Underspecification theory and the Coronal node*

Peter Avery and Keren Rice
University of Toronto

1. Introduction

In this paper we will discuss some problems which arise in a theory of phonology which assumes a version of underspecification theory such as that found in Kiparsky (1982) and a model of segment structure along the lines proposed in McCarthy (1988) (see also Clements (1985), Sagey (1986)). The major focus of the paper is on the underspecification of articulator features with particular reference to the Coronal node. We set out a theory of underspecification which is constrained by universal markedness conditions and a node activation condition. This theory is concerned with how segments come to be specified rather than how they come to be underspecified. Thus the problem for the language learner is one of building up representations consistent with universal markedness conditions and the Node Activation Condition.

The structure of the paper is as follows. In §2, we outline the theory of segment structure which we assume. In §3, we turn to the workings of underspecification, contrasting different approaches to the problem of underspecifying distinctive features and nodes. We then introduce the Node Activation Condition and outline its function in constraining underspecification. In §4, we present data from Ponapean, Catalan and English which require that the Coronal node be absent from underlying representation and in §5, we present data from Sanskrit, Chumash and Navajo which require that the Coronal node be present in underlying representation.

2. Segment Structure

Clements (1985) argues that segments be represented with hierarchical structure. He proposes that segments consist of a set of nodes which in turn dominate other nodes or terminal features. The highest level of structure is the Root node, which is linked directly to the CV skeleton or the organizing tier. The Root node dominates a Laryngeal node, which in turn dominates laryngeal features, and a Supralaryngeal node, which ultimately dominates all non-laryngeal features. McCarthy (1988) has proposed a modification to this model, arguing that the Supralaryngeal node is not necessary. His claim is that the Root node itself is composed of the features [consonantal] and [sonorant] and that the Root node in turn dominates a Laryngeal node, a Place node and the features [continuant] and [nasal].1 We are for the most part in agreement with McCarthy’s model and assume its overall correctness in this paper. The model we assume is outlined in (1). (For more standard views of segment structure see, for instance, Clements 1985, Sagey 1986, Pulleyblank 1988, Schein and Steriade 1986.)

![Segment Structure Diagram]

The terminal features enclosed in [ ] are the traditional binary features of Chomsky and Halle (1968) and thus can have either a + or a - value. The non-terminal features are class...
nodes which are distinguished from the traditional binary features in that they are privative, being either present or absent in phonological representations. Thus, a segment which is labial does not need to be specified as [-dorsal], [-coronal] as the presence of the Labial node implies the absence of the Dorsal and Coronal nodes.  

3.0 Underspecification

All proponents of underspecification agree that redundant values should be underspecified at the underlying level though there may be some disagreement on the definition of redundancy. For example, the value for [voice] need not be marked on sonorants in a language with only voiced sonorants. Disagreements about underspecification centre around the treatment of distinctive features, or those features which are minimally required to distinguish two segments in an inventory. Recent discussion of underspecification has questioned whether the distinctive features of a language need to be marked both plus and minus underlyingly or whether only a single value can be present. Two positions on underspecification have been espoused in the literature. Kiparsky (1982) and Archangeli and Pulleyblank (1986) propose that only a single value of a distinctive feature is present underlyingly, the choice of the feature being supplied by universal markedness conditions. This position we term 'maximal underspecification.' Steriade (1987b) and Clements (1987) have retreated somewhat from this view, arguing that both values of a distinctive feature must be present underlyingly. This position we term 'redundant underspecification.' The difference between these positions can be seen in underspecification for [voice] of the consonant system in (2).

(2a) Maximal Underspecification

\[ p \quad b \quad t \quad d \quad k \quad g \quad m \quad n \quad l \quad r \]
voice \quad +++

(b) Redundant Underspecification

\[ p \quad b \quad t \quad d \quad k \quad g \quad m \quad n \quad l \quad r \]
voice \quad -+++-+

In this language, voicing is distinctive for obstruents but not for sonorants. Under maximal underspecification, only the marked value of the feature need be present in underlying representation, as in (2a). Universal markedness conditions supply the marked value for voice and thus the voiced obstruents will be marked \(+\). The voiceless obstruents need not have any marking for [voice] as minus is the unmarked value and is supplied by a default rule. With sonorants, as voicing is nondistinctive and predictably \(+\), the value is absent in underlying representation.

Under redundant underspecification all distinctive oppositions are present in underlying representations and only values 'predictable from feature co-occurrence restrictions' (Steriade 1987b, page 339) may be underspecified. Thus for a feature that minimally distinguishes two segments in a particular system, both plus and minus values must be specified, as shown in (2b). Redundant underspecification and maximal underspecification are thus similar with respect to the value of the feature [voice] in sonorants. However, redundant underspecification requires that both values of the feature [voice] be present in underlying representation when the feature is distinctive.

While the workings of underspecification are relatively simple to contrast when we are dealing with binary features, certain complications arise when underspecification theory is combined with current views of segment structure. Clements (1987) deals overtly with the issue of underspecification of class nodes, claiming that nodes must be present in underlying representation. He points out that the use of unary nodes allows for automatic underspecification as the presence of one node, such as Labial, implies the absence of the
other articulator nodes. While this restricts options available to a theory of underspecification, we argue that such a position cannot be maintained. In particular, we will focus on the Coronal articulator node and argue that this node can be absent in underlying representation.

The evidence that forces us to conclude that the Coronal node can be underspecified comes from both markedness considerations and the behaviour of coronals in the phonological systems of particular languages. In a theory which requires that articulator nodes be present in underlying representation, there is no mechanism to capture markedness facts. Kean (1976) noted that, with the possible exception of Hawaiian, all languages have coronal consonants. If we wish to capture this fact in terms of markedness theory, the Coronal articulator node should be underspecifiable, with the coronal node being supplied by default. Of course, if this proposal is to be maintained we must have empirical evidence showing that Coronal is absent from underlying representations. This means that coronals should behave asymmetrically with respect to other places of articulation. We will argue based on data from Ponapean, Catalan and English that the behaviour of coronals in these phonological systems provides just such evidence. On the other hand, we are not suggesting that coronal is always underspecified. Sanskrit, Chumash and Navajo provide evidence that some or all of the coronal consonants must be underlyingly marked for Coronal.

3.1 Constraining Underspecification

Our goal in this section is to present a theory of underspecification in which unmarked values, in the sense of markedness theory, are absent from underlying representation. At the same time, we hope to capture the notion of distinctiveness in the sense of Steriade (1987b). This means that two segments which are minimally distinct, i.e., are distinguished simply by the + or - value of a single feature, will be structurally identical except for the presence of the marked value on one of the segments. This is opposed to the view espoused by Steriade (1987b) (and Clements 1987), who seeks to constrain underspecification by forcing both values of a distinctive feature to be present underlyingly. We hold that Steriade is forced to this position because she fails to utilize the hierarchical representation made available by the enriched segmental representations outlined in section 2. However, we are in full agreement with Steriade that there is a 'linguistically significant boundary ... separating distinctive and non-distinctive assignments of feature values' (page 358). We will take a somewhat different approach to the problem of constraining underspecification, claiming that it is not the +/- values that are significant, but the nodes which dominate these values. For example, if [voice] is distinctive in a system, we would like to maintain the generalization that the unmarked value for [voice] is [-voice] and be able to underspecify this. This can be achieved if we require that nodes which dominate terminal features which are distinctive in a system be present in underlying representation. This is equivalent to claiming that a node which dominates a distinctive feature in a system is activated in that system and is thus present.

Underspecification is constrained by two conditions: the Node Activation Condition and the Markedness Condition. The Node Activation Condition (NAC), stated in (3), determines the amount of structure that must be present for a given segment in a phonological system.

(3) Node Activation Condition

If a feature is distinctive for a class of segments in a phonological system, then the node which dominates that feature is said to be activated for that class of segments. Active nodes must be present in underlying representation. Inactive nodes are absent in underlying representation.

The second condition, the Markedness Condition (MC), determines which values of features appear in underlying representation.
(4) Markedness Condition

Marked values are present in underlying representations. Unmarked values are absent.

The MC is meant to capture generalizations about markedness along the lines proposed in Chomsky and Halle (1968). What characterizes particular segments are the marked features which must be present in underlying representation and the activated nodes within the system.

Given the NAC and the MC, the simplest statement possible regarding the working of underspecification is given in (5).

(5) Specify

(5) is constrained by the NAC and the MC, thus yielding the most parsimonious representation. Structure is added only as necessary to maintain distinctiveness within the system. From the point of view of the learner, as marked values are added, additional structure is created and nodes are activated in the phonology.

To see how these conditions work consider a language in which /p/ contrasts with /b/. We assume the contrast between the two segments is with respect to a laryngeal feature such as [voice]. If the marked value for [voice] is [+voice], then this value must be present on the segment /b/ by the MC. However, the contrast at the Laryngeal node also forces the presence of a Laryngeal node for /p/ by the NAC. Thus the segments would be represented as in (6) (irrelevant details have been suppressed).

(6)  

/p/           /b/

[+]voice       

Root
Laryngeal
Place
Labial

Note that our theory requires that the Laryngeal node be present for both /b/ and /p/. These segments would remain distinct if the Laryngeal node were absent from /p/. However, a contrast at the Laryngeal node suggests that Laryngeal is an active tier in the phonology and it would be expected that alternations may be found involving laryngeal features. If both /p/ and /b/ have a Laryngeal node, while other segments for which [voice] is not contrastive do not have a Laryngeal node, then the susceptibility of the /p/ and /b/ to participate in voicing alternations is unsurprising. Likewise, the transparency of other segments to laryngeal alternations is predicted. (See, for example, the case of Rendaku and Lyman's Law in Japanese (Itoh and Mester 1986.)

Now consider a system in which /s/ contrasts with /š/. If the distinction between /s/ and /š/ is based on the feature [anterior] and the marked value of this feature is [-anterior], then this feature must be present on /š/. As [anterior] is directly dominated by the Coronal node, the Coronal node must be activated for /š/. As /s/ and /š/ are distinct only with respect to the feature [anterior], the NAC requires a Coronal node in the underlying representation of both segments. We thus have representations as in (7) (irrelevant details omitted).
If there were no /š/ in the system, the Coronal node need not be present for /s/ since it would not be forced by the NAC.\(^5\)

Next consider a common stop system, one with the stops /p t k/. We claim that the stops are represented as in (8).

As Labial and Dorsal are marked articulator nodes, the MC requires their presence in underlying representation. Coronal, on the other hand is supplied by default. We assume that Place is not a contrastive feature\(^6\) in a /p t k/ system and that it is present only to hold actual articulator nodes. In the absence of an articulator node, no Place node is required, thus /t/ can be represented as the unmarked consonant in this system, with only a Root node.

In the remainder of the paper we examine evidence for the view of underspecification just outlined. We argue that class nodes can be underspecified and that this underspecification is determined by examining contrasts within an inventory as well as by universal markedness conditions. Universally the Coronal node may be absent; however, Coronal must be present for segments contrasting on a feature dominated by the Coronal node. Finally, we argue that unmarked values for features and unspecified nodes are filled in late in the phonology, if at all. It may be that fill-in is an aspect of phonetic implementation (see, for instance, Beckman and Pierrehumbert (to appear) on the issue of late fill-in).

With this background, we are ready to turn to examples. We will begin by presenting examples from Ponapean, Catalan, and English which show that Coronal must be absent in underlying representation. We will then turn to Sanskrit, Chumash and Navajo, languages which argue for the existence of the Coronal node at the underlying level.

4. Absence of a Coronal node

4.1 Ponapean

Ponapean has the obstruent inventory given in (9).\(^7\)

(9) Ponapean obstruents

\[
\begin{array}{ccc}
p & t & k \\
p'w & \ddash s & \ddash s \\
\end{array}
\]

(note - t = orthographic d, \ddash s = orthographic t)

Rehg and Sohl 1981, p. 34

As there are no contrasts between places of articulation within the coronals in this inventory, the NAC and the MC do not require a Coronal node to be present. This is borne out by phonological processes of the language as well.

In Ponapean, consonant clusters are generally not allowed, and consonantal sequences are usually subject to epenthesis, as shown in the examples in (10).
(10) a. /kitik - men/  -->  kiti\text{i}m\text{en}  'rat'
b. /ak - p\text{w}uq/  -->  akup\text{w}uq  'petty'
c. /ak - suwei/  -->  akusuwei  'demonstrating boastfulness'

Itoh 1986, p. 120

When labial-labial and velar-velar sequences occur a different pattern is found. Instead of epenthesis, a process which Itoh (1986) refers to as fusion takes place. After fusion, the first consonant becomes a nasal by a separate process of nasal substitution (See Itoh, 1986 and Rehg and Sohl 1981 for details. For a different analysis, see Rice and Avery 1987.). Examples of such sequences are shown in (11).

(11) Labial + labial and velar + velar combinations
a. /kehp - m\text{w}ot/  \rightarrow  khe\text{m}\text{w}m\text{w}ot  'variety of yam'
b. /ep - p\text{woatol}/  \rightarrow  em\text{w}p\text{woatol}  'game'
c. /sap\text{w} - paa/  \rightarrow  sampaa  'world, earth'
d. /ak - keelai/  \rightarrow  akeelai  'demonstrate strength'

Itoh 1986, p. 137

Now consider what happens with a sequence of coronals. One might expect them to pattern like labial-labial and velar-velar sequences, with fusion and nasal substitution. However, this is not what occurs. When a sequence of coronal consonants arises, epenthesis rather than fusion takes place. This is illustrated in (12).

(12) Identical coronal consonants
a. /weid - da/  \rightarrow  weid\text{i}da  'proceed upward'
b. /lus - saq/  \rightarrow  lus\text{i}saq  'jump from'
c. /daur - di/  \rightarrow  daur\text{i}di  'climb downward'

Rehg and Sohl 1981, p. 63

Itoh explains the asymmetrical behaviour of the coronals by underspecifying the feature [coronal]. If [coronal] is underspecified, fusion of place features cannot occur. Thus coronal sequences are treated like any other consonant-consonant sequences and epenthesis applies.

We analyse these facts in basically the same way as Itoh. However, we claim that fusion is actually the result of spreading of the rightmost node followed by delinking of the left, as in (13).

(13)

\begin{center}
\begin{tikzpicture}
  \node (root) at (0,0) {Root};
  \node (place) at (-1,-1) {Place};
  \node (articulator) at (-2,-2) {articulator node};
  \draw (root) -- (place);
  \draw (place) -- (articulator);
\end{tikzpicture}
\end{center}

With labial-labial and velar-velar sequences, the structural description of the rule is met. With coronals, on the other hand, as no Place node exists, no spreading occurs and epenthesis applies.\(^8\)

The argument for the absence of Coronal based on the Ponapean inventory is thus supported by the phonology: labials and velars pattern as if the Place node had content whereas Coronals pattern as if they were totally unmarked for place. We thus can conclude, based on both inventory and phonological patterning, that in Ponapean the Coronal node is not present in underlying representation. These facts are an embarrassment for a theory which requires the presence of unary nodes, and some stipulation concerning the asymmetrical behaviour of coronals would be required.
Ponapean also sheds light on the question of the fill-in of default values such as Coronal. Phrasal data suggest that not only must the Coronal node be absent underlyingly, it also must be absent until very late in the derivation, until after the lexical and postlexical phonology. Support for the argument that Coronal is not filled in can be seen by examining the connected speech data in (14).

(14) Post-lexical fusion
a. E kalap pahn soupisek → kalam pahn
   'He will always be busy.'
b. E saik kengwini → saiq kengwini
   'He hasn't yet taken medicine.'
c. E ekiŋ suwed → *ekiŋ suwed
   'It's kind of bad.'
d. Ke meinŋ dangaŋga → *meinŋ dangaŋga
   'Aren't you lazy!'

Rehg and Sohl, 1981, p. 63

(14a, b) show sequences of homorganic noncoronals at word boundaries. Notice that even across a word boundary, fusion and nasal substitution can occur. In the coronal-coronal sequences in (14c, d), fusion and nasal substitution are blocked. If Coronal were filled in, the coronals should pattern postlexically with the labials and velars. When is Coronal filled in? The evidence suggests that Coronal is not a relevant node in the phonology of Ponapean and that perhaps the specification of coronal segments is postponed until after the postlexical phonology and is an aspect of phonetic implementation.

In Ponapean, we find strong evidence for the absence of a Coronal node. As there are no contrasts within coronals, the MC requires that Coronal be unspecified. Empirical support for this can be seen in the behaviour of the coronals in the phonology.

4.2 Catalan

The behaviour of coronals in Catalan also presents evidence for the underspecification of the Coronal node. We will first consider assimilation of nasals and then assimilation of coronal stops.

4.2.1 Nasal Assimilation

In Catalan, four places of articulation must be distinguished underlyingly for nasals: labial, coronal, palatal and velar. Under our markedness assumptions, the labial and velar nasals require specification for place. The treatment of the palatal nasal is, on the other hand, less obvious. We will follow Keating (1987) in considering palatals to be complex coronals which branch at the Place node. Palatals are at the surface specified Coronal and [high]. By our assumptions the Coronal node in palatals is underspecified and is provided by a default rule. The feature [high] is not dominated by an articulator node, but links directly to the Place node. The representations of the nasals are as in (15).

(15) /m/ /n/ /n̥/ /ŋ/
    Root
    Place
      labial [nasal]
      [nasal] [nasal]
      [nasal] [nasal]
      [high] dorsal

Support for the underspecified system in (15) comes from a process of nasal assimilation that is found in Catalan. /n/ assimilates to all places of articulation, as in (16).
(16)  a. unassimilated alveolar  so[n] amics  'they are friends'  
b. labial  so[m] pocs  'they are few'  
c. labiodental  so[n] feliços  'they are happy'  
d. dental  so[n] dos  'they are two'  
e. alveolar  so[n] sincers  'they are sincere'  
f. postalveolar  so[n] rics  'they are rich'  
g. laminopalatal  so[n,] [z]er man's  'they are brothers'  
h. palatal  so[n,] [ç]iures  'they are free'  
i. velar  so[n] grans  'they are big'

Kiparsky 1985, p. 95

(Note that the assimilation is incomplete when the nasal precedes a palatal, with /n/ becoming laminopalatal. We assume that this is due to the structure of the complex segment /ni/. A solution to this problem is presented at the end of this section.)

The other nasals do not assimilate in the way that /n/ does; they assimilate only within their own articulator nodes. /m/ thus assimilates to a following labial (bilabial, labiodental) and the palatal and velar nasals do not assimilate at all since there are no place distinctions below their articulator nodes. This is illustrated in the forms in (17).

(17) /m/:  
so[m] amics  'we are friends'  
so[m] pocs  'we are few'  
so[n] feliços  'we are happy'  
so[m] dos  'we are two'  

/ŋ/, /n/:  
ti[ŋ] pa  'I have bread'  
a[ŋ] feliç  'happy year'

Kiparsky 1985, p. 95

There are two distinct phonological processes that result in the effect of nasal assimilation in Catalan. The same spreading and delinking process as found in Ponapean (see 13) accounts for the examples in (17). The second process resulting in nasal assimilation is spreading to an empty Place node. This is shown in (18).

(18)  
Root  
Place  
articulator

This rule spreads the articulator node of a segment on the right to a Place node unspecified for an articulator on the left. All of the examples in (16) are handled by this rule. Thus, as Kiparsky (1985) notes, it is the unmarked status of the coronals which allows for free assimilation. If the /n/ had a Coronal node, some special stipulation would be required about the assimilative behaviour of the coronals. On our account everything follows from the underspecification of Coronal, which in turn follows from markedness considerations.

Consider now the incomplete assimilation of the unmarked nasal to the palatals illustrated in (16h) and repeated below.

(16)  h. palatal  so[n,] [ç]iures  'they are free'
Under most accounts of nasal assimilation the behaviour of the nasal in this position is something of a mystery (see Kiparsky 1985, note 10). Our account shows why incomplete assimilation is the expected result. Recall that with palatals, the feature [high] is attached directly to the Place node. Following Kiparsky (1985), we assume that [high] consonants are redundantly [distributed]. When the redundant values are filled in for the palatal consonant, the feature [+distributed] will be added, creating the need for a Coronal node, as illustrated in (19).

\[(19)\]

```
[high]  ---->  [high]
        \     /  \     /  \     /  \     /  \     /  \     /  \\
         \    / \    / \    / \    / \    / \    / \    / \\
          \  /  \  /  \  /  \  /  \  /  \  /  \\
             \ /   \ /   \ /   \ /   \ /   \\
                 Place
```

Once Coronal is present, the structural description of nasal assimilation is met. It is just the Coronal node, along with the features that it dominates, in this case [+distributed], that spreads. The feature [high] will not spread since it is attached to the Place node rather than the Coronal node. This is illustrated in (20).

\[(20)\]

```
\[\text{n} \ \wedge \ \]
```

```
[high]  ---->  spreading
        \     /  \     /  \     /  \     /  \     /  \\
         \    / \    / \    / \    / \    / \    / \\
          \  /  \  /  \  /  \  /  \  /  \  /  \\
             \ /   \ /   \ /   \ /   \ /   \\
                 Place
```

\[\text{Root} \]

```
[high]  ---->  [high]
        \     /  \     /  \     /  \     /  \\
         \    / \    / \    / \    / \    / \\
          \  /  \  /  \  /  \  /  \  /  \\
             \ /   \ /   \ /   \ /   \ /   \\
                Coronal
```

4.2.2. Assimilation of coronal stops

Mascaro (1978) discusses an optional process in Catalan which involves the assimilation of coronal stops /t/ and /d/ to following consonants. This is illustrated in (21).

\[(21)\]

```
se[t] seven
se[m] mans 'seven hands'
se[p]focs 'seven fires'
se[k] cases 'seven houses'
```

Mascaro 1978, p. 43

As with the nasals, labial and velar stops assimilate only within their own place of articulation, as illustrated in (22).

\[(22)\]

```
ca[p] 'no'
ca[m] ma 'no hand'
ca[p] foc 'no fire'
ca[p] signe 'no sign'
ca[p] casa 'no house'
pok 'few'
po[k] pa 'few bread'
po[k] sol 'few sun'
```

Mascaro 1978, p. 43
Again this asymmetric patterning of the coronals suggests that the Coronal node is absent throughout the lexical phonology and that its specification is postponed to a very late level, resulting in the widespread assimilation of coronals in cross-word environments.

The MC and the NAC predict the behaviour of the different places of articulation with respect to assimilation processes. The unique patterning of the coronals in the phonology is best explained by the absence of a Coronal node.

### 4.3. English

It has been assumed that the Coronal node must be specified in English (see, for instance, Yip 1988). However, inventory and phonological evidence suggest that this is not the appropriate analysis of English.

First, consider the English consonant inventory. Among the stops there are no contrasts under the Coronal node and thus the Coronal node should be underspecified according to the MC. Furthermore, as English does have a contrast between /t/ and /d/, the NAC requires a Laryngeal node. We assume the representation in (23) is the underlying specification for English /t/.

\[
\text{(23)} \quad /t/ \\
\]

There is also phonological evidence suggesting that (23) is correct. In some dialects of English, /t/ is realized as a glottal stop when in syllable-final position followed by the syllabic nasal /n/, (24a), or in word-final position followed by a consonant-initial word, (24b). /t/ and glottal stop thus function as allophones and form a natural class in English.

\[
\text{(24a).} \quad \begin{align*}
\text{b} & \text{\textcopyright n} & \text{'button}' \\
\text{b} & \text{\textcopyright e} & \text{\textcopyright n} & \text{'batten'} \\
\text{k} & \text{\textcopyright a} & \text{\textcopyright n} & \text{'cotton'} \\
\end{align*}
\]

b. \text{h} & \text{\textcopyright t} & \text{\textcopyright θ} & \text{'hit the.'} \\
\text{k} & \text{\textcopyright t} & \text{\textcopyright \textcopyright f\textcopyright l\textcopyright a\textcopyright w\textcopyright t\textcopyright z} & \text{'cut flowers'}

While we are not concerned with the specific environment of the rule (see Avery (in preparation) for details), the simplest account of these facts follows from the underspecification of the Coronal node. If we assume that the representation of glottal stop is just Laryngeal node with no Place node (see Clements 1985, McCarthy 1988), then the alternation between /t/ and glottal stop is totally natural as the specification for English /t/, given in (23), is the same as the representation of a glottal stop. When /t/ is realized as a glottal stop, default values for Coronal are not filled in.

If we compare the Catalan data in (21) with the English data in (24), we see that in Catalan the alternation is not between /t/ and glottal stop but rather that /t/ takes on place features from an adjacent consonant: it may be that /t/; like /n/ in Catalan, has a Place node. While in English, the Place node is not present distinctively. In Catalan, then, /t/ and glottal stop are not likely to alternate but in English the alternation unsurprising given the representations.

Further evidence for the absence of a Coronal node in English comes from nasal assimilation. As pointed out by Borowsky (1986), nasal assimilation applies optionally between words in English. For instance, consider the assimilation found with the preposition 'in', shown in (25).

\[
\text{- 110 -}
\]
(25) labial i[m] Brussels
labiodental i[ŋ] France
dental i[n] there
alveolar i[n] Toronto
velar i[ŋ] Kingston

Nasals of other places of articulation assimilate only within their place of articulation. This is illustrated for the labial nasal in (26).

(26) labial fro[m] Belgium
labiodental fro[ŋ] France
alveolar fro[m] Toronto
velar fro[m] Kingston

Again, the coronal nasal does not pattern with the other nasals. This is best explained if the Coronal node is absent.

4.4 Summary

The Ponapean, Catalan, and English, data strongly suggest that the Coronal node must be absent in underlying representation. In all three languages, the MC and the NAC require that there be no Coronal node. As expected, phonological processes separate the coronals from the other places of articulation in all three of the languages.

5.0 Presence of a Coronal node

We now turn to evidence for the specification of Coronal at the level of underlying representation. We will examine Sanskrit, Chumash, and Navajo, languages which display distinctions in place of articulation below the Coronal node. The NAC requires that a Coronal node be present. Coronal harmony processes found in these languages confirm the representations required by the NAC.

5.1 Sanskrit

According to Whitney (1889), dental and retroflex consonants are distinctive in Sanskrit. The inventory is shown in (27).

(27) retroflex dental
\[
\begin{array}{ll}
\eta & t \\
\theta & t\hphantom{h} \\
\theta & d \\
\theta & d\hphantom{h} \\
\eta & n \\
\theta & l \\
\eta & s
\end{array}
\]

Allen 1962, p.11

If we assume that dental and retroflex consonants are distinguished by the feature [distributed] and that this feature is dominated by the Coronal node, then the NAC requires that Coronal be present for those segments which are distinguished by [distributed]. We assume that the unmarked value for [distributed] is minus and that the dentals are unmarked for [distributed], while the retroflexes are marked [-distributed]. That Coronal is an active node in the Sanskrit consonant system is borne out by phonological alternations found in Sanskrit.

Schein and Steriade (1986) discuss a rule of n-retroflexion (Natf) in Sanskrit. This process spreads the coronal features of /s/ (retroflex /s/) and /t/ to a following /n/, creating /n/ (retroflex /n/). The rule is non-local, the target can be a great distance within a word from the triggering /s/ or /t/ and it is blocked by the presence of a coronal but not by a non-coronal. The full range of the process can be seen in the examples in (28).
In (28i), n-retroflexion is found when there is an adjacent retroflex trigger or a retroflex trigger separated from the target by a non-coronal consonant or by a vowel. When the trigger is separated from the target by a coronal, retroflexion is blocked as shown in (28ii).

Schein and Steriade present the rule of n-retroflexion in (29).

This rule spreads the Coronal node of a consonant to an adjacent Coronal nasal, delinking the Coronal node of the nasal. If a Coronal intervenes between the trigger and the target, the structural description of the rule is not met since the trigger cannot see over an intervening Coronal. This phonological process requires the presence of a Coronal node as a blocker for Nati. The NAC predicts that Coronal must be present thus explaining why it can block Nati.

Allen (1962) discusses cross-word nasal assimilation in Sanskrit. He claims that final /n/ assimilates only within its place of articulation and is realized as /n/ otherwise. In (30 i-ii) a final /n/ does not assimilate to a non-coronal and in (30 iii-iv) it assimilates to a following coronal.

This provides further evidence for the presence of a Coronal node in Sanskrit. Note the parallel between the behaviour of velar and labial nasals in Catalan and English and coronal nasals in Sanskrit. When an articulator node is specified, only assimilation within the articulator node will be found. If there were no Coronal node, as in Catalan and English, a different array of facts would be expected.

5.2 Chumash

Sibilant harmony in Chumash also presents evidence for the presence of a Coronal node at the level of underlying representation. The standard analysis of sibilant harmony is that all sibilants in a word agree for the feature [anterior], with the rightmost sibilant determining the anteriority of the preceding ones. (See Beeler 1970, Poser 1984, Steriade 1987b and Lieber 1987.)
The Chumash obstruent inventory is shown in (31).

(31)

<table>
<thead>
<tr>
<th>Obstruents</th>
<th>Plain</th>
<th>Glottalized</th>
<th>Aspirated</th>
<th>Sibilants</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>p</td>
<td>t</td>
<td>k</td>
<td>q</td>
</tr>
<tr>
<td></td>
<td>pʰ</td>
<td>tʰ</td>
<td>kʰ</td>
<td>qʰ</td>
</tr>
</tbody>
</table>

Anterior: s, ʃ, ʃʰ
denoted by \( \ddash \)
Nonanterior: s, ʃ, ʃʰ
denoted by \( \dash \)

Beeler 1970, pp. 15-16

Note that while there are contrasts between /s/ and /ʃ/ with respect to anteriority, no such contrast exists for the stops. Given the NAC, a Coronal node is required for the sibilants, while no Coronals are necessary for the stops.

This analysis is supported by the facts of sibilant harmony in Chumash illustrated in (33).

(32) a. within morphemes

<table>
<thead>
<tr>
<th>Word</th>
<th>Meaning</th>
</tr>
</thead>
<tbody>
<tr>
<td>osos</td>
<td>'heel'</td>
</tr>
<tr>
<td>psos</td>
<td>'gopher snake'</td>
</tr>
</tbody>
</table>

b. between morphemes

<table>
<thead>
<tr>
<th>Morpheme pair</th>
<th>Meaning</th>
</tr>
</thead>
<tbody>
<tr>
<td>kʃaqutinaˈn us vs. ʃaqutinanˈiʃ</td>
<td>'I tell him a story' vs. 'story'</td>
</tr>
<tr>
<td>hekʼi vs. ɡipiš</td>
<td>'I carry a load on my back' vs. 'a load'</td>
</tr>
<tr>
<td>kačkaw vs. ačkawiš</td>
<td>'I sin' vs. 'a sin'</td>
</tr>
<tr>
<td>kiʃkin vs. kiʃkinus</td>
<td>'I save it' vs. 'I saved it for him'</td>
</tr>
</tbody>
</table>

Beeler 1970, pp. 16-17

Noncontinuant coronals are neutral with respect to sibilant harmony, as can be seen in (33).

(33) kʃaqutinaˈn us vs. ʃaqutinanˈiš
    I tell him a story vs. story

Beeler 1970, p. 17

The rule acts as if Coronals were absent for the stops as they do not block the harmony process. The absence of a Coronal node for the stops is precisely the prediction drawn from the NAC.

Poser (1984), Steriade (1987b) and Lieber (1987) analyse sibilant harmony as an unbounded, directional, feature-changing process. These authors argue that [anterior] (or a similar feature) spreads from the right to the left, delinking the other value. We propose that the rightmost Coronal node spreads to an adjacent Coronal, carrying whatever features it has. The rule is given in (34).

(34) Spread Coronal leftward.

As Coronal can see only Coronal nodes and Coronal nodes are present only for sibilants, this will give the correct results.

A typical form is shown in (36). Only relevant structure is given.
A form with a coronal stop consonant is shown in (36).

(36)  s a q u t i n a n ' i š  \rightarrow  [šaqutinan'ič]

In this form, the rule crosses the intervening coronal because the Coronal node is not present on /t/.

It is worth commenting on the difference between Sanskrit and Chumash. Recall that in Sanskrit the coronal stops block n-retroflexion, while in Chumash the coronal stops are transparent to sibilant harmony. The difference between Sanskrit and Chumash with respect to the other coronals is that in Sanskrit a Coronal node is required for the whole range of coronal segments, while in Chumash, it is only distinctive for sibilants. Therefore, we do not expect to find stops blocking harmony in Chumash as they do in Sanskrit.18

5.3 Navajo

Navajo, like Chumash, has a process of sibilant harmony. Sibilant harmony in Navajo works very much as it does in Chumash. The Navajo consonant inventory is shown in (37).

(37)  D  DL  DZ  D\̣
plain      b  d  dl  dz  d\̣  g
vl. asp.   t  tt  ts  t\̣s  k
glottalized  t'  tt'  ts'  t\̣s'  k'
vd. fricatives  l  z  ŵ  γ
vl. fricatives  t  s  s\̣  x  h
nasals       m  n
semiglides   w  y

In Navajo, the different places of articulation of consonants are generally identified as consonant series. The four series labelled at the top of (37) as D, DL DZ, and D\̣ are generally considered to be consonants of the alveolar-palatal region, or coronals. The DZ and D\̣ series contrast with respect to [anterior], a feature dominated by Coronal, and thus the NAC requires the presence of a Coronal node. Both the D and DL series are distinguished without reference to coronality and no Coronal node is required.

Consider now the rule of sibilant harmony in Navajo. As the examples in (38) show, Navajo sibilant harmony is parallel to the sibilant harmony found in Chumash.
(38)  i. dži-di-baah 'he (4p) starts off the war'
dži-sii 'he (4p) steams it'
ii. dži-z-ti 'he (4p) is lying, sleeping'
dži-ẑ-ŷiiš 'he (4p) is stooped over'

Sapir and Hoijer 1967

In these examples, alternations in the morphemes /dži/ 'fourth person', (38i), and /z/ 'conjugation marker,' (38ii), are illustrated. The fourth person surfaces as [dž] or [dz] and the conjugation marker as [ẑ] or [z], with the rightmost sibilant determining the value of [anterior] for the other sibilants in the word.

The conclusion that can be drawn for Navajo is the same as that for Chumash. The NAC requires that a Coronal node be present for the sibilants. Phonological evidence supports this prediction in that it is only the sibilants that participate in the harmony process in the language and other coronals are transparent to this harmony.

6. Conclusion

Our data show that the articulator node Coronal is underspecified if no contrast exists under the Coronal node. This is predicted by markedness theory and also explains, in part, the special status of coronal consonants in the phonological systems of many of the languages of the world. A position which requires the presence of all privative features is too strong in that the special status of coronal consonants does not follow from anything and must be stipulated.

One possible problem for our view of the unmarked status of coronals arises when we consider a system such as Hawaiian, which has no coronal stop: /p k ʔ/ being considered the phonemic stops (see Maddieson 1984). We would claim that the Coronal default rule is inactive in Hawaiian. A similar situation exists in English where /t/ and /ð/ alternate, as discussed in section 4.3. However, the conditions under which the coronal default rule does not operate are much more complex. What may be unusual about Hawaiian is that the default rule filling in Coronal is never activated for the underspecified stop.

We have also speculated that fill-in rules must be late, if at all. Catalan stop assimilation and Ponapean fusion show that Coronal cannot be present lexically or postlexically. There is no evidence that the Coronal node is ever filled in, except as part of phonetic implementation.

It may be appropriate to speculate on why a condition such as the NAC would be present in the grammar. It seems reasonable to us to assume that some such condition would aid in learning the phonological system as activated nodes would be those that play a major part in phonological alternations. Thus in a language such as Ponapean the child does not have to learn that coronals are exceptional as the child would never be led to assume that coronal is active in the system. Similarly, the Navajo child would not have to learn that coronal stops are transparent to harmony as these stops do not have any representation on the coronal tier when harmony takes place.

---

* An earlier version of this paper was presented at the annual meeting of the Canadian Linguistic Association in May 1988. Many thanks to Elan Dresher for discussion of an earlier draft and to members of the phonology reading group, Tom Wilson, Bill Idsardi, Gabrielle Bernstein, and Karen Carlyle.

1 See Piggott, 1987 for arguments that [nasal] must be a daughter of the Root node.

2 McCarthy, following Levin (1987), places [lateral] under the coronal node.
It has been proposed (Steriade 1987a) that the Dorsal node is for vowels and that there is a Velar node for consonants. Arguments for this position are not relevant in this paper. Note also that the model does not exclude the possibility that there can be complex segments for which two articulator nodes are activated. The existence of such complex segments is one of the primary arguments for the existence of articulator nodes. See Sagey (1986).

Nothing hinges on this particular choice of feature.

We are assuming here that /s/ is distinguished from /s/ by the feature [anterior]. This may not be the only way of capturing the alveolar-alveopalatal or palatal distinction. See the discussion of Catalan in section 4.2 for an alternative suggestion.

See section 4.2 for discussion of Catalan palatals, where the role of the Place node takes on more significance.

It should be noted that the Ponapean orthographic system is used in all examples.

Itoh claims, based on facts of reduplication, that there are two levels of word formation in the lexicon and that values for [coronal] are filled in at the end of level 1. She argues that affixation takes place at level 1.

She points out that labials, velars, and coronals pattern identically in reduplication and she thus requires that [coronal] be filled in by level 2. We argue in Rice and Avery (1987) that even though coronals pattern with labials and velars with respect to reduplication, it is not the case that the Coronal node must be filled in when reduplication takes place.

We use the feature [nasal] in these representations. It might be more appropriate to have [nasal] follow from the presence of [sonorant]; this is not relevant to this paper.

One aspect of this system is worthy of note. We have specified the /n/ as having a Place node. The argument for this is as follows. We assume that in a system which distinguishes four places of articulation one of which is palatal, Place is an active node and required by the NAC. This is because the feature [high] which distinguishes the palatal from the plain /n/ is dominated by Place. Since /n/ and /\n/ are both coronals and are distinguished solely by a feature dominated by Place, the Place node must be present for both /n/ and /\n/.

We assume that spreading is motivated by the Obligatory Contour Principle (McCarthy 1986). Furthermore, redundancy rules which distinguish labials from labiodentals apply late, perhaps at the level of phonetic implementation.

Since we consider /\n/ to be a coronal, it may be asked why /\n/ does not assimilate in the manner of the other coronal /n/. There are a variety of answers that may be given. One possibility is that the rule does not apply because the structural description is not met, given the feature [high] on the Place node in the palatal.

See Kiparsky (1985) for discussion of the redundant features of Catalan consonants.

The vast majority of retroflex consonants are derived from dentals by retroflexion. However, they are distinctive in the underlying inventory.

It is mysterious to us why the target must be specified [+nasal]. We expect that this rule is local spreading the coronal node of a retroflex consonant to an adjacent coronal. The data appear to be rather murky on this question. We have repeated the data as described by Scheln and Steriade (1986).

We adopt Schein and Steriade's rule. We do not agree that both [anterior] and [distributed] are required to distinguish the retroflex from the non-retroflex coronals.
17. We assume that Sanskrit palatals are not like those found in Catalan. Possibly [high] is attached to the Coronal node rather than the Place node in Sanskrit. Otherwise we would expect no visible effect of assimilation.

18. This conclusion is very similar to the one reached by Steriade (1987b) in her discussion of Chumash. Steriade concludes that the feature [anterior] must be present for the sibilants in Chumash, with the alveolar sibilants marked [-anterior] and the alveopalatal sibilants [+anterior]. This feature is redundant for the other series and need not be specified. Our solution is thus identical to Steriade's with the exception that the introduction of the Coronal node allows maximal underspecification of features to be maintained.

19. This is an intermediate rather than underlying representation.

20. In a presentation of this paper at the Canadian Linguistic Association, it was suggested to us that in some Hawaiian dialects there are [t]'s rather than glottal stops and that [s] varies with glottal stop (Harold Paddock, personal communication). This is expected under the view of underspecification presented here.
References


Borowsky, T. Topics in English phonology. Ph.D. dissertation, University of Massachusetts


