The phonological systems of the Mbam languages of Cameroon with a focus on vowels and vowel harmony

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Contrastive features and the relationship between inventory and behaviour

> "Feature markedness refers to the likelihood (or the unlikelihood) of certain features co-occurring. For instance, vowel height features and tongue root features have a close connection (see Archangeli & Pulleyblank 1994): Tongue root advancement, [+ATR], and [+high] are compatible, as are [+low] and tongue root retraction (or [-ATR]). The opposite combinations are not compatible" (Archangeli 1999: 543).

The above point of view is widely accepted and does indeed have some validity. It is clear that there is good evidence that certain combinations of height and tongue-root features can be treated as especially marked (Casali 2013: 2). However, in vowel inventories with ATR contrast in the high vowels (**i/ɪ** and **u/ʊ**), there is evidence that □[ɪ], [ʊ] often occur with very high frequency, characteristically have unrestricted distributions, and may have a wider distribution than their [+ATR] counterparts [i], [u] (Casali 2002, 2012).

This typological generalisation, coupled with the difficulty in identifying certain vowels in previous studies and the tendency of these vowels to function in contradictory ways vis-à-vis the vowel-harmony system is an indicator that an /i, e, ɛ, a, ɔ, o, u/ inventory analysis of the Mbam languages is inadequate. In many ways, the misanalysis of the Mbam vowel inventories is not surprising; others have noted as Schadeberg (1994/95: 74) that "linguists are all too often influenced by their own spellings."[259]

4.1 Vowel inventories and vowel harmony

Languages with the most clear and ideal form of ATR harmony have ten contrastive vowels which divide into two mutually exclusive sets of five vowels: a [-ATR] set and a [+ATR] set, which vary at each chart position only in their ATR value, see Table 63.

[259] Including, I doubt not, myself.

Table 63: Ideal ten-vowel ATR-harmony languages

a. [-ATR] vowels	front	central	back
high	ɪ		ʊ
mid	ɛ		ɔ
low		a	

b. [+ATR] vowels	front	central	back
high	i		u
mid	e		o
low		ə	

Ten-vowel systems however are not the most common. More frequent are languages which lack a contrastive [+ATR] counterpart of /a/. This leaves nine contrastive vowels which divide into five [-ATR] vowels but only four [+ATR] vowels, see Table 64.

Table 64: Nine-vowel ATR-harmony languages

a. [-ATR] vowels	front	central	back
high	ɪ		ʊ
mid	ɛ		ɔ
low		a	

b. [+ATR] vowels	front	central	back
high	i		u
mid	e		o
low		---	

Another common vowel system in ATR-harmony languages is the 7/9-vowel system. These languages have seven contrastive vowels and two additional predictable vowels. Malila (Kutsch Lojenga 2006: 2-3) has seven underlying vowels but nine surface realisations with [e] and [o] as the allophonic [+ATR] variants of /ɛ/ and /ɔ/. In addition, as with some 9-vowel systems, /a/, although phonetically [-ATR], is neutral, and may occur in [+ATR] environments.

Among the seven-vowel languages which have ATR harmony. Two types of systems are attested: type (1) which lack [+ATR] mid vowels /e/ and /o/ as in Table 65, and type (2) which lack the [-ATR] high vowels /ɪ/ and /ʊ/, as in Table 66. Type (1) seven-vowel languages tend to have ATR harmony (Casali 2003). Type (2) seven-vowel languages tend to have a retracted root harmony (RTR) (Casali 2003, Leitch 1996).

Table 65: Seven-vowel systems (type 1)

a. [-ATR] vowels	front	central	back
high	ɪ		ʊ
mid	ɛ		ɔ
low		a	

b. [+ATR] vowels	front	central	back
high	i		u
mid	---		---
low		---	

An eight-vowel variant of the (type 1) vowel system, with a [+ATR] counterpart of the central vowel also exists.

Table 66: Seven-vowel systems (type 2)

a. [-ATR] vowels	front	central	back
high	---		---
mid	ɛ		ɔ
low		a	

b. [+ATR] vowels	front	central	back
high	i		u
mid	e		o
low		---	

These are typical vowel inventories commonly found in Bantu languages. The vowel inventories of three Mbam languages, Mmala, Yangben and Mbure fit the very typical and frequent 9-vowel system presented above in Table 64 which is common in many ATR-harmony languages. A fourth language, Baca, has a 9/10-vowel inventory consisting of nine contrastive and one non-contrastive vowel, [ɜ]. Most of the Mbam languages, however, have a less typical inventory. These will be discussed in section 4.1.1 below.

4.1.1 The high front vowel in the Mbam 8-vowel languages

A number of the Mbam languages, however, do not have particularly common vowel inventories. The 8-vowel languages appear asymmetric when one looks at them from a merely phonetic perspective with two [+/-ATR] pairs of back/round vowels and only one [+/-ATR] pair of front vowels, see Table 67.

Table 67: Mbam 8-vowel vowel inventory (phonetic specifications)

	Front	Centre	back/round	
High	i		u	[+ATR]
			ʊ	
Mid		ə	o	[+ATR]
	ɛ		ɔ	
Low		a		

Hyman proposes a "bottom-up" or "system-driven" approach to the analysis of the vowels of two Mbam languages, Yangben and Gunu. He (Hyman 2001, 2003a) identifies only those features which are "phonologically active" in the vowel system, and suggests four active features either present or once present in the Mbam languages. For example, Hyman (2003a) proposes four contrastive features for Yangben (Kalɔŋ): ATR, front, round and open (or non-high). Table 68 illustrates how Hyman's (2001, 2003a) features present a more symmetrical inventory which we will see fits the phonological characteristics of the Mbam languages, Table 68.

Table 68: Mbam 8-vowel inventory modified Hyman (2001, 2003a)

	[(+front) -round)]	[(-front)+round]	
[-open]	i	u	[+ATR]
	ɪ (ɛ)	ʊ	
[+open]	ə	o	[+ATR]
	a	ɔ	

The [+/-ATR pair] [i]/[ɛ] illustrates an asymmetry in the Mbam 8-vowel inventories. Although phonetically and acoustically a mid vowel, [ɛ] patterns phonologically as a high vowel, /ɪ/.

Maande gives evidence that this [-ATR] front vowel is actually a high rather than a mid vowel. Noun class 5 in many of the Mbam languages is **nɪ-**/**ni-**; however, in Maande, the nasal is palatalised before high front vowels, so the noun-class 5 prefix in Maande is **ɲɪ-**/**ɲi-**. In Example 337, the noun-class 5 prefix in Maande is compared with the same prefix in a selection of other Mbam languages. Where Maande has /ɲ/ before a high front vowel, the others have /n/.

Example 337: Variation in prefix nasal in NC 5 before high front vowels

	previous analyses	**this study**	***gloss***
Maande	nyɛbána	ɲì≠bánà	*breast, teat*
	nyikekú	ɲì≠kə̀kú	*beard*
Mmala	---	nì≠bánà	*breast, teat*
	---	nì≠sèlú	*chin*
Gunu	nɛbánya	nì≠báɲà	*latrine*
	niheŋé	nì≠hèŋé	*tree sp.*
Yambeta	nɛdóm	nì≠dʊ́m	*breast, teat*
	nigúu	nì≠gúù	*village*

The Maande high vowels, /i/ and /ɪ/, in the causative suffixes **-i** and **-is-i** and in the neuter suffix **-ɪ**, will cause anticipatory palatalisation of alveolar nasals /n/ to /ɲ/ (right-to-left). In the case of the causative suffixes, occurring at the right edge of the verb word, /i/ will trigger the iterative palatalisation of several alveolar nasals in the verb word. In Example 338 (a), the verbal suffixes **-on** and **-ɪn** become **-oɲ** and **-iɲ** (bolded below) preceding the causative suffixes (underlined). The palatalisation is not limited to the suffix immediately preceding the causative, multiple suffixes with /n/ may be palatalised by the causative suffix **-i**, as in Example 338 (b).

Example 338: Palatalisation of /n/ in Maande causative constructions

(a)	o≠ból-ót-ó**n**-o	*become red*	o≠ból-ót-ó**ɲ**-<u>ís-i</u>	*to make red*
	ɔ̀≠hʊ̀l-ì**n**-à	*pass by*	ò≠hùl-ì**ɲ**-<u>ì</u>	*transmit, cause to pass*
(b)	ò≠sìm-ìn-ìn-ə̀			*to enclose*
	ɔ̀≠làt-ìn-ìn-à			*to add, enlarge*
	ò≠tóŋ-í**ɲ**-í**ɲ**-<u>i</u>			*to show*

The neuter suffix **-ɪ**, unlike the causatives, occurs either in the first or second suffix slot after the root (see Example 339 (b) below). In this position, there are never multiple targets for palatalisation. Non-high vowels will block the spread of palatalisation (see Example 339 (c) below). In Example 339 (a), the alveolar nasal of the verb root **≠san** *disperse*, (bolded below) is palatalised by the neuter suffix **-ɪ** (underlined).

Example 339: Palatalisation of /n/ with the Maande neuter suffix -ɪ

(a)	ɔ̀≠sá**n**-à	*disperse*	ɔ̀≠sá**ɲ**-<u>ì</u>-à	*escape, flee, scatter oneselves*
(b)	ò≠tʃìk-ìl-<u>ì</u>-ə̀n-ə̀			*arrange, classify*
	ɔ̀≠hàt-<u>ì</u>-àk-ìn-à			*catch, stop as a group*
(c)	ɔ̀≠bɔ́n-ɔ́s-<u>ì</u>-à			*punish*

Other suffixes and extensions with high vowels /i/ or /ɪ/ do not cause palatalisation. In Example 340, the applicative suffix **-ɪn** (underlined) does not palatalise /n/.[260]

[260] See footnote 47 above.

Example 340: Non-palatalisation by applicative suffix -ɪn/-in (Maande)

ò≠lə́n-ə̀	*love, desire*	ò-bí≠lə́n-ín-ə̀	*rejoice in, take pleasure in*
ɔ̀≠tʃàn-à	*split*	ɔ̀≠tʃàn-ɪ̀n-à	*split (APPL)*

In conclusion, although previously analysed otherwise, the [-ATR] front vowel is high and is best analysed as /ɪ/. For what reason does an underlying high [-ATR] front vowel /ɪ/ have a surface form as [ɛ]. One reason may be that, with a lack of underlying front mid vowels, the [-ATR] high vowel is lowered. Roark (2001: 4), in his theoretical article on vowel-inventory tendencies, posits three underlying assumptions:

1. "there is a range of possible vowel locations that makes up a perceptual "space";
2. there is a tendency to maximise contrast between vowels within a particular inventory;
3. contrast = distance in the perceptual space"

It is the second and third of these assumptions which are of particular interest as a possible explanation to 1) the lowering of /ɪ/ to [ɛ] in the 8-vowel inventories, and 2) the tendency in most[261] of the Mbam languages for all the [+ATR] vowels to be higher than all of the [-ATR] vowels as is the case with Nen (Bancel 1999: 3). The acoustic "distance" maximises the contrast between the [-ATR] vowels and their corresponding [+ATR] counterparts. So the [+ATR] vowel is *not* acoustically adjacent to its [-ATR] counterpart. While /ʊ/ and /o/ may be very close to each other in the acoustic space, they are acoustically quite distant from their tongue-root counterparts, /u/ and /ɔ/. In the case of the front vowels, /ɪ/ has two allophones, [ɪ] and [ɛ], in 9-vowel languages, but with the loss of the **e/ɛ** pair in the 8-vowel languages, /ɪ/ maximises the distance from /i/ and always surfaces as [ɛ]. This acoustic distance between the [+ATR] and the [-ATR] members of a pair facilitates the ability to "hear" the difference between them, and in part explains why /ʊ/ has been often confused with /o/ (or /ɔ/). For the native speaker, there is no ambiguity between /ʊ/ and /o/ as these two vowels never occur in the same phonological context.

Figure 24 below, illustrates the general order of positions (based on the acoustic data) of the vowels in most of the Mbam 9- and 8-vowel languages. The [+/-ATR] pairs are indicated by the connecting lines. While customarily, [-ATR] high vowels are presented as being above [+ATR] mid vowels, as has been shown elsewhere in many of the Mbam languages, the [-ATR] high vowels acoustically have a higher F1 than the [+ATR] mid vowels. This tendency is seen below and highlights the maximum contrast (distance) between the members in the [+/-ATR] vowel pairs.

[261] The exceptions are Elip, Baca and Mbure. In these three languages, the [-ATR] high vowels /ɪ/ and /ʊ/ have a lower F1 than the [+ATR] mid vowels /e/ and /o/. In the other seven languages, the F1 of /ɪ/ and /ʊ/ is *higher* than the F1 of the mid vowels /e/ and /o/.

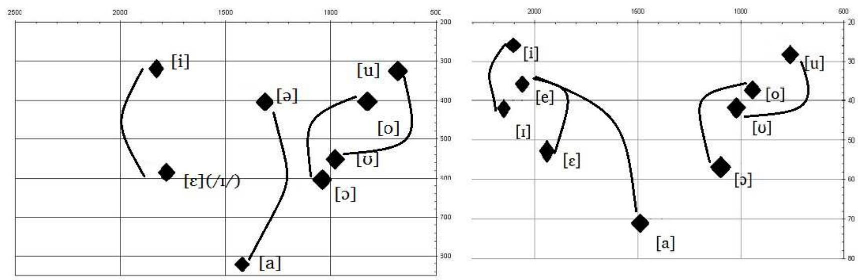

Figure 24: Positions and [+/-ATR] pairs of 8- and 9-vowel inventories[262]

The phonetic content of a phoneme is determined by its 'patterning' and "the behaviour of a phoneme is a function of its contrastive features" (Dresher 2009: 72). By this definition, the patterning of the [-ATR] counterpart of /i/ differs phonologically from /i/ only in the contrastive feature [ATR], despite its tendency to have acoustically a rather high F1. It patterns as a high vowel.

4.1.2 Comparison of the Mbam vowel systems

The Mbam languages have two sets of vowels that are mutually exclusive within the phonological word. One set is [+ATR] and usually "dominant" the other [–ATR] and usually "recessive". These pairs vary somewhat depending on the language. Table 69 below shows the [+ATR]/[-ATR] vowel pairs for each language. The non-contrastive forms are noted in phonetic brackets.

In some of the languages, the underlying front [-ATR] high vowels surface with a high F1. Interestingly, these languages are the ones which no longer have two pairs of front vowels (**ɪ/i** and **ɛ/e**). An additional independent phenomenon, a fronting of /ə/ to [e], is also taking place. Table 69 lists each of the languages in this study, and the [+/-ATR] vowel pairs attested. Two of the languages have non-contrastive vowels included. These are Tuki, which has a non-contrastive [o], which is the [+ATR] counterpart of /ɔ/, and Baca, which has a non-contrastive [ɜ], which is the [+ATR] counterpart of /a/. These two non-contrastive vowels are bolded below.

[262] The values of these charts are taken from the averages of the vowel formants for two representative languages, one eight-vowel language (Nen), and one nine-vowel language (Yangben).

Table 69: Comparison of the [-/+ATR] pairs in the Mbam languages

Name	[+/-ATR] vowel pairs				
Nen	ɪ/i	–	a/ə	ɔ/o	ʊ/u
Maande	ɪ/i	–	a/ə	ɔ/o	ʊ/u
Yambeta	ɪ/i	–	a/ə	ɔ/o	ʊ/u
Tuki	ɪ/i	–	a/a, e	ɔ/[o]	ʊ/u
Gunu	ɪ/i	–	a/e[263]	ɔ/o	ʊ/u
Elip	ɪ/i	–	a/e	ɔ/o	ʊ/u
Mmala	ɪ/i	ɛ/e	a/e	ɔ/o	ʊ/u
Yangben	ɪ/i	ɛ/e	a/e	ɔ/o	ʊ/u
Baca	ɪ/i	ɛ/e	a/[ɜ]	ɔ/o	ʊ/u
Mbure	ɪ/i	ɛ/e	a/e	ɔ/o	ʊ/u

In addition to ATR harmony, all of the Mbam languages except for Baca and Mbure also have rounding harmony. There are two sets of vowels: those that have a contrastive feature for rounding and either trigger or undergo rounding assimilation, and those that are neutral to rounding harmony even if they are phonetically round. Rounding-neutral vowels fall into two types in the Mbam languages: opaque neutral vowels (indicated in the shaded cells) and transparent neutral vowel (indicated in the non-shaded cells in the neutral column in Table 70. Neutral vowels will be discussed at greater length in section 4.3 below. Yangben fronting harmony functions as the mirror image of rounding harmony. The high vowels in Yangben are transparent in both fronting and rounding harmony.

Table 70: Comparison of vowels sets in rounding/fronting harmony

Name	[+round]	[-round]	neutral	
Nen	o, ɔ	a, ə	i, ɪ,	u, ʊ
Maande	o, ɔ	a, ə	i, ɪ,	u, ʊ
Yambeta	o, ɔ	a, ə	i, ɪ,	u, ʊ
Tuki	ɔ	a	i, ɪ,	u, ʊ
Gunu	o, ɔ	a, ə	i, ɪ,	u, ʊ
Elip	o, ɔ	a, e	i, ɪ,	u, ʊ
Mmala	o, ɔ	a, e	i, ɪ,	u, ʊ
Yangben	o, ɔ	a, e	i, ɪ,	u, ʊ
Baca	---	---	---	
Mbure	---	---	---	
	[+front]	[-front]	neutral	
Yangben	e, ɛ	a, e (ə)	i, ɪ	u, ʊ

[263] The [+ATR] counterpart of /a/, although often found with a relatively high F2, with some speakers is slightly centralised. Due to this, Robinson (1984: 50) considered it a central vowel. A similar situation is found in Tuki, and Hyman (2003: 87) states concerning Yangben that "While some speakers pronounce schwa, others convert it to [e]..." It is clear that despite the high F2, [e] as the [+ATR] counterpart of /a/ is derived from a central vowel.

Height harmony, reminiscent of the Bantu Vowel-Height Harmony (presented in detail in section 4.3.3.1 below) with the high vowels *ɪ and *ʊ lowering to *ɛ and *ɔ (Hyman 1999: 236-7) is found only in Mmala. Only the [-ATR] high vowels are targeted by the harmony and only the [-ATR] mid vowels, /ɛ/ and /ɔ/ trigger height harmony, although some speakers will idiosyncratically lower /ɪ/ and /ʊ/ also in the context of /a/. The [+ATR] vowels never participate in height harmony, as in Table 71 below.

Table 71: Height-harmony vowel sets in Mmala

	-ATR			+ATR
		[+mid]	[-mid]	
Mmala	ɪ, ʊ	ɛ, ɔ	a	i, e, o, u

The two principal types of vowel harmony found in the Mbam languages, ATR and rounding, are attested in both 9-vowel and 8-vowel inventories. Fronting and height harmonies are found in only one language each, both of which have 9-vowel inventories. The vowels tend to divide into subsets according to whether or not they participate in a given vowel-harmony type.

4.2 The vowel /a/ in ATR-harmony systems.

In vowel-harmony languages with seven- or nine-vowel inventories, the vowel /a/ does not have a contrastive [+ATR] counterpart. The behaviour of this vowel in these systems is noteworthy and therefore merits further discussion.

4.2.1 An overview of the behaviour of /a/ in ATR-harmony systems

The vowel /a/ is inherently [-ATR], but in some languages, it may occur in a [+ATR] environment. In languages where /a/ occurs in a [+ATR] environment, there are three harmony-resolution processes found:

1) The vowel /a/ is realised as [a] and is neutral with respect to vowel-harmony spreading, namely it can be either transparent or opaque. Although it is [-ATR], it occurs in both [+ATR] and [-ATR] vowel sets. The vowel /a/ may be transparent, in that it does not block ATR harmony, as in languages such as Kibudu (D35) (Kutsch Lojenga 1994: 128), or opaque, in that it will block ATR harmony, as in languages like Akan (Clements 1976: 27). Blocking is the more common type of neutral /a/ according to typological and theoretical studies.
2) The vowel /a/ has a predictable [+ATR] variant which is not contrastive. Kinande (Mutaka 1995: 42) is an example.

3) In some languages, the [+ATR] counterpart of /a/ is realised as a mid front or mid back round [+ATR] vowel, [e] or [o]. In some languages, the /a/ may not occur in a [+ATR] environment and the back vowel /o/ functions as the [+ATR] counterpart of both /ɔ/ and /a/. Lika, a Bantu language of the northern Bantu borderland spoken in the north-east of the D.R. of Congo, is an example (Kutsch Lojenga 2008). In other languages, a front vowel /e/ functions as the [+ATR] counterpart both of /ɛ/ and /a/. Alur, a Western-Nilotic language of the D.R. of Congo is an example (Kutsch Lojenga 1989).

Of the ATR-harmony resolution techniques for /a/ listed above, all three are attested in various Mbam ATR-harmony languages.

4.2.2 Behaviour of /a/ in the Mbam languages

As discussed above, there are various types of harmony-resolution processes when the [-ATR] /a/ is found in a [+ATR] environment.

Nen, Maande, Yambeta and Tuki[264] each have atypical eight-vowel systems with four pairs of [+/-ATR] vowels: **i/ɪ**, **ə/a**, **o/ɔ** and **u/ʊ**. Two additional languages, Gunu[265] and Elip, have a variation in which the [+ATR] counterpart of /a/ is more fronted, so that the four pairs are **i/ɪ**, **e/a**, **o/ɔ** and **u/ʊ**. In all these languages except Tuki, the vowels /e/ or /ə/ occur without exception[266] as the [+ATR] counterpart of /a/ within the phonological word.

In the 9-vowel Mbam languages, such as Mbure, Yangben and Mmala, the vowel which functions as the [+ATR] counterpart of /a/ is realised as an open front [+ATR] vowel, /e/ (option 3, above). In the case of Yangben and Mmala the /a/ never occurs in a [+ATR] context.

In Baca, the vowel /a/ in [+ATR] contexts is realised as [ɜ] a predictable [+ATR] variant which is not contrastive (option 2, above). In all [+ATR] contexts, this non-contrastive counterpart of the vowel /a/ is found.

The most interesting is the behaviour of /a/ in Tuki and Mbure. Both these languages have a contrastive [+ATR] counterpart to /a/, yet both languages, unlike all the others, allow /a/ to occur as unchanged in certain [+ATR] contexts.

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[264] Tuki does not have a contrastive [+ATR] counterpart of /ɔ/.

[265] Robinson (1984: 50) notes in his Phonologie du gunu: parler yambassa that “Chez certains locuteurs la réalisation [du phonème /e/] est légèrement centralisée.” This being the case, Robinson defines /e/ as a central vowel.

[266] Nen has an instance of post-lexical anticipatory ATR harmony involving **a/ə** and affecting only the last vowel of the word, see section 3.2.2 below. In such cases, a [+ATR] word may have a final /a/ if the following word is [-ATR]. The reverse is true as well: a [-ATR] word may have a final /ə/ if the following word is [+ATR].

The greatest co-occurrence restrictions on /a/ in [+ATR] contexts are found in the noun root. In both Tuki and Mbure, the [+ATR] counterpart of /a/, namely /e/ or /ə/, will occur in a ≠CVCV noun root. In Table 72 below, V_2 in ≠CVCV noun roots must respect ATR harmony and is limited to either a high, open, front or round vowel in Mbure. In Tuki, V_2 may only be high, open or round. Certain combinations are neutralised, such as **ɛ-ɪ** and **ɛ-ɛ** in Mbure. In Tuki, **i-u** and **ɪ-ʊ** are lowered to [i-o] and [ɪ-ɔ] due to a constraint of having two high vowels together. This same constraint lowers **ʊ-ɪ** to [o-i] and causes a change in vowel harmony.

Table 72: Mbure

V1/V2	high	open	front/round	high	open	front/round
i	i-i	i-e	---			
e	e-i	e-e	(e-e)			
o	o-i	o-e	o-o			
u	---	u-e	---			
ɪ				---	ɪ-a	---
ɛ				(ɛ-ɛ)	ɛ-a	ɛ-ɛ
a				a-ɪ	a-a	a-ɛ
ɔ				ɔ-ɪ	ɔ-a	ɔ-ɔ
ʊ				---	ʊ-a	---

Tuki

V1/V2	high	open	round	high	open	round
i	i-i	i-ə	i-u ([i-o])			
e	ə-i	ə-ə	ə-u			
u	u-i	u-ə	u-u			
ɪ				ɪ-ɪ	ɪ-a	ɪ-ʊ ([ɪ-ɔ])
a				a-ɪ	a-a	a-ʊ
ɔ				ɔ-ɪ	---[267]	ɔ-ɔ
ʊ				ʊ-ɪ ([o-i])	ʊ-a	ʊ-ʊ

Vowel harmony in the verb is limited to the verb stem in both Tuki and Mbure. The final vowel /a/ will assimilate to the ATR value of the verb root in Tuki (see Example 341), but many verbal suffixes will block ATR harmony.

[267] The absence of **CɔCa** is due to rounding harmony, so underlying forms surface as [CɔCɔ].

Example 341: The behaviour of the final vowel in Tuki CVC verb stems

Rt vowel	ATR	Round	FV	example	*gloss*
i	x	---	-ə	≠hít-ə́	*coil (rope)*
ɪ	---	---	-a	≠tít-á	*draw (water)*
ə	x	---	-ə	≠pə́t-ə́	*seal (door)*
a	---	---	-a	≠pát-á	*pick (fruit)*
ɔ	---	x	-ɔ	≠sɔ́t-ɔ́	*dwell, inhabit*
ʊ	---	---	-a	≠kʊ́t-á	*dry (INTR)*
u	x	---	-ə	≠sús-ə́	*ask, demand*

In Mbure, however, vowel harmony is more restricted. The final vowel is realised as the [+ATR] counterpart /e/, only in the context of the high vowels /i/ and /u/. In all other cases, the vowel /a/ in affixes is realised as [a], even with other [+ATR] verb-root vowels (note the bolded examples) in Example 342.

Example 342: The behaviour of the final vowel in Mbure CVC verb stems

	ATR	surface form	*gloss*
i	x	≠tʰíb-è	*pierce*
ɪ	---	≠mɪ́ɲ-à	*drink*
e	x	**≠pél-à**	*call*
ɛ	---	≠sɛ́ɾ-à	*flow*
a	---	≠sáɾ-à	*chop*
ɔ	---	≠sɔ́d-à	*live*
o	x	**≠sòg-à**	*wash*
ʊ	---	≠pʊ́h-à	*bark (dog)*
u	x	≠pʰùg-è	*close*

In both Tuki and Mbure, the domain of vowel harmony is essentially the root. Within the root, the vowel /e/ is the [+ATR] counterpart of /a/ and occurs in all [+ATR] contexts. This extends, in Tuki in particular, to the final vowel in verbs, whereas other affixes with the vowel /a/ occur as [a] and do not undergo ATR harmony.

4.2.3 Conclusion

With the exception of the eight-vowel languages where the vowel /a/ has a [+ATR] counterpart, the vowel /a/ in the Mbam languages fits one of three patterns. In most of the nine-vowel languages, /a/ in a [+ATR] context has a [+ATR] counterpart, /e/. Baca, however, has a non-contrastive vowel, [ɜ] in [+ATR] contexts. In Mbure (nine vowels) and Tuki (seven vowels), /a/ in [+ATR] contexts will take the [+ATR] counterpart /e/ or /ə/ within noun roots and between the verb root and the final vowel, but where the vowel /a/ occurs in other affixes, it is neutral and blocks ATR harmony from spreading.

4.3 Neutral vowels

All types of Mbam vowel harmony have neutral vowels. But what is neutral in ATR harmony is not neutral in rounding harmony and vice versa. ATR-neutral vowels will be discussed in section 4.3.1. Rounding and fronting neutral vowels will be discussed in section 4.3.2. Neutral vowels in rounding harmony are particularly challenging as they demonstrate both opaque and transparent tendencies. Height-harmony neutral vowels are presented in section 4.3.3, and finally, in section 4.3.4, we will consider various analyses of opaque and transparent neutral vowels and discuss their merits in the context of rounding harmony in the Mbam languages.

4.3.1 Neutral vowels in ATR harmony

One of the more complex problems in analysing vowel-harmony systems involves the occurrence of neutral vowels. According to Van der Hulst and Smith (1986: 234), neutral vowels may occur in one of two circumstances, (1) where the two non-overlapping sets of vowels intersect, resulting in a situation where one or more vowels do not have a harmonic counterpart, and (2) where the "... harmony system is "obscured" by the presence of vowels which, although they do have a harmonic counterpart [...] fail to harmonise, either in particular morphemes, or everywhere."

In both these circumstances, neutral vowels may either be transparent, in which the harmony, so to speak, passes through the vowel as if it were not there, or opaque where the neutral vowel blocks the harmony process. The Mbam languages have both circumstances where neutral vowels may occur, as mentioned by Van der Hulst and Smith (1986) above: those that do not have a harmonic counterpart and those that do, but fail to harmonise. In addition, certain vowels are neutral in relationship to ATR harmony, but they participate in rounding harmony, and others there are others that are neutral in relationship to rounding harmony, but participate in ATR harmony. These will be discussed in turn below.

4.3.1.1 Neutral vowel /a/ in ATR harmony

Two languages, Mbure and Tuki, have an ATR-neutral vowel /a/. In both cases, the vowel /a/ has a harmonic counterpart /e/ or /ə/, which occurs predominantly in roots. As Van der Hulst and Smith (1986: 234) find, "the harmony system is obscured" because the vowel /a/ fails to harmonise in particular morphemes. In both Tuki and Mbure, the vowel /a/ occurs external to the root and is opaque, blocking-ATR harmony spread. In Example 343, the bolded elements are [+ATR]. The suffixes with /a/ which block ATR harmony are underlined.

Example 343: Suffixes blocking ATR-harmony spread in the verb stem

Mbure		≠ɛ̌n-àn-**ì**	*see*
		≠see-CONT-CAUS	
		≠màt-ìk-àn-**ì**	*divide, separate*
		≠divide-INTENS-CONT-CAUS	
Tuki	≠húm-ə́	≠**húm**-án-à	*exit / sprout*
		≠exit-CONT-FV	
	≠dì^{ŋ}g-ə̀	≠**dì^{ŋ}g**-àn-à	*love / love e.o.*
		≠love-RECP-FV	
	-βe≠tù^{m}b-j-ə̀	≠**tù^{m}b-ùɾ**-àn-à	*bathe / swim (ITER)*
	-REFL≠bathe-?-FV	≠bathe-EXTENS-CONT-FV	

In both Mbure and Tuki, noun-class prefixes with the vowel /a/ do not have a [+ATR] counterpart. The prefix vowel is realised as [a], even with [+ATR] vowels in the noun root, as indicated by the bolding in Example 344.

Example 344: Neutral vowel /a/ in prefixes

Mbure	[pàká^{n}d̪]	pà≠ká^{n}d	*women*
	[pà**kónì]**	pà≠kónì	*adults*
Tuki	[βàkʊ́tʊ́]	βà≠kʊ́tʊ̋	*women, wives*
	[βà**wùtə̀]**	βà≠wùt-ə̀	*farmers*

Outside the root, the only affix in Tuki with the vowel /a/ which optionally undergoes ATR harmony is the reflexive verb prefix, **βá-**. The [+ATR] elements are bolded in Example 345.

Example 345: Optional ATR harmony of the reflexive prefix in Tuki

ʊ̀-βá≠**tíj-ə́**	~	ʊ̀-**βə́≠tíj-ə́**	~	**ù-βə́≠tíj-ə́**	*embrace, hug*
c3-REFL≠hug-FV					
ʊ̀-βá≠**tə́m**-ìn-à	~	ʊ̀-**βə́≠tə́m**-ìn-à	~	**ù-βə́≠tə́m**-ìn-à	*lie down, sleep*
c3-REFL≠sleep-APPL-FV					
ʊ̀-βá≠**hún-ə́**	~	ʊ̀-**βə́≠hún-ə́**	~	**ù-βə́≠hún**-ə́	*blow (nose)*
c3-REFL≠blow-FV					

In Tuki, if the prefix /a/ undergoes ATR harmony, other prefixes to its left may also undergo ATR harmony. If the prefix /a/ does not undergo ATR harmony, it is neutral and blocks the spread of ATR.

4.3.1.2 Other neutral vowels in ATR harmony

While the vowel /a/ is the most common neutral vowel in ATR harmony, Tuki has another neutral segment with a high [-ATR] neutral vowel. The applicative suffix **-ɪn** (underlined) occurs in verbs as neutral and blocks ATR harmony from spreading, although the vowel /ɪ/ has a [+ATR] counterpart /i/.

Tuki	---	**-βə́≠tə́m**-ìn-à	*lie down, sleep*
		-REFL≠sleep-APPL-FV	
	≠gún-ə́	≠**gún**-ín-à	*drive away*
		≠drive.away-APPL-FV	
		≠ɾìt-ìn-**j-ə̀**	*harmonise*
		≠harmonise-APPL-CAUS-FV	

While most ATR-neutral vowels are [-ATR], there is a handful of [+ATR] neutral vowels found in Tuki and Maande noun-class prefixes. In the case of Tuki, noun-class prefixes 5, 8, and 19 are invariably [+ATR] even with noun roots which are [-ATR] as in Example 346.

Example 346: Invariable [+ATR] noun-class prefixes in Tuki

ì≠táːní	*c5.rock*
ì≠bùmù	*c5.stomach*
βì≠tɔ́ⁿdɔ́	*c8.navels*
βì≠tə́tí	*c8.roosters*
ì≠hʊ́ɾá	*c19.broom*
ì≠kə́kú	*c19.breast, chest*

Taylor (1990: 5) notes that in Maande, there are a few [-ATR] words which are exceptional in that their prefix may optionally be [+ATR]. Of the three cases given by Taylor (see Example 347 below), two are from noun class 19[268].

Example 347: Optional disharmonic [+ATR] prefixes in Maande

Maande	hì≠kɔ́lɔ́kɔ́tɔ̀	~	**hì**≠kɔ́lɔ́kɔ́tɔ̀	*c19.wasp*
	hì≠ɔ̀fɔ̀	~	**hì**≠ɔ̀fɔ̀	*c19.fish*
	ì≠bálà	~	**ì**≠bálà	*c9.leopard*

Prepositions in Maande will generally become [+ATR] when followed by a [+ATR] noun as seen in Example 348 (a). However, these disharmonic [+high, +ATR] prefixes are not dominant; rather like [-ATR] words, they do not cause the preposition to become [+ATR], as seen in Example 348 (c) and compared with (b).

Example 348: Maande disharmonic [+ATR] prefixes in noun phrases

a)	ìbálà **nə̀ hìsə́tì**[269]	*leopard and duiker*
b)	tʊ̀nààná **nà** bìlàŋà	*pots and clothes*
c)	nà tʃʲɔ́yɔ́ **nà** hìkɔ́lɔ́kɔ́tɔ̀	*bee and wasp*

The disharmonic [+high, +ATR] prefixes, although they are neutral vowels, cannot be said to be either transparent or opaque to vowel harmony. In the Mbam languages, [-ATR] does not spread, rather it is the default value. Thus in Example 348 above, one cannot speak of [-ATR] spreading through a "transparent" [+ATR]

[268] It is not surprising that noun class 19 would be [+ATR] since it is a reflex of the proto-Bantu *pi-.
[269] The first two examples come from Taylor (1990: 8) with my phonetic transcriptions.

vowel. Rather, the [+ATR] vowel is disharmonic but not dominant so that its [+ATR] feature does not spread to the preposition which then surfaces in its default form.

4.3.1.3 Relevance of neutral vowels in the context of the Mbam languges

As mentioned above, one of the more complex problems in analysing vowel-harmony systems involves the occurrence of neutral vowels. In the following sections, we will look at how neutral vowels (both opaque and transparent) have been previously analysed and discuss some of the problems with these analyses given the facts of the behaviour of neutral vowels in the various vowel-harmony types present in the Mbam languages.

First, in sectons 4.3.2 and 4.3.3 we will discuss Mbam rounding, fronting and height harmonies and their neutral vowels, placing these vowel harmonies in the wider context of Bantu and African lingustics. Then in section 4.3.4, we will look at various analyses of neutral vowels taking into account the characteristics and behaviours of neutral vowels in Mbam rounding harmony, and discussing the problems they pose to the theories pertaining to neutral vowels. Later in section 4.4, we will consider the interaction of vowel inventory and vowel harmony in the Mbam languages and what they can reveal about neutral vowels.

4.3.2 Neutral vowels in rounding and fronting harmony

Rounding and fronting harmony are less common in African or Bantu languages, but, especially in the case of the former, are robustly attested in the Mbam languages. This section looks at these two harmonies in the wider context of African languages (sections 4.3.2.1 and 4.3.2.2 respectively), in order to place the rounding and fronting harmony of the Mbam languages into the wider context of Niger-Congo and other African languages. Then in section 4.3.2.3, we will discuss neutral vowels in rounding (and fronting) harmony. Neutral vowels occur in both rounding and fronting harmony. However, fronting harmony occurs only in Yangben and patterns identically with rounding harmony. For this reason, fronting neutral vowels will be discussed with Yangben rounding neutral vowels.

Rounding neutral vowels include both opaque and transparent vowels. For example, the vowels (/i/, /ɪ/, /u/ and /ʊ/) are all neutral in rounding and fronting harmony and can be either transparent or opaque depending on the language. Of most interest is that in Tuki, the vowels /i/ and /ɪ/ are opaque to rounding harmony, and the vowels /u/ and /ʊ/ are transparent, but in Gunu, the opposite is true: the vowels /i/ and /ɪ/ are transparent to rounding harmony and the vowels /u/ and /ʊ/ are opaque to it.

4.3.2.1 Overview of rounding harmony

Rounding harmony “is a phonological process whereby certain vowels surface as rounded under the influence of a neighbouring rounded vowel” (Kaun 2004: 87).

Rounding or round harmony is common in the Turkic, Mongolian and Tungusic branches of Altaic, but it is also found in many Niger-Congo languages. Rounding harmony is often restricted, and only applies when the affected vowel happens to “agree with respect to a second feature like height or backness” (Krämer 2003: 7).

Akan, a Kwa (Niger-Congo) language of Ghana, is described by O'Keefe (2003) as having both ATR and rounding harmony. O'Keefe looks at three dialects of Akan: Asante, Akuapem and Fante. In this section, I look only at what O'Keefe says about Akan rounding harmony. He lists several Akan prefixes which undergo rounding as well as ATR harmony (2003: 10). In particular, the future prefix is either /be-/ or /bɛ-/ in Akuapem and Asante dialects, but it can also surface as /bo-/ or /bɔ-/ in Fante (O'Keefe 2003: 11), when the verb root has a round vowel. In Fante, when the root vowel is not round, the future prefix is not round. He gives the following in Example 349 as evidence. The rounded future prefix is bolded and the round root vowel, which triggers rounding, is underlined:

Example 349: Akan rounding harmony in verbal prefixes

Dialect	**[-ATR]**	***gloss***	**[+ATR]**	***gloss***
Akuapem/Asante	ɔ.bɛ.kʊ	*he will fight*	o.be.tu	*he will dig it up*
Fante	ɔ.**bɔ**.<u>kʊ</u>	*he will fight*	o.**bo**.<u>tu</u>	*he will dig it up*
			o.be.dzi	*he will eat it*

In Example 350, O'Keefe (2003: 15-16) demonstrates a case in Asante where both rounding and ATR harmony are at work. A past tense suffix /-Vyɛ/ and a nominal suffix which is a mid vowel undergo both ATR and/or rounding harmony. The target vowel is bolded and the trigger vowels are underlined.

Example 350: Akan (Asante) rounding harmony in suffixes

Suffix	**[-ATR]**	***gloss***	**[+ATR]**	***gloss***
-V:yɛ	ɔ.<u>tʊn</u>.**ʊ:**yɛ	*he sewed it*	ɔ.kan.**ɪ:**yɛ	*he read it*
$-V_{[mid]}$	adɪ.**ɛ**	*thing*	esi.**e**	*anthill*
	ɛw<u>ʊ</u>.**ɔ**	*honey*	ow<u>u</u>.**o**	*death*

4.3.2.2 Overview of fronting harmony

Fronting harmony is commonly found in Finno-Ugric and Turkic languages, among others (Krämer 2003: 6), where it is more generally called palatal or back harmony. All vowels in the domain, often the phonological word, are either front vowels or back vowels. As in other types of vowel harmony, there are often some vowels which are neutral, either transparent or opaque to the vowel harmony.

Unlike the Uralic languages, which have two mutually exclusive sets of vowels differing only in regards to the feature back, many African languages have a fronting vowel harmony where the feature affects only susceptible vowels.

Kera, an East Chadic (A.3) language of south-western Chad, has height, fronting and rounding harmony (Pearce 2007: 94). In Kera, height harmony is bidirectional and will raise a low vowel (ex. /ɛ/ or /a/) to high in the environment of a high vowel (Pearce 2003: 8 and 2007: 93), as is seen when the suffix /-ɛ/ becomes /-i/ when it is added to /viːg/ *empty* or the suffix /-i/ causes /bàːd/ *wash* to assimilate to /bɨ̀ːd/ as in Example 351. Fronting harmony in Kera is illustrated when the underlying high central vowel, /ɨ/, is fronted to /i/ by an underlying high front vowel (Pearce 2007: 94), as is seen in the words /cɨɨ/ *head* and /ɨsk/ *hear* when the suffix /-i/ is added also in Example 351 below.

Example 351: Fronting harmony in Kera (Pearce 2003: 8)

	underlying form	**surface form**	***gloss***
H. trigger/target	cɨɨ-i	cīirī:	*your (f) head*
	ɨsk-i	īskī:	*hear you (f)*
non-H trigger	viːg-ɛ	viːgi	*is emptying*
non-H target	baad-i	bɨ̀ɨdì:	*wash you (f)*

Pearce (2003: 9, 14; 2007: 95) also identifies another type of fronting harmony triggered by a front suffix vowel and targeting central vowels in the same foot,[270] Example 352 Kera feet are identified by parentheses. Note that fronting does not occur across the foot boundaries.

Example 352: Kera suffix-triggered fronting (Pearce 2003: 2007)

	underlying form	**surface form**	***gloss***
single foot	ɨs-ɛ	(īsī:)	*to sit down*
	bɨŋ-ɛ	(bìŋì:)	*to open*
	bal-ɛ	(belɛ)	*to love*
	fal-ɛ	(félɛ́:)	*to find*
two feet	ɨsk-ɛ	(ɨ́s)(kí:)	*sit you (f) down*
	fal-t-ɛ	(fál)(tɛ́:)	*find (HAB)*

Kɔnni, a Gur language of Ghana, has a type of front assimilation which occurs where a sequence **a**C**ɪ** optionally becomes **ɛ**C**ɪ** if the C is coronal (Cahill 2007: 277), as in Example 353 (a). When the intervening consonant is a velar or labial, front assimilation does not occur, as in Example 353 (b).

[270] Kera is a weight-sensitive language. Feet may include one or two syllables. The licensed feet are 1) one heavy (CV: or CVC) syllable, 2) a light syllable (CV) with a heavy syllable, or 3) two light syllables. (Pearce 2003: 22).

Example 353: Kɔnni fronting of /a/ with coronal (Cahill 2007: 277-8)

(a)	balı	~	bɛlı	*speak (v)*
	tası	~	tɛsı	*kick (v)*
	gbáríáŋ	~	gbɛ́ríáŋ	*earthworm*
	gbalıgı	~	gbɛlıgı	*be tired*
	pıası	~	pıɛsı	*ask*
	kpıası	~	kpıɛsı	*chickens*
(b)	dagı			*show (v)*
	ŋmabı			*shatter*

Fronting harmony is probably the least attested vowel harmony in African languages, with only a few languages found having it. While the fronting harmony of Yangben is more general and robust than is found in the languages above, it does illustrate that although perhaps rare, the fronting harmony of Yangben is not an anomaly.

4.3.2.3 Neutral vowels in rounding harmony

While the neutral vowel /a/ in ATR harmony is clearly opaque or occurs at the word edge, the neutral vowels in rounding harmony are more complicated. The fact that /i, ı, u, ʊ/ are neutral to rounding harmony is not exceptional, since they are phonologically-motivated non-participating vowels (Finley 2009: 18). Following Dresher (2009: 9), who proposes assigning "contrastive features based on an ordering of features into a hierarchy" rather than "based on minimal differences between fully specified phonemes..." none of the high vowels /i/, /ı/, /u/, /ʊ/ in the Mbam languages has a contrastive feature [round], see section 4.4 for a more complete discussion of Dresher's contrastive-feature hierarchy and its application to the Mbam languages.

The question therefore is why there is variation between the Mbam languages concerning the opacity or the transparency of these high vowels (/i/, /ı/, /u/, /ʊ/) in rounding harmony. Four patterns are attested: (1) both high front and high back vowels are opaque and block rounding harmony, (2) only high front vowels are opaque, (3) only high back vowels are opaque, (4) neither high front nor high back vowels are opaque:

High front and high back vowels are opaque to rounding harmony.

In Nen and Maande, all high vowels block rounding harmony from spreading from the verb root to the final vowel, as in Example 354.

Example 354: All high vowels are opaque to rounding harmony

Nen	ʊ̀≠kɔ́ŋ-**ʊ́n**-à	*tip over-SEPAR-FV*
	ù≠hól-**ín**-ə̀	*wrap up-APPL-FV*
	ʊ̀≠mʲɔ̀t-**ɪ̀l**-à	*press (v)-DIM-FV*
Maande	ɔ̀≠bɔ́ŋ-**ʊ́n**-à	*find, obtain-SEPAR-FV*
	ò≠bók-**ít**-ə̀	*cry-DIM-FV*

In Yambeta, high front vowels are clearly opaque to rounding harmony in the verb stem. Very few examples of suffixes with high back vowels are found in the corpus, and the few examples found either do not have a target vowel /a/, or occur on verbs without a non-high (open) round vowel. However, in Yambeta preverbal morphemes, the high back vowels do block rounding harmony, see section 3.3.4.1 above.

Example 355: Yambeta opaque high front vowels

Yambeta	≠ɔ̀p-**ɪ̀n**-à	*crush-APPL-FV*
	≠kós-**ín**-ə̀	*cough-CONT-FV*

Only high front vowels are opaque

While high front vowels are opaque, high back vowels are transparent. In Tuki, only /ɔ/ triggers rounding harmony. The high back vowels /ʊ/ and /u/ do not trigger or block rounding harmony. Example 356 shows the opacity of the high front vowels /ɪ/ and /i/, but it shows also that /ʊ/ is transparent to rounding harmony. Since the [+ATR] [o] is not contrastive, examples of the transparency of /u/ are precluded.

Example 356: High front vowels are opaque

Tuki	≠nɔ̀ᵑg-**ɪ̀t**-à	*fold-DIM-FV*
	≠tòᵐb-**ìj**-è	*calm o.s.-CAUS-FV*
	≠tʃók-óm-**ìj**-è	*narrow-STATIV-CAUS-FV*
	≠sɔ́m-**ʊ́n**-ɔ̀	*accuse-SEPAR-FV*
	≠tɔ́ᵑg-ɔ́ɾ-**ʊ̀n**-ɔ̀	*admire-SEPAR-FV*

Only high back vowels are opaque

While high back vowels are opaque, high front vowels are transparent to rounding harmony. In contrast to Tuki, high back vowels in Gunu are opaque and block rounding harmony, while even multiple high front vowels are transparent to rounding harmony, as in Example 357.

Example 357: High back vowels are opaque

Gunu	≠sɔ́m-**ìn**-ɔ̀	*accuse-APPL-FV*
	≠sɔ́l-**ìg**-ɔ̀	*insist-INTENS-FV*
	≠pòl-**ìn**-ò	*pierce-APPL-FV*
	≠bóɲ-**ìg-ì**-ò	*cause to drink-INTENS-FV*
	≠fɔ̀j-**ʊ̀g**-à	*wake up-SEPAR-FV*
	≠jɔ̀b-**ʊ̀m**-à[271]	*stagger-STATIV-FV*

High front and high back vowels are transparent to rounding harmony

In three Mbam languages, Elip, Mmala and Yangben, all high vowels are transparent to rounding harmony. Example 358 below illustrates Elip and Yangben.

Example 358: All high vowels are transparent to rounding harmony

Elip	≠dɔ́l-**íg**-ɔ̀n	*set fish trap-INTENS-CONT*
	≠sòn-**ìg**-òɲ-è[272]	*insert-INTENS-CONT-CAUS*
	≠ɔ̀^{m}p-**ʊ̀n**-ɔ̀n-ìn	*peel-SEPAR-RECP-APPL*
	≠ǒ^{n}d-**úg**-òɲ-è	*heal-?-CONT-CAUS*
Yangben	≠pɔ́^{n}d-**ìk**-ɔ̀n	*shrink-INTENS-CONT*
	≠ǒk-**ìk**-òn	*bank a fire-INTENS-CONT*
	≠jɔ́p-**ìl**-ɔ̀	*stutter, babble-?-FV*
	≠tɔ̀t-**ìn**-ɔ̀	*smile-APPL-FV*
	≠ǒm-**ùk**-òs-ì	*honour, praise-SEPAR-CAUS*
	≠kɔ́s-**ʊ̀n**-ɔ̀	*cough-SEPAR-FV*

In Mmala, the intensive extension **-ɪg** lowers to **-ɛg** due to height harmony triggered by /ɔ/ in the verb root. It is underlyingly a high vowel, see section 2.7.3.2.4. The separative suffix **-ʊn** never surfaces with a [-ATR] vowel in the context of /ɔ/, see Example 359. The reasons for this are discussed in section 4.4.4 below.

Example 359: Transparent high vowels in Mmala

Mmala	-bí≠dɔ̀l-**ɛ̀g**-ɔ̀n	*REFL≠listen-INTENS-CONT*
	≠góg-**íd**-òɲ-ì	*pull-DIM-RECP-CAUS*
	≠ɔ̀ŋ-**ùn**-ɔ̀	*sell, barter-SEPAR-FV*
	≠ɔ̀^{ɱ}f-**ùn**-ɔ̀	*peal-SEPAR-FV*
	≠ol-**un**-o	*unwrap, untie-SEPAR-FV*

As with rounding harmony, no high vowels block fronting harmony in Yangben, as is seen in Example 360 (a). However, there is loss of contrast between [+ATR/-front] and [+ATR/+front] harmony combinations. Since front is dominant in Yangben, it is assumed that the final vowel **-e** is due to fronting and ATR harmony rather than merely to ATR harmony in Example 360 (b).

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[271] No [+ATR] examples were found in the Gunu corpuses, because /o/ is less commonly found in roots.

[272] As indicated above, most dialects of Elip never round the final vowel, see section 2.6.3.2.4 above.

Example 360: High-vowel transparency in fronting harmony

Yangben	(a)	≠tὲt-**ìn**-ὲ	*tremble-INTENS-FV*
		≠sὲs-**ɔ̀n**-ὲ	*crush, step on-SEPAR-FV*
	(b)	≠sèŋ-**ùl**-è	*tickle-EXTENS-FV*
		≠pèp-**ìn**-è	*palpitate (of heart)-INTENS-FV*

4.3.3 Neutral vowels in height harmony

While height harmony is fairly common in Bantu languages, only one Mbam language, Mmala, has a robust and active height harmony. Since Elip has only unproductive traces of height harmony in its noun-class system, it will not be discussed in this section. An overview of Bantu height harmony is presented in section 4.3.3.1, and a description of Mmala height-neutral vowels is discussed in section 4.3.3.2.

4.3.3.1 Overview of height harmony in Bantu languages

Hyman identifies vowel height harmony (VHH) as the harmonising of the historical degree-2 vowels (**ɪ*, **ʊ*) in height with a preceding mid vowel. This process may be different with respect to the back vs. front vowels (Hyman 2003: 46).

Hyman (1999: 236-8) identifies certain characteristics considered canonical in vowel-height harmonies in Bantu languages. These characteristics are that only mid root vowels trigger vowel harmony. The high vowels undergo harmony and the low vowel /a/ is generally opaque. Vowel-height harmony usually affects only certain derivational suffixes and may be symmetric as in the case of proto-Equatorial Bantu, or asymmetric, as in the case of proto-Savannah Bantu where the front mid vowels do not trigger the harmonic lowering of /u/.

Kinande (D/J.42) has a 7/9-vowel system ([e] and [o] are not contrastive) and asymmetric vowel-height harmony where both high vowels are lowered after a back mid vowel, but only the front high vowel is lowered after a front mid vowel (Hyman 1999: 237). In Example 361, given by Mutaka (1995: 43),[273] the suffixes **–ul** and **-ir** in the bolded examples are lowered to **-ɔl** and **-ɛr** after the back mid vowel /ɔ/, but only **-ir** is lowered after the front mid vowel /ɛ/.

[273] There is more going on in Kinande that I go into here. This example does not take into account more recent analyses.

Example 361: Kinande VHH (Mutaka 1995: 43)

-lim-a	-lim-ir-a	*to work (for)*
-hɛk-a	-hɛ̲k-**ɛr**-a	*to carry (for)*
-sɛng-a	-sɛ̲ng-ul-a	*to (un)pack*
-hat-a	-hat-ir-a	*to peel (for)*
-lɔg-a	-lɔ̲g-**ɛr**-a	*to bewitch (for)*
-βɔh-a	-βɔ̲h-**ɔl**-a	*to (un)tie*
-lung-a	-lung-ul-a	*to join (straighten)*

Unlike in the previous example, where the front mid vowels did not trigger lowering of the round mid vowels, vowel-height harmony in many Western or Equatorial Bantu languages have symmetrical VHH in which both the front and the back mid vowel(s) will lower all high vowels of the extensions to mid. Hyman (2003: 47) illustrates symmetric VHH of Mongo (7-vowel system) in Example 362. Note (in the bolded examples) that both suffixes **-el** and **-ol** are lowered to **-ɛl** and **-ɔl** (bolded) after both /ɛ/ and /ɔ/ in the verb root (underlined).

Example 362: Mongo-Nkundo VHH (Hyman 2003: 47)

-íy-el	steal for	-is-ol-	*uncover*
-ét-el-	call for/at	-bet-ol-	*wake up*
-kɛ̲nd-**ɛl**-	go for/at	-tɛ̲́ng-**ɔl**-	*straighten out*
-kamb-el	work for/at	-bák-ol-	*untie*
-kɔ̲t-**ɛl**-	cut for/at	-mɔ̲m-**ɔl**-	*unglue*
-tóm-el	send for/at	-komb-ol-	*open*
-lúk-el-	paddle for	-kund-ol-	*dig up*

4.3.3.2 Neutral vowels in Mmala height harmony

Height harmony spreads from right-to-left from a height-dominant suffix or root vowel to all [-ATR] high vowels. The vowel /a/ is opaque to height harmony unless it has also undergone rounding harmony. The vowel /ɔ/, whether it is underlyingly /ɔ/ or the result of rounding harmony, always participates in height harmony. The [+ATR] disharmonic vowel /u/ is transparent to height harmony in Mmala.

In Example 363 (a), the height-dominant suffix **-ɛn** (underlined) triggers lowering of the vowel in the verb root, the reflexive prefix **bí-**, and the near-future prefix **gàgʊ́-** (bolded). The vowel /a/ in the tense markers is neutral and blocks height harmony to the c1 (3s) concord **ʊ-**, which does not undergo lowering.

In Example 363 (b), the height-dominant root vowel (underlined) will cause lowering in the vowel of the negative preverbal morpheme **dì-** (bolded). As /ɔ/ also triggers rounding harmony, both the final vowel and the tense markers with the vowel /a/ are rounded. The rounded vowel is *not* opaque to height harmony, allowing the height harmony to trigger the lowering of the vowel in the negative marker.

Due to the [+ATR] disharmonic vowel in the context of /ɔ/ (see section 4.4.4 for a full discussion on the disharmonic [+ATR] high back vowel in Mmala), all the high back vowels are [+ATR] and as such do not participate in height harmony, as seen in Example 363 (c). However, these disharmonic [+ATR] high vowels are *transparent* to height harmony as well as rounding harmony. In Example 363 (d), the verb root with /ɔ/ triggers height harmony in the first person plural concord, despite the fact that the [+ATR] /u/ is in the present tense marker **gú-**.

Example 363: Height harmony in Mmala preverbal morphemes

(a)	UF	ò-sà-bí≠dóg-ɛ̀n		*S/he put her load on her head.*
	SF	ò-sà-**bɛ́≠dɔ́g**-ɛ̀n		
		c1-P1-REFL≠load-APPL		
	UF	ò-gàgó-bí≠dóg-ɛ̀n		*S/he will put her load on her head.*
	SF	ò-gàgɔ́-**bɛ́≠dɔ́g**-ɛ̀n		
		c1-FT1-REFL≠load-APPL		
(b)	UF	ǹ-dì-má-g^{w}≠ɔ̀n-à		*I am not laughing at you.*
	SF	ǹ-**dɛ̀**-mɔ́-g^{w}≠ɔ̀n-ɔ̀		
		1s-NEG-P0-2sIO-laugh-FV		
(c)	UF	ò-gàgó≠dɔ́ŋ-à		*S/he will sing.*
	SF	ù-gɔ̀gú-dɔ́ŋ-ɔ̀		
		c1-FT1-sing-FV		
(d)	UF	dì-gó≠ɔ̀^{n}d-à	mò≠ɔ̀bɔ̀	*We are buying fish*
	SF	**dɛ̀**-gú≠ɔ̀^{n}d-ɔ̀	m^{w}ɔ̀bɔ̀	
		1p-PRES≠buy	mu≠fish	

4.3.4 Various analyses of neutral vowels

Neutral vowels, especially transparent vowels, have been a topic of discussion in many phonological theories:

> "... vowel transparency flies in the face of the assumption maintained in this dissertation that assimilation only applies between strictly adjacent segments" (Baković 2000: 266).

Many efforts have been made to explain why certain neutral vowels "seem to allow the opposite value of the harmonic feature to pass right through them..." (Baković 2000: 265). Baković (2000: 266-8) summarises three different analyses of transparent vowels, favouring the last one:

- **Non-local assimilation**: The harmonising feature skips over the transparent vowel. There have been many arguments against this analysis in the literature.
- **Feature copying**: The transparent vowel blocks the spread of vowel harmony, as though it were opaque, but then the harmonic feature is copied onto a vowel on the opposite side of the neutral vowel and vowel harmony continues as usual.
- **Derivational opacity**: The neutral vowel is harmonic at an intermediate level, which later is neutralised at the surface level.

Van der Hulst and Smith (1986: 261) propose classing vowels into two categories "accessible" and "inaccessible". Inaccessible vowels are opaque. They are represented autosegmentally as having segmental boundaries which extend to the harmonic tier. Accessible vowels fall into two subsets: those that are underlyingly associated (i.e. transparent vowels) and those that are not associated (i.e. harmonising vowels). Opaque vowels are those which are outside "the scope of a feature" and cannot associate to it or are associated to a feature within a segmental domain and cannot associate to a feature outside that domain (Van der Hulst & Smith 1986: 260). Van der Hulst and Smith's analysis assumes privative features for vowels, with the unassociated vowels taking a default value.

Archangeli and Pulleyblank (1994) propose that the lack of contrast may underlie the transparency of these vowels. That is, in Wolof, the non-contrastiveness of [+high, –ATR] vowels is reflected in their neutrality to vowel harmony.

Finley (2008) proposes an adaptation on Goldrick's (2001) Turbidity Theory to explain the occurrences of opaque and transparent neutral vowels in vowel harmony. Finley (2008: 127-8) explains that

> "In Turbid Spreading, all features have three levels of representation: an underlying form, a projection (abstract) form and a phonetic (surface) form. These three levels interact such that spreading is initiated by an underlying form and applies through the projection level. Because the pronunciation representation need not share the same feature value as the projection level, vowels may undergo spreading abstractly, but pronounce a different feature, providing an account of transparent vowels. Because this mismatch of pronunciation and projection comes at a cost (violating a RECIPROCITY constraint), some rankings will produce transparent non-participating vowels, while other rankings will produce opaque non-participating vowels."

So transparent vowels are those that undergo spreading abstractly, but their underlying form is pronounced, while opaque vowels are those that do not have a mismatch of pronunciation and projection.

Following Finley's (2008) examples but using the feature [round] instead of [ATR], her Turbid Spreading does account for some of the Mbam data. The modified features used therefore are:

- *[+high, +round]: high vowels may not be *contrastively* round (following Dresher's (2009) contrastive-feature hierarchy (see Section 4.4). The high back vowels /u/ and /ʊ/, which are redundantly round, are also neutral.
- SPREAD [+round]-R: Rounding harmony spreads to the right ([-round] does not spread).
- RECIPROCITY: “When projection and pronunciation are mismatched, the RECIPROCITY constraint is violated” (Finley 2008: 65).
- ID[round]: “ID[F][274] is violated by any segment that is projected by its surface representation or the projection of one of its neighbours” (Finley 2008: 88).
- The down arrow (↓) represents a phonologically unchanged (faithful) representation; a projection from the underlying form. The side arrows (←, →) represent spreading from a neighbouring form (Finley 2008: 75).

Taking an example from Yangben (Table 73), in which all high vowels are transparent to rounding harmony and as well an example from Maande (Table 74) in which all high vowels are opaque, Finley's model works rather well. In Finley's model, SPREAD[F] involves the spread of both [+F] and [-F]. In order to best fit the data of the Mbam languages, this study claims that only [+round] spreads. For the neutral vowels to be transparent, SPREAD is ordered before RECIPROCITY.

[274] ID(F) is featureal identity and "...governs the relationship between the underlying form and the projection level" (Finley 2008: 88).

Table 73: Transparency & Turbid Spreading (Finley 2008: 95): Yangben

/≠pɔ́^{n}d-**ìk**-àn/ [≠pɔ́^{n}d-**ìk**-ɔ̀n] *shrink*-INTENS-CONT	*[+high, +round]	Spread [+round] - R	Recipro-city	ID [round]
a /+ - -/ ↓ ↓ + - → - [+ - -]		**!		*
b /+ - -/ ☞ ↓ + → + → + [+ - +]			*	**
c /+ - -/ ↓ ↓ ↓ + - - [+ - -]		**!		
d /+ - -/ ↓ + → + → + [+ + +]	*!			**

In Yangben, where all high vowels are transparent to rounding harmony, options (a) and (c) are excluded due to the lack of spreading rounding harmony. Option (d) is excluded because it produces the ungrammatical [+high, +round] vowel. This leaves the winner as (b) even though reciprocity is violated.

In Maande (Table 74), where all high vowels are opaque, RECIPROCITY is ordered before SPREAD. Option (a) is excluded because it produces the ungrammatical [+high, +round] vowel. Options (b) and (d) are excluded because reciprocity is violated. This leaves the winner as (c), although spread is violated.

Table 74: Opacity & Turbid Spreading (Finley 2008: 96): Maande

/≠bók-**ít**-ə̀/ [≠bók-**ít**-ə̀] *cry-DIM-FV*	*[+high, +round]	Recipro-city	Spread [+round] - R	ID [round]
a /+ - -/ ↓ + → + → + [+ + +]	*!			**
b /+ - -/ ↓ + → + → + [+ - +]		**!		**
c /+ - -/ ☞ ↓ ↓ ↓ + - - [+ - -]			**	
d /+ - -/ ↓ + → + → + [+ - -]		**!		**

Finley (2008: 91) states, “If RECIPROCITY is ranked above SPREAD, the non-participating vowel is opaque. If RECIPROCITY is ranked below SPREAD, the non-participating vowel is transparent” (Finley 2008: 91). While this works for those languages which have only transparent or only opaque vowels (as illustrated above), the problem with Finley's Turbid Spreading becomes apparent with those languages with both opaque and transparent vowels active in the same vowel-harmony process. It is not clear what kind of ranking would permit certain high vowels to be transparent while others are opaque to rounding harmony. There is inconsistency between the languages about whether the [+high, +back] vowels are transparent or opaque to rounding harmony. In Gunu, the [+high, +back] vowels are opaque, but in Tuki, they are transparent (see Example 356 and Example 357 above).

Kiparsky and Pajusalu (2006: 221) following Van der Hulst and Smith (1986) posit three typological generalisations concerning neutral vowels: (1) *Unmarkedness* meaning that the neutral vowel is [-F] where [F] is the harmonic feature. (2) *Uniformity* meaning that all vowels with a given value [αF] will be either opaque or transparent. [-F] neutral vowels are transparent, [+F] vowels are opaque. (3) *Asymmetry* in that transparent vowels are predictably [-F].

The rounding neutral vowels in the Mbam languages do not support Kiparsky and Pajusalu's generalisations. Vowels transparent to rounding harmony in the Mbam languages are not predictably [-round]. In some of the Mbam languages with rounding harmony, the high [+round] vowels /u/ and /ʊ/ are transparent and in others the high [-round] vowels, /i/ and /ɪ/, are opaque to rounding harmony or vice versa.

Generally, Optimality Theory assumes strict segmental locality and that "no outputs are generated in which a single featural autosegment is associated with segments S1 and S3 but not an intervening segment S2" (Walker 2012: 585). In support of this strict segmental locality, Ní Chiosáin and Padgett (2001) claim that intervening consonants also participate in vowel harmony, but may not be perceived as altered.

Following a similar line, Gafos and Dye (2011) discuss the phonetic bases of vowel harmony in general and of neutral vowels in particular. According to Gafos and Dye and others (2011: 22-3), there is a discontinuity in both the articulatory and electromyographic measures of lip rounding when English speakers pronounce identical vowels with an intervening consonant (uCu). There is a trough in the electromyographic signal co-occurrent with the production of the intervening consonant. "The cessation of muscle activity during the consonant is consistent with the analysis that [...] the rounding of the two identical vowels [represents] two independent events". However when a speaker of a vowel-harmony language, like Turkish, produces a similar uCu utterance, instead of a trough, there is a "plateau of continuous activity" through the production of the consonant.

> "... the linguistic representation underlying the production of lip rounding in Turkish is consistent with a central idea of autosegmental theory, namely, that assimilation and harmony involve representations in which a single instance of the assimilating or harmonising property extends over a domain encompassing all segments required to agree on that property" (Gafos and Dye 2011: 23).

If vowel harmony extends throughout the domain, affecting even consonants, the logical conclusion would be that even transparent vowels are somehow affected by rounding harmony in the Mbam languages. Then, it is assumed that even the high [-round] vowels, /i/ and /ɪ/, are affected by rounding harmony even though they do not show any perceptible rounding to [y] and [ʏ].

"If the phonetics of 'rounding' is pursued with some care (Goldstein 1991, Disner 1983), lip posture can be hypothesised to spread through the intervening [i] without a substantial effect on its acoustics. Overall, then, the plausible hypothesis is that transparency is not failure to participate in harmony but *failure to produce salient acoustic consequences of harmony* (my italics) on a specific class of segments" (Walker 2012: 25). It is generally held that lip rounding will lower all three of the first formants. So, if rounding harmony spreads though the transparent vowels, there should be some symptom of this rounding (even if it is subphonemic) in the acoustic output of the transparent vowels. With this theory in mind, acoustic measures were taken for two languages, Yangben with all transparent high vowels in rounding harmony, and Maande with all opaque high vowels in rounding harmony to see whether there was any acoustic difference between the “transparent” vowels of Yangben and the “opaque” vowels of Maande. The tokens analysed are as found in Example 364. The shaded cells indicate high vowels in the context of rounding harmony.

Example 364: Rounding neutral suffixes in Yangben and Maande

Yangben	≠pɔ́^{n}d-**ìk**-ɔ̀n	*shrink-CONT*
	≠ɔ̌k-**ìk**-ɔ̀n	*bank a fire-CONT*
	≠jɔ́p-**ìl**-ɔ̀	*stutter, babble-EXTENS-FV*
	≠tɔ̀:t-**ìn**-ɔ̀	*smile-APPL-FV*
	≠kɔ́s-**ɔ̀n**-ɔ̀	*cough-SEPAR-FV*
	≠ɔ̌m-**ùk**-ɔ̀s-ì	*honour, praise-SEPAR-CAUS*
	≠kít-**ìk**-èɲ-ì	*find (at some place)-INTENS-CONT-CAUS*
	≠a^{m}b-**ìk**-àn	*spread out, dry-INTENS-CONT*
	≠sím-**ìl**-è	*surprise, be astonished-EXTENS-FV*
	≠sík-**ìl**-à	*notch, carve something small and round-EXTENS-FV*
	≠fàːt-**ìn**-àn	*carve, sharpen-APPL-CONT*
	≠àn-**ɔ̀n**-à	*examine-SEPAR-FV*
	≠àt-**ɔ̀k**-ɛ̀n	*get up and leave-SEPAR-FV*
	≠tép-**ùk**-ès-ì	*pass, traverse-SEPAR-CAUS*
Maande	≠bɔ́ŋ-**ɔ́n**-à	*find, obtain-SEPAR-FV*
	≠sɔ́l-**ɔ́n**-à[275]	*extract-SEPAR-FV*
	≠ɔ́t-ɔ́k-**ín**-à	*attach-SEPAR-APPL-FV*
	≠òt-**ìn**-ə̀	*water, sprinkle-APPL-FV*
	≠lɔ́ŋ-**ít**-à	*call, invite-DIM-FV*
	≠bók-**ít**-ə̀	*cry-DIM-FV*
	≠fál-**ɔ́n**-à	*succeed, lead to-SEPAR-FV*
	≠fàŋ-**ɔ̀n**-à	*unhook-SEPAR-FV*
	≠ták-**ín**-à	*plan, organise-DIM-FV*
	≠bí-bíén-**ín**-ə̀	*REFLEX-give birth-APPL-FV*
	≠tʃàn-**ít**-à	*wound-DIM-FV*
	≠fàl-**ìt**-à	*weed a little-DIM-FV*
	≠líh-**ít**-ə̀	*last, remain-DIM-FV*

In Yangben, where all the high vowels are transparent to rounding harmony, there is an indication that the high vowels have slightly lower frequencies in the context of rounding harmony than where there is no rounding harmony. The vowels /i/ and /ɪ/ in particular have, on average, lower F3 formants, and somewhat lower F1 (for the vowel /i/) or F2 (for the vowel /ɪ/). The high back vowels /u/ and /ʊ/ are less

[275] No example of the [+ATR] **-un** suffix in a [+round] context was found in the corpus. While examples were found for non-round verb roots, these were excluded due to the lack of the corresponding round verb roots.

consistent which may be due to the fact that they are already phonetically round vowels. However, a similar phenomenon is evident in Maande, where all the high vowels are opaque to rounding harmony. The high front vowels /i/ and /ɪ/ were perhaps even more consistently lowered in the rounding harmony contexts than in Yangben. The shaded boxes in Example 365 indicate the lower formant averages for the neutral vowels in rounding harmony, and the italics show where the lower formant averages showed up in the non-round contexts.

Example 365: Variation in F1/F2/F3 values of neutral vowels in [+/-round] verbs: Yangben

AVE	in [+round] verbs			in [-round] verbs		
	F1	F2	F3	F1	F2	F3
/i/	203	2215	2896	265	*2172*	2994
/ɪ/	335	2027	2723	*321*	2099	2789
/u/	287	893	2524	*272*	891	*2325*
/ʊ/	347	955	2572	*334*	1225	*2229*

[+/-round] verbs: Maande

AVE	in [+round] verbs			in [-round] verbs		
	F1	F2	F3	F1	F2	F3
/i/	216	2077	3075	268	2285	3102
/ɪ/	444	2129	2684	*400*	2156	2815
/u/[276]	---	---	---	---	---	---
/ʊ/	510	1028	2552	*471*	*979*	2584

"The hypothesis grounding transparency in articulatory-acoustic relations may also allow us to understand why certain vowels exhibit transparency but other similar vowels exhibit opacity" (Gafos and Dye 2011: 25). In these two Mbam languages, however, there is not much evidence that the lowering of the frequencies of the first three formants in the context of rounding harmony is different in a language with transparent vowels than it is in a language with opaque vowels. The most that can be said from this limited data is that there is some indication that the frequencies of all rounding-neutral vowels are slightly lowered in the context of rounding harmony as opposed to the same vowels in non-round contexts. This slight lowering, too slight to make a perceptible difference, is perhaps sufficient to justify Ní Chiosáin and Padgett (2001) and Gafos and Dye (2011)'s hypothesis that vowel harmony does encompass all segments occurring in the vowel-harmony domain, including transparent vowels.

In rounding harmony, all the high vowels are neutral. They may be either transparent or opaque, but none of the high vowels, even the phonetically round vowels /u/ and /ʊ/, are phonologically [+round]. While no one disputes that /u/ and /ʊ/ are

[276] No example of /u/ in suffixes in a [+round] context was found in the corpus.

phonetically round "... the question [...] is whether they function *phonologically* as though they are specified..." for rounding (Dresher 2009: 175).

It is possible that, with more sophisticated testing and a larger data sample, those languages where all the high vowels are transparent to rounding harmony (Yangben, Mmala and Elip) will provide evidence that the transparent vowels do undergo some phonetic variations as a result of rounding harmony, and that those languages where all the high vowels are opaque to rounding harmony (Maande, Nen, Yambeta, etc.), the opaque vowels are not (or less) affected by the phonetic variations caused by the rounding harmony. As a result, the vowel harmony is blocked.

The neutral vowels in ATR harmony are different. The ATR-neutral vowels, unlike the rounding-neutral vowels, are contrastively indicated as [-ATR]. Since they do in fact have the opposite value of the harmonising feature, in this case [+ATR], these vowels are invariably opaque.

4.4 Interaction of vowel inventory and vowel harmony

In this section we will look a phonological framework of contrastive features proposed by Dresher (2009) to explain a number of anomalies in Mbam vowel-harmony systems. While Dresher's approach is used, I am in no way claiming that it is superior to other approaches, nor do I try to improve on the theory as such. After looking at a number of other approaches, I found it a useful tool to enhance the description of the Mbam languages and the peculiarities of their vowel-harmony systems. Section 4.4.1 describes Dresher's (2009) contrastive-feature hierarchy and section 4.4.2 gives further information about Dresher's (2009) Modified Contrastive Specification (MCS) which is used to assign an order to the contrastive-feature specifications into a hierarchy. Then in section 4.4.3, we will apply Dresher's model to the Mbam languages and in section 4.4.4 discuss some of the anomalies on which it sheds light.

4.4.1 Contrastive-feature hierarchy in phonology (Dresher 2009)

> "Phonological contrast refers to those properties of phonemes that are distinctive in a given phonological system. In most theories of phonology, this means determining which features are contrastive and which are redundant" (Dresher 2009: 2).

In the Mbam languages, it is evident, by this definition, that ATR must be a contrastive feature. But what are the other vowel features which account for the secondary vowel harmonies present in these languages and how do we account for the differences in the vowel-harmony systems with similar vowel inventories? Dresher (2009: 169) proposes a contrastive-feature hierarchy which makes two empirical claims:

1. “Distinctive features in each language are organised into a hierarchy.”
2. “This hierarchy determines which feature values are contrastive in a given language.”

Dresher (2009) considers that the most logical approach assigns “contrastive features based on an ordering of features into a hierarchy” (Dresher 2009: 9) rather than “based on minimal differences between fully specified phonemes.” He lists five diagnostics for identifying contrastive features.

Figure 25: Diagnostics for identifying contrastive features (Dresher 2009: 72)

A phoneme φ has the contrastive feature F if:

a. φ enters into an alternation or neutralisation that is best explained if F is part of φ.
b. φ causes other phonemes to alternate or neutralise in a way that is best explained if F is part of φ.
c. φ participates in a series with other phonemes, ϕ, with respect to phonotactic distribution, where F is required to characterise φ in a general way.
d. the set of allophones which make up φ all have F in common.
e. speakers adapt a sound from another language in a way that can be explained by supposing that they assign F to the foreign sound.

According to Dresher (2009: 74), “Only contrastive features are active in the phonology. System-redundant features are inert.” This view reflects Hyman's in his discussions of the vowel-harmony systems of Kalɔŋ (Yangben) and Gunu. Hyman proposes a “bottom-up” or “system-driven” approach to the analysis of Yangben vowel harmony in which “the study of languages is informed by theory” (Hyman 2003a: 85). He follows a similar approach for Gunu (Hyman 2001).

Hyman (2001, 2003a) identifies only those features which are “phonologically active” in the vowel system, and suggests four active features either present or once present in the Mbam languages. For example, Hyman (2003a) proposes four contrastive features for Yangben (Kalɔŋ): ATR, front, round and open. In Table 75, reproduced from Hyman (2003a: 8), the double line indicates a tenth underlying vowel /ə/ which surfaces as [e]. This tenth vowel is phonetically undistinguishable from /e/.

Table 75: Hyman's (2003a: 8) contrastive features for Yangben (Kalɔŋ)

	i	u	ɪ(I)	ʊ(U)	e	o	ɛ	ɔ	a	ə[e]
A	+	+			+	+				+
F	+		+		+		+			
R		+		+		+		+		
O					+	+	+	+	+	+

These four features are the only ones Hyman (2001, 2003a) needs to account for, and they explain all the types of vowel harmony found in Gunu and Kalɔŋ (Yangben).[277] Dresher has a different approach to determine the contrastive features of a phoneme based on its behaviour within the system. While both Hyman and Dresher identify the "phonologically active" features, they differ in how these features are determined. Dresher proposes an algorithm for defining contrast and redundancy for members of an inventory as indicated in Table 76.

Table 76: The Successive Division Algorithm (Dresher 2009: 16-7)

a. Begin with no feature specifications: assume all sounds are allophones of a single undifferentiated phoneme.
b. If the set is found to consist of more than one contrasting member, select a feature and divide the set into as many subsets as the feature allows for.
c. Repeat step (b) in each subset: keep dividing up the inventory into sets, applying successive features in turn, until every set has only one member.

While both Hyman and Dresher speak of "phonologically active" features, Hyman does not assume a hierarchical organisation of these features. As a result, although Hyman's (2003a) contrastive features for Yangben do explain much of the vowel-harmony processes, it does leave open the question why the high vowels, which do have a feature round or front, do not participate in rounding and fronting harmony. Hyman's solution is "... since /i/ and /u/ do not condition front or rounding harmony, we need a feature open on which these harmonies are -parasitic" (Hyman 2003a: 5). Why this should be true is not explained.

Dresher's (2009) contrastive-feature hierarchy provides a different rationale as to why the high vowels do not participate in rounding and fronting harmony in Yangben. Using Dresher's (2009: 16-7) Successive Division Algorithm (SDA) as in Table 76 above, we can identify the contrastive specifications "by splitting the inventory by means of successive divisions, governed by an ordering of features" (Dresher 2009: 16) as in Figure 26 below. The height feature is [+/-open] following Hyman (2001, 2003a). Only two height levels are required for most of the Mbam languages. For reasons which will become clear in the discussion of the contrastive-feature hierarchy for Mmala (section 4.4.3.3), I prefer [open] to [low] as it is more general and with the addition of a feature [mid] for Mmala, it fits the pattern better.

While this hierarchical ordering of features necessitates a feature "back" as well as a feature "front", that Hyman (2003a) doesn't require, it allows for high vowels not to have the contrastive features "round" and "front" and thus explains why they do not undergo rounding or fronting harmony.

[277] While Hyman (2003a) only finds seven surface vowels, he effectively argues that Yangben must have nine underlying vowels based on the active features of the language and the vowel-harmony processes. His (2001) treatment of Gunu is similar.

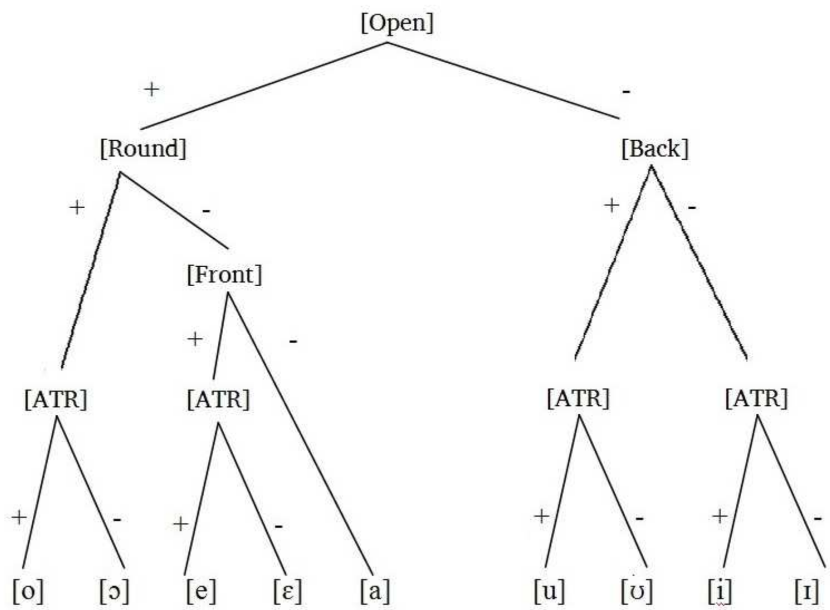

Figure 26: Contrastive-feature hierarchy for Yangben vowels

Dresher's ordering of contrastive features and his premise that it is only contrastive features that are phonologically active are both elements in an approach to phonology that comes out of research done at the University of Toronto since the mid 1990s known as Modified Contrastive Specification or MCS.

4.4.2 Modified Contrastive Specification

Modified Contrastive Specification (MCS) assigns a central role to contrastive feature specifications and has two main tenets (Dresher 2009: 75):

1) "Only contrastive feature specifications are active in the phonology (the Contrastivist Hypothesis)"
2) "Contrastive features are assigned by ordering the features and applying the Successive Division Algorithm (SDA)"

Modified Contrastive Specification started as a focus of complexity in phonology and grew into a discussion of the interrelation between contrast and markedness. Dresher's notion of markedness is structural (logical), rather than phonetic (natural), and as a result relative to a particular inventory (Dresher 2009: 164, footnote 2). In the MCS model, complexity in phonology is driven by both contrast and structural markedness. Features are binary with both marked and unmarked values rather than privative. Complexity is driven only by marked features, so segments with fewer marked features are less complex than those with more marked features (Dresher 2009: 163-4).

> “MCS proposes that contrasts are determined by the SDA operating on a hierarchy of features. Since a more marked representation is permitted only if needed to establish a contrast with a less marked one, the theory of MCS leads us to expect a relation between the amount of segmental markedness a system allows and the number and nature of contrasts it has” (Dresher 2009: 163-4).

The MCS approach assumes that phonology is underspecified with respect to phonetics. While “the number and nature of contrasts that a segment enters into influence, [they] do not determine its phonetic realisation. Therefore, the contrastive specifications assigned by the phonological component must be supplemented by further principles to derive the detailed phonetic specification of a speech sound” (Dresher 2009: 168). As a result, the concept of phonetic enhancement is adapted by MCS.

Phonetic enhancement is posited by Stevens, Keyser and Kawasaki (1986) and Stevens and Keyser (1989), who propose that “phonological contrasts can be *enhanced* by phonetic specification of non-contrastive features” (Dresher 2009: 168). Phonetic enhancement also explains why certain vowel inventories are more common than others.

4.4.3 Contrastive-feature hierarchy and MCS analysis of the Mbam languages

The Mbam languages, despite similar vowel inventories, have rather distinct vowel-harmony systems. Given Dresher's premise that only contrastive features are phonologically active and that features are hierarchically ordered, the differences in what vowel harmonies occur are the function of which features are active and their position in the language-specific contrastive-feature hierarchy. No feature can occur at different levels within the hierarchy of any given language, nor does the level of the feature tell us anything about the robustness of the vowel harmony associated with it. Languages with very robust ATR harmony may rank ATR high or low. The most important aspect of the contrastive-feature hierarchy is that it determines which vowels are affected by which feature. Vowels such as /u/ or /ʊ/ in Yangben (see Figure 26 above), although they are clearly round vowels (phonetically), are not contrastively round. The feature [+round] affects only [+open] vowels in Yangben.

4.4.3.1 Yangben

As discussed above in Figure 26 and reproduced in Figure 27 below, Yangben has a contrastive-feature hierarchy, open>>round/back>>front>>ATR.

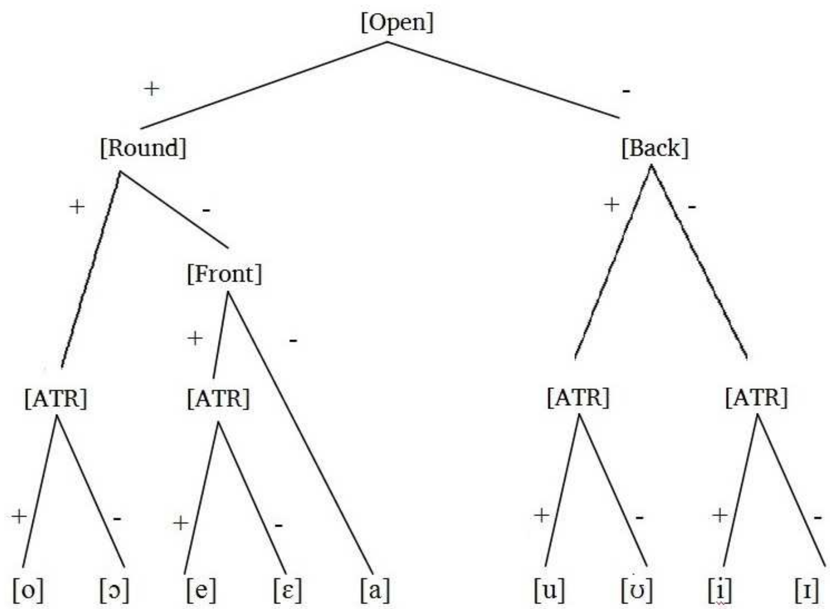

Figure 27: Contrastive-feature hierarchy for Yangben vowels

The first contrast divides the vowels into [+open] (**e, ɛ, a, ɔ, o**) and [-open] (**i, ɪ, u, ʊ**) separated in Table 77 below by the double line. As Dresher (2009: 177) finds for Classical Manchu, "Splitting the inventory in this manner has the effect of allowing for different contrasts in each set." The next features, [back] and [round] (separated by the heavy line) apply to different sets. The feature [back] applies only to the [-open] vowels and distinguishes between **i, ɪ** and **u, ʊ**. The feature [round] only applies to the [+open] vowels. It distinguishes **o**, **ɔ** from **a, ɛ, e**. The [round] feature is relevant in Yangben for rounding harmony, the [-open] vowels, even **u**, **ʊ** are not contrastive for rounding and do not participate in or block rounding harmony. The next feature, [front], applies only to the [-round] vowels and distinguishes **ɛ**, **e** from **a**. The [front] feature (indicated by the fine line) is relevant in Yangben for fronting harmony. The [-open] vowels, even **i** and **ɪ** are not contrastive for [front] and hence do not participate in fronting harmony. The last contrastive feature is [ATR] (distinguished by the dashed lines). It distinguishes between all of the remaining pairs except for **a**. The [ATR] contrast for **a** is determined in Yangben by the next higher node, which in this case is the feature [front], so **a** takes its [+ATR] counterpart from the [front] node, hence /e/.

Table 77: Contrastive features for Yangben

i	**[ATR]**			**u**
ɪ			[back]	ʊ
[open]	**e** **[ATR]**		**o**	
	ɛ	a	ɔ	
	[front]		[round]	

The contrastive-feature hierarchy differs between the various Mbam languages. Baca and Mbure, which have inventories similar to Yangben's, do not have fronting harmony.

4.4.3.2 Baca and Mbure

Baca and Mbure both have 9-vowel systems with similar features to Yangben, but with a different order. While the features [front] and [back] are at the same level, [front] is associated with the [-open] vowels in Baca and Mbure, and with the [+open] vowels for Yangben. Since the vowels /e/ and /ɛ/ are not contrastive for [front], they do not undergo fronting harmony. There is still need for a contrastive feature [round] (needed to distinguish between /a/ and the round vowels /ɔ/ and /o/), and to account for the trace of rounding in both these languages. The contrastive-feature hierarchy for Baca and Mbure is: open>>back/front>>round>>ATR, as illustrated in Figure 28.

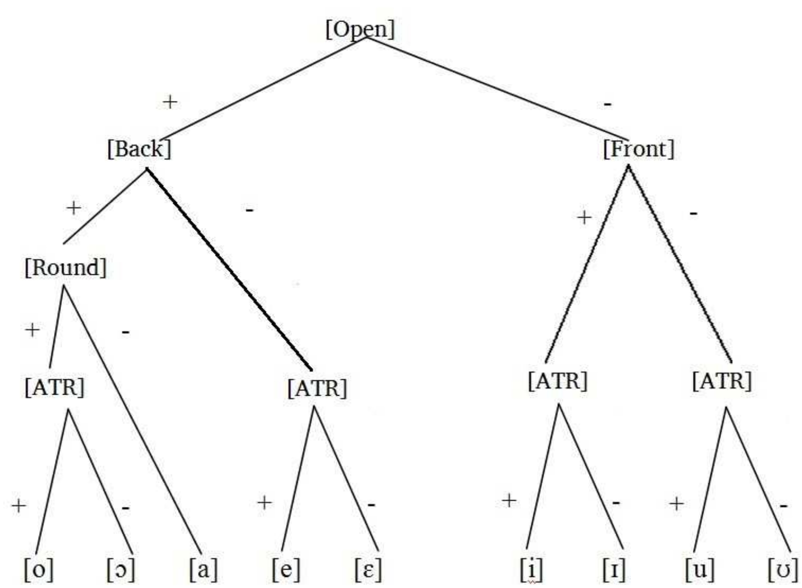

Figure 28: Contrastive-feature hierarchy for Baca and Mbure vowels

Like with Yangben, both Baca and Mbure first divide vowels by the feature [+open]. Unlike Yangben, the next contrastive feature [back] applies only to [+open] vowels and the contrastive feature [front] only to [-open] vowels and distinguishes **i**, **ɪ** from **u**, **ʊ**. This slight change is the reason why fronting harmony does not occur in either Baca or Mbure. The feature [back] distinguishes **a**, **o**, **ɔ** from **e**, **ɛ**. The feature [round] distinguishes **o**, **ɔ**, from **a**. The final contrastive feature, [ATR], distinguishes between all the remaining pairs except for **a**, which does not have a [+ATR] counterpart in certain environments and uses /e/ in others.

Table 78: Contrastive features for Baca and Mbure

i				**[ATR]**	**u**
ɪ		[front]			ʊ
[open]	**e**	**[ATR]**		**o**	
	ɛ		a	ɔ	
			[back]	[round]	

4.4.3.3 Mmala

Mmala, which is unique for its active height harmony, has a rather different contrastive-feature hierarchy. The feature [mid] is proposed rather than [front] to distinguish the [+open] mid vowels **ɔ**, **ɛ** from **a**. Unlike the languages discussed above, the feature [ATR] is the highest ranked. The features [back] and [round] are similarly ranked after [mid] with [back] affecting only the [-open] vowels and [round] affecting only the [+open] vowels. The contrastive-feature hierarchy for Mmala is: ATR>> open>>mid >>round/back as illustrated in Figure 29.

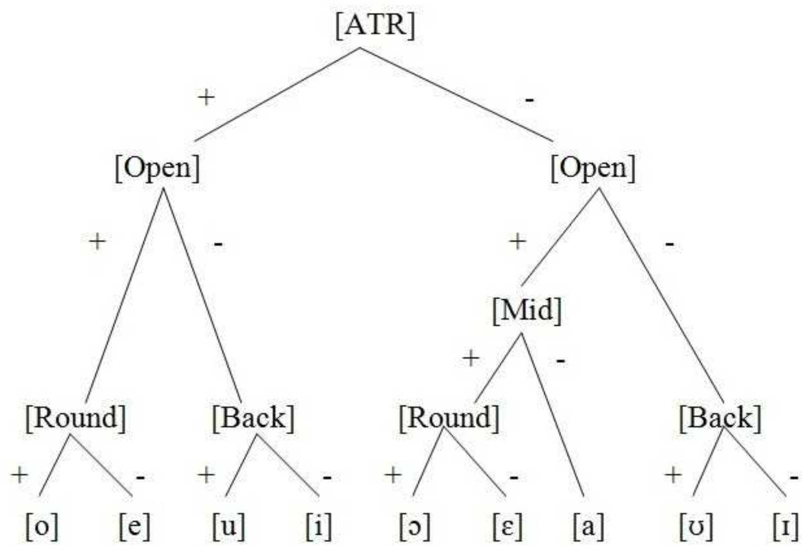

Figure 29: Contrastive-feature hierarchy for Mmala vowels

[ATR] is the highest-ranked feature in the hierarchy for Mmala. It separates **i**, **u**, **e**, and **o** from **ɪ**, **ʊ**, **ɔ**, **ɛ**, and **a**. Second in the hierarchy is [open] which applies to both [+ATR] and [-ATR] vowels. The feature [mid] applies only to [-ATR], [+open] vowels and distinguishes **ɔ**, **ɛ** from **a**. The feature [mid] is required to account for height harmony in Mmala, which is triggered by /ɔ/ and /ɛ/ but not generally by /a/. The lowest-ranked features in the Mmala hierarchy are [round], which applies to all [+open] vowels and [back] which only applies to [-open] vowels. This distinction accounts for why rounding harmony in Mmala only affects the [+open] vowels.

Table 79: Contrastive features for Mmala

ɪ			[ATR]		i
ʊ			**[back]**		**u**
[open]	**ɔ**			**o**	**[round]**
	ɛ			e	
		[mid] a			

4.4.3.4 The 8-vowel languages

Five languages with 8-vowel systems, Elip, Gunu, Nen, Maande and Yambeta, all have similar contrastive feature hierarchies. As with most of the other languages, the highest-ranked feature is [open] and separates **a**, **ə**, **ɔ**, **o** from **i**, **ɪ**, **u**, **ʊ**. Since there is no fronting harmony, only the feature [back] is necessary for distinguishing between the [-open] vowels. The [+round] feature is needed to account for rounding harmony in the [+open] vowels. The contrastive-feature hierarchy for the 8-vowel languages is open >>round/back>>ATR as illustrated Figure 30.

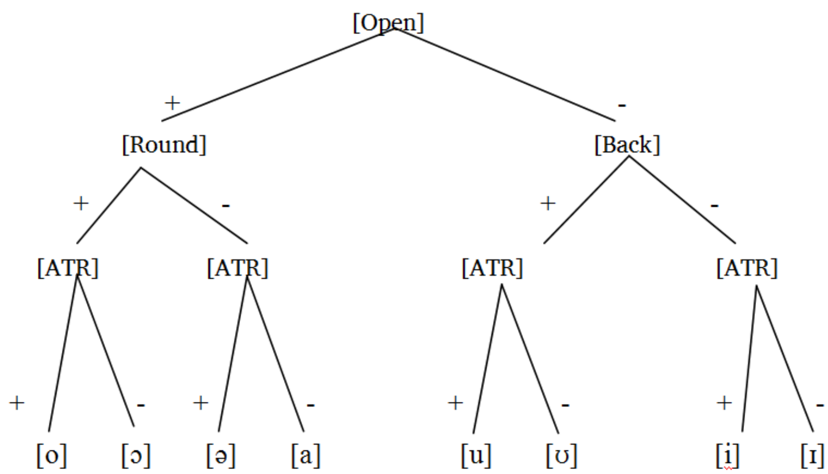

Figure 30: Contrastive-feature hierarchy for the 8-vowel languages

Like the 9-vowel systems, the feature [round] applies to the [+open] vowels and the feature [back] to the [-open] vowels. Unlike the 9-vowel systems, /a/ in the 8-vowel languages has a distinct [+ATR] counterpart.

Table 80: Contrastive features for the 8-vowel Mbam languages

i	**[ATR]**		**u**
ɪ		[back]	ʊ
[open]		[round]	
[ATR]	**ə**		**o**
	a		ɔ

4.4.3.5 Tuki

The tenth language, Tuki, has only seven contrastive vowels, having lost the [+ATR] open vowel /o/, which now only occurs as an allophone of /ɔ/ in a [+ATR] context. The contrastive-feature hierarchy of Tuki ranks the feature [ATR] as second after [open]. The lowest-ranked contrastive features are [back] and [round]. The contrastive-feature hierarchy for Tuki is open>>ATR>>round/back as illustrated in Figure 31.

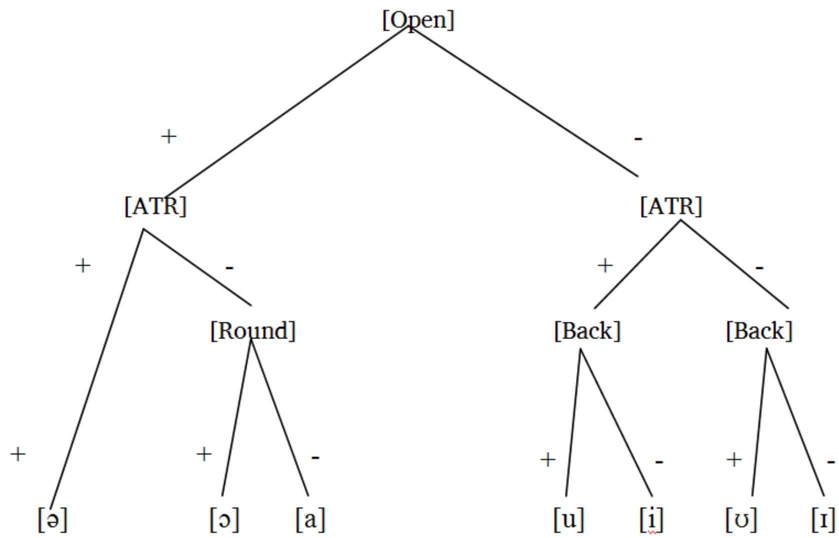

Figure 31: Contrastive-feature hierarchy for Tuki

Tuki, like Mmala, places [ATR] high in the contrastive-feature hierarchy. The features [open] and [ATR] affect all vowels. The features [back] and [round] are ranked last; the former applies only to [-open] vowels and the latter to [+open] vowels. The feature round is needed to distinguish between /ɔ/ and /a/ and accounts for the rounding harmony, which occurs in the word root.

Table 81: Contrastive features for Tuki

ɪ		[ATR]	i
ʊ	[back]		**u**
ɔ [round]	a	ə	[open]

4.4.3.6 Summary of the contrastive feature hierarchies of the Mbam languages

Yangben, Mbure and Baca have similar contrastive features, but the ranking is different. The differences in ranking affect which types of vowel harmony are present. While both Baca and Mbure, like Yangben, have a contrastive feature [front], this feature, because of its position in the feature hierarchy, only applies to the [-open] vowels and does not trigger fronting harmony.

Mmala, unique among the 9-vowel languages, does not have a contrastive feature [front]. It is replaced with the feature [mid] which allows for the height harmony found in the language.

The 8-vowel languages, Elip, Gunu, Nen, Maande and Yambeta, have similar contrastive features to Tuki, but the ranking differs, with [ATR] ranking higher than [round/back] in Tuki. Table 82 summarises the contrastive features of the Mbam languages and their hierarchical ranking.

Table 82: Summary of the contrastive-feature hierarchy for the Mbam languages

Yangben	[open]>>[round/back]>>[front]>>[ATR]
Mbure, Baca	[open]>>[back/front]>>[round]>>[ATR]
Mmala	[ATR]>>[open]>>[mid]>>[round/back]
Elip, Gunu, Nen, Maande, Yambeta	[open]>>[round/back]>>[ATR]
Tuki	[open]>>[ATR]>>[round/back]

While Dresher's (2009) contrastive-feature hierarchy of features is useful to explain how vowel harmony is triggered and to some degree why certain vowels do not participate (e.g. why the high vowels do not trigger rounding or fronting harmony), the situation is less clear about why some segments are transparent and others opaque. “There are various reasons why segments may block harmony, not all derived from their contrastive status. Similarly, targets may be restricted for reasons beyond their contrastive status” (Dresher 2009: 176 footnote). In rounding harmony, in particular, the high vowels, /i, ɪ, u, ʊ/ do not have the contrastive feature [+/-round] (or in the case of fronting harmony the feature [+/-front]) and thus do not participate in rounding or fronting harmony. In certain languages, however, they are all transparent, while in other languages, they are all opaque and in some cases /i, ɪ/ are opaque while /u, ʊ/ are transparent or vice versa.

Van der Hulst and Smith (1986: 246) propose a universal law that a neutral vowel is transparent if it shares the dominant value, and is opaque if it has the recessive value. This hypothesis does not work in the Mbam languages nor in Dresher's model with regards to rounding harmony, since neutral vowels are those vowels that have no specification at all for the harmonising (contrastive) feature. Even the concept “phonetic enhancement”, posited by Stevens, Keyser and Kawasaki (1986) and Stevens and Keyser (1989), which adds phonetic specification with non-contrastive features, does not help. It cannot account for why even the phonetically-enhanced round vowels, /u/ and /ʊ/,[278] (i.e. the dominant feature) are opaque to rounding harmony in Gunu and transparent to rounding harmony in Tuki. Likewise it cannot account for why /i/ and /ɪ/ (i.e. the recessive value vis-à-vis rounding harmony) is transparent in Gunu (as well as Elip, Mmala and Yangben), and opaque in Tuki (and Nen and Maande). This study can offer no solution for these problems, but it is

[278] If the high vowels are phonetically enhanced, it would make sense to associate the redundant feature [+round] with [+back], but this still doesn't help us. The vowels /u/ and /ʊ/ in Gunu are [+back], thus redundantly [+round], but they block rounding harmony, while /i/ and /ɪ/, which are [-back], thus redundantly [-round], are transparent to rounding harmony.

hoped that the issues and questions brought forward here will contribute to the understanding of the behaviour of neutral vowels.

In the 9-vowel inventory, Dresher's contrastive-feature hierarchy can explain in part why the [+ATR] counterpart of /a/ surfaces as /e/ and not /o/, as happens in a number of other Bantu languages. Several methods are found depending on the language:

1) The [+ATR] counterpart of the odd vowel is drawn from the next higher node.
2) A non-contrastive [+ATR] allophone occurs in [+ATR] contexts.
3) /a/ occurs without alternation in [+ATR] contexts (i.e. /a/ is neutral).

Illustration of method (1): The [+ATR] counterpart of /a/ is /e/ in Yangben and Mmala. Where there is a lack of a contrastive [+ATR] counterpart [a̧], we must go up to the first superior node which can provide it to get the [+ATR] counterpart for /a/. In Yangben, which has [ATR] as the lowest node, the [+ATR] counterpart of /a/ ([+open]>>[-round]>>[-front]) must come from the [front] node, which is the immediately superior node, see Figure 26 above. So we go down the [+front] side to get to the [ATR] node, which gives us /e/ ([+open]>> [-round]>> [+front]>> [+ATR]) as the [+ATR] counterpart of /a/.

In Mmala, since [ATR] is the highest node, we must get the [+ATR] counterpart of /a/ ([-ATR]>>[+open]>>[-mid]) from the highest node. We must go down the [+ATR] side and chose [+open] (since /a/ is an open vowel), and [-round] (since /a/ is [-round] phonetically, even though not [-round] contrastively and hence not specified as [-round]). The [+ATR] counterpart of /a/ in Mmala therefore is /e/ ([+ATR]>> [+open]>> [-round]), see Figure 29 above.

Method (2) above, is illustrated in Baca. A non-contrastive [+ATR] vowel [ɜ] occurs in [+ATR] contexts in Baca.

Since "... harmony observes limitations that are not due to contrast, but to other factors, that is, having a contrastive feature is a necessary but not sufficient condition for triggering harmony..." (Dresher 2009: 184), we see two methods at work in Mbure and Tuki.

In Tuki, it is the vowel /ɔ/ (not /a/) that lacks a contrastive [+ATR] counterpart. Tuki uses method (2) and has a non-contrastive allophone [o] occurring in [+ATR] contexts.

However, for both Tuki and Mbure, the vowel /a/ functions differently depending on its position: within the word root or in affixes. In noun roots, the vowel /a/ must undergo ATR harmony. Both languages use method (1) for the [+ATR] counterpart.

In Mbure, the [+ATR] counterpart of /a/ is /e/. Since /a/ ([+open]>>[+back]>> [-round]) has no [ATR] value in the feature hierarchy, it must get it through the superior node, [back]. As the feature [round] distinguishes /a/ from /o/ and /ɔ/ and is hierarchically higher than [ATR], the vowel /a/ must get its ATR value from the node higher than [round], that is the [back] node, see Figure 28 above. There we must take the [-back] side and choose the [+ATR] side to /e/ ([+open]>>[-back]>> [+ATR]) when imposed by [+ATR] dominance within the root. In affixes, both languages use method (3): the vowel /a/ occurs unaltered in [+ATR] contexts in prefixes and suffixes.

The choice between these methods is language specific, and Dresher's model offers an explanation only for the first.

4.4.4 The problem of ATR disharmony in Mmala

> "Any new theory puts old questions into a new light..." (Dresher 2009: 138).

As seen earlier, Mmala has an unusual ATR disharmony which cannot be explained by either positional neutralisations of [ATR] contrasts or the favouring of a disharmonic but faithful candidate over a spreading one. The Mmala ATR disharmony is not the instance of a [-ATR] segment occurring in a [+ATR] context, but rather that of a [+ATR] segment occurring exceptionally in a [-ATR] context. The context is extremely limited and it seems impossible to find a way of ordering OT constraints to account for it. Descriptively, it is easy to define:

- All instances of /ʊ/ found in the context of /ɔ/ in the phonological word will surface as a [+ATR] vowel, /u/.
- /ɔ/ will trigger rounding harmony, and height harmony in /ɪ/ but not in /ʊ/.
- The [+open] allophone of /ʊ/[279] will trigger height harmony in both /ɪ/ and /ʊ/, but it never triggers rounding harmony.

There are numerous examples found both in prefixes and suffixes in nouns and verbs. In Example 366, the vowel /ɔ/ is underlined and the effect on the [-ATR], high back vowel is bolded. In Example 367, the rounding harmony triggered by /ɔ/ is also underlined.

[279] With the limitation of symbols, this allophone must be written as "ɔ"; however, phonologically, it is not identical to the contrastive vowel /ɔ/. The vowel /ɔ/ has a contrastive feature [+round] whereas the allophone of /ʊ/ does not, as we will see below, the contrastive features of this allophone are [-ATR], [+open] and [+back], while the contrastive features of /ɔ/ are [-ATR], [+open], [+mid] and [+round]

Example 366: Mmala ATR disharmony in nouns

bʊ̀≠ɲánʊ̀	*c14.yam (generic)*
nʊ̀≠mà^{n}dì / dʊ̀≠mà^{n}dì	*c11/13.wild cat*
b**ù**≠lɔ̀g	*c 14.meat*
n**ù**≠bɔ̀mɔ́ / d**ù**≠bɔ̀mɔ́	*c11/13.river*
n**ù**≠bɔ̀l / d**ù**≠bɔ̀l	*c11/13.rain*

Example 367: Mmala ATR disharmony in verbs

[≠ɔ̀ŋ-ɔ̀]	*join*	[≠ɔ̀ŋ-**ù**n-ɔ̀]	*separate*
[≠nʊ́ŋ-ʊ́n] ~ [nɔ́ŋ-ɔ́n]	*evade*	[≠nʊ́ŋ-**ʊ́n**-à]	*evade (cont)*

[**ù**-sɔ̀≠sɔ́s-ɛ̀d]	*s/he smoked.*
c1-P2≠smoke-DIM	
[gɔ́-n**ù**-ŋ≠gɔ́l-ɛ̀n]	*you (pl) take me.*
DIST-2p-1sIO≠take.IMP-APPL	
[**ù**-gɔ̀g**ú**-dɔ́ŋ-ɔ̀]	*s/he will sing*
c1-FT1-sing-FV	

However easy it may be to describe the phenomenon, *explaining it* is more difficult. While OT constraints and orderings do not shed light, Dresher's contrastive-feature hierarchy does. This study will argue that, instead of being an unexpected occurrence of [+ATR], the presence of /u/ is an instance of a height analysis.

While Dresher does not speak about allophones in detail, he does state that “the set of allophones which make up φ all have F in common...” (Dresher 2009: 72). Regardless of how similar a particular allophone might be *phonetically* to another phoneme, ϕ, the allophone(s) of φ will have similar contrastive features to φ, varying from φ only within the hierarchical position of φ. Therefore, allophones will have only the contrastive features of the phoneme; they will not assume additional contrastive features from elsewhere in the hierarchy.

For example, in Mmala, the high vowels (see Figure 29 above) are contrastively [+/-ATR]>>[-open]>>[+/-back]. Their allophonic variations, therefore, must include only these contrastive features, and therefore logically may only be [+/-ATR] or [+/-open] or [+/-back]. So theoretically, there are 2^3 possible allophones of /ʊ/ ([-ATR]>>[-open]>>[+back]):

- [-ATR]>>[-open]>>[+back]: [ʊ].
- [-ATR]>>[-open]>>[-back]: [ɪ]. This does not occur as an allophone of /ʊ/ in Mmala

- [-ATR]>>[+open]>>[+back]: the feature [+back] is not a contrastive element for the [+open] node. It would be interpreted as something close to [ɔ], but lacking the contrastive feature [+round]. This does occur as an allophone for /ʊ/ in Mmala.
- [-ATR]>>[+open]>>[-back]: the feature [-back] is not a contrastive element for the [+open] node. It would be interpreted as something close to [ɛ]. This does not occur as an allophone of /ʊ/ in Mmala.
- [+ATR]>>[-open]>>[+back]: [u]. This does occur as an allophone of /ʊ/ in Mmala.
- [+ATR]>>[-open]>>[-back]: [i]. This does not occur as an allophone of /ʊ/ in Mmala.
- [+ATR]>>[+open]>>[+back]: the feature [+back] is not a contrastive element for the [+open] node and does not occur as an allophone of /ʊ/ in Mmala.
- [+ATR]>>[+open]>>[-back]: the feature [-back] is not a contrastive element for the [+open] node and does not occur as an allophone of /ʊ/ in Mmala.

In Mmala, at least, an allophone, α, of any given phoneme, φ, will allow for only *one* feature to vary; so that the allophones of /ʊ/ are actually reduced to four possibilities:

- [-ATR]>>[-open]>>[+back]: /ʊ/
- [-ATR]>>[+open]>>[+back]: similar to [ɔ]
- [+ATR]>>[-open]>>[+back]: /u/
- *[-ATR]>>[-open]>>[-back]: [ɪ]

Of these options, the first three are found in Mmala. Likewise, for /ɪ/ ([-ATR]>>[-open]>>[-back]), the possible allophones are:

- [-ATR]>>[-open]>>[-back]: /ɪ/
- [-ATR]>>[+open]>>[-back]: similar to [ɛ][280]
- *[+ATR]>>[-open]>>[-back]: /i/
- *[-ATR]>>[-open]>>[+back]: /ʊ/

Of these options, the first two are found for /ɪ/.

While phonetically the same, or at least very similar, the contrastive features of /ɔ/ in Mmala are very different from those of the [ɔ][281] allophone of /ʊ/. The former has the contrastive features [-ATR]>>[+open]>>[+mid]>>[+round], while the latter, since it is the [+open] allophone of /ʊ/, is [-ATR]>>[+open]>>[+back]. As a result,

[280] This allophone occurs wherever height harmony lowers /ɪ/.
[281] Since the contrastive features of these two vowels are very different, I choose to consider them as entirely different vowels despite their phonetic similarity, hence the the usage of the square brackets, [ɔ], rather than referring to it as /ɔ/, which featurally, it is not.

[ɔ], not having a contrastive feature [round] will never trigger rounding harmony, but since it *does* have the feature [+open] it will trigger height harmony.

In Mmala, /ʊ/ is lowered predominantly in closed syllables.[282] This lowering will also trigger lowering in preceding (including open) syllables. In Example 368, the underlying /ʊ/ ([-ATR]>>[-open]>>[+back]) in roots is lowered to [ɔ] ([-ATR]>>[+open]>>[+back]) in closed syllables and will trigger lowering of the prefix vowel (bolded).

A second allophone of /ʊ/ occurs within the phonological word with /ɔ/ ([-ATR]>>[+open]>>[+mid]>>[+round]). While /ɔ/ generally triggers height harmony, which lowers high affix vowels, in this case, the opposite occurs, and /ʊ/ in a prefix is raised and surfaces as /u/ ([+ATR]>>[-open]>>[+back]). The surface variation of the prefix vowel is bolded in Example 368 below.

Example 368: Comparaison of /ʊ/ and /ɔ/ in Mmala.

Underlying /ʊ/ in root				Underlying /ɔ/ in root	
gʊ̀≠dɔ́m	~	g**ɔ̀**≠dɔ́m	*send something*	g**ù**≠dɔ́m	*eat first fruits*
gʊ̀≠gɔ́l	~	g**ɔ̀**≠gɔ́l	*crush, grind*	g**ù**≠gɔ́l	*take*
nʊ̀≠bɔ́g	~	n**ɔ̀**≠bɔ́g	*c11/13.prophecy*	b**ù**≠lɔ̀g	*14/6.meat*

Logically, ATR harmony must be triggered by a vowel which is contrastive for ATR, which /ɔ/ evidently is not. The disharmonic variation of /ʊ/ ~ [u] in the context of /ɔ/ is therefore not due to any spread of ATR. This disharmonic variation precludes the height-harmony lowering of /ʊ/ by /ɔ/. Since the allophone of /ʊ/ is [+ATR], it is excluded from height harmony as are all [+ATR] vowels.

4.5 Conclusions

In this chapter we looked at two questions:

- Is there a relationship between vowel inventory and ATR harmony cross-linguistically?
- Can we account for the apparent gaps in vowel harmony in the Mbam languages by using language-specific feature hierarchies to identify which features are phonologically active and which are phonologically inert?

4.5.1 The relationship of vowel inventory and ATR harmony.

Casali (2003, 2008) gives good typological evidence that there is a strong correspondence between vowel inventory and tongue-root harmony, so that [+ATR]

[282] Refer to chapter 2, section 2.7.3. Some speakers idiosyncratically lower /ʊ/ even in open syllables. The tendency to phonetically lower the [-ATR] high vowels is a common occurrence in many of the Mbam languages, and as we have seen elsewhere, acoustically it has, even in its non-lowered form, a rather high F1.

is normally dominant in languages with an [ATR] contrast among high vowels, whereas [-ATR] generally serves as the dominant value in languages in which [ATR] contrasts only for non-high vowels (Casali 2003: 307).

Previous studies of the Mbam languages (Nen, Yangben[283] and Gunu in particular) seem to contradict Casali's findings of a correspondence between vowel inventories and ATR harmony, as all previous studies of the Mbam languages have analysed these as 7-vowel systems with contrast in the non-high vowels *and* robust dominant [+ATR] harmony. However, almost all these studies also posit an underlying or a historical 9/10-vowel inventory. While there has been disagreement on this point, Casali's typological arguments lend credence to those theories which argue for an ATR contrast in the high vowels.

It is the premise of this study that, while certain vowels in the Mbam languages are realised phonetically and acoustically as rather low, notably /ɪ/ and /ʊ/, they function *phonologically* as high vowels. In other words, it is not the phonetic make-up which determines what a phoneme is, rather the phoneme is determined by its behaviour in the system. The behaviour of a phoneme in the system is a function of its contrastive features (Dresher 2009: 72). As a result, rather than having 7-vowel inventories with [+ATR] contrast in the non-high vowels and having a typologically atypical dominant [+ATR] harmony, these languages are better analysed as having an [ATR] contrast in the high vowels, and having a typologically expected dominant [+ATR] harmony.

4.5.2 Gaps in vowel harmony and language-specific feature hierarchies

Dresher (2009) argues that only phonologically active features are contrastive, and by extension, in the domain of vowel harmony, in that “harmony triggers should be contrastive features” (Dresher 2009: 175). In considering Mbam rounding harmony, the high back vowels /u/ and /ʊ/, although phonetically round, are not *contrastively* round. Roundness is a redundant feature for the high vowels and therefore inert and cannot trigger rounding harmony. The fact that /u/ and /ʊ/ do not participate in rounding harmony is phonetic evidence that the feature [round] is unspecified for the high vowels.

Dresher's (2009) contrastive-feature hierarchy also explains why languages with similar vowel inventories and even similar contrastive features may have rather different vowel-harmony processes. Within the feature hierarchy, certain features may apply only to a subset. In the cases of Yangben, Mbure and Baca, the second-highest features apply separately, the first of the set to the [+open] subset, the second to the [-open] subset, as illustrated in Table 83.

[283] Referred to as Kalong or Nukalonge in much of the literature.

Table 83: Comparison of Yangben, Baca and Mbure contrastive hierarchies

Yangben	[open] >>	+	[round >>	[front] >>	[ATR]
		--	[back] >>		[ATR]
Mbure, Baca	[open] >>	+	[back] >>	[round] >>	[ATR]
		--	[front] >>		[ATR]

The difference in the hierarchical order and to which subset each feature is applied accounts for the difference in vowel harmony between these languages. In Yangben, rounding and fronting harmony apply to the only vowel which is both [-round] and [-front], /a/. Both these harmonies target /a/ and cause it to assimilate to the contrastive feature wherever it occurs within the phonological word. As the high [-open] vowels have neither [round] nor [front] as contrastive features, they do not participate in rounding or fronting harmony.

The difference in the hierarchical order of features in Baca and Mbure cause the feature [front] to apply only to the high [-open] vowels. Since [front] is not a contrastive feature to distinguish /a/ from other vowels, it does not trigger fronting harmony. A minimal rounding harmony does occur in Mbure verb stems, which is consistent with the presence of [round] as a contrastive feature separating /a/ from the back vowels /ɔ/ and /o/. In the case of Baca, although it also has [round] applying to differentiate /a/ from /ɔ/ and /o/, it does not have any rounding harmony tendencies. Hence, while vowel harmony *must* be triggered by a contrastive feature, the presence of a contrastive feature doesn't obligate the presence of vowel harmony.