Segment Structure and Coronal Underspecification

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1 Introduction

In this paper we present a theory of underspecification which capitalises in crucial ways on the structural representations of segments made available in much current work on segment structure (see in particular the work of Clements 1985, Archangeli & Pulleyblank forthcoming and Sagey 1986). We assume that universal grammar provides a markedness theory which supplies information as to which features are underspecifiable. In the unmarked case, these features will be absent from underlying representation. However, there are cases in which the features predicted to be absent in underlying representation are active in the phonology of a language. In this case, we claim that the universal markedness theory is overridden by a Node Activation Condition which requires unmarked features to be present if they dominate dependent features that create a minimal contrast between two segments. For example, if we assume that the unmarked articulator node is the Coronal node, then Coronal must be absent from underlying representation. However, Coronal must be present in the phonology of a language if two segments are distinguished by a feature that is a dependent of the Coronal node.

We claim that underspecification is inventory-driven rather than rule-driven, and that rules must follow from representations rather than *vice versa*. This is consistent with the position that the burden of explanation in phonology should be in the representational component rather than the rule component.

We present evidence for the specific proposals that we make in this paper based on the behaviour of coronal consonants in a wide range of languages. We choose coronals as a starting point because of the special place that coronals appear to occupy in many of the world's languages (see for example Paradis & Prunet 1988 and Yip 1988, among others). In some languages coronals behave asymmetrically with respect to other consonants, while in other languages they pattern as do the other consonants. We attempt to derive this behaviour from the general theory of underspecification developed in this paper.

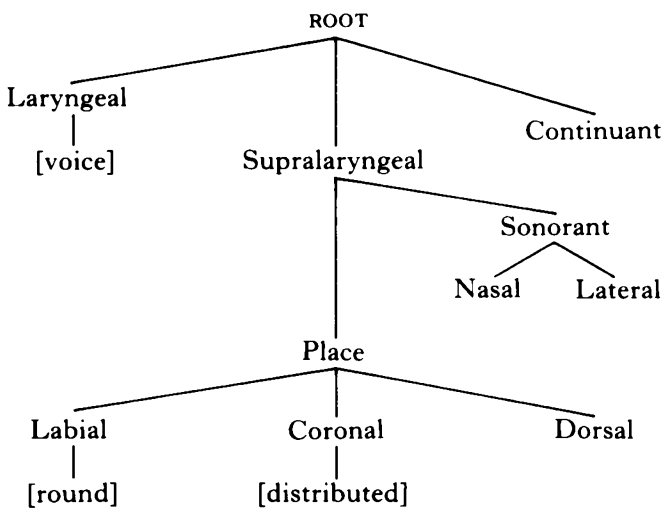
The structure of this paper is as follows. In §2 we outline our assumptions concerning rule application and segment structure. In §3 we turn to the workings of underspecification, introducing the Node Activation Condition and its role in constraining underspecification. In §4 we present data from Ponapean, Catalan and English which require that the Coronal node be absent from underlying representation, and in §5 we present data from Sanskrit and Chumash which require that the Coronal node be present in underlying representation.

2 Theoretical assumptions

2.1 Segment structure

Following Clements (1985), Sagey (1986), Archangeli & Pulleyblank (forthcoming), McCarthy (1988) and others, we assume that segments are not merely unordered feature bundles but that they have hierarchical structure. The model of segment structure that we adopt is shown in (1):[1]

(1)



We distinguish two major node types: ORGANISING NODES and CONTENT NODES. Organising nodes (roughly equivalent to Clements' 1985 class nodes) serve to define major organisational units such as Supralaryngeal, Place and Sonorant. The content nodes are actual articulatory instructions and divide into two types: primary and secondary. The primary nodes which are of interest in this paper are those defining places of articulation: Labial, Coronal and Dorsal. The secondary content nodes are the daughters of the primary nodes and provide more refined articulatory instructions. They are often redundant in languages, but can be distinctive (see Christdas 1988 and Stevens & Keyser 1989 for discussion of the primary/secondary difference).[2]

We assume that all features are monovalent, and that it is only presence

vs. absence that gives the appearance of binarity. While arguing against binary features would take us beyond the scope of this paper, we refer the reader to Anderson & Ewen (1987) and van der Hulst (1989, this volume) for work which makes this assumption. Other research has examined individual features, arguing that monovalency is required since only single values are ever referred to in the phonology (see, for example, Steriade 1987 on [round] and Mester & Itô 1989 on [voice]).

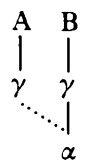
2.2 Rule component

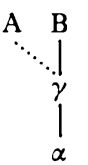
In line with much current phonological research (e.g. Archangeli & Pulleyblank forthcoming; Yip 1988; Piggott 1988), we adopt the strategy that phonological processes are best explained through a focus on the representational component rather than on the rule component. We view the rule component as impoverished, involving at most three basic operations, spreading, fusion and delinking.

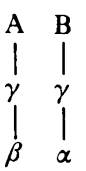
We assume that spreading is a language-particular operation which may include trigger and target conditions as well as a directionality parameter. The spreading theory we adopt is outlined in (2) (see Piggott 1988 for similar assumptions):

(2) a. Spreading can occur only if a structural target is present
b. A feature or node can spread only to an empty position

(2a) states that there can be no node generation through spreading and (2b) rules out cases of spreading triggering delinking. The workings of spreading theory are illustrated in (3):

(3) a. 

b. 

c. 

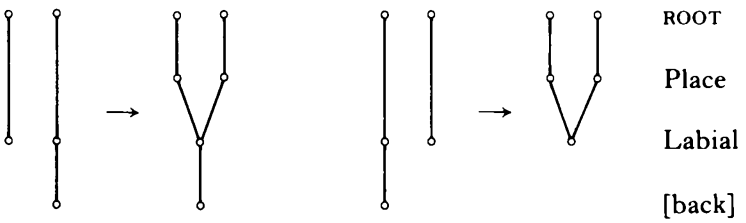
In (3a), spreading of α to γ can occur since γ is present in the representation of A, has no dependents, and is the structural node which dominates α. In (3b), on the other hand, spreading of α to A is not allowed because there is no docking site; spreading of γ to A is allowed. In (3c), α can not spread to γ because γ has the dependent β. Only if an independent rule delinking β existed could α spread to γ.

Fusion is an operation which takes identical primary content nodes and fuses them provided that the nodes are non-distinct; i.e. both nodes do not dominate different secondary nodes. We assume that fusion is headed in that the secondary features of the triggering segment are maintained. Normally fusion takes place under conditions of strict adjacency, from an onset to a rhyme.

To make the workings of fusion clear, we present an example from Ponapean. In Ponapean, there are two types of labial consonants, plain labials and velarised labials (Rehg & Sohl 1981). Labial–labial sequences

such as /m–m^{w}/ become [m^{w}m^{w}] and /m^{w}–m/ become [mm], with features of the righthand labial maintained. Following Mester (1986), we describe the velarised labials as having a secondary content node [back] as a dependent of the Labial node. The fusion process is illustrated in (4):

(4) m m^{w} → m^{w} m^{w} m^{w} m → m m

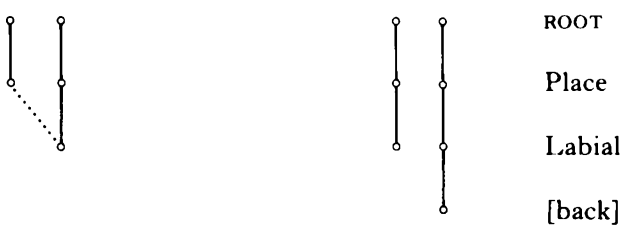


The result of the fusion is that only secondary features of the righthand segment, the head, are maintained.

It is important to note that only content nodes, not organisational nodes, can fuse. Fusion of organisational nodes such as Place would make the incorrect prediction that words could have only one place of articulation. We assume that fusion falls under the general rubric of the Obligatory Contour Principle (McCarthy 1986; Yip 1988).

Given our assumptions, only spreading can apply in (5a) and only fusion in (5b):

(5) a. spreading b. fusion



Fusion is blocked in (5a) because Place nodes cannot fuse. Fusion is required in (5b) because the Labial content nodes must fuse under conditions of adjacency.[3]

Delinking is a neutralisation process which eliminates content nodes in neutralising positions, such as syllable-final. Delinking is not relevant to this paper and will not be discussed further. (For some development of a theory of delinking, see Rice & Avery 1989.)

3 Underspecification

We assume that underspecification is desirable in the phonology (see Archangeli 1988 for arguments concerning underspecification). We hold the position that one of the major requirements of a theory of underspecification is a universal markedness theory which provides information as to which features are present and/or absent in underlying represent-

ations (see Kiparsky 1982 and Archangeli & Pulleyblank forthcoming for similar assumptions). As the focus of this paper is on the coronal obstruents, we will discuss underspecification with respect to place features. We assume, based on the work of Kean (1975), that coronal is the unmarked place of articulation. Kean claims that, with the possible exception of Hawaiian, all languages have coronal consonants, but that not all languages have labial and dorsal consonants. We interpret this to mean that Coronal is the underspecified primary content node under the Place node and may be absent from underlying representation, while Labial and Dorsal are marked and are present in underlying representation. This assumption thus differs from that of Clements (1988), who assumes that all primary content nodes under the Place node must be present underlyingly.

The finer articulatory instructions which secondary content nodes carry are normally redundant in languages, and thus absent from underlying representations. However, when these nodes are distinctive for a segment in a language, they must be present in underlying representation for that segment. In cases where secondary content nodes are distinctive, more segmental structure is required than is given by markedness alone. Clearly, a segment with a distinctive secondary node requires the presence of the dominating primary node. We claim that it is not only this segment that requires the presence of the primary node underlyingly. In addition, any segments that are distinguished from this segment only by the secondary content node must also have the primary content node present underlyingly. For example, both Catalan and Sanskrit have retroflex coronals phonetically. The status of these consonants differs underlyingly, however. In Catalan, where retroflexion is non-distinctive, Coronal is underspecified. In Sanskrit, where retroflexion is distinctive, Coronal must be present for both the retroflex and plain coronal consonants underlyingly. The intuition behind this requirement is that minimally contrasting segments must be represented as such.

To formally capture the above insight, we propose a Node Activation Condition, stated in (6):

(6) *Node Activation Condition* (NAC)
If a secondary content node is the sole distinguishing feature between two segments, then the primary feature is activated for the segments distinguished. Active nodes must be present in underlying representation.

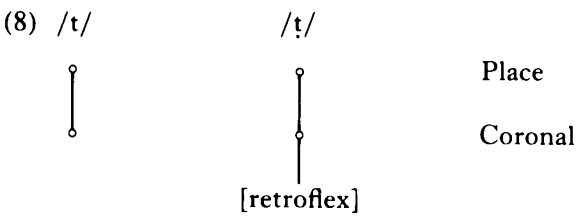
As a concrete example consider the representations of Catalan and Sanskrit coronals. Universal Markedness Theory (UMT) alone determines the underlying place representation of a coronal in Catalan: it simply has the organising node Place, as in (7):

(7) t
° Place

In Sanskrit, /t/ and /ṭ/ both occur distinctively. The /ṭ/ requires that a

secondary content node be present underlyingly. We will call this node [retroflex]. Since [retroflex] is directly dominated by the Coronal node, the Coronal node must be activated for /ṭ/. As /t/ and /ṭ/ are distinct only with respect to the node [retroflex], the NAC is called into play, forcing a Coronal node in the underlying representation of both segments. We thus have place representations as in (8):

(8)



While Coronal is not present underlyingly in Catalan, it is present phonetically, as there are redundant coronal distinctions in the language (see §4.2). These distinctions arise through the application of default rules. As we view them, default rules apply as part of phonetic implementation, inserting redundant secondary nodes (and primary nodes, as triggered by the insertion of secondary nodes). Because default specification is confined to the phonetic implementation component, default features can never play any role in the phonology of a language. We thus do not expect to find active participation of default nodes in the phonology.[4]

To summarise, we see underspecification in the following way: UMT supplies minimal structure, ensuring that unmarked values are absent in underlying representation while marked values are present. UMT can be overridden only if the NAC requires additional structure, and this is determined solely by secondary contrasts within a system. The innovation which the NAC represents is that segments which are minimally distinct, in the sense that they contrast only with respect to the presence of a secondary node on one of the segments, will be represented as such. This can be contrasted with the theory of 'radical' underspecification (Archangeli 1988), which has no requirement of this nature, and 'contrastive' specification (Steriade 1987), which forces full specification on contrasting segments.[5] The position we take offers a middle ground between these two theories.

In the remainder of the paper we examine evidence for the view of underspecification outlined. In particular, we show that, assuming that the unmarked primary content dependent of Place is the Coronal node, Coronal is only activated if segments in an inventory contrast on a secondary content node dominated by Coronal. Our arguments are based on coronal assimilation processes. First, we argue from asymmetries in coronal assimilation that Coronal is underspecified. Secondly, we argue from cases where coronals assimilate as do the other places of articulation that the NAC is required, since without such a condition non-occurring coronal assimilations would be expected.

4 Absence of a Coronal node

4.1 Ponapean

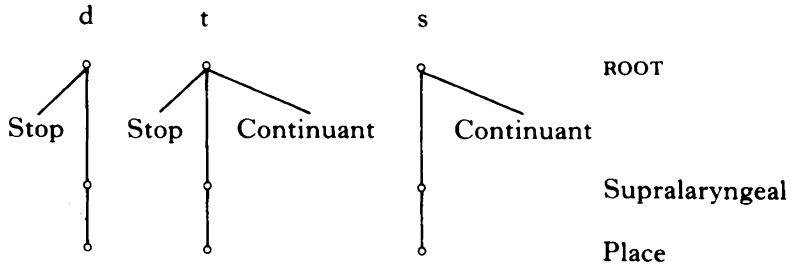
4.1.1 *Inventory*. Ponapean has the obstruent inventory given in (9):

(9) *Ponapean obstruents* (Rehg & Sohl 1981: 34)

p	d	k
p^w	t	
	s	

Rehg & Sohl (1981) describe /d/ as a voiceless coronal stop and /t/ as a voiceless coronal affricate. We assume the representations for the coronal obstruents given in (10). We use Stop and Continuant to distinguish manner of articulation (see Anderson & Ewen 1987 for a similar claim in dependency phonology). However, the particular feature choices are not really relevant to the issue at hand; what is important is that Coronal is not distinctive within this inventory:

(10)



As there are no contrasts between places of articulation within the coronals in this inventory, the Coronal node is underspecified. The phonological processes of Ponapean bear this prediction out.

4.1.2 *Fusion and epenthesis*. In Ponapean, sequences of two consonants are usually subject to epenthesis, as shown in the examples in (11):

(11) *Epenthesis* (Itô 1986: 120)

a. /kitik-men/ → kitikimen 'rat'
b. /ak-p^wuŋ/ → akup^{w}uŋ 'petty'
c. /ak-suwei/ → akusuwei 'demonstrating boastfulness'

When labial–labial and velar–velar sequences occur, a different pattern is found. Instead of epenthesis, a process which Itô (1986) refers to as fusion takes place. After fusion, the first consonant becomes a nasal by a separate process of nasal substitution (see Itô 1986 and Rehg & Sohl 1981 for details).[6] Examples of such sequences are given in (12):

(12) *Labial + labial and velar + velar combinations* (Itô 1986: 137)

a. /kehp-m^wot/ → kehm^{w}m^{w}ot 'variety of yam'
b. /ep-p^woatol/ → em^{w}p^{w}oatol 'game'
c. /sap^w-paa/ → sampaa 'world, earth'
d. /ak-keelail/ → aŋkeelail 'demonstrate strength'

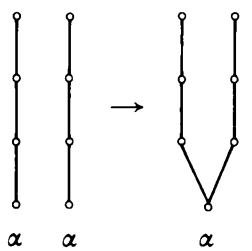
Now consider coronal sequences. One might expect them to pattern like labial–labial and velar–velar sequences, with fusion and nasal substitution. However, this is not what occurs. When a sequence of coronal consonants arises, epenthesis rather than fusion takes place, as illustrated in (13):

(13) *Coronal consonants* (Rehg & Sohl 1981: 63)
a. /weid-da/ → weid̲ida 'proceed upward'
b. /lus-saŋ/ → lus̲isaŋ 'jump from'

Itô 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 Itô, with the primary content nodes fusing:

(14)



ROOT

Supralaryngeal

Place

primary content node

With homorganic labial and velar sequences, a primary content node dominated by the Place node exists, and thus the structural description of (14) is met. With coronals, as no primary content dependent of the Place node exists, fusion cannot take place and instead epenthesis applies.[7]

The argument for the absence of Coronal based on the Ponapean inventory is thus supported by the phonology: labials and velars pattern as specified segments whereas Coronals pattern as unmarked segments.

4.1.3 *Postlexical fusion.* The data given so far illustrate that the Coronal node is absent underlyingly. Phrasal facts of Ponapean suggest that not only must this node be absent underlyingly, it must be absent in the phrasal phonology as well. Consider the connected speech data in (15):

(15) *Postlexical fusion* (Rehg & Sohl 1981: 63)
a. E kalap̲ pahn soupisek → kalam̲ pahn
'He will always be busy'
b. E saik̲ keŋwini → saiŋ̲ keŋwini
'He hasn't yet taken medicine'
c. E ekis̲ suwed → *ekin̲ suwed
'It's kind of bad'
d. Ke meid̲ daŋahŋa → *mein̲ daŋahŋa
'Aren't you lazy!'

(15a, b) show sequences of homorganic non-coronals at word boundaries. Even across a word boundary, fusion and nasal substitution occur. In the coronal–coronal sequences in (15c, d), fusion and nasal substitution are

blocked. If Coronal were filled in, the coronals should pattern postlexically with the labials and velars.

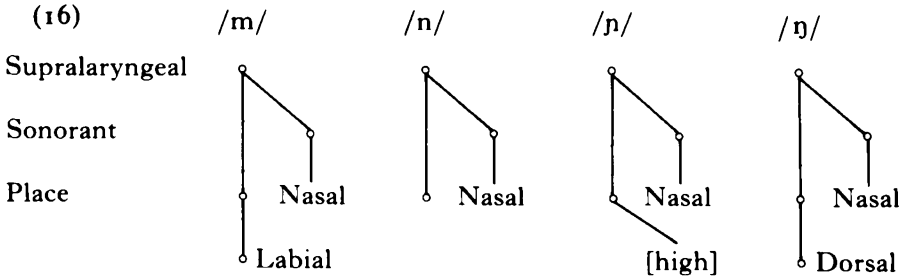
These data suggest that Coronal is not a relevant node in the phonology of Ponapean; even phrasally, the phonology patterns as if no Coronal node is present. This supports the claim that the specification of unmarked nodes in a language is postponed until after the postlexical phonology and is an aspect of phonetic implementation.

4.2 Catalan

The behaviour of coronals in Catalan also presents evidence for the underspecification of the Coronal node. We will begin by considering assimilation of nasals.

4.2.1 *Catalan nasals.* In Catalan, four places of articulation must be distinguished underlyingly for nasals: labial, coronal, palatal and velar. The underspecified nasals are shown in (16):

(16)



Under our markedness assumptions, the labial and velar nasals require specification for place. The treatment of the palatal nasal is less obvious. We consider the palatals in Catalan to be complex coronals which branch at the Place node. (For more general arguments about the representation of palatals as complex coronals, see Keating 1987.) We represent specified palatals as Coronal and the feature [high] linked directly to the Place node.[8] The Coronal node in Palatals is underspecified and is provided by a default rule.

Now consider the facts of Catalan nasal assimilation. /n/ assimilates to all places of articulation, as in (17):[9]

(17)	a. unassimilated alveolar	so[n] amics	'they are friends'
	b. labial	so[m] pocs	'they are few'
	c. labiodental	so[ɱ] feliços	'they are happy'
	d. dental	so[n̪] dos	'they are two'
	e. alveolar	so[n] sincers	'they are sincere'
	f. postalveolar	so[n̠] rics	'they are rich'
	g. laminopalatal	so[n, ʒ]ermans	'they are brothers'
	h. palatal	so[n, ʎ]iures[10]	'they are free'
	i. velar	so[ŋ] grans	'they are big'

(Kiparsky 1985: 95)

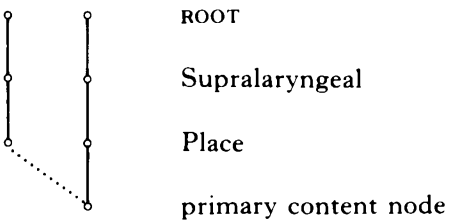
The other nasals do not assimilate in the way that /n/ does; they assimilate only within their own primary content nodes. /m/ thus assimilates to a following labial (bilabial, labiodental) and the palatal and velar nasals do not assimilate at all since there are no place distinctions below their primary content nodes. This is illustrated in the forms in (18):

(18) /m/:	a. so[m] amics	'we are friends'	
	b. so[m] pocs	'we are few'	
	c. so[ŋ] feliços	'we are happy'	
	d. so[m] dos	'we are two'	
/ŋ/, /ɲ/:	e. ti[ŋ] pa	'I have bread'	
	f. a[ɲ] feliç	'happy year'	

(Kiparsky 1985: 95)

Two distinct phonological processes result in the effect of nasal assimilation in Catalan. The first process resulting in nasal assimilation is spreading to an empty Place node, shown in (19). This accounts for the examples in (17b, c, i), cases where a non-coronal follows the nasal.

(19) *Spreading*



The second process resulting in nasal assimilation in Catalan is fusion. Fusion in Catalan, as in Ponapean, fuses identical primary content nodes under the Place node. Fusion thus accounts for the forms with labial–labial sequences (18b, c). The Labial nodes fuse; phonetic implementation rules realise the labial as a labiodental in (18c).

While the treatment of labials and velars is straightforward, that of coronals requires some comment. The structural description of neither fusion nor spreading is met with coronal sequences until the phonetic implementation component because of the absence of the Coronal node distinctively. When redundancy rules apply, filling in non-distinctive features that differentiate the coronals, the structural description of fusion is met and it must automatically apply, yielding the assimilation seen in the forms with coronal sequences.[11]

4.2.2 *Catalan laterals*. Catalan exhibits a process of lateral assimilation which also shows asymmetric patterning of the coronals. In lateral assimilation, the /l/ assimilates in place of articulation to a following non-labial consonant, as in (20):

(20)

a.	unassimilated alveolar	e[l]	'the'
b.	labial	e[l] pa	'the bread'
c.	labiodental	e[l] foc	'the fire'
d.	dental	e[l̪] dia	'the day'
e.	alveolar	e[l] sol	'the sun'
f.	postalveolar	e[l̠] ric	'the rich'
g.	laminopalatal	e[l, ʒ]ermá	'the brother'
h.	palatal	e[l, λ]ibre	'the book'
i.	velar	e[ɬ] gos	'the dog'

(Mascaró 1976: 46)

The assimilation of the laterals is parallel to that of the nasals, with spreading and fusion giving the correct results. The lack of assimilation to the labial in (20b, c) is a phonetic effect. Such assimilation may indeed take place, but as the lateral involves the tongue and labials involve the lips, a feature conflict is resolved by delinking.[12]

4.2.3 *Catalan stop assimilation.* An optional process of stop assimilation found in Catalan also displays asymmetric patterning of coronals. We find almost full assimilation of coronal stops to a following consonant, as in (21):[13]

(21)

se[t]	'seven'
se[m] mans	'seven hands'
se[p,] focs	'seven fires'
se[l] línies	'seven lines'
se[t, š]ais	'seven lambs'
se[λ λ]ibres	'seven books'
se[k] cases	'seven houses'
se[d] dones	'seven women'
se[b] beus	'seven voices'

(Mascaró 1976: 43, 1987)

Labial and velar stops only assimilate within their primary content node, as in (22):

(22)

ca[p]	'no'	po[k]	'few'
ca[m] ma	'no hand'	po[k] pa	'few bread'
ca[p,] foc	'no fire'	po[k] sol	'few sun'
ca[p] signe	'no sign'	po[k š]ai	'few lamb'

(Mascaró 1976: 43)

While certain details of /t/-assimilation remain to be worked out, it is clear that the coronal stop, like the coronal nasal and the lateral, patterns as if it had no specified place of articulation. Unlike the other places of articulation, its articulation is dependent totally on that of the following consonant. This behaviour is predicted if Coronal is absent in underlying representation.

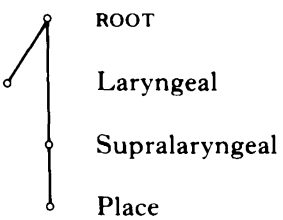
4.2.5 *Summary.* The asymmetric patterning of the coronals in Catalan suggests that the Coronal node is absent throughout the lexical phonology

and that its specification is postponed until the phonetic implementation component, resulting in the widespread assimilation of coronals in cross-word environments. As Kiparsky (1985) notes, it is the unmarked status of the coronals which is the key to understanding assimilation processes in Catalan. The unique patterning of the coronals in Catalan is best explained by the absence of the Coronal node. In a theory which requires the presence of all primary content nodes (e.g. Clements 1988), some special stipulation would be required to account for the behaviour of the coronal consonants.

4.3 English

4.3.1 *t–ʔ alternations*. Among the English stops there are no contrasts under the Coronal node and thus the Coronal node should be underspecified.[14] We assume that the representation in (23) is the underlying specification for English /t/. (Note that there could be other structure that is not relevant to the issue at hand.)

(23) /t/



Phonological evidence suggests that (23) is the appropriate representation. Ladefoged (1982) notes that glottal stops frequently occur as allophones of /t/ in English. Kahn (1976) points out that final /t/ in English may be realised as either unreleased or as glottal stop. Voiceless stops at other places of articulation may be unreleased, but are not realised as a glottal stop in the dialect reported by Kahn. Lass (1976) indicates that /t/ can be realised as a glottal stop before another consonant. One set of environments described by Lass in which /t/ is realised as a glottal stop is shown in (24): /t/ is pronounced 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). The data in (24) represent the Toronto dialect of one of the authors. In this dialect, glottal stop substitutes for /t/, but not for /p k/.

(24) a. bʌʔn̩ 'button'
bæʔn̩ 'batten'
kaʔn̩ 'cotton'

b. hɪʔ ðə 'hit the...'
kʌʔ flawɹz 'cut flowers'

We are not concerned with the specific environment of this rule, but rather with the representation that allows the dialect in which /t/ (but not the other voiceless stops) alternates with glottal stop. The simplest

account of these facts follows from the underspecification of the Coronal node. If we assume that glottal stop has no specification for place, then the alternation between /t/ and glottal stop is totally natural, as the specification for English /t/ also lacks specification for place. When the unmarked node Coronal is filled in in phonetic implementation, this segment is realised as [t]; when the default Coronal is not filled in, it is realised as glottal stop.

4.3.2 *Nasal assimilation.* 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.[15] Consider the assimilation found with the preposition *in*, as in (25):

(25)	labial	i[m] Brussels
	labiodental	i[ɱ] France
	dental	i[n̪] there
	alveolar	i[n] Toronto
	velar	i[ŋ] Kingston

Labial and velar nasals assimilate only within their place of articulation. This is illustrated for the labial nasal in (26):[16]

(26)	labial	fro[m] Belgium
	labiodental	fro[ɱ] 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

Ponapean, Catalan and English provide strong evidence that the Coronal node must be absent in underlying representation. In none of these languages are coronals distinguished by a secondary content node, and thus the NAC does not force the presence of a Coronal node. As expected, phonological processes separate the coronals from the other places of articulation in these languages.

5 Presence of a Coronal node

We now turn to an examination of the conditions under which Coronal is specified. The NAC takes on importance as it is the NAC which forces the presence of a Coronal node.

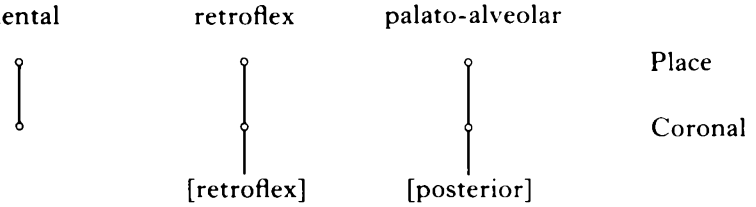
5.1 Sanskrit

5.1.1 *Inventory*. The coronal inventory of Sanskrit is shown in (27) (Whitney 1889: 26):

(27)								
	retroflex	ṭ	ṭh	ḍ	ḍh	ṇ	r	ṣ
	dental	t	th	d	dh	n	l	s
	palato-alveolar	č	čh	ǰ	ǰh	ñ		š

We assume that the dental consonants are the unmarked coronals (see Kean 1975). Retroflex consonants have a secondary content node that we will call [retroflex], a Coronal dependent, and palato-alveolar consonants have a secondary content node that we will call [posterior], also a Coronal dependent. Nothing crucial hinges on the particular features; what is important is that they are dependents of Coronal. Since the dental is distinguished from the retroflex and palato-alveolar consonants just by a Coronal dependent, the NAC requires that Coronal be present for all the coronals. Place representations are given in (28):[17]

(28)



5.1.2 *Nati* (n-*retroflexion*). That Coronal is an active node in the Sanskrit consonant system is borne out by phonological alternations found in Sanskrit. Schein & Steriade (1986) discuss the rule of Nati (*n*-retroflexion) in Sanskrit. This process spreads the coronal features of /ṣ/ and /r/ to a following /n/, creating /ṇ/. The full range of the process can be seen in the examples in (29):

(29) *-āna-* middle participle

a. pur-āṇa 'fill'
b. kṣubh-āṇa- 'quake'
c. marj-āna- 'wipe' (Schein & Steriade 1986: 717)

Schein & Steriade analyse this rule as spreading the Coronal node of a consonant to an adjacent coronal nasal,[18] delinking the Coronal node of the nasal. We analyse the rule as the spreading of [retroflex] to an adjacent coronal nasal.[19] As (29b) shows, non-coronal consonants are transparent to this rule. If a coronal intervenes between the trigger and the target, as in (29c), the structural description of the rule is not met as 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.

5.1.3 *Nasal assimilation*. Nasal assimilation also provides evidence that Coronal is specified in Sanskrit. Allen (1962) states that final /n/

assimilates only within its own place of articulation and is realised as /n/ otherwise.[20] In (30a, b) a final /n/ does not assimilate to a non-coronal and in (30c, d) it assimilates to a following coronal:

(30) a. mahān + kaviḥ → mahānkaviḥ
b. mahān + bhāgaḥ → mahānbhāgaḥ
c. tān + janān → tāñjanān
d. tān + ḍimbhān → tāṇḍimbhān

(Allen 1962: 83–84)

Thus the coronals in Sanskrit pattern like the specified labials in Catalan and English and the labial–labial and velar–velar sequences in Ponapean, assimilating only within the Coronal articulator.

5.2 Sibilant harmony in Chumash

Sibilant harmony, found in languages such as Chumash and Navajo, also presents evidence for the presence of a Coronal node. We will discuss only Chumash here; the facts of Navajo are very similar.

The Chumash obstruent inventory is shown in (31):

(31) *stops*

plain	p	t	k	q	
glottalised	p'	t'	k'	q'	ʔ
aspirated	p^h	t^h	k^h	q^h	

sibilants: fricatives			*sibilants: affricates*		
plain	s	š	plain	c	č
glottalised	s'		glottalised	c'	č'
aspirated	s^h	$š^h$	aspirated	c^h	$č^h$

(Beeler 1970: 15–16)

Note that while there are contrasts between /s/ and /š/ with respect to anteriority, no such contrast exists for the stops. The NAC thus requires a Coronal node for the sibilants, but not for the stops.

This analysis is supported by the facts of sibilant harmony in Chumash illustrated in (32):

(32) a. *harmony within morphemes*
osos 'heel'
pšoš 'gopher snake'
b. *harmony between morphemes*
i. ksaqutinán'us 'I tell him a story' *vs.* šaqutinan'iš 'story'
ii. kaćkáw 'I sin' *vs.* aćkáwiš 'a sin'
iii. kiškín 'I save it' *vs.* kiskinus 'I saved it for him'

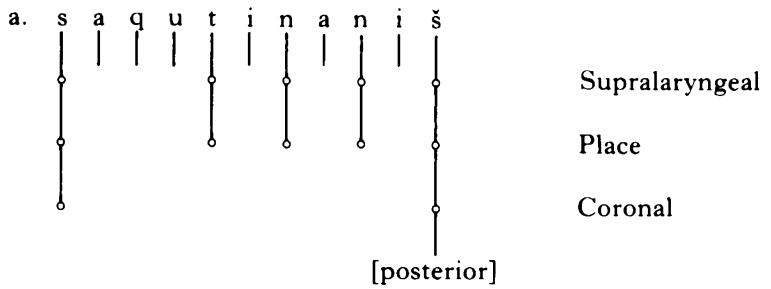
(Beeler 1970: 16–17)

Non-continuant coronals are neutral with respect to sibilant harmony, as can be seen in (32b.i).

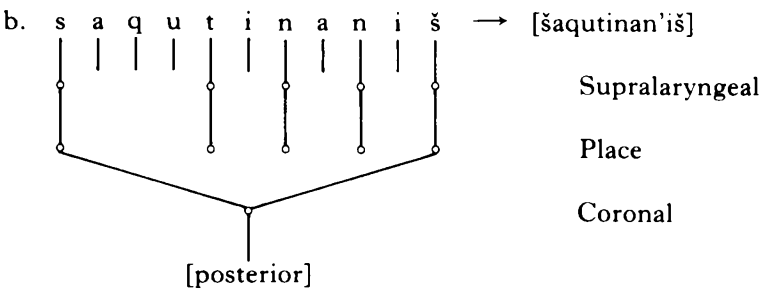
The harmony rule acts as if Coronal were absent for the stops as they do not block harmony. The absence of a Coronal node for the stops is precisely the prediction drawn from the NAC.

Poser (1984), Steriade (1987) 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 sibilant harmony is not feature-changing, but is an instance of fusion of identical primary content dependents of the Place node. Fusion here operates on nodes that are not locally adjacent, and thus must be stipulated for the language. As with Ponapean, fusion is right-headed, so the features of the rightmost sibilant remain. A derivation is shown in (33). (33a) is the underlying representation and (33b) the form derived by fusion. Only relevant structure is given:

(33) a.



b.



It is worth commenting on the difference between Sanskrit and Chumash. Recall that in Sanskrit the coronal stops block Nati, 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.[21]

6 Other evidence for the NAC

The two different patterns of coronal assimilation that are found in languages provide support for the NAC. When Coronal is absent, coronals may assimilate fairly freely; when it is present, coronals assimilate only within the coronal place of articulation. A question we have not addressed is whether there are additional uses for the NAC. We believe that labial assimilation provides such evidence and will briefly outline a possible analysis of labial assimilation.

In Korean we find not only assimilation of coronals (34a) but also of labials to a following dorsal consonant (34b) (data are from Cho 1988 and Iverson & Kim 1987):

(34) a. *Coronal assimilation*

pat + ko	→ pakko	'to receive'
kotpalo	→ koppalo	'straight'
han + kan	→ haŋkan	'the Han river'
han + ben	→ hamben	'once'
pap + to	→ papto	'rice also' (*patto)

b. *Labial assimilation*

kamki	→ kaŋki	'a cold'
əpko	→ əkko	'carry (person) on the back and ...'
kukmul	→ kuŋmul	'liquid part of soup' (*kummul)[22]

Consider now the patterns of nasal assimilation in Ponapean. Under certain circumstances Ponapean allows place assimilation from a labial or dorsal consonant to a coronal nasal, as illustrated in (35) (see Regh & Sohl 1981 for details):

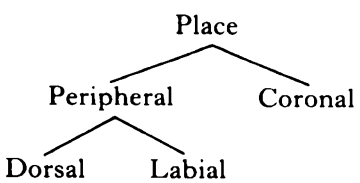
(35)

nan-par	→ nampar	'trade wind season'
nan-kep	→ naŋkep	'inlet'
kisin pakas	→ kisimpakas	'small species of fish'
tihn kidi	→ tihŋkidi	'bone of a dog'

However, while /n/ may assimilate to the place of articulation of the following consonant, the labial nasal does not assimilate in place to a following dorsal.

Examination of the Korean and Ponapean inventories is illuminating in understanding the difference in assimilative behaviour. Korean has labial, coronal, palatal and velar consonants while Ponapean has labial, velarised labial, coronal and velar consonants. The lack of assimilation in Ponapean could be related to the fact that the labials are distinguished by a secondary feature. The analysis runs as follows. We add an extra layer of structure to the Place node, introducing a Peripheral (or Grave) node as a sister to the Coronal node as in (36):

(36)



If we assume that the unmarked daughter of the Peripheral node is Labial, that would mean that Labial would only be marked if required by the NAC. The Labial node would then be absent in a language such as Korean but present in a language such as Ponapean. Then the spreading found in Korean would follow in a straightforward manner as the spreading of Dorsal to an adjacent empty Peripheral node. This spreading would of course not be permitted in a language such as Ponapean, as the Labial node would be activated in the system.[23]

The ramifications of this proposal are well beyond the scope of the present paper, and the introduction of a Peripheral node requires a great deal more research. We note in passing, however, that vowels, which are generally analysed as having labial and dorsal features, could be treated as a natural class in this geometric configuration.

7 Conclusion

We have argued in this paper that the Coronal node is underspecified unless Coronal dominates a secondary feature. While the focus of the paper has been on coronals, our claim is much broader. UMT, supplemented by the NAC, provides us with a theory of how phonological representations come to be specified in general. The task for the language learner is thus not one of choosing the correct underspecified system from the set of possible underspecified systems based on the manipulation of features by phonological rules. Rather the representations are determined based on the UMT and the contrasts which exist in the inventory. The success of this approach in the analysis of coronal asymmetries, and its possibilities in accounting for labial assimilation patterns, is encouraging.

NOTES

* An earlier version of this paper was presented at the Canadian Linguistic Association, at *NELS* 18, and in colloquia at the University of Arizona and the University of Toronto. Many thanks to the audiences at these places for helpful comments. In particular, we would like to thank Diana Archangeli, Elan Dresher, Michael Hammond, Harry van der Hulst, Bill Idsardi, Tom Wilson, Moira Yip and two anonymous *Phonology* reviewers.

[1] See Rice & Avery (1989) for arguments for the Sonorant node. We omit features under the Dorsal node since they are not relevant to the arguments in this paper. See Sagey (1986) and others for discussion of dorsal features.

[2] In representations, the organisational nodes and primary content nodes are written with initial capital letters while the secondary content nodes, sometimes called features, are enclosed in square brackets.

[3] Note that spreading of [back] to Labial could occur in (5b), but its effects would be obscured since fusion is required.

[4] There are certain expected default nodes; for instance a Place node without dependents is generally realised as Coronal. In the languages we examine there is no evidence that Coronal is relevant to the phonology, but only to phonetic implementation. In Catalan, for instance, Coronal is filled in only if spreading has not already assigned place features to an empty Place node. In English, it

appears that the Coronal default rule does not operate in certain circumstances (see §4.3). In a language 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. What may be unusual about Hawaiian is that the default rule filling in Coronal is never activated for the underspecified stop. Harold Paddock (personal communication) has pointed out that there are dialects of Hawaiian which have a coronal consonant and that in those dialects there is no glottal stop.

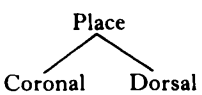
[5] Of course, if the proponents of 'contrastive' specification were to adopt unary valued features, they might arrive at a position very similar to the one espoused in this paper. However, even if we retreated from the assumption of unary valued features, we would still assume that the contrastive secondary feature would have a marked and an unmarked value and the representations would differ from those of contrastive specification.

[6] For a different analysis see Rice & Avery (1987, 1989), where it is argued that nasal is a result of a default rule.

[7] Itô (1986) 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, after affixation occurs. She points out that labials, velars and coronals pattern identically in reduplication and she thus requires that [coronal] be filled in by level 2, where reduplication occurs. We argue in Rice & 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. The appearance of similarity is the result of the coronal occupying a mora in the reduplicated form and thus escaping epenthesis. Further evidence against Itô's analysis is presented immediately below when we examine phrasal data.

[8] Keating (1987) argues based on palatograms that palatals have both Coronal and Dorsal nodes, as in (i):

(i)



We simply use the feature [high]. Arguments for this are beyond the scope of this paper and await a more fully worked-out theory of palatals.

[9] The places of articulation within the major articulators are supplied by default rules. For instance, /p/ and /f/ are not distinctive under Labial phonologically. The coronal articulations are also not distinctive phonologically. See Kiparsky (1985) for details.

[10] 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 palatals. See Avery & Rice (1988) for details.

[11] Since we consider /ɲ/ to be a coronal, it may be asked why it does not assimilate in the manner of the other coronal /n/. With a following coronal, fusion of Coronal nodes can occur once Coronal is filled in; however, the palatal retains the feature [high] since it is a daughter of the non-fusing Place node. With a following non-coronal, spreading is blocked by structure preservation because there are no high labials or dorsals.

[12] Levin (1987) argues that [lateral] is a daughter of the Coronal node, using data similar to that in (17) to support her argument. Note, however, that there is no straightforward account for the assimilation to the velar under this hypothesis. Levin's data appear to be consistent with the model of segment structure shown in (1).

[13] Continuant is placed higher in the segment structure in (1) than the sonorant features based on data such as Catalan stop assimilation. Notice that the /t/ assimilates fully to a sonorant, but only partially to a continuant.

[14] It has been assumed that the Coronal node must be specified in English (see, for instance, Yip 1988). However, the data presented here suggest that this is not the appropriate analysis. Additional research is required to account for the facts that Yip discusses. See Davis (forthcoming) for further evidence that Coronal must be absent from the underlying representation of /t/ in English.

[15] Note that lexical nasal assimilation also requires the absence of a Coronal node in English.

[16] An anonymous reviewer noted that in his/her dialect, /m/ can assimilate to a velar in rapid speech. See note 23 for comments.

[17] The representations of palatal and palato-alveolar consonants require some comment. We proposed that the palatals in Catalan were to be represented with a feature [high] as daughter of the Place node; in Sanskrit, we are proposing that the palato-alveolars are distinguished by a Coronal dependent. The argument for the presence of Coronal in Sanskrit goes through whether or not the representation of the palato-alveolars is correct since the distinction between dental and retroflex consonants is enough to force Coronal. For the moment, we maintain the position that the phonetic cues for palatals differ from those for palato-alveolars. Questions about the representations of palatals and palato-alveolars are the subject of current work.

[18] It is mysterious to us why the target must be specified [+nasal].

[19] Fusion is not required since the Coronal nodes are not locally adjacent.

[20] According to Whitney (1889) Sanskrit words can end only in a limited range of consonants. Neither a retroflex nor palato-alveolar is possible finally. We predict that if a retroflex or palato-alveolar preceded another non-distinct coronal consonant, fusion would occur, keeping the features of the righthand consonant. This prediction cannot be tested.

[21] This conclusion is very similar to the one reached by Steriade (1987) 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.

[22] Stops must assimilate in nasality to a following nasal consonant; hence the form *[kukmul] is ungrammatical. See Cho (1988) for some discussion. We thank Younghee Na for checking the Korean glosses.

[23] This analysis could also account for the assimilation of [m] to the place of articulation of a following velar, as pointed out in note 16:

(i) fro[m k]ingston ➛ fro[ŋ k]ingston

(ii) fro[m t]oronto ➛*fro[n t]oronto

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