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*Vowel geometry**

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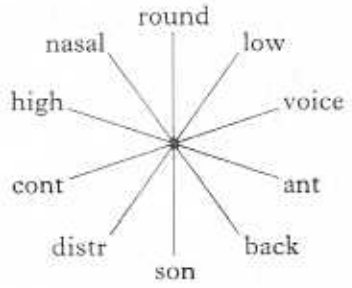
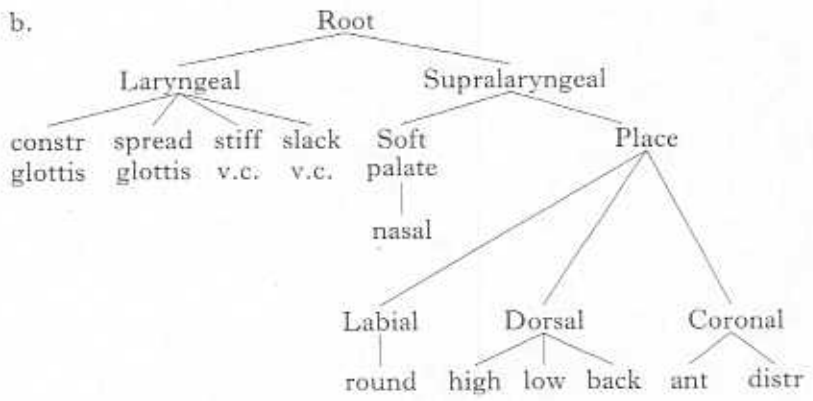
1 Introduction

A basic assumption in current phonology is that features are not an unstructured set like (1a), but are arranged hierarchically into a constituent structure tree such as (1b), proposed in Sagey (1986: 61):

(1) a.



b.



Other groupings of features have been proposed (Clements 1985; Steriade 1987; *inter alii*).

A fundamental assumption of theories like (1b) is that rules operate on constituents, an assumption which is formalised by limiting rules to spreading or delinking a single node. This constraint limits the power of phonological rules, so that it remains possible to state a rule spreading

place of articulation features, since these features form a constituent, but it becomes impossible to state a rule simultaneously spreading [nasal] and [voice],[1] since those two features, to the exclusion of all others, do not form a constituent in this model.

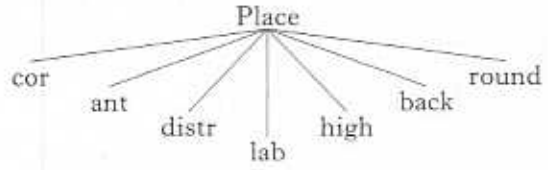
The aim of this paper is to focus on the place features of vowels, traditionally [round], [back], [high], [low] and [ATR], and to raise the question whether at some level these features form a phonological constituent, to the exclusion of other features. In so far as this question will be answered in the affirmative, a related issue to be investigated is the existence of intermediate nodes between that vowel feature node and its terminals. Following an overview of previous work on the grouping of place of articulation features, especially those assigned to vowels, the proposed organisation of vowel features into nodes is presented. It is first argued that the features governing vowel backness and rounding constitute a subconstituent under the Vowel Place node; it is then shown that features governing vowel height form a separate constituent under the Vowel Place node.

2 Background

2.1 Previous feature theories

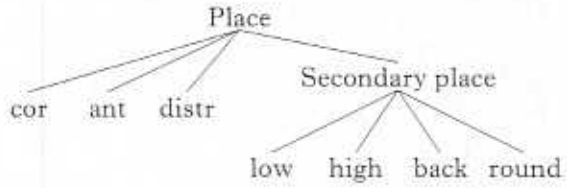
The proposal that features for place of articulation should be gathered under a single node is set forth in Clements (1985), who does not assume any subgrouping under the Place node. The geometry assumed there seems to be as follows:[2]

(2)



A further elaboration of this model is set forth in Archangeli & Pulleyblank (1987), who follow the suggestion of Clements (1985) that place features might be distinguished for being primary *vs.* secondary features. The following organisation of place features is proposed:

(3)



However, no arguments are given for this organisation of features.

Subsequent work by Sagey (1986) organises place features into sub-

groups, as seen in (1
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presented by Sagey
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To account for the
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Steriade (1987) prop
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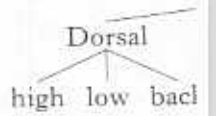
(4)



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causative *snV*.[3] This r
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1964).

groups, as seen in (1b). A motivating principle which underlies this grouping is that 'the terminal features are grouped at the next level in the tree into constituents according to which articulator in the vocal tract executes the particular feature' (1986: 15). The primary argument presented by Sagey for the structure in (1b) is that such a feature organisation captures generalisations regarding possible complex segments, in a way that (2) does not.

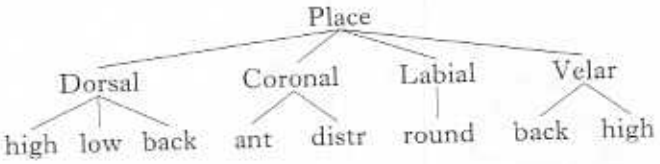
To account for the fact that consonants, including dorsal consonants, are usually transparent to vowel harmony, Sagey (1986: 147) claims that the dorsal place of articulation in consonants is represented with a Dorsal node unspecified for the features [back] and [high]. Thus any single vowel feature can spread over dorsal consonants. However, the model predicts that no vowel harmony rule could spread both [high] and [back] across dorsal consonants, since such a rule must be expressed as spreading of the Dorsal node (Dorsal is the lowest node which [high] and [back] have in common), and the intervening Dorsal node of velar consonants would block such a harmony process.

Steriade (1987) proposes a development of the model in Sagey (1986) which explains certain phenomena that might seem to motivate segregating vowel and consonant place features into disjoint tiers. Steriade proposes that:

> tongue body position corresponds to different Articulator nodes in vowels and consonants; we would reserve for the vowels the Dorsal node and the features it dominates ([high], [low], [back]) and posit a separate Articulator, Velar, for velar/uvular consonants. Aside from this, vowels and consonants will share their class tiers: they will have Place, Supralaryngeal, Laryngeal and Root nodes on the same tiers even in cases where these nodes dominate disjoint sets of terminal features. (1987: 597)

The following organisation of place features is assumed:[3]

(4)



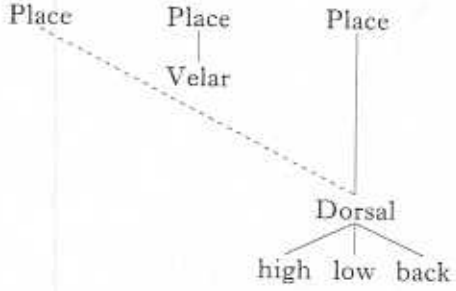
An advantage of this model over that of Sagey (1986) is that it allows an account of rules spreading multiple vowel place features, rules which are not blocked by consonants, including dorsal consonants. For example, there is a process in Klamath (which has the vowels *i*, *e*, *a* and *o*) which spreads the place features of a vowel to certain prefixes such as the causative *sn*V.[4] This rule applies across all consonants, including velars and uvulars (the latter transcribed as *q*, *q'* and *ġ*; data from Barker 1963, 1964).

(5)

sna-batgal	'gets someone up from bed'
sna-čk'a·Wa	'makes cold'
sne-l'e·mlem'a	'makes someone dizzy'
sne-ge·ǰiga	'makes tired'
sno-bo·stgi	'causes something to turn black'
sni-ǰi·qǰiq'a	'makes someone ticklish'
sni-nklilk'a	'makes dusty'
sni-gičtgi	'makes tight'

Since multiple vowel place features spread, this process would have to be expressed as spreading of the Dorsal node from the root vowel to the target vowel under the geometry of Sagey (1986). But such spreading would be impossible, since there is an association line between the Place and Dorsal nodes of the intervening dorsal consonants which stands between target and trigger in *sna-čk'a·Wa*, *sne-ge·ǰiga*, *sni-nklilk'a*. If we adopt the model in (4), the rule can be expressed as spreading of the Dorsal node; since consonants, and particularly velar consonants, in this language do not have features under the Dorsal tier, they do not block the spreading of vowel features:

(6)



Under this model of feature organisation, the features [back], [high] and [low] may freely spread across any consonants, either singly or as a group.

The model advanced by Steriade predicts that the feature [round] may spread along with some other vowel features only if all vowel place features spread. Furthermore, such spreading can only apply across consonants having no Place node, typically laryngeal consonants. (Paradis & Prunet 1989 have argued that coronal consonants in Fula, Guere and Mau are unspecified for place features, hence may be skipped.) This prediction follows from the geometry in (4), and the fact that the only way within the model to assimilate both Dorsal features and the feature [round] is to spread the Place node, since the Place node is the lowest node in the feature hierarchy which dominates [round] and the remaining vowel place features.[5] Regular consonants should not intervene, since spreading Place features from vowel to vowel would cross lines with the consonant, as in (7):

(7)

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(8)

Supralaryngeal

Place

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2.2 An alternative ge

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(9) *Place*

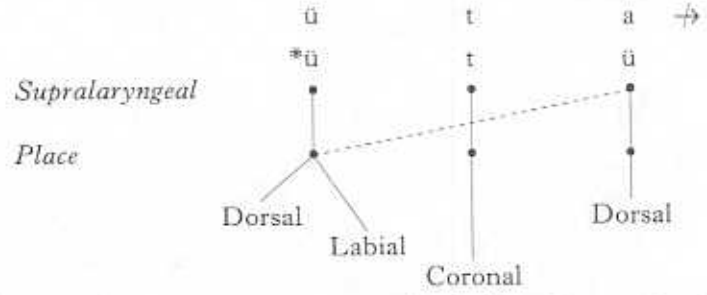
Dorsal

Labial

Coronal

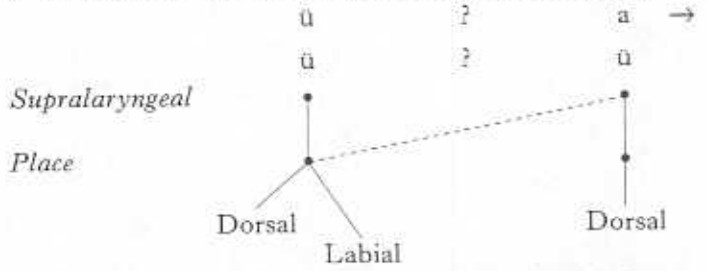
Vowel Place

(7)



Since laryngeal consonants are assumed to lack a Place node, they can intervene between the vowels involved in total assimilation:

(8)

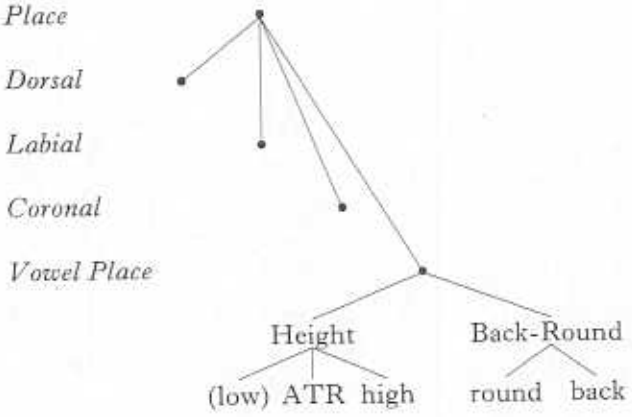


A crucial step in this argument is the assumption that the feature [round] is dominated by the Labial node, and that [high], [back] and [low] are dominated by the Dorsal node.

2.2 An alternative geometry

In this paper evidence is given against the assumption that [round] is to be segregated from other vowel features in this manner. An alternative geometry is proposed, where the features [back] and [round] are dominated by one node, and [high], [ATR] and possibly [low] are dominated by a separate node.[7] Finally it is shown that the totality of vowel place features are dominated by a single node, the Vowel Place node. Thus, the geometry in (9) is proposed:

(9)



As with all previous models, this constituency allows any single feature to spread. In addition, [back] and [round] may spread together as a constituent, to the exclusion of the features for height: this prediction will be shown to be correct in §3. Harmony rules from Tunica, Cheremis and Wikchamni are discussed, where the features [back] and [round] spread, without spreading vowel height; such rules support the Back-Round constituent of Vowel Place in (9).

The second prediction is that features for vowel height may spread to the exclusion of the features for backness and rounding: this prediction will be shown to be correct in §4. Harmony rules in Kimatuumbi and Ewe which spread [high] and [ATR] will be discussed, in support of the left branch grouping. This leaves open the question of where [low] should be placed. In (9), [low] has been tentatively assigned to the Height node, based on evidence from Esimbi to be discussed in this paper. However, the evidence for this decision is not totally compelling, and until more substantial evidence for the location of [low] in the feature hierarchy becomes available, proposals for locating [low] must be viewed as speculative.

2.3 Round and labial

The model in (9) departs most radically from previous models in not placing [round] under the Labial node. It is therefore necessary to scrutinise the arguments for assigning [round] under Labial, and to consider whether that assignment makes other incorrect predictions. Finally, it is important to consider whether the grouping of [back] and [round] is grounded in plausible phonetic reasoning.

The theoretical driving force behind the geometry of Sagey (1986) is the assumption that feature geometry is motivated by articulatory phonetics. In articulatorily driven geometry, each articulator[8] has a corresponding node which dominates all and only the features executed by that articulator. On these grounds, tongue position features could not be a constituent with a lip protrusion feature, since lip protrusion and tongue backing are not executed by the same articulator. While we have no quarrel with the belief that aspects of phonological structure should be grounded in phonetic properties, there is no reason to give articulatory phonetics a privileged position over acoustic phonetics in explanations.

The grouping of [high], [low] and [ATR] on the one hand, *vs.* [back] and [round] on the other, has a very natural explanation in terms of acoustic properties – the primary acoustic correlate of the first group is an effect on F1, and the primary acoustic correlate of the second group is an effect on F2 (Ladefoged 1975: 173). In the case of [high], [low] and [ATR], acoustics and articulation make roughly the same prediction. But in the case of [back] and [round], acoustics and articulation make different predictions – the test of constituent spreading, which we shall apply below, shows us that the prediction of the acoustically driven model is

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iko → ikü
uke → uki
ikö → iku

In the geometry in (4),

(11) *Place*

Dorsal

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correct. This underscores the point made by Clements (1985), that decisions about feature geometry are not to be based on *a priori* decisions about vocal tract anatomy, but should be grounded on generalisations regarding phonological processes, as well as acoustic and articulatory arguments.

In fact, the articulatorily driven model, which excludes [round] from the remaining vowel features (except at the level of the Place node), predicts non-existent types of multiple feature harmony, namely assimilation of [high], [low] and [back], without assimilation of [round]. Suppose one were to find alternations like those in (10), which is complete vowel harmony excluding [round]:

(10) eko → ekö
iko → ikü
uke → uki
ikö → iku

In the geometry in (4), such a process could be formalised as (11):

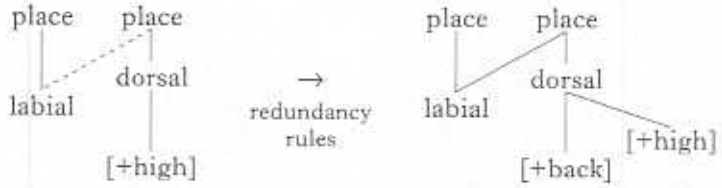
(11) *Place*

Dorsal

Under the proposal made here, any rule spreading [back] and [high] must be a rule of total vowel harmony, since the Vowel Place node is the lowest node dominating both [back] and [high]. Since [round] is also under the Vowel Place node, that feature would also spread if [back] and [high] spread. Since rules like (11) are unattested and since the model in (9) predicts the impossibility of such harmony, this constitutes an argument against assigning [round] to a node separate from the one which [back] is assigned to.[9]

Before proceeding to arguments for the Back-Round constituent relation, it is necessary to dispense with one argument commonly given for the claim made by the geometries in (1b) and (4), that [round] is dominated by the Labial node, rather than whatever node dominates the remaining vowel features (Dorsal, in these models). Apart from the *a priori* decision to place [round] under Labial based on the articulation ~ constituency homology, the empirical argument for placing [round] under the Labial node is that certain languages exhibit some connection between the feature [round] on vowels and labial consonants. Sagey (1986: 137), citing Campbell (1974), gives a typical example from Tulu. According to Sagey, Tulu has a rule which rounds /i/ to [u] after either a round vowel or a labial consonant. In the *SPE* system of features, there are no features which make labial consonants and round vowels a natural class. Sagey argues that this process can be rendered as the natural process of Labial spreading. The following rule is offered (1986: 138):

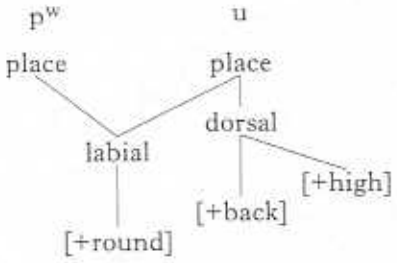
(12)



Two redundancy rules are assumed: (i) a Labial node linked to a vowel is assigned the value [+round], and (ii) a Dorsal node on a vowel with a Labial node is interpreted as [+back]. This second convention is actually unnecessary since, as Bright (1972) states, the back unrounded vowel [ï], not [i], becomes [u], so the vowel is [+back] to begin with.

Sagey does not comment on the fact that since the Labial node is spread from the consonant to the vowel, and is later given the value [+round], then the consonant itself should also be rounded. In other words, applying the labial spreading rule followed by the redundancy rule for [round] to underlying /kappï/ 'blackness' would give the following structure:

(13)



Bright gives no evidence that the labial consonant becomes round, and, especially when the consonant is syllable-final and not immediately followed by a rounded vowel as in [avtu] from /avtï/ 'out', where consonant rounding would be especially salient, it is unlikely that such rounding is present. Additional machinery is necessary in this case, and others like it, to split the Labial node into two, so that only the Labial node of the vowel is filled in with the feature [+round].

There is no reason to reject the geometry in (9) based solely on the fact that the theory does not encode the relationship between [round] and Labial in constituent structure. There are analogous problems in the relation between vowel and consonant place features which still remain unexplained in the theories of Sagey (1986) and Steriade (1987). One such relation is the one between [coronal] and [−back]. Hume (1990) shows that there is a vowel-fronting rule in Maltese Arabic whereby /o/ becomes [i] when immediately followed by a coronal obstruent. Thus, the prefix vowel of imperfective verbs in the first binyan is a copy of the root vowel, but just in case the immediately following consonant is a coronal obstruent, the prefix has the vowel *i*:

(14) yo-lʔot 'he
yo-ktor 'he
yi-skot 'he
yi-dhol 'he

Similar effects are di
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node on the strength
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assign [−back] unde
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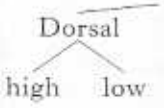
(15)



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place node, the V-pl

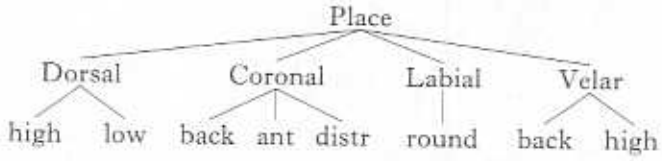
(14)

yo-lʔot	'he hits'
yo-ktor	'he/it increases'
yi-skot	'he is silent'
yi-dħol	'he enters'

Similar effects are discussed in Hyman (1973), Pulleyblank (1989) and others.

By the reasoning that would force us to assign [round] under the Labial node on the strength of the fact that vowels can become [+round] in the environment of labial consonants, we would be equally compelled to assign [−back] under the Coronal node, based on the evidence from Maltese, *inter alia*, that vowels can become front in the environment of coronal consonants.

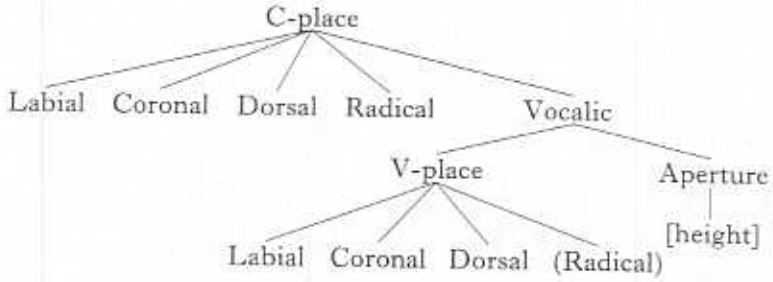
(15)



This would be impossible under Steriade's geometry (4), since such a move would imply that [back] and vowel height could never spread across consonants. Since the lowest node dominating [back] and [high] is the Place node, rules of total vowel harmony such as are found in Klamath would have to spread the Place node, but such spreading would be incorrectly blocked by the Place nodes of intervening consonants.

The relationship between labial consonants and round vowels therefore does not constitute an argument for grouping [high], [low] and [back] under the Dorsal node, to the exclusion of [round], since the same reasoning would also force [back] to be assigned to the Coronal node, based on the coronal ~ front interaction. Yet it is desirable to have a functional explanation for why vowels do become round in the context of labial consonants, and why vowels front near coronals. A model which addresses the functional identity of consonantal and vocalic place features is presented in Clements (1989, 1990) and Hume (1990). In that model, place of articulation for both vowels and consonants is defined in terms of a single set of features, [labial], [coronal], [dorsal] and [radical]. The exclusively vocalic features [back], [round] and perhaps [ATR] are eliminated. Place features are placed on different planes, depending on whether they function as consonantal place features, in which case they are immediately dominated by the highest Place node, the C-place node, or function as vocalic features, in which case they are dominated by the lower place node, the V-place node.

(16)



Under this model, Labial on the consonantal plane denotes labial closure as under previous models, but Labial on the vowel plane denotes lip protrusion, i.e. rounding. Similarly, Coronal on the consonantal plane is interpreted as raising of the tongue blade, but Coronal on the vocalic plane is interpreted as fronting of the tongue.

As far as the constituent structure of vowel features is concerned, the model proposed in (9) is fundamentally compatible with Clements' proposal, (16). In particular, both models agree in assigning the features for vowel height under one constituent, and assigning the features for rounding and the front–back distinction under a different constituent. The differences between the models, while not trivial, do not materially affect the debate over the constituency of vowel features, but rather centre around the substance of the features themselves. The model in (16) employs two features for representing front *vs.* back vowels, whereas the present model assumes a single binary feature. The model in (16) adopts a vocalic version of Radical (to describe pharyngealised vowels in the Lezgian languages Tsakhur and Udi), where such a feature is not assumed in the current theory; nothing in the nature of the proposal precludes including this feature.[10]

2 Back-Round constituency

Given the previously noted problem that surface [+round] vowels might in some languages be treated as underlyingly unspecified for rounding (the phonetic value of [round] being assigned on the basis of the backness of the vowel), rules motivating the constituency of [round] and [back] must come from languages where [round] cannot be predicted on the basis of other features. Furthermore, it is not sufficient merely to show that both [back] and [round] spread. Rather, one must show that there is a single spreading rule, not one rule spreading [back] and another spreading [round].

2.1 Eastern Cheremis

Eastern Cheremis (Mari), a Uralic language of the Soviet Union, has such a harmony rule. The vowels of Eastern Cheremis are those in (17):

(17)

	high
i	+
ü	+
e	–
ö	–
a	–
ə	–
o	–
u	+

The vowel harmony rul
& Ingemann (1961: 1
alternation between fin
after *ü* or *ö*, and *e* after
underlying these altern
between the triggering
1960; Ristinen 1960; Se
with the 3rd singular p

(18)

kit-še	'h
ergə-že	'h
kobaštə-že	'it
bokten-že	'b
šužar-že	'h
boz-šo	'h

Other affixes exhibit
markers *-šte* and *-ne*, a

(19)

čodra-šte	'
pörtə-štö	'
bujə-što	'
leš-ne	'
mündər-nö	'
ońča-l-no	'

Finally, underived sten
& Ingemann (1961) lis
vowel harmony (*kue* 'l
not'), all involving the
final stems which obey

Suffixes with the vo
suffix *-na*:

(20)

čodra-na	'ou
pört-na	'ou
buj-na	'ou
ergə-na	'ou

(17)

	high	low	back	round
i	+	−	−	−
ü	+	−	−	+
e	−	−	−	−
ö	−	−	−	+
a	−	+	+	−
ə	−	−	+	−
o	−	−	+	+
u	+	−	+	+

The vowel harmony rule of Eastern Chermis is illustrated in (18). Sebeok & Ingemann (1961: 10) state that certain suffixes have a three-way alternation between final [e], [o] and [ö], with *o* appearing after *u* or *o*, *ö* after *ü* or *ö*, and *e* after *i*, *e*, *ə* and *a*. We therefore assume that the vowel underlying these alternations is *e*. Consonants and the vowel *ə* may stand between the triggering and harmonising vowels (Ingemann 1960; Minn 1960; Ristinen 1960; Sebeok & Ingemann 1961). This is illustrated below with the 3rd singular possessive suffix *-že*:

(18)

kit-še	'his hand'	surt-šo	'his house'
ergə-že	'his boy'	üp-šö	'his hair'
kobaštə-že	'its fur'	šör-žö	'its milk'
bokten-že	'beside it'	surtəškə-žo	'to his house'
šužar-že	'his sister'	pörtəštə-žö	'in his house'
boz-šo	'his wagon'	kornə-žo	'his way'

Other affixes exhibit this alternation, for example the inessive case markers *-šte* and *-ne*, and the verbal noun suffix *-me*:

(19)

čodra-šte	'forest' INESSIVE		
pörtə-štö	'house' INESSIVE		
bujə-što	'head' INESSIVE		
leš-ne	'near'	pur-mo	'entering'
mündər-nö	'in the distance'	əštə-me	'made'
ońčə-l-no	'in front'	šogə-mo	'standing'

Finally, underived stems are subject to harmony. The glossary of Sebeok & Ingemann (1961) lists only four lexical items which fail to undergo vowel harmony (*kue* 'birch', *kuze* 'how', *šue* 'sparse' and *uke* 'there is not'), all involving the sequence *u ... e*, and over 200 underived mid-vowel final stems which obey the vowel harmony rule.

Suffixes with the vowel *a* do not alternate, as shown by the 1st plural suffix *-na*:

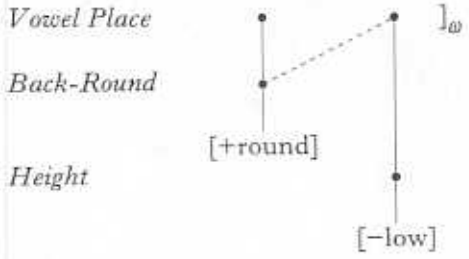
(20)

čodra-na	'our forest'
pört-na	'our house'
buj-na	'our head'
ergə-na	'our son'

I assume that the neutral vowel ə is merely specified as a skeletal position, so lacks place feature entirely. This assumption has independent justification in the language. Morpheme-final mid vowels reduce to ə when followed by another consonant, accounting for the alternation *kobašte* 'fur' ~ *kobaštə-že* 'its fur' or *erge* 'boy' (NOM) ~ *ergə-m* 'boy' (ACC). This can be handled by deleting the place features of the vowel (or any node dominating place features), and by application of later default rules, the vowel is realised as ə. Rules of epenthesis insert the vowel ə to render syllabifiable certain consonant sequences. So, sequences of shibilants are broken up with epenthetic schwa, as shown by *joltaš-əže* 'his friend' (cf. *ača-ž-at* 'his father' (EMPHATIC)). Under the assumptions that vowel epenthesis merely inserts a prosodic element, and that ə lacks segmental features, we correctly predict that the epenthetic vowel of Cheremis is ə.

This leaves us with the matter of formalising a harmony rule which spreads a single node and assimilates [back] and [round], but not [high]. Under the hypothesis advanced here, that [back] and [round] are a constituent, the harmony rule will be formulated as in (21):

(21) *Chermesis Back-Round Harmony*



If we reject the hypothesis of Back-Round constituency in favour of models like that of Sagey (1986) or Steriade (1987), there are two routes to take to account for these alternations. The first would be to reduce this phenomenon to spreading of one feature, and let default rules assign the appropriate value for the other feature. But since there is a contrast between *e*, *o* and *ö*, this is impossible. Spreading the feature [round] alone is insufficient, since there is no way of knowing on the basis of the value of [round] whether a vowel is front or back. We could suppose that the rule spreads [back], with the value of [round] being assigned on the basis of [back]. But [−back] vowels are not necessarily [+round] – *i* and *e* are not. Therefore, underspecification and default values are irrelevant to the analysis of Cheremis harmony.

Alternatively, we could assume two separate harmony rules, one assimilating [back] and the other assimilating [round], as in (22):

(22) a. *Round Ha*

Place

Dorsal

Labial

b. *Back Ha*

Place

Dorsal

There are good r
(23), harmony only
harmonise:[11]

(23) šoge-m
šoge-na
šogə-ne-m
šogə-ne-že
burgem-že

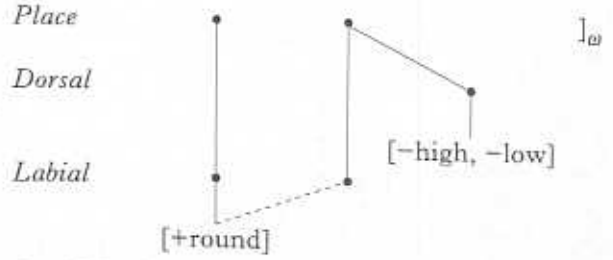
If harmony were de
condition, which is a
would have to be sta

The second piece
which are exceptions
few underived forms
kuze, *šue* and *uke*.
exceptions to a singl
stems are exceptions
word is an exception
the other. As the ex
harmonise. If harmo
morpheme to be an e
is only one rule to b

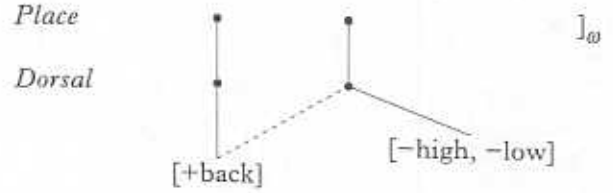
(24) šogə-de
tol-de
koč-te
šogə-də-mo
koč-tə-mo

10

(22) a. *Round Harmony*



b. *Back Harmony*



There are good reasons not to have two rules. First, as shown in (23), harmony only applies to word-final *e*, and non-final *e* does not harmonise:[11]

(23)	šoge-m	'I stand'
	šoge-na	'we stand'
	šogə-ne-m	'I want to stand'
	šogə-ne-že	'he wants to stand'
	burgem-že	'his clothing'

If harmony were decomposed into two rules, the absolute word-final condition, which is a rather unusual condition on a vowel harmony rule, would have to be stated twice.

The second piece of evidence comes from the vocalic pattern of words which are exceptions to vowel harmony. We have noted that there are a few underived forms which are exceptions to vowel harmony, *viz. kue, kuze, šue* and *uke*. Under the single-rule approach, these words are exceptions to a single rule, whereas under the two-rule approach, these stems are exceptions to both rules – it is an unexplained accident that no word is an exception to one harmony rule without being an exception to the other. As the examples of (24) show, the suffix *-de* regularly fails to harmonise. If harmony is made into two rules, there is no reason for this morpheme to be an exception to both rules. If there is only one rule, there is only one rule to be an exception to.

(24)	šogə-de	'without standing'
	tol-de	'without coming'
	koč-te	'without eating'
	šogə-də-mo	'without standing'
	koč-tə-mo	'without eating'

The last two examples show that a suffix may follow *-de*, causing reduction of *e* to *ə*, and harmony propagates over that vowel to affect the verbal noun suffix *-me* (seen earlier in (19)). Thus one cannot dispose of the problem of *-de* by assigning that morpheme to a stratum after vowel harmony.

2.2 Tunica

A second argument for the constituency of [back] and [round] comes from Tunica (formerly spoken in Louisiana). Haas (1940, 1946) states that the vowels of Tunica are *i*, *e*, *ɛ*, *a*, *ɔ*, *o* and *u*. The vowels *ɛ* and *ɔ* are described as low vowels: *ɛ* is 'a low vowel, slightly closer than the *a* of Eng. *mat* but not so close as the *e* of Eng. *met* . . ', and *ɔ* is 'a rounded low back vowel but not quite so low as *a* in Eng. *all*' (1940: 15). Based on this description, and the pattern of vowel harmony, we will treat *ɛ* and *ɔ* as [+low] vowels. The vowels of Tunica are thus as follows:

(25)

	high	low	back	round
i	+	−	−	−
e	−	−	−	−
ɛ	−	+	−	−
a	−	+	+	−
ɔ	−	+	+	+
o	−	−	+	+
u	+	−	+	+

The low vowel *a* becomes *ɛ* after a front non-round vowel, and becomes *ɔ* after a back round vowel: see Odden (1977) and Hammond (1984) for additional discussion of Tunica. Besides the Back-Round harmony rule, there are two additional processes which are relevant to the discussion. By the first rule, Truncation, the leftmost of two adjacent vowels deletes. The relevant vowel cluster may be brought into existence by applying a rule to delete intervocalic *h* which is preceded by at least two syllables:

(26)

lɔ́takáta		'they run'
lɔ́takáta-áni	→ lɔ́takatáni	'they run, it is said'
nísara		'young person'
nísara-áni	→ nísaráni	'young person, it is said'
sáku		'to eat'
sáku-hila-wihč	→ sákilawihč	'when he was about to eat'
ʔámi		'to go'
ʔámi-hila-wihč	→ ʔámilawihč	'when he was about to go'
lɔ́ta		'to run'
lɔ́ta-hila-wihč	→ lɔ́tilawihč	'when he was about to run'
(cf. lá-hila-tihč 'when the sun was about to set')		
ʔúnima		'we'
ʔúnima-hat	→ ʔúnimat	'we, on our part'
(cf. má-hat 'you, on your part')		

By a second process
before a glottal stop:

(27)

hára	'to sing
náši	'to lead
yá	'to do'
hopí	'to eme

The vowel harmony
vowels, and to vowels
we see examples of Bac
suffixes *-anti* and *-(h)*
becomes *ɔ* after any bac
round vowel. The trigg

(28)

míli
mili-áni
tášle
tášle-áni
lúpitɛhɛ
lúpitɛhɛ-áni
mólu
mólu-áni
mólʔɔhɔ
mólʔɔhɔ-áni
ʔúwi
ʔúwi-hat
sahku
sahku-hat

This process also appli
across *h*. The vowel wh
Preglottal Apocope if
that *h* postvocalically,
Back-Round harmony

(29)

ʔáki
čú-ʔáki
pó-ʔáki
mɛ́-ʔáki
náši-ʔáki
mólu-ʔáha-áni

This process of har
consonant intervenes

(30)

hipu-hk-ʔaki
ču-hk-ʔaki

By a second process of Preglottal Apocope, an unstressed vowel deletes before a glottal stop:

(27)	hára	'to sing'	hár-ʔaki	'she sang'
	náši	'to lead'	náš-ʔuhki	'he sang'
	yá	'to do'	yá-ʔaki	'she did'
	hopí	'to emerge'	hopí-ʔuhki	'he emerged'

The vowel harmony rule, illustrated in (28), applies to strictly adjacent vowels, and to vowels separated by the laryngeal glides *h* and *ʔ*. In (28), we see examples of Back-Round harmony applying to the vowel *a* of the suffixes *-anti* and *-(h)at* (seen in (26)) after a vowel. Suffix-initial *a* becomes *ɔ* after any back round vowel, and becomes *ɛ* after any front non-round vowel. The triggering vowel to the left then deletes by Truncation:

(28)	míli		'it is red'
	mili-áni	→ mil-éni	'it is red, it is said'
	tášle		'it is beautiful'
	tášle-áni	→ tašl-éni	'it is beautiful, it is said'
	lúpitɛhɛ		'she will not die'
	lúpitɛhɛ-áni	→ lúpitɛhéni	'she will not die, it is said'
	mólu		'it is full'
	mólu-áni	→ molóni	'it is full, it is said'
	mólʔɔhɔ		'it is not full'
	mólʔɔhɔ-áni	→ mólʔɔhóni	'it is not full, it is said'
	ʔúwi		'he'
	ʔúwi-hat	→ ʔuwɛt	'he, on his part'
	sahku		'one'
	sahku-hat	→ sahkɔt	'one, on one's part'

This process also applies across *ʔ* and, at least in the negative suffix *ʔaha*, across *h*. The vowel which conditions Back-Round harmony will delete by Preglottal Apocope if unstressed. Other suffixes beginning with *h* delete that *h* postvocalically, so it is not possible to find additional examples of Back-Round harmony applying across *h*:

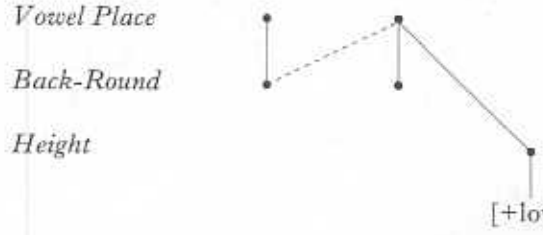
(29)	ʔáki		'she is'
	čú-ʔáki	→ čú-ʔɔki	'she took'
	pó-ʔáki	→ pó-ʔɔki	'she saw'
	mɛ́-ʔáki	→ mɛ́-ʔɛki	'she searched'
	náši-ʔáki	→ náš-ʔɛki	'she led'
	mólu-ʔáha-áni	→ mól-ʔɔh-óni	'it is not full'

This process of harmony is blocked if a supralaryngeally articulated consonant intervenes between the target and trigger vowels:

(30)	hipu-hk-ʔaki	'she is dancing'
	ču-hk-ʔaki	'she is taking'

We now turn to the matter of formalising this harmony rule. The feature [round] is contrastive for the two low back vowels *ɔ* and *a*. Therefore, the simultaneous assimilation of [back] and [round] seen above cannot be reduced to assimilation of [back] plus default assignment of [+round] to back (low) vowels, since the back vowel *a* itself is [−round]. As these data also show, vowel height is not assimilated by this process, so the rule cannot be construed as spreading of the Place node. Only [back] and [round] are assimilated, and in the model proposed here, the rule is formulated as (31):

(31) *Tunica Back-Round Harmony*



The condition that only laryngeals may stand between trigger and focus is unusual: in other harmonies where only laryngeal consonants may stand between the vowels, the harmony is complete assimilation. This condition on intervening elements is problematic for the following reason. It is widely assumed (see Steriade 1987, *inter alii*) that phonological rules do not contain an explicit list of elements allowed to stand between the elements of the rule (e.g. 'X ≠ ...[αF]...'). Rather, such conditions are held to be the consequence of the representation of segments and a theory of adjacency conditions (e.g. 'the focus and determinant must be adjacent at level X'). The condition on intervening consonants could be handled by requiring the Place nodes of the trigger and focus to be adjacent. This condition would be satisfied only between strictly adjacent vowels, or by vowels separated just by laryngeals: regular consonants, having a Place node, would block the spread of vowel features. This kind of adjacency requirement would be at best highly marked, the unmarked choices being that the vowels involved in vowel-to-vowel assimilation must be in adjacent syllables, or else may be indefinitely separated.

Subjecting the rule to the requirement that the Place nodes of focus and determinant be adjacent is, in fact, unprecedented. Steriade (1987) proposes that adjacency conditions are stated prosodically, hence will involve X-slots, syllables, and the like. Archangeli & Pulleyblank (1987) propose that adjacency be determined either at the highest level of phonological representation (X-slots or syllable heads) or at the lowest level (the spreading node itself). Neither theory would countenance the requirement that the Place nodes of the involved vowels must be adjacent, since it is not the Place node which is spreading.

There is a plausible alternative account of apparent 'translaryngeal harmony' in Tunica, grounded in the assumption that low vowels and

laryngeals form a n
harmony rule sprea
[pharyngeal] or [radi
applies to strictly ac
syllabics only the lary
cannot affect *a* separ
Thus the derivation

(32)

Place

Vowel Place

Back-Round

Assigning [+low] t
Brame (1972) shows
Arabic form a natural
consonants. Odden (1
vowel dissimilation ir
by a laryngeal conson
be explained by assigr
partially unifying lary
(1989).[12] Although Ha
of *h* and *ʔ* which wo
[+back] and [+roun
that such an effect, w
event very hard to h
hypothesis cannot be

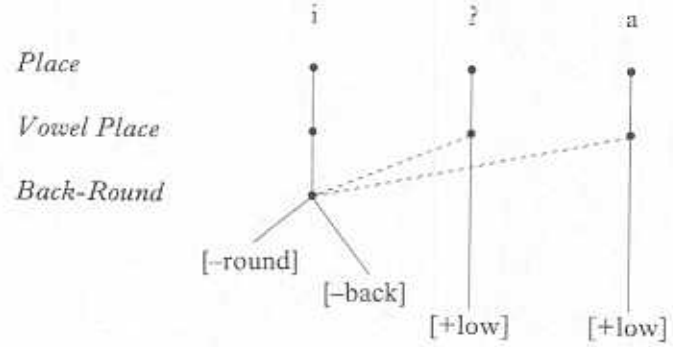
Whichever account
should be only one r
vowel height. The onl
rule is to postulate tw
[round]. If there are
highly marked adjac
apply to [+low] cons

2.3 Wikchamni

The Wikchamni dial
spreading [round] anc
dialect, the underlyir

laryngeals form a natural class defined by the feature [+low]. The harmony rule spreads [back] and [round] to [+low] (equivalently, [pharyngeal] or [radical]) segments, as is stated in (31). The rule only applies to strictly adjacent segments, and given that among the non-syllabics only the laryngeals *h* and *ʔ* are specified [+low], vowel harmony cannot affect *a* separated from the trigger vowel by any other consonant. Thus the derivation for *iʔa* to *iʔɛ* proceeds as follows:

(32)



Assigning [+low] to the laryngeals has precedent in other languages – Brame (1972) shows how the laryngeals and pharyngeals of Maltese Arabic form a natural class in triggering a rule lowering *i* to *a* near [+low] consonants. Odden (1988) discusses a rule of vowel harmony and a rule of vowel dissimilation in Kera which apply to *a* provided it is not preceded by a laryngeal consonant, and shows that blockage of these two rules can be explained by assigning laryngeals the feature [+low]. Similar proposals partially unifying laryngeals and pharyngeals are presented in McCarthy (1989).[12] Although Haas does not mention any special phonetic properties of *h* and *ʔ* which would directly lead us to conclude that they too are [+back] and [+round] between back round vowels, it is quite possible that such an effect, which is non-contrastive and would have been in any event very hard to hear, was simply not recorded. Unfortunately, this hypothesis cannot be verified phonetically.

Whichever account of the 'translaryngeal' condition is preferred, there should be only one rule, one which spreads [back] and [round], but not vowel height. The only alternative to spreading [back] and [round] by one rule is to postulate two rules, one spreading [back] and the other spreading [round]. If there are two rules, both rules would either be subject to the highly marked adjacency condition, or else both would coincidentally apply to [+low] consonants and vowels.

2.3 Wikchamni

The Wikchamni dialect of Yokuts (California) also has a harmony rule spreading [round] and [back], as pointed out in Archangeli (1985). In this dialect, the underlying vowels are *i*, *ï*, *u*, *o* and *a*. The vowels which

Archangeli treats as front round vowels and writes as *ü* and *ö* are written as *ï* and *ë* in Gamble (1978). The choice of symbols made by Gamble and data from vowel formants suggest strongly that these should be interpreted as back unround vowels. I follow Gamble in writing them as *ï* and *ë*:

(33)

	high	low	back	round
i	+	−	−	−
ï	+	−	+	−
u	+	−	+	+
o	−	−	+	+
a	−	+	+	−

In Wikchamni, vowels of the same height assimilate [back] and [round], as illustrated in (34):

(34)

pin'ši	→ pin'ši	'stung'
hutši	→ hutšu	'knew'
tiʔisši	→ tiʔïsšï	'made'
tʰanši	→ tʰanši	'went'
tawtʰat	→ tawtʰat	'might run'
t'oyxat	→ t'oyxot	'might doctor'
hukyat	→ hukyat	'might mix'

The same-height condition can be formalised either in terms of the feature [high], or else in terms of the total set of vowel height features. Nothing of substance depends on this choice.

Vowel harmony is formalised as (35) under the theory that [back] and [round] are a constituent. The identical vowel height condition can be explained by fusing height features, so that identical height sequences are represented with a branching structure:

(35) *Wikchamni Back-Round Harmony*

Vowel Place

Back-Round

Height

Since the rule is subject to an identical-height condition, it is quite unlikely that assimilation of [back] and [round] is accomplished by two separate rules which happen to share this condition.

As pointed out to me by a reviewer, this rule could also be construed as total vowel harmony, in so far as the height features of the involved vowels agree to begin with, and the [back] and [round] specifications of the vowels are assimilated by the rule, rendering the resulting vowel (segmentally) identical to the preceding vowel. The rule could therefore be formalised as place spreading:

(36) *Wikchamni Place*

Place

Vowel Place

Height

However, this is still onl
Under the Steriade/Sage
[round] and other vowel
would have to be expres
harmony rule applies acr
of the Place node of the
Place nodes of consonant
block the rule. So even
Round spreading as som
evidence for placing all
Place node), one which d

2.4 Other examples

Other examples of Back-
Back-Round harmony is
that Macushi has a rule
affixes, as illustrated with

(37) pi-riw 'arrow (
pu-moi 'egg (of
pi-si 'leg (of

Clements (1989) cites a
phonological constituent
process in Maxakali 'voc
inserting a glide betwee
consonant (*t*, *n*, *c*, *ñ*). The
after *o*, and as the approx
ŋ and *w̃* after nasal vowe

(38)

/pĩtĩc/	→ [p
/kĩtĩt/	→ [k
/pĩn/	→ [p
/pohoc/	→ [p
/cõn/	→ [š
/kakcoppit/	→ [k
/cokñĩn/	→ [š
/tat/	→ [t
/ñõŋtat/	→ [ñ

(36) *Wikchamni Place Spreading*

However, this is still only possible under the geometry proposed here. Under the Steriade/Sagey model, where the lowest node dominating both [round] and other vowel features is the Place node, total vowel harmony would have to be expressed as spreading of the Place node. Since this harmony rule applies across all consonants, the rule cannot be spreading of the Place node of the first vowel, on the grounds that the intervening Place nodes of consonants (for example *t* and *š* in the form *hutš-u*) should block the rule. So even under the interpretation of Wikchamni Back-Round spreading as some kind of place spreading, we would still have evidence for placing all vowels features under a single node (the Vowel Place node), one which does not characterise consonants.

2.4 Other examples

Other examples of Back-Round harmony can be found, suggesting that Back-Round harmony is not particularly rare. Carson (1982: 51–52) notes that Macushi has a rule harmonising backness and roundness in certain affixes, as illustrated with the Class A prefix *pɨ-*:

(37) pi-riw 'arrow (of someone)'
pu-moi 'egg (of someone)'
pi-si 'leg (of someone)'

Clements (1989) cites additional cases where [back] and [round] form a phonological constituent. Gudchinsky *et al.* (1970: 82–86) describe a process in Maxakali 'vocalising' coda consonants, part of which involves inserting a glide between the nuclear vowel and a vocalised coronal consonant (*t*, *n*, *c*, *ñ*). The glide which is inserted is realised as *y* after *i*, *ɯ* after *o*, and as the approximant ɣ after *a* and *ɨ* (or the nasal equivalents *ỹ*, *ŋ* and *ɯ̃* after nasal vowels):

(38)

/pïtïc/	→[pïtïɣiį]	'heavy'
/kïtït/	→[kïtïɣəT]	'old'
/pĩn/	→[pĩŋ̃ãn]	'noise made by jumping'
/pohoc/	→[pohowi]	'arrow'
/cõn/	→[šõw̃ãn]	'to open'
/kakcoppit/	→[kakšoëpiyə]	'boy'
/cokñĩn/	→[šognñĩỹãn]	'meat'
/tat/	→[taɣat]	'to carry'
/ñõŋtat/	→[ñõŋktaɣəθ]	'breast'

The inserted segment then is a [+high] segment agreeing in the features [back] and [round] with the preceding vowel.

In Fe?Fe? Bamileke (Hyman 1972), the features [back] and [round] spread from the stem vowel to the high vowel of the reduplicated syllable, without spreading the height of the stem vowel:

(39) si-sii 'spoil'
si-suu 'vomit'
si-suɯ 'miss'
ku-ko 'take'[13]

The prefix vowel is realised as [+high], presumably by application of default rules for vowel height.

In a Western Interior dialect of Ewe (Westermann 1930: 193–195; Clements 1974: 288), postclitics with the vowel *a* assimilate backness and roundness, but not vowel height, from an immediately preceding vowel. Thus, *a* becomes the low back rounded vowel ɔ after *u*, *o* and ɔ, and becomes the low front rounded vowel ɛ after *i* and *e* (examples of ɛ are not provided):

(40) ga-a → gaa 'the money'
kɔ-a → kɔɔ 'the knot'
te-a → tɛɛ 'the yam'
to-a → toɔ 'the mountain'
bli-a → bliɛ 'the corn'
du-a → duɔ 'the town'

The same assimilation affects the habitual suffix *-a*:

(41) me ta-a → me taa 'I usually draw'
me dɔ-a → me dɔɔ 'I usually sleep'
me de-a → me dɛɛ 'I usually go there'
me do-a → me doɔ 'I usually plant'
me di-a → me diɛ 'I usually look for'
me blu-a → me bluɔ 'I usually stir'
me de-a → me dɛɛ 'I usually go there'

Westermann mentions that this harmony is optional in the plural (when the article is followed by *wo*), so both *azi-a-wo* and *azi-ɛ-wo* 'the groundnuts' are possible. If this harmony process were implemented by two separate rules, one spreading [round] and the other spreading [back], one would expect to find optional spreading of one feature without spreading of the other feature. If there is a single process of Back-Round harmony, we correctly predict that *a* assimilates both [back] and [round], or neither [back] and [round].

3 High-ATR and low

The second proposition to be supported is that [high] and [ATR] are a constituent. To show this, we will consider the height harmony rule of

Kimatuumbi, a Bantu langu
(42). Data for Kimatuumbi

(42)

	high	low
i	+	–
u	+	–
ɪ	+	–
ʊ	+	–
ɛ	–	–
ɔ	–	–
a	–	+

Breaking with traditional u
familiar phonetic symbols
have transcribed the high
vowels as *i*, *u*, and the mi

Stem-medial vowels are
from the [+high, +ATI
vowels assimilate the valu
low vowel. This height h
out the lexicon, and can b
in (43), which contains
alternates according to
reciprocal suffix *an*, whi

(43) út-a 'tc
yíb-a 't
yóyʊʊt-a 't
bíɪk-a 't
gɔ́ɔnja 't
chéɛng-a 't
káat-a 't
búlut-a
líp-a
yóʊngʊy-a

wíkɪly-a
gɔ́ɔmb-a
ék-a

káat-a

Further examples
initial *U*. No produ
vowel harmony alte
The consonant *l* is ir
(such as underlying

Kimatuumbi, a Bantu language of Tanzania, whose vowels are given in (42). Data for Kimatuumbi are from my own field notes:

(42)

	high	low	ATR	back
i	+	−	+	−
u	+	−	+	+
ɪ	+	−	−	−
ʊ	+	−	−	+
ɛ	−	−	−	−
ɔ	−	−	−	+
a	−	+	−	+

Breaking with traditional transcription for Bantu languages, I will use the familiar phonetic symbols. Other works on Kimatuumbi by this author have transcribed the high [+ATR] vowels as *i̱*, *u̱*, the high [−ATR] vowels as *i*, *u*, and the mid [−ATR] vowels as *e*, *o*.

Stem-medial vowels are either (phonetically invariant) *a*, or are selected from the [+high, +ATR] vowels *i* and *u*.[14] The stem-medial non-low vowels assimilate the value of [high] and [ATR] from the preceding non-low vowel. This height harmony rule is observed systematically throughout the lexicon, and can be directly motivated through alternations as seen in (43), which contains stems followed by the causative suffix *iy*, which alternates according to the height of the preceding vowel, and the reciprocal suffix *an*, which is invariant.

(43)

út-a	'to pull'	út-iy-a	'to make pull'
yíb-a	'to steal'	yíb-iy-a	'to make steal'
yóyʊʊt-a	'to whisper'	yóyʊʊt-ɪy-a	'to make whisper'
bíɪk-a	'to put'	bíɪk-ɪy-a	'to make put'
gɔ́ɔnja	'to sleep'	gɔ́ɔnj-ɛy-a	'to make sleep'
chɛ́ɛng-a	'to build'	chɛ́ɛng-ɛy-a	'to make build'
káat-a	'to cut'	káat-iy-a	'to make cut'
búlut-a	'to drag'	búlut-an-a	'to drag each other'
líp-a	'to pay'	líp-an-a	'to pay each other'
yʊ́ʊngʊy-a	'to hurry someone'	yʊ́ʊngʊy-an-a	'to hurry each other'
wíkɪly-a	'to cover'	wíkɪly-aan-a	'to cover each other'
gɔ́ɔmb-a	'to shoot'	gɔ́ɔmb-an-a	'to shoot each other'
ɛ́k-a	'to laugh'	ɛ́k-an-a	'to laugh at each other'
káat-a	'to cut'	káat-an-a	'to cut each other'

Further examples of height harmony can be seen in (44), involving non-initial *U*. No productive suffixes in Kimatuumbi contain *U*. However, vowel harmony alternations affecting *U* can still be directly illustrated. The consonant *l* is inserted between a stem which ends in a non-low vowel (such as underlying /tɪɪkʊ/) and a following non-low suffix such as the

applied *-I* (which undergoes Glide Formation before another vowel). Before a suffix beginning with a low vowel, *I* is not inserted, so Glide Formation applies. In the following example, we find pairs of verbs derived from a verb root, the first illustrating the stem without inserted *I* (therefore Glide Formation applies), and the second illustrating insertion of *I*, and hence application of height harmony:

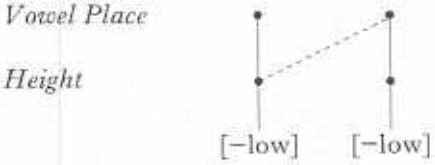
(44)

típw-a	'to break off maize'
típul-y-a	'to break off maize for'
gúlw-a	'to wash dishes'
gúlul-y-a	'to wash dishes for'
tíɪkw-a	'to break'
tíkɔl-y-a	'to break for'
yóongw-a	'to answer'
yóngɔl-y-a	'to answer for'
lɔ́ɔndw-a	'to find a witch'
lɔ́ndɔl-y-a	'to find a witch for'
tyáamw-a	'to sneeze'
tyámul-y-a	'to sneeze on'

When final *u*~*w* appears as a vowel, its height is determined by the preceding vowel.

The fact that [high] and [ATR] spread together, without spreading [back] or [round], shows that [high] and [ATR] are a constituent under the Height node. This harmony will be formulated as in (45):

(45) *Kimatuumbi Height Harmony*



One might consider treating this as two rules, [ATR] harmony and [high] harmony. There are good reasons not to do this. First, harmony has a peculiar condition on it seen in (46), namely that the vowel *ɛ* does not cause *u* to assimilate, although all other vowels cause *u* to assimilate, and *ɛ* will cause *i* to assimilate:

(46)

chɛ́kul-y-a	'laugh for'	
nɛ́mul-y-a	'dance for'	
tíkɔl-y-a	'break for'	/tɪkulya/
wɛ́sɛkana	'possible'	/wɛsikana/

This peculiar condition, however, it is to be stated, should not be stated twice.

Second, various suffixes such as the perfective (*-itɛ*) fail to harmonise, and stems such as *lɔ́ɔkiy* which are lexical exceptions to Height Harmony are exceptions to assimilation of both features, as shown in (47):

(47)

akálaang-itɛ	'l
achélɛɛw-itɛ	'l
akón'ɒond-itɛ	'l
alɔ́ɔt-itɛ	'l
lɔ́ɔkiya	'

Hyman (1989) and Val
height harmony in the
vowels in the non-initial s
non-low vowel in [high]
vowels after [a] surface a
non-initial syllables as b
affecting the applied su
spreading [ATR] leftwar
feature [ATR]:

(48)

eri-lim-ir-a	
eri-huk-ir-a	
ɛrɪ-lɪm-ɪr-a	
ɛrɪ-hʊm-ɪr-a	
ɛrɪ-hɛk-ɛr-a	
ɛrɪ-bɔh-ɛr-a	
ɛrɪ-kar-ɪr-a	
eri-himat-ɪr-a	
eri-gumat-ɪr-a	

Similar height harmony
Clements (1974), includ
Sɛlɛ. The data in (49) sl
[ATR] from the precedi

(49)

àvù́ é	→ àvù í
àsi é	→ ásí í
əwo é	→ əwo é
àye é	→ àyé é
ə̀sɔ́ é	→ ə̀sɔ́ é
àβlɛ é	→ àβlɛ é

These data all provide
a constituent, since the
[back] and [round].

The position of the
could be assigned in
theory of feature cons
here, as spelled out in (
node, giving (50a). It
Height node, giving (5
so-called Vertical Mov
node, which then dom

(47)

akálaang-itɛ	'he fried'
achélɛɛw-itɛ	'he was late'
akón'ʊʊnd-itɛ	'he filtered'
alɔ́ɔt-itɛ	'he dreamed'
lɔ́ɔkiya	'to request'

Hyman (1989) and Valinande (1984: 89–120) discuss a similar rule of height harmony in the Bantu language Kinande. Like Kimatuumbi, vowels in the non-initial syllable of the stem harmonise with the preceding non-low vowel in [high] and [ATR]. Unlike the case with Kimatuumbi, vowels after [a] surface as [+high, −ATR]. We will treat the vowels of non-initial syllables as being underlyingly [+high, −ATR]. Examples affecting the applied suffix *-ir* are given below. By a separate rule spreading [ATR] leftward, prefix vowels (*eri-*) agree with the stem in the feature [ATR]:

(48)

eri-lim-ir-a	'to exterminate for'
eri-huk-ir-a	'to cook for'
ɛrɪ-lɪm-ɪr-a	'to cultivate for'
ɛrɪ-hʊm-ɪr-a	'to beat for'
ɛrɪ-hɛk-ɛr-a	'to carry for'
ɛrɪ-bɔh-ɛr-a	'to tie for'
ɛrɪ-kar-ɪr-a	'to tie for'
eri-himat-ɪr-a	'to squeeze for'
eri-gumat-ɪr-a	'to stuff in mouth for'

Similar height harmony is found in a number of languages discussed in Clements (1974), including Ewe (see also Westermann 1930), Likpe and Sɛlɛ. The data in (49) show that postclitics in Ewe assimilate [high] and [ATR] from the preceding vowel:

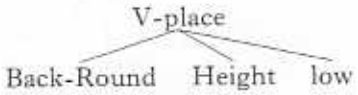
(49)

àvù́ é → àvù í	'it's a dog'
ʌ̀si é → ʌ́si í	'it's water'
əwo é → əwo é	'it's you'
ʌ̀ye é → ʌ̀ye é	'it's a spider'
ə̀sɔ́ é → ə̀sɔ́ é	'it's a horse'
ʌ̀βlɛ é → ʌ̀βlɛ é	'it's a load'

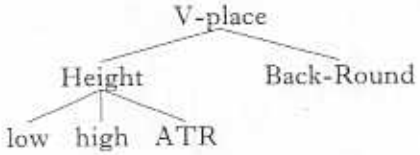
These data all provide evidence that the features [high] and [ATR] form a constituent, since these features can spread as a unit to the exclusion of [back] and [round].

The position of the feature [low] is more problematic. That feature could be assigned in three different places consistent with the overall theory of feature constituency and examples of height harmony given here, as spelled out in (50). It might directly descend from the Vowel Place node, giving (50a). It might be a sister of [high] and [ATR] under the Height node, giving (50b). Or, as in (50c), Vowel Place might dominate a so-called Vertical Movement node, which dominates [low] and the Height node, which then dominates [high] and [ATR]:

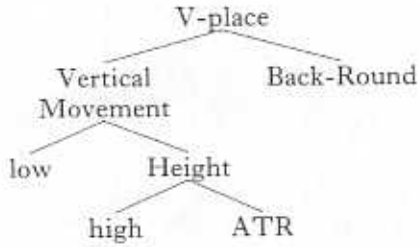
(50) a.



b.



c.



As we have seen with the constituency of [back] and [round], invoking *a priori* arguments based on the articulators used to execute features is not uniformly reliable for deciding where in the feature hierarchy a feature resides. The best argument for selecting among these competing theories would be constituent spreading. What we specifically require is a rule which spreads [low] and some other feature. It is crucial that this rule not be a rule of total harmony (spreading of the Vowel Place node), since total vowel harmony would only establish that [low] is somewhere under the Vowel Place node. I have found no truly compelling evidence which answers this question; therefore, an answer to the question of the location [low] in feature geometry must await future research – note, though, that the organisation in (50a) predicts that we will never find such spreading. I present the one salient case below.

Hyman (1988) motivates a height harmony rule in the Cameroonian Grassfields Bantu language Esimbi which may support grouping the three height features together. The non-low prefix vowels *I* and *U* are realised as *i*, *u* before underlying *i*, *u*, as *e*, *o* before *e*, *o*, ɔ, and as *ɛ*, ɔ before *ɛ*, ɔ, *a*. By a later rule, all stem vowels become [+high, +ATR].

(51)

/I-tla/	→ɛ-tli	'place'	/U-ba/	→ɔ-bi	'come'
/I-zɔ/	→ɛ-zu	'snake'	/U-hɔ/	→ɔ-hu	'knead'
/I-yɛsɛ/	→ɛ-yisi	'hole'	/U-rɛ/	→ɔ-ri	'daub'
/I-bə/	→e-bi	'cane rat'	/U-dzə/	→o-dzi	'steal'
/I-nono/	→e-nunu	'bird'	/U-to/	→o-tu	'insult'
/I-gbe/	→e-gbi	'bushfowl'	/U-se/	→o-si	'laugh'
/I-su/	→i-su	'fish'	/U-zu/	→u-zu	'kill'
/I-bi/	→i-bi	'goat'	/U-ri/	→u-ri	'eat'

If we interpret the
nations straightforwa
vowel height feature
following derivations

(52) a.

Vowel Pl

Height

b.

Vowel Pl

Height

However, as Hymar
for by spreading the
is redundantly [−h
harmony process,
location of [low] in

4 Conclusions

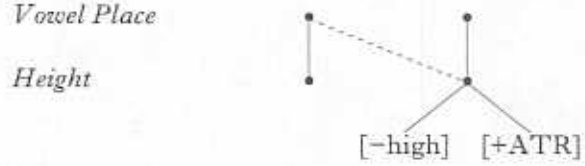
In this paper it ha
articulation in vowe
into a constituent, t
vowel harmony wh
Furthermore, it has
acoustic effect is ar
subconstituent (Ba
shown that [high]
quence is an effect
vowel place.

We have seen su
may also be a part
there are other inte
clear evidence rega
future research tur
[high] and [ATR]
continuum of vow

If we interpret the vowels *a*, *ɔ*, and *ɛ* as [+low] vowels, these alternations straightforwardly support the inclusion of [low] in the set of vowel height features, and are thus consistent with (50b) or (50c). The following derivations illustrate this interpretation of height spreading:

(52) a. i t l a → ɛ-tla (→ ɛtli)

b. i g b e → e-gbe (→ egbi)



However, as Hyman points out, these alternations can also be accounted for by spreading the features [high] and [ATR], given that the vowel [a] is redundantly [−high, −ATR]. Under such an interpretation of the harmony process, we lack the evidence needed for determining the location of [low] in the feature hierarchy.

4 Conclusions

In this paper it has been demonstrated that the features for place of articulation in vowels must be grouped together in the feature hierarchy into a constituent, the Vowel Place node, to explain the existence of total vowel harmony which spreads vowel place features across consonants. Furthermore, it has been demonstrated that those features whose primary acoustic effect is an effect on F2, namely [back] and [round], form one subconstituent (Back-Round) under Vowel Place. Finally, it has been shown that [high] and [ATR], features whose primary acoustic consequence is an effect on F1, form a separate constituent (Height) under vowel place.

We have seen suggestive evidence from Esimbi that the feature [low] may also be a part of the Height constituent, though we have noted that there are other interpretations of the facts, which would leave us with no clear evidence regarding the status of [low]. It would not be surprising if future research turns up evidence that [low] belongs with the features [high] and [ATR] under the Height node, given that the phonetic continuum of vowel height is expressed phonologically with the three

features [high], [low] and [ATR]. If the organising principle behind vowel place features is the acoustically driven distinction between features affecting F1 and those affecting F2, we would predict precisely this outcome. However, as this paper has also shown, one cannot determine constituency relations between phonological features solely on the basis of *a priori* decisions regarding the kinds of phonetic principles which phonology is grounded in. Such decisions must be made on empirical grounds, using the evidence of phonological rules themselves.

NOTES

* An earlier version of this paper was presented at the Winter LSA meeting in New Orleans, December 1988. I would like to thank Jill Beckman, Nick Clements, Laura Downing, Larry Hyman, Lisa Selkirk and Robert Vago for helpful comments on this paper.

[1] A reviewer reminds me of the nasal spreading rule of Terena, which spreads [nasal] up to the first obstruent; the obstruent becomes a voiced prenasalised consonant. This rule operates in nouns and verbs inflected for 1st person singular, so /owoku/ becomes [õw̃õŋgu] 'my house'. This would seem to be a case of voice and nasal spreading simultaneously; however, all nasalised consonants in Terena are voiced, so the secondary voicing of the nasalised obstruent can be explained on independent grounds.

[2] Clements (1985) does not provide a display or a verbal statement of the features which are dominated by the Place node. The display given here, which appears to conform to the spirit of Clement's proposal, is drawn from Sagey (1986: 27).

[3] Steriade (1987) does not provide a display listing all place features and their organisation, so I have constructed the following display on the basis of her examples. She does not state where the feature [ATR] is to be assigned, and she also does not state which features are assigned under the velar node.

[4] Numerous prefixes in Klamath have a vowel which harmonises completely with the following vowel. These prefixes can be treated as having a vowel nucleus unspecified for place features; their surface features then arise by spreading from the following vowel.

[5] A number of languages, such as Klamath, have rules of total vowel assimilation which applies across all consonants. It would thus appear that the form *sno-bo·stgi* 'causes something to turn black' involves spreading of [round] along with other vocalic features, in contradiction to Steriade's prediction. Since the vowel system of Klamath is /i e a o/, the value of the feature [round] can be predicted on the basis of the values of the features [back] and [low]. Counterexamples to this prediction would therefore have to come from languages where [round] can be shown not to be redundantly predictable on the basis of other vowel features.

[6] The existence of a Supralaryngeal node is controversial – see Iverson (1989). Nothing in Steriade's argument depends on the existence of such a node, and this rule could be rewritten to spread Place to whatever node is assumed to immediately dominate Place.

[7] In so far as [low] is one of the features used to express the notion of vowel height, one might expect [low] to be dominated by the Vowel Height node. However, I have found little empirical evidence in the form of constituent-spreading arguments to show that this expectation is borne out.

[8] It is far from clear, from the perspective of phonetic theory, what an 'articulator' is in any meaningful way, how one distinguishes one articulator from another, or whether phoneticians and phonologists are speaking of the same thing when speaking of 'articulators'. In short, it is far from certain that the notion 'articulator' a real construct of pho

[9] The theory proposed [round], which croc theory of Steriade (19 totally convincing cas lated consonants fron of other features. H harmony rule totally than schwa, *viz.* /ɻoli /ŋamur/ → *ŋaməɾ* 'ar contrast between *o* ar of [back]. However, i to /i a e o u/ (in whic ə by later epenthesis

[10] Obviously it is a mat vocalic feature [radic phonological alternat tainly none which un in Pančvidze & Džei between pharyngeal

(i) sa '1'
sa-c'c'e '11

(ii) xib-qô' '60
sa-qo-vic' '30
xib-qo-vic' '70

In the first case, *p'* 'decades' suffix *-c'c'e* its pharyngealisation consonant. No other what principle goveri is governed by a lar similations are not tot we will leave this que ing on the question.

[11] Prefinal *e* does not re vowel-initial: cf. *tol-* only takes place befo

[12] This proposal is at laryngeal consonant laryngeals may, on a less, or may have a undeniable – laryngea some vocalic process segments. One would in a single language - vocalic harmony, wh

[13] The harmony is not t stem vowel is non-hi non-roundness from complications do not

[14] The stem-medial non vowel height feature assigned the value [+ underlying values of [[−high] spread rema

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