Chomsky and Halle (1968) proposed the feature [±distributed]. This feature roughly corresponds to the more traditional apical/laminal distinction. [-distributed], or apical, sounds are made with the tongue tip and [+distributed], or laminal, sounds are made with the tongue blade. Thus, not only must we divide the passive articulators into sub-articulators, but it seems that we must also divide the front of the tongue into two distinct active sub-articulators. What is the simplest and most economical way to do this?

1.3 Manner of articulation

Although there is some disagreement about the particulars of place of articulation, there is a fair amount of agreement as to how to broadly characterize them with respect to features and geometry. However, the features and representations for manner of articulation are far less standard. Although [±nasal], [±lateral] and [±continuant] are usually described as manners, there are any number of geometries that have been proposed for them. At one time or another each has been associated either directly with the root node (e.g. Sagey 1990), under a manner node (e.g. Clements 1985), or split among a variety of different nodes (e.g. Clements and Hume 1995). [±continuant] has even been positioned under the place node (Padgett 1991). It is particularly curious to note that these three features are often grouped geometrically with the major class features, as is the case with Sagey's representations. This point will be returned to below.

A fourth manner feature that has been much discussed in the literature is [±strident]. Some argue that this feature is also associated directly with the root node (e.g. Sagey 1990), others that it is associated with a manner node (e.g. Clements 1985), and one might even be tempted to claim that it is dependent on [+continuant] since it is specific to segments with frication noise.

1.3.1 Manner problems: Consistency, completeness, economy, and dependency

The most obvious problem with manner of articulation is the general lack of agreement regarding the representations of even the most agreed upon features. Are [lateral], [continuant], [nasal] and [strident] a class that associate with the same node in the representation? If they do associate with the same class node, what is it? Similarly, are the manner features related to the major class features? If they are, as one might expect given that they all capture types of stricture, how do we explain their different behaviors? Finally, is there a relationship between [strident] and [continuant] or even [lateral] and [coronal]? If there is, how are those dependencies encoded in the geometry? If there is not, how do we explain (rather than just describe) the apparent relationships?

Another unresolved issue is simply the question of what the most complete and economical set of manner features might be. Certainly flaps and trills must be accounted for, and if we assume a definition of manner as roughly how the airflow is blocked and/or restricted then flaps and trills must involve some sort of manner features. However, do we want to admit a feature [flap] and a feature [trill]?

Finally, it is interesting that some of the current models of feature geometry (e.g. Clements and Hume 1995) make an effort to unify the place features for both consonants and vowels, but do not do the same for the manner features. That is, the place geometry in (3) is economical from the perspective of the number of necessary features and explanatory from the perspective of assimilation, harmony and segment inventory facts. However, there has been no attempt to locate a set of features that might be considered vowel manner, and we are left with a set of consonant manner features, as well as either a set of vowel heights dependent on [dor] place (e.g. Sagey 1990) or a recursive [±open] feature on a vocalic aperture node (e.g. Clements and Hume 1995). Is there a straightforward way to unify consonant and vowel manner?

1.4 Laryngeal features

The laryngeal features are an interesting set. Despite the fact that they are widely studied, and there are a number of feature sets and representations proposed for them, they continue to be a focal point of disagreement. Currently, linguists working on laryngeal features seem to fall into two main camps: those that believe the features are based on articulator configuration, and those that believe the features are based on timing and/or acoustics. Most phonologists assume some variation of the articulator-based features [voice], [spread glottis] and [constricted glottis] (e.g. Halle and Stevens 1971; Mascaró 1987; Lombardi 1991) while others (particularly phoneticians) lean toward Voice Onset Time (VOT) (Lisker and Abramson 1964; Ladefoged 1971; Keating 1984). A typical articulator-based representation assumed in the literature is given in (8).

(8) Laryngeal

[voice] [S.G.] [C.G.]

VOT refers to the relative timing of the laryngeal articulations with respect to non-laryngeal articulations and are primarily associated with voicing and aspiration. Voiced segments are said to have a negative VOT because voicing begins prior to release. Plain segments have no VOT because voicing begins spontaneously upon release, and aspirated segments have positive VOT because the spontaneous voicing of the following sonorant occurs a significant period after release.

Like many phonologists, we will assume that VOT is a good tool with which to diagnose particular laryngeal specifications in initial positions, but it is not a phonological feature. As pointed out by Lombardi (1991), combining the three articulator-based features provides all the relevant laryngeal contrasts found cross-linguistically.

1.4.1 Laryngeal problems: Privativity, phonetics and default voicing

Even if we assume articulator-based laryngeal features, there is much controversy regarding the nature of those features. Particularly, are they binary or privative? While there is much evidence for the privativity of [S.G.] and [C.G.] (e.g. processes do not make reference to the minus value), the arguments for voicing privativity are more controversial – particularly since there have been many traditional (and current) analyses which rely on the assimilation of the minus value. While Mascaró (1987), Lombardi (1991), Mester and Itô (1989) and others have provided clever mechanisms to account for apparent spreading of [-voice] without using a [-voice] feature, there is still some reluctance to this move.

We believe that one of the sources of confusion in investigating and explaining voicing phenomena is that there is uncertainty among phonologists as to the actual phonetics of “voicing” and the relationship between phonetics and phonology. Despite the fact that SPE and Halle and Stevens (1971) make a clear distinction between glottal configuration and the actual vibration of the vocal folds, more recent phonological literature does not always maintain that distinction. Thus, the intervocalic voicing of “voiceless” obstruents is often analyzed as assimilation of a voicing feature from “voiced” vowels rather than the natural result of the aerodynamics of the vocal tract interacting with a neutral glottal configuration (vocal folds together loosely). Similarly, default “voicing” of sonorants is often assumed to occur as the direct result of a required [voice] specification on sonorants rather than the result of aerodynamics and neutral glottal configuration. If one views the phonological feature system as economical in nature, then one must ask if there is a phonological feature "voice" assigned to a segment with no contrastive voicing, and can a segment spread a non-contrasting feature?

Finally, one must ask if the same set of laryngeal features is used for both consonants and vowels, given that laryngeal features are typically used to contrast consonants (specifically obstruents) and not vowels.

1.5 Tone[1]

There are many phonological proposals at this time to account for lexical tone. Some notable recent work on Asian tones is that of Yip, Bao, Abramson, Gandour and Duanmu. Unlike most other features, tone is typically described in the phonological literature on the basis of acoustic, rather than articulatory, properties. However, there have been attempts to conceptually unify the grammar by relating the acoustics of tone with laryngeal features.

Currently, many phonologists working on tones accept at least four distinctive tonal levels. Following Yip (1995), these levels are due to the combination of two binary features, which she refers to as Register and Pitch. Register may have a value of high (H) or low (L), and it represents a range within the tonal space. Pitch, on the other hand, may have a value of high (h) or low (l), and it represents relative pitch within the register range. Combined, we see that four distinct level tones are predicted if we assume full feature specification.

(9) Level tone feature combinations

Hh	high-register high	"top high"
Hl	high-register low	"high"
Lh	low-register high	"low"
Ll	low-register low	"bottom low"

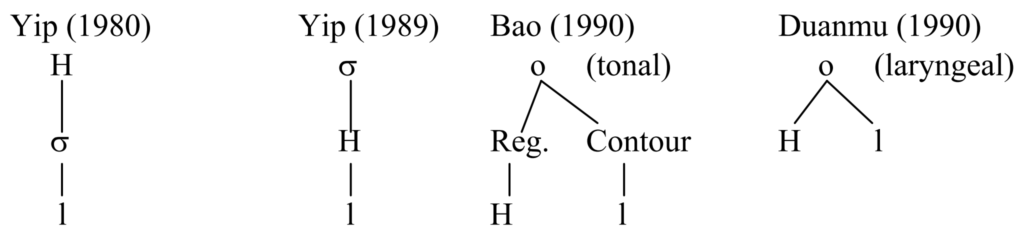
[1] We concentrate on lexical tone in this paper and leave phrasal and intonational tones for future research.

Note that a fifth level (mid) could be a lack of tonal features in a language without mandatory register and pitch requirements, and that the pitch features may combine to form contour tones (e.g. “high register falling” is Hhl).

1.5.1 Tone problems: Representations and laryngeal features

There are several major difficulties in assessing tonal features and representations. First, tone is relevant to a variety of levels of phonological representation, and one must ask if the same features are used at all prosodic domains. That is, are the same features used for lexical tone and phrasal contours? Second, there are a number of representations proposed in the literature to associate the tonal features with segmental or syllable structure. For example, Yip (1980) proposes that register and pitch features are each associated directly to the syllable, but Yip (1989) proposes that the pitch features are dependent on the register features, and only the register features are associated with the syllable. On the contrary, Bao (1990) proposes a tone node with dependent register and contour nodes which have dependent register and pitch features, respectively; and Duanmu (1990) proposes that the register and pitch features are dependent on the laryngeal node.

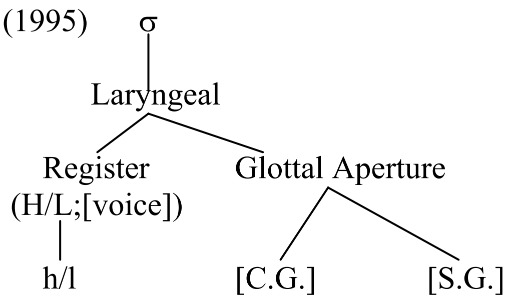
(10)



A third difficulty is the question of relating these tonal features to laryngeal features. Although Duanmu assumes that register and pitch are dependent on the laryngeal node, it is unclear how they explicitly relate to the other laryngeal features. Certainly, there has been much research over the years that clearly shows tone/laryngeal feature interactions both from a phonological and phonetic perspective (e.g. Anderson 1978, Hombert 1978, Ohala 1978, Ladefoged 1983). However, while there are some clear interactions, there are other areas in which the interactions are a little more ambiguous. For instance, although aspirated stops clearly induce a higher F0 on the following vowel and voiced stops induce a lower F0, plain and glottalized stops sometimes induce higher or lower F0 depending on the language.

Yip (1995) suggests that her 1989 representation might be incorporated into a laryngeal feature representation by assuming that [±voice] corresponds directly to high and low register, that the pitch features are dependent on the voice feature, and that there is a separate glottal aperture node which dominates [C.G.] and [S.G.] features.

(11) Yip (1995)



The major problems with this suggestion are 1) it will not work if we assume privative features, 2) it does not allow for the ambiguity of voicelessness and tone, and 3) it does not explain the interactions of the glottal aperture features with tones.

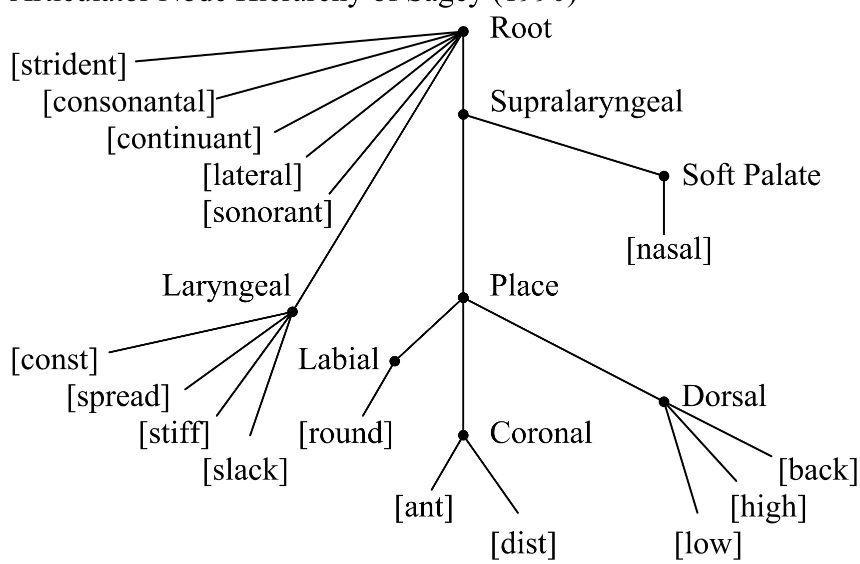
Finally, it is interesting to note that while laryngeal feature harmony is extremely rare (if not non-existent) among consonants, tone harmony/spread is quite common. One wonders if there might be a straightforward explanation of this interesting asymmetry.

1.6 Summary of the current state of feature geometry

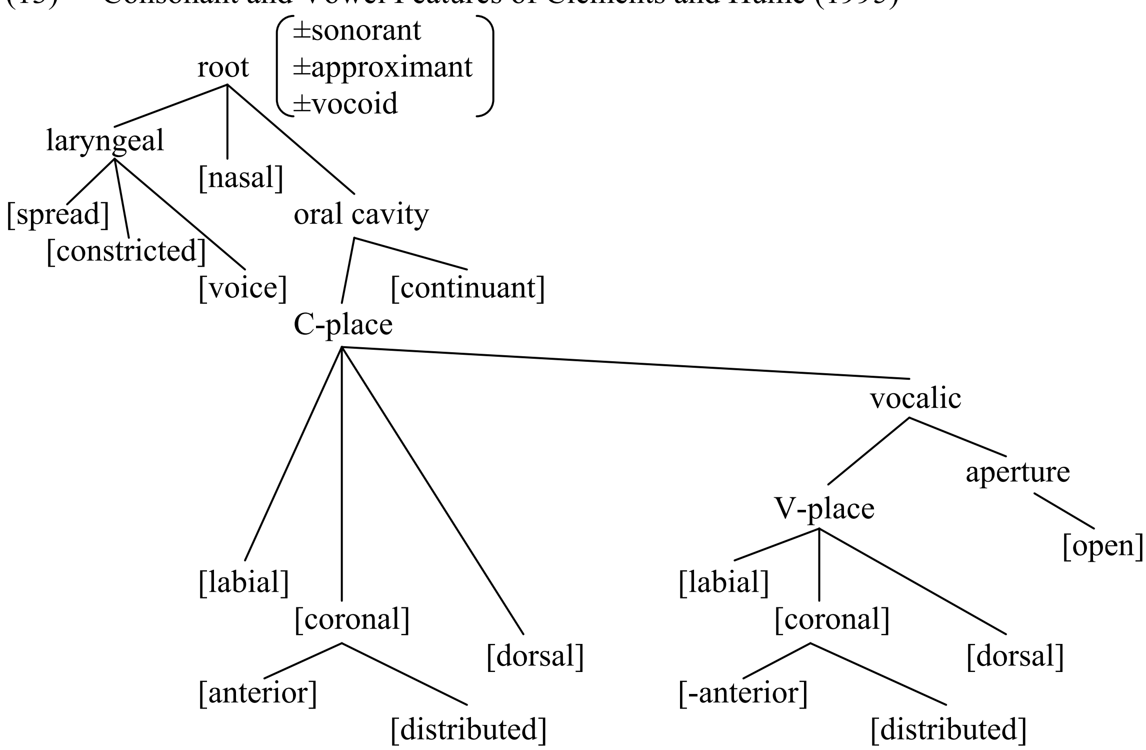
(12) and (13) illustrate two of the more common sets of major class, place, manner and laryngeal features with some proposed representations. Comparing these two geometries highlights several of the problems discussed above. First, there is disagreement regarding the existence and location of the major class features [±consonantal]/[±vocoid], [±sonorant] and [±approximant]. Second, there is disagreement regarding the nature and relationship among the place features. Third, there is disagreement regarding the placement of the manner features [±continuant], [±lateral],

[±strident] and [±nasal]. Finally, there is disagreement regarding the nature and location of the vowel height features.

(12) Articulator Node Hierarchy of Sagey (1990)



(13) Consonant and Vowel Features of Clements and Hume (1995)[2]



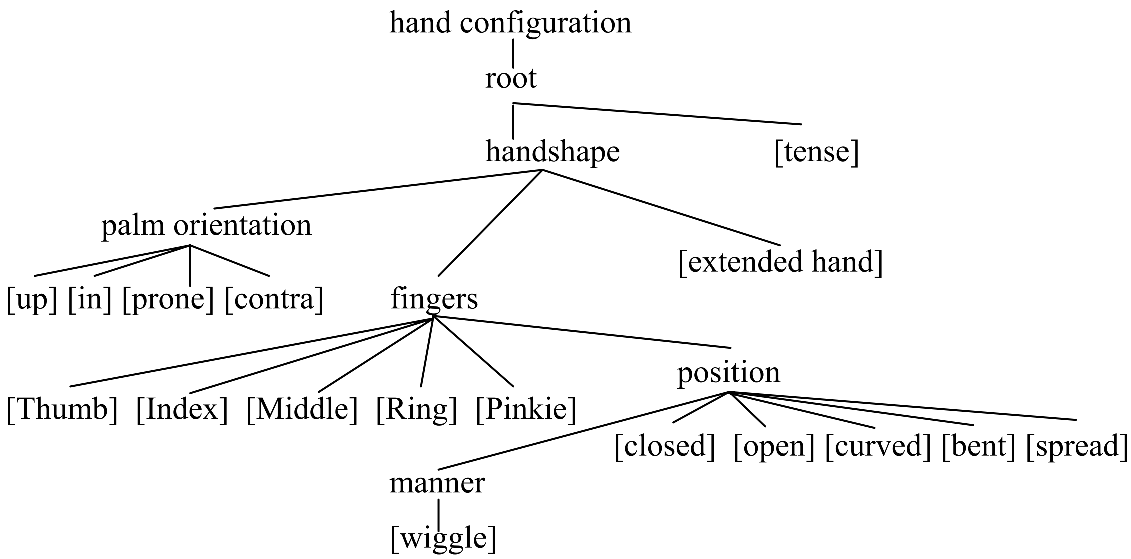
[2] Clements and Hume do not deny the existence of the [±strident] and [±lateral] features. They omit them from their representation because the placement of these features in the geometry is unresolved and they choose not to make a representational commitment.

Note that there are also many simple segments that are commonly found cross-linguistically that are not differentiated via these features and representations. For instance, bilabial and labio-dentals are not distinguishable, nor are velars and uvulars. In addition, pharyngeals, epiglottals, flaps and trills are not mentioned, and one wonders how linguo-labials might be captured.

There are three additional issues that are not satisfactorily addressed in the literature on feature geometry. First, tone is rarely discussed in a more general context of overall feature theory, and is usually addressed only in literature specific to tone (note that (12) and (13) do not mention tonal features). Second, although the features and class nodes proposed in the literature are both articulatorily and behaviorally motivated, it seems odd that the abstract mental representations for segments do not make use of more limited structural possibilities both for segment classes and for feature classes. For instance, while the work of Clements makes use of the same features and basic structures for both consonant and vowel place, there is no attempt in the literature to use similar structures for place, manner and/or laryngeal features, or for both consonant and vowel features generally. It would be much more satisfying if we could use the same basic representations and relationships in a number of domains, rather than just proposing unique structures for very limited domains (Jakobson, Fant and Halle 1963).

Finally, a major problem with current models of feature geometry is that they are absolutely modality specific. That is, the representations proposed for spoken language segments are vastly different from those proposed for signed languages. If we assume that the Innateness Hypothesis is correct and that abstract linguistic structures are universal, then the lack of a single model for the abstract representations of segments in both spoken and signed languages is unacceptable. While one might expect the actual phonetic implementation of features and segments to be quite different in the two modalities, it seems reasonable to assume the strong hypothesis that the abstract organization of those features/segments is the same. At present, there is little similarity in the representations proposed for spoken and signed languages, as can be seen in comparing the above representations with the following partial representation from Sandler (1989).

(14) Hand Configuration (Sandler 1989:46)



As we can see, Sandler incorporates the tenets of autosegmental phonology into her representation, but there is only a passing resemblance between it and (12) or (13).

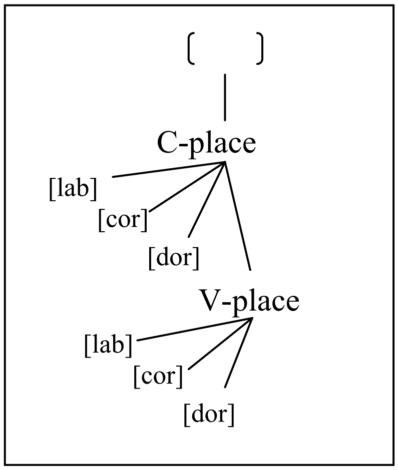
In short, there has been much insightful work done on segmental features and geometry in the past several decades, and we continue to refine the feature sets and representations that we assume to be universal. However, there are still many unresolved issues and many important questions to answer. In the remainder of this paper, we suggest a unified model of segment geometry that not only captures the cross-linguistic facts, but does so in a very economical way. Once the core of the model is presented for spoken language, we will show how it may be used for signed languages as well.

2. The Parallel Structures Model: Simple segments

2.1 Simple place of articulation

Let us begin with the representation of place proposed by Clements (1991). As already discussed, current work on place of articulation unifies consonant and vowel place representations by proposing a single set of place features (e.g. [lab], [cor], [dor]) and two class nodes (e.g. C-place and V-place). In addition, there is evidence (e.g. harmony patterns and secondary articulations) that V-place is dependent on C-place. The following diagram is a slightly simplified representation from Clements and Hume (1995).

(15)



In this section, we present a modified version of the Clements and Hume model, and propose that place must be further divided into an active and a passive articulator node. This is in line with the work of Gorecka (1989) and will allow us to distinguish among sounds using the same passive articulator but different active articulators (e.g. apical versus laminal alveolars), and among sounds made with different passive places but the same active articulator (e.g. apical alveolar versus apical palatal (retroflex)). As we will see, the combination of active and passive articulators has only limited use in spoken language because of physiological restrictions; however it is used quite extensively in sign language. Let us begin by looking at a phonetic description of the articulators used in place of articulation in spoken languages.

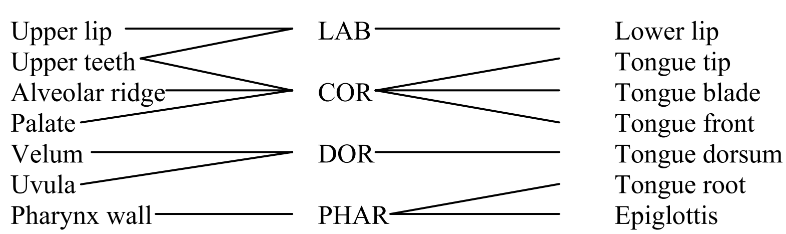
When investigating the articulation of place, it quickly becomes apparent that there are actually two sets of articulators needed – those that are stationary (passive) and those that move (active). The passive articulators may be described as the points on the upper surface of the vocal tract used to distinguish among sounds within languages. The active articulators may be described as those points on the lower surface of the vocal tract used to distinguish among sounds within languages. These are given below.

(16)

Passive articulators – upper surface	**Active articulators** - lower surface
Upper lip	Lower lip
Upper teeth	Tongue tip
Alveolar ridge	Tongue blade
Palate	Tongue front
Velum	Tongue dorsum
Uvula	Tongue root
Pharynx wall	Epiglottis

Place of articulation is usually divided into four major groups based on both articulatory similarity and cross-linguistic phonological patterning – labial, coronal, dorsal, and pharyngeal; however, there is not always a transparent one-to-one correspondence from passive or active articulator to what is usually described as the four places of articulation, as seen in (17).

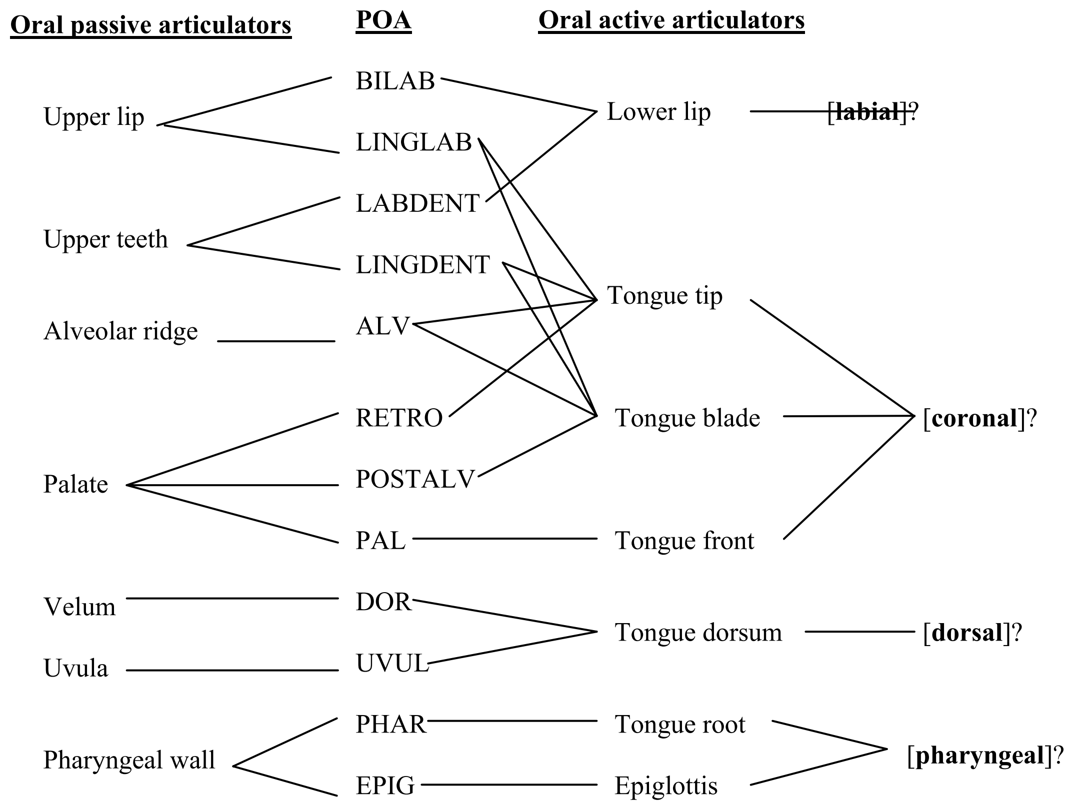
(17) **Passive articulators** **POA** **Active articulators**



Given the mix of active and passive articulators involved at any one place of articulation, it is difficult to see what the decisive articulatory definition might be. Pre-SPE, place of articulation was usually defined via the passive articulator. However, we can see that this is not adequate given that more than one place of articulation may be found at a given passive articulator (e.g. upper teeth may be either labial or coronal).

One might come to the same conclusion as SPE that active articulator is a more adequate means of classification, especially if we take into account the linguo-labial consonants found in some Austronesian languages. However, this also falls short of being able to describe all possible contrasts in place of articulation, as shown in (18).

(18)



There are several observations worth noting here. First, there are physical limitations to the combination of active and passive articulators in spoken language. For example, the lower lip cannot easily combine with the alveolar ridge, and the tongue tip cannot easily combine with the velum. Second, the most agile/mobile articulators (tongue tip and blade) can combine with the largest number of passive articulators. Finally, the possible active/passive combinations are exhausted when we look at cross-linguistic contrasts. These are points that are not typically discussed in the phonological literature on place, but will be quite important below when making comparisons between spoken and sign languages. These facts lead to the conclusion that both active and passive articulator are necessary to describe *some* of the possible place contrasts in spoken languages.

Now that we have the basic description of articulators and combinations, it is important to posit a set of features that will distinguish among them in the most economical way possible. As stated above, there are four traditional major places of articulation. These four are established in two ways, articulatory properties and behavior in phonological patterns. Although phonological patterning plays a vital role in determining phonological structures, we wish to emphasize that segment representations should be modeled as close to the physical realization as possible while still being phonologically relevant and economical. Therefore, we will concentrate on looking at phonologically contrastive segments from an articulatory perspective and leave a detailed analysis of phonological processes for future research.

2.1.1 Passive place of articulation

In this section, we argue for a set of place features based on the passive articulator involved. Although some of the above relationships are fairly straightforwardly grouped, others are more difficult. Linguo-dental, alveolar, retroflex, post-alveolar and palatals use the roof of the mouth and are given the [coronal] passive feature. Those sounds traditionally described as velar and uvular are made with at the velum passive articulator. Therefore we give them the [velar] passive feature. Pharyngeal and epiglottal sounds have a passive articulator feature of [pharyngeal] because they involve the pharyngeal wall. Finally, although they do not phonetically share the same passive articulator, we claim that bilabials and labio-dentals both have a phonological specification of [labial] for the passive articulator. This will be discussed in more detail below.

(19)

Phonetic Classes	Sample Segments	Passive Place Feature
Alveolar/Palatal	[t, d, θ, ð, n, s, z, c, j, č, ǰ, ɲ]	[cor]
Bilabial/Labio-dental	[p, b, ɸ, β, m, f, v]	[lab]
Velar/Uvular	[k, g, x, ɣ, ŋ, q, G, χ, ʁ, ɴ]	[vel]
Pharyngeal/Epiglottal	[ħ, ʕ, ʡ, ʜ, ʢ]	[phar]

Now that we have classified the sounds into four categories based on the passive articulator, it is important to distinguish among those that share the *same* passive articulator.

There have been several features proposed in the literature to accomplish this. Since the coronals are the best studied, let us begin there.

A major division among coronal consonants is that between the anterior and posterior coronals. These are made with the tongue at the teeth/alveolar ridge and the hard palate, respectively. Not surprisingly, these have been labeled [anterior] and [posterior] in the literature. Although many phonological accounts have proposed either [±anterior] or [±posterior] binary features, we will use only the privative feature [posterior] for reasons of economy and relative markedness. That is, one might suppose that in a binary contrast only one of the features in a pair is actually necessary and the binarity is most simply captured by the presence or absence of that feature. Further, since anterior segments are quite common cross-linguistically, posterior segments seem to be less common, and neutralizations that are not co-articulatory in nature seem to be to anterior, let us assume that [posterior] is the marked feature. Thus a language with an alveolar stop in contrast with a palatal stop will specify them as [cor] and [cor, post], respectively.

At first glance this might seem a little odd because there do seem to be languages with alveo-palatal/palato-alveolar/post-alveolar segments that do not fall neatly into either the alveolar or palatal categories. How could such segments be described using just the dichotomy of [posterior] versus no feature? As it happens, post-alveolars have been the subject of much debate and seem to have peculiar properties. First, only fricatives and affricates are made at the post-alveolar place. Thus, there is a much smaller inventory of manners than are found at other places – this deserves an explanation. Second, post-alveolar and palatal segments never seem to be in contrast within a given language unless there is also a difference along another dimension (e.g. apical/laminal or see Miller-Ockhuizen and Zec this volume). As Ladefoged (1993:. 144) puts it, “there is no clear-cut distinction between these sounds [i.e. palatal] and palato-alveolar sounds.” Thus, calling both post-alveolar and palatal consonants [posterior] poses no problem for either contrastive systems or the use of privative [posterior].

Given the discussion of coronal features, we can now move on to other places. Note that it is very curious that not only can coronal have a more anterior articulation and a more posterior articulation, but this frontness and backness can be distinctive for the other places as well. Bilabials can be distinct from labiodentals, "velars" can be distinct from uvulars, and pharyngeals can be distinct from epiglottals. Further, it is suspicious that at least the [velar] and [phar] pairs seem to be in a markedness relationship similar to that of coronals. That is, the posterior version seems more marked than the anterior version. This parallel behavior among the passive places is easily captured if we assume that [posterior] can be combined with passive places other than coronal, as illustrated in (20).

(20)	Bilabial	[p, b, ɸ, β, m]	[lab]
	Labiodental	[f, v]	[lab, post]
	Velar	[k, g, x, ɣ, ŋ]	[vel]
	Uvular	[q, G, χ, ʁ, ɴ]	[vel, post]
	Pharyngeal	[ħ, ʕ]	[phar]
	Epiglottal	[ʜ, ʢ]	[phar, post]

This proposal departs from standard views regarding these features in two ways. First, it is a standard assumption that bilabials are more marked than labio-dentals. This is because only fricatives seem to contrast them, and if a language has only one fricative, it is most likely labio-dental. Thus, one would suspect the bilabial in a contrastive pair to be the more marked segment (having more features and thus is rarer). This reasoning is faulty for three reasons. First, if we look at all other manners, exactly the opposite markedness relationship holds. There are no languages with contrastive labio-dental stops or sonorants, and approximants that are labial are preferably bilabial. Second, there are many cases of labial spirantization where a bilabial stop remains bilabial and does not become labio-dental (e.g. Bashkir, Basque, Catalan, Dahalo, Efik, Gothic, Manobo, Périgourdin, Senoufo, Tatar, Tamil, Tzeltal – Lavoie 2001). Third, articulatory preference in the absence of a contrast is not a valid reason on its own to propose markedness relationships among phonological features. There are a number of competing articulatory and perceptual forces that may drive a segment toward one articulation or another (e.g. labio-dental fricatives may be preferred because more noise can be generated by using the hard edge of the teeth than the soft flesh of the upper lip, thus making them more perceptible). If there is no phonological featural contrast, it will not matter, phonologically, which articulation is chosen.

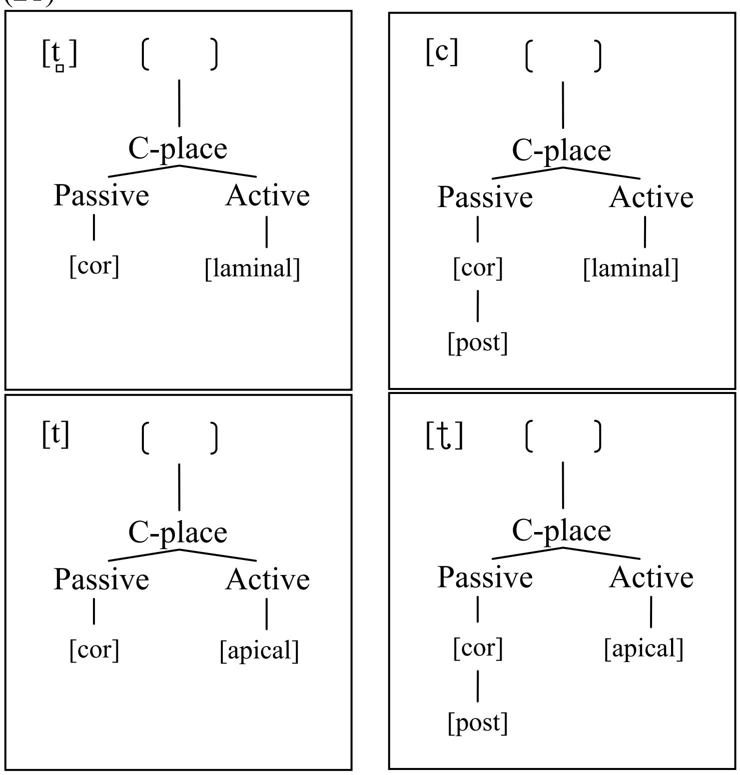
The second departure from standard views of [posterior] is that this feature is usually assumed to only be associated with coronal segments. This has led some to propose a universal feature geometry in which [posterior] ([±anterior]) is a dependent feature of coronal and cannot associate with other places. However, what is lost by such a claim is the fact that there seems to be a nice symmetry between "backness" and markedness *within each passive place of articulation*. Further, such models are forced to propose three additional features ([dental], [uvular], [epiglottal]), thus uneconomically propagating features. It would be nice to capture that front/back symmetry among passive places using the same, economical, mechanism.

2.1.2 Active place of articulation

The next descriptive split is among the active places of articulation. Since languages can contrast coronal sounds made with the tip of the tongue or the tongue blade, the tongue must be divisible as an active articulator. Those sounds made with the tip of the tongue have been called [apical], while those made with the blade have been called [laminal]. These differ from anterior/posterior in that they describe differences within an active articulator rather than a passive articulator. If we assume that each active articulator is privative and potentially specified in a given language, we must have the features [lower lip], [apical], [laminal], [dorsal] and [tongue root] minimally.

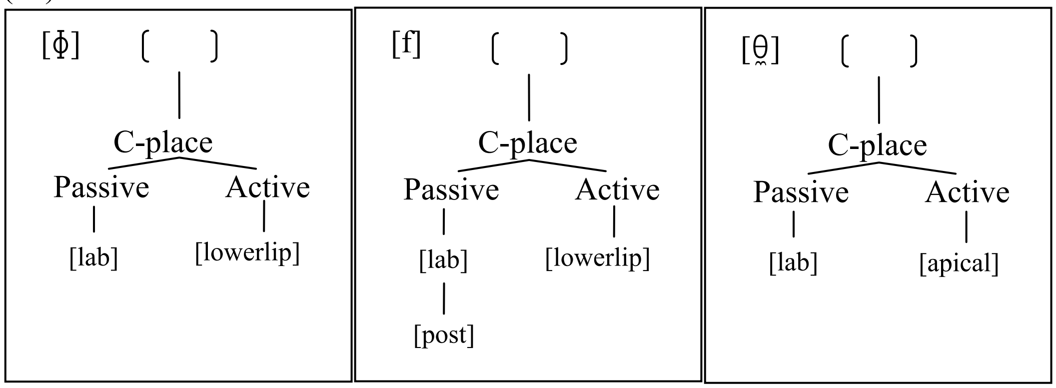
To briefly summarize, there is a variety of possible coronal contrasts. The class of coronals shares a [cor] passive articulator feature specification, and there are two ways to distinguish among them. Along the passive articulator dimension, they may be described as either anterior or posterior, where anterior coronals do not have an addition feature, but the posterior coronals have a feature [posterior]. In addition, coronals may contrast via the particular active articulator involved. Those made with the tongue blade/front have a [laminal] feature and those made with the tongue tip are [apical]. Combining these features fully, we find the representations and possible contrasts seen in (21). Note that although the active and passive place nodes are both represented here as dependent on the same C-place node, this is merely for convenience and is not meant to imply a particular universal structure. It may be the case that passive and active place are represented separately, as C-place$_{\text{Passive}}$ versus C-place$_{\text{Active}}$. We remain agnostic regarding this issue until further research is undertaken.

(21)



Before summarizing the discussion thus far, it is important to note that one place of articulation has been left out of the discussion – linguo-labial. This type of segment is quite rare cross-linguistically, and it is unclear if it is ever in contrast with linguo-dentals. The literature generally suggests that these are treated as coronals, not labials. If they are found to contrast with linguo-dentals, and that contrast cannot be analyzed as a difference between apical and laminal, then we will have to specify them as apical labials. If they are not found to contrast with linguo-dentals, then perhaps they are simply a phonetic variant of the coronal. At this point, we remain agnostic. However, the following are fully specified representations for some labial fricatives.

(22)



The table in (23) summarizes a sample of places of articulation and the features necessary to distinguish among them. Keep in mind that not all contrasts are found in any given language. In addition, we assume that features are only phonologically specified if there is a phonological contrast or overt evidence that that feature is relevant to a phonological process. Therefore, the table is slightly misleading in that it provides full feature specification.

(23)

	POA Features									
	Passive					Active				
POA Description	[lab]	[cor]	[vel]	[phar]	[post]	[lip]	[apic]	[lam]	[dor]	[root]
Bilabial	✓					✓				
Labiodental	✓				✓	(✓)				
Apical linguo-labial	✓						✓			
Laminal linguo-labial	✓							✓		
Apical anterior coronal		✓					✓			
Laminal anterior coronal		✓						✓		
Retroflex		✓			✓		✓			
Laminal palatal		✓			✓			✓		
Palatal		✓			✓				✓	
Velar			✓						✓	
Dorsal uvular			✓		✓				✓	
Gutteral uvular			✓		✓					✓
Pharyngeal				✓						✓
Epiglottal				✓	✓					✓

To summarize, there are four major place features, which can be characterized via the passive articulator involved. [labial] uses the upper lip region, [coronal] uses the roof of the mouth, [velar] uses the velum, and [pharyngeal] uses the pharyngeal wall. Within each passive place, there can be a further division based on how far front or back the articulation takes place on the passive articulator. A lack of specification implies a front articulation and [posterior] specifies a back articulation (if there is a contrast in the language). It is also possible to contrast sounds using active articulators. Bilabial sounds use the lower lip and are specified with [lip]. There is a division among those sounds using the front region of the tongue as the active articulator. If the tongue tip contrasts with the tongue blade/front, then the sounds made with the former have a specification of [apical] and those made with the latter are [laminal]. Note that retroflex is not assumed to have its own feature in this model, but is a combination of an active [apical] feature with a passive [coronal, posterior] specification. If the back region of the tongue is used, then there is a [dorsal] feature involved. Sounds of this type are back palatals, velars and non-guttural uvulars. Finally, those sounds that use the tongue root as active articulator (i.e. [root]) are guttural uvulars, pharyngeals and epiglottals.

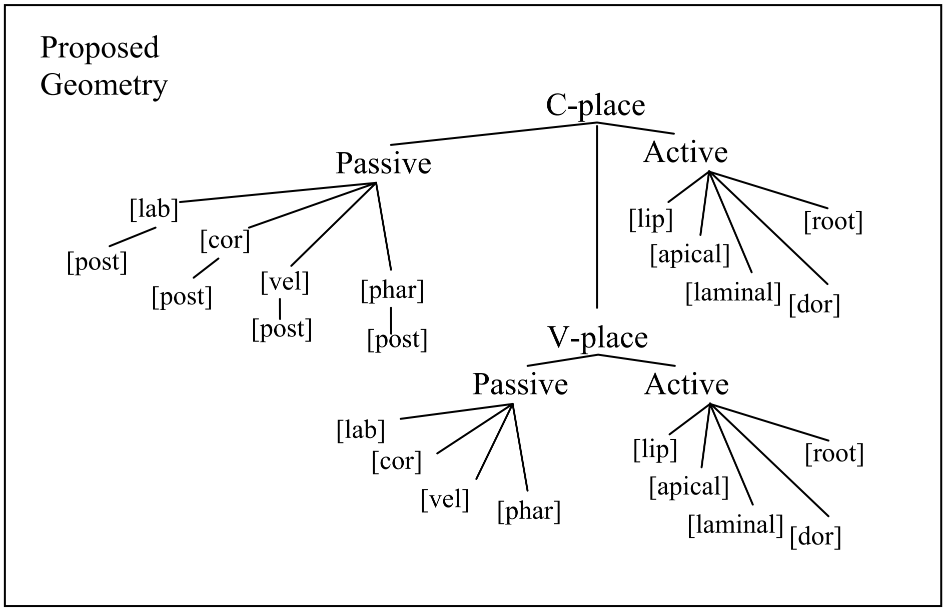
2.1.3 Simple vowel place

Within the Clements (1991) model of place, vowel place is quite simple: round vowels involve participation of both of the lips, thus are [lab], front vowels involve the front of the tongue and the palate, thus are [cor] and back vowels involve the tongue dorsum and the velum, thus are [dor]. The result is that vowel place features are the same as consonant place features. Within the model proposed here, however, we are differentiating between active and passive articulators, thus we must ask if vowels also make this distinction. In addition, we have seen that passive features may have dependent features (e.g. [posterior]). Are these also relevant for vowel place?

Since vowels are formed via shaping resonance cavities, it is very difficult to tell what the feature specifications are for a given vowel inventory. In the absence of definitive evidence for an active/passive split within vowel place, we remain agnostic and continue to use Clements' representations for convenience.[3] However, we assume, based on the sign language evidence below, that consonant and vowel place both include active and passive articulator features universally.

[3] One possible direction to look in answering this question is in the realm of gutturals. One natural way to unify uvulars, pharyngeals and epiglottals in some languages is to propose that they all involve a tongue [root] active place feature. This would be distinct from those languages in which velars and uvulars behave as a class and are defined as [velar] passive place. Interactions among guttural consonants and vowels might also be used as evidence for active place features. ATR/RTR systems might also be a place to look.

(24)



2.2 Simple manner of articulation and the major class features[4]

Recall that one of the difficulties with the feature geometry literature is the lack of consistency in the placement of both the major class features and the manner features – in some models, they are all associated directly with the root node, but in other models, manner and major class are represented differently. Also recall that Schein and Steriade (1986) and McCarthy (1988) propose that the major class features do not behave like other features, so are actually a part of the root node. Let us begin by addressing the first issue.

One reason to suppose that the manner and major class features should be represented similarly in the feature geometry comes from the original description of the major class features in SPE (see section 1). Each of the major class features "focuses on a different aspect of the open-versus-closed phase." (Chomsky and Halle 1968, p. 302) That is, they have to do with degrees of vocal tract constriction. Interestingly, the manner features also involve degrees of constriction and these capture the major stricture-based sonority classes within the consonant class, as shown in (25).

[4] I will not discuss the feature [nasal] in this paper. Pending further research, I remain agnostic with respect to how to represent this important feature. However, my intuition is that it is like the other manner features, which can be dependent on the C-manner and/or V-manner class nodes.

(25)

Consonant Class	Relative Openness	Relative Sonority
rhotic approximants		
lateral approximants		
fricatives		
stops		

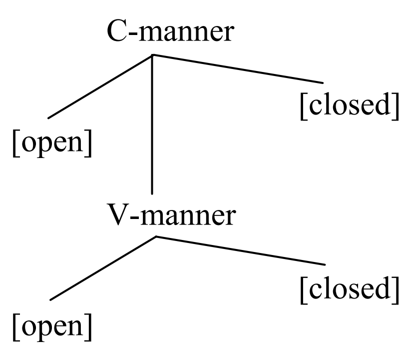
Not surprisingly, we find the same relationship among the vowels. High vowels are more closed than mid vowels, which are more closed than low vowels.

(26)

Vowel Class	Relative Openness	Relative Sonority
low		
mid		
high		

Within the class of obstruents, Steriade's Aperture Model (1993) captures this relative openness by using different types of root nodes. A_0 root nodes have a complete closure (i.e. stop gesture) and A_f root nodes have a partial closure that creates a turbulent air stream (i.e. fricative gesture). Within the class of vowels, Clements' Constriction Model (1991) captures relative openness of vowels via different features associated with an "aperture" node. [-open] corresponds roughly to a higher vowel, and [+open] corresponds roughly to a lower vowel. To unify the consonant and vowel constriction features, and to use manner structures that parallel the structures used for place, we propose (27).

(27)



In this representation, there are simply two manner nodes, one for consonants and one for vowels, and two features, [open] and [closed]. Further, V-manner is dependent on C-manner, just as Clements claims V-place is dependent on C-place. Using this geometry, a stop has a

C-manner of [closed], a fricative has a C-manner of [open], a high vowel has a V-manner of [closed] and a low vowel has a V-manner of [open] (we return to mid vowels in section 3.1).

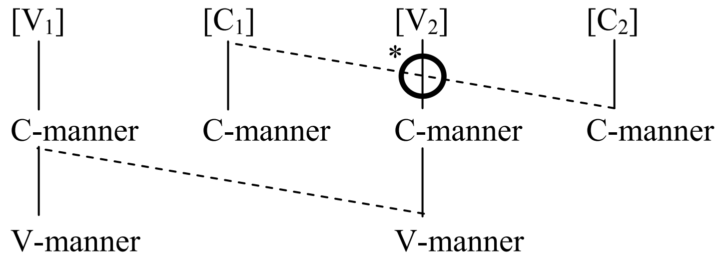
Just as in the place discussion above, this representation helps to explain several things. First, the articulatory similarity between consonant constriction and vowel constriction is captured using parallel nodes and the same terminal features. Second, the representation of sonorant consonants is captured in a natural way that relates directly to secondary place articulations. That is, a sonorant consonant has both a terminal C-manner feature and a terminal V-manner feature. This makes sense from an articulatory perspective because sonorants have a more constricted vocal tract than vowels but less constricted than fricatives. For example, a lateral approximant has a closure through the center of the oral tract, but is laterally open enough not to have significant air turbulence. The manner representation for a lateral approximant is given in (28).

(28)

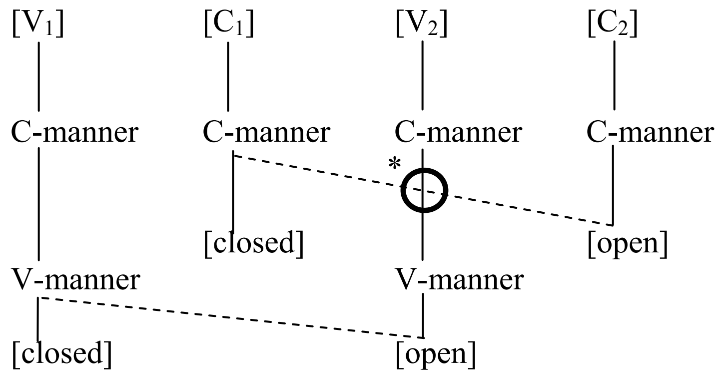
C-manner
[closed]
V- manner
[closed]

The third piece of evidence to support the representation in (27) comes from harmony asymmetries. While vowel height harmony is quite common cross-linguistically, obstruent manner harmony is quite rare. If all segments have a C-manner, but only vowels typically have a V-manner, then spreading a manner node or feature from one consonant to another consonant without the intervening vowel participating is prohibited because it involves line crossing. However, vowel manner may spread across intervening consonants with impunity if there are adequate constraints against forming sonorant consonants from obstruents, or if only the terminal feature spreads.

(29)



(30)

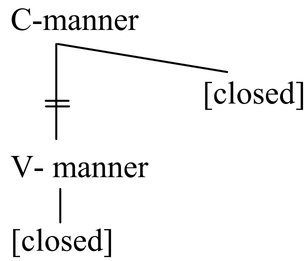


Finally, (27) helps to explain a longstanding puzzle regarding the relationship among lateral approximants, stops and high vowels. Let us begin with lateral-stop alternations. Many languages have a process of delateralization, in which a lateral approximant changes into a stop, e.g. Icelandic /al+la/ → [at.la]. This has been something of a phonological puzzle because there is very little featural similarity between lateral approximants and stops in the traditional feature specifications or traditional geometry, and it violates McCarthy's (1988) claim that major class features cannot delink. As (31) demonstrates, delateralization involves changing not only the manner features but also two of the major class features in a traditional analysis.

(31)
$$\left/\begin{array}{l}\textbf{+sonorant}\\ \textbf{+approximant}\\ \textbf{-vocoid}\\ \textbf{+continuant}\\ \textbf{+lateral}\end{array}\right/ \rightarrow \begin{pmatrix}\textbf{-sonorant}\\ \textbf{-approximant}\\ \textbf{-vocoid}\\ \textbf{-continuant}\\ \textbf{-lateral}\end{pmatrix}$$

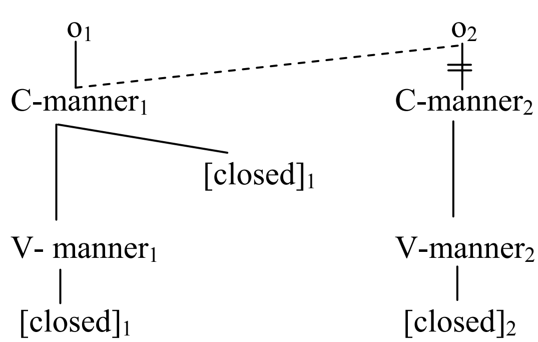
However, if a lateral approximant has both a stop feature and a vowel feature, then the simple delinking of the vowel feature turns the approximant directly into a stop.

(32) /l/ → [t]

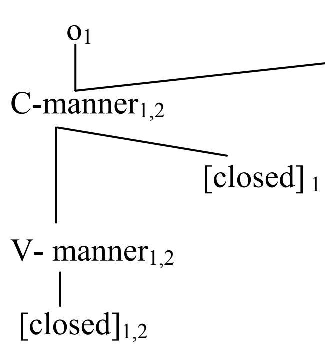


This representation also helps to explain the manner assimilation of high vowels to adjacent sonorants in the language Yi (Dell 1993). In this language, a high vowel peak will share all features with the preceding sonorant (except aspiration) in certain syllables. This may be straightforwardly captured in one of two closely related ways. The first is demonstrated in (33) and entails spreading one C-manner node and delinking the other. The second is shown in (34) and involves fusion/coalescence. In both of these depictions, 'o' indicates an unspecified dominant node and the indices indicate underlying affiliation.

(33) /li/ → [ll]



(34) /li/ → [ll]



What is important here is that a sonorant consonant seems to be able to spread its consonant aspect to an adjacent vowel. This is counter to McCarthy's (1988) claim that the major class features cannot spread, but is predicted in the present model. Note that there are two further important results of the unification of consonant and vowel manners proposed here. First, there is no longer a need for the feature [lateral]. Laterality is the result of a simultaneous [closed] C-manner and a more open oral gesture, as we saw in (28) for the approximant lateral.

Second, this model eliminates the need for the major class features. Consonants differ from vowels via the presence or absence of a C-manner terminal feature. Sonorants differ from obstruents via the presence or absence of a V-manner terminal feature. Thus, we have explained why the major class features do not seem to behave the way other features behave – they are not features at all. The major classes are defined representationally, not featurally as shown in (35).

(35)	Consonant class:	Presence of a C-manner feature
	Vowel class:	Absence of a C-manner feature
	Sonorant class:	Presence of a V-manner feature
	Obstruent class:	Absence of a V-manner feature

To summarize, we have proposed an economical representation and set of features for manner in which the manner geometry parallels place geometry in that there is a V-manner node dependent on a C-manner node, and the same features are used at both levels. This explains several puzzles, such as harmony asymmetries and the relationship between approximants and both stops and high vowels. Importantly, it reduces the set of necessary features by eliminating the [lateral] and major class features.

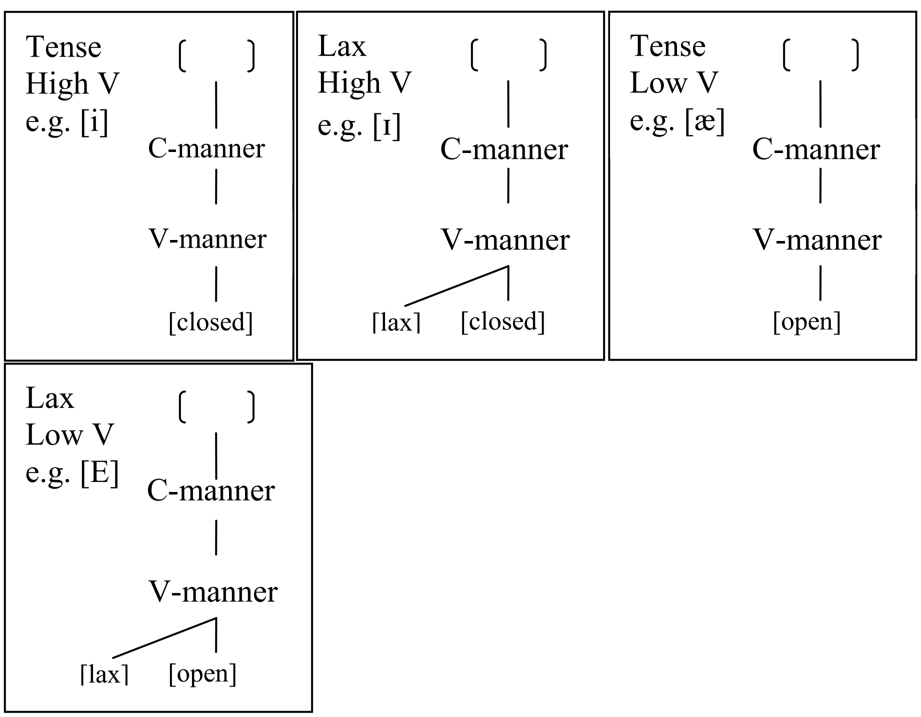
2.2.1 Articulator rigidity: Stridency, trills, flaps and laxness

In addition to the relative constriction of the vocal tract, we must also discuss the issue of articulator rigidity when exploring manner of articulation. Within the realm of consonants, non-stridents, trills and flaps are somewhat problematic for current models of feature geometry since stridency is relevant only to fricatives, and trills and flaps are relevant only to stops and/or approximants. In addition, the literature is not clear regarding where these features should appear in the geometry. Traditionally, these characteristics have been given their own features, [strident], [trill], [flap] and [tense]/[lax] (for vowels). However, this proliferation of features is certainly uneconomical, and the apparent manner-particular restrictions on cooccurrence are difficult to capture in a natural, non-stipulative way.

We propose that viewing articulator rigidity more generally as an aspect of manner of articulation allows for the natural unification of stridency, trills, flaps and laxness across segment types. Further, we propose that the feature [lax], combined with other features within the consonant and vowel manner structures, provides the full range of contrastive manner segments. This move not only eliminates the need for manner-particular cooccurrence restrictions, but it does so using phonetic motivation.

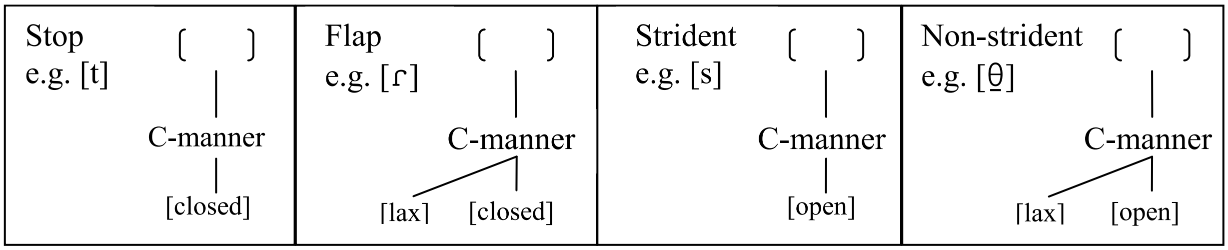
Given the assumption that the unmarked case is tense and the marked case is lax, then tense high and low vowels have only a closed and open V-manner feature, respectively, while lax high and low vowels have an added V-manner feature of [lax]. This is illustrated in (36).

(36)



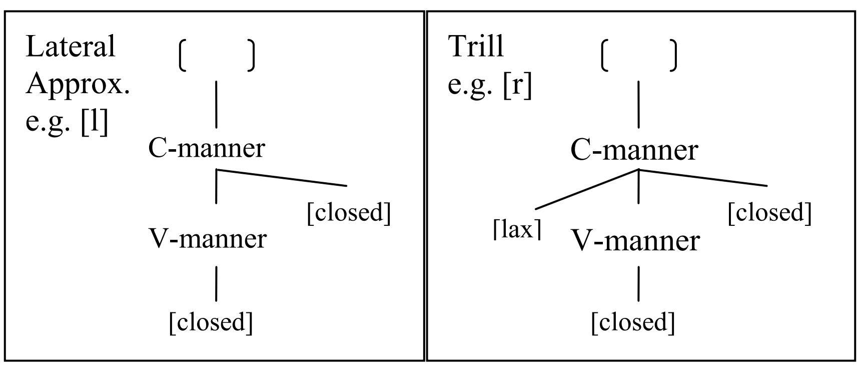
If we look at stops and fricatives, we find that the more lax articulation is also the more marked. Therefore, we propose that a flap in contrast with a stop differs only in the presence of a [lax] C-manner feature, as does a non-strident fricative at the same place of articulation as a strident fricative. This is shown in (37).

(37)



Finally, a lateral approximant differs from a trill in that the trill has a less rigid articulation, thus allowing the airflow to disrupt the closure gesture.

(38)



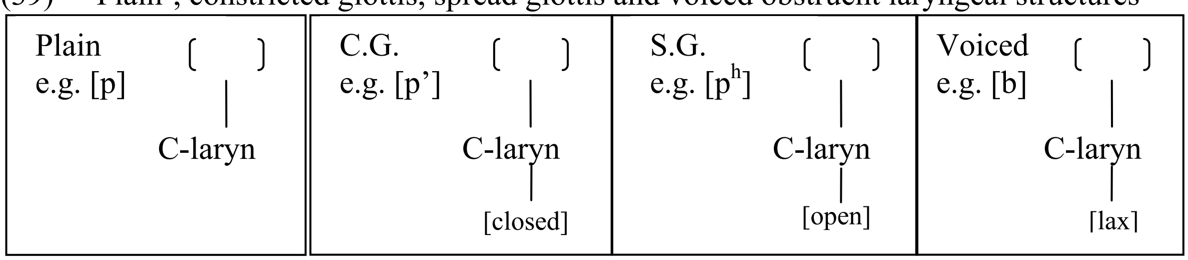
To summarize, viewing relative articulator rigidity as a characteristic of manner of articulation and formalizing this with a [lax] manner feature reduces the set of features and straightforwardly explains stridency, trills, flaps and tense/lax vowels.

2.3 Simple laryngeal features and tone

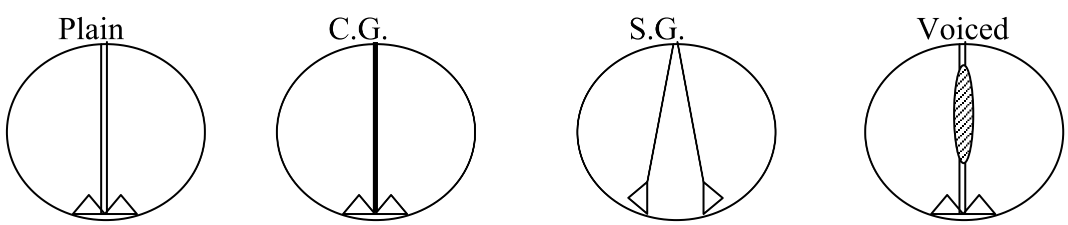
Using manner of articulation as a backdrop, we can now move on to a discussion of laryngeal features and tone. Recall that manner may be defined as a combination of vocal tract constriction and articulator rigidity. Interestingly, Halle and Stevens (1971) described the laryngeal features in terms of glottal width and glottal tension. We propose that laryngeal features and geometry mirror those used for manner. Let us begin with consonant laryngeal specifications.

Consonants with simple laryngeal specifications may be described as plain, constricted glottis, spread glottis and voiced. Plain obstruents have a neutral glottal configuration (section 1.4.1 and Chomsky and Halle 1968, p. 301), and thus have no laryngeal features. Glottalized obstruents have a constricted glottis and, therefore, have a consonant laryngeal specification of [closed]. "Aspirated" obstruents have a spread glottis, and thus a consonant laryngeal specification of [open]. Finally, phonologically voiced obstruents have a feature of [lax]. The proposed representations are given in (39), and the corresponding glottal configurations are illustrated in (40).

(39) Plain[5], constricted glottis, spread glottis and voiced obstruent laryngeal structures



(40)



[5] We remain agnostic regarding the presence or absence of class nodes in the absence of dependent feature specifications.

Since one of the goals of this paper is to show parallels between consonant and vowel features and representations, it would be nice to find a vowel equivalent to laryngeal features. If we look carefully enough at the articulation of tones, we find that there are various degrees of glottal constriction and glottal tension involved there as well. High tones have a narrowing of the glottal opening accomplished by using the intrinsic laryngeal muscles to stretch the vocal folds, and low tones have a widening of the glottal opening accomplished by using the intrinsic laryngeal muscles to slacken the vocal folds. In addition, overall pitch range, or register, is manipulated via adjustments of the extrinsic laryngeal muscles that adjust the distance between the cricoid and thyroid cartilages. We may interpret these facts as evidence of [closed], [open] and [lax] features associated with a V-laryngeal node. Note that unmarked mid tones are represented here by the lack of a terminal tone feature.

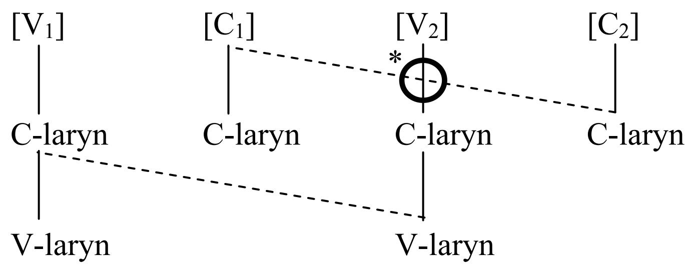
(41)

Unmarked Mid Tone	High Tone	Low Tone
[ ] | C-laryn | V-laryn	[ ] | C-laryn | V-laryn | [closed]	[ ] | C-laryn | V-laryn | [open]

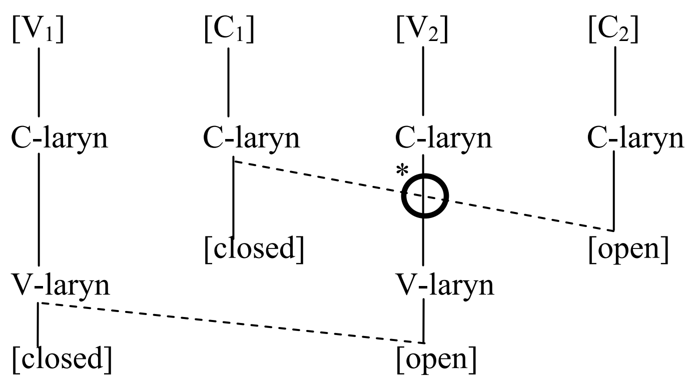
Register Tone
[ ] | C-laryn | V-laryn | [lax]

Note that viewing laryngeal features and tones in this way straightforwardly captures the harmony asymmetries found between consonant laryngeal features and tones. While vowel tone harmony/spreading is quite common cross-linguistically, obstruent laryngeal harmony is quite rare (if not non-existent). If all segments have a C-laryngeal, but only vowels typically have a V-laryngeal, then spreading a larygneal node or feature from one consonant to another consonant without the intervening vowel participating is prohibited because it involves line crossing. However, vowel larygneal may spread across intervening consonants with impunity if there are adequate constraints against associating tones with consonants or if only the terminal feature spreads.

(42)



(43)



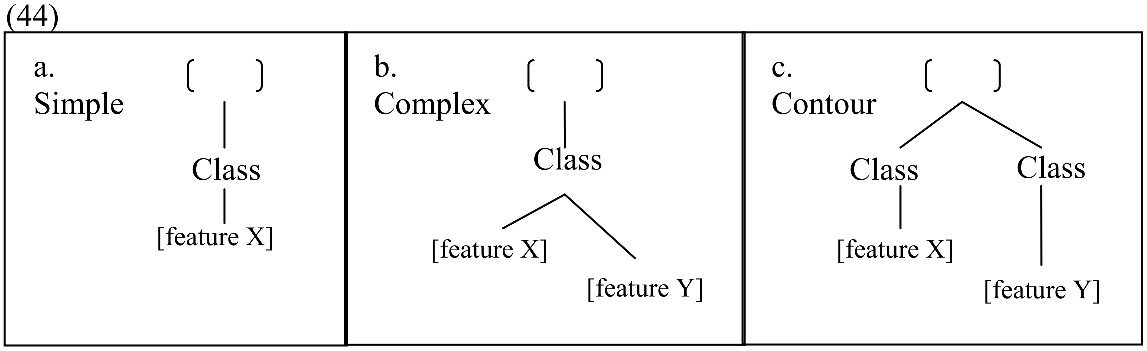
Interestingly, the documented raising and lowering effect of spread glottis (C-laryn[open]) and phonological voicing (C-laryn[lax]) on the tone of the following vowel described in section 1.5.1 is now easily explained. The transition from a spread glottis consonant to the vowel involves an active *closing of the glottis*. This has the same raising effect on F0 as the V-laryn[*closed*] configuration of a lexical high tone. Similarly, the lowering effect of a preceding voiced consonant is easily explained since both phonological voicing and low tone involve a slight *opening of the glottis*. Although we claim that this a phonetic effect, we suggest that it may be phonologized (interpreted as the presence of V-laryngeal features) over time, resulting in tonogenesis.

To summarize, we claim that the laryngeal representations and feature set are basically the same as manner of articulation. This makes sense from an articulatory perspective since both laryngeal specifications and manner of articulation involve degrees of constriction of the vocal tract and articulator rigidity. Further, we claim that tones are represented as [open], [closed] and [lax] features associated with a V-laryngeal node.

3. Simple, complex and contour segments

So far, the discussion has revolved almost exclusively around simple segments, i.e. segments with a single root node and only a single class node or feature on any given tier. However, there are other segment-internal structural possibilities that should not be ignored. Complex segments have a single root node, one class node of a particular type, and more than one terminal feature associated with that class node. In contrast, contour segments have a single root node and more than one class node of a particular type, each of which has at least one terminal feature. The phonetic contrast between the complex and contour segments is in the timing of articulations. In complex segments, the terminal features are simultaneously articulated, as one might expect given no tier adjacency. However, contour segments have terminal features that are sequentially articulated because of the adjacency of more than one class node on a single tier. These three segment types can be represented as in (44).

(44)

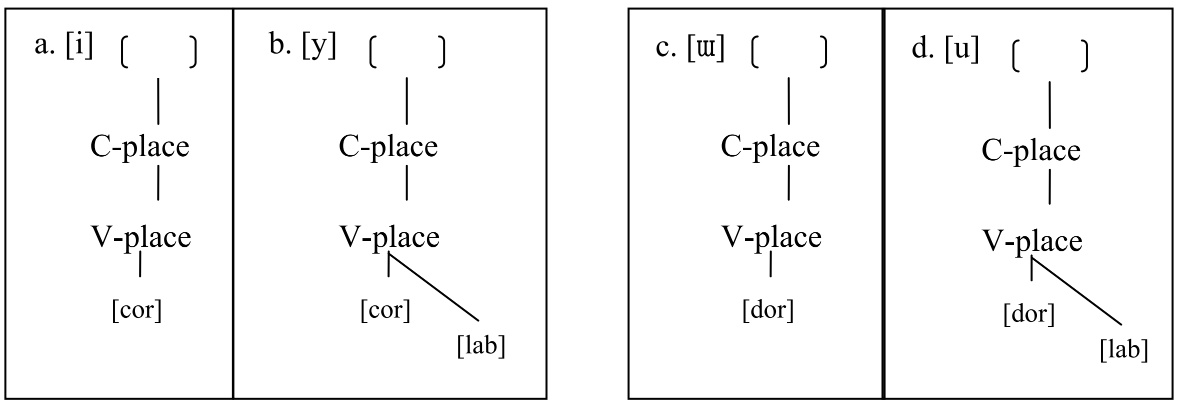


3.1 Complex segments

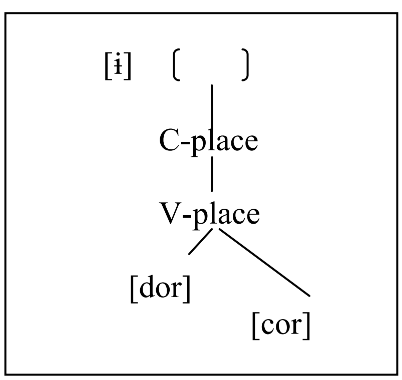
Unlike the secondary articulations discussed above, which have different terminal features on different class nodes, complex segments have different terminal features on the same class node. We find these both within the class of vowels and the class of consonants, and for place, manner and laryngeal articulations.

Within the class of vowels, complex place is found in contrastive rounding and possibly contrastive central vowels[6], as shown in (45) and (46).

(45) Unrounded/rounded front vowels Unrounded/rounded back vowel contrast



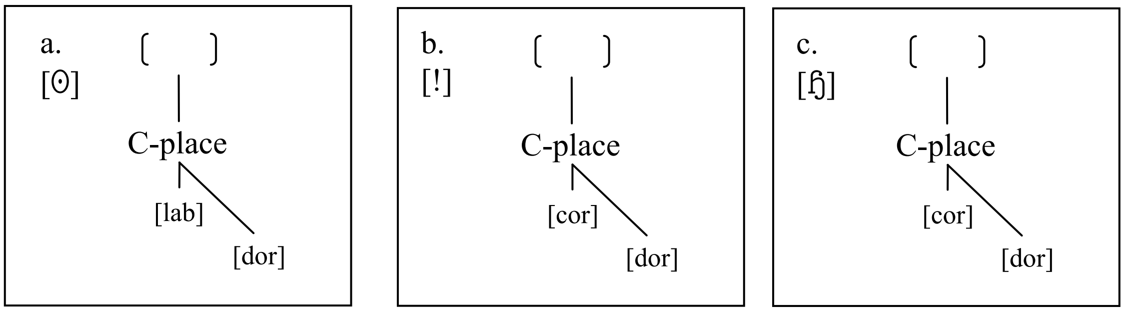
(46) Central vowel as a combination of [dor] and [cor]



In the realm of consonants, there are several languages that have multiply articulated consonants. It is clear that clicks have simultaneous multiple place articulation, since the defining characteristic of the velaric airstream mechanism is a simultaneous velar closure and a more anterior closure. In addition, fricatives can have complex place, as in the [ɧ] found in Swedish.

[6] We maintain that contrastive central vowels are not structurally identical to reduced central vowels, which some have claimed are placeless.

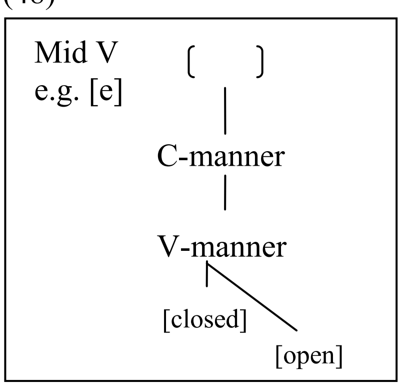
(47)



Complex manner is also found for both vowels and consonants. We have already discussed complex consonants and vowels that have an [open] or [closed] feature in combination with a [lax] feature (i.e. non-stridents, flaps, trills and lax vowels). However, there are other complex segments that combine both [open] and [closed] features under the same manner node.

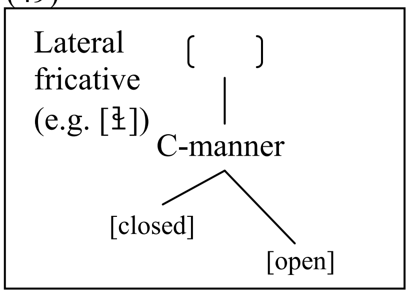
Mid vowels are complex in this model. Contrary to SPE, which claims that “it is impossible to raise the body of the tongue above the neutral position and simultaneously lower it below that level” (p. 305), we claim that simultaneous raising and lowering gestures result in an intermediate tongue position and a vocal tract constriction mid-way between a high and low vowel. The manner structure proposed here for mid vowels is shown in (48).

(48)



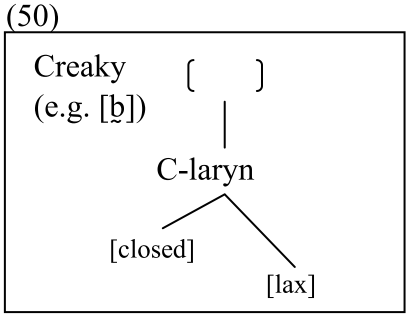
An example of a consonant with complex manner is the lateral fricative. Recall that laterals are defined in this model by a C-manner of [closed] simultaneously articulated with a more open gesture. In the case of the fricative, the tongue creates a complete closure (C-manner[closed]) in the center of the oral tract and a slightly more open articulation (C-manner[open]) laterally. The lateral constriction is such that frication occurs.

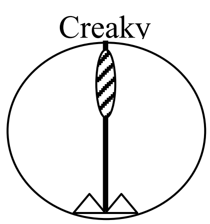
(49)



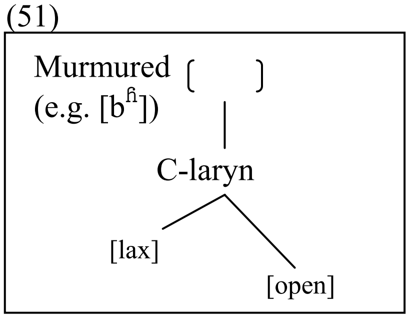
Simultaneous laryngeal articulations are also found for both consonants and vowels. Creaky voice has a C-laryngeal node with both a [closed] and [lax] feature, murmured voice has both an [open] and a [lax] feature, and breathy voice has both an [open] and a [closed] feature. The breathy voiced configuration has a glottal opening intermediate between constricted glottis and spread glottis (characterized by simultaneous glottal pulses and glottal frication). These representations are given in (50) through (52) with illustrations of corresponding glottal configurations.

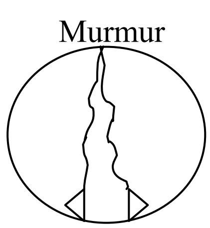
(50) <u>Glottal Configurations</u>



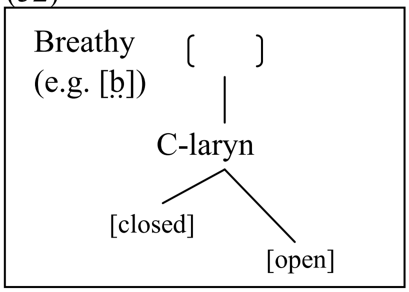


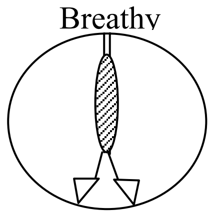
(51)





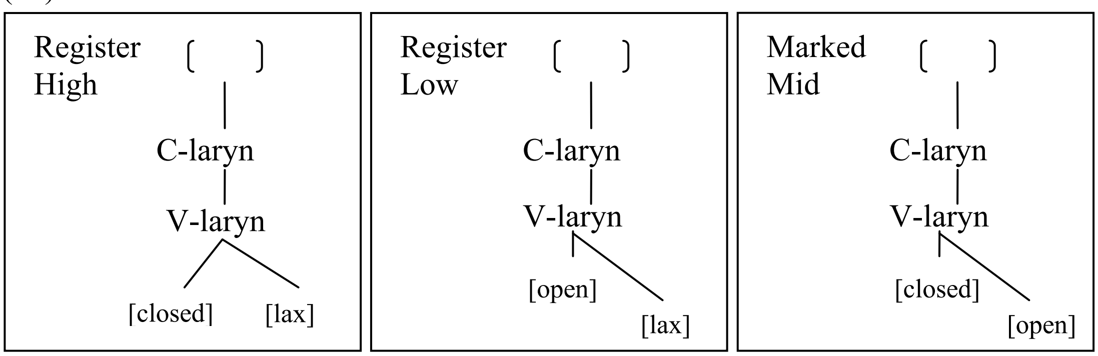
(52)





Complex vowel laryngeal specifications correspond to register high, register low and marked mid tones in this model.

(53)



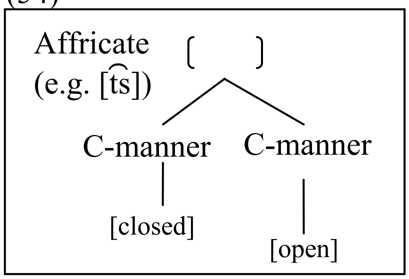
To summarize, complex segments in this model are defined as single segments with more than one feature associated with a single class node. Unlike the traditional literature, we claim that segments can have complex place, manner and laryngeal representations.

3.2 Contour segments

Unlike complex segments, which have different terminal features on the same class node, contour segments in this model have different terminal features on different adjacent class nodes. We find these both within the class of vowels and the class of consonants, again, for place, manner and laryngeal articulations.

Most researchers discuss contour segments only from the perspective of contour manner, specifically affricates. Since these are the best studied, let us begin there. The distinguishing characteristic of affricates is that they are sequentially ordered manner gestures that are treated phonologically as part of a single segment. This is easily captured via the representation in (54). A single root node implies a single segment, and adjacent C-manner nodes imply linearity of the dependent stop and fricative features.

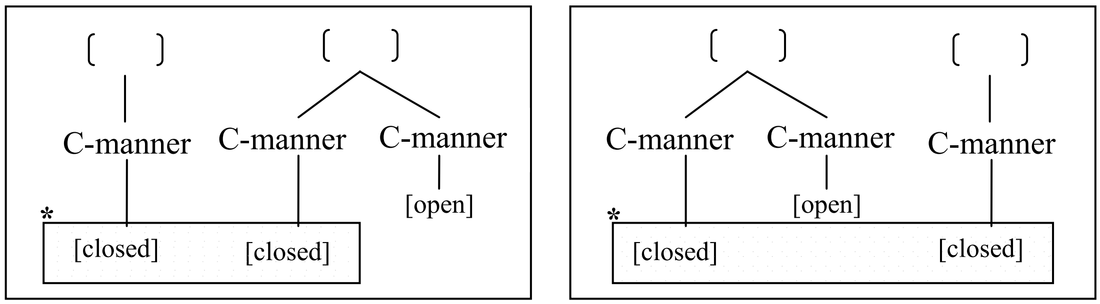
(54)



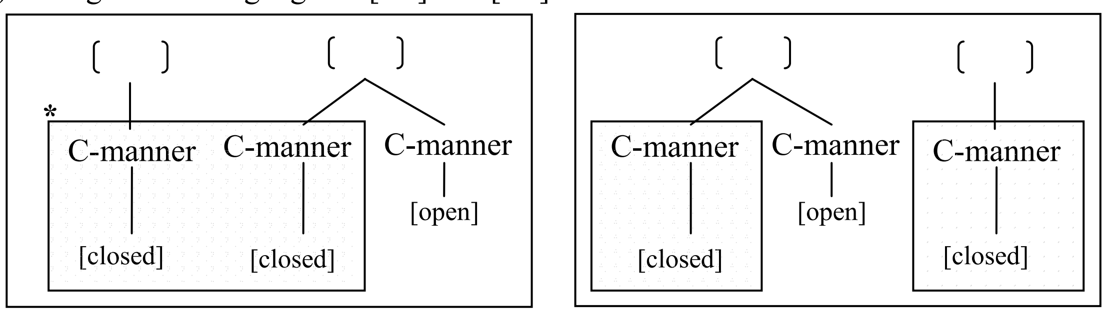
Note that this representation potentially resolves the "edge effect" (Anderson 1976) controversy with respect to affricates. In some languages, affricates seem to bear one continuancy feature with regard to segments on one side but the opposite feature with regard to segments on the other side, while in other languages, the continuancy features seem phonologically unordered (see Hualde 1988, Lombardi 1990 and Steriade 1993). For example, one language might prohibit a stop followed by an affricate across a syllable boundary (*[t.t͡s]) and allow an affricate followed by a stop ([t͡s.t]), while another might prohibit both (*[t.t͡s] and *[t͡s.t]). As (55) and (56) show, parameterizing the structural definition of the OCP will result in the two language types. If the OCP is sensitive to just the adjacent terminal feature, *[closed][closed], then there is no edge effect.[7] However, if the OCP is sensitive to a more complex structure, *C-manner[closed]C-manner[closed], there will be an edge effect.

[7] Another way to do this might be to parameterize the local domain under which the OCP conditions apply. For an anti-edge effect case, the local domain under which *[closed][closed] applies is adjacent C-manner nodes. For an edge effect case, the local domain for *[closed][closed] is adjacent root nodes.

(55) Anti-edge effect language – *[t.t͡s] and *[t͡s.t]



(56) Edge effect language – *[t.t͡s] and [t͡s.t]

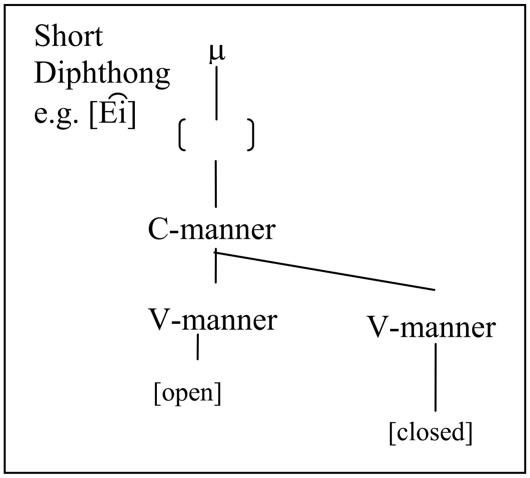


To briefly summarize, we propose that affricates are contour segments with two adjacent consonant manner class nodes, each with a different terminal feature. In addition, we suggest that edge effects and anti-edge effects could be the result of differences in the structural complexity under which processes/restrictions apply.

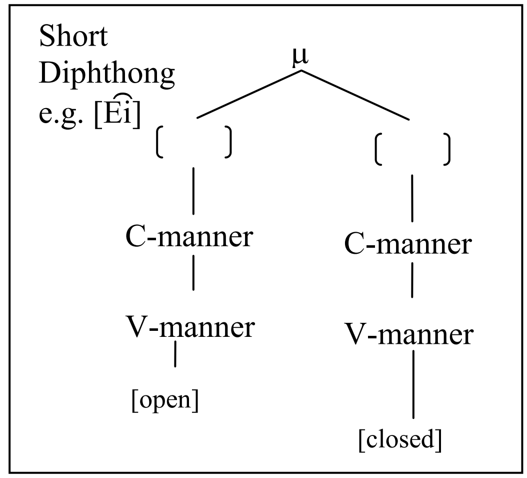
One further interesting fact worth noting is that there is a strong, if not absolute tendency for contour obstruents to begin with a stop gesture and end with a fricative gesture. This may simply be the result of a phonetic preference for a sonority cline from least sonorous to most sonorous in the first half of the syllable, or it may be a phonological principle. As we will see in the discussion of sign language, there is evidence that phonology is involved in this generalization.

Within the class of vowels, one likely candidate for status as a contour manner segment is the short diphthong. In some languages, certain diphthongs (sequence of vocalic gestures) are short. There are two logical possibilities to account for this. One possibility is that two root nodes are associated with a single mora, and the other possibility is that two vowel manner nodes are associated with a single root node. These are shown in (57).

(57) One-root analysis of a short diphthong



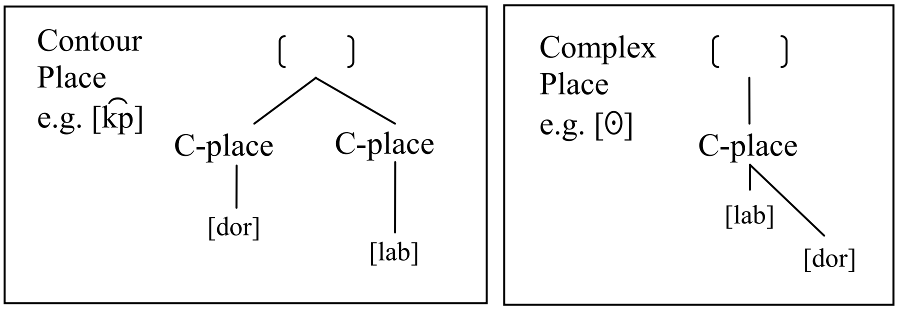
Two-root analysis of a short diphthong



Although more research is needed here, it seems likely that both possibilities will be found to exist in different languages. Interestingly, short diphthongs seem to move from a more open gesture to a more closed gesture, exactly the opposite of affricates. We will return to this fact during the discussion of sign language below.

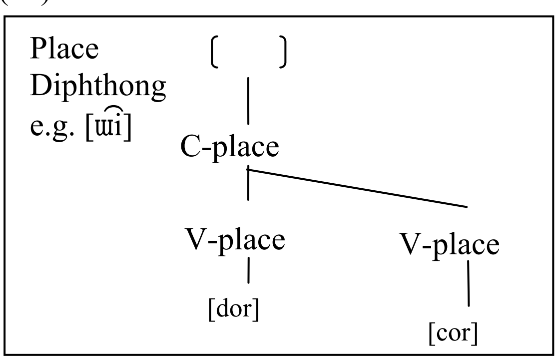
Contour place of articulation is a little more controversial than contour manner. Many have claimed that the multiply articulated stops in some languages have *complex* place. For example, Clements and Hume (1995) briefly discuss the labio-velar stop [k͡p] of Yoruba and the alveolar click [!] of Bantu and Khoisan languages as being complex segments since they are described by Maddieson and Ladefoged (1988) and Ladefoged (1968) as having simultaneous articulations, respectively. However, some languages also have labial clicks that have simultaneous labial and velar stop articulations, and one must wonder what the phonological difference is between a [k͡p] segment and [ʘ] segment. One possibility is that there is a feature [click] or [velaric airstream]. However, we reject this feature in favor of a representational option. The proposal made here is that one of these segments has a complex place and the other a contour place. Our tentative proposal is that clicks are complex place segments since the nature of the velaric airstream mechanism requires simultaneous closure at two places of articulation. Thus, the other multiply articulated stops have contour place.

(58)



Finally, there is little literature on contour vowels in general, and none on contour vowel place. However, given the representations proposed in our model, the prediction is that we should find short diphthongs that change place. One possible candidate is the Russian high central vowel, which is sometimes pronounced (depending on the individual and context) as a high back to high front diphthong (Wayles Browne, pc). The proposed representation is shown in (59).

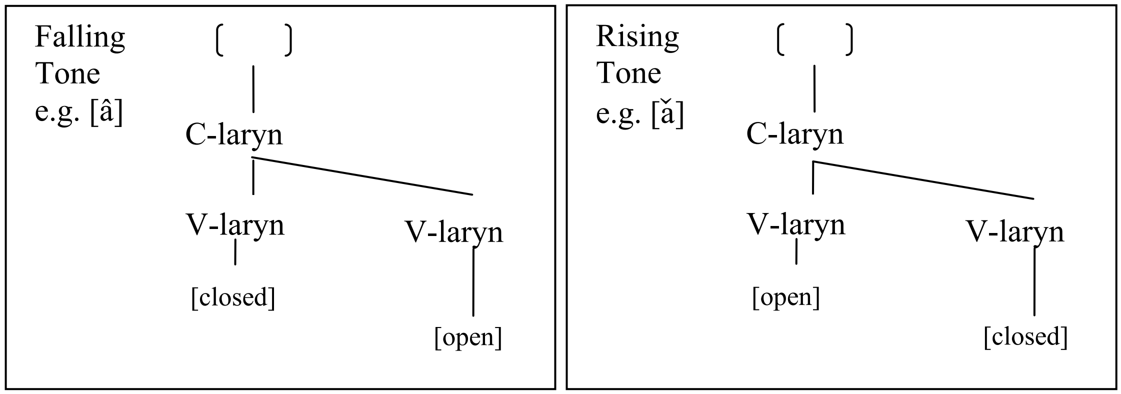
(59)



Of the contour laryngeal configurations, those for vowels (tones) are the most straightforward. Assuming that all phonological features must ultimately be associated within a segment regardless of the prosodic domain that may have licensed it (e.g. the tone bearing unit can be the mora, syllable, foot, etc.), then a contour tone segment is one in which there are two V-laryngeal nodes, each with a terminal feature. The falling and rising contour tone segment representation proposed in this model are shown in (60). Comparing (60) with

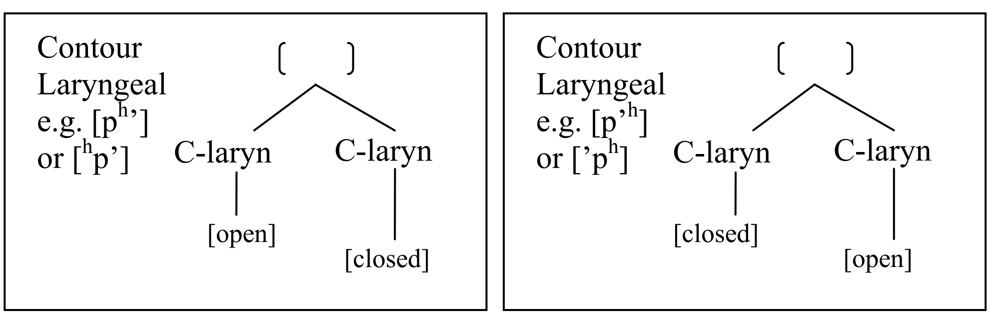
(53), we see that these contour tones differ from a complex tone (i.e. marked mid tone) in that the former have two V-laryngeal class nodes and the later has only one.

(60)



Contour laryngeal structures for consonants are a little more difficult. While we are not aware of consonants with laryngeal contours, the prediction here is that they would be glottalized-aspirated or aspirated-glottalized segments. The obvious implication of these structures is that there is a linear order between the constricted and spread glottis gestures. The relevant representations are given in (61).

(61)



Contour segments in this model are defined as single segments with more than oneclass node on a single tier, each of which has at least one terminal feature. Unlike the traditional literature, we claim that segments can have contour place, manner and laryngeal representations.

To summarize the Parallel Structure Model and the discussion of spoken language, this model makes use of parallel structures and feature sets wherever possible. The underlying assumption is that the grammar should make use of an economical set of phonetically grounded features and structures. Thus, we find that manner of articulation, place of articulation and laryngeal structure all have a V-class node dependent on a C-class node, with the same features shared between the two related class nodes. Further, we claim that manner of articulation and laryngeal specification use the same features since they both represent degree of vocal tract constriction and articulator rigidity. This model denies the existence of major class features and the features [lateral], [strident], [trill] and [flap]. In addition, we demonstrated that segments can have simple, complex or contour place, manner or laryngeal structures. Finally, we claim that place of articulation must include a set of active, as well as passive articulator features.

4. Sign language segments

As stated earlier, one of the major problems with current segmental work in sign language phonology is the fact that the proposed representations are very modality specific. Although they do make use of autosegmental representations and in some cases feature privativity, the features and representations have very little resemblance to those proposed for spoken languages. This is not to say that sign language segments should slavishly conform to current phonological models (which may be wrong), but there should be some attempt to bridge the gap between spoken and signed language representations. We claim that the Parallel Structures Model is a major step toward a unification of segmental structures across modalities.

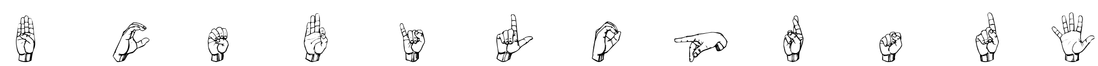
In this paper, we begin with the assumption that abstract mental representations are universal and that the same basic structures are used in both modalities. Our job, then, is simply to look for functional parallels (both phonetic and grammatical functions) and to map the various phonetic features found in both language types to the same phonological representations. Ultimately, our unified model of phonology should be the result of a convergence of as many facts from as many different languages as possible, including signed languages.

In this section, we briefly review three of the core components of any sign (handshape, location and movement) and show that location corresponds to passive place of articulation and overall handshape corresponds to manner of articulation, but that the fingers selected in different handshapes correspond to active place articulators. We will not address the issue of movement, but will make some tentative suggestions regarding the nature of non-manual gestures (e.g. linguistic features articulated with facial expressions). Although we acknowledge that a cross-linguistic study of signed languages is necessary to truly support our claims of universal structure, we concentrate on the phonetics and phonology of American Sign Language (ASL) in this paper.

4.1 ASL manner = Handshape (almost)

Every sign in ASL has been described as having at least three components: a handshape, a location and a movement (Stokoe 1960). Handshape is fairly self-explanatory in that it is the shape of the hand, and can consist of a number of selected fingers held in a number of configurations. Examples of some of the handshapes used in ASL are given in (62) with their corresponding finger-spelling and numerical values.

(62)



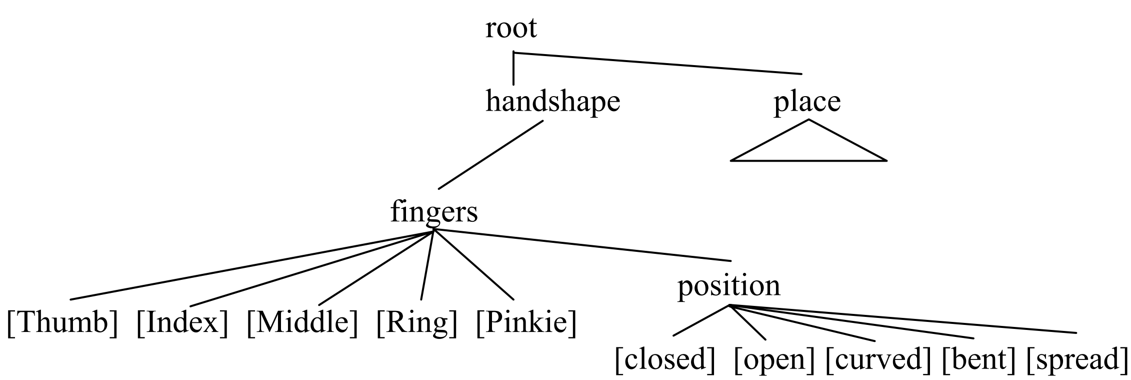
B C E F I L O P R S 1 5

Location refers to where the hand is in the sign space. For example, the sign THINK uses the 1 handshape (a fist with an extended index finger) with the tip of the index finger touching the ipsilateral forehead with the palm of the hand toward the signer. Here the forehead is the location of the sign. In comparison, the same handshape can be used with the tip of the index finger touching the sternum in the sign for 1^{st} person singular. Here the center of the torso is the location.

Finally, movement refers to what type of movement the hand makes during the articulation of a sign. For instance, the sign THINK actually consists of the 1 handshape which moves from neutral signing space (roughly the area in front of the torso) to the forehead. In comparison, the sign WHERE uses the same handshape in neutral space, but rather than moving to a location on the body, the finger points up and wags back and forth while the palm faces away from the signer.

There are many proposals in the sign language literature for how to represent these three components in a phonological representation. What is important for us in the present discussion is that all of the segment representations proposed regard handshape as a single constituent that is modality-specific. (63) provides a representative structure proposed in the sign language literature.

(63) Sandler 1989 (only relevant structures are shown here)



Note that this type of representation shows little similarity with the models of feature geometry for spoken languages that have been proposed in the literature and discussed above. What is the spoken language equivalent of the handshape node, or the fingers node, or the position node? What might the [index] or [curved] features functionally correspond to in spoken language?

We propose that handshape is not a constituent, despite traditional descriptions and analyses. Rather, the node that Sandler labels “position” actually corresponds to manner of articulation in spoken language geometry. In addition the selected fingers that are listed under the fingers node are actually active articulators that are a part of the place of articulation structure (similar to lower lip, tongue, and epiglottis in spoken language). We begin with the manner features here and move on to the place features in the following subsection. We will show that what are usually called “closed” handshapes and “open” handshapes in the sign language literature correspond to C-manner and V-manner segmental structures, respectively, and we find simple, complex and contour handshapes that correspond nicely with spoken language simple, complex and contour manners.

4.1.1 Simple, complex and contour "open" handshapes: ASL "vowel" manner

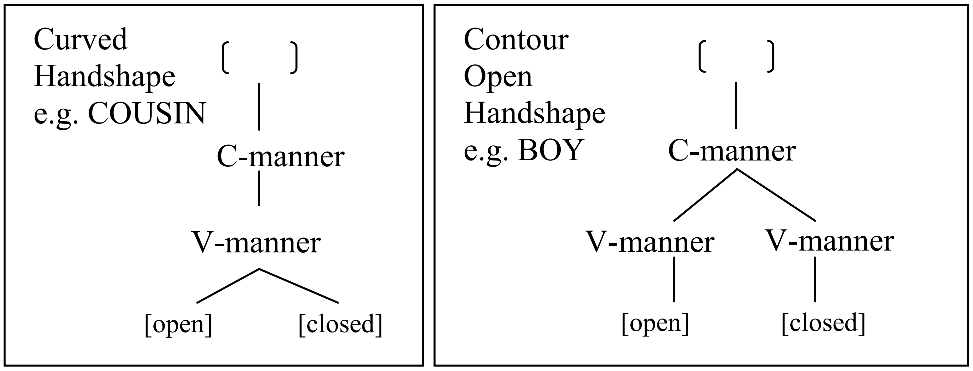
Handshapes are usually described in terms of various degrees of openness, just as spoken language manner may be described as various degrees of openness of the vocal tract. This is the first functional clue that these two characteristics may be represented similarly in the grammar. The most open handshape has all fingers extended, and is sometimes called the "open B". It is used in the POSSESSIVE signs, and looks like the finger-spelled B in (62), but with the thumb extended. If one bends the fingers at the base joint, then one gets what is sometimes called the "bent B". This handshape is found in the sign AGAIN. We claim that the "open B" and the "bent B" are structurally equivalent to low and high vowel manners, respectively. The relevant structures are given in (64).

(64)

Open Handshape e.g. MINE	[ ] | C-manner | V-manner | [open]	Bent Handshape e.g. AGAIN	[ ] | C-manner | V-manner | [closed]

Combining both [open] and [closed] features under the same V-manner node, we get a complex handshape sometimes called the "curved B". This handshape is found in the finger-spelled C in (62), is used in the sign COUSIN, and is equivalent to a mid vowel with respect to manner. Combining the [open] and [closed] features under two different V-manner nodes, we get the equivalent of a false-diphthong (contour vowel manner) – that is, a sequential handshape change from "open B" to "bent B". This contour handshape is found in the sign for BOY.

(65)

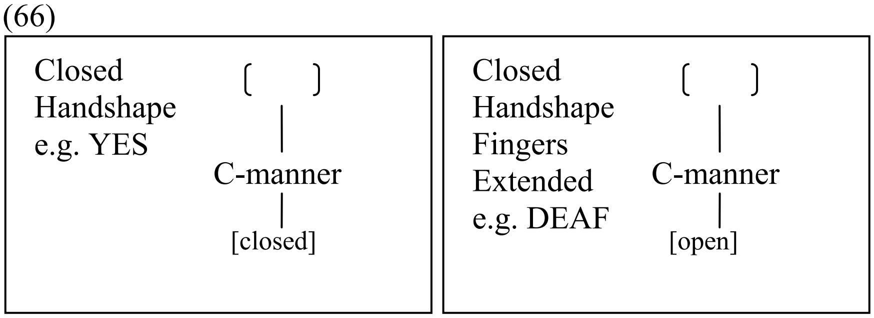


An interesting fact about contour "open" handshapes is that they preferably move from more open to more closed, just as contour vowel manner spoken segments do. If we are correct in our assertion that "open" handshapes do have V-manner structures and features, then this preference for closing rather than opening must be a phonological condition. After all, there is no phonetic or sonority motivation for this preference in signs – opening and closing "open" handshapes are both equally easy.

4.1.2 Simple, complex and contour "closed" handshapes: ASL "obstruent" manner

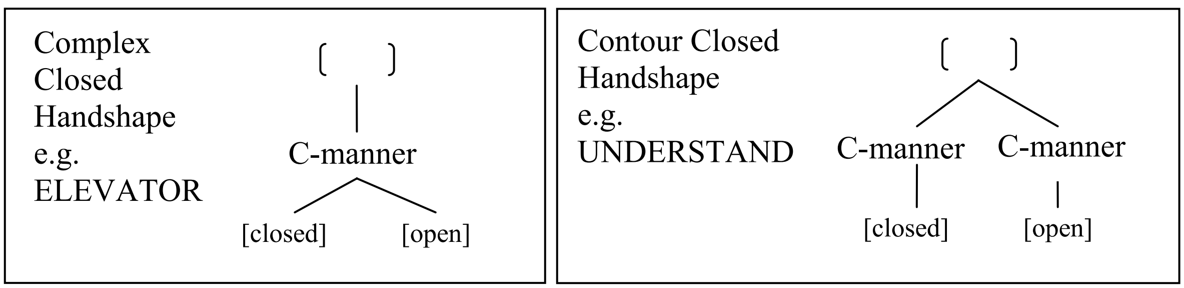
The most closed handshape has all finger joints flexed. This handshape is found in the finger-spelled S in (62), and is used in the sign YES. We claim that it has a manner representation equivalent to a stop consonant. In contrast, the handshape equivalent of a fricative consonant has a generally closed handshape but with some selected fingers extended. The sign for the number 1 in (62) is of this type, and is found in the sign DEAF. The proposed structures for these handshape manner configurations are given in (66).

(66)



Combining both [open] and [closed] features under the same C-manner node, we get a complex segment corresponding to the finger-spelled E in (62) if all fingers are selected. This handshape is found in the sign ELEVATOR and is equivalent to a lateral fricative from a manner perspective. Finally, combining the [open] and [closed] features under two different C-manner nodes, we get a contour segment equivalent to an affricate. For example, the sign UNDERSTAND has a sequential handshape change from S to 1. The manner representations for the complex and contour segments are given in (67).

(67)

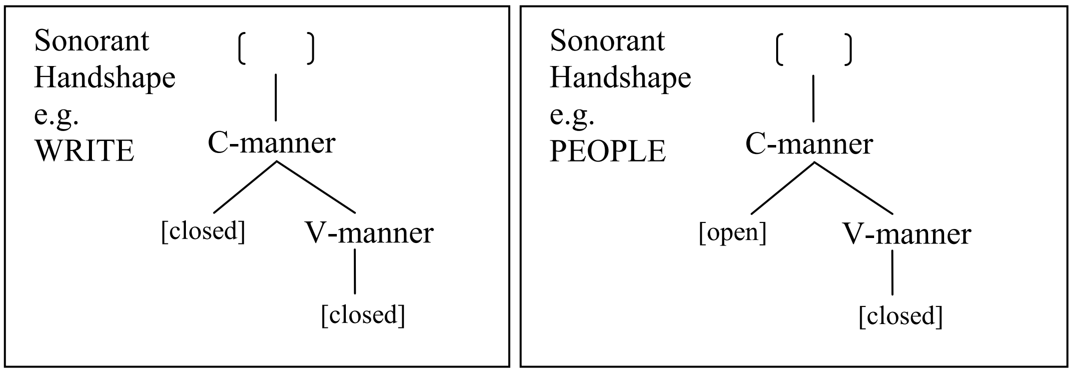


Interestingly, the "closed" handshape contours invariably move from more closed to more open, exactly as we might expect from an obstruent contour (affricate) and exactly the opposite of the "open" handshape/vowel contours. Again, this suggests the spoken language preference for manner contours to move in a particular direction is phonological, not phonetic. In addition, it provides further functional clues that handshape openness and spoken manner of articulation correspond to the same abstract representations.

4.1.3 Simultaneous "open" and "closed" handshapes: ASL "sonorant consonant" manner

We propose that ASL handshapes that are simultaneously "open" and "closed" are structurally equivalent to sonorant consonants in spoken language. That is, they are segments that have both a consonant and a vowel manner. A good example to demonstrate this is the handshape used in the sign WRITE. Descriptively, this handshape is like the 1 handshape, but with the index finger bent at the base joint and the tip of the index touching the tip of the thumb. The generally closed handshape indicates a C-manner of [closed], but the extended and *bent* index finger indicates a V-manner of [closed]. Another example is the finger-spelled P in (62) and used in the sign PEOPLE. The extended index finger indicates an [open] C-manner, but the *bent* middle finger indicates a [closed] V-manner. From a manner perspective, these handshapes are structurally equivalent to a lateral approximant and a rhotic approximant, respectively.

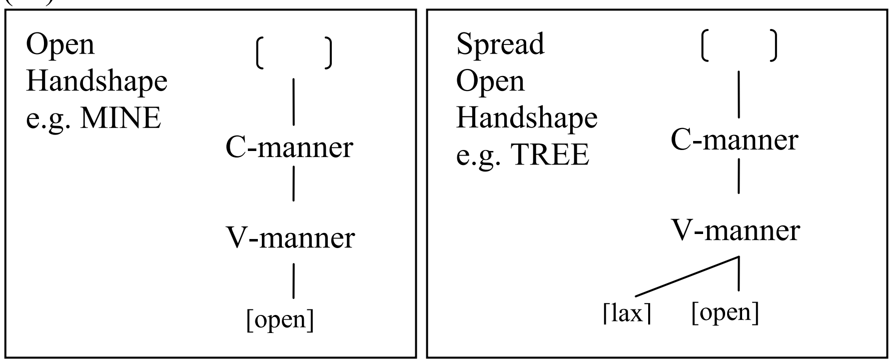
(68)



4.1.4 Spread fingers: ASL [lax] manner

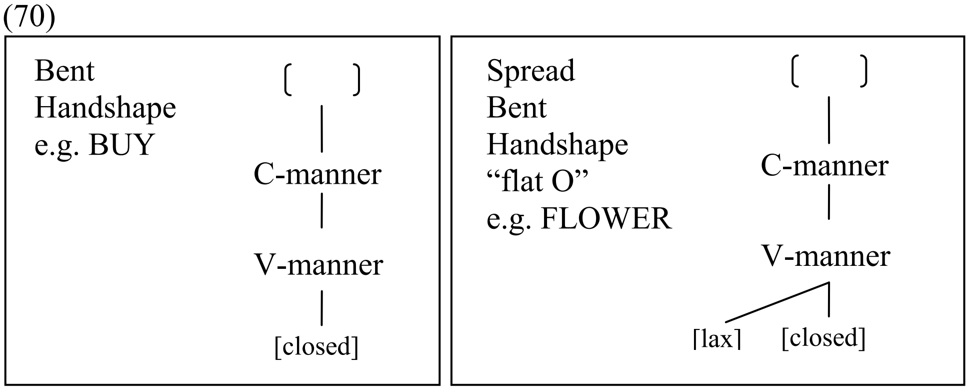
As discussed above for spoken language, manner of articulation not only has to do with degrees of vocal tract constriction, but also articulator rigidity. Might there be an equivalent to articulator rigidity in ASL that could correspond to the presence or absence of the feature [lax]? We suggest active finger spreading is the ASL reflex of the [lax] manner feature. For example, (69) shows the proposed manner representations for the handshapes “open B” and the number 5 (see 62). Note that these are identical except that the latter has spread fingers. We claim that these handshapes correspond to tense and lax low vowel manners in spoken language.

(69)



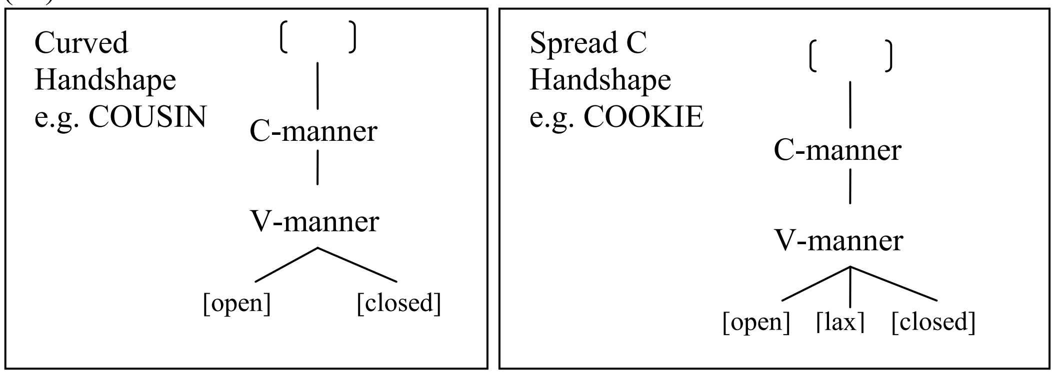
The ASL equivalents to high tense and high lax vowel manners are given in (70). What is interesting about this pair of handshapes is that it is articulatorily difficult to keep the fingers spread while the base joints are bent. Therefore, the relevant phonetic difference is in the amount of flexing in the non-base joints. The handshape for BUY is a "bent B" with the pad of the thumb touching the pads of the fingers. The handshape for FLOWER is a "flat O", which is identical to the BUY handshape, but with the non-base joints slightly flexed.

(70)

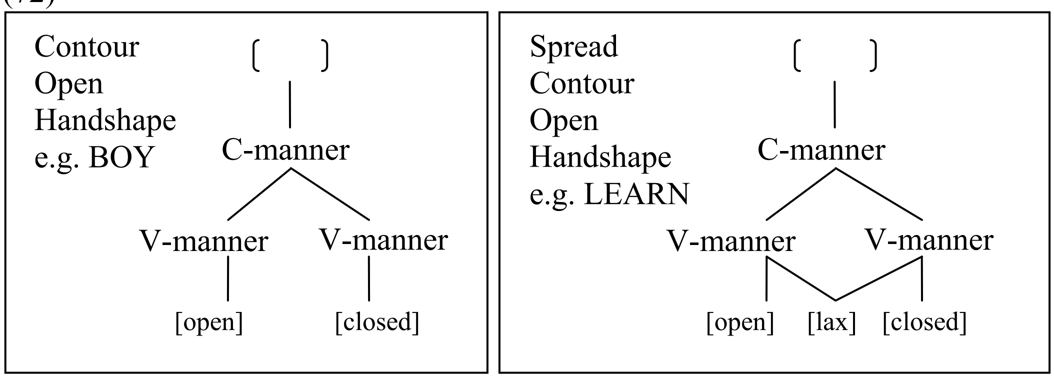


Complex and contour V-manner pairs differentiated by presence or absence of [lax] are given in (71) and (72). The first pair consists of a "curved" handshape and a "spread C" handshape.

(71)

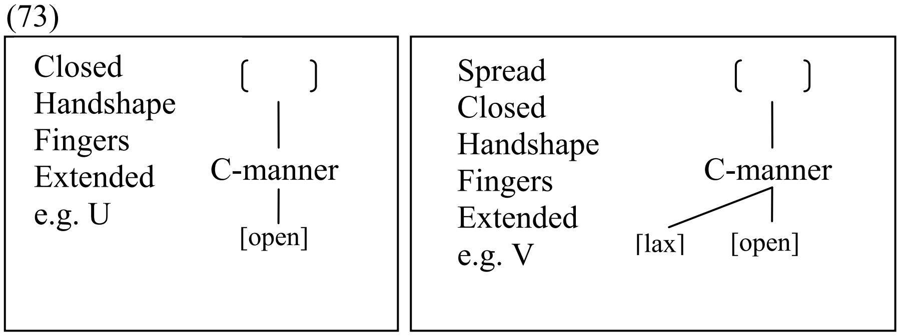


(72)

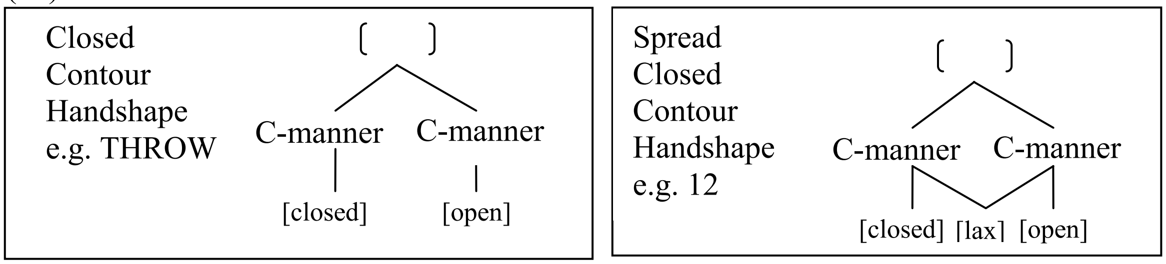


Since a simple [closed] C-manner has a completely closed handshape, there is no way for it to realize a [lax] feature. However, we do see this feature at work in simple [open] C-manner handshapes and contour C-manner handshapes, as shown in (73) and (74).

(73)

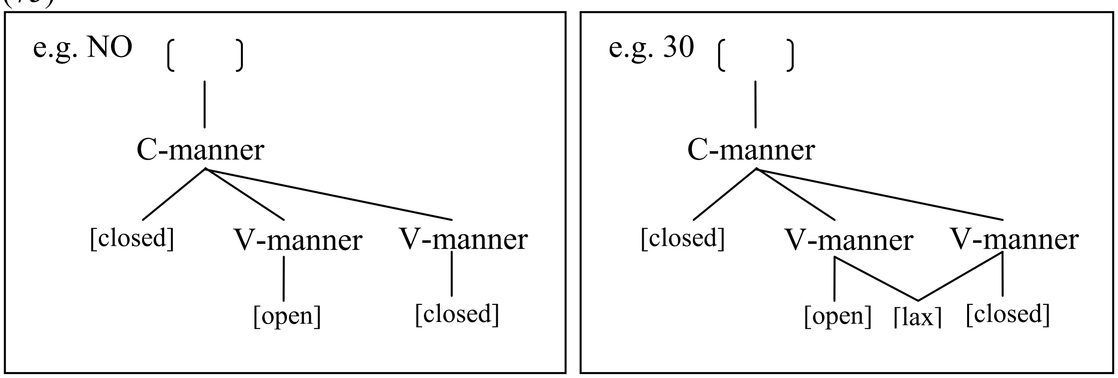


(74)



We also find [lax] at work in contour sonorant handshapes, as seen in (75).

(75)



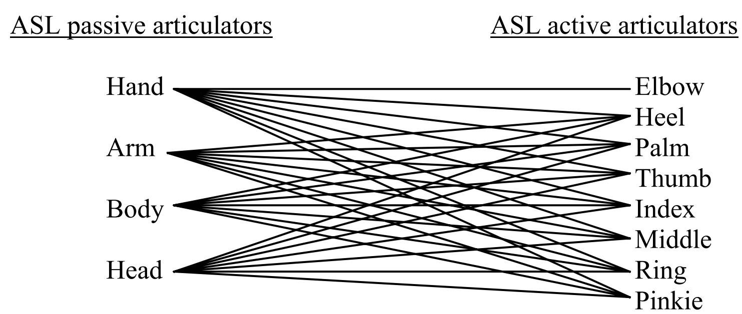
4.1.5 Summary of ASL manner of articulation

We have seen that just as spoken languages have a variety of degrees of constriction of the vocal tract, which correspond to what is known as manner of articulation, ASL has a variety of degrees of handshape constriction, which we claim correspond to manner as well. Viewing handshape in this way takes it out of the realm of modality-specific elements and unifies the phonological representations. Using the Parallel Structures Model we get a wide range of handshapes using the same very simple representation used in spoken languages. In addition, we have a straightforward distinction among simple, complex and contour handshapes that seem to correspond nicely with spoken segments and even show the same closed-open and open-closed asymmetries in contour segments.

4.2 ASL place of articulation: Location and selected fingers

In ASL, there are four major passive place locations corresponding to major parts of the body (if we ignore plane): head, body, arm and hand. In addition, there are only a limited number of major active articulators used to approach or make contact with the passive articulators. The active articulators are the elbow and certain parts of the hand (if we ignore eye gaze and tongue point). As with spoken language, these active and passive articulators may be combined in a number of ways. However, there are simply more physical combinations possible in signed languages than in spoken languages since the latter have certain physiological limitations (e.g. the tongue tip cannot easily combine with the pharyngeal wall). The only place restriction due to physiology seen in ASL is the ability of the elbow active articulator to only combine with the hand passive articulator. A range of combinations of major active and passive articulators is shown in (76).

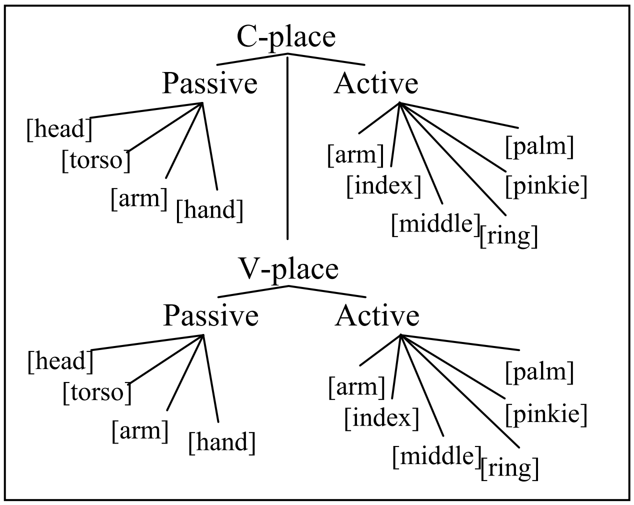
(76)



As we can see, with just four major passive articulators and eight active articulators there are a large number of possible combinations. In fact, the situation is even more complex than this because each major passive articulator has eight sub-places and several of the active articulators have more than one sub-specification. For example, the tip, front, back, radial and ulnar region of each finger (excluding thumb) can be used distinctively, as can the top of the head, the forehead, the eye, the cheek/nose, the upper lip, the mouth, the chin and the area under the chin.

Since a full investigation of the many active and passive articulators used in ASL is beyond the scope of this paper, we will present an analysis of simple, complex and contour place in ASL using just the major active and passive articulator divisions and the representation shown in (77).[8]

(77)



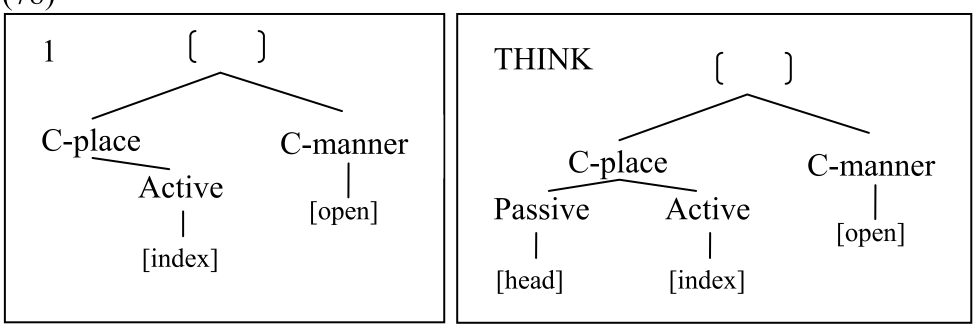
We propose that handshape determines which active place feature is relevant for a particular sign, with C-place active features used for "closed" handshapes (C-manner) and V-place active features used for "open" handshapes (V-manner). The passive places, however, are a slightly different matter. We propose that a sign in which the active articulator makes contact or near contact with a passive articulator is specified with a C-place passive feature, and a sign in which the active articulator does not make contact or near contact with a passive articulator is specified with a V-place passive feature. From the perspective of spoken language, this makes sense since C-place may be interpreted as an active and passive articulator combination blocking and/or restricting the airflow, while V-place may be interpreted as a combination of articulators which approach one another, but not too closely. In the following two sections, we will provide representations for a variety of signs of various complexities, and not only demonstrate the use of C-place and V-place features in ASL, but also provide a practical summary of the ASL discussion by integrating the place features into structures with manner features.

[8] Recall that we are agnostic as to whether the active and passive place nodes should be sisters under a more general place node or if they should be represented separately, e.g. $\text{C-place}_{\text{passive}}$ versus $\text{C-place}_{\text{active}}$, etc.

4.2.1 Simple ASL place of articulation

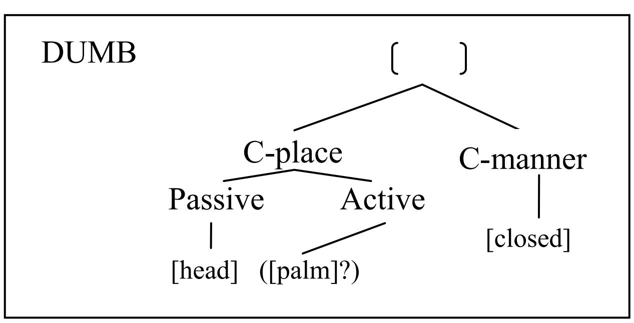
Using the Parallel Structures Model and ignoring movement and sub-place, we can represent a large number of signs with C-place active and/or passive articulators. In (78), we see two signs that differ only in the presence or absence of a C-place passive feature. The sign for the number 1 is made in neutral space, so there is no passive articulator. However, the overall handshape is closed with only the index finger selected, so it has an open C-manner and an index finger active C-place. In contrast, the sign THINK has the same handshape, but the active articulator makes contact with the head.

(78)



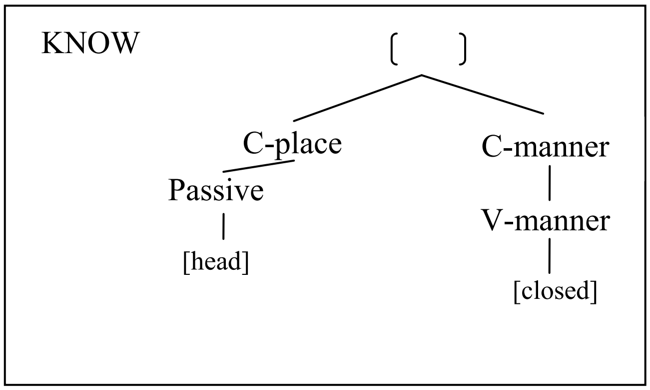
In (79), we see the representation for the sign DUMB, which is different from the previous signs in not having selected fingers participating in manner. In the absence of active place features, all fingers participate in manner. Although we represent the sign with an active [palm] feature, it may, in fact, not be specified with an active articulator.

(79)



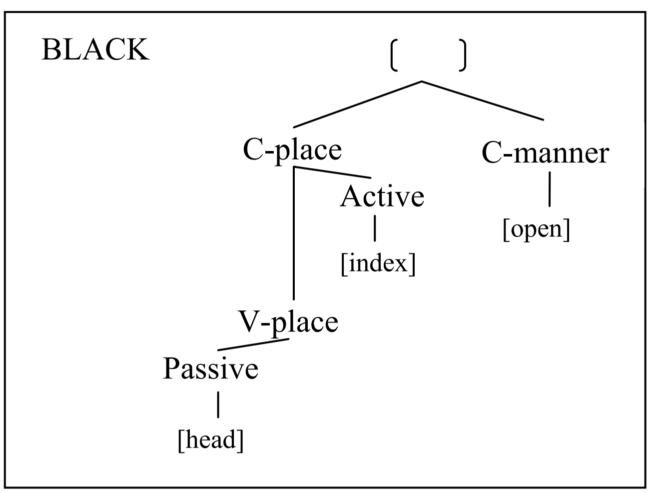
As we can see from the representation of KNOW in (80), V-manner may be combined with passive C-place. This sign must be specified with a V-manner because there is an "open" handshape. However, there is contact between the active hand and the body, so it has a passive C-place.

(80)



An example of a sign with a passive V-place, where there is no contact between the active and passive articulator, is BLACK. The 1 handshape begins pointing at the contralateral forehead and moves across the forehead without touching to the ipsilateral forehead. We might partially represent BLACK as in (81).

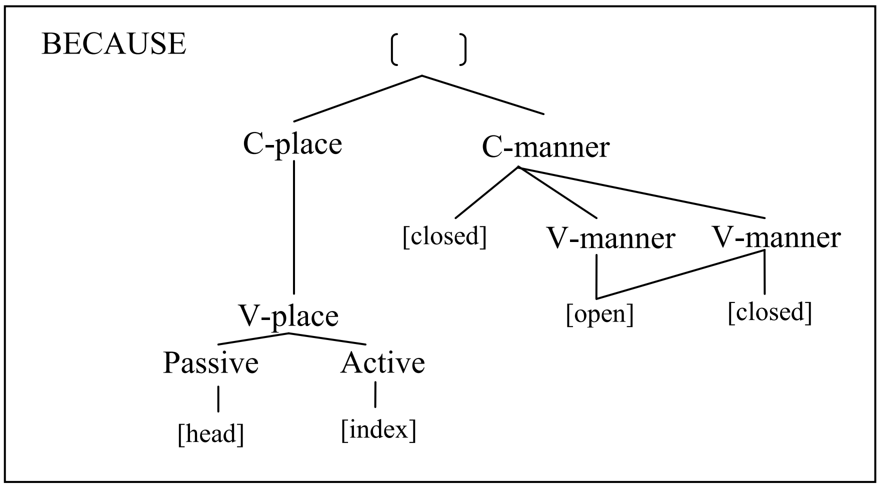
(81)



Note that BLACK seems to form a phonetic minimal pair with BECAUSE, which has an added hooking of the index finger. However, other than sharing the same passive V-place, the rest of the abstract representation is quite different. The overall closed handshape of

BECAUSE indicates a C-manner of [closed], however, the contour handshape change from extended index to curved index indicates a contour V-manner from [open] to complex [open] and [closed]. The index finger must be an active V-place feature because it corresponds with the V-manner change. Finally, the fact that contact is not made between the active articulator and the passive articulator indicates that a passive V-place.

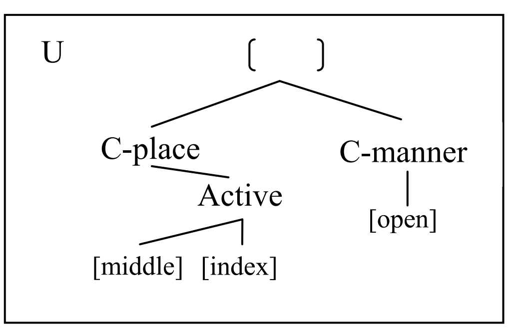
(82)



4.2.2 Complex ASL place of articulation

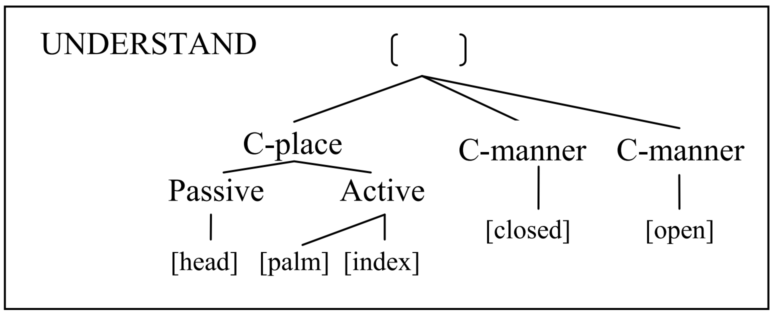
Recall that a complex segment has a single class node of a particular type and more than one dependent feature on that class node. Under this definition, there are two possible types of complex place representations in ASL – complex active place and complex passive place. An example of a sign with complex active place is the finger-spelled U. Here there are two selected fingers and an open C-manner handshape.

(83)



In the case of UNDERSTAND, we see that there are two active C-place articulators – one that specifies the selected finger involved in C-manner and one that specifies the articulator that makes contact with the passive C-place. This makes UNDERSTAND a complex place segment and a contour manner segment.[9]

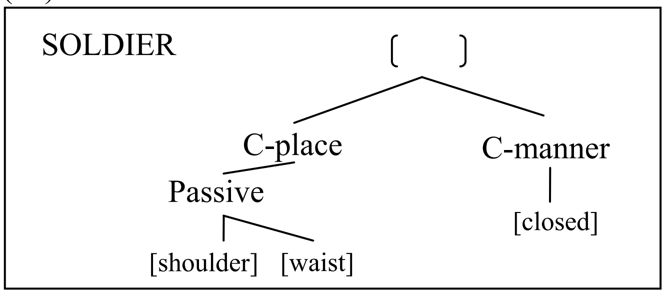
(84)



At first it is difficult to imagine what complex passive C-place might mean in ASL. The implication is that there is simultaneous contact at two passive places. However, how is it possible for the same active articulator to be in two places at once? Upon careful consideration of the phonetic components of sign, the answer to this question is immediately obvious – use two hands! One of the major issues in the literature on ASL phonology is how to represent two-handed signs. Like handshape, two-handed signs have been held up as a potential problem for the unification of spoken and sign language phonological representations. However, given that spoken language does use segments with complex passive place, we propose that the representation for two-handed signs is the same. For example, the sign SOLDIER both hands have the shape of the finger-spelled A (see 62), one of which is at the ipsilateral shoulder and the other at the ipsilateral lower torso. This could represented as in (85).

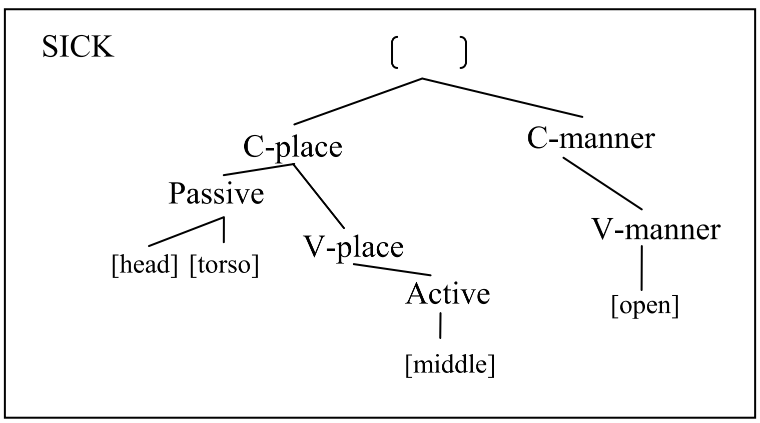
[9] Simplification of this sign is the delinking of the non-finger active articulator. Otherwise the handshape would change as well.

(85)



Another example of a two handed sign is SICK. In this sign, both handshapes are open, and there is contact between the middle finger of one hand with the forehead and contact between the other middle finger and the torso. We might represent this sign as in (86).

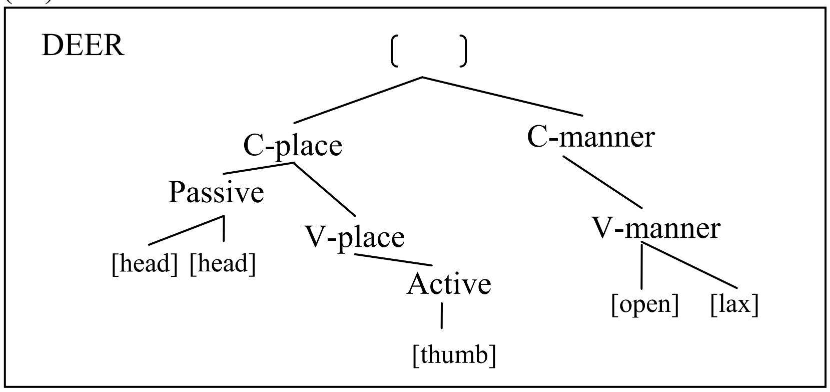
(86)



One advantage of this proposal is that it explains why two-handed signs must have the same handshape.

Finally, there is one last type of two-handed sign that is the result of simultaneous C-place features – one in which both hands are used at the same location on the ipsilateral side of the body, e.g. DEER. In this sign, both hands have an “open B” handshape with spread fingers, and there is contact between the thumb and the forehead on both sides of the body. This is shown in (87).

(87)



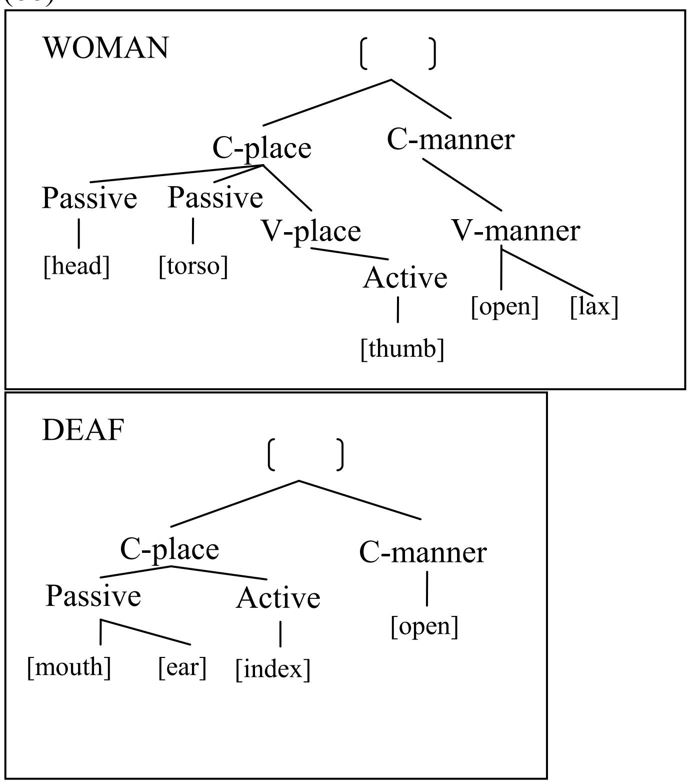
This representation is perhaps slightly unexpected from the perspective of the Obligatory Contour Principle since there are two identical features within a single segment. However, note that this representation straightforwardly captures the details of the sign, and it might help explain the fact that this type of two-handed sign in which both hands are at the same passive location often undergoes what is usually called "weak hand drop". That is, although the citation form of DEER uses both hands, this type of two-handed sign is notoriously susceptible to not realizing the articulation of the non-dominant hand. Therefore, weak hand drop in a two-handed sign like DEER might be a natural response to the OCP violation.

Complex V-place signs are also possible, but they will not be discussed in detail here. We propose that complex V-place signs are two-handed signs with no body contact.

4.2.3 Contour ASL place of articulation

Recall that segments with contour place have two sequential passive places. There seem to be two types of signs that have been described in the literature as having contour place – signs like WOMAN and signs like DEAF. In WOMAN, the active articulator (the thumb) first makes contact at the chin, followed by contact at the chest. The order of contact for WOMAN is never from chest to chin. In contrast, DEAF has contact between the active articulator (the index finger) and either the mouth followed by the ear, or vice versa. We propose that the difference between these signs with respect to direction of contact indicates that only WOMAN is a contour place sign. DEAF, on the other hand, has complex place. The consistent linearity for WOMAN is explained naturally if we assume that linearity is encoded via adjacency of class node – thus, the representations in (88) (see Channon 2002 for more on temporal sequencing in sign languages).

(88)



4.3 ASL laryngeal features: Non-manual gestures?

The question of what the sign language equivalent of laryngeal features might be will not be explored in detail here. However, if we look for functional parallels across modality, then it might be the case that the sign realization of V-laryngeal features (tones) are non-manual gestures. The fact that tones are used in spoken languages to mark lexical contrast, as well as phrasal and pragmantic phenomena such as phrase boundaries, focus, topic, question formation, etc., and the fact that sign languages use non-manual gestures for the same reasons, it is very likely that the two modalities use the same abstract representations for the same grammatical functions. Since the Parallel Structures Model claims that tones are represented as laryngeal features in the segment geometry, we would suggest that non-manual gestures might be represented that way as well.

5. Conclusions

In this paper we began by reviewing the feature sets and segment-internal representations currently assumed for spoken languages, and highlighted several difficulties/unresolved issues regarding the major class features, the manner features, the place features and the laryngeal/tone features. To resolve those issues, we proposed a new model of feature geometry, the Parallel Structures Model, in which the same structures and features are used whenever possible across the various feature types. Specifically, manner of articulation, place of articulation and state of the glottis/tone all have a similar structure in which a vowel class node is dependent on a consonant class node.

(89)

C-class node

[feature X] [feature Y] [feature Z] …

V-class node

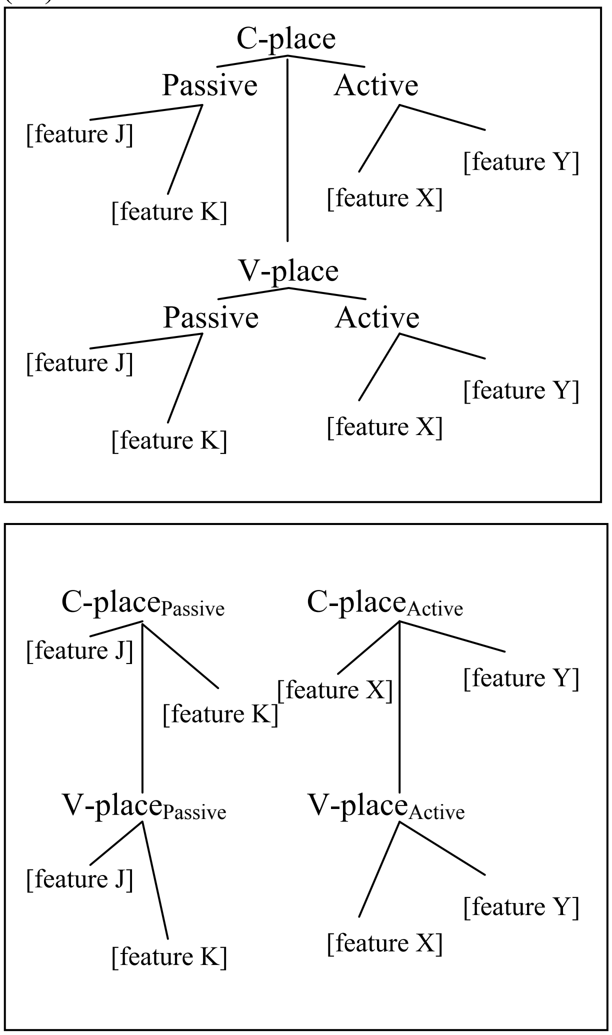
[feature X] [feature Y] [feature Z] …

Manner of articulation is defined via relative constriction of the vocal tract combined with relative articulator rigidity, and is represented in this model as a combination of a C-manner and V-manner node with dependent [open], [closed] and [lax] features. C-manner of [open] or [closed] differentiates between stops and fricatives, with an additional [lax] feature differentiating between stops and flaps, and stridents and non-stridents. V-manner of [open] or [closed] differentiates between low and high vowels, and the feature [lax] between tense and lax vowels. Combining [open] and [closed] features under the same manner node results in complex manner for both consonants and vowels, e.g. lateral fricatives and mid vowels. Combining these features under two different nodes of the same class results in contour manner, e.g. affricates and short height diphthongs. Finally, combining these features under two different manner class nodes (C-manner and V-manner) results in sonorant consonants. A major result of this proposal for manner of articulation is the elimination of the major class features, as well as the features [lateral], [strident], [flap] and [trill].

The laryngeal and tone articulations are defined via relative constriction and rigidity of the glottis in this model. In fact, the same features are used for these feature types as for manner of articulation. C-laryngeal with dependent [open], [closed] and [lax] features correspond to traditional [spread glottis], [constricted glottis] and [voice] features. Similarly, V-laryngeal [open], [closed] and [lax] features correspond to low, high and register tones, respectively. As with manner of articulation, simple, complex and contour consonant and vowel laryngeal configurations are found cross-linguistically.

In the realm of place of articulation, we propose that both active and passive articulations are necessary, and that all passive articulator features may have a dependent [posterior] feature. In addition, we claim that the factorial combination of the active and passive articulators is limited only by articulatory and perceptual constraints. The passive place features are [labial], [coronal], [velar] and [pharyngeal], and the active place features are [lower lip], [apical], [laminal], [dorsum] and [tongue root]. As with manner and state of the glottis/tone, simple complex and contour places of articulation are found for both consonants and vowels. Finally, until further research is conducted, we propose two possible representations for place of articulation. These differ only in whether passive and active class nodes are sisters under a place node, or if they are independent.

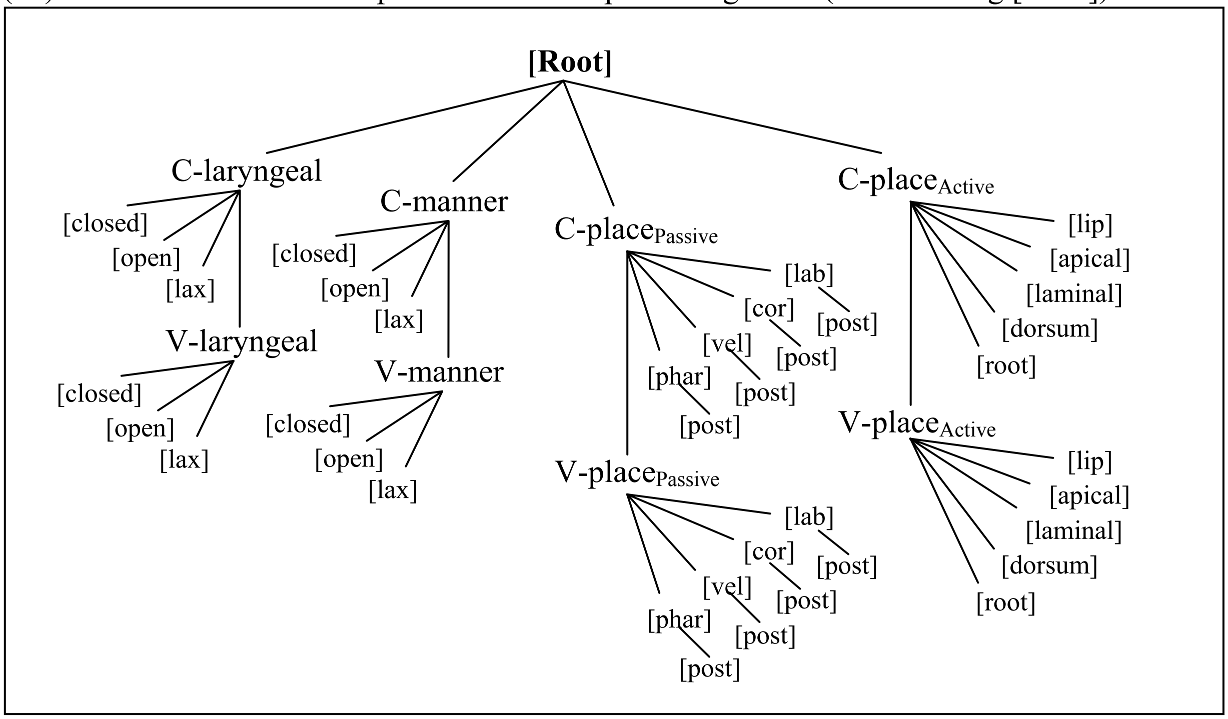
(90)



Combining place, manner and laryngeal structures under a single root node in spoken language, we are left with the representation shown in (91).[10]

[10] The location of the feature [nasal] within this representation is left for future research.

(91) Parallel Structures Representation for Spoken Segments (not including [nasal])



After the discussion of spoken language segments, we briefly reviewed some of the core components of signed languages and criticized the current phonological literature on sign languages for only drawing minimal functional and representational parallels across modalities. We claim that the mapping from abstract phonological structures to actual articulations will obviously be different across modalities, but the abstract structures themselves should be very similar, if not identical. We propose that the sign language component called handshape is not a phonological constituent as claimed in the sign language literature. Rather, the selected fingers of handshapes are actually active articulators better represented under a place node, and the relative openness and spreadedness of the handshape corresponds to C-manner and V-manner. Specifically, a C-manner of [closed] or [open] relates to a completely closed handshape or a closed handshape with selected fingers extended, respectively. On the other hand, a V-manner of [open] or [closed] corresponds to a completely open handshape or one bent at the base joints, respectively. Combining these representations with [lax] results in handshapes with spread fingers.

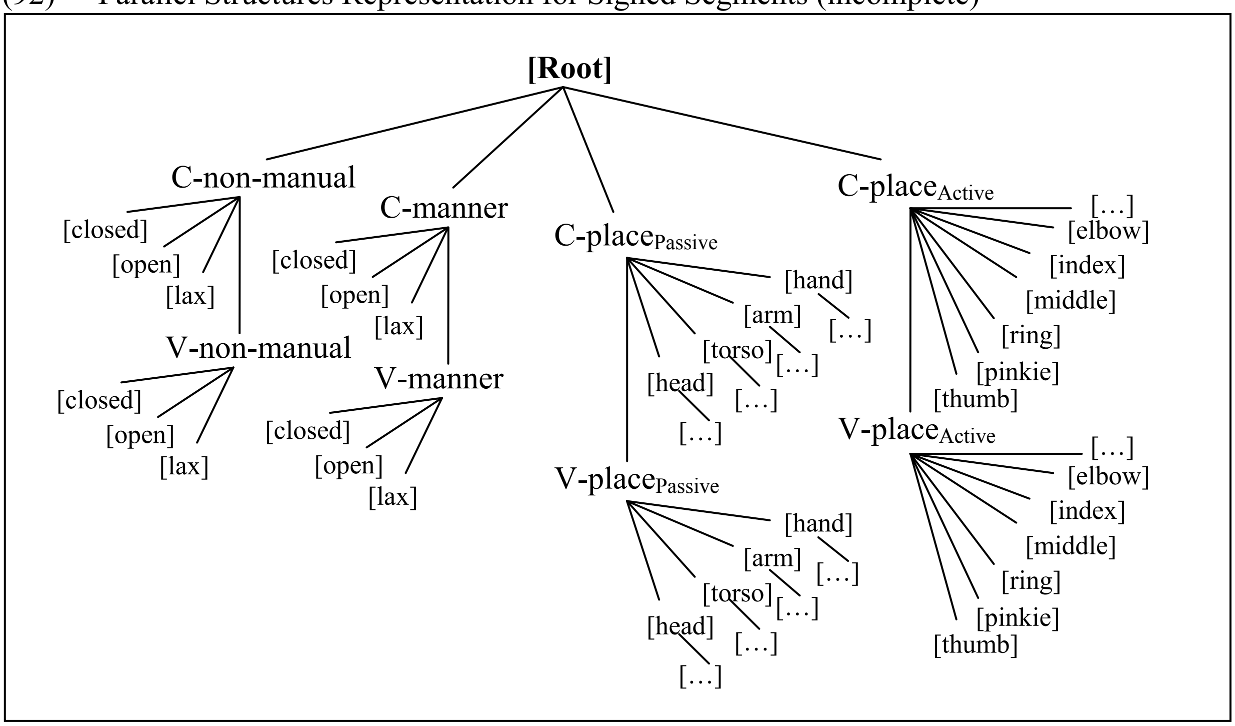
We show that handshape constriction can be simple, complex or contour just as spoken language manner can be, and that there are handshapes that are structurally equivalent to sonorant consonants. Interestingly, we also show that C-manner contours move from [closed] to [open], while V-manner contours move from [open] to [closed] in both modalities, thus suggesting that this preference/principle is phonological in nature.

In addition to the discussion of handshape constriction, we also show that sign languages have many more combinatorial possibilities among active and passive articulators, thus supporting the claim that universal feature geometry must include both active and passive place features.

Finally, although not discussed in detail, we suggest that non-manual gestures in sign languages might be represented as laryngeal features/tones because they mark lexical contrasts, as well as phrasal and pragmatic phenomena (e.g. phrase boundaries, focus, topic, questions, etc.) just as tones do in spoken languages.

Finally, a speculative segmental structure for sign language segments is given in (92).

(92) Parallel Structures Representation for Signed Segments (incomplete)



References

Anderson, S. 1976. Nasal consonants and the internal structure of segments. *Language* 52: 326-344.

Anderson, S. 1978. Tone features. In V. Fromkin (ed.), *Tone: A Linguistic Survey* (pp. 133-176). New York: Academic Press.

Avery, P. and K. Rice. 1989. Segmental structure and coronal underspecification. *Phonology* 6: 179-200.

Avery, P. and W. Idsardi. 2001. Laryngeal dimensions, completion and enhancement. In T. Allen Hall (ed.), *Distinctive Feature Theory* (pp. 41-70). Berlin: Mouton de Gruyer.

Bao, Z. 1990. *On the nature of tone*. Doctoral dissertation, MIT.

Channon, R. 2002. *Signs are single segments: phonological representations and temporal sequencing in ASL and other sign languages*. Doctoral dissertation, University of Maryland, College Park.

Chomsky, N. and M. Halle. 1968. *The Sound Pattern of English*. New York: Harper and Row.

Clements, G. N. 1985. The geometry of phonological features. *Phonology* 2: 225-252.

Clements, G. N. 1987. Phonological feature representation and the description of intrusive stops. In A. Boshch, B. Need, and E. Schiller (eds.), *CLS 23: Parasession on Autosegmental and Metrical Phonology* (pp. 29-50). Chicago: CLS.

Clements, G. N. 1991. Place of articulation in consonants and vowels: A unified theory. In *Working Papers of the Cornell Phonetics Laboratory* 5:77-123. Ithaca: Cornell University.

Clements, G. N. and E. V. Hume. 1995. The Internal Organization of Speech Sounds. In John A. Goldsmith (ed.) *The Handbook of Phonological Theory* (pp. 245-306). Cambridge: Blackwell.

Dell, F. 1993. Assimilations supralaryngales dans deux parlers de la Chine méridionale. In B. Laks and A. Rialland (eds.), *L'Architecture et la géometrie des representations phonologiques*. Paris: Editions du C.N.R.S.

Duanmu, S. 1990. *A formal study of syllable, tone, stress and domain in Chinese languages*. Doctoral dissertation, MIT.

Ghini, M. 2001. Place of articulation first. In T. Allen Hall (ed.), *Distinctive Feature Theory* (pp. 147-176). Berlin: Mouton de Gruyer.

Goad, H. 1994. *On the configuration of height features*. Doctoral dissertation, University of Southern California.

Gorecka, A. 1989. *Phonology of articulation*. Doctoral dissertation, MIT.

Grijzenhout, J. 2001. Representing nasality in consonants. In T. Allen Hall (ed.), *Distinctive Feature Theory* (pp. 177-210). Berlin: Mouton de Gruyer.

Halle, M. and K. Stevens. 1971. A Note on Laryngeal Features. *QPR* 101: 198-213. Research Laboratory of Electronics, MIT.

Hombert, J. 1978. Consonant types, vowel quality and tone. In V. Fromkin (ed.), *Tone: A Linguistic Survey* (pp. 77-112). New York: Academic Press.

Hualde, J. 1988. Affricates are not contour segments. In H. Borer (ed.), *Proceedings of WCCFL 7* (pp. 77-89). Stanford: SLA.

Jakobson, R., G. Fant and M. Halle. 1963. *Preliminaries to speech analysis*. Cambridge: MIT Press.

Keating, P. 1984. Phonetic and phonological representation of stop consonant voicing. *Language* 60: 286-319.

Ladefoged, P. 1968. *A Phonetic Study of West African Languages*. Cambridge: CUP.

Ladefoged, P. 1971. *Preliminaries to Linguistic Phonetics*. Chicago: University of Chicago.

Ladefoged, P. 1983. The linguistic use of different phonation types. In D. Bless and J. Abbs (eds.) *Vocal fold physiology, contemporary research and clinical issues.* San Diego: College Hill.

Ladefoged, P. 1993. *A Course in Phonetics*. Harcourt.

Lavoie, L. 2001. *Consonant strength: phonological patterns and phonetic manifestations*. New York: Garland.

Lisker, L. and A. Abramson. 1964. A cross-language study of voicing in initial stops: Acoustical measurements. *Word* 20: 384-422.

Lombardi, L. 1990. The nonlinear organization of the affricate. *NLLT* 8: 375-425.

Lombardi, L. 1991. *Laryngeal features and laryngeal neutralization*. Doctoral dissertation, Unviersity of Massachusetts, Amherst.

Maddieson, I. 1984. *Patterns of sounds.* Cambridge: CUP.

Maddieson, I. and P. Ladefoged. 1988. Multiply articulated segments and the feature hierarchy. MS, UCLA.

Mascaró, J. 1987. Place and voicing assimilation: A reduction and spreading account. MS, Universitat Autònoma de Barcelona.

McCarthy, J. 1988. Feature geometry and dependency: A review. *Phonetica* 43: 84-108.

Mester, A. and J. Itô. 1989. Feature predictability and underspecification: Palatal prosody in Japanese mimetics. *Language* 65: 258-293.

Morén, B. 2001. Manner of articulation in two modalities: A unified approach. MS, Modern Foreign Languages and Literatures, Boston Univeristy.

Morén, B. 2001. Place of articulation in two modalities: A unified approach. MS, Modern Foreign Languages and Literatures, Boston Univeristy.

Ohala, J. 1978. Production of tone. In V. Fromkin (ed.), *Tone: A Linguistic Survey* (pp. 5-42). New York: Academic Press.

Padgett, J. 1991. *Stricture in feature geometry.* Doctoral dissertation, MIT.

Sandler, W. 1989. *Phonological Representation of the Sign: Linearity and Nonlinearity in American Sign Language*. Providence: Foris.

Sagey, E. 1990. *The Representation of Features in Non-Linear Phonology: The Articulator Node Hierarchy.* New York: Garland.

Schein, B. and D. Steriade. 1986. On geminates. *Linguistic Inquiry* 17: 691-744.

Steriade, D. 1993. Segments, contours and clusters, In C.Oellon (ed.) *Actes du 15eme Congrès International des Linguistes* (pp. 71-82) Presses de l'Université Laval, Ste Foy

Steriade, D. 1995. Complex onsets as single segments. In J. Cole and C. Kisseberth (eds.), *Perspectives in Phonology*. Stanford: CSLI.

Stokoe, W. 1960. Sign Langauge Structure: An Outline of the Visual Communication Systems of the American Deaf. *Studies in Linguistics, Occasional papers* 8. Silver Spring: Linstock Press.

Yip, M. 1980. *The Tonal Phonology of Chinese*. Doctoral dissertation, MIT.

Yip, M. 1989. Contour tones. *Phonology* 6: 149-174.

Yip, M. 1995. Tone in East Asian Languages. In John A. Goldsmith (ed.) *The Handbook of Phonological Theory* (pp. 476-494). Cambridge: Blackwell.