Front Vowels are Not Coronal
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1 Preliminaries

In the last few years, a significant body of research has been devoted to the problem of how best to capture the class of front vowels and coronal consonants (e.g. Mester & Itó 1989, Pulleyblank 1989, Cheng 1990, Clements 1990, Lahiri & Evers 1991, Hume 1992, Clements & Hume to appear; cf. Gorecka 1989a). The consensus reached is that front vowels are Coronal, a feature formerly restricted to consonants. A single set of articulators then marks place in both consonants and vowels and, as a result, the approach is often labelled Unified Articulators (henceforth UA).

Perhaps the most significant advantage of UA is its ability to express as spreading the assimilation of anterior coronals to palato-alveolar before front vowels; see (1). This widely attested palatalization process has proven to be rather problematic for standard articulator-based feature geometry. Because Coronal is restricted to segments executed with the tip or blade of the tongue, palato-alveolar consonants and front vowels do not share a common articulator. Consequently, Palatalization must involve two steps. The intermediate stage, [tv] in (2a), is derived through spreading of Dorsal; [tv] is subsequently reanalysed as [ti] (2b) (cf. Sagey 1986:108-110).

(1) \( t \rightarrow [ti] \)  
Place  Place  
Cor  Cor  
[ant]

(2a)  
Place  Place  
Cor  Dor  
[back]  
[ant]

(2b)  
Place  Place  
Cor  Dor  
[back]  
[ant]

As reanalysis is formally unconstrained, (2a,b) is inconsistent with the goal of nonlinear phonology to express cross-linguistically common processes with the limited set of operations that the theory makes available, spreading, delinking, and the like.

While UA has resolved this and other long-standing problems, we argue that it is not adequately constrained. We focus on three empirical problems as follows. 1 Coronal Harmony: In UA, where all articulators are available to both consonants and vowels, the restriction of consonant harmony to coronals must be stipulated (see Section 2.2.1). In Sagey, where Coronal is the only articulator not accessible to vowels, this restriction is readily explained (Shaw 1991). 2 Unattested Assimilations: UA advocates that Coronatization, where velars are realized as Coronal before front vowels, should be expressed as spreading. The formally identical process, where labials become Coronal in the same context, should then be attested and yet it is not (see Section 2.2.2). 3 Anterior Coronals: UA permits both anterior and posterior coronals to pattern with front vowels. While there is no dispute about the latter as was demonstrated in (1) and (2), the situation with anterior coronals is not as straightforward. What we have found, in fact, is that in languages with both apical and laminal anterior coronals, only the apicals pattern with front vowels (see Section 2.2.3).

In response to these problems, in Section 3 we propose a less radical departure from Sagey (1986), one where Coronal is again inaccessible to vowels but, at the same time, one which can express Palatalization as spreading and capture the natural class of apical anteriors and front

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vowels. Before we turn to a discussion of this geometry, we will look in some detail at our reservations about UA.

2 Unified Articulators Approach
2.1 Clements (1990)

As was mentioned in Section 1, in UA, a single set of features characterizes place of articulation in both consonants and vowels. In contrast to Sagey (1986), then, Coronal is redefined to include not only tip/blade articulations but also articulations produced with the front of the tongue. As we saw in (1), a significant advantage of this proposal is that the well-attested process where /t/ surfaces as [t] before front vowels receives a satisfactory explanation as spreading of [-anterior]. To palatalize /t/ to [tv], however, the feature Coronal must be able to dominate itself, something along the lines of (3a). For such a representation to be interpreted as distinct from that of a simple /t/, each Coronal node must be mediated through a different dominating tier. To this extent, Clements (1990) proposes independent C-Place and V-Place nodes as in (3b) (irrelevant structure omitted).

(3) a. Coronal
    \[\text{Coronal}\]

b. t
   \[\text{C-Place}\]
   \[\text{Coronal}\]
   \[\text{C-Place}\]
   \[\text{Coronal}\]
   \[\text{V-Place}\]
   \[\text{Coronal}\]
   \[\text{V-Place}\]
   \[\text{Coronal}\]

As is most apparent from the structure provided for [tv], C-Place and V-Place representations are partially segregated: V-Place docks into C-Place and, more importantly, C-Place Coronal and V-Place Coronal define independent tiers (but cf. Hume 1992 below). Partial segregation is required to capture certain asymmetries between consonants and vowels: dependents of V-Place spread more freely than dependents of C-Place. For instance, the representations in (3b) permit spreading of Coronal from vowel to vowel without being blocked by intervening coronal consonants. This holds whether spreading is at the level of the articulator node (4a) or at the level of V-Place (4b).

(4) a. u→u t i
   \[\text{C-Pl}\]
   \[\text{V-Pl}\]
   \[\text{Lab}\]
   \[\text{Cor}\]

b. i→i t i
   \[\text{C-Pl}\]
   \[\text{V-Pl}\]
   \[\text{Lab}\]
   \[\text{Cor}\]

While partial segregation of consonant and vowel place features is required to obtain the effects in (4), it is precisely this fact which makes Clements' approach within UA somewhat unwieldy. Consider, for instance, cross-tier assimilations, cases where a particular feature spreads from the C-Place tier to the V-Place tier or vice versa. One example of consonant-to-vowel spreading discussed by Clements is Tulu, where /i/ is rounded to [u] after labial consonants:
compare [kantu] ‘eye’ with [kappu] ‘blackness’ (original source Bright 1972). Clements implies that such processes simply involve the spreading of Labial from C-Place to V-Place as in (5).

(5) **Cross-Tier Assimilations:**

\[
\begin{array}{c}
\text{C-Pl} \\
\uparrow i \rightarrow u \\
\text{C-Pl} \\
\downarrow \\
\text{V-Pl} \\
\text{Lab}
\end{array}
\]

However, since dependents of C-Place and V-Place occupy different tiers, the operation in (5) is in fact impossible: the doubly-linked Labial specification cannot be in two places as once. Instead, cross-tier assimilation must be a two-stage operation as in (6): Labial spreads from C-Place\(_1\) to C-Place\(_2\), and is then demoted from C-Place\(_2\) to V-Place\(_2\). Under what conditions demotion takes place remains unanswered.

(6) **Spreading:**

\[
\begin{array}{c}
\text{C-Pl}_1 \\
\downarrow \\
\text{Lab}
\end{array}
\quad \text{C-Pl}_2
\]

**Copying:**

\[
\begin{array}{c}
\text{C-Pl}_1 \\
\downarrow \quad \text{V-Pl}_2 \\
\text{Lab}
\end{array}
\]

2.2 *Hume (1992)*

The complication with cross-tier assimilations would not arise if articulator nodes for consonants and vowels defined a *single* tier. This is precisely the position taken by Hume (1992) in a further development of the Unified Articulators approach; see (7).

(7) \[
\begin{array}{c}
\text{Cons} \\
\downarrow \text{Place}_{\text{cons}} \\
\downarrow \text{Voc} \\
\downarrow \text{Place}_{\text{voc}} \\
\text{Cor}
\end{array}
\quad \begin{array}{c}
\text{Cons} \\
\downarrow \text{Place}_{\text{cons}} \\
\downarrow \text{Voc} \\
\downarrow \text{Place}_{\text{voc}} \\
\text{Cor}
\end{array}
\quad \begin{array}{c}
\text{Cons} \\
\downarrow \text{Place}_{\text{cons}} \\
\downarrow \text{Voc} \\
\downarrow \text{Place}_{\text{voc}} \\
\text{Cor}
\end{array}
\]

However, to allow vowel features to spread across intervening consonants, Place\(_{\text{voc}}\) defines a separate *plane* from Place\(_{\text{cons}}\). The result is the bowed representation in (8), one which splits apart at the Place\(_{\text{cons}}\) tier and comes together again at the level of the articulator nodes (Cor).

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2 In fact, the only cross-tier assimilation rule that Clements provides is borrowed from Herzallah (1990).

3 In this paper, we will focus for the most part on Hume’s proposal as it is the most comprehensive to date. The problems we address also hold for Clements.
As Hume points out, if association lines cannot cross within a plane, spreading from vowel to vowel over top of an intervening vowel at any level in the geometry is ruled out. However, the spreading operations in (9) are all licit. In (9a), vowel to vowel assimilation across an intervening consonant can involve spreading of an articulator node [F], of Place\textsubscript{voc}, or of Voc, whether or not the consonant is specified for [F]. In (9b), though, consonant to consonant assimilation across an intervening vowel can only involve spreading at the level of [F].

(9) a. V C V  
    Place\textsubscript{cons}  Place\textsubscript{cons}  Place\textsubscript{cons}  
    [F] [F] 
    Voc  
    Place\textsubscript{voc} 

2.2.1 Coronal Harmony

(9b) is the analysis proposed by Hume for Coronal Harmony (p. 122). Yet, it is precisely this case which is problematic: it allows for unrestricted consonant harmony at the level of articulator nodes. Shaw's (1991) cross-linguistic survey has revealed that long distance spreading of consonant features is restricted to coronals.\footnote{This restriction naturally does not hold of languages with independently motivated CV plane segregation (McCarthy 1989).} In a model along the lines of Sagey's, this fact is captured by positing Coronal as the only articulator for which vowels are never specified.

However, Shaw also observes that Coronal Harmony only involves a subset of the coronal segments in a language. Perhaps, then, Hume's geometry could be maintained with spreading of the type diagrammed in (9b) restricted to sub-articulator features. Since in UA, Coronal is (potentially) the only articulator with dependents, this would restrict spreading to sub-Coronal features, to [anterior] and [distributed] or their equivalents. While this will work for many attested cases of Coronal Harmony, e.g. that in Chumash, it will not permit a unified account of the alternations observed in Tahlitan and Basque. In both languages, spreading (or fusion) must be at the level of the articulator node, as \textit{three} sets of coronals alternate in the process. In Tahlitan (10),
assimilation is to the rightmost dental, alveolar, or palato-alveolar (Shaw 1991). In Basque (11), there is a morpheme structure constraint which prohibits apico-alveolar, lamino-alveolar, and palato-alveolar consonants from cooccurring (Hualde 1988).

(10) **Tahitian Coronal Harmony (Shaw 1991):**

a. **Assimilation to Rightmost Dental:**
   
   \[
   \text{e̱gdu} - \hat{O} \quad \text{’I whipped him’}
   \]
   
   \[
   \text{cf. esk’a} \quad \text{’I’m gutting fish’}
   \]

b. **Assimilation to Rightmost Alveolar:**
   
   \[
   \text{desit’} \hat{a} \hat{s} \quad \text{’we are walking’}
   \]
   
   \[
   \text{cf. desigutti} \quad \text{’we threw it’}
   \]

c. **Assimilation to Rightmost Palato-alveolar:**
   
   \[
   \text{e̱džuni} \quad \text{’I’m singing’}
   \]
   
   \[
   \text{u̱šidže} \quad \text{’we are called’}
   \]

(11) **Basque Coronal Morpheme Structure Constraint (Hualde 1988):**

a. **Apico-alveolar:**
   
   \[
   \text{sug} \text{en}
   \]
   
   \[
   \text{s} \text{m} \text{i} \text{nt} \text{s}
   \]

b. **Lamino-alveolar:**
   
   \[
   \text{a} \text{š} \text{os} \text{i} \text{s}
   \]
   
   \[
   \text{el} \text{š} \text{i} \text{š} \text{u} \text{nt} \text{i} \text{s}
   \]

c. **Palato-alveolar:**
   
   \[
   \text{u} \text{š} \text{i} \text{š} \text{i} \text{n} \text{i} \text{s}
   \]

2.2.2 **Unattested Assimilations: Coronalization**

The second problem to which we now turn concerns UA’s ability to express unattested assimilations. One apparent advantage of UA is that Coronalization, the change from velar to palato-alveolar before front vowels, involves spreading. In (12a), Coronal–[-anterior] spreads from the front vowel to /k/ with subsequent delinking of Dorsal. However, any theory which can express /k/→[tʃ] as a single operation can similarly express the unattested /p/→[tʃ]: the derivations in (12a) and (12b) are formally identical.

(12) a. \[k \rightarrow \text{tʃ} \]

\[\text{Place}_{\text{cons}} \]

\[\text{Lab} \]

\[\text{Cor} \]

\[-\text{ant}\]  

\[\hat{\Phi} \]

\[\text{Dor} \]

\[\text{Voc} \]

\[\text{Place}_{\text{voc}} \]

\[\text{Place}_{\text{cons}} \]

\[\text{i} \]

\[\text{Place}_{\text{cons}} \]

\[\text{b.} \]

\[p \rightarrow \text{tʃ} \]

\[\text{Place}_{\text{cons}} \]

\[\text{Lab} \]

\[\text{Cor} \]

\[-\text{ant} \]  

\[\hat{\Phi} \]

\[\text{Voc} \]

\[\text{Place}_{\text{voc}} \]

\[\text{Place}_{\text{cons}} \]

\[\text{i} \]

In geometries in which front vowels are Dorsal, Coronalization cannot be expressed as spreading. Following Spencer (Linguist List, 27 April 1993), we believe that this is in fact an advantage. Spencer points out that: “[while] k > ch type softenings are extremely common historically and abound in synchronic morphophonological systems, ... it’s extremely hard to track down this type of process as a genuine postlexical allophonic rule (akin to aspiration in English). This is despite the fact that t > ch type softenings are common as postlexical rules and in principle can easily give rise to non-structure preserving alternations, and despite the frequency with which postlexical palatalization processes induce allophony in the form of secondary articulations.” If
Spencer's observations are correct, which appears to be the general consensus from respondents to his initial query on the Linguist List, then the geometry which prevents /k/→[t] but permits /t/→[t] is the more constrained; see further Section 5.2.

2.2.3 Anterior Coronal

Let us turn finally to the interaction between anterior coronals and front vowels. As mentioned in the introduction, UA permits both anterior and posterior coronals to pattern with front vowels. Since there is no contrast among types of coronal vowels (on the place dimension), a vowel specified with a bare Coronal node and one with an additional dependent [-anterior] will be interpreted identically. The structures in (13a) and (13b), for instance, illustrate the interaction of /i/ with both unmarked coronal /t/ and palato-alveolar /ti/ (irrelevant structure omitted).

(13) a. \[ \begin{array}{c} \text{P}_{\text{cons}} \\
\text{\text{\text{\text{\text{Voc}}}}}
\end{array} \begin{array}{c} \text{\text{\text{\text{\text{P}}}}}_{\text{voc}} \\
\text{\text{\text{\text{\text{Cor}}}}}
\end{array} \]

b. \[ \begin{array}{c} \text{P}_{\text{cons}} \\
\text{\text{\text{\text{\text{Voc}}}}}
\end{array} \begin{array}{c} \text{\text{\text{\text{\text{P}}}}}_{\text{voc}} \\
\text{\text{\text{\text{\text{Cor}}}}}
\end{array} \]

As was demonstrated earlier in (1) and (2), there is no argument about the interaction between palato-alveolars and front vowels. We also remarked earlier that the situation with anterior coronals is not as straightforward. In our investigations, in fact, we have found that in languages with both apical and laminal anterior coronals, only the apicals pattern with front vowels. Within UA, there is no (non-arbitrary) way of capturing this fact.

2.2.3.1 Malayalam Central Vowels

To clearly demonstrate the difference in behaviour between types of anterior coronals, we will first look at the quality of central vowels adjacent to various types of consonants in Malayalam. Examples are in (14).
(14) a. Epenthetic i:

**CORONALS:**

<table>
<thead>
<tr>
<th>Lamino-dental:</th>
<th>Retroflex:</th>
<th>Apico-alveolar:</th>
<th>Prepalatal:</th>
</tr>
</thead>
<tbody>
<tr>
<td>katṭi ‘letter’</td>
<td>kaṭṭi ‘show’</td>
<td>kaṭṭi ‘wind’</td>
<td>waači ‘watch’</td>
</tr>
<tr>
<td>ḥaṇḍi ‘that day’</td>
<td>ḥaṇḍi ‘male’</td>
<td>ponni ‘gold’</td>
<td></td>
</tr>
<tr>
<td>awali ‘she’</td>
<td></td>
<td>kalli ‘stone’</td>
<td></td>
</tr>
</tbody>
</table>

**Lamino-alveolar:**

<table>
<thead>
<tr>
<th>wayari ‘stomach’</th>
<th>taaṛi ‘bend’</th>
<th>kuḷi ‘cold’</th>
</tr>
</thead>
<tbody>
<tr>
<td>paasi ‘pass’</td>
<td>maaśi ‘teacher’</td>
<td>kaaśi ‘cash’</td>
</tr>
</tbody>
</table>

**PERIPHERALS:**

<table>
<thead>
<tr>
<th>Velar:</th>
<th>Labial:</th>
</tr>
</thead>
<tbody>
<tr>
<td>paakkki ‘betel nut’</td>
<td>parippki ‘lentil’</td>
</tr>
</tbody>
</table>

b. Fronted a:

**CORONALS:**

<table>
<thead>
<tr>
<th>Lamino-dental:</th>
<th>Retroflex:</th>
<th>Apico-alveolar:</th>
<th>Prepalatal:</th>
</tr>
</thead>
<tbody>
<tr>
<td>kutt-al ‘to stab’</td>
<td>ḵeṭṭ-al ‘to tie’</td>
<td>aatt-ēl ‘to cool’</td>
<td>ṭeṇa ‘Rama’</td>
</tr>
</tbody>
</table>

*rema ‘Rama’ (rama in Tamil)*

**PERIPHERALS:**

<table>
<thead>
<tr>
<th>Velar:</th>
<th>Fronted Velar:</th>
</tr>
</thead>
<tbody>
<tr>
<td>wikk-al ‘to have a lisp’</td>
<td>wekk-ēl ‘keep’</td>
</tr>
</tbody>
</table>

Before we continue, it is important to point out the differences between the consonants in (14) and those in Mohanan (1986). First, the prepalatal affricate which we symbolize as /č/ is labelled as ‘palato-alveolar’ in Mohanan. In the dialect of our informant, however, it is clearly not equivalent to /č/ (cf. Tamil below). /č/ is tip-down and executed with the blade and front of the tongue. Second, in the dialect of our informant, /Ṭ/, /š/ and /Ṭ/ are all articulated in the same way. In Mohanan, the latter are labelled as ‘palatalized alveolars’. The difference between prepalatal and palatalized alveolar may in fact be trivial and, below, we provide structures for them that contain identical primitives. (The only difference is whether the two articulations, Coronal and Dorsal-Front, are simultaneous or ordered.) Third, the palatalized velar is labelled ‘palatal’ in Mohanan. Yet, it is identical to the [k] in English ‘keep’. Finally, Mohanan uses the symbol [z] for the retroflex approximant where we use [r].

Returning to the alternations in (14), all of the word-final vowels in (14a) are epenthized. As is apparent from those which appear after peripheral consonants, the epenthetic vowel is inherently [i]. Interestingly, though, after a subset of the coronals, this vowel fronts to [i]. While this is to be expected after the prepalatals, among the anterior coronals, the apicals trigger fronting
while the laminals do not. It is clearly apical vs. laminal that is relevant and not dental vs. alveolar because the alveolars divide into two classes along the apical-laminal dimension; compare [kaatti] ‘wind’ with [wayari] ‘stomach’ for instance.

The data in (14b) are entirely consistent with those in (14a): central /a/ is fronted to [ɛ] after apicals and prepalatals. [ɛ] additionally appears after fronted velars. (Epenthetic [i] does not occur after [k] in the dialect of our informant.)

2.2.3.2 Liquid Alternations

As additional support for the patterning of apical anterior with front vowels, we turn to liquid alternations in Ganda and Ifugao. In Ganda, [l] and [ɾ] are in complementary distribution. [l] is articulated as a laminal or apico-laminal lateral flap and [ɾ] as alveolar and often flapped (IPA [ɾ]) (Francis Katamba, p.c. 1994). As expected, it is apical [ɾ] which occurs after front vowels. Examples are in (15) (from Halle & Clements 1983:51):

(15) Ganda:
  wulira  ‘hear’
  beera  ‘help’
  kola  ‘do’
  lagira  ‘command’
  eddwaliro  ‘hospital’

In the Guhang dialect of Ifugao, a language spoken in the Philippines, there is one liquid phoneme (/l/) with three allophones whose distribution is conditioned by syllable structure and by the quality of adjacent vowels (Newell 1956). Here, we are concerned with the two [l] allophones. As expected, the alveolar (apical) lateral flap [l] occurs before front vowels, while the dental (laminal) lateral [l] occurs before central and back vowels. ([ɾ], a retroflexed palatal vibrant occurs in coda position.) Examples are in (16).

(16) Guhang Ifugao:
  a. /bål/t/  →  pfaɬ AVL  ‘banana’
    /lumá/hu/  →  lumá/hu  ‘hot’
    /l5ʔad/  →  l5ʔATɬ  ‘later’
  b. /madɬ/t/  →  mADɬɬ  ‘move’
    /bål/  →  pfaɬL̥  ‘house’
  c. /pɗolo/  →  pɗoL̥  ‘sun’
    /pɗol/  →  pɗɒL̥  ‘body’

3 Current Proposal: Doubly Dependent Front
3.1 Coronal Substructure

We can conclude the following from the palatalization facts discussed in Section 1 and from the alternations exhibited in Malayalam, Ganda, and Ifugao: apical anterior, palato-alveolars, prepalatals, fronted velars, and front vowels define a natural class to which laminal anterior and retroflexes do not belong. There are two particularly troubling facts about this observation. One, apical anterior pattern with front vowels and yet front vowels are clearly not apical. Two, laminal anterior do not pattern with front vowels but laminal posterior (palato-alveolars) do. Our solution
to this problem starts with a new feature Front which is doubly dependent on both Coronal and Dorsal nodes. See (17) (irrelevant structure omitted).

(17) **Current Proposal:**

```
  Root
   /      \
  Laryngeal  Supralaryngeal
    \      /  \
     Place Vocalic
       /  \
  Labial  Coronal  Dorsal  Phar
     /  \\
    Distr  Retro  Front
```

Front is defined as the *anterior* part of an articulatory region. Its interpretation is thereby mediated through the articulator to which it reports: a Front Coronal is one executed in the apical region, while a Front Dorsal is one produced with the front of the tongue body. We can thereby capture the natural class of apical anteriors and front vowels as segments which bear a dependent Front although this feature maps to a different articulator for each.

Before turning to representations for coronals and dorsals under (17), several details must be clarified. First, as we have said, when Front is dominated by Coronal, it is interpreted as apical. However, we also have a separate feature Distributed (cf. Hamilton 1993). The implication is then that a segment can be simultaneously apical and laminal. On the basis of the phonetic facts discussed in Keating (1991), we suggest that this is the representation for a palato-alveolar.

Second, according to Keating (1991), retroflex segments vary on the apical-laminal dimension (although they are laminal in Dravidian languages (Ladefoged & Maddieson 1986)).

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6 Two departures from standard feature geometry must be mentioned immediately. First, as may be apparent from the absence of brackets around the terminal features Distributed, Retroflex and Front, we assume that all features are monovalent. However, to distinguish the primitives that we adopt from those of standard binary feature theory, we will continue to place the latter in square brackets. Second, we assume that height features define their own Vocalic constituent independent of Place. Evidence to this effect is provided in e.g. Hyman (1988), Clements (1989), Goad (1991, 1993), Odden (1991), Wiswall (1991), Davis (1992), Dyck (1993).

7 Our proposal is in the spirit of Gorecka (1989b) who argues for a division of the Place node of Sagey into separate site and articulator nodes. Site dominates e.g. Anterior and Palatal, and articulator dominates e.g. Tongue Blade and Tongue Body. Since sites and articulators are in a sister relation, any site can in principle combine with any articulator. One result of current interest is that Palatal can combine with both Tongue Blade (= t,  , ) and Tongue Body (= c, i, ...). Two important differences between Gorecka's proposal and ours are as follows. One, we build in only the site-articulator combinations we wish to express in terms of double dependency. Two, most importantly, in Gorecka, each site has a single phonetic interpretation; for us, Front has a variable interpretation, depending on the node to which it docks.

8 On the basis of evidence from Australian languages, Hamilton (1993) arrives at similar conclusions to those discussed here. (1) Apical and laminal are independent of one another: Hamilton proposes Apical and Laminal articulators subordinated to Coronal. Apical dominates [retroflex] and Laminal [dentals]. (2) There is no feature [anterior] (see below in the text).
From (17), it can be seen that we (tentatively) assume that there is an independent feature Retroflex. Whether this feature is truly needed or whether retroflexion can ultimately be reduced to a combination of independently needed primitives we leave to further research.

Finally, it is apparent from (17) that we have dispensed with the feature [anterior]. We argue that contrasts among coronals can be captured with Distributed and Front (and Retroflex) alone. It has already been seen that in languages with dentals, alveolars and palato-alveolars, the dentals and alveolars do not pattern as a class as is incorrectly predicted by the feature [+anterior].

Representations for coronals are provided in (18).9 Anterior laminals, which are usually dental, are represented with a dependent Distributed. Anterior apicals have a dependent Front which, when mediated through Coronal, is interpreted as apical. Palato-alveolars have both Distributed and Front as they involve both the tongue tip and blade. Without evidence to the contrary, retroflexes are marked by an independent feature Retroflex. Prepalatals and palatalized coronals are structurally similar; in the former, the Coronal and Dorsal articulations are simultaneous, while in the latter, the pointer indicates that Coronal is primary (after Sagey 1986). (Depending on the nature of the palatalized coronal, the Coronal node in (18f) may have additional dependents.)

(18) a. Anterior Laminal (Dental) b. Anterior Apical (Alveolar) c. Posterior Apico-laminal (Palato-alveolar)
Place
Cor
Distr
Place
Cor
Front
Place
Cor
Distr
Front
d. Retroflex e. Prepalatal f. Palatalized Coronal
Place
Cor
Retro
Place
Cor
Dor
Front

3.2 Dorsal Substructure

As mentioned in note 6, we assume that height features define their own Vocalic constituent independent of Place. Dorsal, then, only dominates Front. In Sagey (1986), Dorsal is defined to include any segment articulated with the body of the tongue; this naturally includes [back] as well as [high] and [low]. Once the height features are removed, Dorsal must be redefined to indicate displacement of the tongue body on the horizontal dimension only. Dorsals are then of two types: velars which involve constrictions made with a retracted tongue body and palatalized/fronted velars which involve constrictions made with a fronted tongue body.10 The fact that velars often assimilate place from adjacent vowels suggests that they are represented as bare Dorsals (19c). Since fronted velars are often the output of assimilation to front vowels, they are represented with a dependent Front (19a).

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9 On the underspecification of Distributed in systems in which apicals and laminals do not contrast, see Section 4.

10 According to Keating & Lahiri (1990), palatalized velars and fronted velars are acoustically and articulatorily identical, which falls out of the current proposal; see Section 5.1.
(19) **Dorsals:**

a. Front Vowel  
   Fronted/Pal Velar  
   Place  
   Dor  
   Front  

b. Central Vowel  
   Place  

<table>
<thead>
<tr>
<th>Dor</th>
</tr>
</thead>
<tbody>
<tr>
<td>Front</td>
</tr>
</tbody>
</table>

c. Back (Unrnd) Vowel  
   Place  
   Dor

Parallel to velar consonants, back unrounded vowels are plain Dorsals. Whether back rounded vowels are Dorsal, Labial, or both Dorsal and Labial, we leave to further research.

Finally, from (19b), it can be seen that we assume that central vowels are specified for Place only. The SPE option, where central vowels share [+back] with back vowels, is not a possibility once the following facts are considered: Woleaian contrasts /u/ vs /u/, and Nimboran contrasts /i/ vs /u/ (see Clements 1990). Treating central vowels as articulator-less actually has desirable consequences: central vowels rarely transmit their own place but frequently assimilate place from adjacent segments; and, consistent with our definition of Dorsal, they involve no movement of the tongue body on the horizontal dimension.

4 Palatalization and Underspecification

In languages in which apical and laminal anterior obstruents contrast, as expected from our representations, it is the laminals which palatalize to palato-alveolar. To exemplify this, we will look at Tamil. Unlike in Malayalam, where noncontinuants in the palatal region are prepalatal, cognates in Tamil are pronounced with palato-alveolars: e.g. Tamil [tɔŋgu] corresponds to Malayalam [tʃɑŋɡi] 'neck'. Given the structures we have provided above, we correctly expect to find Palatalization in Tamil only. Some examples are in (20a). Lamino-dental /t/ is realized as [t] after (as well as before) /l/. (ɔu) is additionally fronted to [i] after [t]. From the examples in (20b), it is apparent that neither apico-alveolar /l/ nor retroflex /l/ is subject to Palatalization.

(20) **Palatalization in Tamil:**

a. /marai-tu/  →  marai t i  
   /pori-tu/  →  pori t i  
   cf. /poru-tu/  
   "having hidden"  
   "having fried"  
   "having waited"

b. /itti/  →  itti, *iti t i  
   /wiitu/  →  wiidu, *widzi  
   "club"  
   "house"

The rule for Tamil is expressed as in (21) (mirror image). Front spreads from /i/ onto /l/, deriving a segment with two dependents, Front and Distributed.

(21)  

<table>
<thead>
<tr>
<th>i</th>
</tr>
</thead>
<tbody>
<tr>
<td>1→t i</td>
</tr>
<tr>
<td>Dor</td>
</tr>
<tr>
<td>Cor</td>
</tr>
<tr>
<td>L - - 7</td>
</tr>
<tr>
<td>Front</td>
</tr>
<tr>
<td>Distr</td>
</tr>
</tbody>
</table>

While (21) is fine for languages such as Tamil, we have yet to address how Palatalization is expressed in systems which do not distinguish among anterior coronals. As Keating (1991:46) points out, in languages in which dentals and alveolars do not contrast, “they vary rather freely in apicality...”. As a result, anterior coronals cannot bear the dependents Distributed and Front. Once these features are eliminated from the representations in (22a) and (22b), we lose the contrast in favour of an unspecified anterior coronal (23a). However, unlike Distributed which is arguably inactive in systems such as that in (23), Front is still required for vowels (23c). If Front were to
spread from Dorsal /i/ onto Coronal /t/, the result would be the representation in (23b) which we suggest in such systems is the structure for a palato-alveolar.

(22) Languages with Contrasts among Anterior Coronals:

<table>
<thead>
<tr>
<th>Place</th>
<th>Place</th>
<th>Place</th>
</tr>
</thead>
<tbody>
<tr>
<td>a. Anterior Laminal</td>
<td>b. Anterior Apical</td>
<td>c. Palato-alveolar</td>
</tr>
<tr>
<td>Cor</td>
<td>Cor</td>
<td>Cor</td>
</tr>
<tr>
<td>Distr</td>
<td>Front</td>
<td>Distr</td>
</tr>
</tbody>
</table>

(23) Languages without Contrasts among Anterior Coronals:

<table>
<thead>
<tr>
<th>Place</th>
<th>Place</th>
<th>Place</th>
</tr>
</thead>
<tbody>
<tr>
<td>a. Anterior Coronal</td>
<td>b. Palato-alveolar</td>
<td>c. Front Vowel</td>
</tr>
<tr>
<td>Cor</td>
<td>Cor</td>
<td>Dor</td>
</tr>
<tr>
<td>Front</td>
<td>Front</td>
<td>Front</td>
</tr>
</tbody>
</table>

An important question which arises at this point is how we can determine that the representation in (23b) is that of a palato-alveolar rather than that of an apical anterior. First, in most of these languages, only the palato-alveolar will be indisputably apical. More importantly, though, we can appeal to markedness. Leaving retroflexes aside, in languages with two sets of coronals, the contrast is virtually always between anterior and palato-alveolar. It is typically only in languages with three sets of coronals that an apical/laminal contrast is introduced among the anteriors. In Maddieson's (1984) survey of 317 languages, only 5-7% have a dental/alveolar contrast without additionally having palato-alveolars. (Over 66% of the languages investigated have palato-alveolars.)

5 Residual Issues
5.1 Palatalization and Velar Fronting

Regardless of whether a language has a contrast among anterior coronals or not, the representations in (22)/(23) and those provided in (19) for dorsals correctly capture the fact that palato-alveolars and palatalized alveolars are phonetically distinct, while fronted velars and palatalized velars are not. In the former, spreading of Front from /i/ to /t/ will yield a palato-alveolar, while spreading of Dorsal–Front will yield the multiply articulated /ty/; see (24a). (For clarity, we use the representations in (23) over those in (22).) In the case of the dorsals, however, /i/ and /k/ share the same articulator node; the output of spreading, whether of Front or of Dorsal–Front, will therefore be identical as in (24b). The latter is not necessarily true in theories in which Front vowels are Coronal: spreading of Coronal and spreading of Place vo–Coronal will yield different representations.

(24) a. i \[ \rightarrow \text{i} \]

Place          | Place          | Place          |
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Cor</td>
<td>Dor</td>
<td>Front</td>
</tr>
</tbody>
</table>

b. i \[ \rightarrow \text{ty} \]

Place          | Place          | Place          |
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Cor</td>
<td>Dor</td>
<td>Front</td>
</tr>
</tbody>
</table>
5.2 Coronalization Revisited

Since front vowels have no Coronal component in our geometry, one process which we cannot capture as a single operation is Coronalization. Instead, /k/ to [tʃ] must be expressed as in (25): Front spreads from /i/ to /k/ yielding a fronted (palatalized) velar; the fronted velar is then reanalysed as [tʃ], something along the lines of (25b).

(25) Coronalization:
\[
\begin{align*}
\text{a. Spreading:} & \\
& \begin{array}{c}
k \quad i \\
| \quad | \\
\text{Dor} \quad \text{Dor} \\
\text{Front}
\end{array} \\
\text{b. Reanalysis:} & \\
& \begin{array}{c}
k > \quad \varepsilon > \quad \text{tʃ} \\
| \quad | \\
\text{Dor} \quad \text{Cor} \quad \text{Dor} \quad \text{Cor} \\
\text{Front} \quad \text{Front} \quad \text{Front}
\end{array}
\end{align*}
\]

(25) is in contrast to UA where, as discussed in Section 2.2.2, Coronalization is expressed as Coronal Spread with subsequent delinking of the Dorsal specification of /k/. Consistent with Spencer's observations about the absence of Coronalization from allophonic rule systems, we suggest that any geometry which prevents a unified account of /k/ to [tʃ] (i.e. as spreading) is the more constrained.

5.3 The Representation of Palatals

So far, we have argued that fronted velars, palato-alveolars and palatalized segments all contain a dependent Front. One question which naturally arises is: how are palatals represented? On the basis of X-ray evidence, Keating (1988) argues that palatals are complex corono-dorsals with dorsal dependents identical to those which mark palatalization. In the current framework, this suggests the representation in (26a), identical (in relevant respects) to that for a prepalatal or a palatalized coronal (cf. (18e,f)). A priori, it might seem that palatals and prepalata/palatalized coronals should contain the same primitives; however, they behave differently from one another. On phonological grounds, we argue instead that palatal nonvocoids have the representation in (26b).

(26) a. \[
\begin{array}{c}
\text{Place} \\
\text{Cor} \quad \text{Dor} \\
\text{Front}
\end{array}
\]

b. Palatal Nonvocoids:

\[
\begin{array}{c}
\text{Place} \\
\text{Cor} \quad \text{Dor} \\
\text{Front}
\end{array}
\]

First, we will briefly consider the evidence that palatals are multiply-articulated. Benger (1993) notes that palatals are often restricted to onset position which she attributes to their complex representation. She provides the languages in (27a) as observing this constraint. As evidence for their Coronal and Dorsal components, Benger points out that in coda position, Spanish palatals are simplified to plain coronals, while Canadian French /tʃ/ is simplified to a plain dorsal. These facts are consistent with both representations in (26).
(27) Palatal as Complex Dorso-Coronal (Benger 1993):
   a. Palatals Restricted to Onset Position:
      Ekparabong, Korean, Catalan, Basque, Spanish, Québec French dialects
   b. Spanish: /θ, ʎ/ → coronal [n,l] in coda position
      Québec French: /θ/ → dorsal [g] in coda position

   Let us now consider the status of the dependent Front in (26a). Oddly enough, palatal
   nonvocoids are not derived through the palatalization of coronals; yet ,with the representation in
   (26a), this is exactly what is predicted. Instead, as we have seen, palatalization of coronals yields
   palato-alveolars. 11 As a parallel phenomenon, we may note that palatals behave neutrally in Front
   Harmony. In languages such as Hungarian and Eastern Cheremis in (28), they are neither opaque
   nor do they initiate spreading.

(28) Front Harmony: Palatals as Neutral:
      Non-opaque:
      meʃt-unk, *meʃ-unk ‘to go’
      Non-triggers:
      vaʃ-unk, *vaʃ-unk ‘to be’
   b. Eastern Cheremis (Sebeok & Ingemann 1961):
      Non-opaque:
      jũţo, *jũţo ‘oats’
      jōrtŋo, *jōrtŋo ‘gold’
      Non-triggers:
      koʃmo, *koʃmō ‘spade’
      oʃtŋo-1-no, *oʃtŋo-1-nō ‘in front’

   This behaviour of palatal is in direct contrast to that of palatalized consonants. Palatalized velars
   trigger Front Harmony in Turkish (29a), and palatalized anterior coronals block Umlaut in
   Kyungsang Korean (29b).

(29) a. Turkish Front Harmony (Clements & Sezer 1982):
      idräk-y-i, *idräk-y-i ‘perception’ (acc)
      cf. hakk-i ‘law’ (acc)
      usüly-yi, *usüly-u ‘system’ (acc)
      cf. okul-u ‘school’ (acc)
   b. Kyungsang Korean Umlaut (Hume 1990):
      /tači-ta/ → taj ida, *tæj ida ‘to mince’
      cf. /salpʰ-i-ta/ → sälpʰida ‘to inspect closely’
      /pʰeči-ta/ → pʰejo ida, *pʰejo ida ‘to spread out’
      cf. /mek-hi-ta/ → mekʰida ‘to be eaten’

   All of these facts suggest that palatals are represented not as in (26a) but instead as in
   (26b), without a dependent Front. Palatalized consonants, on the other hand, must have a Dorsal–
   Front component. In this way, they can impede the spreading of Front from front vowels as well
   as initiate their own Front Spread to vowels.

11 We should point out that this gap is not expected in Hume’s (1992) model, where palato-alveolars and
   palatals differ only in their specification for [strident]. In fact, Hume predicts that /θ/ should palatalize to [ɛ] more
   readily than it does to [t].
One problem remains. Adjacent to front vowels, velars surface not always as fronted velars but sometimes as plain palatals. This is true of German and Greek for instance; see (30). If palatals do not contain a dependent Front and, furthermore, if front vowels do not contain Coronal, it seems that this fact cannot be readily captured.

(30) **German:**
    /x/ → [c] / front vowels

**Greek:**
    /k, x/ → [c, ʃ] / front vowels

However, since languages do not contrast fronted velar and palatal fricatives, the German case can be expressed as spreading of Front. In other words, German palatal [c] is structurally identical to a fronted velar. The Greek situation is somewhat more complicated: not only does /x/ become [c], but /k/ is realised as [ʃ] as well. In this case, we are forced to treat both palatal stop and fricative as fronted velars. Since Greek does not otherwise have fronted velars, this is perhaps an adequate solution.

5.4 **Coronal Harmony Revisited**

We have argued that both palato-alveolar consonants and front vowels have a dependent Front. We must then guarantee that Coronal Harmony, which commonly involves palato-alveolars, will not be blocked by intervening front vowels. Consider the Chumash data in (31): anterior and palato-alveolar sibilants agree for sub-Coronal features with the rightmost sibilant in a word.

(31) **Chumash** (data from Beeler 1970, Poser 1982):
    a. **Assimilation to Rightmost Anterior Coronal:**
        puspelus    ‘you hold it for him’
cf. puipel    ‘you hold something’
    b. **Assimilation to Rightmost Palato-alveolar:**
        kaʔalafunal ‘he’s the boss’
cf. kasunun    ‘I command’
    c. **Front Vowels as Neutral:**
        sixut, *ixut ‘it burns’
        silakl, *silakl ‘it is soft’

It is clear from (31c) that front vowels do not participate in Coronal Harmony: they do not spread their Front specification onto anterior coronals, nor do they block spreading which targets anterior coronals. Far from being a problem, this is exactly what we predict. While both palato-alveolars and front vowels bear a dependent Front, this feature docks into different nodes, into Coronal and Dorsal respectively. We suggest that harmony involves right-headed fusion of Coronal as in (32) (cf. Rice & Avery 1989).

(32) **Right-headed Fusion of Coronal:**

\[
\begin{array}{ccccccc}
\text{S} & \text{i} & \text{f} & \rightarrow & \text{f} & \text{i} & \text{f} \\
\text{P} & \text{P} & \text{P} & \text{P} & \text{P} & \text{P} & \text{P} \\
\text{Dor} & \text{Dor} & \text{Dor} & \text{Dor} & \text{Dor} & \text{Dor} & \text{Dor} \\
\text{Cor} & \text{Cor} & \text{Cor} & \text{Cor} & \text{Cor} & \text{Cor} & \text{Cor} \\
\text{Front} & \text{Front} & \text{Front} & \text{Front} & \text{Front} & \text{Front} & \text{Front}
\end{array}
\]
5.5 Total Vowel Assimilation

Let us turn finally to Total Vowel Assimilation within the current framework. Unlike standard vowel harmony, where vowels assimilate for a single feature within some domain (usually the word), in several languages, the entire vowel melody if subject to assimilation. In the examples in (33) from Klamath, the vowel of the causative prefix is a complete copy of the immediately following vowel. Consonants of any quality can intervene (examples from Odden 1991; original source Barker 1963, 1964).

(33) Klamath:
  sna-batgal \( \rightarrow \) ‘gets someone up from bed’
  sne-leemlem’a \( \rightarrow \) ‘makes someone dizzy’
  sno-bo’estgi \( \rightarrow \) ‘causes something to turn black’
  sni-nkiik’a \( \rightarrow \) ‘makes dusty’

In the Unified Articulators approach, where the place node for vowels is a dependent of that for consonants, Total Vowel Assimilation can be readily explained as spreading of the vowel place constituent. In Hume’s (1992) model, spreading is of Voc as in (34).

(34)

```
  V    p    u
  \|/    \|/    \|
 P_{cons} P_{cons} P_{cons}
     \-----------> Voc
         \|/    \|/    \|
     P_{voc} Stric\| Lab\| High
```

Since there is a single place node for both consonants and vowels in the current framework, spreading of the entire vowel melody over top of a consonant is impossible. The only alternative is that Total Vowel Assimilation involve melody copy. We argue that this is not a drawback but is in fact an advantage of our model. Unlike standard vowel harmony, Total Vowel Assimilation does not apply successively to all vowels within some domain. It typically (if not always) applies once, to fill a position which has been epenthized for syllabification reasons. In other words, outside of languages with independently motivated CV plane segregation, we do not find languages in which all vowels in a word are completely identical. We therefore argue that Total Vowel Assimilation and Vowel Harmony are formally different; they involve copying vs spreading respectively.
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