

*Underspecification and vowel height transfer in Esimbi**

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1 Introduction

Since the advent of distinctive feature theory, few issues have received as many interpretations as the phonological representation of vowel height. Vowel height features have been defined acoustically and articulatorily, have allowed three, four or five distinct heights, have been unary, binary and n-ary, and have been on a single tier, multiple tiers or in various head-dependency relationships. It is fair to say that there is no consensus on how vowel height should be represented. While many generative phonologists have been quite content working for nearly three decades with a pair of binary vowel height features, the literature of this period includes a steady flow of criticisms of this approach as well as suggestions for improvement or radical change. This literature generally addresses itself to two problems inherent in the *SPE* features [high] and [low] and the three vowel heights they define: First, how does one account for systems with four (five?) vowel heights? Second, how can rules that raise (lower) vowel heights by one step each be accounted for? In the first question we ask what the theory has to say about distinctive oppositions such as /i e ε æ/; in the second question we ask what the theory has to say about a rule such as one that would lower /i/ to [e] and /e/ to [ε]. Researchers sensitive to these questions have either elaborated on the binary system (e.g. by redefining or adding to the two binary features), have built in additional structure (e.g. tiers, nodes, dependencies), or have abandoned the binary approach altogether.

In this paper I propose to examine once again the phonological representation of multiple vowel heights. Rather than surveying the data and solutions of past researchers who have argued for and against the *SPE* account of vowel height, I shall focus the discussion on some rather unusual, but revealing, vowel height facts from a single language, Esimbi, spoken just outside the Grassfields Bantu region of Cameroon. As I shall show, the Esimbi vowel system is, even beyond the question of vowel height, of considerable theoretical interest. With respect to vowel height, the major focus of this paper, we shall see that it provides data problematic for the binary approach in both senses mentioned above. Below, I shall examine closely the implications of these properties for

distinctive feature theory. In particular, I will argue that given the basic assumptions of underspecification theory (Kiparsky 1982, 1985; Archangeli 1984; Pulleyblank 1986a), a binary approach to the Esimbi vowel height problem is not only viable, but also raises interesting questions concerning the geometry of vowels and possible stability effects of vowel features.

In the discussion to follow I first present the Esimbi data (§2). In §3, I present the underspecification analysis using binary vowel height features. In §4, I consider possible objections to this analysis and draw upon data from other languages to support my conclusions. Finally, in §5 I briefly consider the question of abstractness and the possibility of having 'floating' vowel height features in Esimbi.

2 The Esimbi data

The basics of the Esimbi vowel system were described in two short papers published by Stallcup (1980a, b), though I shall be elaborating on these papers based on Stallcup's field notes, lexicon and texts as well as one unpublished paper (Stallcup 1977). From these materials one can establish the distribution of vowels in Esimbi as in (1):

- (1) a. the seven surface vowels [i u], [e o], [ɛ ɔ] and [a] are found on prefixes
 b. only the three high vowels [i u i] are found in stems
 c. all (necessarily high) vowels are identical within a single stem

Surface pattern			Underlying stem <i>V</i>
u-i	u-ri u-bini u-fihiri	'eat' 'dance' 'dangle'	/i/
u-u	u-zu u-tumu u-suhuru	'kill' 'send' 'crouch'	/u/
o-i	o-si o-kibi o-yihiri	'laugh' 'pour' 'learn'	/e/
o-u	o-tu o-zumu o-yuwuru	'insult' 'dry up' 'hear'	/o/
o-i	o-dzi o-tini o-nimini	'steal' 'refuse' 'think'	/ɔ/
ɔ-i	ɔ-ri ɔ-rini ɔ-njihiri	'daub' 'be poor' 'chew'	/ɛ/
ɔ-u	ɔ-hu ɔ-buru ɔ-zumulu	'knead' 'be tired' 'wither'	/ɔ/
ɔ-i	ɔ-bi ɔ-nimi ɔ-simbiri	'come' 'bite' 'scatter'	/a/

[Table I. *Prefix-stem vowel distributions in infinitives*]

In order to exemplify the realisation of underlying stem prefix /U-/, a vowel articulation specification is [+round]. Stems of the shape CV, CV in (1c) will be evident.¹

As seen in Table I, the [+round] vowels found in the vowel height of the infix in the surface form of the vowel in the two minimal triplets

- (2) a. u-mu 'drink'
 o-mu 'go up'
 ɔ-mu 'sit'

The choice of [u-] vs. [o-] is some less than transparent

To explain the distribution given in Table I, Stallcup has vowel height features from this analysis the [+high] redundant one, a position 1 (1c), though it appears to oppositions within the stem

It is quite clear from diacritic features from stem to prefix correspondences between present day Esimbi in (3), *u-CA... is now realised as specification of the proto stem

- (3) Proto-Bantu
 a. *bá- ~ ɔ
 *táng- ~ ɔ
 *gáb- ~ ɔ
 *káng- ~ ɔ
 *kám- ~ ɔ
 b. *bám-bá ~ ɔ
 *bábá ~ ɔ
 *gàng-gá ~ ɔ

Let us then suppose that [o-] and [ɔ-] in Table I originate in the column of Table I, we set u ɛ ɔ a/, whose height features §2).³

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[ε ɔ] and [a] are found on

found in stems tical within a single stem

Underlying stem V

/i/

/u/

/e/

/o/

/ɔ/

/ε/

/ɔ/

/a/

tions in infinitives]

In order to exemplify the properties in (1), Table I illustrates the realisation of underlying stem vowels as they appear with the infinitive prefix /U-/, a vowel archiphoneme whose only underlying feature specification is [+round]. The data include mono-, bi- and trisyllabic stems of the shape CV, CVCV and CVCVCV, so that the generalisation in (1c) will be evident.¹

As seen in Table I, the infinitive prefix is realised as one of the three [+round] vowels found in the language, i.e. [u-], [o-] or [ɔ-]. However, the vowel height of the infinitive prefix cannot be predicted from anything in the surface form of the verb stem. This fact is seen particularly clearly in the two minimal triplets in (2):

(2) a.	u-mu	'drink'	b.	u-wu	'uproot'
	o-mu	'go up'		o-wũ	'burn' (intr.)
	ɔ-mu	'sit'		ɔ-wũ	'grind'

The choice of [u-] *vs.* [o-] *vs.* [ɔ-] thus depends on the particular stem in some less than transparent way.

To explain the distributional facts of (1a) and (1b), and the observations given in Table I, Stallcup argued that there is a synchronic transfer of vowel height features from the stem onto the prefix vowel, which itself can have only one of three underlying values, designated as /I-, U-, A-/.² In this analysis the [+high] specification of all stem vowels would be a redundant one, a position I shall also adopt. No explanation is given for (1c), though it appears to be part of the gradual erosion of vowel oppositions within the stem.

It is quite clear from diachronic evidence that a transfer of vowel height features from stem to prefix has taken place in the history of Esimbi. The correspondences between Proto-Bantu starred forms (Guthrie 1971) and present day Esimbi in (3), for instance, show that pre-Esimbi class 3 *u-CA... is now realised phonetically as [ɔ-Ci...], i.e. with the [+low] specification of the proto stem vowel *a being realised on the *u- prefix:

(3)	Proto-Bantu	Surface Esimbi		Underlying
a.	*bá-	~ ɔ-mi	'to be'	/Ú-ma/
	*táng-	~ ɔ-tíŋi	'to count'	/U-taŋa/
	*gáb-	~ ɔ-gíbi	'to divide'	/U-gaba/
	*káng-	~ ɔ-híŋi	'to fry'	/U-haŋga/
	*kám-	~ ɔ-kimi	'to squeeze'	/U-kama/
b.	*bám-bá	~ ɔ-himbi	'cowry'	/U-hamba/
	*bábá	~ ɔ-píbirí	'wing'	/U-pábarà/
	*gàngá	~ ɔ-yíŋgí	'root'	/U-yáŋgà/

Let us then suppose that the vowel height features distinguishing [u-], [o-] and [ɔ-] in Table I originate on the stem. As seen in the righthand column of Table I, we set up the eight underlying stem vowels /i u e o ɔ ε ɔ a/, whose height features transfer by rule to their respective prefix (see §2).³

	singular	plural	
/i/	u-nyimi u-tili	o-nyimi o-tili	'grave' 'end'
/u/	ú-ku u-wúsu	ó-ku o-wúsu	'death' 'fire'
/e/	ó-ki o-yimbi	é-ki e-yimbi	'tail' 'song'
/o/	ó-tu o-gúru	ó-tu o-gúru	'ear' 'foot'
/ɔ/	o-ti o-ními	o-ti o-ními	'spear' 'tongue'
/ɛ/	ɔ-simi	a-simi	'grain'
/ɔ/	ɔ-bu ɔ-gúnu	á-bu a-gúnu	'hand' 'disease'
/a/	ɔ-bi a-kiri	á-bi a-kiri	'broom' 'rope'

[Table IV. Singular/plural alternations in 3/6 nouns]

Looking only at the height feature on each prefix, we note, first, the expected height on the singular U- prefix predicted from the underlying stem vowels in the lefthand column, i.e. [u-] before stem /i u/, [o-] before stem /e o ə/ and [ɔ-] before stem /ɛ ɔ a/. In the corresponding plural forms with class 6 prefix A-, however, the vowel heights are 'one step' lower than the corresponding singulars: [o-] before /i u/, [ɛ- ɔ-] before /e o ə/ and [a-] before /ɛ ɔ a/. Assuming that the frontness of [ɛ-] and the roundness of [o- ɔ-] are captured by independent rules, the effect of the A- prefix is then to *depress* the vowel height that is transferred onto it from the stem.

The same height alternations are replicated in other noun classes which either duplicate the U-/A- relation (e.g. singular class 14 /bU-/ ~ plural class 6a /bA-/) or have an I-/A- relation (e.g. singular class 5 /I-/ ~ plural class 6 /A-/). In this latter case, the singulars have prefixes segmentally identical to those in 9/10 in Table III, while the plurals have prefixes segmentally identical to those in the class 6 forms in Table IV.

From Tables II and IV we determine that /A-/ has the following realisations when occurring in combination with the indicated stem vowels:

- (4) a. /A-/ is realised [o-] when the stem vowel is /i/ or /u/, i.e. when the stem vowel is [+high]
- b. /A-/ is realised [ɔ-] when the stem vowel is /o/ or /ɔ/, i.e. [-high, -low, +back]
- c. /A-/ is realised [ɛ-] when the stem vowel is /e/, i.e. [-high, -low, -back]
- d. /A-/ is realised [a-] when the stem vowel is /ɛ/, /ɔ/ or /a/, i.e. [+low]

For purposes of description, let us refer to the height of Esimbi vowels (underlying, surface) as in (5):

we can now summarise in words having a prefix vowel

/A-/
o-Ci
o-Cu
e-Ci
ɔ-Cu
ɔ-Ci
a-Ci
a-Cu
a-Ci

vowel distributions]

with an U- prefix (Table I). Both singular class 9 and its prefix (though differing in

rat'
ick'
ih'
orn'
ashfowl'
telope'
e'
rd'
nerat'
ck'
imal'
le'
ake'
ppo'
ace'
adpad'

ons in 9/10 nouns]

the lefthand column. As with an I- prefix, which is surface patterns are exactly I.

and, work quite differently. partial contribution to their his, one has but to compare vowel height of an A- prefix seen in Table IV, where cal to the infinitive prefix in urals take an A- prefix:

- (5) a. i i u = high vowels
 b. e ə o = mid vowels
 c. ε ɔ = low-mid vowels
 d. a = low vowel

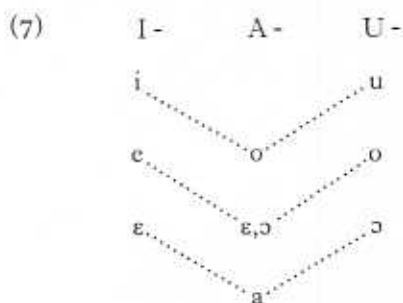
With these terms we can restate the observations in (4) as follows (ignoring, for the moment, backness and roundness):

- (6) a. When the stem vowel is high, /A-/ is realised mid
 b. When the stem vowel is mid, /A-/ is realised low-mid
 c. When the stem vowel is low-mid or low, /A-/ is realised low

In other words, when the height of the stem vowel is transferred onto an A- prefix, this height is lowered by one step: high to mid, mid to low-mid, low-mid to low (and, vacuously, a low vowel remains low).

I will claim that the back and round features are assigned to A- by secondary processes. When the stem vowel is /e/, A- takes on the [-back] specification of this vowel, and ultimately becomes [ɛ-] on the surface. When the stem vowel is either high or one of the remaining mid vowels /o ɔ/, A- will acquire the feature [+round]. Finally, when the stem vowel is either low-mid or low, A- will be realised as [a-] with the redundant features [+back, -round].

To summarise, (7) shows the three height values obtained for each of the prefix vowels I-, A- and U-:



What is crucial, however, is that the three values of A- are one step lower than the three values for I- and U-, as we have seen. While such data have in the past been cited in support of multivalued or n-ary vowel height features (see, for instance, Lindau 1978, though also Yip's 1980a reply), in the next section I will present an analysis of the Esimbi vowel system within an underspecification framework employing binary vowel height features.

3 The analysis

To repeat our aim, an analysis must be sought that correctly and insightfully captures the vowel height relations between the prefixes I- and U- vs. those of the prefix A-, which are one step lower. With the four vowel heights (high, mid, low-mid, low) in (5), we appear to have gone

beyond the formal capacity because of the impossibility of three vowel heights. It is possible to capture the vowel height features from the stem vowels, even if modified (1968), capture the height 'steps' on the expense of having separate prefix A-.

For reasons of space I will not present a wide variety of solutions. I will present an analysis where only non-redundant representations (Kiparsky 1986a, b; Archangeli & Pulleyblank 1986) stem vowels of Esimbi are (8):

(8)

	i	u	e	o
back	-	-	-	-
round	-	+	-	-
high	-	-	-	-
low	-	-	-	-

As seen, the prespecified values are [-high] and [+low]. The other values are derived from the derivation, specified via (9):

- (9) a. [] → [+back]
 b. [] → [-round]
 c. [+low] → [-high]
 [] → [+high]
 d. [] → [-low]

The above prespecified values in (9) constitute the set of values in the number of prespecified features in the lexical phonology precedes the above prespecifications are:

- (10) a. the prespecification of /A-/ to [ɛ- -high]⁵
 b. the prespecification predict the value of the stem vowel but not *vice versa*
 c. the prespecification stem vowels are [-high] receive by default /A-/ assimilation [high] when assimilation
 d. the prespecification

beyond the formal capacity of the two features [high] and [low], which, because of the impossibility of a * [+high, +low] combination, define only three vowel heights. It is possible within an *SPE* framework to transfer the vowel height features from stem to prefix. However, two binary height features, even if modified to [high] and [mid], as proposed by Wang (1968), capture the height 'downstepping' effect of the A- prefix only at the expense of having separate rules for the prefixes I- and U- vs. the prefix A-.⁴

For reasons of space I will not be able to demonstrate why we should reject a wide variety of solutions that potentially come to mind. Instead, I will present an analysis embracing a version of underspecification theory where only non-redundant feature values are present in underlying representations (Kiparsky 1982, 1985; Archangeli 1984; Pulleyblank 1986a, b; Archangeli & Pulleyblank forthcoming a). The eight underlying stem vowels of Esimbi are thus proposed to have the specifications in (8):

(8)		i	u	e	o	ə	ɛ	ɔ	a
	back	-		-			-		
	round		+		+			+	
	high			-	-	-			
	low						+	+	+

As seen, the prespecified values for these features are [-back], [+round], [-high] and [+low]. The opposite values are, at the appropriate point in the derivation, specified via the default spelling rules in (9):

- (9) a. [] → [+back]
 b. [] → [-round]
 c. [+low] → [-high]
 [] → [+high]
 d. [] → [-low]

The above prespecified values in (8) and default rules spelling the opposite values in (9) constitute the simplest feature analysis, involving the fewest number of prespecified features. In addition, assuming that all of the lexical phonology precedes the assignment of default features values, the above prespecifications are supported by the following facts:

- (10) a. the prespecification of [-back] correlates with the assimilation of /A-/ to [ɛ-] before stem vowel /e/, which is [-back, -high]⁵
 b. the prespecification of [+round] is necessary since one can predict the value of [back] on the basis of the value of [round], but not *vice versa*
 c. the prespecification of [-high] provides an account for why stem vowels are [+high] on the surface – the feature value they receive by default; [-high] also allows us to single out /e/ for /A-/ assimilation, since both /i/ and /ɛ/ are unspecified for [high] when assimilation applies⁵
 d. the prespecification of [+low] follows from the decision that

variations in (4) as follows (ness):

s realised mid
 s realised low-mid
 low, /A-/ is realised low

owel is transferred onto an
 gh to mid, mid to low-mid,
 remains low).

res are assigned to A- by
 e/, A- takes on the [-back]
 comes [ɛ-] on the surface,
 the remaining mid vowels
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 5), we appear to have gone

vowels unspecified for height are by default [+high] and therefore [-low]

As a result of this analysis, a stem vowel will have at most one prespecified height feature, either [-high] or [+low]. It is further assumed that I- and U- prefixes have no height feature. In order to get the three vowel heights on I- and U- prefixes, as in (7), the prespecified values [-high] and [+low] are simply transferred from the stem to its prefix. The remaining vowel height features are then assigned to both prefixes *and* stems by the default rules in (9). These steps are illustrated in (11):

(11)

a.	I - C U	I - C U [-high]	I - C U [+low]
b.	I - C U	I - C U [-high]	I - C U [+low]
c.	I - C U (+high) (+high) (-low) (-low)	I - C U [-high] (+high) (-low) (-low)	I - C U (-high) (+high) [+low] (-low)
	[i - C u]	[e - C u]	[ɛ - C u]

The underlying representations are given in (11a), where /I-/ stands for a prespecified [-back] prefix vowel, and /U/ stands for a prespecified [+round] stem vowel. The inputs are thus /I-Cu/, /I-Co/ and /I-Cɔ/ in the lefthand, middle and righthand columns, respectively. In (11a) I have started with prespecified height features being linked to the stem vowel: [-high] to the underlying mid vowel in the middle column, and [+low] to the underlying low vowel in the righthand column.

In (11b) the prespecified [-high] or [+low] has been transferred to the prefix vowel /I-/ (equivalently, we could have had /U-/). Finally, in (11c) the default values for all six vowels have been assigned (designated by parentheses). The result is as desired in each of the three columns: respectively, a high, mid and low prefix vowel and high vowels in all stems.

The simplicity of this system can be admired, but in order to be adopted as correct, it must be extendable in some principled way to the A- prefixes. The first question is: what is the correct underlying representation of /A-/?

Given the two features respectively minus and plus. The reader can verify that these describe four vowel height lowering, as in (6).⁶ We now

When Chomsky & Halle [high] and [low], they were more than three phonetic vowel heights made and which has been the fourth vowel height is needed. This feature in SPE was [tense] can theoretically double the role of the feature [feature [advanced tongue pharynx] (Lindau 1979).

The feature that we are characterised as a secondary effect of one of its binary values. The effect of the other value which it might be compared to (1980b). In order not to let the height feature be identified suggest, may trigger different languages. I will return to

In adopting [ATR] as the phonetic expectations as high vowels [i u i] should wind low vowel [a] should wind low-mid vowels [e o e ɔ] w

There are several ways in which a feature in the system, though assumptions about minimal to be completely unspecified. Thus, in underlying representation we reach is one where or specification. We now are which undergo derivations

(12)

a.	A - C U [-ATR]	
b.	A - C U [-ATR]	

Given the two features [high] and [low] and their prespecified values, respectively minus and plus, we have two choices: [-high] or [+low]. The reader can verify that neither of these works, since we can neither describe four vowel heights, as in (5), nor a unitary process of vowel lowering, as in (6).⁶ We must therefore look elsewhere for a solution.

When Chomsky & Halle (1968) introduced the vowel height features [high] and [low], they were clearly aware of the possibility of having more than three phonetic vowel heights in a single language. The claim that was made and which has been followed by many phonologists is that when a fourth vowel height is needed, a third binary feature is necessitated. The feature in *SPE* was [tense], which, if viewed as relating to vowel height, can theoretically *double* the number of vowel heights. In post-*SPE* work, this role of the feature [tense] has been usurped by Stewart's (1971) feature [advanced tongue root] or its reinterpretation as [expanded pharynx] (Lindau 1979).

The feature that we would like for Esimbi is one that could be characterised as a secondary or register feature on vowel height. The effect of one of its binary values would be to 'downstep' vowel height, while the effect of the other value would be to 'upstep' vowel height. In this regard it might be compared to the tonal feature [raised] proposed by Yip (1980b). In order not to proliferate features, I will let the needed register height feature be identified with the [ATR] feature, which, I would like to suggest, may trigger different phonetic implementation rules in different languages. I will return to this point in §4.

In adopting [ATR] as the third feature, I shall attempt to stay as close to phonetic expectations as possible. In the Esimbi case this means that the high vowels [i u i] should wind up with a [+ATR] specification, while the low vowel [a] should wind up with a [-ATR] specification. The mid and low-mid vowels [e o ε ɔ] will be the subject of some discussion.

There are several ways in which [ATR] might be introduced as the third feature in the system, though only one which is consistent with our general assumptions about minimal prespecification. Since we want high vowels to be completely unspecified, I will take [+ATR] to be the default value. Thus, in underlying representations we can have [-ATR]. The analysis we reach is one where only A- prefixes have an underlying [-ATR] specification. We now are prepared to consider words with an A- prefix, which undergo derivations such as in (12):

- (12)
- a.
- | | | | | | | | | | | | | | |
|--------|---|---|---|--|--------|---------|---|---|--|--------|--------|---|---|
| A | - | C | U | | A | - | C | U | | A | - | C | U |
| | | | | | | | | | | | | | |
| [-ATR] | | | | | [-ATR] | [-high] | | | | [-ATR] | [+low] | | |
- b.
- | | | | | | | | | | | | | | |
|--------|---|---|---|--|---------|--------|---|---|--|--------|--------|---|---|
| A | - | C | U | | A | - | C | U | | A | - | C | U |
| | | | | | | | | | | | | | |
| [-ATR] | | | | | [-high] | [-ATR] | | | | [+low] | [-ATR] | | |

by default [+high] and

at most one prespecified
rather assumed that I- and
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fied values [-high] and
its prefix. The remaining
prefixes and stems by the
in (11):

I - C U
|
[+low]

I - C U
|
[+low]

I - C U
| |
(-high) (+high)
[+low] (-low)

[e - C u]

a), where /I-/ stands for
stands for a prespecified
A/, /I-Co/ and /I-Cɔ/ in
pectively. In (11a) I have
inked to the stem vowel;
idle column, and [+low]
olumn.

as been transferred to the
d /U-/). Finally, in (11c)
assigned (designated by
of the three columns:
and high vowels in all

out in order to be adopted
ed way to the A- prefixes.
rlying representation of

<p>c.</p> <table style="margin-left: 40px; border-collapse: collapse;"> <tr> <td style="text-align: center;">A</td> <td style="padding: 0 10px;">-</td> <td style="text-align: center;">C</td> <td style="padding: 0 10px;">U</td> <td style="padding-left: 40px;">A</td> <td style="padding: 0 10px;">-</td> <td style="text-align: center;">C</td> <td style="padding: 0 10px;">U</td> <td style="padding-left: 40px;">A</td> <td style="padding: 0 10px;">-</td> <td style="text-align: center;">C</td> <td style="padding: 0 10px;">U</td> </tr> <tr> <td style="text-align: center;"> </td> <td></td> <td style="text-align: center;"> </td> <td></td> <td style="text-align: center;"> </td> <td></td> <td style="text-align: center;"> </td> <td></td> <td style="text-align: center;"> </td> <td></td> <td style="text-align: center;"> </td> <td></td> </tr> <tr> <td style="text-align: center;">(+high)</td> <td></td> <td style="text-align: center;">(+high)</td> <td></td> <td style="text-align: center;">[-high]</td> <td></td> <td style="text-align: center;">(+high)</td> <td></td> <td style="text-align: center;">(-high)</td> <td></td> <td style="text-align: center;">(+high)</td> <td></td> </tr> <tr> <td style="text-align: center;">(-low)</td> <td></td> <td style="text-align: center;">(-low)</td> <td></td> <td style="text-align: center;">(-low)</td> <td></td> <td style="text-align: center;">(-low)</td> <td></td> <td style="text-align: center;">[+low]</td> <td></td> <td style="text-align: center;">(-low)</td> <td></td> </tr> <tr> <td style="text-align: center;">[-ATR]</td> <td></td> <td style="text-align: center;">(+ATR)</td> <td></td> <td style="text-align: center;">[-ATR]</td> <td></td> <td style="text-align: center;">(+ATR)</td> <td></td> <td style="text-align: center;">[-ATR]</td> <td></td> <td style="text-align: center;">(+ATR)</td> <td></td> </tr> </table>	A	-	C	U	A	-	C	U	A	-	C	U													(+high)		(+high)		[-high]		(+high)		(-high)		(+high)		(-low)		(-low)		(-low)		(-low)		[+low]		(-low)		[-ATR]		(+ATR)		[-ATR]		(+ATR)		[-ATR]		(+ATR)		<p>d.</p> <table style="margin-left: 40px; border-collapse: collapse;"> <tr> <td style="text-align: center;">*[i - C u]</td> <td style="padding-left: 40px;">*[ə - C u]</td> <td style="padding-left: 40px;">[a - C u]</td> </tr> </table>	*[i - C u]	*[ə - C u]	[a - C u]	<p>b.</p> <table style="margin-left: 40px; border-collapse: collapse;"> <tr> <td style="border-left: 1px solid black; border-right: 1px solid black; padding: 0 5px;">[-high]</td> </tr> <tr> <td style="border-left: 1px solid black; border-right: 1px solid black; padding: 0 5px;">-low</td> </tr> <tr> <td style="border-left: 1px solid black; border-right: 1px solid black; padding: 0 5px;">-ATR</td> </tr> </table>	[-high]	-low	-ATR
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The representative inputs are /A-Cu/, /A-Co/ and /A-Cɔ/. As seen with the I- prefix in (11), the features [-high] and [+low] transfer from the stem in (12a) to the prefix in (12b). Also as before, the default values in parentheses in (12c) are assigned by the rules in (9), i.e. [-high] to [+low] vowels, [+high] to other vowels, and [-low] to all vowels. In addition, a default [+ATR] specification has been assigned to all vowels lacking a value for this feature.

The derived outputs are as shown in (12d). In the lefthand column, where the stem high vowel has no underlying height feature, the [-ATR] of the A- prefix combines with the default values [+high] and [-low]. The result is a high vowel with retracted tongue root, or [i-], as it would appear with the default values [+back, -round]. In the middle column, the underlying mid stem vowel begins with a [-high] specification, which transfers to the A- prefix, combining with its [-ATR]. The result is a mid vowel with retracted tongue root, or [ə-], as it would appear with the default values [+back, -round]. Finally, in the righthand column, where the stem vowel is underlyingly [+low], this feature transfers to the prefix, deriving a surface low vowel with retracted tongue root, i.e. [a-], given default [+back, -round].

Of course, the resulting high and mid vowels with retracted tongue root do not surface with default [+back, -round]. Instead, they acquire the specifications [-back, -round], when the stem vowel is /e/, otherwise [+back, +round]. The reason for this is that Esimbi does not allow back unrounded vowels in the mid or low-mid portion of the vowel space: it allows [i] and [a], but not, for instance, [ə] or [ʌ], or, in this case the similar, if not identical vowels [i̠] and [ə̠]. In other words, we need secondary rules to derive the desired outputs in (12e).

If these secondary rules involve only fronting and rounding, we actually derive vowels such as [y ɔ̠ e̠], instead of [o ɔ̠ e̠]. What I would like to suggest is that pairs of feature matrices such as in (13) should be viewed as phonologically distinct, but phonetically non-distinct in Esimbi:

$$(13) \quad a. \quad \begin{bmatrix} +\text{high} \\ -\text{low} \\ -\text{ATR} \end{bmatrix} = \begin{bmatrix} -\text{high} \\ -\text{low} \\ +\text{ATR} \end{bmatrix} \quad \text{i.e. } [y-] = [o-]$$

The matrices in the lefthand column are those obtained for advanced tongue root high vowels (13a), and that retracted tongue root low vowels (13b).

Since I am assuming that the same feature values for different gestures, one for high and one for low, need not be viewed as one value of the features [-high, -low]. Since vowels unspeaking high vowels be designated in (14), each of the three to add an integer to derive the integer the lower the

$$(14) \quad a. [-\text{high}] = [+1] \\ b. [+low] = [+1] \\ c. [-\text{ATR}] = [+1]$$

Viewed this way, we derive

$$(15) \quad a. \circ : [+high, -low] \\ b. \text{ɪ} : [+high, -low, -ATR] \\ c. \text{z} : [-high, -low, -ATR] \\ d. \text{ɔ} : [-high, +low, -ATR]$$

As shown, there are two heights. There is only one height. In this way we are needed in Esimbi and accordingly degrees of I- and U- prefix schematised earlier in (7).

With the above interpretation, which, along with the [-high] should be lowered by one integer value). In other languages [-ATR] values of the same of [-ATR] may be different [-ATR] adds a value of less between [i] and [e]. In fa

	A	-	C	U
1)	(-high)		(+high)	
	[+low]		(-low)	
2)	[-ATR]		(+ATR)	
	[a	-	C	u]
	[a	-	C	u]

and /A-Cɔ/. As seen with [+low] transfer from the 'ore, the default values in g), i.e. [-high] to [+low] all vowels. In addition, a d to all vowels lacking a

In the lefthand column, ight feature, the [-ATR] ies [+high] and [-low]. e root, or [i-], as it would]. In the middle column, high] specification, which ATR]. The result is a mid t would appear with the righthand column, where re transfers to the prefix, gue root, i.e. [a-], given

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-] = [o-]

$$b. \begin{bmatrix} -\text{high} \\ -\text{low} \\ -\text{ATR} \end{bmatrix} = \begin{bmatrix} -\text{high} \\ +\text{low} \\ +\text{ATR} \end{bmatrix} \quad \text{i.e. } [\epsilon-] = [\epsilon-] \\ [\sigma-] = [\sigma-]$$

The matrices in the lefthand column are those obtained from (11) with an additional default [+ATR] specification.⁷ The matrices in the righthand column are those obtained from (12). What (13) indicates is that retracted tongue root high vowels are equivalent to advanced tongue root mid vowels (13a), and that retracted tongue root mid vowels are equivalent to advanced tongue root low vowels (13b).

Since I am assuming that [ATR] (or related label) is but a cover feature for different gestures, one of which involves vowel height, the equivalences in (13) need not be viewed as problematic. In Esimbi, I propose that only one value of the features [high], [low] and [ATR] actually affects vowel height. Since vowels unspecified for height will automatically be high vowels (receiving the specifications [+high], [-low] and [+ATR]), let high vowels be designated as having 'zero' (o) degree of height. As shown in (14), each of the three feature values indicated instructs the phonetics to add an integer to derive mid, low-mid and low vowels (where the higher the integer the lower the vowel):

- (14) a. [-high] = [+1]
 b. [+low] = [+1]
 c. [-ATR] = [+1]

Viewed this way, we derive the following results:

- (15) a. 0 : [+high, -low, +ATR] = i, u, i
 b. 1 : [+high, -low, -ATR] = e, o
 [-high, -low, +ATR]
 c. 2 : [-high, -low, -ATR] = ε, σ
 [-high, +low, +ATR]
 d. 3 : [-high, +low, -ATR] = a

As shown, there are two ways to derive degree 1 and degree 2 vowel height. There is only one way to derive degree 0 and degree 3 vowel height. In this way we are able to distinguish the four vowel heights needed in Esimbi and account for the relationship between the three degrees of I- and U- prefixes *vs.* the three degrees of the A- prefix, as schematised earlier in (7).

With the above interpretation, [-ATR] has a very clear definition, which, along with the [-high] and [+low] specifications, says that a vowel should be lowered by one step (here represented as the addition of an integer value). In other languages where there are *surface* [+ATR] *vs.* [-ATR] values of the same vowel height, e.g. [i] *vs.* [i̠], the interpretation of [-ATR] may be different. In these cases it may be necessary to say that [-ATR] adds a value of less than one, such that [i̠] is calculated at a height in between [i] and [e]. In fact, it is likely that [ATR] should be viewed as

a more general cover feature possibly involving different gestures in different languages (height, quality, pharyngealisation, centralising, flattening, etc.). Thus, while [ATR] is exploited only for vowel height in Esimbi, this feature may have additional phonetic consequences in other languages.

4 Possible objections

In the above analysis it was necessary to invoke a third binary feature to capture the vowel height 'downstepping' of A- prefixes. In addition, this feature was identified with the [ATR] feature used for other purposes in other languages. At this point I would like to consider three possible objections to the analysis presented in §3.

4.1 Arbitrariness

The first objection is that the choice of the feature [ATR] is an arbitrary one. Or, to cite Kiparsky (1968), it may be objected that this analysis represents the 'diacritic use of a phonological feature'. The answer to this question comes in two parts.

First, as shown by Lindau (1979) and others, the [ATR] parameter has an important effect on vowel height. Physiologically, her cineradiographic tracings show that the highest point of the tongue body is lower for a [-ATR] vowel than for its [+ATR] counterpart in Akan. Acoustically, Lindau concludes that 'the major difference between members of harmonizing vowel pairs is in the frequency of the first formant' (pp. 167-168), or, again: 'the first formant is the most important acoustic correlate of vowel harmony' (p. 168). Since the first formant provides the acoustic definition of vowel height, the choice of [ATR] as a vowel height feature is not an arbitrary one.

Second, one might object that although [ATR] is implicated in vowel height, so are other features, any one of which might just as easily have been chosen to meet the needs in Esimbi. Ohala (1974, 1975) and others have shown that the first formant is raised when high and mid vowels become nasalised, thereby causing a lowering in vowel height. Perhaps A- prefixes could be represented with an underlying [+nasal] specification, i.e. \tilde{V} -, which, when combined with the transferring height features from a stem, would result in vowel lowering. It should be noted that nasalisation plays no phonological role on vowels in Esimbi. By contrast, the tongue root is presumably involved in the production of vowels in all languages. Thus, even if we could use [+nasal] as an instruction for the phonetics to lower vowel height (though not the velum), we would be seriously violating the 'sound pattern' of Esimbi. Thus, [ATR] seems well-suited to the task, while [nasal] does not.

4.2 Phonetic overlapping

The second objection one might have to the analysis in §3 is the use of what I shall term 'phonetic overlapping'. In cases of 'phonemic over-

lapping' (neutralisation), merge into a single phonological phonetics. In the case of distinct phonological outputs identical implementations prohibited outright?⁸

The first question is to a are known. In so-called te is the norm. In the Mbu instance, a H-M sequence (H tone followed by downstepping) have is from the pitch level H will be realised higher than the same level as the second appears before pause there is correct.) Attempts to give into some difficulty (see F actually a 'raised L' tone possibility that the phone (toneless) TBU which is present either case, there is phonetic outputs.

Coming back to vowel evidence for overlapping [ATR] and vowel height, analysis of Akan vowels, for mid set *i* vowel [e] are acoustically'. In the same formant structure. Lindau's the Esimbi equivalences such

The oft-cited phonetic is responsible for the merger as Okpe (Hoffmann 1973; and, as cited by Stewart & Buem, Avatime, Likpe and there is an underlying opposition and the [+ATR] vowels /i/ with either set of vowels.) /u/ are phonetically identical. Thus, Hoffmann indicates indistinguishable in isolation

- (16) a. /sɔ/ [sɔ]
b. [ɛ-sw-ɔ]

However, two differences exist (16b). First, an -o/-ɔ suffix infinitive of verbs whose root

lapping' (neutralisation), two or more phonological representations merge into a single phonological output, which then serves as input to the phonetics. In the case of the equivalent representations in (13), two distinct phonological outputs merge in the phonetics, where they receive identical implementations. Perhaps phonetic overlapping should be prohibited outright?⁸

The first question is to ask whether other cases of phonetic overlapping are known. In so-called terrace-level tone systems, phonetic overlapping is the norm. In the Mbui dialect of Ngemba (Grassfields Bantu), for instance, a H-M sequence is realised exactly the same as a H-H sequence (H tone followed by downstepped H). The only way to know which one you have is from the pitch level of a following tone. For example, a following H will be realised higher than the second tone of a H-M sequence, but at the same level as the second tone of a H-H sequence. (When the sequence appears before pause there is no 'local' way to know which representation is correct.) Attempts to give the same representation to M and H tones run into some difficulty (see Hyman 1986). Since the 'M' tone of Mbui is actually a 'raised L' tone (Hyman & Tadadjeu 1976), this raises the possibility that the phonetics may in fact only be seeing a L (or even toneless) TBU which is pronounced M before a (linked or floating) H. In either case, there is phonetic overlapping of two different phonological outputs.

Coming back to vowels, there is both phonetic and phonological evidence for overlapping of the type I have proposed with respect to [ATR] and vowel height. Lindau (1979: 168) shows in her formant analysis of Akan vowels, for instance, that 'the high set 2 vowel [i] and the mid set 1 vowel [e] are so close that they have practically merged acoustically'. In the same language [u] and [o] are also quite close in formant structure. Lindau's acoustic analysis thus lends some support for the Esimbi equivalences summarised above in (13).

The oft-cited phonetic similarity between [i u] and [e o] is apparently responsible for the merger of these two series of vowels in languages such as Okpe (Hoffmann 1973; Pulleyblank 1986b), Uvwie (Omamor 1973), and, as cited by Stewart & van Leynseele (1979), Lobiri, Nyangbo-Tafi, Buem, Avatime, Likpe and Tunen. In the Okpe vowel harmony system there is an underlying opposition between the [-ATR] vowels /i u e o/ and the [+ATR] vowels /i u e o/. (/a/ is 'neutral', since it can combine with either set of vowels.) However, the [+high, -ATR] vowels /i/ and /u/ are phonetically identical to the [-high, +ATR] vowels /e/ and /o/. Thus, Hoffmann indicates that the two imperative verb forms in (16a) are indistinguishable in isolation:

- | | | | | | | |
|---------|------|----------|-----------|------|--------|------------|
| (16) a. | /sù/ | [só] | 'sing!' | /só/ | [só] | 'steal!' |
| b. | | [è-sw-ó] | 'to sing' | | [è-só] | 'to steal' |

However, two differences surface in the corresponding infinitive forms in (16b). First, an -o/-o suffix appears on 'to sing' which is required in the infinitive of verbs whose root vowel is [+high]. Second, there is an [ATR]

ing different gestures in isation, centralising, flat-only for vowel height in tic consequences in other

a third binary feature to prefixes. In addition, this sed for other purposes in consider three possible

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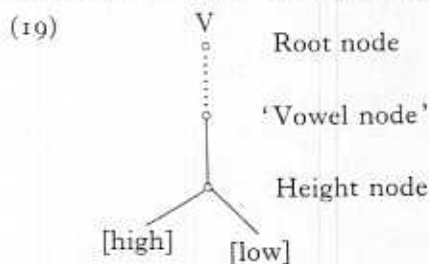
philosophical arguments that have accompanied the abstractness debate (which, notably, has attracted little attention among non-linear phonologists). Instead, I wish to consider a slightly modified alternative that should, I believe, go a long way to satisfying phonologists of different persuasions.

The basic intuition we wish to capture is that prefixal vowel height derives from stems in Esimbi. The way we captured this insight in §2 was to set up the three /mu/ stems in (2a) essentially as /mu₁/, /mu₂/ and /mu₃/. This is the 'abstract phonological' solution presently under attack. The opposite, 'concrete morphological' solution would be to give each of these stems a diacritic feature or subscript, i.e. /mu₁/, /mu₂/ and /mu₃/, which would then condition vowel height on prefixes. I would now like to consider a 'compromise non-linear' solution, as follows. Since all stem vowels must be identical, let us assume that there can be at most one specification for each vowel feature per stem. A single prespecified [-back] or [+round] thus links up to all vowels in a mono-, bi- or trisyllabic stem. The features [-high] and [+low], on the other hand, do *not* link up to the stem vowels. Instead, they float, awaiting the assignment of a prefix via the morphology.

Rather than claiming a specific height for each underlying stem or stem vowel, the compromise solution, like the morphological solution, merely claims that a stem potentially has a height feature, [-high] or [+low], to pass on to its prefix. With these two features floating, the stems have no underlying height features and, as desired, receive a [+high, -low] specification by default.

The adoption of floating height features raises further questions and a speculative alternative approach, which I would like to consider briefly. As far as I am aware, no one has proposed a means to capture the unique relationship between the features [high] and [low]. One current strategy for capturing interdependencies between features is to assign such features to a single node, e.g. a laryngeal node, a place node and so forth (Clements 1985; Sagey 1986; Archangeli & Pulleyblank forthcoming b). Since I would like to claim that [high] and [low] form more of a natural class than, say [high] and [back] or [high] and [round], the two height features might (should?) be assigned to a single height node.

With this in mind, let us consider an alternative where [high] and [low] are the only vowel height features in Esimbi and in which their relationship is captured via a height node, as shown in (19):



g that the two verb roots
wn in (16a). Okpe thus
mony system and with
e specifications [+high,

ne feature [ATR] should
derlying /i u e o ə ε ə a/
ords, it is a redundant
erlying representations,
low] should be sufficient
s. The basic response to
vel systems have shown
on so-called redundant
n Pulaar (Paradis 1986),
comes the seven-vowel
vowels /ε/ and /ə/ to [e]
seen in the examples in

le 'peser avec'
le 'casser avec'
l-de 'éborgner'
-de 'abattre'

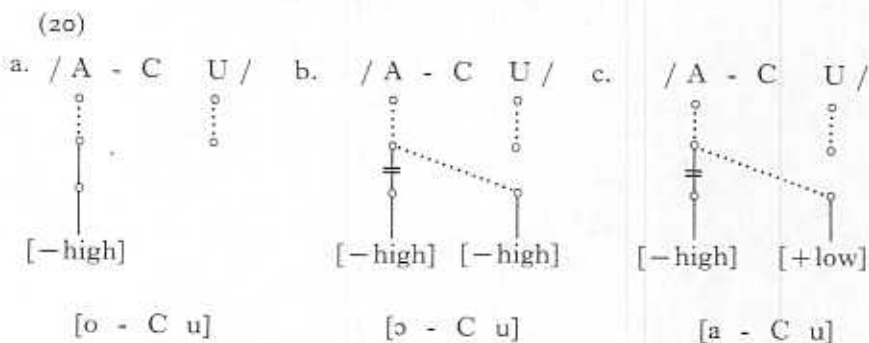
undant [+ATR] speci-

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Ci] and [ε-Cu] derive,
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heard as [+high] on the
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Since stem vowels are identical in Esimbi, as seen above in Table I, we can assume a single vowel node with a single (floating) height node per stem. The prefixes I- and U- will not have a height node, since they are marked only for [-back] and [+round], respectively. The A- prefix, on the other hand, will have a height node and a prespecified [-high] (replacing the [-ATR] in §3).

Now, when the (floating) stem height node links to the prefix, the height node of the A- prefix will automatically delink (since there cannot be two height nodes on the same vowel). As seen in (20), this will result in a floating [-high] height node preceding the A- prefix:



In (20a) height transfer does not occur, since the stem vowel has no prespecified height. In (20b), however, the height node of the [-high] stem spreads onto the prefix vowel, causing the delinking of the [-high] height node of the prefix. Similarly, in (20c), the height node of the [+low] stem spreads onto the prefix vowel, again delinking the [-high] height node of the prefix. The result in both (20b) and (20c) is a floating [-high] height node at the beginning of the word. Could this floating [-high] be a *vocalic downstep* marker, causing height lowering just as a floating L tone causes tonal downstep?

This alternative is presented as a footnote to the [ATR] account developed in this paper. It became a serious contender at the point where we started to consider the idea of floating features (or floating nodes). Since there appears to be no principled argument against the latter, we must ask whether comparable motivation is available from other languages.

We thus seem to have a number of separate questions that need to be answered: Can a feature like [ATR] be used exclusively for vowel height? Do vowel height features report to a height node? Can vowel height features (or nodes) float in underlying representations? Can vowel height features (or nodes) float in derived representations (functioning as downstep operators)? The present study has, I believe, provided some insight into the Esimbi vowel system, and has raised the above questions for future research. To conclude, it has been my intention to show that such unusual facts as those from Esimbi can be readily accounted for within the

framework of underspecific distinctive features.⁹

NOTES

- * Earlier versions of this paper were presented at the UCLA/USC Phonology Symposium, UCLA, 1981, and at the UCLA/USC Phonology Symposium, Archangeli, three anonymous reviewers, and John Goldsmith, Jean-Roger Vergnaud, and the members of his Fall 1981 Phonology class. I am particularly indebted to John Goldsmith. This work is based on research funded by a National Science Foundation grant IRI-8108081.
- [1] Stallcup marks tone as follows: (a) = low tone; (ā) = [low tone].
- [2] Stallcup tentatively set up a tone analysis which would predict the tone immediately following /i/ or /e/ to be high.
- [3] There is no underlying stem vowel *o-Ci with the I-, U- and /- prefixes. The stem vowels are: *gbiri* 'to beat', etc.
- [4] There are numerous possibilities for the floating [-high] height node. I have analyzed it at the UCLA/USC Phonology Symposium, 1981:

$$(i, u) \rightarrow \begin{bmatrix} \alpha \text{ high} \\ \beta \text{ low} \end{bmatrix} / -$$

$$a \rightarrow [-\text{back}] / -$$

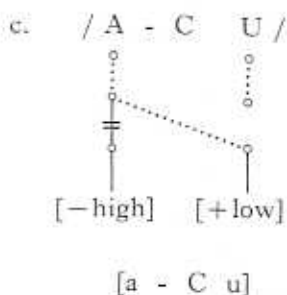
$$a \rightarrow \begin{bmatrix} +\text{round} \\ \alpha \text{ low} \end{bmatrix} / -$$

$$V \rightarrow \begin{bmatrix} +\text{high} \\ -\text{low} \end{bmatrix} / -$$

- [5] One reviewer pointed out that the Redundancy Rule Ordering (RRO) analysis of secondary fronting and roundness is not a default vowel feature specification.
- [6] It might be suggested instead that the floating [-high] height node is a feature of the A- prefix. I will leave it to the reader to decide if these reanalyses do not help us understand the data.
- [7] Perhaps significantly, there is no floating [-high] height node ever assigned in Esimbi. (Doug Pulleyblank, personal communication). This feature is finally understood as a floating [-high] height node.

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links to the prefix, the height (since there cannot be two (20), this will result in a - prefix:



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te to the [ATR] account ntender at the point where atures (or floating nodes). gument against the latter, n is available from other

2 questions that need to be clusively for vowel height? : node? Can vowel height ntations? Can vowel height ions (functioning as down- eve, provided some insight d the above questions for intention to show that such ily accounted for within the

framework of underspecification theory and the binary approach to distinctive features.⁹

NOTES

- * Earlier versions of this paper were presented at UC Berkeley and to the UCLA/USC Phonology Seminar. I would like to thank those audiences, Diana Archangeli, three anonymous reviewers, and the following phonologists for lending an ear to the ideas that were to develop into this paper: Nick Clements, John Goldsmith, Jean-Roger Vergnaud and especially Doug Pulleyblank and the members of his Fall 1987 seminar at the University of Southern California. I am particularly indebted to Kenneth Stallcup, on whose materials this paper is based. Research in Cameroon by Kenneth Stallcup, myself, and other members of the Grassfields Bantu Working Group was supported in part by National Science Foundation grant BNS76-81261.

- [1] Stallcup marks tone as follows: (á) = high tone; (a) [unmarked] = mid tone; (à) = low tone; (ã) = [low to mid] rising tone; (â) = [mid to low] falling tone.
- [2] Stallcup tentatively set up an E- prefix for a particular verb tense, but an alternative analysis would postulate an A- prefix vowel that fuses with an immediately following /i/ or I-.
- [3] There is no underlying stem vowel /i/ which would surface as *i-Ci, *u-Ci and *o-Ci with the I-, U- and A- prefixes. Late, local backing of [i] to [i] in certain consonantal environments accounts for forms such as *u-kpíri* 'to add' and *u-gbiri* 'to beat', etc.
- [4] There are numerous possibilities, the following being the set of rules I circulated at the UCLA/USC Phonology Symposium at Lake Arrowhead in 1981:

$$(i, u) \rightarrow \begin{bmatrix} \alpha \text{ high} \\ \beta \text{ low} \end{bmatrix} /- [C \begin{bmatrix} \alpha \text{ high} \\ \beta \text{ low} \end{bmatrix} \quad ([= \text{initial stem bracket})$$

$$a \rightarrow [-\text{back}] /- [C \begin{bmatrix} -\text{high} \\ -\text{low} \\ -\text{back} \end{bmatrix}$$

$$a \rightarrow \begin{bmatrix} +\text{round} \\ \alpha \text{ low} \end{bmatrix} /- [C \begin{bmatrix} -\text{high} \\ -\text{low} \\ V \end{bmatrix}$$

$$V \rightarrow \begin{bmatrix} +\text{high} \\ -\text{low} \end{bmatrix} /- [X-$$

- [5] One reviewer pointed out that these rules violate Archangeli & Pulleyblank's Redundancy Rule Ordering Constraint (RROC). If their RROC is correct, the secondary fronting and rounding of A- would have to follow the assignment of all default vowel feature specifications.
- [6] It might be suggested instead that we identify A- as either [+back] or [-round]. I will leave it to the reader to verify that this and other such reanalyses do not help us escape the problems with only two vowel height features.
- [7] Perhaps significantly, there is in fact no evidence that a default [+ATR] need ever be assigned in Esimbi. The same conclusion has been reached for Yoruba (Doug Pulleyblank, personal communication), suggesting that when the [ATR] feature is finally understood, it might be single-valued rather than binary in nature.

- [8] Trivially, the above characterisation of phonetic overlapping can be avoided if late in the phonology we convert one equivalent feature representation to the other. In this case it would be this conversion process that would be suspect.
- [9] In the originally submitted manuscript I included sections addressing other approaches (unary, n-ary) to vowel height. A unary account of Esimbi within dependency phonology was judged to be no more revealing than a binary account utilising a 'meta-rule' (Lass 1976) that changes [+high] to [-high] and [-high] to [+low]. An n-ary account of Esimbi vowel height within particle phonology provided a straightforward account, but raised basic questions about n-ary features in general.

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