5 Phonology

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5.1. Introduction

The historical relation between African and general phonology has been a mutually beneficial one: the languages of the African continent provide some of the most interesting and, at times, unusual phonological phenomena, which have contributed to the development of phonology in quite central ways. This has been made possible by the careful descriptive work that has been done on African languages, by linguists and non-linguists, and by Africanists and non-Africanists who have peeked in from time to time. Except for the click consonants of the Khoisan languages (which spill over onto some neighboring Bantu languages that have "borrowed" them), the phonological phenomena found in African languages are usually duplicated elsewhere on the globe, though not always in as concentrated a fashion. The vast majority of African languages are tonal, and many also have vowel harmony (especially vowel height harmony and advanced tongue root [ATR] harmony). Not surprisingly, then, African languages have figured disproportionately in theoretical treatments of these two phenomena. On the other hand, if there is a phonological property where African languages are underrepresented, it would have to be stress systems – which rarely, if ever, achieve the complexity found in other (mostly non-tonal) languages. However, it should be noted that the languages of Africa have contributed significantly to virtually every other aspect of general phonology, and that the various developments of phonological theory have in turn often greatly contributed to a better understanding of the phonologies of African languages.

Given the considerable diversity of the properties found in different parts of the continent, as well as in different genetic groups or areas, it will not be possible to provide a complete account of the phonological phenomena typically found in African languages, overviews of which are available in such works as Creissels (1994) and Clements (2000). More recently, Clements and Rialland (2008) treat African phonology from an areal perspective. Drawing from a database of 150 African languages, they address a range of phonological properties that have significant African distributions as compared with a non-African database of 345 languages.

Rather than surveying the phonological properties of African languages, we will focus in this chapter on issues that have been important both to Africanists and to phonologists in general, following the traditional order of presentation: segmental phonology (section 2: nasals; complex segments), suprasegmental phonology (section 3: tone; harmony systems; prosodies), segment organization and

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word structure (section 4: syllable structure, slots, and moras; reduplication; prominence, accent, and metrical structure), and phonology and its interfaces (section 5: interactions between phonology and syntax; tonal morphology; dependent and construct states; phonologically conditioned mobile affixation). Whenever relevant we will include considerations on the historical origin of the phonological phenomena discussed, and show how African languages have contributed and may still contribute to our understanding of the origin of some of the most intriguing of these phenomena. The concluding section argues for a comparative approach to theoretical, descriptive, and historical work in Africa as a strategy for addressing the most important issues that are yet to be resolved.

5.2. Segmental phonology: Complex segments

In terms of segmental phonology, Africa has mostly contributed to our understanding of complex segments, which are frequently attested in many languages of the continent, from prenasalized consonants to labial-velars and clicks, the latter two being almost exclusively African. Our understanding of nasal segments has also been improved by African languages, which we will see with prenasalized consonants (section 2.1 below), and the complementary distribution of nasal and oral consonants, best analyzed as resulting from a word-level nasal prosody (section 3.4).

Whether some sequences of segments constitute unitary segments or clusters has been a recurring fundamental issue in phonology, with nontrivial consequences for the theory and representation of segments. Three types of complex segments characteristic of Africa have figured prominently in that debate: prenasalized consonants, labial-velars, and clicks (cf. Maddieson, this volume, section 2 for details on the phonetics of these complex segments).

5.2.1. Prenasalized consonants

Numerous Africanists have worked on the problem of homorganic NC sequences. African languages figure prominently in Herbert's (1986) seminal work on prenasalization and N+C sequencing. Many if not most African languages allow NC segments or clusters of some type, and it is not surprising to see African cases contributing to their analysis: Are they one or two segments? If one, what is their feature geometry? If two, is the nasal moraic or not?

This seems to be a purely phonological problem: phonetics has been shown to be of little help in the analysis of NC sequences, since there does not seem to be any phonetic distinction between ^{N}C and N+C (cf. Downing 2005: 183, and references therein). Furthermore, only two languages are said to contrast ^{N}C and N+C intervocalically: Sinhala and Fula, and that contrast is, according to Maddieson

and Ladefoged (1993) best analyzed as one between a singleton and a geminate ^{N}C rather than between a unit segment and a consonant cluster. The unit versus cluster analyses can thus only be based on phonological evidence.

Herbert (1986) uses the fact that prenasalized consonants may, depending on the language, pattern either with nasals or with oral consonants to argue that they should not be added to the universal phonological inventory, but rather be analyzed as underlying clusters. Surface prenasalized consonants arise later through "consonant unification" triggered by syllabification constraints (cf. Maddieson, this volume, section 4.3).

At about the same time, Walli-Sagey (1986) argued in favor of the opposite view based on Kinyarwanda data. She showed that in this language with an otherwise strict CV(V) syllable structure, NC sequences are best analyzed as single complex segments. This in turn served as a compelling argument in favor of a radically new feature-geometric representation of distinctive features (Clements 1985; Walli-Sagey 1986): rather than representing the features for a segment as a single matrix (as in Chomsky and Halle (1968) or Steriade's (1982) "melodic core" hypothesis), Walli-Sagey proposes to organize them in separate tiers corresponding to each articulator. This representation captures the fact that features referring to different articulators often behave independently, while features referring to the same articulator are interdependent. This elaboration on autosegmental representations would prove extremely powerful in accounting for blocking and transparency effects in vowel harmony and other feature spreading phenomena.

The debate on the analysis of homorganic NC clusters in specific languages and language families is not closed, as we will see in section 4.1.1 below.

5.2.2. Labial-velars

Labial-velar stops are very common in West and Central Africa, while they are nearly absent elsewhere (with very few exceptions, mainly in Papua New Guinea): they are one of the features proposed by both Clements and Rialland (2008) and Güldemann (2008) for their (Macro-)Sudan(ic) linguistic area. These complex consonants, produced with nearly simultaneous bilabial and velar closure, have figured prominently in debates about complex segments and their representations. Sagey (1990) was the first to propose a feature-geometric treatment of labial-velars. Cahill (1999) gives a comprehensive overview of the various phonological patterns of labial-velars in a sample of over 80 languages, showing how different they are from both velar and labial consonants, and how to best account for them in phonology.

The first major characteristic of labial-velars is that they behave as single segments, not a K+P cluster. This can be seen, for instance, in the formation of the gerund in Ewe, whereby the first consonant of a verb stem is reduplicated, as illustrated in (1). When the verb stem starts with a cluster, only the first consonant is

reduplicated (1b), but when it starts with a labial-velar, it is the whole labial-velar that reduplicates, as shown in (1c).

(1) Ewe

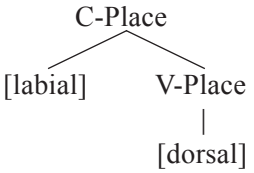
a.	fo	'to beat'	fo-fo	'beating'
	bia	'to ask'	ba-biam	'asking'
b.	fle	'to buy'	fe-fle	'buying'
	kplo	'to lead'	kpo-kplo	'leading'
c.	g͡bla	'to extert oneself'	g͡ba-g͡blam	'exerting oneself'

(Ansre 1963, cited in Cahill 1999: 157)

The phonological behavior of labial-velars, which Cahill shows differs somewhat from language to language, also makes their featural definition potentially problematic: are they primarily either labial (with velarization) or velar (with labialization), as in Chomsky and Halle's (1968) feature system, or coequally labial and velar, as in Ohala and Lorentz's (1977) approach? Cahill shows that either of these approaches may be appropriate depending on the language, and that both can be implemented using the representations of feature geometry.

A representation of labial-velars as primarily labial as in (2), for example, accounts for the fact that in many languages labial-velars form a natural class with labials and not velars. It is the case in Nawuri, for example, where labial-velars behave on a par with labials in blocking rounding harmony from the stem vowel to the high vowel of the prefix /gI-/, as shown in (3c).[1]

(2)



(3) Nawuri

a.	gɨ-ɲi	'tooth'	b.	gu-jo	'yam'
	gɨ-ke:li:	'kapok tree'		gu-ku:	'digging'
	gɩ-ba:	'hand'		gʊ-sʊ	'ear'
	gɩ-sɩbɩta	'sandal'		gʊ-lɔ	'illness'
c.	gɨ-mu	'heat'			
	gɨ-bo:to:	'leprosy'			
	gɨ-k͡po:	(type of dance)			

(Casali 1995: 651–2)

[1] The prefix vowels in (3c) are phonetically rounded in casual speech, but even in that case always have an "intermediate" degree of rounding which makes them "phonetically distinct from the fully round prefix vowels" in (3b) (Casali 1995: 652).

5.2.3. Clicks

Click consonants are only attested in about two dozen languages in the world, all but one spoken in eastern and southern Africa.[2] They are particularly prominent in the so-called "Khoisan" group of languages, which comprises three families (Khoe-Kwadi, Tuu, Kx'a) and the two Tanzanian isolates Sandawe and Hadza (Güldemann and Voßen 2000; Güldemann 2014).[3] They are further attested, albeit to a lesser extent, in a few Southern Bantu languages, which borrowed them from neighboring "Khoisan" languages, and in the Cushitic language Dahalo.

Clicks are among the most articulatorily complex segments (cf. Maddieson, this volume, section 2.1.2). As Exter (2008: 137) notes, this very "complexity, combined with their rareness, is surely the main reason why clicks have received so little attention in the [phonological] literature … [however] it is just this complexity that makes clicks potentially ideal candidates for testing the descriptive adequacy of any given phonological framework."

5.2.3.1. Clicks are consonants

Five basic click types are attested ("influxes" in Beach's (1938) terminology): bilabial /ʘ/, dental /ǀ/, (post)alveolar /!/, (alveo)palatal /ǂ/, and lateral /ǁ/. A sixth click type called (alveo)retroflex /!!/ has been described in a few !Xuun dialects (Snyman 1997; Scott et al. 2010), and reconstructed in Proto-Ju (Miller-Ockhuizen and Sands 1999; Sands and Miller Ockhuizen 2000; Sands 2010).

Traill (1997: 103) pointed out that before his work on !Xóõ, "existing analyses of clicks and non-clicks [were] seldom integrated into a single coherent phonological system." Nakagawa (2006: 283–291), drawing on Traill (1985, 1997) and on his own work on Gǀui (Kalahari Khoe), shows that clicks can easily be integrated with all other consonants into a single set of features. Regular place- and manner-of-articulation features are sufficient to distinguish clicks among themselves. One single additional feature referring to airstream mechanism and its perceptual correlate is needed to distinguish clicks from non-click consonants, such as Chomsky and Halle's (1968: 309) [suction], adopted by Traill (1985), or Ladefoged's (1995) feature [click]. Traill (1997: 115) proposes to interpret clicks as perceptually salient, "enhanced versions" of non-click stops "exploit[ing] all the features of non-click stops but utilis[ing] a novel source for the production of these features, namely the noise bursts generated by the velaric suction." Building on this intuition, Nakagawa (2006: 287) proposes the binary feature [±enhanced] to

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2 Outside of Africa only Damin, a now-extinct ceremonial form of the Lardil language of Australia, is reported to have used contrastive click consonants (Hale and Nash 1997).

3 The nomenclature used here for Khoisan languages is the one proposed by Güldemann (2014).

account for the difference in airstream mechanism. Table 1 below illustrates his featural analysis of the G|ui consonant system (see Exter (2008) for a summary of other proposals).

Table 1: Partial featural analysis of G|ui click and non-click consonants (after Nakagawa 2006: 290)

	labial		**coronal**							**velar**	**uvular**		**glottal**
			[-apical]					**[+apical]**					
			[-palatal]			**[+palatal]**							
[affricated]	–	+	–	+	+	+/–	–	–	+	–	–	+	–
[lateral]	–	–	–	–	–	–	–	–	+	–	–	–	–
[grave]	–	+	–	–	–	–	–	+	+	+	+	+	–
[enhanced]	–	–	–	–	+	–	+	+	+	–	–	–	–
Example	p	Θ	t	ts	|	tʃ/c	ǂ	!	‖	k	q	qχ’	ʔ

Interestingly, this analysis makes use of the acoustic feature [grave], first proposed by Jakobson et al. (1952), but excluded from the set of (mostly articulatory) features proposed by Chomsky and Halle (1968) and from most feature systems adopted by phonologists to this day. This feature distinguishes in particular the [-grave] laminal [|, ǂ] from the [+grave] apical [!, ‖] and labial [Θ] clicks. Traill (1995, 1997) justifies the use of this feature on the basis of its role in explaining two processes affecting click consonants: click replacement and click-vowel assimilation.

Click replacement is a type of sound change whereby clicks become non-click consonants. The regularly attested cases in Khoe languages show that the target non-click consonant may have a different place of articulation from that of the original click, but always has identical acoustic gravity, for example, [+grave] /!/ → /k/ in G‖ana, or [-grave] /ǂ/ → /c/ in Eastern Khoe (Traill 1980; Traill and Vossen 1997, cited in Nakagawa 2006: 285).

A widespread assimilatory process in South-African Khoisan languages also shows evidence for the role of acoustic gravity: in Taa and G|ui (and most probably in other Khoisan languages awaiting phonetic and phonological description), the back vowel /a/ fully assimilates to an immediately following front vowel /i, e/ only if it is preceded by a coronal egressive consonant, dental /|/ or palatal /ǂ/. Interestingly, the equally coronal /!/ patterns with non-coronal consonants, lateral /‖/ and bilabial /Θ/, in preventing this assimilation (cf. Nakagawa 2006: 288; Naumann forth.). The assimilation summarized in [ExGuia] thus appears to be impossible to capture using only articulatory features, but can be very easily stated using the acoustic feature [grave] as shown in (4b):

(4) a. a → {i,e} / {|, ǂ, t, ts …} ___ {i,e}
b. V[+grave] → [-grave] / C[-grave] ___ V[-grave]

Click consonants and the phonological processes that target them can be added to earlier evidence advanced in favor of re-including the acoustic feature [grave] in phonological theory (cf. Hyman 1973; Vago 1976; Odden 1978).

5.2.3.2. Clicks and their "accompaniments": Unit vs. cluster analysis

The six click types mentioned above combine with what has traditionally been termed "effluxes" or "accompaniments" (cf. Maddieson, this volume, section 2.1.2). Whether all attested accompaniments form one complex segment with the click type they are coarticulated with or constitute a separate segment is subject to debate. Traill (1985: 208), later followed by Güldemann (2001), Nakagawa (2006), and Naumann (forth.), was the first to depart from a "unit" analysis of all click consonants as single segments, suggesting instead that some of the complex click consonants might be better analyzed as consonant clusters. Table 2 below illustrates the cluster analysis proposed by Naumann (forth.) for the West !Xoon dialect of Taa (using IPA symbols): this extremely rich inventory of 165 consonant sounds (the largest known) is here reduced to 88 distinctive consonantal segments and 77 clusters.

As can be seen, a very interesting and rare distinction is made in Taa between complex clicks and clusters involving a glottal articulation: ejective (!') and aspirated (!ʰ) clicks are distinct from clusters involving a glottal stop (!ʔ) and glottal fricative (!h) respectively, as illustrated in (5).

(5)

	Complex click	*Click cluster*
a.	/!'/ = ejective	/!ʔ/ [n̥!ʔ] = plain + /ʔ/
b.	/!ʰ/ = aspirated	/!h/ [n̥!h] = plain + /h/ (known as "delayed aspiration")

Nakagawa (2006) first identified the phonemic distinction between /!'/ and /!ʔ/ in G|ui, in great part thanks to the predictions made by his cluster analysis of complex click consonants. Basing his analysis of Taa on Nakagawa's findings, Naumann discovered that this distinction also existed in Taa, where it had gone unnoticed despite the thorough phonetic and phonological analysis of its eastern dialect by Traill (1985): "the presence of ejected clicks in Taa (in contrast to sequences of clicks and glottal stop) was only discovered due to phonological expectations of the present analysis" (Naumann forth.).

Opposing the cluster analysis, Miller et al (2009) argue that complex click consonants in N|uu should be analyzed as airstream contours (cf. Snyman's (1983) "multigressive" clicks) rather than consonant clusters, that is, "unary" complex segments involving a rapid change from lingual (i. e., velaric) to pulmonic air-

Table 2: Consonants of West !Xoon (Taa), including clusters (after Naumann forth.)

	Egressive			**Ingressive**					**Egressive**			
	labial	alveolar	alv. affr. /palatal	labial	dental	alveolar	palatal	lateral	velar	uvular	uvular-aricate	glottal
Oral stops												
Plain	p	t	t͡s	ʘ	ǀ	!	ǂ	ǁ	k	q		(ʔ)
Voiced	b	d	d͡z	ʘ̬	ǀ̬	!̬	ǂ̬	ǁ̬	g	ɢ		
Vl. aspirated	pʰ	tʰ	t͡sʰ	ʘʰ	ǀʰ	!ʰ	ǂʰ	ǁʰ	kʰ	qʰ		
Vd. aspirated	bʰ	dʰ	d͡zʰ	ʘ̬ʰ	ǀ̬ʰ	!̬ʰ	ǂ̬ʰ	ǁ̬ʰ	gʰ	ɢʰ		
Vl. ejective	p’	t’	t͡s’	ʘ’	ǀ’	!’	ǂ’	ǁ’	k’	q’	q͡χ’	
Vd. ejective			d͡z’		ǀ̬’	!̬’	ǂ̬’	ǁ̬’	g’	ɢ’	ɢ͡ʁ’	
Nasal stops												
Plain (vd.)	m	n	ɲ	ʘ̃	ǀ̃	!̃	ǂ̃	ǁ̃	ŋ			
Voiceless					ǀ̥̃	!̥̃	ǂ̥̃	ǁ̥̃				
Glottalized	ˀm	ˀn		ˀʘ̃	ˀǀ̃	ˀ!̃	ˀǂ̃	ˀǁ̃				
Fricatives	f	s								χ		h
Sonorants	w	l, r	y									
Obstruent clusters												
Plain+ q				ʘq	ǀq	!q	ǂq	ǁq				
+voice				ʘ̬q	ǀ̬q	!̬q	ǂ̬q	ǁ̬q				
Plain+ qʰ				ʘqʰ	ǀqʰ	!qʰ	ǂqʰ	ǁqʰ				
+voice					ǀ̬qʰ	!̬qʰ	ǂ̬qʰ	ǁ̬qʰ				
Plain+ q’				ʘq’	ǀq’	!q’	ǂq’	ǁq’				
+voice					ǀ̬q’	!̬q’	ǂ̬q’	ǁ̬q’				
Plain+ χ		t͡χ	ts͡χ	ʘχ	ǀχ	!χ	ǂχ	ǁχ				
+voice		d͡χ	dz͡χ									
Plain+ q͡χ’	pq͡χ’	tq͡χ’	ts͡q͡χ’	ʘq͡χ’	ǀq͡χ’	!q͡χ’	ǂq͡χ’	ǁq͡χ’				
+voice		dzχ’	d͡zq͡χ’	ʘ̬q͡χ’	ǀ̬q͡χ’	!̬q͡χ’	ǂ̬q͡χ’	ǁ̬q͡χ’				
Plain+ ʔ				ʘʔ	ǀʔ	!ʔ	ǂʔ	ǁʔ				
+voice				ʘ̬ʔ	ǀ̬ʔ	!̬ʔ	ǂ̬ʔ	ǁ̬ʔ				
Plain+ h				ʘh	ǀh	!h	ǂh	ǁh				
+voice				ʘ̬h	ǀ̬h	!̬h	ǂ̬h	ǁ̬h				

stream before the release of the consonant (cf. Maddieson, this volume, p.XX text before fig.7).

Güldemann and Nakagawa (2013) provide an overview of both analyses and conclude, on the basis of phonetic, phonological, and typological arguments, in favor of the cluster analysis, criticizing in particular the lack of descriptive and explanatory power of the notion of airstream contour. The stimulating debate about the correct analysis of click consonant systems is not settled yet, and current and planned work on other South African Khoisan languages is likely to shed light on this very interesting issue, and refine our understanding of complex consonant systems.

5.3. Suprasegmental phonology

5.3.1. Tone and the autosegmental revolution

Of all of the phonological properties discussed in this chapter, Africa has contributed the most to our understanding of tone, and the understanding of African tone has in turn considerably influenced the shaping of modern theoretical phonology.

The main contribution of African tone to modern phonological theory is undoubtedly the development of autosegmental phonology. Drawing disproportionately from African tone systems, Leben (1973), Goldsmith (1976), Williams (1976), and others showed up the inadequacies of classical segmental generative phonology, as encoded in Chomsky and Halle (1968), *The Sound Pattern of English*. The resulting autosegmental "revolution" then spread from tone to other aspects of non-linear phonology, including vowel harmony (cf. 3.2), nasal harmony (cf. 3.4), and feature geometry. In fact, Goldsmith's tier metaphor, based originally on African tone, also spread from phonology to morphology (e. g., McCarthy 1981; Marantz 1982), and ultimately to syntax and semantics, such as Sadock (1991) and Yip et al. (1987), among others.

5.3.1.1. The autosegmental revolution

The dominant view within structuralist and early generative phonology was that phonological strings could be subdivided into a succession of discrete segments. Each segment, in turn, consisted of a matrix of simultaneous "distinctive features", generally claimed to be binary, in the Jakobson–Halle tradition. These features had both a classificatory and phonetic function, being designed to capture the phonological oppositions found in languages as well as their output realizations. While not yet receiving very much attention, the assumption in the 1960s was that tone could be characterized with additional features on vowels, as in (6).

(6) Segmental representation of H and HL falling tone

a. [á] = $\begin{bmatrix} \text{+syll} \\ \text{-cons} \\ \text{-high} \\ \text{+low} \\ \text{+back} \\ \text{-round} \\ \text{+HIGH} \end{bmatrix}$ b. [â] = $\begin{bmatrix} \text{+syll} \\ \text{-cons} \\ \text{-high} \\ \text{+low} \\ \text{+back} \\ \text{-round} \\ \text{+FALLING} \end{bmatrix}$

In feature systems such as Wang (1967), based largely on Chinese dialects, high (H) tone could be indicated as [+HIGH], as in (6a), while a high-to-low (HL) falling tone would be [+FALLING], as in (6b). Pike (1948) had split tone systems into what we can refer to as a Chinese- vs. African-type: whereas Chinese dialects have an abundance of contour tones, which Sinologists generally view as indivisible units, contours seem quite secondary in African tone languages, where they are typically analyzed as combinations of the level tones independently attested in the respective language.

The early autosegmentalists showed that tonal representations such as the above run into a number of problems (cf. Hyman 2011a for an update). The first major problem is the existence of extensive evidence against the idea that tones are inseparable features on segments, in particular suprasegmental tone melodies, which are semi-independent from the tone-bearing units (TBU) on which they are realized.

The second problem comes from the representation and analysis of contour tones. In two-height tone systems, for instance, rising and falling tones typically act as sequences of L+H and H+L, respectively, realized on a single TBU. In many African languages, a falling tone shows "edge effects": it appears to be an H tone from the point of view of what precedes it, but an L tone from the point of view of what follows. Thus, if an L tone is raised to a mid (M) tone before an H tone, we expect also that it will be raised before an HL falling tone. Additionally, contour tones may be broken into two separate level tones in certain conditions, as can be seen from the Mende noun forms in (7), which are arranged according to the five tonal melodies attested in this language.

(7) Mende

		Base noun		+=hu 'in'	+=ma 'on'
a.	/H/	kɔ́	'war'	kɔ́=hú	kɔ́=má
b.	/L/	bɛ̀lɛ̀	'trousers'	bɛ̀lɛ̀=hù	bɛ̀lɛ̀=mà
c.	/HL/	mbû	'owl'	mbú=hù	mbú=mà
d.	/LH/	mbǎ	'rice'	mbà=hú	mbà=má
e.	/LHL/	nyàhâ	'woman'	nyàhá=hù	nyàhá=mà

(Leben 1978: 195)

As seen in (7c–e), when the toneless locative enclitics =*hu* 'in' and =*ma* 'on' provide an extra available syllable, falling and rising tones map as H-L and L-H sequences, respectively. The feature specifications [+FALLING] and [+RISING] do not capture these facts, and any attempt to represent the fall and rise as a sequencing of [+HIGH][-HIGH] or [-HIGH][+HIGH] squeezed into a single matrix below the segmental features would be incoherent in a formal framework which otherwise views segments (here, vowels) as a single vertical array of distinctive features.

In establishing autosegmental phonology, Goldsmith's (1976) proposal was thus that an /a/ with high or falling tone should be represented roughly as in (8).

(8) Autosegmental representation of H and HL falling tone

a. [á] = $\begin{bmatrix} +\text{syll} \\ -\text{cons} \\ -\text{high} \\ +\text{low} \\ +\text{back} \\ -\text{round} \\ | \end{bmatrix}$ H

b. [â] = $\begin{bmatrix} +\text{syll} \\ -\text{cons} \\ -\text{high} \\ +\text{low} \\ +\text{back} \\ -\text{round} \\ \wedge \end{bmatrix}$ H L

As seen, Goldsmith proposed a distinction between a segmental tier vs. a tonal tier, which are semi-autonomous in the sense that they are separate, but linked by association lines. This relative autonomy of the two tiers forms the basic premise of autosegmental tonology, which can be stated as follows: tones (Ts) must be represented as semi-autonomous from the tone-bearing units (TBUs) on which they are realized. Among the familiar arguments for a two-tier representation are the three listed below:

non-isomorphism: features of one tier do not line up/synchronize with features of the other tier (i. e., overlapping of segmental versus tonal features)

stability: features of one tier may be deleted without affecting (deleting) features of the other tier

zero representation: features may be specified on one tier but partially/totally lacking on the other tier

5.3.1.1.1. Non-isomorphism

By *non-isomorphism* is meant that associations of tones to tone-bearing units (TBUs) are often not one-to-one. Two tones may link to a single TBU, as in (8b) above. Alternatively, a single tone may link to two TBUs. As a result, a potential contrast may arise as in (9):

(9) Teke-Kukuya

	Medial	Pre-pausal
a.	má-bá	má-ba̅
	| |	| |
	H H	H M
b.	wátá	wāta̅
	╲╱	╲╱
	H	M

(Paulian 1975; Hyman 1987)

Both *má-bá* 'they are oil palms' and *wátá* 'bell' are pronounced H-H in medial position. Before pause, however, there is a rule that lowers an H to M. As seen in (9b), the H → M rule affects the last H feature, not just the last TBU. The contrasting representations in (9a), which had no equivalent in pre-autosegmental tonology, provide the structural difference that results in the surface opposition of H-M versus M-M before pause. These and other facts from Teke-Kukuya showed that at least in some cases we must be able to talk about tones in terms of abstract melodies, rather than concrete features on syllables, moras, or vowels.

Rather than viewing tone as a segmental property, Paulian (1975) recognizes five *schèmes tonals* (tonal melodies) in Teke-Kukuya (H, L, HL, LH, LHL), which can be predictably mapped onto stems of five different shapes (CV, CVV, CVCV, CVVCV, CVCVCV), as shown in (10).

(10) Teke-Kukuya

	Tone melody	Mapping	Example	
a.	/H/	H	-bá	'oil palms'
		HH	-báá	'cheeks'
		H.H	-bágá	'show knives'
		HH.H	-báámá	'liana'
		H.H.H	-bálágá	'fence'
b.	/L/	L	-bà	'grasshopper-killer'
		LL	-bàà	'jealousy'
		L.L	-bàlà	'to build'
		LL.L	-bààlà	'to cleave'
		L.L.L.	-bàlàgà	'to change route'
c.	/HL/	HL	-kâ	'to pick'
		HL	-káà	'to grill'
		H.L	-kárà	'paralytic'
		HL.L	-káàrà	'to be just right'
		H.L.L	-kàràgà	'to be entangled'

d.	/LH/	LH	-sǎ	‘weaving knot’
		LH	-sàá	‘seed necklace’
		L.H	-sàmí	‘conversation’
		LL.H	sààbí	‘roofing’
		L.L.H	ŋ^{w}àrəgí	‘younger brother’
e.	/LHL/	LHL	(ndɛ́-) bvĩ	‘(he) falls’
		LHL	(ndɛ́-) kàây	‘(he) loses weight’
		L.HL	(ndɛ́-) pàlî	‘(he) goes out’
		LH.L	(ndɛ́-) bààmì	‘(he) wakes up’
		L.H.L	(ndɛ́-) kàləgì	‘(he) turns around’

(Paulian 1975: 130–131)

As can be seen from the data in (10), the five tone melodies are assigned to stems regardless of their shape, clearly showing the (semi-)independence of the tonal and segmental tiers. Leben (1973) had proposed exactly the same for Mende, although not without complications and challenges (Leben 1978; Dwyer 1978; Conteh et al. 1983).

While the suprasegmental analysis of tone melodies was first developed by Leben (1973) and Goldsmith (1976), as well as Paulian’s (1975) independent and converging research on Teke-Kukuya, one can go back at least as far as Welmers (1962: 85) to find the same insight, this time concerning Kpelle: “Tonemes must be analyzed in terms of segments between two open transitions”). Welmers describes “the five types of forms” in Kpelle as follows (presented with his transcriptions):

(11) Kpelle

a. High throughout

pá	‘come’	ɓóa	‘knife’
láa	‘lie down’	píli	‘jump’

b. Low throughout

kpòo	‘padlock’	kpàki	‘loom’
tɔ̀nɔ	‘chisel’	tòloŋ	‘dove’

c. High followed by low (low begins on the next vowel if there is one)

yɛ̂	‘for you’	tôa	‘pygmy antelope’
kpôŋ	‘door’	kâli	‘hoe’

d. Mid throughout

kpɔŋ	‘help’	sua	‘animal’
see	‘sit down’	kali	‘snake’

e. Mid with first vowel, then high followed by low

tɛɛ̂	‘black duiker’	konâ	‘mortar’
yuɔ̂	‘axe’	kpanâŋ	‘village’

(Welmers 1962: 86)

Note, first, that Welmers uses only one tone mark per word. He thus writes /kâli/ for what is pronounced [kálì] 'hoe', that is, H-L. Second, there is no difficulty reducing Kpelle to an underlying two-level system: the M that occurs in the MHL melody in (11d) can be analyzed as a L which is raised before H, and the "M throughout" melody in (11b) is underlyingly /L-H/, as is seen when two "mid throughout" words occur in sequence:

> In mid-mid, for the dialect being described here, the first mid has a slightly rising allotone … In some areas, the first mid is level, but the second mid begins a little higher and drops quickly to the level of the first. In still other areas, both phenomena occur: the first mid ends a little higher, and the second begins a little higher. In all cases, the conjunction of two mids is accompanied by an upward pressure (Welmers 1962: 87, note 2).

Welmers goes to considerable trouble to justify his suprasegmental analysis, with one tonal melody per word, or, in his terminology "one toneme between two open transitions" (1962: 86). What is clear is that he had the same insight as Leben, Goldsmith, and Paulian concerning the semi-autonomy of the five tonal patterns. However, he did not have an adequate framework such as autosegmental phonology to express this insight.

The formal recognition of tonal melodies then expanded beyond tone and even beyond phonology, inspiring analogous non-linear analyses of Semitic templatic morphology (McCarthy 1981) and partial reduplication (Marantz 1982).

5.3.1.1.2. Stability effects

Another argument for a separate tonal tier is what is known as *stability effects*: a tone may survive even when its TBU is deleted, giving rise to so-called "floating" tones, as the following two examples show. In Twi, two dialectal realizations of /mé + ɔ̀bó/ 'my stone' are attested, as shown in (12).

(12) Twi

```
                                  → a.  mɪ      bʊ  →  mɪ      bʊ    [mî bʊ́]
                                        |       |      ↑⋱     |
/mɪ   ɔbʊ/   'my stone'                 H   L   H      H   L   H
  |   |  |
  H   L  H                        → b.  mɪ      bʊ                  [mí ˡbʊ́]
                                        |       |
                                        H   L   H
```

(Stewart 1965; Schachter and Fromkin 1968)

As seen in the first step of the derivation, when the vowel of the noun prefix /ɔ̀-/ is deleted, its L appears unlinked on its tier. In (12a) it reassociates to the preceding vowel, creating a HL falling tone. In (12b) it remains unlinked and conditions a

following downstep (ꜜ). Compare the following examples from Laal, where the segmental content of the connective (used here as a relative marker) may be completely deleted without affecting its H tone, which is then realized on the preceding TBU, making tone the only mark of the connective construction (cf. (13c) with (13a)).

(13) Laal

a.	sū	nīīr			‘the water is hot’			(water be.hot)	
b.	sū	yí	nīīr		‘hot water’			(water which be.hot)	
c.	sū	yí	nīīr	>	*sū*	*nīīr*	>	*sū*	*nīīr*
	|	|	⋁		|	⋁		⌈⋱	⋁
	M	H	M		M H	M		M H	M

(Lionnet, field notes; Boyeldieu 1982: 13)

This stability of tone is also widely attested in diachrony: tones very often survive the historical reduction and deletion of their TBU. Deletion of segmental material is actually the main origin of floating tones, as we will see in the next paragraph.

5.3.1.1.3. Zero representation

The Laal example above also illustrates the third argument in favor of autosegmental tiers: the possibility of a *zero representation* on one or the other tier. On the one hand, there are toneless morphemes such as the enclitic postpositions =hu ‘in’ and =ma ‘on’ in Mende already presented in (7) above, which are unspecified on the tonal tier. Such toneless morphemes are often assigned the tone of a neighboring TBU, which is the case for the Mende postpositions, as shown in (14) for =hu ‘in’.

(14) Mende

a.	/kɔ́=hu/	>	kɔ́=hú
	|		⌊⋱
	H		H
b.	/mbû=hu/	>	mbú=hù
	⋀		| ⋮
	H L		H L
c.	/mbǎ=hu/	>	mbà=hú
	⋀		| ⋮
	L H		L H

(Leben 1978: 195)

On the other hand, there are tonal morphemes (such as the H floating tone in the Laal example in (13) above), that is, morphemes that are specified on the tonal tier

but not on the segmental tier. Such morphemes are extremely frequent in African tone languages. The historical deletion of a morpheme's segmental content may lead it to become purely tonal. Such tonal morphemes may have exactly the same properties as segmental morphemes, as Van de Velde shows for Eton:

> Floating tones arise from concatenative segmental morphology and can therefore best be analyzed as morphemes (affixes, clitics, words) that combine with stems in a certain linear order (Van de Velde 2009: 42–43).

Van de Velde identifies tonal prefixes, clitics, and words in Eton by analyzing the various properties of H tone copying and spreading in the language. In Eton, a structurally linked H tone followed by a boundary (word #, clitic =, or affix –) is copied and attaches to the following low-toned syllable with different consequences depending on the type of boundary it crosses, as schematized in (15) below. When crossing an affix boundary, a floating H tone spreads to the following L-toned syllable, replacing its L tone. This H-tone may further spread to the next L-toned syllable, forming a HL contour (15b).[4] When crossing a clitic boundary, the floating H tone replaces the L tone of the following syllable, but may not spread to a subsequent L-toned syllable (15c). Finally, when a floating H crosses a word boundary, it does not replace the L of the following syllable to which it attaches, but only delinks it. The presence of the floating L tone thus created is evidenced by the downstep it causes on a following H, as in (15d).

(15) Eton

a.	H-tone copy:	cv́{#, =, –}	>	cv́H{#, =, –}
b.	Affix boundary:	cv́H-cv̀(cv̀)	>	cv́-cv́(cv̂)
c.	Clitic boundary:	cv́H=cv̀(cv̀)	>	cv́=cv́(cv̀)
d.	Word boundary:	cv́H # cv̀(cv́)	>	cv́ # cv́(ꜜcv́)

(Van de Velde 2009: 44–46)

Crucially, the same rules apply to purely tonal morphemes, as illustrated by the segmental/non-segmental allomorph pairs in the following examples (floating tones are underlined and deleted tones crossed out in the autosegmental representations):

(16) Eton

Eton augment (prefix): segmental í- vs. non-segmental allomorph H-

a.	*í- bì-lɔ̀lì*	#	*bí*	>	/í – bílwâlì bí/
	AU-8-duck		VIII.DEM		
	'these ducks'				H ~~L~~ L
b.	*H-ɛ̀-dʒɔ̀ŋ*	#	*dí*		/Ø – ɛ́dʒɔ̂ŋ dí/
	AU-5-clan		V.DEM		
	'this clan'				H ~~L~~ L

(Van de Velde 2009: 44–46)

[4] This H tone spreading rule is a regular process in Eton (Van de Velde 2009: 45).

(17) Eton

Eton connective (clitic): segmental cv́= vs. non-segmental allomoroph H=

a. mə̀-vùl # mə́=ì-lɔ̀lì > /məvùl m[ə́]=ílwàlì/ (V deletion)
6-feather VI.CON=7-duck
'the feathers of a duck' H ~~L~~

b. mə̀-vùl # H=bì-lɔ̀lì > /məvùl Ø=bílwàlì/
6-feather VI.CON=7-duck
'the feathers of a duck' H ~~L~~
(Van de Velde 2009: 44–46)

(18) Eton

Eton locative preposition (word), segmental á vs. non-segmental allomorph H

a. á # mə̀-dʒɔ́ŋ > /á # mə́ ˬdʒɔ́ŋ/
LOC 6-hole
'in the holes' H L ˬH

b. H # ɛ̀-dʒɔ́ŋ > /Ø # ɛ́ ˬdʒɔ́ŋ/
LOC 5-hole
'in the hole' H L ˬH
(Van de Velde 2009: 44–46)

Van de Velde further shows that the same three processes are attested with tonal morphemes that do not have any segmental allomorphs: all tonal morphemes in Eton can thus be affixes, clitics or independent words, thus preserving the morphological category of their segmental "ancestor".

The importance of tonal morphology cannot be underestimated: the grammar of many African languages crucially relies on tonal morphemes. Many northwest Bantu languages, for example, mark tense-aspect-mood (TAM) distinctions on verbs almost exclusively with tonal affixes as shown in the Abo verb paradigms presented in (19–21).

(19) Abo

a.	present:		L-	Verb	-H[5]	
b.	past:		H-	Verb	-H	
c.	perfect:	má	L-	Verb	-H	
d.	future:	káà		Verb	-L	
e.	stative:			Verb	-HL	(+umlaut)
f.	imperative:			Verb	-HL	
g.	subjunctive:		H-	Verb	-HL	

(Hyman and Lionnet 2012)

[5] Additionally, L-toned clitic pronouns are realized with a LH contour when followed by a verb in the present tense, e. g., *à* → *ǎ* '(s)he'.

(20) Abo
Low-toned verb *pɔ̀ŋɔ̀* ‘make’

TAM	underlying	pre-pausal	+ object (*bìtámbé* ‘shoes’)	
present	/ă L-pɔ̀ŋɔ̀-H/	ă pɔ̀ŋɔ̀	ă pɔ̀ŋɔ́ bítámbé	‘he is making shoes’
past	/à H-pɔ̀ŋɔ̀-H/	à pɔ̂ŋɔ̀	à pɔ́ˬŋɔ́ bítámbé	‘he made shoes’
perfect	/à má L-pɔ̀ŋɔ̀-H/	à má pɔ̀ŋɔ̀	à má pɔ̀ŋɔ́ bítámbé	‘he has made shoes’
future	/à káà pɔ̀ŋɔ̀-L/	à káà pɔ̀ŋɔ̀	à káà pɔ̀ŋɔ̀ bìtámbé	‘he will make shoes’
stative	/à pòŋò-HL/	à pòŋó	à pòŋó bìtámbé	‘he has made shoes’
imperative	/pɔ̀ŋɔ̀-HL/	pɔ̀ŋɔ́	pɔ̀ŋɔ́ bìtámbé	‘make shoes!’
subjunctive	/sá H-pɔ̀ŋɔ̀-HL/	sá pɔ́ˬŋɔ́	sá pɔ́ˬŋɔ́ bìtámbé	‘let’s make shoes!’

(Hyman and Lionnet 2012)

(21) Abo
High-toned verb *sálá* ‘use’

TAM	underlying	pre-pausal	+ object (*bìtámbé* ‘shoes’)	
present	/ă L-sálá-H/	ă ˬsálá	ă ˬsálá bítámbé	‘he is using shoes’
past	/à H-sálá-H/	à sálá	à sálá bítámbé	‘he used shoes’
perfect	/à má L-sálá-H/	à má ˬsálá	à má ˬsálá bítámbé	‘he has used shoes’
future	/à káà sálá-L/	à káà sálá	à káà sálá bìtámbé	‘he will use shoes’
stative	/à sélé-HL/	à sélé	à sélé bìtámbé	‘he has used shoes’
imperative	/sálá-HL/	sálá	sálá bìtámbé	‘use shoes!’
subjunctive	/sá H-sálá-HL/	sá sálá	sá sálá bìtámbé	‘let’s use shoes!’

(Hyman and Lionnet 2012)

These paradigms are a clear illustration of the analytical power of autosegmental tonology, whose simple tools — here floating tones — elegantly account for very complex tonal phenomena. Two tonal prefixes account for the tonal alternations observed at the left edge of the verb. An H- prefix accounts for the extra H tone coming in from the left in the past and subjunctive forms of L-toned verbs, while

an L- prefix in present and perfect forms explains the initial downstep on H-toned verbs after an H or LH subject pronoun (cf. Pulleyblank 1985, 1986 for more on tonal cyclicity).

Additionally, three tonal suffixes account for the tonal alternations taking place at the right edge of the verb. The -H suffix on the present, past and perfect, realized only when not pre-pausal, accounts for an alternation resembling what Meeussen (1967: 111) and subsequent authors have labeled "metatony" in other Bantu languages: the final H tone of past, present and perfect verb forms attaches to the last syllable of the verb only when not pre-pausal, and additionally spreads onto the class prefix of a following noun, as shown in (22).[6]

(22) ă pòŋɔ́ bí-támbé 'He is making shoes' (present)

L H ~~L~~ H

The -L suffix posited for the future tense is never realized as such, but prevents the final H of H-toned verbs from spreading onto the initial syllable of the following word, which is what one would expect a final H to do in Abo (cf. the metatonic -H). Finally the -HL suffix on stative, imperative and subjunctive forms accounts for the extra H tone realized on the final syllable of the verb, and for the fact that this H tone does not spread onto the next word, as shown in (23).

(23) à pòŋó bì-támbé 'He has made shoes' (stative)

L H L L H

We will see in section 5.3 below cases of non-concatenative tonal morphology that do not lend themselves to the same type of analysis and thus still constitute analytical challenges.

While there had been early descriptions of tonal grammatical morphemes, studies in the 1970s showed that floating tones could also be lexical. A particularly persuasive case comes from Aghem. Although the two nouns *kɨ́-fú* 'rat' and *kɨ́-wó* 'hand' are both pronounced H-H in isolation, the phrases in (24) show that they exhibit quite different tonal behaviors in the following contexts (where the noun class prefix *kɨ́-* deletes in the presence of the following modifiers):

[6] This is the analysis proposed by Hyman and Lionnet (2012) for Abo. The term "metatony" corresponds to different phenomena in different languages.

(24) Aghem

	+ *kìà* 'your (sg.)'			+*kín* 'this'			Underlying
a.	fú	kɨ́à	'your (sg) rat'	fú	kɨ́n	'this rat'	/fú/
	H	L		H	H		
b.	wó	kɨ̀à	'your (sg) hand'	wó	ˬkín		
	H L	L		H	L H	'this hand'	/wó ̀/

(Hyman 1979)

In the forms on the left, each noun is followed by the L tone second person singular possessive pronoun /kɨ̀à/. As seen in (24a), the H of *-fú* 'rat' spreads onto the pronoun to derive an HL falling tone realization. H tone spreading does not occur after *wó* 'hand' in (24b). The reason is that the root /-wó ̀/ carries a lexical floating L tone which is absent on the root/-fú/. That the floating tone is not simply an ad hoc device added for the sole purpose of blocking H tone spreading is seen from the forms on the right, where each root is followed by the H demonstrative /kɨ́n/ 'this'. As seen, the floating L tone conditions a downstep on the demonstrative in (24b), but not in (24a), where the floating L tone is absent.

Medʉmba illustrates a complex case of interaction between grammatical and lexical floating tones. The H-toned nouns in (25) behave very differently when surrounded by other H-toned nouns, as in the associative constructions in (26).

(25) Medʉmba

	Isolation		Underlying	
a.	sáŋ	'bird'	/sáŋ/	(noun class 1a, no prefix)
b.	mɛ́n	'child'	/ ̀mɛ́n/	(noun class 1, L prefix)
c.	yú	'thing'	/ ̀yú ̀/	(noun class 7, L prefix + lexical floating L)

(Voorhoeve 1971, Hyman 2003a)

(26) Medʉmba

	Isolation			/Possessee +	H +	Possessor/
a.	tɨ́ sáŋ	[˥ ˥]	'tree of bird'	/tɨ́	́	sáŋ/
b.	tɨ́ ˬmɛ́n	[˥ ˥]	'tree of child'	/tɨ́	́	̀mɛ́n/
c.	yú ˬsáŋ	[˥ ˥]	'thing of bird'	/ ̀yú ̀	́	sáŋ/
d.	yú ˬˬmɛ́n	[˥ ˩]	'thing of child'	/ ̀yú ̀	́	̀mɛ́n/

(Voorhoeve 1971; Hyman 2003a)

The downstep in (26b) is caused by a floating L-tone prefix (which is present in all but noun class 1a). The downstep in (26c) cannot be due to a floating L prefix, which class 1a /sáŋ/ 'bird' lacks, as evidenced by the absence of downstep in (26a), and is hence to be ascribed to the effect of a floating L stem tone following the

H stem /`yú`/. Finally, the double downstep in (26d) results from a floating LHL sequence between two linked H tones. Each floating L causes downstep of the following H. The Floating H of the connective fails to be realized but its downstep remains, adding up to a double downstep on the H of *mén*, as illustrated in (27).

(27) Medʉmba

```
Proto-Bantu:  *kì-júmà   kí-á   mù-jánà
Medʉmba:        yú              mɛ́n
                 |               |
              L H L     H     L H L
              > H      ↓H      ↓H
              > H       Ø     ↓↓H
```

(Voorhoeve 1971, Hyman 2003a)

In all the above examples, the posited "abstract" floating H and L tones do exactly what we expect H and L tones to do: H tones are expected to spread onto a following L under certain conditions; L tones are expected to (i) block an H from spreading onto a following L and (ii) condition a downstep when wedged between two H tones. As discussed in some detail in Hyman (2003b, 2011a), the floating tone hypothesis provides an analytic framework that both accounts for the observed facts as well as accounting in a direct way for the insight that roots such as /-wó `/ in Aghem act "as if" they have an L tone following them. The effects of the floating L are "natural" in the sense of phonetically plausible. In contrast, a diacritic approach, which might set up the arbitrary tone classes $H_1$ versus $H_2$ for /-fú/ 'rat' and /-wó `/ 'hand', respectively, is not only uninteresting, but makes the prediction that the properties could have aligned in an unattested way, e. g., with H_1 triggering both H tone spreading AND downstep and H_2 conditioning neither. It would be hard to express such a distinction in a floating tone analysis. Since such an alignment of properties is unknown, this is a good result and hence a strong argument for floating tones, if not ultimately for autosegmental representations.

One could argue that the properties of Aghem H tones are not explainable in synchrony, but rather are due to historical changes. We know that floating L tones in Aghem are due to the loss of an L-toned syllable (cf. Proto-Bantu **-bókò* > Aghem /-wó`/ 'hand'). One could thus argue that from a purely synchronic point of view, floating L tones are just another kind of diacritic. In other words, there's really no difference between the two approaches.

Clements and Ford (1977, 1979), however, show that there might be a good reason not to equate floating tones with diacritics. They first demonstrate that non-automatic, phonological downstep canonically occurs when a floating L tone is wedged between two linked H tones. Their argument is based on the phonological consequences in modern Kikuyu of a historical process of tone shift affecting words of all classes, whereby each original tone shifted one TBU to the right across the word, delinking final L tones. This is illustrated in (28) by lexical cor-

respondences between Proto-Bantu, Kikuyu and closely related Tharaka in which this tone shift did not take place (Clements and Ford 1979: 187).

(28)

		Proto-Bantu	*Tharaka*	*Kikuyu*
a.	'belonging to sb. else'	*-yéné	-éné	-ènɛ́
b.	'way of releasing oneself quickly'	(*-dèk- 'to leave')	moěrè-káŋgérié	moèrɛ́-kàŋgérié
c.	'tree'	*-tí	mò-té	mò-tě
d.	'bush land'	*-càká	kè-ðàká	ɣèðàkǎ
e.	'bamboo'	*-dàŋgí̩	mò-ràŋgí	mò-ràŋgǐ
f.	'charcoal'	*-kádà	è-kárà	ì-kàrá↓
g.	'big'	*-nénè	-nénè	-nènɛ́↓
h.	'teardrop'	*-yí̩còdì̩	rɛ̌:ðɔ́rì	reìðɔ́rì↓
i.	'firewood'	*-kúnì̩	rò-kó	rò-kǒ↓

(Clements and Ford 1979: 187)

Clements and Ford then proceed to show that words that used to end with a L tone still have a lowering effect on a following H (represented by the final downstep sign ↓ in (28f–i). Clements and Ford analyze this downstep as the effect of a floating L tone: the final L in those forms was historically delinked, but not deleted, much like in Aghem, as illustrated in (29).

(29) *i ka ra > i ka ra > i ka ra 'charcoal'

L H L L H L L H L̲

Their main argument against a diacritic analysis and in favor of the floating L tone hypothesis is the existence of phonological rules in Kikuyu that manipulate those floating tones, such as the two rules illustrated in (30).

(30) Kikuyu

a.	ndɔ̀:nìrɛ́↓	mɔ̀ɣèràniá	nà	ɲjòɣóná↓	'I saw the examiner and Njũgũna'
b.	ndɔ̀:nìrɛ́	mɔ̀ɣèrà**niá**↓	nà	ɲjòɣóná↓	(rule 1)
c.	ndɔ̀:nìrɛ́	mɔ̀ɣèràniá	**ná**	**ɲjó↓ɣó**ná↓	(rule 2)
d.	ndɔ̀:nìrɛ́	mɔ̀ɣèràniá	ná	ɲjó↓ɣóná↓	(other rules)

(Clements and Ford 1979: 204)

Rule 1 in (30b) applies when a downstep-inducing verb is in an "assertive" tense and is followed by a phrasal constituent: in that case, the verb-final downstep is not realized on the following constituent but shifted to the end of this constituent. Rule 2 in (30c) causes a downstep preceding an L-toned TBU to be realized on the next H tone, while all the intermediate L tones are raised to H. A diacritic analysis of downstep similar to the one we imagined (and rejected) for Aghem earlier would fail to account for such facts.

The above and other arguments thereby justify the basic premise of autosegmental tonology that tones are semi-autonomous from their TBUs.

5.3.1.2. Analyses of tonal systems and processes

The conceptualization of tone as "semi-autonomous" from other vowel features was the traditional view that pre-autosegmental phonologists were hard-put to formalize. The autosegmental revolution, by providing the adequate analytical and descriptive tools, helped phonologists better understand the often complex tonal processes at work in many African languages.

Consider, for example, the question of how tone spreading, such as that illustrated in (24a) above, should be represented. In pre-autosegmental phonology, Hyman and Schuh (1974) expressed such a rule roughly as in (31). Goldsmith's (1976) autosegmental representation, on the other hand, is shown in (32).

(31) H-L > H-H͡L

(32)
```
V  C  V
└──────┐
H     L
```

Whereas Goldsmith's representation clearly indicates that there is a single H feature involved in tone spreading, Hyman and Schuh's formulation implies that an H feature is being copied onto the following vowel, consistent with the conception of assimilation given in *The Sound Pattern of English*.[7] However, consider Hyman and Schuh's prose statement about what they feel is going on:

> "Spreading is an assimilatory process of the progressive or perseverative type, rather than of the regressive or anticipatory type. That is, the earlier tone appears to last too long, rather than the later tone starting too early. This in fact is the way that we should like to view this phenomenon. There is no process of tone copying or tone addition in the second syllable. Rather, the earlier tone simply enlarges its domain" (Hyman and Schuh 1974: 88).

Clearly Hyman and Schuh had something in mind that they could not formalize, but which is conceptually identical to the autosegmental representation of tone spreading in (32).

Goldsmith's representation, on the other hand, makes it very easy to account for complex cases of tone spreading, such as the systematic H- and L-spreading

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[7] Actually, Hyman and Schuh's formulations are even worse, since they use F and R instead of H͡L and L͡H. Their formulation /ábà/ → [ábâ] is at best ambiguous between the two interpretations. It should be clear, however, that marking tone words via accents on vowels cannot distinguish between the two types of Teke-Kukuya H-H word in (9).

attested in Yoruba: as shown in (33), both H and L systematically spread on the syllable to the right, thus creating contour tones.

(33) Yoruba partial HTS and LTS
/má yọ̀ mí rà wé/ [máyọ̀mǐ râ wě] 'Mayomi bought books'
H L H L H
(Laniran and Clements 2003: 207)

High tone spreading may also cause delinking of the following L tone, as in Dagbani, where the delinked L causes downstep of the following H. This, again, is easily represented in autosegmental terms, as seen in (34) (see also the Twi example in (12b)).

(34) Dagbani
págá + kòdú > pág(á) kó↓dú 'woman's banana'
H L H H L H
(Hyman 1993)

Tone spreading may also be unbounded, as shown in the Ndebele examples in (35). In this H-marked language, i. e., with an H versus Ø tone inventory (cf. Hyman 2001, and last paragraph of this section), a lexical H spreads to all the following toneless TBUs across the word up to the antepenultimate TBU, as illustrated in (35) below, where underlying H tones are underlined. (The stem-initial H is downstepped by a subsequent rule.)

(35) Ndebele
a. ú-kú-lima 'to cultivate'
b. ú-kú-lím-is-a 'to cause to cultivate' (output: ú-kú-↓lím-is-a)
c. ú-kú-lím-ís-el-a 'to cause to cultivate for' (output: ú-kú-↓lím-ís-el-a)
H
(Sibanda 2004)

Such unbounded tone spreading may be accompanied by tone deletion in languages that allow only one tone per word. Such a tone shift is illustrated in the Zulu example in (36): The underlying H tone of each of the three verb forms is systematically realized only on the antepenultimate TBU, a process which can be analyzed as the same spreading rule as in Ndebele, simply followed by delinking of the H from all its TBUs except the antepenult, as illustrated in (37).

(36) Zulu

a.	u̲-kú-hleka	'to laugh'
b.	u̲-ku-hlék-is-a	'to amuse'
c.	u̲-ku-hlek-ís-an-a	'to amuse each other'

(Downing 1990: 265)

(37) Zulu

'to amuse each other'

u̲-ku-hlek-is-an-a > u̲-ku-hlek-ís-an-a [ù-kù-hlèk-ís-àn-à]

H H

(Downing 1990: 265)

The autosegmental revolution has also made possible a better analysis and understanding of how African (as well as other) tone systems are structured. Once the possibility of underspecifying autosegments is added to the autosegmental principle of semi-independence of the tonal and segmental tiers, two-height systems may be analyzed in at least four ways. As explained in detail in Hyman (2001), in additional to the straightforward equipollent /H, L/ analysis that is illustrated, among others, by Aghem, Medʉmba and Abo above, one may propose a privative analysis by underspecifying either H or L, or having a third zero value /Ø/ in addition to underlying H and L: /H, L/ versus /H, Ø/ versus /L, Ø/ versus /H, L, Ø/.

As we have shown, the complex tonal alternations and processes presented in this paragraph would be extremely difficult to account for in a purely segmental approach. The semi-autonomy of the segmental and tonal tiers proposed by autosegmental tonology, on the other hand, not only offers an elegant account of both the historical stability of tones and the complex rules that govern their realization on TBUs, but has also provided Africanists with analytical tools of unprecedented efficiency that caused a tremendous leap forward in our understanding of tone systems, both in Africa and outside.[8]

It would be interesting to speculate on the form the subsequent autosegmental revolution might have taken without the impetus of African tone. Would present-day phonologists such as Yip (1980, 1989, 2002), Chen (2000), Bao (1999), Duanmu (1994), and others be talking as readily about autosegmentalized H(igh) and L(ow) features for Chinese tonal contours if it were not for the input from Hausa, Igbo and Mende? Would Pierrehumbert (1980) have developed an analogous approach to intonational systems such as in English (subsequently applied to Japanese by Beckman and Pierrehumbert [1986])? And what would our view be of other phonological phenomena to be discussed below, which also have autosegmental properties?

[8] See Odden (1995) for an overview of African tone systems. See, among others, Hyman (2010) for an Africanist analysis of a non-African tone system.

5.3.2. Harmony systems

5.3.2.1. Vowel harmony

5.3.2.1.1. The autosegmental account

African languages are well known for providing vast numbers of phonological systems with vowel harmony, particularly of the advanced tongue root (ATR) and height varieties (cf. Maddieson, this volume, section 3.1). Stewart (1967), cited in Chomsky and Halle (1968), and Schachter and Fromkin (1968) educated early generations of generative phonologists as to the intricacies of Akan ATR harmony, illustrated in (38), where the vowels of the verbal prefixes /wU-/ 'he' and /bE-/ (future) take the [ATR] value of the vowel of the verb stem they are added to.

(38) Akan

	Vowel inventory:		[+ATR]:	i, e, ɜ, o, u
			[-ATR]:	ɪ, ɛ, a, ɔ, ʊ
a.	/wU-bE-núḿ/	→	wú-bé-núḿ	'he will suck it' (*núḿ* 'suck')
b.	/wU-bE-nɔ́ḿ/	→	wʊ́-bɛ́-nɔ́ḿ	'he will drink' (*nɔ́ḿ* 'drink')

(Stewart 1967)

However, it was Clements (1977a, 1981) who applied the new autosegmental framework both to Akan and to vowel harmony in general. Although the existence of transparent neutral vowels had been known from Finnish and Hungarian, Clements provided an autosegmental account of opaque neutral vowels, based on Akan. Since this language has both prefixal and suffixal harmony, as seen in (39), he also was able to establish the general property of "root-control", illustrated in (39) (/O, I/ = non-specified for [ATR]).

(39) Akan

O +fItI + I [o-fiti-i] 'he punctured (it)'

[+ATR]

(Clements 1977: 114)

For Clements this meant that the directionality of assimilation in vowel harmony need not be stipulated, but rather followed from convention: the root features [+ATR] and [ATR] spread left and/or right, as needed, so that no vowel would lack a specification and, hence, be ill-formed.

5.3.2.1.2. ATR harmony

Since Clements, Niger-Congo and Nilo-Saharan ATR harmony systems have figured prominently in the theoretical study of vowel harmony. At the same time, they have contributed to theories of vowel features and feature geometry. For extensive documentation and typological generalizations concerning such African vowel harmony systems, see Casali's (2003) survey of over 100 Niger-Congo and Nilo-Saharan languages, where he shows in particular that the dominant value of the feature [ATR] in a language depends on the structure of its vowel inventory: [+ATR] tends to be dominant in languages with an [ATR] contrast among high vowels, while [-ATR] is dominant in systems where [ATR] contrasts only for non-high vowels.

Government or dependency theories involving the vowel elements I, U, A were developed by Kaye, Lowenstamm and Vergnaud (1985) and Rennison (1986) based on Kpokolo (Kru) and Koromfe (Gur) respectively, two languages whose vowel systems make active use of the [±ATR] distinction. African ATR systems also provide the fuel for Archangeli and Pulleyblank's (1994) grounded phonology and a number of subsequent optimality theoretic works, including Bakovic (2000) and Krämer (2003).

As in the case of tone, African ATR harmony has not only contributed to linguistic theory, but also to the way vowel harmony is described in other languages. Hall and Hall (1980), for example, are explicit in applying their Africanist insights to Nez Perce, whose unusual harmony, they suggest, should be analyzed in terms of ATR. There are striking resemblances between the vowel harmony found in the Pacific Northwest and that found on much of the Asian land mass. It is thus not surprising that Advanced/Retracted Tongue Root (ATR/RTR) has also been recognized in Tungusic languages (Li 1996, Zhang 1996) and may very well be implicated in languages extending from Tibetan to Chukchee (Anderson 1980: 34).

5.3.2.1.3. Height harmony

African languages have also provided the world's greatest supply of vowel harmony systems based on vowel height. Best known are those found in Bantu, exemplified below from Ganda in (40).

(40) Ganda

	plain stem	*stem + causative*	*stem + applicative*	
a.	lim-a	lim-is-a	lim-ir-a	'cultivate'
b.	túm-a	túm-is-a	túm-ir-a	'send'
c.	land-a	land-is-a	land-ir-a	'climb'
d.	sek-a	sek-es-a	sek-er-a	'laugh'
e.	kól-a	kól-es-a	kól-er-a	'work'

As seen, the causative and applicative suffixes surface with the vowel [i] when preceded by /i, u, a/, but with [e] when preceded by /e/ or /o/. Sometimes called "mid harmony," variants of height harmony are found in most Bantu languages (Hyman 1999).

The relation to ATR has not been missed by Africanists or theoreticians such as Clements (1991), who provides a geometric model of vowel aperture designed to capture both types of vowel harmony. Vowel height is conceptualized as a uniform phonological dimension corresponding to the feature [±open] and forming an "abstract phonological space which is divided into a series of regions, or *registers*." Each register is characterized by a binary opposition between [+open] and [-open], and there are as many registers as there are contrastive vowel heights in the language. A language with three vowel heights and an [±ATR] distinction among high vowels would thus be represented as in Figure 1.

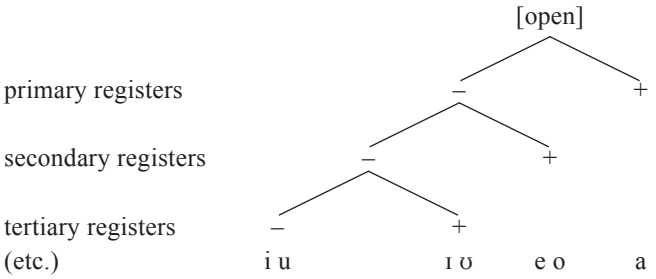


Figure 1. A hierarchical conception of vowel height (after Clements 1991: 27)

Finally, within Optimality Theory, Beckman's (1997) notion of positional faithfulness is based on Shona height harmony, which has the same properties as in Ganda, Swahili, Chewa, Bemba, and so forth (cf. section 4.4.4 below).

Other types of height harmonies are attested in African languages that depart from typical Bantu mid-harmony in many ways and illustrate interesting properties. Kera has a height harmony process very reminiscent of the typical cases of ATR harmony seen above, in that one value of the feature [high] is dominant, as shown in (41): if a [+high] vowel appears in a polymorphemic word, all vowels within this word become [+high]. Height harmony applies across a morphological boundary, and is neither root-controlled nor directional.

(41) Kera

a.	/gus-ɛ/	→	gusi	'to buy'
b.	/sɛːn-u/	→	siːnu	'his brother'

(Pearce 2003: 8)

At least one case of multiple height harmonies is attested. Laal – which also has two types of rounding harmony (cf. 3.2.1.4 below) – has two different height

harmonies that operate in opposite directions: high-harmony, whereby a root-initial [+high] vowel triggers raising of a following mid vowel, is perseverative, as shown in (42), while low-harmony, which enforces agreement in the feature [low] between a non-high vowel and the following vowel, is anticipatory, as shown in (43) (note that low harmony does not apply in (42), since the target vowel is [+high]).[9]

(42) Laal

a.	mín ‘ask’	+ -ə́r	→	mín-ír	‘ask me’
b.	mín ‘ask’	+ -ár	→	mín-ár	‘ask him’

(Lionnet, field notes, cf. Lionnet 2016: 9)

(43) Laal

a.	dāg ‘drag’	+ -ə́n	→	də̀g-ə́n	‘drag me’
b.	dāg ‘drag’	+ -nŭŋ	→	də̀g-nŭŋ	‘drag you (pl.)’
c.	cə̄r ‘look for’	+ -ár	→	càr-ár	‘look for him me’

(field notes, cf. Lionnet 2016: 9)

Such a complex case, which involves both distinct behaviors for the two height features [high] and [low], and a conflict in directionality, questions the role of positional prominence in accounting for directionality in vowel harmony: high-harmony seems to illustrate both root prominence and stem-intial prominence (the initial CV sequence is phonologically prominent, cf. Lionnet 2016: 7–8), while low-harmony on the other hand targets the prominent vowel, the trigger vowel being in this case reminiscent of Walker’s (2005) “weak triggers”. Laal is thus characterized by a complex harmony system where the prominent vowel triggers one harmony (high), but undergoes two (low, and rounding, cf. next section).

5.3.2.1.4. Rounding harmony

Contrary to ATR and height harmony, rounding harmony in African languages has not figured prominently in the literature: Nawuri (Casali 1990, 1995; cf. section 2.2 above) is the only African language in Kaun’s (1995, 2004) typological survey of rounding harmony systems. This is most probably due to the fact that rounding harmony is far less frequent in African languages (at least in the available documentation) than ATR or height harmony. It is, however, attested in quite a few languages south of the Sahara, for example, the Bantu languages Gunu, Punu, Duala, Wongo, Koyo, Mboshi, Lengola, Maore, and Yao, but also Kera (Chadic), and most probably many more still awaiting description. It appears to often have properties in those languages that differ from the better-known cases of Turkic, Mongolian or Tungusic.

[9] It is difficult to know whether root control is involved in Laal high harmony, since the language does not have any prefixes.

Laal is a perfect case in point, where two morphologically conditioned rounding harmony processes co-exist. The first one is a systematic anticipatory rounding harmony process that applies between noun or verb roots and pronominal (possessive or object) suffixes, as shown in (44).

(44) Laal

a.	/tɨ́r+-òn/	>	túr-ùn	‘put her across’	
b.	/dəg+-òn/	>	dòg-òn	‘drag her’	
c.	/léér+-nǔ/	>	lüóór-nǔ	‘wrap us (excl.)’	([üoo] = /øː/)

(Lionnet 2016: 15–16, in press)

The second process is a rare and intriguing doubly triggered rounding harmony, applying within stems and between stems and number-marking suffixes, whereby the first vowel of a stem is rounded in the presence of a round V2 of identical height (high or mid) and backness specification ([-front]), only if the root contains a labial consonant, which acts as a co-trigger with the round V2. The labial consonant may be before (45a) or after (45b) the target (note that most words in Laal are maximally disyllabic). This is illustrated in (45) below, where a check mark indicates that a specific condition (Height, -Front or Lab) is met, while a star indicates that it is not.

(45) Laal

					Height	-Front	Lab
a.	/ɓɨ̀r-ú/	→	ɓù̱r-ú	‘hook-pl’	✓	✓	✓
b.	/təb-ó/	→	tò̱b-ó	‘fish(sp.)-pl’	✓	✓	✓
c.	/mə̀ə̀g-ú/	→	mə̀ə̀g-ú	‘tamarind-pl’	*	✓	✓
d.	/bìrú /	→	bìrú	‘burn’	✓	*	✓
e.	/gɨ́n-ù/	→	gɨ́n-ù	‘net-pl’	✓	✓	*
f.	/mèn-ú/	→	mèn-ú	‘road-pl’	*	*	✓
g.	/dən-ú/	→	dən-ú	‘tree(sp.)-pl’	*	✓	*
h.	/nèn-ù/	→	nèn-ù	‘pus-pl’	*	*	*

(Lionnet 2016, in press)

Such cases of cumulative effects, or “subphonemic teamwork” (Lionnet 2016), pose a problem for traditional autosegmental accounts of vowel harmony using binary or privative features, since no part of the theory would explain why spreading of the [round] feature of the second vowel should only occur in such limited circumstances: the constraints on spreading would somehow have to be stipulated, and the theory and its representations would lose much of their explanatory power (cf. Flemming 2002: 77). Lionnet (2016: 163–176) also shows that substance-free, grammar-driven theories such as Nevins’s (2010) Search-and-Copy theory of vowel harmony, or cumulative constraint interaction modeled either through Local Constraint Conjunction or Harmonic Grammar, fail to account for the partial effects that drive subphonemic teamwork. Accounting for such effects using only classic binary features is feasible, but at the expense

of explanatory power and grammatical simplicity (Lionnet 2016: 176–180, in press).

Instead, Lionnet (2016: 36–57; in press) proposes an account that involves new, gradient phonological representations called "subfeatures". He shows, on the basis of instrumental measurements, that this alternation involves partial coarticulatory effects: /ɨ/ and /ə/ are realized with partial rounding [ɨᵇ, əᵇ] under the influence of a neighboring labial consonant. Such partial effects are given dedicated "subfeatural" representations: the partially rounded [ɨᵇ, əᵇ] are analyzed as featurally [-round], but subfeaturally [[*x* round]] ($0 < x < 1$). The doubly triggered rounding harmony can thus be analyzed as a case of rounding harmony parasitic on height and backness, targeting only [[*x* round]] vowels. Any theory of parasitic harmony can account for this harmony – and other similar cases of subphonemic teamwork – if it is granted access to subfeatural representations.

5.3.2.2. Consonant harmony

Many African languages are well known for having long-distance consonant harmony: nasal harmony in particular is well represented in Bantu languages, and many East African languages display various kinds of laryngeal harmony. Hyman (1995) presents the dramatic case of consonant nasal harmony in Yaka, illustrated in (46) below, with verb roots combining with the perfective suffix /-idi/, realized [-ele] after mid vowels, through a variant of mid-harmony (cf. 3.2.1.3 and (40) above; note that /d/ and /l/ are in complementary distribution: /di, le, la, lo, lu/).[10]

(46) Yaka

a.	/tsúm-/	→	tsúm-ini	'sew'	cf. /tsúb-/ → tsúb-idi 'wander'
	/kún-/	→	kún-ini	'plant'	cf. /kúd-/ → kúd-idi 'chase'
b.	/nók-/	→	nók-ene	'rain'	cf. /dók-/ → dók-ele 'bewitch'
	/mák-/	→	mák-ini	'climb'	
	/nútúk-/	→	nútúk-ini	'bow'	
c.	/bíímb-/	→	bíímb-idi	'embrace, hug'	
	/kúúnd-/	→	kúúnd-idi	'bury'	
	/ngéng-/	→	ngéng-ele	'glow'	
d.	/mwáng-/	→	mwáng-ini	'sow'	
	/mééng-/	→	mééng-ene	'hate'	
	/núúng-/	→	núúng-ini	'be victorious'	

(Hyman 1995)

[10] See Hyman (1998) for an analysis of the Yaka mid-harmony as a plateauing harmony.

As seen from (46a) and (46b), a nasal consonant triggers nasalization of any following voiced consonant within the stem (root + suffixes). Any intervening non-target (vowels and voiceless consonants) are transparent (46c). Interestingly, prenasalized consonants pattern with voiceless consonants in that they neither trigger (46d) nor block the harmony (46c).

In Chaha, coronal and velar oral stops agree in laryngeal features within roots: all stops are thus either voiceless (47a), voiced (47b), or ejectives (47c).

(47) Chaha

a.	jɨ-kətf	'he hashes (meat)'
	jɨ-kəft	'he opens'
b.	jɨ-dəg(ɨ)s	'he gives a feast'
	jɨ-dərg	'he hits, fights'
c.	jɨ-t'ək'ɨr	'he hides'
	jɨ-t'əβk'	'it is tight'

(Rose and Walker 2004, based on Leslau 1979, and Banksira 2000)

Data such as the Yaka and Chaha alternations above prompted Walker (2000a, 2000b) to propose one of the earliest surface correspondence–based analyses of long-distance consonant harmony, which later gave rise to Agreement by Correspondence theory, developed by Hansson (2001) and Rose and Walker (2004) on the basis of a wide range of languages among which Africa occupies a prominent position: all the patterns surveyed are attested in at least some African languages, nasal and laryngeal harmonies being by far the most frequent. African languages have thus played once again an important role in the development of a novel theory, which has since been extended successfully to vowel harmony (Sasa 2009; Rhodes 2012), long-distance consonant dissimilation (Bennett 2013), consonant-tone interaction (Shih 2013), the behavior of contour segments and tones in harmony processes (Inkelas and Shih 2014a, 2014b), as well as local cases of assimilation involving subphonemic threshold effects (Lionnet 2014, 2016, in press; cf. section 3.2.1.4 above).

5.3.3. Prosodies and process morphology

While the properties of tone – crucially its semi-autonomy from the segments on which it is realized – prompted the development of autosegmental phonology, as we have seen, African languages of the Afro-Asiatic phylum in particular have shown that features other than tone, though less "prosodic" at first sight, may also behave in a similar way. Such is the case of the [palatal] and [labial] features, which are usually analyzed as part of the featural definition of segments, but in many Afro-Asiatic languages behave like syllable-, stem- or word-level autosegments with properties very similar to tone melodies and floating tones.

Such "prosodies" in the sense of Firth (1948), first identified at the very begin-

ning of the 1970s in Biu-Mandara (also known as Central Chadic) and Ethio-Semitic languages, pose the same interpretative problems as tone, and, like tone, are crucial for the understanding of the nature and structure of the substance that phonological processes manipulate. As a consequence, prosodies have been particularly relevant for feature theory and feature geometry, and were among the phonological phenomena whose understanding was greatly improved by the development of autosegmental phonology.

5.3.3.1. Palatal and labial prosodies

Most Chadic languages of the Biu-Mandara subgroup have rich surface vowel inventories, but are often analyzed as having only one (/a/ versus Ø) or two (/a/ versus /ə/) underlying vowels, either in synchrony or in diachrony. Mada, for instance, has eight surface vowels,[11] presented in Table 3 using Barreteau and Brunet's (2000) analysis in terms of the three features [±close] (or tense versus lax), [±palatalized], and [±labialized].

Table 3: Mada's eight surface vowels (Barreteau and Brunet 2000: 15)

	+palatalized		*-palatalized*	
	-labialized	*+labialized*	*-labialized*	*+labialized*
+close (lax)	i	ü	ə	u
-close (tense)	e(:)	œ(:)	a(:)	o(:)

Barreteau and Brunet (2000: 16–17) note that vowel aperture is not distinctive: [+close]/lax vowels are either epenthetic vowels used to break certain consonant clusters, or allophones of [-close]/tense vowels derived in unaccented contexts or through assimilation with neighboring consonants. The number of phonemic vowels can thus be reduced to four: /e, œ, a, o/.

However, in addition, Barreteau and Brunet show that palatalization and labialization are word-level prosodies rather than segmental features: words are either neutral (Ø), palatalized (y), labialized (w), or both palatalized and labialized (y/w), as shown in Table 4.

Table 4: Word-level palatal and labial prosodies in Mada (Barreteau and Brunet 2000:15)

Ø	ɗɗàɮ	'standing(?)'	ássa	'fox'	sámallák	'motionless'
y	ɗɗèɮ	'exactly'	esse	'vital principle'	sémellék	'thin, meager'
w	ɗɗòɮ	'comfortably'	ossó	'bucket'	sómollókw	'big'
y/w	ɗɗœ̀ɮ	'unsuccessful'	œssœ́ɗ	'twig'		

[11] Twelve with the long counterparts of the [-close] series, which we ignore here, since vowel length is derived.

They conclude that Mada has only one underlying vowel /a/ (which could be noted as underspecified /V/), contrasting with its absence. This vowel is then colored by the addition of the word-level palatal and/or labial prosodies, as shown in (48). Finally schwa-epenthesis and vowel reduction and assimilation account for the four [+close]/lax vowels.

(48) Mada

a.	/ɗɗàɮ/	→	ɗɗàɮ
b.	/ɗɗàɮ/^{Y}	→	ɗɗe̱ɮ
c.	/ɗɗàɮ/^{W}	→	ɗɗo̱ɮ
d.	/ ɗɗàɮ/$^{Y/W}$	→	ɗɗœ̱ɮ

(adapted from Barreteau and Brunet 2000)

Schuh (2002) shows that morpheme-level palatalization is also a frequent feature of West Chadic languages.

5.3.3.2. No underlying vowel contrast?

The reduced underlying vowel inventory of Biu-Mandara languages has been typologically intriguing at least since Mirt's (1969) analysis of the Wandala vowel system as /a, ə/ (reminiscent of Trubetzkoy's (1969: 97 [1939]) "linear" vowel systems). The prosody account of the variety of surface vowels in such two-vowel systems was first developed for Higi (Hoffmann 1965; Mohrlang 1971, 1972; Barreteau 1983) and Gude (Hoskison 1974, 1975), and then applied to Mofu-Gudur (Barreteau 1978a, 1978b, 1988) and Mafa (Barreteau and Le Bléis 1987, 1990). De Colombel (1986) analyzes Waɮam (Ouldémé) as having the four contrastive vowels /a, ə, e, i/, with /e, i/ originating in the recent phonologization of palatalized /a, ə/.

Wolff (1983: 226) goes one step further, stating that he is "convinced that, taking all evidence together, two-vowel systems in Central Chadic, whether contrasting in height or frontness, allow further analysis and can be reduced to a system in which only one "vowel contrasts with its absence, i. e. a system without true vowel contrasts". This is exactly Barreteau and Brunet's (2000) analysis of Mada, sketched above. More recently, Smith (2010) proposes a similar analysis for Muyang – although Gravina (2010), in the same volume, gives arguments in favor of a two-vowel analysis /a, ə/ of closely related Mboku.

It is this system, crucially based on palatal and labial prosodies, that Wolff et al. (1981) and Wolff (1981, 1983) propose to reconstruct for Proto-Wandala-Lamang (a sub-group within Biu-Mandara). Wolff (2008) extends this analysis to the whole Biu-Mandara group, and tentatively proposes to consider it a plausible reconstruction of the Proto-Chadic vowel system (see section 3.3.6). If this hypothesis is correct, the Biu-Mandara languages, either synchronically and/or diachronically, are among the only languages in the world with no real underlying

vowel contrast, thus going against Maddieson's (1997: 636) claim that "no language is known which does not have some distinctions of height" and Hyman's (2008b: 94) vocalic universal #1: "Every phonological system contrasts at least two degrees of aperture."

5.3.3.3. Prosodies as morphemes: non-segmental/non-concatenative morphology

While palatal and labial prosodies regularly mark lexical distinctions in Biu-Mandara languages, as we saw for Mada above, they very often have grammatical functions as well. Like floating tones, they can be morphemes. As early as 1977, Ma Newman showed that the palatal prosody ("Y-prosody") in Ga'anda is used as a morphological device in the nominal and verbal systems. Ga'anda has the surface six-vowel system typical of many Biu-Mandara languages: /i, e, ə, a, u, o/. Noun stems belong to one of two classes, depending on the type of morphological change they undergo when combining with specific suffixes: the T-class, marked with the suffix *-t(ə)-*, and the Y class, marked with the Y-prosody.[12] This Y-prosody applies to Y-stems when they combine with the indefinite suffix *-a* and the genitive marker *-ì*. The effect of this stem-level prosody is to front the central vowels /a, ə/ → [e, i], palatalize /s/ → ʃ and change stem-final /ŋ/ into the glide /y/. This is illustrated with the indefinite suffix *-a* in (49), where the Y-prosody is indicated with a superscript Y following the stem (our notation).

(49) Ga'anda

	Stem+pl. indef. -ca	*+sg. indefinite* -a			
a.	ʔāl-cá	/ʔāl^{Y} +-a/	→	ʔē̱l-á	'bone'
b.	sàʔ-cá	/sàʔ^{Y}+-a/	→	ʃ̱èʔ-á	'leaf'
c.	ɓəɓ-cá	/ɓəɓ^{Y}+-a/	→	ɓī̱ɓ-á	'breast'
d.	kəlàr-cà	/kəlàr^{Y}+-a/	→	kìlèr-à	'side'
e.	pəpəf-cá	/pəpəf^{Y}+-a/	→	pìpìf-á	'lung'
f.	mbòʔəm-cá	/mbòʔəm^{Y}+-a/	→	mbòʔì̱m-á	'flea'
g.	kútər-cá	/kútər^{Y}+-a/	→	kútì̱r-á	'chief'
h.	ùsən-cá	/ùsən^{Y}+-a/	→	ùʃ̱ì̱n-á	'type of grass'
i.	p̀ərs-cà	/p̀ərs^{Y}+-a/	→	p̀í̱rʃ̱-à	'salt'
j.	kəlàŋgàr-cà	/kəlàŋgàr^{Y}+-a/	→	kì̱lè̱ŋgè̱r-á	'wild boar'

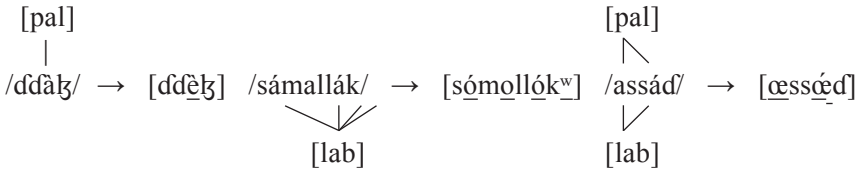
(Ma Newman 1977)

[12] The distinction between T-nouns and Y-nouns corresponds to a former gender distinction which does not exist anymore in synchrony (Ma Newman 1977: 122).

5.3.3.4. Autosegmental representation

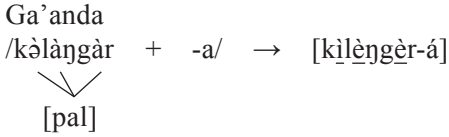
It is obvious to the modern reader how easily the Mada and Ga'anda examples above lend themselves to an autosegmental representation, where the [palatal] and [labial] features, represented on their own autonomous tier, link to the appropriate targets, based on language specific rules, as shown in (50), where [pal] and [lab] target the only underlying vowel /a/, and (51), where the empty morph [pal] targets /a, ə, s, ŋ/.

(50) Mada



(adapted from Barreteau and Brunet 2000)

(51) Ga'anda



(adapted from Ma Newman 1977)

Afro-Asiatic prosodies and featural morphemes were introduced into current phonology by McCarthy (1983), who proposed the first autosegmental analysis of the labial and palatal morphemes found in Chaha. As can be seen in (52), the second person feminine singular object is marked on a verb by the palatalization of its last palatalizable consonant (i. e., everything but a labial or r/n).[13]

(52) Chaha

2nd m. sg.	*2nd f. sg.*	
gʸækʸət	gʸækʸətʸ	'accompany'
nəmæd	nəmædʸ	'love'
nəqəṭ	nəqətʸ	'kick'
nəkəs	nekesʸ	'bite'
gəræz	gəræzʸ	'be old'
wəṭæq	wəṭæqʸ	'fall'
fəræx	fəræxʸ	'be patient'

(McCarthy 1983: 179)

The examples in (53) show that the third person masculine singular object is marked by a labialization feature that links to the right-most labializable consonant, i. e., a non-coronal.

[13] For more details on Chaha phonology and morphology, see Rose (2007).

(53) Chaha

	No object	*3rd m.sg. object*	
a.	dænæg	dænæg^{w}	'hit'
b.	nædæf	nædæf^{w}	'sting'
c.	nækæb	nækæb^{w}	'find'
d.	s^{y}æfær	s^{y}æf^{w}ær	'cover'
e.	nækæs	næk^{w}æs	'bite'
f.	kæfæt	kæf^{w}æt	'open'
g.	qætær	q^{w}ætær	'kill'
h.	mæsær	m^{w}æsær	'seem'
i.	mæk^{y}ær	m^{w}æk^{y}ær	'burn'
j.	sædæd	sædæd	'chase'

(McCarthy 1983: 179)

Hetzron (1971), for the first time, described such palatalizations and labializations as morphemes consisting of less than a segment, but, like Welmers (1962) or Hyman and Schuh (1974) for tones, lacked an adequate representation to translate his intuition. McCarthy (1981), in order to account for Semitic templatic morphology, uses autosegmental representations to distinguish a prosodic tier (CV skeleton tier), a vowel feature tier and a consonant feature tier:

(54) Classical Arabic

Vowel feature tier u i

Prosodic template tier CVCCVC = *kuttib* 'he was caused to write'

Consonant feature tier k t b

(McCarthy 1983: 177)

Adding a separate tier for floating features, McCarthy can account for the labial and palatal featural morphemes found in Chaha, as shown in (55).

(55) Chaha

a. *Rightmost labialization:*

[+round]

$[Q\ \alpha\ \ X]_{root}$ Condition: Q is maximal

b. *End palatalization:*

[+high, -back]

$[X\ \alpha]_{root}$

c. *Examples:*

[gʸækʸətʸ]	[dænægʷ]	[kæfʷæt]	[sædæd]
/gʸækʸət/	/dænæg/	/kæfæt/	/sædæd/
| | |	| | |	| | |	| | |
C C C	C C C	C C C	C C C
|	|	|	
[+high, -back]	[+round]	[+round]	[+round]

(McCarthy 1983: 180)

5.3.3.5. Featural affixes versus processes

As Inkelas (2008: 1) points out, there is much in common between realizational morphology and morphologically conditioned phonology. The above Y- and W-prosodies could thus be interpreted either as phonological rules triggered in the context of certain morphosyntactic features or as underlying "featural affixes" (Akinlabi 1996, 2011) which "float" in the string. Like floating tones, floating features are only semi-autonomous from the segmental tier: they need to be realized on segments, which they do in various ways, depending on their nature (e. g., consonantal versus vocalic features) and on feature co-occurrence constraints (either language-specific or due to feature geometry).

Featural morphemes refer most of the time to specific edges of the stem, which Akinlabi (1996, 2011) takes as evidence that they are segmentable affixes. Labialization in Chaha, illustrated in (53) above, is thus a case of suffixation in Akinlabi's (2011: 1949) analysis: the requirement that the featural morpheme [round][14] attach to the rightmost labializable consonant tells us that much. However, the fact that it is a consonantal feature implies that it may only be licensed by a consonant; it thus targets the rightmost consonant root node. Additionally, in Chaha, labialization may not co-occur with the feature [coronal]. The feature [round] may thus only be licensed by the rightmost non-coronal consonantal root node, moving inwards until it finds it, as in (53b) and (53c). This is reminiscent of properties of segmental affixes, such as the *-um-* infix in Tagalog, analyzed as a prefix by McCarthy and Prince (1993: 79), pushed inwards by a phonotactic requirement dispreferring coda consonants. Finally, when there is no labializable consonant in the root, the featural morpheme is simply not realized, as in (53d).

Akinlabi (1996), using data from African and non-African languages, develops an Optimality-theoretic analysis of featural affixation relying on the notion of generalized alignment developed by McCarthy and Prince (1993, 1994), which

[14] Akinlabi (2011) assumes [round], among other features, to be privative.

shows that featural affixes behave like their segmental counterparts: no additional theoretical machinery is needed.[15]

With the exception of Ga'anda, to which we will come back below, the featural affixes we have seen so far consist in one floating feature only. But more complex cases are attested in Africa, in particular featural affixes consisting in more than one feature (Mokilko), affixes that are both segmental and featural (Ga'anda, North Atlantic languages, Nuer), and finally affixes with a segmental and a featural allomorph (Mafa).

In Mokilko the perfective aspect marker consists in the two features [voice] and [high] (Jungraithmayr 1977, 1990; Roberts 1994): the initial consonant of the perfective is voiced (whenever possible), while its first vowel is raised to high (if not already high), as shown in (56).

(56) Mokilko

	Imperfective	*Perfective*	
a.	kóòbìyó	gúùbé	'laugh'
	súyyìsó	zúyyè	'wash (oneself)'
	kázà	gízè	'count'
b.	dé'ú	dí'é	'seek'
	dòokìdé	dìikìdá	'share'
c.	'ókké	'úkké	'run'
	'òndɗé	'ùndɗá	'suck'
	'ômɓó	'íìmí	'eat ("boule")'
	'áàdùmú	'íìdìmá	'eat (something hard)'
	'ûntó	'ìndá	'die'

(Jungraithmayr 1990: 44)

Akinlabi (2011, fn. 3) suggests that the perfective aspect in Mokilko is marked by a bi-featural prefix composed of the two features [voice] and [high], which may only be licensed by a consonant and a vowel respectively. The perfective prefix thus not only consists in two features, but each one of these two features is systematically realized on a different segment. Possible representations of this prefix and its effects on the verb root /káz-/ 'count' are given in (57):

[15] See Zoll (1998) for a different approach within Optimality Theory, and Mc Laughlin (2005) for its application to consonant mutation in Pulaar and Seereer Siin.

(57) Mokilko

a. /[voice, high]- + káz-/
[high]
|
b. /káz-/ → gíz- ‘count (imperf.)’
|
[voice]

(adapted from Jungraithmayr 1990: 44)

As Mc Laughlin (2000, 2005) notes, once one accepts the idea of featural affixes, it follows that a morphological category may be expressed in one of three ways: as a segmental affix, as a featural affix or as a mixed segmental and featural affix. All of the above are attested in North Atlantic languages, famously characterized by pervasive initial consonant mutation in the nominal and verbal systems. Mc Laughlin (2000, 2005) analyzes consonant mutation in Pulaar, Seereer Siin and Wolof as resulting from the prefixation of a floating feature to the root node of the stem-initial consonant. Seereer Siin initial consonant mutations are illustrated in (58) with nouns with different noun class prefixes (class numbers are indicated in parentheses).

(58) Seereer Siin

		a-grade	*b-grade*	*c-grade*	
a.	*Voicing*	o-gac (10)	a-kac (4)	fo-ŋgac (13)	‘stone’
	mutation	ɟir (5)	a-cir (4)	a-ɲɟir (3b)	‘illness’
b.	*Continuancy*	saytaane (7)	caytaane (9)	a-ɲaytaane (3b)	‘devil’
	mutation	xaɓ (5)	a-qaɓ (4)	a-ᴎgaɓ (3b)	‘manioc’

(Mc Laughlin 2000: 339–340)

As seen, class prefixation involves the features [+voice], [-continuant] and [+nasal]. The floating feature [+voice] accounts for the a-grade mutation. It affects only [-voice] segments that can be voiced, i. e., all but fricatives. The feature [-continuant], affecting only [+continuant] segments, accounts for the b-grade mutation. Finally [+nasal] accounts for the c-grade mutation. These featural prefixes may occur together with a segmental prefix, as in (59), or on their own, as in (60).

(59) Seereer

a.	/o[+voice]	+	-kac/	→	ogac	(10)
b.	/a[-continuant]	+	-xaɓ/	→	aqaɓ	(4)
c.	/fo[+nasal]	+	-kac/	→	foŋgac	(13)

(adapted from Mc Laughlin 2000: 339–340)

(60) Seereer

a.	/[+voice]	+	-cir/	→	ɟ̠ir	(5)
b.	/[-continuant]	+	-saytaane/	→	c̠aytaane	(9)

(adapted from Mc Laughlin 2000: 339–340)

The verbal system of Nuer offers the mirror image of Seereer Siin: stem-final consonant mutation caused by suffixes. Akinlabi (2011) analyzes these suffixes as segmental, featural or both. The first person plural suffix -[cont]kɔ below is one such mixed suffix, whereas the past participle suffix -[cont] is purely featural (the vowel changes caused by the former suffix are ignored), as illustrated in (61).

(61) Nuer

a.	*Verb*	*+ 1st pers. pl.*	→		
	/còp	+ [cont]kɔ/	→	còɔf-kɔ̀ jɛ	'overtake'
	/lot̪	+ [cont]kɔ/	→	lòɔθ-kɔ̀ jɛ	'suck'
	/paat	+ [cont]kɔ/	→	páar̥-kɔ́ jɛ̀	'sharpen'
	/jaac	+ [cont]kɔ/	→	jáaç-kɔ́ jɛ̀	'hit'
	/ɟæk	+ [cont]kɔ/	→	ɟæ̀-kɔ̀- jɛ	'throw away'
b.	*Verb*	*+ past participle*			
	/còp	+ [cont]/	→	cof	'overtake'
	/lot̪	+ [cont]/	→	loθ	'suck'
	/paat	+ [cont]/	→	pàar̥	'sharpen'
	/jaac	+ [cont]/	→	jaaç	'hit'
	/ɟæk	+ [cont]/	→	ɟæh	'throw away'

(Crazzolara 1933: 156–160; cited in Akinlabi 2011)

Fula, if analyzed along the same lines, offers the rare case of mixed featural/segmental circumfixes in its nominal system. Noun classes are indeed marked with suffixes in contemporary Fula, but these suffixes trigger initial consonant mutation, as shown in (62) with examples from the Pulaar dialect.

(62) Pulaar

			a-grade	*b-grade*	*c-grade*
			'BE (hum. pl)	KO (hum. sg)	KON (dim. pl)
a.	'woman'	/rew-/	rew-ɓe	d̠ebb-o	nd̠ew-on
b.	'man'	/wor-/	wor-ɓe	g̠or-ko	ŋg̠or-on

(Mc Laughlin 2005: 115)

As seen, the b-grade and c-grade class suffixes can be analyzed as circumfixes consisting in a featural prefix and a segmental suffix:

(63) Pulaar

a.	-ɓe	:	/		wor-	+	ɓe/	→	wor-ɓe
b.	[-cont]-…-(k)o	:	/[-cont]-	+	wor-	+	-ko/	→	g̠or-ko

c. [nas]-…-(k)on : /[nas]- + wor- + -(k)on/ → ŋgor-on (adapted from Mc Laughlin 2005: 115)

Finally, a very interesting type of featural affix is attested in Mafa, which has two allomorphs: one segmental, one featural. As illustrated in (64) below, the imperfective form of the verb in Mafa is indeed marked with a suffix realized as segmental *-y* (IPA [j]) with verb roots ending in a vowel (64a), and as a root-level [palatal] prosody with roots ending in a consonant (64b) and (64c). Likewise, the perfective form is marked with the suffix /-w/ with verbs ending in *-a*, and with a labial prosody with consonant-final verbs. As seen, palatalization affects vowels as well as coronal stridents (affricates and fricatives), while labialization affects only vowels and /h/.

(64) Mafa

	Stem	*Imperfective*	*Perfective*	
a.	ndzá	ndzá-y	ndzá-w	'stay'
	ndá	ndá-y	ndá-w	'eat'
	gudza	gudza-y	gudza-w	'tremble'
	sá	sá-y	sá-w	'drink'
b.	təv	tiv	túv	'scale'
	ngəh	ngih	nguh^{w}	'hide'
	kərɗ	kirɗ	kurɗ	'grind'
c.	pán-	pén	pón	'wash'
	saf	ʃef	sof	'breathe'
	zám	ʒém	zóm	'spit out'
	tsák	tʃék	tsók	'take a little'
	ndzáv	ndʒév	ndzóv	'raise'

(Barreteau and le Bléis 1987, 1990; Ettlinger 2004)

Ettlinger's (2004) analysis of the Mafa imperfective suffix integrates the main autosegmental insight of the separation between the segmental and autosegmental tiers into an otherwise purely output-oriented, constraint-based analysis, couched in Optimality Theory (Prince and Smolensky 1993). Ettlinger divides the suffix -y into a segment and a [palatal] feature, semi-autonomous from each other. The separation of the parse of the feature from the parse of its segment through two distinct parse constraints is what accounts for the allomorphy: with the segmental allomorph *-y* [j] both the segmental and the featural parts are parsed, satisfying both constraints. A phonotactic constraint against consonants followed by *-y* prevents the realization of the segment with consonant-final verbs, violating the constraint that the segment should be parsed, but the palatal feature may still be realized on palatalizable segments within the roots, satisfying the second constraint.

But the most insightful theoretical contribution of Ettlinger's analysis is his

account of how the [palatal] featural allomorph is realized on stems. What phonological mechanism accounts for the autosegmental descriptive statement "the palatal feature attaches to vowels and strident coronals"? What consequences does this have for phonological theory, in particular the theory of agreement? There are two main accounts of agreement: feature spreading, as in Akinlabi's (1996) account of featural affixes, and Agreement by Correspondence (Hansson 2001, 2010; Rose and Walker 2004) (cf. section 3.2.2). Ettlinger shows that neither of them is appropriate for Mafa.

Note, first, that two phonotactic constraints in Mafa complicate the process of palatalization in the imperfective: a constraint against velar consonants adjacent to the vowel /ü/ (IPA /y/) (*Kü, [65a]), and one against the derivation of palatalized consonants that are not attested in the consonant inventory (*Cy, [65b]). The combined effect of these two constraints is that only coronal stridents may palatalize, as shown by the unaffected forms in (65c).

(65) Mafa

a. *Effects of *Kü:*

wurts	→	wurtʃ	'engrave with fire'
guts	→	gutʃ	'squirt'

b. *Effects of *Cy*

ðaðay	→	ðeðey	'light (v.)'
təkəd	→	tikid	'grind millet'
kədah	→	kideh	'cook (a fatty sauce)'
bəlað	→	bileð	'lift'
lubok^{w}	→	lübœk^{w}	'obey'

c. *Combined effects of both constraints:*

gud	→	gud	'search with anxiety'
kurk^{w}	→	kurk^{w}	'search everywhere'
gum	→	gum	'work'

(Barreteau and le Bléis 1987, 1990; Ettlinger 2004)

The forms in (65) preclude two possible analyses of the realization of the featural allomorph of the imperfective suffix: if both vowels and consonants may be unaffected, the [palatal] feature cannot be said to target vowels, and then spread through agreement to neighboring stridents, or vice versa. It must target both vowels and coronal stridents at the same time.

Feature spreading, as Ettlinger shows, has to be ruled out altogether. A feature spreading account of agreement crucially rests on the notion of strict locality: a feature may not skip a potential licensor (i. e., a non-transparent segment) when spreading. The fact that /u/ may be transparent in some forms (66b), despite being a possible licensor of the [palatal] feature (66a), renders feature spreading inoperative.

(66) Contextual transparency of /u/

a. /u/ → /ü/

sur	→	ʃür	'sleep with a woman'
lubat	→	lübet	'twist'

b. *Ky does not prevent palatalization of all other licensors

suwdək	→	ʃuwdik	'miss'
tsuwah	→	tʃuweh	'cut into pieces'

Ettlinger also rejects an Agreement by Correspondence analysis, on the basis that vowels and coronal stridents do not form a natural class, hence are both more similar to other segment classes than to each other, which contradicts the notion of similarity that is the basis of Agreement by Correspondence theory.

Instead, Ettlinger proposes that what is at work in Mafa is a form of "generalized agreement" that constrains all segments within a stem to be palatal in the presence of a palatal feature, within the limits of what the phonotactics of the language independently permits.

It is easy to see how the same problem arises (and a similar solution could be proposed) in other languages we have seen, such as Ga'anda, where the palatal prosody targets only the unnatural class /a, ə, s, ŋ/. A more thorough analysis of other Chadic or Ethio-Semitic languages with similar properties in the light of such theoretical questions would most probably yield new insights into phonological structure and the nature of the process of agreement.

5.3.3.6. The origin of prosodies and featural affixes

Finally, it is worth noting that the analysis of floating featural morphemes as affixes is supported by historical evidence: prosodies and featural affixes have been shown to derive from former segmental affixes and the phonological interactions between those affixes and the roots onto which they attached.

Wolff (1981), drawing from Ma Newman's (1977) Ga'anda data, already puts forth the hypothesis that at least the palatal prosody in Wandala-Lamang languages originates in a former segmental suffix, most probably an old Chadic determiner. Wolff (2004, 2006) reconstructs old noun-stem suffixes in the Lamang-Hdi subgroup of Biu-Mandara. "These suffixes, synchronically defunct, have left traces as petrified additional root material, or are simply absent. Some of these suffixes, however, are the diachronic source of prosodies" (Wolff 2006: 143).

Similarly, Rose (1994) shows that palatalization and labialization in Chaha originate in former suffixes. For example, the palatalization of final coronal and velar consonants marking the second person singular feminine in the verbal system, illustrated in (52) above, originates in a suffix *-i*, attested in Amharic (optionally), Ge'ez, Tigrinya, and Arabic, among others.

Historical evidence shows that initial consonant mutation in North Atlantic languages originates in the phonotactic effects of former prefixes (or clitics, cf. Merrill 2013) on root-initial consonants. Those prefixes are still partially attested in Seereer Siin, but have been dropped in Fula, leaving consonant mutation as the only trace of their former presence. Merrill (2013) proposes a reconstruction of the proto-Fula-Seereer class clitics, and a historical account of the sound changes through which initial consonant mutation and the present-day class prefixes or suffixes emerged in both languages.

Finally, Kießling (2010) identifies the emergence of initial consonant mutation systems in Bantoid languages of the Grassfields and Beboid groups through a process that is most probably similar to that which gave rise to consonant mutation in North Atlantic.[16]

> "[In those languages, consonant mutation emerges through] phonological condensation and diffusion of noun class prefix features into the nominal root … The trigger is almost always the same: high vowels of the prefixes in classes 3, 5, 7, 8 spread their labial and/or palatal quality to the nominal root causing purely automatic changes which could be described as progressive assimilations … As soon as the phonetic trigger of these assimilations, i. e. the labial or palatal quality of the prefix, is lost, the changes in the nominal root, labialization or palatalization, lose their motivation and become morphophonemicized as infixes or initial consonant mutations" (Kießling 2010: 215–216).

5.3.4. Nasality as a prosody

In many African languages, nasal consonants are in total or near complementary distribution with voiced oral counterparts. Thus, quite early in generative phonology, Schachter and Fromkin (1968) had proposed derivations such as the following for their dialects of Akan:

(67) Akan

a.	/bã/	→	[mã]	'give'
b.	/dã/	→	[nã]	'and'
c.	/yã/	→	[ỹã]	'receive'
d.	/wãdĩ/	→	[w̃ãnĩ]	'scrape'
e.	/hũ/	→	[h̃ũ]	'fear'

(Schachter and Fromkin 1968)

Rather than representing nasality on vowels, where it is contrastive, they also could quite easily have abstracted the feature away as a prosody, [+nas], in keeping with the Firthian tradition. This was subsequently proposed by Leben (1973) for Terena

[16] He also gives references to similar phenomena in the Plateau languages of Central Nigeria (Gerhardt 1983, 1988, 1990, 2010), but also in the Narrow Bantu languages Nilyamba (Kießling in preparation) and Zezuru and Venda (Gowlett 2003: 621–622).

and Goldsmith (1976) for Guarani, two Amazonian languages, and by Hyman (1982) for Gokana (68). In the latter language, nasality can be considered to be a property of morphemes rather than segments: only one [+nasal] specification per morpheme is allowed in underlying representations. This feature associates with any nasalizable segment, i. e., all vowels, all non-morpheme-initial consonants (restricted to /b, l, g/), and morpheme-intial /v, l, z/ only. Only one segment needs to be underlyingly specified as [+nasal]: morpheme-initial /m/, which is the only segment for which nasality is distinctive (exclusively in that position), as shown by the triple contrast *bá* 'arm' versus *bã́* 'pot' versus *mã́* 'breast'.

(68) Gokana

a.	/lū/	→	[nṹ]	'thing'	cf.	/lí/	→	[lí]	'root'
	[+nas]		[+nas]						
b.	/bá/	→	[bã́]	'pot'	cf.	/bá/	→	[bá]	'arm'
	[+nas]		[+nas]						
c.	/dɛ̄b/	→	[dɛ̃̄m]	'tongue'					
	[+nas]		[+nas]						
d.	/bá/	→	[mã́]	'breast'					
	[+nas]		[+nas]						

(Hyman 1982:126–7)

As seen, the underlying nasal feature associates with all segments in (68a), since both /l/ and /u/ are both nasalizable. The stem-initial consonants /b/ and /d/ in (68b) and (68c) are not, and thus escape nasalization, contrary to stem-final /b/ in (68c). Finally, a comparison between (68b) and (68d) demonstrates the necessity to distinguish between two underlying stem-initial /b/'s: a non-nasal one and a nasal one which surfaces as /m/.

For recent work on African systems that lack a nasal contrast on consonants, see Clements and Osu (2003, 2005).

5.4. Segment organization and word structure

5.4.1. Syllables, slots and moras

In the early 1980s, African languages provided important contributions to the development both of skeletal (CV) and moraic phonology. A good case in point is Ganda compensatory lengthening, by which sequences such as /Cia/ and /Cua/ are realized [Cja:] and [Cwa:], respectively. Clements's (1986) proposal within CV pho-

nology was that the high vowel reassociates to the preceding C slot, delinking from its V slot, which is in turn filled by spreading of the following vowel, as in (69).

(69) Ganda

```
C  V  V  →  C  V  V  →  C  V  V
|  |  |     ∧     |     ∧     ⌋
k  i  a     k i   a     k i   a
```

(adapted from Clements 1986)

In Hyman's (1985) moraic account, the /a/ spreads right to left onto the first mora:

(70) Ganda

```
 μ   μ
 ∧   ⌋
k   i   a
```

(Hyman 1985)

Clements (1986) also considers the lengthening of a vowel before a NC sequence illustrated for Jita in (71) below, where the vowel length contrast is neutralized before NC. This time, if the nasal leaves its V to join the following C slot, the preceding vowel can lengthen to take its place.

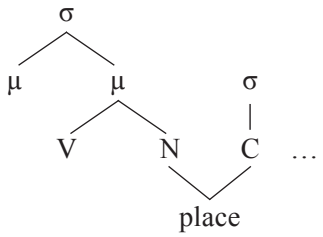
(71) Jita

a.	oku-cuma	'to get wealthy'	oku-cuːma	'to jump'
	oku-loja	'to try'	oku-loːja	'to visit the sick'
b.	oku-fuːmbula	'to guess a riddle'	(*oku-fumbula)	
	oku-saːnjága	'to pulverize'	(*oku-sanjága)	
c.	oku-saːkura	'to grab from'	okuː-n-saːkura	'to grab from me'
	oku-ganíra	'to tell a story'	okuː-ŋ-ganíra	'to tell me a story'

(after Downing 1996; cited in Downing 2005)

We saw in section 2.1 that numerous Bantuists and phonologists have worked on the problem of NC clusters, debating in particular whether they consist of one or two segments. We also saw the important role played by syllabification in choosing between the two alternatives. The analysis of pre-NC lengthening in terms of compensatory lengthening summarized above is often cited as evidence for the unit analysis of NC sequences. Downing (2005), based on phonological evidence indicating that N in VNCV sequences is syllabified as a coda in Bantu languages, proposes an alternative analysis, whereby the homorganic NC sequence is a heterosyllabic cluster, as schematized in (72). Pre-NC lengthening is viewed as arising not from compensatory lengthening following resyllabification of N, but through enhancement of the vowel's duration before a tautosyllabic nasal consonant, and the reduced duration of homorganic NC sequences (cf. also Maddieson, this volume, section 4.3).

(72)



Finally, most of the arguments in favor of moras developed in Hyman (1985) were based on African languages, particularly Gokana (Lower Cross), where there is no evidence for syllable structure above the moras (although see Hyman 2011c).

One of the major successes of a "slot" approach to segmental length was its ability to characterize geminates and their "inalterabilty". Crucial to this inalterability is the fact that geminates are represented as one consonant linked to two C slots, as shown below.

(73) /t/ = C vs. /tt/ = CC

		C			=	CC
		|				⋁
		t				t

Among the major examples of consonant inalterability that prompted this analysis were two Afroasiatic languages: Tigrinya (Schein and Steriade 1986; Kenstowicz 1982) and Hausa. In the latter, Hayes (1986) shows that a CV approach accounts very elegantly for why Klingenheben's Law, a series of sound changes through which coda obstruents became sonorants, illustrated in (74), fails to apply to geminate consonants.

(74) Klingenheben's Law in Hausa

a.	labials	→	/w/	sabroo	→	sawroo	'mosquito'
	alveolars	→	/r̃/	biyad	→	biyar̃	'five'
	velars	→	/w/	batagyee	→	batawyee	'twin'
	(Hayes 1986)						

b. [-cont] → [+son] / $C]_{syl}$ ___

The rule stated in (74b) targets only consonants that are uniquely linked to a C slot, i. e., singleton consonants. Geminate consonants, being doubly linked, are thus invisible to the rule.

Another Afro-Asiatic language, Imdlawn Tashlhiyt (Berber), has also been central to the study of syllabification, particularly of consonantal nuclei (Dell and Elmedlaoui 1985, 1988; Ridouane 2008), which provided one of the centerpieces in the development of Optimality Theory (Prince and Smolensky 1993) (See Maddieson, this volume, section 4.3 for more detail).

5.4.2. Reduplication

The vast majority of African languages exploit partial reduplication as a morphological process. In West African languages such as Akan (Kwa), the reduplicant consists of a CV copy of the base verb, except that the vowel must be [+high]. Nupe examples are given in (75).

(75) Nupe

a.	/gí/	'eat'	→	gi-gí	'eating'
	/ge/	'be good'	→	gi-ge	'goodness'
	/gà/	'separate'	→	gi-gà	'separating'
b.	/gú/	'puncture'	→	gu-gú	'puncturing'
	/gò/	'receive'	→	gu-gò	'receiving'

(Hyman 1970)

The Nupe data comes up in the context of an argument in favor of abstract phonological representations (Hyman 1970), whereas corresponding Akan forms are cited both by Wilbur (1974) and Marantz (1982) for their "underapplication" property. Again, this can be illustrated from Nupe, where underlying /ts, dz, s, z/ are palatalized to [tʃ, dʒ, ʃ, ʒ] before front vowels. The issue is that a verb like /tsà/ 'choose' reduplicates as *tsi-tsà*, not as **tʃi-tsà*. The above-cited authors revert to rule ordering (palatalization precedes reduplication), whereas others have used this kind of African data to argue for a global "identity constraint" (Wilbur 1974), which is easily implemented as a base-reduplicant identity correspondence within Optimality Theory (McCarthy and Prince 1999).

While the above gives some idea of how West African CV reduplication has contributed to phonology, Bantu CVCV verb stem reduplication has also contributed to the development of prosodic morphology. The verb stem is a constituent consisting of a root plus one or more suffixes. In a number of Bantu languages, but not all, the preposed reduplicant may or must be exactly two syllables in length. Thus, in Kinande, *tum-ir-an-a* 'send to each other' (send + APPLICATIVE + RECIPROCAL + FINAL VOWEL) obligatorily reduplicates as *tum-a* + *tum-ir-an-a* 'send to each other here and there' (Mutaka and Hyman 1990). Interestingly, *sw-a* 'grind' reduplicates as *sw-a-sw-a* + *swa* 'grind here and there', where the bisyllabic reduplicant, created by double reduplication, is actually longer than the base verb stem. Odden (1996) shows that in Kerewe there is some choice in how long the reduplicant can be. Hence, *lim-il-an-a* 'cultivate for each other' (applicative -il-, reciprocal -an-) may reduplicate as *lim-il-an-a.lim-il-an-a*, *lim-il-a.lim-il-an-a*, or *lim-a.lim-il-an-a*. The comparisons in (76), which show how Proto-Bantu **gu-a* 'fall' and **dim-ɪd-a* 'cultivate for/at' are reduplicated in three different Bantu languages, reveal that bisyllabicity can be imposed as a minimum (Sukuma), maximum (Kinyarwanda) or exact (Ndebele) requirement on the reduplicant (Hyman 2009):

(76) a. RED ≥ σ-σ
e. g., Sukuma
gw-a-gw-a + gw-a
lɪm-ɪl-a + lɪm-ɪl-a
(Matondo 2003)

b. RED ≤ σ-σ
e. g., Kinyarwanda
gw-aa + gw-aan-a
rim-aa + rim-ir-a
(Fidèle Mpiranya, p. c.)

c. RED = σ-σ
e. g., Ndebele
w-a-yi + w-a
lim-a + lim-el-a
(Hyman, Inkelas, and Sibanda 2008)

As seen, Sukuma double reduplicates a monosyllabic stem, like Kinande, while Kinyarwanda accepts a monosyllabic reduplicant, but appears to augment the base from *gw-a* to *gw-aan-a* to provide an extra syllable. Ndebele inserts a dummy syllable [yi] to fill out the bisyllabic template. While the applicative suffix *-ɪl-* is obligatorily truncated in both Kinyarwanda and Ndebele, it optionally appears in Sukuma, which has no upper limit on the size of the reduplicant, e. g., *leembeel-el-nij-iw-a* + *leembeel-el-nij-iw-a* ('be calm' + APPLICATIVE + SIMULTANEOUS + PASSIVE). However, when a verb stem contains only one productive suffix, it may optionally be truncated, e. g. *lɪm-ɪl-a* + *lɪm-ɪl-a* ~ *lɪm-a* + *lɪm-ɪl-a* 'cultivate for here and there' (Matondo 2003:129–130, 154).

The apparent truncation observed in reduplicated forms such as Kinande *lɪm-a* + *lɪm-ɪl-a and túm-a* + *tum-ir-an-a* has also raised interesting morphological questions. Downing (1999ab, 2000) sees the final *-a* as an indicator that the reduplicant is a morphological constituent, while Hyman, Inkelas and Sibanda (2008) present evidence from Ndebele that the reduplicant is obtained by morphosyntactic doubling, but is subject to additional prosodic restrictions (cf. Inkelas and Zoll 2005).

5.4.3. Accent and positions of prominence

As we said in our introduction to this contribution, one of the only aspects of general phonology that African languages have not substantially contributed to is stress. One reason for this is that, with notable exceptions (mostly Berber, African varieties of Arabic, North Atlantic languages, Swahili), African languages are mostly tonal, and have either no stress or a rather simple stress system.[17] However, African languages are not devoid of any form of "accent", and have actually played, and ought to play, an important role in controversies regarding the very definition of the notion of "accent".

[17] See Heath's (2005) grammar of Tamashek (Malian Tuareg), which includes multiple sections treating the extensive accentual properties of this language, much of it morphologically determined.

In her survey of accent in African languages, Downing (2010) adopts van der Hulst's (1999, 2002, 2006) definition of accent as a "prominence asymmetry that makes one syllable more salient than its neighbors by enhancing some combination of phonetic properties: pitch, duration, intensity, and/or contrastive segmental features" (Downing 2010: 382). Accent is culminative,[18] i. e., there is at most one (main) prominence peak per relevant domain, and demarcative,[19] i. e., prominence peaks are defined with reference to a particular morpheme edge (stem or word). Stress is thus only one form of accent, and we concur with Downing's proposition that prominence asymmetries independent of stress be considered forms of accent, as long as they have the two properties defined above. This idea is also defended by Dimmendaal (2012) in his survey of morphophonological phenomena involving foot structure in Nilotic languages, and was already expressed by Harris (2004[1990]: 26): "Stress prominence is of course not the only symptom of foot-hood … segmental and quantitative factors can also be in play, showing up in the asymmetric distribution of contrast and weight between head and dependent syllables."

While stress systems are rather infrequent in Africa, non-stress-related prominence asymmetries are on the other hand common, particularly in western and central Africa, in Nilotic languages, as well as in the Kalahari Basin, as we will see. As Downing (2010: 385) puts it, "it is this diversity of prominence asymmetries that in fact make African languages particularly interesting for research on the range of phonological properties that can define prominence or provide evidence of metrical constituency." Recent research has shown that metrical structure can indeed successfully account for various such asymmetries in African languages.

5.4.3.1. Stem-initial prominence

There are (at least) two areas in Africa where stem-initial prominence has very strong effects on segmental distribution and positional contrast neutralization: the Macro-Sudan Belt (Güldemann 2008), in particular the Niger-Congo languages of this area, and the Kalahari Basin.

As already shown in Hyman (2008a), Northwest Bantu languages have long been known to present such effects, interpreted as evidence of a stem-initial accent as early as Paulian's (1975) description of Teke-Kukuya. The properties of the prosodic stem in Kukuya are listed in (77).

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18 See Hayes (1995), Hyman (1977, 1978, 2006), Odden (1988, 1999), van der Hulst (1999).

19 See Hyman (1977), van der Hulst (1999), van Zanten and Goedemans (2007).

(77) Teke-Kukuya

a.	Five syllable shapes	:	CV, CV.V, CV.CV, CVV.CV, CV.CV.CV
b.	Five tonal melodies	:	L, H, LH, HL, LHL
c.	Six attested C_2 or C_3	:	P, T, K, l, m, n
d.	Six C_2–C_3 combinations	:	C-n-m, C-T-K, C-l-K, C-l-P, C-K-P, C-T-P
e.	Prefix consonants (Paulian 1975; Hyman 1987)	:	P, K, l, m

As seen in (77a), stems may have from one to three syllables and be mono-, bi- or trimoraic. As we saw in (10) above, stems are assigned one of the five tonal melodies listed in (77b). Of the numerous consonants attested stem-initially, only the six in (77c) are attested in C2 or C3 positions, among which the underspecified consonants /P/, /T/, and /K/, which are realized, respectively, as [b ~ β], [r], and [k~g~ɣ]. Furthermore, out of the 36 (i. e., 6 × 6) possible C2–C3 combinations, only the six indicated in (77d) are attested. These combinations may not include consonants produced at the same place of articulation or disagreeing in nasality, and must be either coronal C2+ non-coronal C3, or velar C2 + labial C3. Finally, prefix consonants are restricted to the four listed in (77e): /P, K, l, m/.

Paulian notes that the left edge of stems is characterized by two additional properties, which she takes to be further evidence of a stem-initial accent in Teke-Kukuya: 1) there is a "pause", however slight, before every C1 consonant, and 2) a C1 nasal or /l/ is automatically geminated (/Pù-nónó/ → [bʊ̀.nnɔ́.nɔ́] 'selfishness'). The additional fact that prefixes, unless they fuse with a vowel-initial root, never form a prosodic domain with their stem, but always with the preceding stem can be used as further evidence that prosodic domains are stem-initial in Teke-Kukuya (Hyman 1987).

Paulian's analysis sets up all domains as accentual units (*unités accentuelles*) with an initial accent, and defines the stem as the minimal accentual unit (*accentogène*). Hyman (1987), formalizing Paulian's interpretation, proposes a metrical analysis of Teke-Kukuya postlexical prosodic domains (stem + any following non-stem material attached to it) using the notion of "stress-foot", defined by Abercrombie (1965: 22) as "the space in time from the incidence of one stress-pulse up to, but not including, the next stress pulse": a stem is parsed into a (maximally ternary) left-headed foot, as in (78a). The unfooted prefix is then added to the preceding foot to create a postlexical foot, as in (78b) (feet are in parentheses, heads are underlined).

(78) a. Lexical: CV-(<u>CV</u>CVCV) ## CV-(<u>CV</u>CVCV)
b. Postlexical: CV-(<u>CV</u>CVCV ## CV)-(<u>CV</u>CVCV)

In this analysis, the foot is the domain of application of both segmental and tonal constraints and rules (among which the assignment of the five tonal melodies seen in (10) above. See section 4.4.5 below for more on the relevance of metrical structure for tonal processes in other languages.

Hyman (2003c, 2008a) shows that similar facts are attested in Basaá (Bantu A.43). Stems in this language are, much like Teke-Kukuya, limited to three syllables, as shown in (79). Table 5 shows that the full consonant inventory is only attested in stem-initial position, with progressively fewer in C_2, C_3 and C_4 positions.

(79) a. 1 syllable: CV, CVC
b. 2 syllables: CV.CV, CV.CVC, CVC.CV, CVC.CVC
c. 3 syllables: CVC.CV.CV

Table 5: Distribution of Basaá consonants

C_1:	p	t	c	k	k^w	s	h	ɓ	l	j	g^w	y	w	m	n	ɲ	ŋ	$ŋ^w$	mb	nd	nj	ŋg
C_2:	b	d		g		s ~ h			l			y		m	n		ŋ		nb	bd		ŋg
C_3:	b	d		g		s ~ h			l						n							
C_4:				g			h								n							

Particularly striking is the distribution of non-contrastive voicing on stops: there is a single series of stops /P, T, K/ which is realized [p, t, k] stem-initially (and optionally before pause), but as voiced (and often continuant) in all other positions, as illustrated in (80). Note that prefix consonants behave like non-C1 consonants, as evidenced by the voiced realization of /P, T/ in examples (80d) and (80e).

(80) Basaá

	Underlying	*Orthographic*	*Phonetic*	
a.	/TíTKí/	tídgí	[tírgí]	'small'
b.	/KɔKnà/	kɔ̀gnà	[kɔ̀ɣnà]	'crush each other'
c.	/lì-màPKà/	lìmabgà	[lì-màβgà]	'taking from' (class 5)
d.	/Pì-Pà/	bìpà	[bì-pà]	'machete' (class 8)
e.	/Tì-KɔTá/	dìkɔ́dá	[dì-kɔ́rá]	'pipes' (class 13)

(Hyman 2008a: 332)

One of the first analyses of stem-initial prominence making use of modern metrical theory was Harris's (2004[1990]: 126sq.) analysis of Ibibio (Lower Cross). Building on research by Urua (1990), Connell (1991) and Akinlabi and Urua (1992), Harris shows that the distributional asymmetries and contrast neutralization patterns attested in Ibibio, illustrated in Table 6 for oral stops, are similar to those attested in English and Danish, where they are clearly dependent on stress

and foot structure: full inventory of consonants and vowels stem-initially, reduced inventory and contrast neutralization (in particular laryngeal contrasts) elsewhere.

Table 6: Distribution of oral stops and related segments in Ibibio (Harris 2004[1990]: 14)

Foot-initial		Non-foot-initial		
[C		VCCV	VC]{#/C}	VC(])V
k͡p	*b*	*pp*	*p̚*	*β*
t	*d*	*tt*	*t̚*	*r*
k		*kk*	*k̚*	*ɣ*

Harris thus proposes the same foot-based analysis for Ibibio. Syllable structure is indeed not explanatory: if the initial syllable were prominent, one would not expect the coda of that syllable to be in the weak part of the foot. Instead, only the foot-initial consonant and vowel, i. e., the stem-initial CV sequence, are prominent. Ibibio is thus a trochaic language, the head of the trochee being the initial CV sequence.

Further evidence for trochaicity in Ibibio comes from verbal morphology. Ibibio verbs, made of a root and an optional suffix, tend to conform to a trochaic CVX.CV shape, as shown in (81).

(81) Ibibio

	Root		*+reversive* -Cá		*+frequentative* -ŋá	
a.	síít	‘block’	sítté	‘unblock’	sííŋé	‘unblock (freq.)
	fáák	‘wedge’	fákká	‘remove wedge’	fááŋá	‘remove wedge (freq.)’
	kɔ́ɔ́ŋ	‘hang on hook’	kɔ́ŋŋɔ́	‘unhook’	kɔ́ɔ́ŋɔ́	‘not hang on hook (freq.)’
b.	nɔ̀	‘give’			nɔ̀ɔ̀-ŋɔ̀	‘give (freq.)’
	k͡pá	‘die’			k͡páá-ŋá	‘die (freq.)’

(Urua 1990; Harris (2004[1990])

As seen, shortening of the root vowel (reversive -*Cá* in [81a]), deletion of the suffix consonant (frequentative -*ŋá* in [81a]), or lengthening of the root vowel (in [81b]) applies in order for the final verb form to conform with the trochaic CVX.CV template. See Akinlabi and Urua (2003) for a more detailed foot-based analysis of the Ibibio verbal system.

5.4.3.2. Conflicting prominence

In a few languages, there seem to be conflicting prominence requirements. Such is the case of most South African Khoisan languages, i. e., languages of the Kx’a, Tuu and Khoe-Kwadi families. In those languages, heavy restrictions are placed

both on root shape and on the distribution of phonemes within roots (Beach 1938; Traill 1985; Miller-Ockhuizen 2001; Miller 2010; Nakagawa 2006, 2010; Naumann forth.). As shown in (82), lexical roots are always bimoraic, and may be of three shapes only. Note that (82b) and (82c) are probably derived from (82a) (Beach 1938; Traill 1985).[20]

(82) a. $C(C)V_{\mu}.CV_{\mu}$
b. $C(C)V_{\mu}N_{\mu}$ (likely from *C(C)V.NV)
c. $C(C)V_{\mu}V_{\mu}$ (likely from *C(C)V.CV)

The distribution of consonants within roots, summarized in (83), offers an unambiguous case of stem-initial prominence.

(83) a. C(C)1: – All consonants except y, ny and ŋ (84 of the 88 consonants of the West !Xoon dialect of Taa)
– All consonant clusters (77 in West !Xoon)
b. C2: Only sonorants and /b/
(8 in West !Xoon: b [b~β~w], m, n, ny, ŋ, r, l, y)
NB: only nasals are attested in coda position, cf. (82b)

As seen, a total of 84 simplex consonants and 77 clusters (according to Naumann's (forth.) analysis, cf 2.3.2 above) are attested in C(C)1 position in West !Xoon, as opposed to only 8 consonants in C2. Additionally, the root-initial consonants and clusters include all the click consonants (arguably articulatorily "strong" and perceptually salient), whereas the intervocalic or coda C2 are all "weak" consonants, sometimes even phonetically weakened, as is the case for /b/, whose realization oscillates between [b], [ḇ], [β] and [w]. Miller (2010) proposes a prosodic account of those consonantal distribution asymmetries in Ju|'hoan in terms of stem-initial prominence. Although her analysis is not foot-based, the data certainly points to a possible trochaic analysis.

The very peculiar distribution of vowels, on the other hand, does not seem to point to any clear positional prominence effect, as shown in Table 7.

[20] The generalizations presented here are drawn primarily from Nakagawa's (2010) analysis of G|ui (Khoe-Kwadi) and Naumann's (forth.) analysis of the West !Xoon dialect of Taa (Tuu), but can be considered to hold, with only minor changes, for all South African Khoisan languages, except perhaps for Kalahari Khoe East and Kwadi, for which much uncertainty remains.

Table 7: The vowel system of West !Xoon (after Naumann forth.: 29)

	Front	*Back*			*Front*		*Back*		
V_1	--	u	+	*tense/glottalized*	--	--	a’	o’	u’
	--	o		*breathy*	--	--	ah	oh	uh
		a		*pharyngealized*	--	--	aq	oq	uq
				strident	--	--	aqh	oqh	uqh
V_2	i	u	+	*nasalized*	in	--	an	--	un
	e	o							
		a							

As seen, it is difficult to determine which vowel is more prominent: while phonation contrasts are neutralized in V_2 position, V_1 is reduced to the three back vowel qualities /a, o, u/. V_2 is also the only nasalizable vowel. This is summarized in (84), where potential prominence-inducing properties are underlined.

(84)		*vowel quality*	*phonation type*	*nasalization*
	a.	V_1: a, o, u	<u>all</u>	no
	b.	V_2: <u>all</u>	modal voice only	<u>yes</u>

Nakagawa (2010) goes one step further in his analysis of this distributional pattern in G|ui, showing that V_1 and V_2 have non-overlapping, complementary feature specifications: V_1 needs only be specified for the two non-dorsal features [round] and [pharyngeal], while V_2 is specified for all non-dorsal features ([high], [low], [back]) and nasality, as summarized in Table 8. A summary of the phonotactic constraints shaping lexical roots in G|ui is presented in Figure 2.

At least two hypotheses can be put forth to explain this asymmetry: either only consonants are sensitive to stem-initial prominence, or foot structure; or both consonants and vowels are affected, in which case the head of the trochee is the initial CV sequence, and aspects of the quality (dorsal features and nasality) of V_1 are subject to phonotactic requirements independent of foot-structure: local CV assimilation similar to the Guttural OCP and Back Vowel Constraint in Ju|’hoan (Miller-Ockhuizen 2001), weak-trigger vowel harmony *à la* Walker (2005). More research is needed to understand exactly how prominence can be determined and how foot-based analyses fare in cases of apparent conflicts in prominence.

Table 8: Distribution of vowel features in disyllabic roots in G|ui (adapted from Nakagawa 2010)

	Phoneme	*V_1 features*		*V_2 features*				*V_1 allophones (predictable from C1, C2 and/or V_2)*
		[rd]	[phar]	[hi]	[lo]	[bk]	[nas]	
V_1	/A/	–	–					[i, e, a, ĩ, ã]
	/U/	+	–					[u, o, ũ]
	/a^{ʕ}/	–	+					[a^{ʕ}, ã^{ʕ}]
	/u^{ʕ}/	+	+					[u^{ʕ}, ũ^{ʕ}]
V_2	/i/			+	–	–	–	
	/e/			–	–	–	–	
	/a/			–	+	+	–	
	/o/			–	–	+	–	
	/u/			+	–	+	–	
	/ĩ/			+	–	–	+	
	/ã/			–	+	+	+	
	/ũ/			+	–	+	+	

C1	V1	C2	V2
|	|	|	|
Obstruents	**Non-dorsal**	**Sonorants**	**Dorsal**
(Sonorants)	[±round]	(Obstruents)	[±high, ±low]
	[±pharyngeal]		[±back]
			&
			[±nasal]

Figure 2: Distribution of C and V features in disyllabic roots in G|ui (Nakagawa 2010)

5.4.3.3. Iambic languages

While stem-initial prominence lends itself, at least in some cases, to a trochaic analysis, iambic languages are also attested in Africa. Pearce (2003, 2006, 2007a,b) convincingly describes Kera as an iambic language. Despite having no word-level phonetic prominence or stress, word-well-formedness, together with phonetic cues of duration, allophony and intensity can indeed be used as evidence for the existence of iambic feet in Kera. The CV.CV shape being disallowed, underlying /CV.CV/ sequences undergo either deletion or lengthening of their final vowel, to

form an acceptable iambic foot, as shown in (86). The possible iambic feet are listed in (85) (heads are underlined).

(85) Kera

a.	monosyllabic:	(CVV)	(CVC)
b.	disyllabic:	(CV.CVV)	(CV.CVC)

(Pearce 2006: 263)

(86)

		phrase-medial	*phrase-final*
a.	/CV.CV/	(CVC)	(CV.CVV)
b.	/bɛ̀gɛ́/ 'cattle, animal'	(bɛ̀g)	(bégɛ́ɛ)

As can be seen in (86b), the metrical structure is also indicated by an alternation in vowel quality: non-head low vowels /ɛ, a, ɔ/ are realized as [+ATR] [e, ə, o], respectively, as further illustrated in (87). Table 9 presents the vowel system of Kera.

Table 9: Kera vowel system

	/i/	/ɨ/	/u/	/ɛ/	/a/	/ɔ/
head [-ATR]	[i]	[ɨ]	[u]	[ɛ]	[a]	[ɔ]
non-head [+ATR]				[e]	[ə]	[o]

(87)

not phrase-final	*phrase-final CV.CVV*		*phrase-final CV.CVC*	
[pɛ́p]	[pépɛ́ɛ]	'god'	[pépɛ́ŋ]	'God'
[gɔ̀l]	[gòlɛ̀ɛ]	'to look'	[gòlɔ̀ŋ]	'looked'
[tár]	[təráa]	'a run'	[fəláŋ]	'found'

This allophony can be analyzed as a case of vowel reduction, the [-ATR] vowels being on average longer than the [+ATR] ones by approximately 20 ms (50 ms versus 30 ms) (Pearce 2006: 266). Additionally, heads are realized with more intensity than non-heads, the former being on average louder than the latter by roughly 3 to 8 dB (Pearce 2006: 270–1, 2007a: 63). The foot is also a relevant domain for vowel harmony and tone assignment in Kera, as we will see in sections 4.4.5 and 4.4.6 below.

As noted by Pearce (2007b: 66–67), Hausa is claimed to possess a similar iambic structure independent from stress (Newman 2000; Schuh 1989, 1999): "It is possible that the foot structure does play a part in several Chadic languages but that they are yet to be analysed in this way" (Pearce 2006: 261–2).

5.4.3.4. Interplay between prominence and vowel harmony

It has been noted that prominence often plays an important role in vowel harmony, for example, the prominence of roots over suffixes in so-called "root control" (cf. section 3.2.1.1 above). Beckman (1997) developed the notion of "positional faithfulness" to account for the fact that only stem-initial vowels trigger height harmony in Shona.

Shona has five contrastive vowels. All five vowels are attested in the initial root syllable of verb stems, but only a subset are attested in the following syllables, as summarized in [ExSho].

(88) Shona

Initial Root σ		Internal V's (extensions)		Final V morpheme
i	u	i~e	u~o	
e	o			-e
a		a		-a

As can be seen, the opposition between high and mid vowels root-internally is fully predictable: it is conditioned by a vowel height harmony typical of many Bantu languages, schematized in (89) (Hyman 1999, cf. section 3.2.1.3 above).

(89) a. Front height harmony: i → e / {e, o} C___
b. Back height harmony: u → o / o C___

Examples (90) and (91) below illustrate the application of front height harmony (89a) when a verb root combines with the applicative (-ir/-er) and causative (-is/-es) extensions, respectively: the examples in (90b) and (91b) show the effect of a root mid vowel on the vowel of the extension.

(90) Shona

a.	ip-a	'be evil'	ip-ir-a	'be evil for/at'
	svetuka	'jump'	svetuk-ir-a	'jump for/at'
	ʃata	'hold'	ʃat-ir-a	'hold for/at'
b.	per-a	'end'	per-er-a	'end for/at'
	sona	'sew'	son-er-a	'sew for/at'

(Beckman 1997, based on Fortune 1955)

(91) Shona

a.	kwir-a	'climb'	kwir-is-a	'make climb'
	bvum-a	'agree'	bvum-is-a	'make agree'
	pamh-a	'do again'	pamh-is-a	'make do again'
b.	sek-a	'laugh'	sek-es-a	'make laugh'
	om-a	'be dry'	om-es-a	'make to get dry'

(Beckman 1997, based on Fortune 1955)

Beckman argues that the absence of a high–mid opposition internally to the verb stem is due to the fact that mid vowels are only licensed in the stem-initial syllable. Mid vowels are analyzed as being in general more marked than both high and low vowels, and they owe their contrastive status stem-initially to a strong requirement that the underlying height of the stem-initial vowel not be changed. Couching her analysis in Optimality Theory, Beckman translates the vowel height markedness scale into the markedness constraint hierarchy: *Mid >> *High, *Low, i. e. the ban against mid vowels is stronger in Shona than the ban against high and low vowels. The reason why mid vowels not only surface but are contrastive stem-initially is because of a highly ranked positional faithfulness constraint preventing any change to the [high] feature of the stem-initial vowel: Ident-σ_1(hi) >> *Mid >> *High, Ident(hi), i. e., mid vowels are more marked than high vowels, but systematically protected and kept in stem-initial position. Consequently, only the stem-initial vowel, the only one that is contrastive for [high], can condition the harmony: the interaction of *Mid, *High and Ident(hi) favors both outputs without any mid vowel and outputs where the stem-initial and stem-internal vowels agree in [high]. Since the stem-initial vowel is protected by Ident-σ_1(hi), the only way to satisfy the latter requirement without modifying the stem-initial mid vowel is to make the stem-internal vowel agree with it in [high], i. e., to allow a stem-internal mid vowel.

Another case of vowel harmony that could lend itself to such an analysis is the Laal high-harmony seen in (42) above, although in that case stem-initial faithfulness does not account for the other two harmonies (low and rounding, cf. [43], [44] and [45] above), which target the intial vowel and thus seem to contradict the very idea of stem-initial faithfulness.

Pearce (2006: 270–272, 2007a: 80–129) shows that one of three types of vowel harmony attested in Kera is sensitive to metrical structure: the central vowels /a, ɨ/ are systematically fronted to /e, i/ by a front suffix, on the condition that both be in the same iambic foot (independently necessary, cf. section 4.4.3), as illustrated in (92).[21]

(92)		*Imperative*	*Imperfective*	*Front harmony*
		Verb + la	*Verb* + -ɛ́	
	a.	(dʒɛ̀l) là	(dʒɛ̀lɛ̀ɛ)	*n/a (non-central V)*
		(dìg) là	(dìgíi)	*n/a (non-central V)*
	b.	(bàl) là	(bɛ̀lɛ̀ɛ)	a > e
		(bɨ̀ŋ) là	(bìŋìi)	ɨ > i
	c.	(bàa)(d-ɨ̀ làa)	(bàa)dɛ̀	*n/a (different foot)*
		(ɨ̄s)(k-ɨ̄ láa)	(ɨ́s)kí	*n/a (different foot)*

[21] Note that in *dìgíi*, *bìŋìi* and *ɨ́skí*, the suffix /-ɛ́/ harmonizes in height with the previous vowel. This height harmony, applying between root and suffix, is independent of foot structure.

(92)	*Imperative*	*Imperfective*	*Front harmony*
	Verb + la	*Verb* + -ɛ́	
a.	(dʒɛ̀l) là	(dʒɛ̀lɛ̀ɛ)	*n/a (non-central V)*
	(dìg) là	(dìgíi)	*n/a (non-central V)*
b.	(bàl) là	(bɛ̀lɛ̀ɛ)	a > e
	(bɨ̀ŋ) là	(bìŋ̀ii)	ɨ > i
c.	(bàa)(d-ɨ̀ làa)	(bàa)dɛ̀	*n/a (different foot)*
	(ɪ̄s)(k-ɪ̄ láa)	(ɪ́s)kí	*n/a (different foot)*

As can be seen, Front harmony applies in (92b), where both vowels are in the same foot, but not in (92c), where this condition is not met.

5.4.3.5. Interactions between metrical structure and tone

Interactions between tone and metrical structure have been noted in a few African languages (cf. Pearce 2013: 132 for references about both African and non-Africa languages). Leben (1997, 2001, 2003) argues that the metrical foot may be a domain of tone-assignment (a "tonal foot"), on the basis of data from Bambara and Hausa. In loanwords from English, for instance, Hausa constructs a binary foot starting with the stressed syllable of the English word. The transition between the stressed and the following unstressed syllable(s) in English is translated into a transition between H and L tone. The H tone is assigned to the foot thus created, and unfooted material receives a default L tone, as shown in (93a). If there is no unfooted material following the tonal foot, the L tone necessary to achieve the HL transition is inserted at the right edge of the tonal foot, as illustrated in (93b), (93c) and (93d).

(93) Hausa

a.	ˈmessenger	→	(máásín)jà	Niˈgeria	→	nà(jéérí)yàà
			H L			L H L
b.	ˈgovernor	→	(gwámnà)			
			H L			
c.	guaranˈtee	→	gàràn(tíì)			
			L HL			
d.	ˈtime ˌkeeper	→	(tâŋ)(kíifàa)			
			HL H L			

(Leben 2001)

The fact that the pitch drop in (93a) does not occur on the same syllable as in the original English words (i. e., on the syllable immediately following the stressed syllable) provides clear evidence that tone is not used in Hausa to simply mimic English intonation, and it thus justifies Leben's foot-based analysis.

Pearce (2006, 2013: ch. 4) analyzes in detail the very interesting case of Kera, where the TBU is either the syllable (in disyllabic words), or the (iambic) foot

(in words of three syllables and more). As can be seen in Table 10, metrical structure is irrelevant in disyllabic words, where tones associate to syllables.

Table 10: Tone melodies on Kera disyllabic words (Pearce 2013:136)

	2σ, 1Ft		**2σ, 2Ft**		**2σ, 1Ft + 1 unfooted σ**	
	(σ σ̲)		(σ̲) (σ̲)		(σ̲) σ	
	T		T		T	
L	(gèdɛ̀l)	'mud'	(gɔ̀r)(nɔ̀y)	'hyena'	(bɔ̀ɔ)bɛ̀	'start of dry season'
M	(kélɛ̄w)	'flute'	(kɛ̄f)(tɛ̄r)	'book'	(lāā)wɛ̄	'sadness'
H	(kókɔ́y)	'muts'	(cúŋ)(kúy)	'spear'	(tɔ́ɔ)má	'snake'
	(σ σ̲)		(σ̲) (σ̲)		(σ̲) σ	
	T_1 T_2		T_1 T_2		T_1 T_2	
LH	(gùɓú:)	'stand for pots'	(gɨ̀i)(gúr)	'chickens'	(màs)ká	'uncultivated land'
HL	(gégɛ̀l)	'basket, cage'	(máa)(hùr)	'flute'	(lám)bà	'taxes'
MH	(sōlɔ́y)	'money'	(kār)(mán)	'thing'	(sɛ̄s)ká	'star'
HM	(kítīr)	'moon'	(kɔ́s)(lɔ̄m)	'laziness'	(fár)tā	'skirt'

For trisyllabic and longer words however, tone melodies associate with feet, as shown in [ExKerTri]: each tone in a bitonal melody is assigned to the head of a separate iambic foot, then spreads within that foot. No tone spreading is allowed across feet.

(94) Kera

a.	(dàk)	(təláw)	'bird *sp.*'	*(dàk)	(təláw)
	L	H		L	H
b.	(sáa)	(tərāw)	'cat'	*(sáa)	(tərāw)
	H	M		H	M
c.	(kúɓúr)	(sī:)	'coal'	*(kúɓūr)	(sī:)
	H	M		H	M
d.	(gə̀dàà)	(mɔ́:)	'horse'	*(gə̀dáá)	(mɔ́:)
	L	H		L	H

(Pearce 2013: 142)

Interesting interactions between tone and metrical structure are also attested in Moro, where Jenks and Rose (2011) show that the distribution of H tone is sensitive to a number of morphological and prosodic factors, including metrical structure: H tones spread rightward on verbs within a binary foot. Similar foot-based analyses of tone doubling (i. e., local spreading of a tone to one adjacent syllable only) have been proposed for many other languages, including the African languages Suma (Bradshaw 1998), Lamba (Bickmore 2003; de Lacy 2002), Northern Karanga Shona (Topintzi 2003), and Bambara (Leben 2003; Weidman and Rose 2006) (all cited in Jenks and Rose 2011). Pearce (2006: 262) mentions that "a number of [Chadic languages] display signs of possible metrical and tonal interaction [e. g., Mukulu, Migaama, Masa, most Central Chadic languages], and … further investigation of the phenomenon within this language family is merited". Such a comment certainly applies to all tonal languages of sub-Saharan Africa, many of which are still poorly known.

5.4.3.6. Similar unresolved issue: the Tiene case

Some templatic developments can be quite mysterious. Tiene, a Bantu Language of the Teke group, closely related to Teke-Kukuya, restricts stems (consisting of a root + possible suffixes) as in (95):

(95) The "prosodic stem" in Tiene
- a. Five shapes: CV, CVV, CVCV, CVVCV, CVCVCV
- b. In case of $C_1V_1C_2V_2C_3V_3$:
  - i. C_2 must be coronal
  - ii. C_3 must be non-coronal
  - iii. C_2 and C_3 must agree in nasality
  - iv. V_2 is predictable (with few exceptions)

  (Ellington 1977; Hyman 2010)

As seen, the Tiene stem, like Teke-Kukuya or Basaá, may consist of up to three syllables. When trisyllabic, there are severe restrictions on the distribution of the second and third consonants: coronals must precede labials and velars. When a coronal suffix such as causative -Vs- or applicative -Vl- threatens to produce the reverse order, the /s/ or /l/ appears to metathesize with the final labial or velar consonant:

(96)	a.	lab-a	'walk'	→	lasab-a	'cause to walk'
		lók-a	'vomit'	→	lósek-ɛ	'cause to vomit'
	b.	dím-a	'become extinguished'	→	díseb-ɛ	'extinguish (tr.)'
		yóm-a	'become dry'	→	yóseb-ɛ	'make dry'

(97)	a.	yɔb-ɔ	'bathe'	→	yɔlɔb-ɔ	'bathe for'
		bák-a	'reach'	→	bálak-a	'reach for'
	b.	dum-a	'run fast' 'load'	→	dunem-ɛ	'run fast for'
		lɔŋ-ɔ		→	lɔnɔŋ-ɔ	'load for'

The examples in (96b) and (97b) show that C2 and C3 must agree in nasality. Thus, stem- /m/ denasalizes in the presence of causative -Vs-, and /l/ nasalizes in the presence of root /m/. While there are a number of ways one might account for the CVTV{P,K}- template (cf. Hyman and Inkelas 1997), it is not at all obvious what the historical motivation was for the observed place-driven metathesis. Based on the limited documentation available, Hyman (2010) shows that there is considerable variation in the templatic properties of CVCVCV stems in the Teke group to which Tiene most likely belongs. What is clearly called for is a comparative study of the group, first to establish what is versus is not attested, and then to resolve the question of how and why such requirements are placed on trisyllabic stems. (There are no corresponding restrictions on the C2 of bisyllabic stems.)

5.5. Interface phenomena

5.5.1. Syntax–phonology interface

From early generative phonology to the present, African languages have also been central in the study of the syntax–phonology interface. Among the earliest and most informative documentations of this interaction are Kisseberth and Abasheikh's (1974) treatment of syntactically conditioned vowel length alternations in Mwiini and Clements's (1978) analysis of syntactically conditioned tonal alternations in Ewe. In Mwiini for example, vowel length is underlying contrastive, as shown in (98).[22]

(98) Mwiini

shta:wa	'clay pot'	*shtawa*	'fish *sp.*'
kuba:rama	'to talk'	*kubalama*	'to promise'
xtu:fa	'to go around the *ka'aba*'	*xtufa*	'to spit'

(Kisseberth and Abasheikh 1974: 194)

However, vowel length is also culminative within the syntactic-prosodic phrase, where only one long vowel is allowed, in either antepenultimate or penultimate position. Any long vowel that does not occupy the (ante)penultimate position is shortened. Long vowels may be lexical, or derived in three ways: pre-clitic lengthening (before certain clitics, e. g., the second person plural imperative *-ni* in

[22] The examples taken from Kisseberth and Abasheikh (1974) are not marked for tone.

[99b]);[23] word-final lengthening (any word within a phrase ends in a long vowel if it is not phrase-final, and if its last syllable is in (ante)penultimate position, as in [99c]); and vowel coalescence across a morpheme boundary (CV_1-[V_2…]$_{stem}$ > C-[V_2:…]$_{stem}$, as in [100a]). Note that when both the antepenult and the penult are long, only the latter is realized long, as shown in (99b) and (100b).

(99) Mwiini

a.	/so:ma/	'read'	
b.	[soma:=ni]$_{\phi}$	'read (pl)!'	*pre-clitic lengthening*
c.	[soma=ni: chuwo]$_{\phi}$	'read (pl)!) a book!'	*word-final lengthening*
d.	[soma=ni chuwo ichi]$_{\phi}$	'read(pl)! this book!'	*no underlying/ derived long vowel in (ante)penultimate position*

(Kisseberth and Abasheikh 1974: 199–200)

(100) Mwiini

a.	/si-oloke/	[s-o:loke]$_{\phi}$	'don't go!'	*VV coalescence*
b.	/si-oloke-ni	[s-oloke:=ni]$_{\phi}$	'don't go (pl)!'	*pre-clitic lengthening*

(Kisseberth 2010)

The phrasal nature of the domain is clear in (99b) and (99c), where the domain of vowel length restriction is the whole verb + object sequence. The examples in (101) illustrate a few other phonological phrases and phrase boundaries in Mwiini, supporting the claim that the realization of vowel length is heavily constrained by prosody.[24]

(101) Mwini

a.	/mp^{h}aka	cho:ndoka	| mp^{h}a<u>n</u>a	hu<u>t</u>awala/	*(clauses separated by |)*
	[mp^{h}aka	cho:ndoka]$_{\phi}$	| [mp^{h}a<u>n</u>a	hu<u>t</u>awala]$_{\phi}$	
	*[mp^{h}aka	chondoka	| mp^{h}a<u>n</u>a	hu<u>t</u>awala]$_{\phi}$	
	cat	leaves	rat	take.over	
	'When the cat leaves, the rat takes over.'				
b.	[maski:ni]$_{\phi}$	[ha:<u>t</u>ali]$_{\phi}$			
	poor	not.choose			
	'A poor man does not choose.'				

23 Kisseberth and Abasheikh (1974) analyze this clitic as a suffix.

24 The original examples are not glossed. We added very approximative glosses for the sake of clarity.

c.	/d̲awa	ya	mulo	ni	mulo/
	[d̲awa	ya:	mulo]$_{\phi}$	[ni:	mulo]$_{\phi}$
	remedy	for	fire	is	fire
	'The remedy for fire is fire'				
d.	/panzize	cho:mbo	mwa:mba/		
	[panzize	cho:mbo]$_{\phi}$	[mwa:mba]$_{\phi}$		
	*[panzize	chombo	[mwa:mba]$_{\phi}$		
	he.ran	vessel	rock		
	'He ran the vessel onto the rock.'				
e.	/nimwand̲ikilile	Nu:ru	xati/		
	[nimwand̲ikilile	Nu:ru]$_{\phi}$	[xati]$_{\phi}$		
	*[nimwand̲ikilile	Nuru:	xati]$_{\phi}$		
	I.wrote	Nuru	letter		
	'I wrote Nuru a letter.'				
	(Kisseberth and Abasheikh 1974: 202, 204)				

As can be seen, a phonological phrase may not include or straddle two different clauses (101a); the subject is phrased separately from the verb (101b) and (101c); the copula is phrased together with its complement (101c); oblique complements are phrased separately from the Verb+Object phrase (101d); and in double object constructions, the first (indirect) object is phrased with the verb, like a regular object, while the direct object is phrased separately, like an oblique.

Studies such as these informed Chen's (1987) approach to Xiamen tone sandhi, from which Selkirk (1986) generalized her end-based theory of derived domains, based largely on Mwiini. Several of the contributions in *Phonology Yearbook 4* (1987) and Inkelas and Zec (1990) deal with the syntax–phonology interface in African languages. Both Kaisse (1985) and Hayes (1987) cite earlier manuscript versions of Odden (1987) on the phrasal phonology of Kimatuumbi to support their views on this interface. Subsequent work by Kanerva (1990a, 1990b), Truckenbrodt (1995, 1999), Zerbian (2007), Downing (2008), and others have provided important advances in our understanding of interactions between phonological phrasing, syntactic representation, and focus based on Bantu languages such as Chewa, Mwiini, Matuumbi, Tumbuka, Northern Sotho and Zulu.

The remainder of this section is devoted to more puzzling cases of interplay between phonology, morphology and syntax, which tend to obscure the boundaries between these three domains in many African languages, and seem to challenge their very definition. We will concentrate on three particularly interesting phenomena: intriguing cases of tonal morphology (5.2), dependent and construct states (5.3), and phonologically conditioned mobile affixation (5.4).

5.5.2. Tonal morphology

Although African tone systems played a crucial role in shaping modern phonology through the autosegmental revolution, as we saw in section 3, subsequent theoretical innovations, most notably within Optimality Theory (Prince and Smolensky 1993), have largely been based on other phonological phenomena: segmental phonology, stress, syllabification, reduplication, etc.[25] However, the general properties of tone make it particularly well suited for probing the limits of phonology, and testing any phonological theory. One crucial property in this respect is the fact that tonal processes apply at both word and phrase levels: while other prosodies (e. g., vowel, consonant-, and nasal harmony, featural affixes) are typically word-bound, and often root-controlled, tone knows no such limitations. The consequences of this property go far beyond the role of tone in the interface between phonology and syntax, as we will show here. Tone gives rise to complex, productive, lexical and postlexical phonology, but also to complex morphology. Tonal morphology, as attested in numerous African languages, challenges our view of grammar: not only can it do anything that non-tonal morphology can do, as we saw in section 3, it can do more than non-tonal morphology, and thus often blurs the boundaries between phonology, morphology and syntax.

5.5.2.1. Non-segmentable tonal morphemes

In section 3.1.1.3, we saw that tonal morphemes could be prefixes, suffixes, clitics or independent words. The Eton (15–18) (Van de Velde 2009) and Abo (19–23) (Hyman and Lionnet 2012) examples illustrated cases where tonal morphemes were easily segmentable. However, it is not always possible to segment tonal exponents, which may in some cases be subject to different possible interpretations, as shown by the examples in (102) from Kunama, where the number distinction on possessive determiners is purely tonal: L in the singular, H in the plural.

(102) Kunama

	a. *paradigmatic*		b. *[[pers.]-number]*		c. *[[number-[pers.]]*	
	sg.	*pl.*	*sg.*	*pl.*	*sg.*	*pl.*
1st pers. incl.		-íŋ-		-iŋ-H-		-H-iŋ-
1st pers. excl.	-àaŋ-	-áaŋ-	aaŋ-L-	-aaŋ-H	-L-aaŋ-	-H-aaŋ-
2nd pers.	-èy-	-éy-	-ey-L-	-ey-H-	-L-ey-	-H-ey-
3nd pers.	-ìy-	-íy-	-iy-L-	-iy-H-	-L-iy-	-H-iy-

(Connell, Hayward and Ashkaba 2000: 17)

[25] There have been some interesting applications in Optimality Theory (Prince and Smolensky 1993; McCarthy 2002), for example Myers' (1997) treatment of the Obligatory Contour Principle (OCP), or the Theory of Tone Mapping developed by Zoll (2003).

As seen, one could equally analyze the number-marking tonal suffixes -L- and -H- as being ordered after the person suffixes as in (102b) or before them as in (102c). The impossibility to segment tonal morphemes unambiguously poses problems to generalizations such as Trommer's (2003: 284) statement that number agreement should be maximally rightwards and person agreement maximally leftwards.[26]

"Replacive" tone (Welmers 1973: 132–3) offers another case of non-segmentable tonal morphology, as illustrated by the Kalabari examples below. As seen, detransitivization of a transitive verb is obtained through imposition of a LH melody on the verb, irrespective of its underlying tonal melody:

(103) Kalabari

	Transitive					
a.	kán	H	'tear, conquer'	kàán	LH	'tear, be conquered'
b.	kɔ̀n	L	'judge'	kɔ̀ɔ́n		'be judged'
c.	ányá	H-H	'spread'	ànyá	L-H	'be spread'
d.	dìmà	L-L	'change'	dìmá		'change'
e.	sá↓kí	H-↓H	'begin'	sàkí		'begin'
f.	kíkímà	H-H-L	'hide, cover'	kìkìmá	L-L-H	'be hidden, covered'
g.	párìrí	H-L-H	'answer'	pàkìrí		'be answered'
h.	gbóló↓má	H-H-↓H	'join, mix up'	gbòlòmá		'be joined, mixed up'

(Harry and Hyman 2014)

While it is impossible to segment the LH melody of the intransitive forms in the Kalabari examples in (103), the Laal examples in (104) show how such non-segmentable replacive tonal melodies might emerge historically from affixes. In Laal, the gerund suffix has two allomorphs:[27] a copy of the root vowel with consonant-final verbs, and Ø with vowel-final verbs.[28] Both allomorphs impose an L-tone melody on the whole verb form, irrespective of the underlying tone of the verb. As seen, the replacive L-tone on Laal vowel-final verbs in (104b) clearly originates in the effect of a suffix, which is still attested with consonant-final verbs (104a).

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[26] See also Hawkins and Gilligan (1988), who indicate that languages show a clear suffix tendency for marking number (as well as gender, case, indefiniteness, nominalization, mood, tense, aspect, valence, causative), vs. Enrique-Arias (2002) who suggests that person marking favors prefixation.

[27] This suffix is used when the gerund is followed by a syntactic object NP *in situ*, i. e. not extracted or elided (Lionnet 2015).

[28] This is true of CVC, CVCVC and CV(:)CV, CVCCV verbs respectively. A few complications arise with verbs of other shapes.

(104) Laal

a. Segmental allomorph with C-final verbs:

	basic		*gerund (tr.)*	
H	sór	→	sòr-ò	'find'
M	pīg	→	pìg-ì	'tie'
L	jàr	→	jàr-à	'cut'
LH	sə̌ny	→	sə̀ny-ə̀	'fight'
HL	págàr	→	pàgr-à	'think' (+V_2 deletion)

b. Tonal allomorph with V-final verbs:

	basic		*gerund (tr.)*	
H	tíwá	→	tìwà	'weave (sp.)'
M	yīrā	→	yìrà	'know'
L	gùmà	→	gùmà	'call'
LH	gùlí	→	gùlì	'turn around'

(NB: there is no attested V-final HL transitive verb)
(Lionnet 2015)

5.5.2.2. Tone cases

Tone case systems, attested in several African languages, notably in the Nilotic and Southwest Bantu groups, offer particularly complex cases of non-concatenative tonal morphosyntax that still constitute analytical challenges. Maasai is a famous example of a language that uses tone to mark nominative versus accusative case, as shown in Table 11.

Table 11: Tone cases in Maasai (Nilotic) (Tucker and Ole Mpaayei 1955: 177–184; Bennett 1974; Plank 1995: 59–62)

	Nominative	***Accusative***		***Nom. vs. acc. patterns***
Class I	èlòkònyá èncòmàtá	èlókónyá èncómátá	'head' 'horse'	L^n-H vs. L-H^n
Class II	èndéròni ènkólòpà	èndèróni ènkòlópà	'rat' 'centipede'	H on σ1 vs. σ2
Class III	òlmérégèsh òlósówùàn	òlmérègèsh òlósòwùàn	'ram' 'buffalo'	H on σ2 & σ3 vs. σ2
Class IV	òmótònyî òsínkìrrî	òmótònyî òsínkìrrî	'bird' 'fish'	No change

While the Maasai system above is relatively simple (only two cases, distinct in only three classes of nouns), the tone cases attested in Southwest Bantu languages

offer a much more complex picture. Consider the five distinct tone cases in Phende (Democratic Republic of Congo), an abridged version of which is presented in Table 12, and illustrated in Table 13 and Table 14 for di- and trisyllabic noun roots (based on unpublished work by Hyman and Mwatha Ngalasso in 1998).[29]

Table 12: Phende tone cases, given for di- and trisyllabic noun roots

	a. /L-L.L/	b. /L-L.L.L/	c. /L-L.H/	d. /L-L.H.L/	e. /L-H.L/	f. /L-H.H/	g. /L-H.H.L/	h. /L-H.H.H/
1	L-L.L	L-L.L.L	L-L.H	L-L.H.L	L-H.L	L-H.H	L-H.H.L	L-H.H.H
2	H-H.L	H-H.H.L						
3			H-L.H	H-L.H.L				
4					H-H.L	H.H-H	H-H.H.L	H-H.H.H
5			H-H.↓H	H-H.↓H.L	H-↓H.L	H-↓H.H	H-↓H.H.L	H-↓H.H.H

L- = noun prefix
1: Citation form, subject, object of negative infinitive, left dislocation
2: Focused object
3: Genitive, second object, object after negative verb, subject after relative verb
4: Predicative (‘it is …’)
5: Object after affirmative verb or *na* ‘with’

Table 13: Phende tone cases illustrated (part 1)

	a. /L-L.L/ ‘knife’	b. /L-L.L.L/ ‘luggage’	c. /L-L.H/ ‘basket’	d. /L-L.H.L/ ‘window’
1	gi-koto	gi-pidinga	gi-kunzú	ma-didíshi
2	gí-kóto	gi-pídínga		
3			gí-kunzú	má-didíshi
4				
5			gí-kú↓nzú	má-dí↓díshi

[29] In the interest of simplicity and legibility, only di- and tri-syllabic noun roots are illustrated here. Note that there is a sixth case, the vocative, which we do not discuss here.

Table 14: Phende tone cases illustrated (part 2)

	e. /L-H.L/ ‘rat *sp.*’	f. /L-H.H/ ‘broom’	g. /L-H.H.L/ ‘ladder’	h. /L-H.H.H/ ‘baby’
1	gi-ndémba	gi-kómbó	gi-kálélo	gi-tébélé
2				
3				
4	gí-ndémba	gí-kómbó	gí-kálélo	gí-tébélé
5	gí-ꜜndémba	gí-ꜜkómbó	gí-ꜜkálélo	gí-ꜜtébélé

As seen in the paradigms above, all but case 1 in Phende seem to involve an H-prefix, which, however, is realized differently in each case. In case 2, H- appears only if the stem is all L (a–b), and spreads from the prefix to the penult. In case 3, H- appears only if the stem begins L (a–d) and spreads to the penult if the stem is all L (a-b). In case 4, H- appears on all nouns, spreads onto all following L’s (a–d) and downsteps a following H. In case 5, H- appears on all nouns, only on the prefix, except when the stem is all L, in which case it spreads to the penult (a–b); it does not condition downstep.

Such a complex system lends itself to many different analyses: it could be interpreted in in terms of prefixal versus proclitic H tones, realizational morphology, or co-phonologies (Inkelas 2008, 2011) converting the underlyingly toneless prefix to H- as indicated in (105), with H- spreading to the penult if the noun stem is underlyingly toneless (assuming a privative /H/ versus Ø analysis of the tone system).

(105) A co-phonology account of Phende tone cases (where underlying Ø is represented as L in the interest of legibility)
- a. case 1: L- remains L- on all nouns (Ø → L)
- b. case 2: L- → H- unless there is a H anywhere in the stem, i. e., a skeleton-insensitive OCP(H) restriction
- c. case 3: L → H- unless there is a H in the first syllable of the stem to avoid a local, skeleton-sensitive OCP(H) restriction
- d. case 4: L- → H- in all nouns; the H spreads to the penult or up to a H, which is downstepped to avoid an OCP violation
- e. case 5: L- → H- in all nouns; the H spreads to the penult if the stem is all L, otherwise is realized only on the prefix, without downstepping the following H, the OCP violation thus being tolerated

It is not clear, however, what such a system is the manifestation of: as seen above, the contexts conditioning the use of cases 1–5 do not seem to form natural group-

ings and have as much to do with information structure as they do with grammatical relations. For example, case 1, the citation form, is used to mark the subject of a verb, the object of a negative infinitive, but also left dislocation. Since the five patterns can affect the realization of noun tones at the word level, this does seem to be morphology determined by phrasal conditions.[30]

5.5.2.3. Postlexical assignment of tonal morphemes

The examples of tonal morphology we have seen so far are all word-bounded. However, tonal morphology may extend beyond the word, blurring the boundaries between both lexical and postlexical processes, and phonology and morphosyntax.

Intriguing cases of non-phrasal, lexical and morphological tone assigned postlexically at the phrase level are attested in many African languages, in particular in /H, Ø/ Bantu languages. In Giryama (Mijikenda, Kenya), for example, the lexical H tone of a verb surfaces on the penultimate syllable of its syntactic object:

(106) Giryama

a.	ku-tsol-a	ki-revu	'to choose a beard'	/-tsol-/ 'choose'
b.	ku-on-a	ki-révu	'to see a beard'	/-ón-/ 'see'
		H		

(Philippson 1998: 321)

Mwiini offers a clear example of a tonal morpheme assigned at the phrase level. In this H-marked Bantu language spoken in Somalia, tone ("accent" in Kisseberth's terms) is only grammatical, and is limited to one H tone per phrase, on one of the last two moras. As can be seen by comparing (107) and (108), the final versus penultimate H tone that distinguishes first and second person subjects from third person subjects is assigned postlexically at the phrase level, although it seems like it should be word- (or stem-) level (notice also the lengthening of the verb-final vowel before the object in [108]). Note that the realization of vowel length in (108) is subject to the prosodic requirement described in section 5.1 above.

(107) Mwiini

	pers.	*tone*	*singular*		*plural*	
a.	1st:	Final H	n-ji:lé	'I ate'	chi-ji:lé	'we ate'
b.	2nd:	Final H	ji:lé	'you sg. ate'	ni-ji:lé	'you pl. ate'
c.	3rd:	Penult H	jí:le	's/he ate'	wa-jí:le	'they ate'

(Kisseberth 2009, 2010)

[30] Other Southwest Bantu languages with tone cases include Kikongo (Daelemann 1983), Umbundu (Schadeberg 1986) and Herero (Kavari, Marten and van der Wal 2012).

(108) Mwiini

a.	jile: n̪amá	'you sg. ate meat'
b.	jile: n̪áma	's/he ate meat'
c.	jile ma-tu:ndá	'you sg. ate fruit'
d.	jile ma-tú:nda	's/he ate fruit'

(Kisseberth 2009, 2010)

An even more intriguing case of postlexical morphological tone assignment comes from Kuria, which assigns an H tone to different moras of the verb stem (ignoring prefixes), depending on tense, aspect and mood. The H then spreads to the penultimate mora, as illustrated in (109) (where "[" represents a stem-initial boundary).

(109) Kuria

a.	*μ1*	n-to-o-	[hóótóótéér-a	'we have reassured'	*Past*
b.	*μ2*	n-to-o-	[hoótóótéér-a	'we have been reassuring'	*Past prog.*
c.	*μ3*	n-to-re-	[hootóótéér-a	'we will reassure'	*Future*
d.	*μ4*	to-ra-	[hootoótéér-a	'we are about to reassure'	*Inceptive*

(Marlo et al. 2015)

The examples in (110) illustrate verbs of different sizes (from one to four moras) in the inceptive form, which assigns an H tone on the fourth mora of the verb stem. As seen in (110b), when the stem is one mora short, a rising tone is obtained. When it is more than one mora short, as in (110c) and (110d), the final L tone is not realized as a L falling tone, which is the default realization of final L tones, but as a level tone L^{o}, which betrays the presence of a following floating H tone.

(110) Kuria

			H tone assignment
a.	to-ra-[karaaŋg-á	'we are about to fry'	[karaaŋg-á
b.	to-ra-[sukură	'we are about to rub'	[sukur-a *μ́*
c.	to-ra-[βun-a^{o}	'we are about to break'	[βun-a *μ μ́*
d.	to-ra-[ry-a^{o}	'we are about to eat'	[ry-a *μ μ μ́*

(Marlo et al. 2015)

When the following word[31] is underlyingly toneless, some speakers count its moras and the TAM-dependent H tone is assigned accordingly, and then spreads to the penultimate mora of the whole phrase, as shown in the following example with the sequence Inceptive verb + /eɣetɔɔkɛ/ 'banana'.

[31] The word following the verb may be a locative enclitic, a second infinitival verb, the negative marker *hai*, or a noun (Mwita 2008; Marlo et al. 2009).

(111) Kuria

a.	to-ra-[karaaŋg-á	éɣétɔ́ɔ́kɛ	'we are about to fry a banana'
b.	to-ra-[sukura	éɣétɔ́ɔ́kɛ	'we are about to rub a banana'
c.	to-ra-[βun-a	eɣétɔ́ɔ́kɛ	'we are about to break a banana'
d.	to-ra-[ry-a	eɣetɔ́ɔ́kɛ	'we are about to eat a banana'
	(Marlo et al. 2015)		

Once again, H-tone assignment seems as if it should be word-level morphology (or stem-level, since the prefixes are irrelevant), but it is actually calculated at the phrase level. Such examples of "wandering morphs" are extremely intriguing: is this a case of incorporation? Postlexical cophonology? More research is definitely needed on such phenomena, which may change our definition of phonology and its limits.

5.5.2.4. Construction tonology

The last case of morphological tonology challenging current theoretical approaches to phonology and interface phenomena is what Harry and Hyman (2014) term "construction tonology", i.e., morphosyntactically governed replacive tonal overlays (cf. McPherson 2014b). Replacive tone assigned by word-level morphological constructions, illustrated in (103) above, is a relatively common phenomenon. It is far less common for such tonal overlays to be syntactically governed. At least two cases have been reported in Africa in the recent literature: Kalabari and the Dogon languages of Mali.[32]

In Kalabari, a head-final language, the noun appears finally within the NP, followed by the definite article. Whenever the noun is non-initial, it loses its tones and receives one of four "melodies" depending on the word class of the preceding specifier/modifier (the "controller", in McPherson's (2014b) terms). Thus the /H-H-H/ tone of /ɓúrúmá/ 'indigo' has the four realizations shown in (112) (both ` and unmarked = L).[33]

(112) Kalabari

	controller	*controllee tone*	*example* (ɓúrúmá 'indigo')	
a.	Nposs	HL	tʊɓɔ ɓurúmà	'the child's indigo'

[32] Different replacive tone melodies can also be assigned by specific lexical items in other Ijo lects and at least two non-African languages: Urarina (Isolate, Peru; Olawsky 2006), and Yagaria (Trans-New Guinea; Ford 1993), analyzed and compared to Kalabari and Dogon in Harry and Hyman (2014).

[33] We will only focus on the replacive tones within the Kalabari noun phrase here. See Harry and Hyman (2014) for more detail about replacive grammatical tone in the Kalabari verb phrase. In the following examples, L tone is marked (`) only when it is assigned by melody; other L TBUs lack an accent.

b.	PROposs	HLH (→ H-ꜜH)	ɪna ɓurúꜜmá	'their indigo'
c.	Det	LH	tɔ ɓùrumá	'which indigo?'
d.	Quant/Num	L	ja ɓùruma	'some indigo'

(Harry 2004; Harry and Hyman 2012; Hyman 2013)

The following table shows that the five tonal patterns found on bisyllabic nouns neutralize and receive the indicated construction-specific tones.

Table 15: Construction tonal overlays in Kalabari

			'the child's' (HL)	'their' (HLH)	'which' (LH)	'some' (L)
H-H	námá	'meat'	tʊɓɔ námà	ɪna náꜜmá	tɔ nàmá	ja nàma
L-L	pulo	'oil'	tʊɓɔ púlò	ɪna púꜜló	tɔ pùló	ja pùlo
H-L	béle	'light'	tʊɓɔ bélè	ɪna béꜜlé	tɔ bèlé	ja bèle
L-H	garí	'garri'	tʊɓɔ gárì	ɪna gáꜜrí	tɔ gàrí	ja gàri
H-ꜜH	ɓáꜜrá	'hand'	tʊɓɔ ɓárà	ɪna ɓáꜜrá	tɔ ɓàrá	ja ɓàra

The four overlays do not map onto longer nouns in the same way. The HL and HLH melodies link to the last two syllables of trisyllabic nouns (the tone of the initial syllable agrees with the final tone of the controller), as illustrated in (113a) and (113b). The initial L of the LH melody imposed by determiners links to the initial syllable of the noun, while the H tone goes on the last syllable. (Any intervening syllables are also L.) Finally the quantifier-/numeral-controlled L melody is assigned to the whole noun.

(113) Kalabari

a.	$\text{Noun}_{\text{poss}}$ +Noun^{HL}			*'my'*	*'your (sg.)'*
	lubulu	'sheath'	L-L-L	i lubúꜜlú	í lúbúꜜlú
	ɓúrúmá	'indigo'	H-H-H	i ɓurúꜜmá	í ɓúrúꜜmá
	kɔ́kalí	'fruit'	H-L-H	i kʊkáꜜlí	í kɔ́káꜜlí
b.	Pro_{poss}+ Noun^{HLH}			*'child's'*	*'bird's'*
	lubulu	'sheath'	L-L-L	tʊbo lubúlù	fění lúbúlù
	ɓúrúmá	'indigo'	H-H-H	tʊbo ɓurúmà	fění ɓúrúmà
	kɔ́kalí	'fruit'	H-L-H	tʊbo kʊkálì	fění kɔ́kálì
c.	Dem + Noun^{LH}			*'this'*	*'these'*
	lubulu	'sheath'	L-L-L	mí lùbulú	míꜜná lùbulú
	ɓúrúmá	'indigo'	H-H-H	mí ɓùrumá	míꜜná ɓùrumá
	kɔ́kalí	'fruit'	H-L-H	mí kɔ̀kalí	míꜜná kɔ̀kalí

d. Quant/Num + Noun^{L}

lubulu	'sheath'	L-L-L	tɔ̃wá lùbulu	sɔ́ná lùbulu
ɓúrúmá	'indigo'	H-H-H	tɔ̃wá ɓùruma	sɔ́ná ɓùrùmà
kɔ́kalí	'fruit'	H-L-H	tɔ̃wá kɔ̀kalı	sɔ́ná kɔ̀kalı

(Harry 2004; Harry and Hyman 2012; Hyman 2013)

Harry and Hyman (2014) argue that although they apply to entire syntactic phrases, such tonal assignments have all of the properties of morphological rules. Such data raise two types of questions. First, how should the constructional tones be analyzed synchronically: i. e., how are they assigned, and how do they (potentially) interact with each other? The second question is why Kalabari has constructional tones: what is their relationship to what is found in other languages, and where do they come from, diachronically? Although much research is still needed on this fairly recently discovered phenomenon, elements of answers, mainly to the first question, have already been proposed, as we will see in the following paragraphs.

When the controller is followed by several nouns (Controller +N1 +N2), the tonal overlays map over the whole sequence of nouns, as shown in (114) for the three complex melodies HL, HLH and LH (the melody assignment domain is underlined).

(114) Kalabari

a. Noun$_{poss}$ + [N1+N2 …]^{HL}

tʊɓɔ +fɛ́ní +námá	→	tʊɓɔ	fení nàma	'the child's bird's meat'
			H L	
fɛ́ní +minji +kúkú	→	fɛ́ní	mínjí kùku	'the bird's water pot'
			H L	

b. Poss + [N1+N2 …]^{HLH}

ı +fɛ́ní +námá	→	i	feni nàmá	'my bird's meat'
			H L H	
í +minji +kúkú	→	í	mínjí kùku	'your sg. water pot'
			H L	
ı +fɛ́ní +minji +kúkú	→	i	feni mìnji kukú	'my bird's water pot'
			H L H	
í +tʊɓɔ +sírı +námá	→	í	tʊ́ɓɔ́ sìrı namá	'your sg. child's leopard meat'
			H L H	

c. Dem + [N1+N2 …]^{LH}

mí +fɛ́ní +námá	mí	fèni namá L H	'this bird's meat'
mí +minji +kúkú	mí	mìnji kukú L H	'this water pot'
mí +fɛ́ní +minji +kúkú	mí	fèni minji kukú L H	'this bird's water pot'
mí +tʊɓɔ +sírı +námá	mí	tòbɔ sırı namá L H	'this child's leopard meat'

(Harry and Hyman 2014)

In complex noun phrases, e. g., when multiple modifiers imposing different competing overlays precede the head noun, two options are attested. Usually, the first modifier imposes its tone melody on the following sequence of modifier(s)+Noun. Alternatively, with the HLH and L melodies, a default HL melody may be assigned.

Very similar syntactically governed tonal overlays are attested in the Dogon languages. Limiting ourselves once again to the noun system, we will take examples from Jamsay (Heath 2008) and Tommo So (McPherson 2014b; Heath and McPherson 2013; McPherson and Heath 2014).[34] In both languages, two tonal overlays are attested that are imposed by similar morphosyntactic constructions: adjectives, demonstratives and relative clauses impose an L melody on the noun they modify, while possessors impose an H(L)[35] melody on a following (inalienable) head noun. Note that these processes are neutralizing, as can be seen in (116c) and (116d) and (117b) and (117c), where both *náá* 'mother' and nàá 'cow' surface as nàà before *èsú* 'pretty' and *nɔ́* 'this' in Tommo So.

(115) Syntactically governed tone overlays in Jamsay and Tommo So nouns
a. L : [NounL + Adj/Dem]
[NounL + Rel. clause], internal head noun of relative clause
b. H(L) : [Poss NounHL], inalienable noun after possessor[36]
(Heath 2008: 106; McPherson 2013)

[34] Heath (2008: 106) mentions other cases of tonal overlays affecting nouns, which we leave aside here, since they do not seem to be as clearly governed by the syntactic environment.

[35] This overlay is always realized HL in Jamsay. In Tommo So it is realized H on nouns of one to two moras, and HL on nouns of more than two moras.

[36] Only with pronominal possessors in Tommo So.

(116) Jamsay, Tommo So (Dogon)
Noun + Adj: L overlay

a.	/úró + jɛ́m/	→	ùrò^{L} jɛ́m	'black house'	(Jamsay)
b.	/bàbé + kómmó/	→	bàbè^{L} kómmó	'skinny uncle'	(Tommo So)
c.	/nàá + ɛ̀sú/	→	nàà^{L} ɛ̀sú	'pretty cow'	(Tommo So)
d.	/náá + ɛ̀sú/	→	nàà^{L} ɛ̀sú	'pretty mother'	(Tommo So)

(Heath 2008: 106; McPherson 2013)

(117) Jamsay, Tommo So (Dogon)
Noun + Dem: L overlay

a.	/úró + núŋò/	→	ùrò^{L} núŋò	'this/that house'	(Jamsay)
b.	/nàá + nɔ́/	→	nàà^{L} nɔ́	'this cow'	(Tommo So)
c.	/náá + nɔ́/	→	nàà^{L} nɔ́	'this mother'	(Tommo So)

(Heath 2008: 106; McPherson 2013)

(118) Jamsay, Tommo So (Dogon)
Noun + Rel. clause: L overlay

a. ùrò^{L} ù ɛ̂: (< úró) (Jamsay)
house you saw
'the house that you (sg.) saw'

b. sáná jàndùlù^{L} bɛ́nd-ɛ̀=gɛ (< jàndúlú) (Tommo So)
Sana donkey hit-PFV.REL=DEF
'the donkey that Sana hit'

(Heath 2008: 106; McPherson 2013)

(119) Jamsay, Tommo So (Dogon)
Poss + Noun$_{inal}$: HL overlay in Jamsay, H(L) in Tommo So

a.	/mí + dě:/	→	mí dê:^{HL}	'my father'	(Jamsay)
b.	/mí + bàbé/	→	mí bábé^{H}	'my uncle'	(Tommo So)
c.	/ú + ánígé/	→	ú ánígè^{HL}	'your friend'	(Tommo So)

(Heath 2008: 106; McPherson 2013)

As for Kalabari, complexity arises when the head noun is modified by multiple modifiers. If a second adjective is added, both the noun and the second adjective are affected by the L overlay:

(120) Noun^{L} Adj^{L} Adj (Tommo So)

a.	/nàá+póó+ɛ̀sú/	→	nàà^{L} pòò^{L} ɛ̀sú	'pretty fat cow'
b.	/náá+póó+ɛ̀sú/	→	nàà^{L} pòò^{L} ɛ̀sú	'pretty fat mother'

When a noun is targeted by two or more controllers imposing different overlays, different strategies apply in different Dogon languages. For example, in Tommo So, when an inalienable noun is modified by both an adjective and a possessive pronoun, the adjective's L overlay trumps the possessor's H(L), as shown in (121):

(121) Tommo So

/mí	bàbé	kómmó/	→	mí	bàbè^{L}	kómmó	'my skinny uncle'
my	uncle	skinny			*bábé^{H}		
					*bàbé		

(McPherson 2013)

Other Dogon languages resolve such conflicts differently, as schematized in (122), where the controller imposing its overlay is in boldface type, and the domain of assignment of the overlay is underlined:

(122) Dogon
PossPro(HL) + Noun + Adj(L) (e. g. 'your ugly uncle')

a.	Tommo So	:	PossPro <u>Noun^{L}</u> Adj
b.	Jamsay, Yorno So	:	<u>PossPro^{L} Noun^{L}</u> Adj
c.	Nanga	:	PossPro <u>Noun^{HL}</u> Adj

(McPherson 2013)

As all the above examples clearly show, the constructional tones of Kalabari and Dogon are sensitive to both syntactic structure and to syntactic category, and hence are not simply cases of syntactically determined phrasal phonology. They constitute a very intriguing case of syntactically controlled non-linear morphological change, i. e., they are at the intersection of phonology, morphology and syntax, three traditionally distinct compartments of language that are very difficult to disentangle here.[37]

Note that even within each of these compartments, the relevant properties of these constructions are not easy to analyze. Not only are the tonal overlays non-segmentable (cf. section 5.3.2 above), but the exact syntactic definition of the relation between the controller and the controlee itself is not always easy to determine: while both the Kalabari and Dogon constructions appear to be cases of head marking, what is marked is in reality often more than the head itself, and seems to correspond to an entire postlexical prosodic domain, as can be seen in (114) and (122b) above, where several consecutive words that do not constitute a head are assigned one single tonal overlay.

McPherson (2013, 2014b) proposes an innovative analysis of the Dogon data in terms of syntactic c-command: the controller in such Dogon constructions assigns a tonal overlay to material that it c-commands. Drawing from Booij's (2010) construction morphology, which is an output-oriented lexical theory of morphology where particular constructions are lexically listed, McPherson proposes the fol-

[37] Heath (2008: 7), highlighting how tightly prosody is integrated with syntax in Dogon languages, goes as far as to say that "working on Jamsay has deepened [his] conviction that currently dominant grammatical theories, with their sharp compartmentalization of 'phonology' and 'syntax', are badly misguided."

lowing two constructions for Dogon, which both have the same basic format [X^T controller], where T stands for a particular tonal overlay imposed by the controller onto material (X, which can be one word or multiple words) that it c-commands.

(123) Dogon Constructions: [X^T Controller]
a. [X^L Adjective]: 'Adjective X'
b. [Posspro X^H]: 'Pronominal possessor's X'

One of the great advantages of such an analysis of constructional tone is that both the assignment of tonal overlays to more than one word and the non-segmentability of non-discrete morphemes cease to be problematic. McPherson further shows how both conflict resolution between competing constructions and cross-linguistic variation among Dogon languages can be accounted for in a constraint-based approach, by simply changing the relative ranking of construction-specific constraints and faithfulness constraints.

One important question is whether the above effects of one word or word class on another constitute further evidence that there are some things that only tone can do (Hyman 2011a), or whether we can relate these cases to better-known constructional effects on the segmental make-up of words. In fact, as we will show in the next section, the two constructions attested in Africa that seem to be the closest non-tonal equivalents to tonal cases and construction tonology (the "dependent" and "construct" states) are actually only partial counterparts: even if they have similar syntactic and morphophonological properties, only tonal morphology may target postlexical prosodic domains.

5.5.3. Dependent and construct states

5.5.3.1. Dependent state in Berber

The controller–controlee structure we have seen with constructional tone in Kalabari and Dogon is very reminiscent of two similar structures attested in Africa: the Berber "dependent state", and the "construct state" attested in Semitic and various sub-Saharan African languages.[38] Following Creissels (2009) and Good and Creissels (this volume), we wish to keep those two types of constructions distinct, despite their structural similarities: the construct state is a case of head marking (the controlee is the head), and the Berber "dependent state", often misleadingly labeled "construct state", is a case of dependent marking (the head is the controller).

In Berber, nouns beginning with a frozen vowel prefix have a reduced form, which is typically used in three contexts: when the noun is the complement of a

[38] We borrow the label "dependent state" from Heath's (2005) grammar of Tamashek. The Berber dependent state is also frequently called "annexed state" (*état d'annexion*).

preposition, when it is a directly post-verbal syntactic subject, and in noun complement constructions (and after certain numerals). The reduced form always consists in a phonological reduction of the vowel prefix, thus affecting only those nouns that have such a prefix, as shown by Guerssel (1983) based on the Ait Seghrouchen dialect. Tamashek examples are given in (125) through (129), after a brief presentation of the Tamashek vowel system and vowel prefixes in (124).[39]

(124) Tamashek

a. Long/full vowels		b. Short/reduced vowels
i	u	ə
e	o	
ɑ		æ [ǎ ~ ă]

(Heath 2005)

(125) Possible noun vowel prefixes in Tamashek:[40]

a. Sg. ɑ-, e-, æ-/ə-
b. Pl. i-

(126) Prefix reduction in Tamashek:

a. {ɑ, e} → æ (> ə, if followed by high V, through height harmony)
b. i → ə (or Ø with epenthetic /ə/, subject to dialectal variation)

(127) Preposition + Noun

a.	ɑ-rə́zzej	'livestock'	→	s ə̲-rə́zzej	'with livestock'
b.	é-hæn	'home'	→	fæl æ̲-hæn	'on the house'
c.	i-kɑll-æn	'lands'	→	dæɣ Ø̲-kɑll-æn (í-dæɣ)	'in (those) lands'

(128) Noun + Noun

a.	é-dægg	'place'	→	erk ǽ̲-dægg	'bad place'[41]
b.	í-dægg-ɑn	'places'	→	erk Ø̲-dægg-ɑn	'bad places'
c.	t-ɑ-məšer-t	'campsite'	→	t-erk t-ə-məšer-t	'bad campsite'
d.	t-í-mšɑr	'campsites'	→	t-erk t-ə́-mšɑr	'bad campsites'

[39] In the interest of clarity, we have simplified Heath's notation of accent: only lexical accentuation is marked (with an acute accent), and default accentuation, assigned postlexically on the antepenult of an accentual phrase, is left unmarked.

[40] Feminine nouns add a further *t-* prefix before the vocalic prefix.

[41] The word *erk* 'bad' is a noun in Tamashek.

(129) Subject following inflected verb

a. i-nhæy ɑ-jənna (object: no reduction)
3-see:PFV rain
'He saw the rain.'

b. i-wæt ə̲-jənna (subject: prefix reduction)
3-hit:PFV rain
'The rain struck (=fell).'

As seen, the Berber dependent state is "as close as we come in this language to structural case-marking" (Heath 2005: 147).[42] The phonological reduction characterizing this construction thus constitutes, much like the tone cases of Maasai or Southwest Bantu languages, a case of syntactically governed word-level morphophonology.

Heath (2005: 11, 146–160) considers the prefix reduction of the dependent state in Tamashek to be one among several instantiations of a general "local dependency" configuration [X Y' …], where X is a phrase-initial controller (word or particle) triggering morphophonological changes (mostly forms of reduction, marked with an apostrophe) to the following phonological word Y. Table 16 presents a simplified summary of those local dependencies.

Table 16: [X Y' …] Local dependencies (Heath 2005: 11, 146–160)

X	*Y'*	*Type of modification of Y'*
Preposition Inflected verb Noun	Noun	Prefix-reduction (dependent state)
Negative particle *wǽr* Future particle *àd* Definite demonstrative Past *kǽlá*	Verb	Ablaut change

As can be seen, there are roughly two types of modifications, determined by different syntactic environments and targeting different word classes. While nouns are subject to prefix reduction, verbs undergo what Heath terms "ablaut changes": the vocalic make-up of the verb stem, its accentual pattern and the length of certain of its vowels are changed following complex rules varying according to verb stem shape and tense-aspect-mood. Since it is beyond the scope of this contribution to present the (sometimes complex) details of Heath's description, we will content ourselves with one example. After the negative particle *wǽr*, the long form of

[42] See also Creissels (2009: 75): "The so-called [annexed and free] states of Berber nouns are instances of nominal dependent marking, and are therefore functionally … similar to cases."

the indicative imperfective[43] undergoes the following changes: all its vowels are raised to high (if not already high) and the stem-initial stress and first post-consonantal vowel lengthening characteristic of the long imperfective form are lost (i. e., V_1 shortening: {i,e,a,o,u} → ə), as illustrated in (130).

(130) Negative wǽr + long imperfective stem

	positive		*negative*		*V1 shortening (+raising)*	*V2 raising*
a.	-ríddu-	→	-rəddu-	'believe'	i > ə	
b.	-hállək-	→	-həllək-	'destroy'	ɑ > ə	
c.	-jánnɑ-	→	-jənni-	'say'	ɑ > ə	ɑ > i
d.	-báddæd-	→	-bəddəd-	'stand up'	ɑ > ə	æ > ə

(Heath 2005: 334–5)

Once again, we are faced with a phenomenon that is at the intersection between phonology, morphology and syntax. In fact, the interaction between syntax and phonology is so pervasive in Tamashek that it makes "a strong case for a *morphological* view of the grammar" according to Heath (2005: 146), who writes:

> … instead of a model of grammar that starts with an autonomous abstract syntax, and then allows a phonological module to execute more or less natural phonological adjustments to the outputs of the syntax, Tamashek lends itself to a model where grammatical categories, linear ordering, and phonology (segmental, accentual, and ablaut) are inextricably intertwined. (ibid.)

5.5.3.2. Construct form

Similar to, but different from the Berber dependent state is what Creissels (2009) and Good and Creissels (this volume) call "construct form". While many such construct forms of nouns are characterized by segmental affixes, e. g., the so-called "genitive linkers" *-n* (masculine singular, plural) and *-r̃* (feminine singular) marking the head of a genitive construction in Hausa (cf. Good and Creissels, this volume, section 4.3.7, ex. XX), some others are more similar to the phonological reduction at work in Berber dependent forms. Such is the case of the Mende construct forms illustrated in (131).

(131) Mende

a. ndopó-i ḻoko-í (cf. *tokó* 'arm')
child-DEF arm-def
'the child's arm'

b. ndopó-i y̱ilɛ-í (cf. *ngíla* 'dog')

[43] The long imperfective is the only imperfective form that can directly follow the negative particle.

child-DEF dog-def
'the child's dog'
(Creissels 1994: 152–168, 2009: 80)

As seen, the initial consonant of the construct form of nouns in Mende seems to undergo lenition (t → l; ng → y), as suggested by Innes (1971), among others. Creissels shows that the construct form is actually derived through the deletion of an underlying nasal prefix *n-* present in the free form, followed by the lenition of the initial consonant: the free form /n-tokó/, phonotactically unacceptable, is realized *tokó*, while the construct forms /tokó/ and /gíla/, prefixless, are realized *lokó* and *yíla* respectively, after lenition of their initial consonant.

Northern Mao offers a case of tonal construct form, which on the surface looks quite similar to the tonal constructions of Kalabari and Dogon. In this language, there is partial neutralization of a noun's tone when modified: the nine underlying melodies (tone classes) of disyllabic nouns are reduced to a three-way contrast when they are modified: MM, ML and LL, as summarized in (132).

(132) Northern Mao

	Citation Tone Classes		*Construct Form*
a.	H-H_1	>	M-M
b.	M-M, L-L, H-L_1, M-H, M-L	>	M-L
c.	H-H_2, H-L_2, L-H	>	L-L

(Ahland 2012: 145)

As can be seen from the examples in (133), the above changes take place on the noun independent of the tone of the preceding modifier.

(133) Northern Mao

a.	H-H_1:	k'éts'é	'land'	→	M-M	íʃ	k'ēts'ē	'the land'
						nà	k'ēts'ē	'this land'
b.	M-M:	p'īʃ̄ē	'child'	→	M-L	íʃ	p'īʃ̄è	'the child'
						nà	p'īʃ̄è	'this child'
c.	H-L:	múnts'è	'woman'	→	L-L	íʃ	mùnts'è	'the woman'
						nà	mùnts'è	'this woman'

(Ahland 2012: 147–149)

However, this phenomenon is quite different from the Kalabari and Dogon tonal constructions since "… only the head noun/nominal (i. e. whatever serves as the head of the NP) takes on the construct form" (Michael Ahland, p. c.): the tonal melodies are assigned to one word, not to a postlexical prosodic domain.

Similar cases of head marking are also attested in the verb phrase in several African languages, in which the verb is marked when followed by a direct object *in situ*. This symmetry between verb phrase and noun phrase is again reminiscent of tonal constructions, attested both in the noun phrases and verb phrases

in Kalabari and in Dogon. One could propose to enlarge Creissels's definition of the construct form to include construct forms of verbs. Perhaps the most famous (African) case of verbal construct form is Hausa final vowel shortening (FVS), briefly illustrated in (134). As seen, the long final vowel of a transitive verb is shortened only when immediately followed by an overt Object NP, as in (134b).

(134) Hausa

a. *ná:* *ká:mà:* *ká:mà:*
I catch it
'I have caught (it).'

b. *ná:* *ká:mà* *kí:fí:*
I catch fish
'I have caught a fish.'

c. *ná:* *ká:mà:* *wà* *Mú:sá:* *kí:fí:*
I Catch For Musa fish
'I have caught Musa a fish.'
(Hayes 1990)

Hausa final vowel shortening, among other processes in various languages, motivated Hayes' (1990) Precompiled Phrasal Phonology. His account posits two allomorphs derived in the lexicon: *ká:mà:* and *ká:mà*. The sensitivity to syntax of each of the two forms is due to "syntactic instantiation frames", i. e., different syntactic contexts for which each allomorph is diacritically marked, which is a "fossilized or lexicalized version of a phrase-phonological rule" (Crysmann 2005: 109), as illustrated in (135).

(135) Precompiled Phrasal Phonology account of Hausa FVS:

a. Frame 1: [VP___ NP …]
b. Syntax sensitive shortening: V: → V / [Frame 1]
c. The second (not shortened) allomorph *ká:mà:* is inserted in all other contexts (Elsewhere Condition)

One can see how this analysis could be applied to other construct forms, such as the Mende examples in (131).

Crysmann (2003, 2005, 2010), however, convincingly shows that Precompiled Phrasal Phonology does not offer an appropriate account of Hausa final vowel shortening, among other reasons because adjacency between the verb and its object is not required, thus making phrasal boundaries irrelevant. Following Crysmann, Lionnet (2015) shows that the same holds for morphosyntactically conditioned M-lowering on nouns and verbs in Laal. Precompiled Phrasal Phonology also seems to be inapplicable to Kalabari and Dogon constructional tones, because the distribution of tones in this case is determined phrasally, not lexically: see for

example the Kalabari possessive HLH melody in (114b) above, distributed over three successive nouns in the last two examples.

All the above phenomena illustrate complex processes at the crossroad between phonology, morphology and syntax. Many involve some form of marking of head-dependent relations. We have also seen crucial differences between what tonal and non-tonal morphology can do respectively: only tonal morphology (as exemplified by the tonal constructions of Kalabari and Dogon) can target post-lexical prosodic domains. This results in a rather impressive blurring of the distinction between phonology, morphology and syntax, to the point of casting some doubt upon the validity of their strict compartmentalization in various theoretical models. They seem to have all of the properties of lexical "co-phonologies" (cf. Inkelas 2011, and references therein), but some of them apply postlexically at the phrase level. How to account for the properties of such phenomena is still largely an open question.

5.5.4. Phonologically conditioned mobile affixation

We have so far seen cases of morphosyntactically governed phonological processes, but cases of phonologically determined morphology, although rare, are also attested in Africa. Such is the case of mobile affixes, whose realization varies between a prefixal and a suffixal allomorph. Those affixes are attested in a very small number of languages worldwide, the two most-cited cases being Afar (Cushitic) (Fulmer 1991; Rucart 2006) and Huave (isolate, Mexico) (Noyer 1994; Kim 2008, 2010). Such cases of "mobile affixation" (Noyer 1994) are very rare and there has been an ongoing debate on the nature of the conditions governing their mobility, focusing in particular on the question whether phonological constraints should be allowed to determine morphological position (Jenks and Rose 2015, and references therein).

In a recent paper, Jenks and Rose (2015) present evidence in favor of a phonological conditioning of mobile affix position, based on an analysis of the placement of object affixes with respect to the verb stem in Moro. The following examples illustrate the prefixal (136) versus suffixal (137) realizations of the second person singular object marker, with different aspectual forms.

(136) Moro

	no object marker	*2sg object marker ŋá*
a. *proximal imperfective*	g-a-vəléð-a	g-a-ŋá-vəleð-a
	SM-CL-RTC-pull-IPFV	SM-CL-RTC-2SG.OM-pull-IPFV
	‘(s)he is pulling here’	‘(s)he is pulling you here’
	g-a-tʃómbəð-a	g-a-ŋá-tʃombəð-a
	SM-CL-RTC-tickle-IPFV	SM-CL-RTC-2SG.OM-tickle-IPFV
	‘(s)he is tickling here’	‘(s)he is tickling you here’
b. *consecutive imperfective*	ṭ-áŋ-ˬvəléð-ˬó	ṭ-áŋ-ˬŋá-vəleð-ó
	COMP-3SG.SM-pull-CONS.IPFV	COMP-3SGS.SM-2SG.OM-pull-CONS.IPFV
	‘then (s)he is pulling	‘then (s)he is pulling you’
	ṭ-áŋ-ˬtʃómbəð-ˬó	ṭ-áŋ-ˬŋá-tʃombəð-ó
	COMP-3SG.SM-tickle-CONS.IPFV	COMP-3SGS.SM-2SG.OM-tickle -CONS.IPFV
	‘then (s)he is tickling’	‘then (s)he is tickling’you’
	(Jenks and Rose 2015)	

(137) Moro

	no object marker	*2sg object marker ŋá*
a. *distal imperfective*	g-á-vəleð-ó	g-á-vəleð-ə́-ŋá
	SM-CL-DIST.IPFV-pull-DIST.IPFV	SM-CL-DIST.IPFV-pull-DIST.IPFV-2SG.OM
	(s)he is pulling there’	(s)he is pulling you there’
	g-á-tʃombəð-ó	g-á-tʃombəð-ə́-ŋá
	SM-CL-DIST.IPFV-tickle-DIST.IPFV	SM-CL-DIST.IPFV-tickle-DIST.IPFV-2sg.om
	(s)he is tickling there’	(s)he is tickling you there’
b. *perfective*	g-a-vəleð-ó	g-a-vəleð-ə́-ŋá
	SM-CL-RTC-pull-PFV	SM-CL-RTC-pull-PFV-2SG.OM
	‘(s)he pulled’	‘(s)he pulled you’
	g-a-tʃombəð-ó	g-a-tʃombəð-ə́-ŋá
	SM-CL-RTC-tickle-PFV	SM-CL-RTC-tickle-PFV-2SG.OM
	‘(s)he tickled’	‘(s)he tickled you’
	(Jenks and Rose 2015)	

Jenks and Rose show that the position of object markers in Moro does not depend on any single morphosyntactic property, be it aspect (perfective versus imperfective), spatial deixis (distal versus proximal), mood, or the main versus dependent verb distinction. The position of these affixes is actually fully phonologically determined: it follows from restrictions on the distribution of tone in the Moro verb.

> If a verb form requires a particular melodic tone pattern, object markers are suffixes. On the other hand, if a verb form adopts a default, phonologically predictable pattern, then object markers appear as prefixes. The tone property of the object markers themselves also dictates their appearance as prefixes. Only a single H toned object prefix is allowed, whereas low-toned and additional object markers appear as suffixes (Jenks and Rose 2015: 47).

Their analysis, couched in Optimality Theory, crucially relies on what they term a "P >> M" approach, where M-constraints referencing morphosyntactic (verb stem/verb phrase) domains, are dominated by phonological (P) constraints, which enables phonologically driven violations of morphosyntactic requirements on affix position.[44] Moro thus offers evidence in favor of the existence of phonologically determined patterns of affix position, which, despite their rarity, ought to be integrated in the architecture of grammar, at the interface between phonology, morphology and syntax.

5.6. Conclusion

This completes our survey of phonological issues to which African languages have contributed in a significant way, as well as African phenomena whose understanding has been (or have yet to be) greatly improved by theroretical developments. There are doubtless others, and perhaps some phonologists or Africanists will take issue with the choice of topics or specific omissions. As stated in the outset, it is hard to cover the diverse phonological properties of African languages in a chapter of this length. From the sampling just seen, it is safe to say that African languages have been prominent in almost all of the major phonological developments over the past half-century, with the notable exception of metrical stress theory.

In the preceding sections we have outlined some of the major phonological properties of African languages, most of which have had some impact on general linguistics and are well known. The questions we would like to consider in our conclusion are: (i) What is the state of our understanding of these issues? (ii) How should students of African phonology proceed from here? The easy answer

[44] Similar P>>M approaches had already been proposed by Kim (2008, 2010) for Huave, and Wolf (2008).

to (ii) might be "continue as our predecessors have done", but which predecessors? While African phonology has definitely benefited from its alliance with general linguistics, in this final section we would like to emphasize the Africanist side of the equation: the extraordinary progress on the issues raised in sections 2 through 5 have only been possible because of the careful and brilliant work undertaken by scholars deeply committed to Africa. Whether describing, reconstructing, classifying, or formalizing, such scholars have been concerned with what African languages tell us about language and languages in general. Perhaps this has been the strength of African linguistics, and we suggest that we try to follow in their footsteps.

While deep descriptive work is still lacking for many (most?) of the 2,000 languages of Africa, our proposal for making progress at this point is to focus inward on Africa. The publication in the past ten years of language descriptions with detailed phonology sections illustrates the increasing availability of good-quality data. One could cite Heath's grammars of Tamashek (2005) and Jamsay (2008), Van de Velde's (2008) description of Eton, or more recently Hellwig's (2011) grammar of Goemai and McPherson's grammar of Tommo So (2013), to mention just a few. With more and more attention given to detail and exhaustiveness in linguistic fieldwork, and the increased use of instrumental and computational methods, works like Naumann's (2012) description of the phonological inventory of Siwi, in which phonemic segments are established on the basis of acoustic measurements and statistical analysis, will become more frequent and both improve our understanding of the sound systems of African languages and offer new grounds on which to test phonological theory. Finally, we propose that the African phonological phenomena be addressed from a historical and comparative perspective. While we have a basic understanding of the issues in African phonology, the field is still shrouded in mystery once we adopt a diachronic perspective. Questions such as the following have yet to be answered.

(i) Where does tone come from in Niger-Congo, Nilo-Saharan, and Khoisan? How did languages of the Chadic, Omotic, and Cushitic branches of non-tonal Proto-Afro-Asiatic develop their tonal systems?

(ii) Where does ATR vowel harmony come from in Niger-Congo and Nilo-Saharan? While cases of ATR harmony spreading through contact are suspects (e. g., from Central Sudanic to neighboring Bantu languages such as Kinande), we don't fully understand how it originates. Does it have a monogenesis or has it developed separately in different places on the continent? Often correlating with the high concentration of ATR systems is the fact that a number of African languages, including Kpelle (Mande), Jomang (Kordofanian) and Teke-Kukuya (Bantu), contrast two degrees of high vowels /i, u/ versus /ɪ, ʊ/ without having a corresponding contrast of /e, o/ versus /ɛ, ɔ/. Since such a vowel system is highly unusual outside Africa, the natural question that should be addressed is where such systems come from. There is a likely relationship between their development and that of ATR

harmony systems, which would account for why both are so much more prevalent in Africa than elsewhere.

(iii) How do labial and palatal prosodies, as well as other types of "fusion", arise? Fusion is of course rampant in tonal morphology, the stability effect allowing tones to survive the historical loss of their TBUs. Through such fusion, quite complex systems have developed in Africa, such as the one in Dinka, whose resultant polymorphemic monosyllabic words contrast three degrees of length, three tones, and three voice qualities. Thus, "… for many transitive verbs there are at least six stem types, each of which has a distinct derivational status: a simple stem, a centrifugal stem, a centripetal stem, a benefactive stem, a benefactive-antipassive stem, and an antipassive stem" (Andersen 1992–1994: 12).

Some of the phenomena we mentioned in the course of this chapter point to two conclusions. First, there are interesting and important discoveries still to be made in African phonology and morphology. Second, when such phenomena are identified, it is important to pursue them in their genetic and geographic setting. If we are to understand how and why such systems arise, we will need first to establish the full range of possibilities. While such an approach has been applied to certain subgroups or areas with respect to tone (Hyman and Schuh 1974; Hyman 2011a), vowel harmony (Casali 2003), nasalized vowels (Rolle 2014), question markers (Rialland 2007; Clements and Rialland 2008), and a few other issues, there is much more waiting to be done.

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