An Introduction to ATR Vowel Harmony in African Languages

Preliminary Version

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Part 1: General Overview of ATR Harmony

1. Introduction

It is often possible to identify language families or geographic regions as having characteristic phonological features which are especially widespread within that family or region. Well-known examples include the common occurrence of click consonants in Khoisan languages (and some Bantu languages) of Southern Africa, the occurrence of long consonant clusters in Berber languages, and the prominence of contour (rising and/or falling) tones in parts of Southeast Asia.

In the case of the African continent, the most striking and obvious example of a widespread phonological feature is undoubtedly tone, which is found in virtually every part of the continent and all four of the major language families (Niger-Congo, Nilo-Saharan, Afro-Asiatic, Khoisan) on the African mainland. While tone may be the example par excellence of an ubiquitous African linguistic feature, however, several other phenomena also have impressive distributions. These include labio-velar consonants (found in many West African Niger-Congo and East African Nilo-Saharan languages), prenasalized consonants (which have a somewhat similar distribution), and the phenomenon which is the primary topic of the present work, ATR (Advanced Tongue Root) vowel harmony.

For several reasons, it is important for anyone planning to do descriptive field work in a particular part of the world to be acquainted with the characteristic linguistic features of the language families in that region. The obvious reason of course is that such features are very likely to be encountered, and it would therefore be helpful to know something about them so as to be adequately prepared to deal with them. To put it more bluntly, it is helpful to know what you are getting into (unless you like to do things the hard way!). A second, perhaps more encouraging, reason is that features which are particularly widespread will probably have had a lot of research done on them, so that their characteristic behavior is likely to be fairly well understood. This means that there is likely to be a lot of valuable material written on such a feature that one can make use of. Related to this is a third reason: these characteristic linguistic features will often exhibit very similar behavior across much of their geographic range. Becoming familiar with typical behavior of a feature will often allow one to recognize this behavior more quickly when it is encountered. To cite just one example, a tonal assimilation process (commonly known as high tone spreading) in which a low-toned syllable becomes high-toned following a high-toned syllable is found in a great many languages, from virtually all parts of the continent. This process is common enough that it would be useful for almost anyone beginning field work in an African tone language to know something about it and to have seen examples of how it works in various languages (especially, of course, any which are closely related to the language in which field work is intended).

Not all characteristic linguistic features are equally difficult to identify and analyze. Consider in this regard the case of labio-velar sounds like [kp] and [gb], which are common across a wide part of Africa. These sounds are often viewed as somewhat "exotic," which is understandable in light of the fact that they are quite rare outside of Sub-Saharan Africa. It is true, moreover, that most native speakers of non-African languages require a certain amount of practice in order to be able to accurately produce these sounds and distinguish them from [p] and [b] respectively, to which they are

auditorily similar in word-initial position. Nevertheless, with sufficient practice most people eventually do learn to distinguish these sounds from ordinary labials with reasonable reliability. In terms of their phonological analysis, these sounds typically present even less difficulty; often there is little to be said about their behavior beyond noting the fact that they are phonemic and describing any limitations (such as frequently occur; see Cahill 1996, 1997) on their distribution. In contrast to this stands a phenomena like tone, which frequently presents considerable challenges both to accurate phonetic transcription and especially phonological analysis.

After tone, ATR harmony would be a strong candidate for the most challenging and widespread phonological phenomenon in African languages. It is found in all parts of sub-Saharan Africa (though only marginally in southern Africa) and three of the four major African language families (though only in a few Afro-Asiatic languages, e.g. Tangale). It is important for anyone planning to do phonological field work in a family in which this type of vowel harmony commonly occurs to be familiar with its characteristic behavior. Moreover, since (as is discussed in more detail below) many of the problems linguists have encountered in recognizing the presence of vowel harmony are directly or indirectly attributable to difficulty in hearing all of the vowel contrasts in a language, it would be very helpful to have some prior exposure to what these contrasts sound like in a related language(s) known to have vowel harmony.

This introduction is intended primarily to serve as helpful orientation for people who have little previous familiarity with ATR harmony and desire to gain such familiarity in preparation for field work in languages where this phenomena is relevant. Its concerns are thus primarily practical. Some references are however made in a number of places to theoretical analyses of ATR harmony. This is done neither because I assume that most readers will be interested in theory for its own sake, nor because I wish to encourage the use of formal theoretical notation in writing a basic phonological description. Nor is it even the case that the theoretically-based analyses that are presented can confidently be assumed to be "correct"; a number of these analyses have been supplanted by more recent approaches and are no longer assumed by most phonologists. Rather, the analyses are presented in the belief that some readers will find that they provide a useful conceptual framework for thinking and talking about various patterns associated with ATR harmony. To the extent that the theories they are based on may not be strictly correct, any insight these analyses provide into the workings of ATR harmony may need to be viewed as at least partly metaphorical. Nevertheless, such an understanding can still be useful in guiding your thinking and expectations about the behavior of ATR harmony processes. If on the other hand you do not find the digressions into theoretical analyses of harmony processes useful, then you should feel free to skip over them.

2. ATR harmony in its "classic" symmetric form

Vowel harmony of any sort involves a restriction such that all vowels within some domain (e.g. morpheme or word) must have the same value for some phonological feature. To the extent that vowel harmony for a feature is operative in a language, vowels that have opposite values of the feature will not co-occur within the same domain. In a language with rounding harmony, for example, a round vowel like /o/ might be excluded from co-occurring in the same word with a non-round vowel like /e/. Vowel harmony can thus be thought of as a particularly strong kind of co-occurrence restriction among vowels that need not be strictly adjacent.

In the case of ATR harmony, the relevant feature is [ATR]. The relevant domain tends to coincide more-or-less, but often not exactly, with the grammatical word. As a first approximation, ATR harmony can thus be described as a phenomenon in which all the vowels in a word must agree or "harmonize" for their value of [ATR]. That is, the feature [ATR] serves to divide the vowels of the language into two sets: the [+ATR] vowels, and the [-ATR] vowels. Within a word, all the vowels must ordinarily be drawn from one set or the other; the two sets do not mix.[1]

In order to clearly describe ATR harmony in detail, two things are ideally required. One of these is to describe the feature [ATR] itself. What kind(s) of phonetic properties does this feature refer to? How does one determine when it is appropriate to describe a particular set of phonetic vowel contrasts in a language in terms of [ATR], rather than some other phonological feature? The other task is to describe the nature of the agreement patterns which are characteristic of ATR harmony. Which vowels are affected (often only a subset of the vowels in a language are involved)? What is the domain (e.g. root, word, or phrase) in which the agreement requirements hold? Under what circumstances do exceptions to [ATR] agreement typically arise? We might refer to the first of these matters as the *phonetic content* issue, and the second as the *phonological patterning* issue.

Logically, it might appear that the phonetic content issue should be in some sense primary. That is, one might expect that we ought to have a clear picture of what the feature [ATR] is before we go on to talk about harmony based on this feature. For various reasons, however, arriving at a cross-linguistically valid definition of the feature [ATR] turns out to less simple than one might expect. On the one hand, it is easy enough to note that ATR stands for *Advanced Tongue Root*, in keeping with the fact that the vowel contrasts the feature was originally used for in languages like Akan (a Kwa language of Ghana) have been shown (by x-ray and MRI studies) to primarily involve a difference in the position of the root of the tongue, which is further forward for "[+ATR]" vowels such as [e] and [o] than for "[-ATR]" vowels such as [ɛ] and [ɔ]. On the other hand, while it is easy enough to understand the motivation for using a label like [ATR] to describe contrasts of this type in Akan, there has in fact been considerable disagreement among phonologists over the fundamental nature of this feature and the range of contrasts which it appropriately characterizes. (To cite just one example of the absence of consensus which exists, some phonologists have been entirely happy to use [ATR] to describe the contrast between "tense" and "lax" vowels in English, while others have not.) In view of this, it seems simpler to postpone serious discussion of the phonetic properties of [ATR] and first consider the basic kinds of agreement patterns that ATR harmony involves (i.e. the phonological patterning issue). For this purpose, it will suffice as a first approximation to simply characterize the feature [ATR] indirectly by listing, in terms of approximate IPA (International Phonetic Alphabet) values, the commonly encountered vowels which are [+ATR] and those which are [-ATR].

IPA representation of [+ATR] and [-ATR] vowels, harmony sets

Vowels which are generally regarded as [+ATR] include those which have qualities similar to the "tense" vowels in English and are commonly represented with the IPA

[1] Complicating this picture is the fact that many languages also have one or more "neutral" vowels, which can co-occur with either set. (We will come back to this complication later.)

symbols [i], [e], [o], [u]. Although these vowels may not sound in an African language exactly as they do in English (in particular, they are not usually not diphthongized), they are similar enough that errors involving the incorrect transcription of one of these sounds as something else are relatively uncommon. (As we shall see below, on the other hand, instances where some other vowel is likely to be mistranscribed as one of these sounds are disconcertingly common.)

Vowels generally considered to be [-ATR] include those which are roughly comparable to the English lax vowels and are commonly represented (as in English) by the IPA symbols [ɪ], [ʊ], [ɛ], [ɔ] and [ɑ]. It needs to be noted that the vowels [ɪ] and [ʊ] tend, in many (though apparently not all) African languages, to sound rather different from the vowels in English *sit* and *soot*. This fact turns out to have very significant consequences for descriptive field work in languages which have these sounds as phonemes, and will be taken up in considerable detail below. For our present purposes, however, which concern the typical patterns of agreement found in ATR harmony languages rather than the precise phonetic properties of the feature [ATR], it will suffice to think of the common [+ATR] vowels as corresponding roughly to English [i], [e], [o] and [u], and the common [-ATR] vowels as corresponding roughly to English [ɪ], [ɛ], [ɑ], [ɔ], [ʊ], keeping in mind that this is an approximation only and one that will need to be corrected later on.

Languages with exactly these four common [+ATR] and five common [-ATR] vowels as phonemes are extremely common in many branches of both the Niger-Congo and Nilo-Saharan languages families. It is very rare, moreover to find an African language which has this full set of nine vowel phonemes that does not also have some form of [ATR] harmony. We will therefore want to consider the behavior of [ATR] harmony in nine-vowel systems in considerable detail. It happens, however, that while [ATR] harmony languages with nine vowels are extremely common, they do not represent the simplest type of harmony system as far as phonological behavior is concerned. The fact that numbers of [+ATR] and [-ATR] vowels are unbalanced (with one more vowel in the [-ATR] set) gives rise to some interesting complications that are best introduced after we first have a look at a simpler, more symmetric system.

In many respects, the simplest (most regular) [ATR] harmony systems are those which occur in ten-vowel languages having the inventory in (1). (Note that the exact phonetic quality of the vowel symbolized [ə] appears to vary considerably among ten-vowel languages; it is not always a mid central vowel. We will ignore this complication for now, since the phonetic realization of this vowel is not important for our present purposes.)

(1) Ten-vowel system

i		u
ɪ		ʊ
e	ə	o
ɛ		ɔ
	ɑ	

In such a ten-vowel language, the vowels divide into two sets of five [+ATR] and five [-ATR] vowels:

(2)

+ATR vowels:		-ATR vowels:	
i	u	ɪ	ʊ
e	o	ɛ	ɔ
ə		ɑ	

As stated above, vowel harmony can be characterized either as an "agreement" requirement which entails that all vowels within some domain share the same value of the feature in question (in this case [ATR]), or, equivalently, as a kind of co-occurrence restriction that prohibits vowels with opposite values of the feature from occurring together in the same domain. Viewed from either perspective, these requirements manifest themselves within these symmetric ten-vowel systems in several ways. First, in a root morphemes containing more than one vowel, all of the vowels will normally be drawn from the same set. This means that whereas morphemes containing all [+ATR] vowels or all [-ATR] vowels are all possible in such languages, single morphemes which combine both [+ATR] and [-ATR] vowels ordinarily are not. Morphemes containing all [+ATR] or all [-ATR] vowels are illustrated in (3) with examples from Engenni (Thomas 1978), a ten-vowel Edoid (Benue-Congo) language spoken in Nigeria.[2]

(3) [+ATR] morphemes

a. kilo	'to rule'
b. kpomu	'to be ill'
c. əsyi	'four hundred'
d. ənigo	'pour man'
e. dire	'to cook'
f. tukpə	'to scold'
g. opilopo	'pig'
h. eseni	'fish'

[-ATR] morphemes

i. samɪnɑ	'to forget'
j. jɪlɑ	'to stand'
k. kɑɪ	'to be strong'
l. tʊnʊ	'to be long'
m. gbɛrɪ	'small'
n. ɑlɪbɔ	'tortoise'
o. wɔsɛ	'to strengthen'
p. kɔnɪ	'to fight'

[2] The status of Engenni as a ten-vowel language is somewhat marginal. According to Thomas (1978:10), /ə/ does not occur in the southern dialect of Engenni, and even in the northern dialect (from which these examples are taken), contrast between [ə] and [ɑ] is apparently quite limited.

Listed in (4) are some examples of hypothetical morphemes which would not be possible in such a language (and, as far as I know, do not occur in Engenni).

(4)

a. *kulɔ	i. *etɑ
b. *bʊro	j. *əgɑ
c. *esɪ	k. *dɑhi
d. *fɛgi	l. *ʊrə
e. *ɔsi	m. *ɛwubo
f. *omɪ	n. *tɔɔkifɔ
g. *eledɛ	o. *idohɑ
h. *toopɛ	p. *evɪ

Affix harmony

A second form which vowel agreement or co-occurrence restrictions often take in languages of this type involves a requirement that the vowels in certain (perhaps all) affixes agree in their value of [ATR] with the vowels in the root to which they are attached. (Given the first requirement discussed above, these root vowels will of course all agree with each other). This means that (at least some) affixes will have both [+ATR] and [-ATR] forms, and that the vowel(s) in an affix will change (or "harmonize") to agree with the vowels in the root. This is illustrated below with examples from Degema, an Edoid (Benue-Congo) language of Nigeria. (from Elugbe 1983, 1989, and unpublished data courtesy of Sean Fulop).

(5) singular noun class prefix /ʊ/ ~ /u/

a. ʊ-βɑɪ	'house'
b. ʊ-sɔʊ	'ear'
c. u-tom	'head'
d. u-kpe	'year'

(6) singular noun class prefix /ɔ/ ~ /o/

a. ɔ-βɑ	'shoulder'
b. ɔ-βʊ	'doctor'
c. o-bo	'paint'

(7) second person plural pronoun /mə/ ~ /mɑ/

a. mə-der	'you (pl.) will cook'
b. mə-tulə	'you (pl.) will reach'
c. mɑ-dɑ	'you (pl.) will smear'
d. mɑ-tɑ	'you (pl.) will come'

(8) gerund prefix /ʊ/ ~ /u/, gerund suffix /ɑ/ ~ /ə/

a. ʊ-sɔl-ɑm	'jumping'
b. u-gbol-əm	'catching'

These examples show five different harmonizing affixes (four prefixes and one suffix), each of which has a [+ATR] form that occurs with roots that have [+ATR] vowels, and a [-ATR] form that occurs with roots that have [-ATR] vowels. A consequence of this kind of affix agreement is that the domain of [ATR] harmony is larger than the morpheme so that we might justifiably regard it, as many linguists have, as a word-level feature.

In cases like those in (5) through (8), where a particular affix occurs with a [+ATR] vowel in [+ATR] contexts (i.e., when attached to [+ATR] roots) and a [-ATR] vowel in other contexts, the [+ATR] vowel and the [-ATR] vowel are referred to as *harmonic counterparts* of each other. Thus, /u/ is the harmonic counterpart of /ʊ/ (and vice-versa) in Degema, as shown by the examples in (5) and (8), while /o/ is the harmonic counterpart of /ɔ/, as seen in the examples in (6). The examples in (7) and (8) reveal that /ə/ is the harmonic counterpart of /ɑ/. We can also speak of the pairs of vowels /u/ & /ʊ/, /o/ & /ɔ/, and /ə/ & /ɑ/ as being *harmonic pairs*. Normally, we would expect the harmonic counterparts in a ten-vowel system with ATR harmony to be paired as follows:

(9) /i/ is the [+ATR] countpart of /ɪ/ (and /ɪ/ is the [-ATR] countpart of /i/)
/e/ is the [+ATR] countpart of /ɛ/ (and /ɛ/ is the [-ATR] countpart of /e/)
/ə/ is the [+ATR] countpart of /ɑ/ (and /ɑ/ is the [-ATR] countpart of /ə/)
/o/ is the [+ATR] countpart of /ɔ/ (and /ɔ/ is the [-ATR] countpart of /o/)
/u/ is the [+ATR] countpart of /ʊ/ (and /ʊ/ is the [-ATR] countpart of /u/)

Note that the vowels in each pair are those which stand in the same relative position in the charts of the two harmony sets in (2), i.e. those which have the same frontness/backness, height, and (non)roundness, and differ from each other only in terms of their [ATR] value. For example, /i/ and /ɪ/ are both high front vowels, which differ from each other only in that the former is considered [+ATR] while the latter is [-ATR]. As we shall see below, however, there languages which exhibit slightly different pairings among the non-high vowels, e.g. in which /o/ or /e/, rather than /ə/ functions as the [+ATR] counterpart of /ɑ/. (Generally, these are nine-vowel languages which lack the vowel /ə/ altogether.)

Often (there is some inconsistency, and not all phonologists follow the same practice), the term "harmonic counterpart" is reserved for pairs of vowels which actually alternate with each other within one or more affixes. However, even when the vowels in one of the pairings listed in (9) do not actually alternate with each other in some morpheme, we can still refer to these vowels as being *ATR counterparts* of each other (though not, under what may be the most orthodox terminological usage, as being harmonic counterparts of each other). Thus, /e/ is always the [+ATR] counterpart of /ɛ/ in a ten-vowel system, while /ɛ/ is the [-ATR] counterpart of /e/, etc.

It is interesting that while there is no purely logical reason why a language with morpheme-internal ATR harmony (i.e., a language in which all the vowels in the same morpheme must share the same value of [ATR]) must also have harmonizing affixes, it turns out in actual fact that languages in which [ATR] agreement applies only within root morphemes and never affects affixes appear to be fairly uncommon. There are probably good functional reasons for this, in that affix harmonization can be seen to facilitate speech perception (Kaun 1995, Gorecka 1996). In languages in which affixes

harmonize for [ATR] with the root they are attached to, the [ATR] value of the affix provides a clue to the [ATR] value of (and hence, indirectly, to the identity of) the root vowel(s) (and vice versa). This is potentially important, given that listening conditions in real world speech settings are often less than ideal, and that some of the vowels contrasts are often difficult to hear in languages with the kinds of vowel systems ATR harmony is typically found in.[3]

The kind of harmonization described so far, in which affix vowels may change to agree in their [ATR] value with the root to which they are attached, is a typical pattern in Niger-Congo languages of West Africa. While this same pattern is also found in Nilo-Saharan languages of East Africa, it is also very common for these latter languages to show at least some cases where the vowel(s) of a root will change to agree in [ATR] value with the vowel(s) of an affix. This type of pattern, referred to in the literature as "dominant harmony," is discussed in section 3. For our present purposes, it suffices to note that both types of pattern involve alternations in the [ATR] value of certain vowels so as to produce agreement for this feature throughout some larger domain (e.g. the word).

Other harmonization effects

Morpheme-internal agreement for [ATR] and affix harmonization may be said to constitute the most prototypical manifestations of ATR harmony. Beyond this, there are other respects in which [ATR] agreement / co-occurrence restrictions may show up in some languages. First, loan words might be expected to conform to the requirements of vowel harmony, in that a word which contains both [+ATR] and [-ATR] vowels in the donor language might undergo changes so as to show up with all [+ATR] or all [-ATR] vowels in a receptor language with vowel harmony.[4] Also, many languages have epenthetic vowels which are inserted in loanwords to break up unacceptable consonants clusters or prevent a word from ending in a non-permissible final consonant; it is common for the choice of vowel used in a particular word to depend in part on the requirements of ATR harmony. In Nawuri, for example, such epenthetic vowels are always high, but will change to agree in their [ATR] value with other vowels in the word. This is illustrated in (10), where the epenthetic vowels are

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[3] Some linguists have suggested an articulatory, rather than an acoustic/perceptual, motivation for ATR harmony: "That it takes considerable time and effort to move the root of the tongue and the larynx in order to produce the distinctions between [+ATR] and [-ATR] vowels has been pointed out by Dr. Kenneth Pike. This is then a plausible physiological explanation for the fact that in languages with advanced tongue root vowels, we also find advanced tongue root assimilation, usually called vowel harmony" (Larsen 1984:36). Although there is no reason why the articulatory and acoustic/perceptual explanations cannot both be partly right, the latter is to be preferred in my view since it may explain why ATR harmony appears to be both more common and more extensive (e.g. in being more likely to spread across word or root morpheme boundaries, or to apply to a greater number of affixes) in languages with nine or ten vowels /iɪeɛɑ(ə)ɔouu/ than in seven-vowel systems /ieɛɑɔou/. Since there are more vowels to distinguish in nine- and ten-vowel languages, and since some of the vowels are often difficult to tell apart auditorily, the need for harmony as an additional clue to vowel identity is greater than in seven-vowel systems, where the vowels are normally fairly easy to tell apart. In terms of articulatory effort, on the other hand, the challenges in transitioning from [+ATR] to [-ATR] vowels or vice-versa should presumably be no different in a seven-vowel system than in a nine- or ten-vowel system; hence there is no expectation that harmony should be more important in languages with the larger systems.

[4] The extent to which this plausible state of affairs is actually attested in practice is a bit unclear, as studies of [ATR] vowel harmony which discuss the behavior of loan words are not very common. Factors such as orthographic influences must also be taken into account in some areas. The behavior of loanwords in languages with [ATR] harmony would seem to be an area that is ripe for descriptive studies.

underlined.[5] (Note that in addition to showing alternations in [ATR] value, epenthetic vowels also show variation as to whether they are round or non-round. Basically an epenthetic vowel will be round [u]/[ʊ] if it is either followed by a round vowel in the next syllable or (when word-final) immediately preceded by a labial consonant, and non-round [i]/[ɪ] otherwise.)

(10) a. pɛɛnɪ̲ 'pen'
b. s**u̲**ku 'school'
c. kɔɔp**ʊ̲** 'cup'
d. bleed**i̲** 'blade'
e. sɪ̲tɑɑtɪ̲ 'start'
f. d**ʊ̲**rɔbɑɑ 'driver'

A final respect in which ATR harmony sometime shows up is that assimilation for this feature will, in some languages, apply even across word boundaries in some cases. This will be discussed in more detail later.

Terminology: "Cross-height" harmony

ATR harmony of the type illustrated above is often called "cross-height" harmony (a term due to John Stewart), because harmony is operative at more than one height. That is, both the [+ATR] and [-ATR] harmony sets contain high as well as non-high vowels, and the requirement that vowels in a word agree in their value of [ATR] holds regardless of whether the vowels in a word are all high (as in gbili, bʊnɪ), all non-high (as in deerə, dɛɛra), or have both high and non-high vowels (as in tɪŋɛ, bɔnɪ).

Cross-height harmony is not possible in languages in which [+ATR] is contrastive at only one height, for example the common seven-vowel system /iɛɑɔou/, in which there is no [ATR] contrast among high or low vowels, but only the mid vowels.

Fully-symmetric ATR harmony: Summary

As a means of introducing the basic behavior of ATR harmony in its least complicated form, we have considered in this section a kind of "classic" pattern which is completely symmetric in a number of significant respects:

(11) Fully-symmetric ATR harmony

a. There equal numbers (five, in the case of the ten-vowel language used for purposes of illustration) of [+ATR] and [-ATR] vowels.

b. Every vowel is paired with a unique harmonic counterpart from the opposite[ATR] set.

c. Harmony affects both prefixes and suffixes. (There are no directional asymmetries.)

[5] Nawuri is actually a nine-vowel language and not a ten-vowel language of the type we have been discussing up to this point. I have used it because I have data readily available, and because it will serve to illustrate the basic point under consideration here, which is just that epenthetic vowels typically harmonize in their value of [ATR].

d. Harmony was assumed to be exceptionless (or at least no exceptions were discussed!).

e. The behavior of the two values ([+ATR] and [-ATR]) of [ATR] appeared to be entirely symmetric: harmonizing affixes changed in form so as to agree in their value of [ATR] with either a [+ATR] or a [-ATR] roots. in exactly the same way, and there was no other behavior to indicate that one or the other value of [ATR] should be viewed as in some way special.

There are relatively few real ATR harmony languages which conform fully to this ideal pattern. Much of our focus in the remainder of this paper will be on describing various ways in which real languages commonly depart from the ideal, fully symmetric ATR pattern described above.

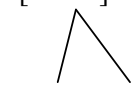
Symmetric ATR harmony as bi-directional spreading onto (unspecified) affixes

Various theoretical analyses of symmetric ATR harmony have been proposed over the years. The focus of this description is not on phonological theory per se, but rather on describing (generally in theory-neutral terms) the various ways in which ATR harmony behaves. Nevertheless, there are certain points at which certain theoretical concepts and analyses can be helpful in making sense of these behaviors. Even theoretical proposals which have been largely abandoned as not strictly correct can sometimes provide useful metaphorical ways of talking about phenomena associated with ATR harmony. For this reason, we will have an occasional brief look at certain theoretical concepts, terminology, and even formal notations, which are relevant to aspects of ATR harmony under discussion. In general, it is not recommended that these theoretical concepts be used as the basis for a rigorous formal analysis of ATR harmony in a written phonology description. (For purely descriptive purposes, a clear prose account of how ATR harmony operates, illustrated with plenty of examples, is usually to be preferred.) Rather, these digressions into theoretical treatments of ATR harmony are offered simply to provide models which you may find helpful in thinking about harmony patterns.

In the case of symmetric root-controlled harmony systems, in which affixes alternate so as to agree in their [ATR] value with that of the root vowels, a useful metaphor for understanding the pattern comes from early autosegmental analyses of ATR harmony. (See for example Clements (1981).) These models conceived of root-controlled harmony in terms of a morpheme-level plus or minus [ATR] feature associated with each morpheme in the language. These morpheme-level [ATR] features (or *autosegments*, in the terminology of autosegmental theory) would be spread themselves onto every vowel in the root morpheme. (In autosegmental notation, this is represented by drawing a line from the relevant [ATR] autosegment to every vowel in the word.) Thus a hypothetical [+ATR] root such as /kulo/ would be represented as in (12), while a hypothetical [-ATR] root like /kulɔ/ would be represented as in (13).

(12)

(13) [-ATR]



k U l O = kʊlɔ

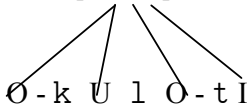
Note that the vowels in both words have been represented with upper case letters. This is in keeping with the fact that once the feature [ATR] is no longer viewed as a feature of individual vowels but rather as a feature of an entire morpheme, it an be extracted from the vowels and placed on a separate tier. Once [+ATR] has been extracted from the vowel /u/ and [-ATR] from the vowel /ʊ/, the remaining features of these two vowels are identical: [+high], [+back], [+round], [-low]. This set of features common to both /u/ and /ʊ/ is represented by an upper case U, in keeping with common autosegmental practice. If associated with a [+ATR] autosegment (as in (12)), U is pronounced as [u]; if associated with a [-ATR] autosegment (as in (13)), it is realized as /ʊ/. Similarly, upper case O is used to represent the features common to both /o/ and /ɔ/; it will be surface as the former if associated with [+ATR] and as the latter if associated with [-ATR]. (The lines which link [+ATR] or [-ATR] to vowels are called *association lines*.)

Assuming that each root morpheme is associated with exactly one (plus or minus) [ATR] autosegment and that this autosegment associates with every vowel in the morpheme serves to account for the fact that all the vowels in a root morpheme must agree in their value of [ATR]. To account for the behavior of harmonizing affixes, two additional assumptions are needed:

- Unlike roots, affixal morphemes are not underlyingly specified with any [ATR] value of their own.
- Once an affix is attached to a root, the [+ATR] or [-ATR] feature of the root will *spread* outward (i.e. leftward in the case of prefixes, rightward in the case of suffixes) from the root onto the affix, so that the affix shares the [ATR] value of the root.

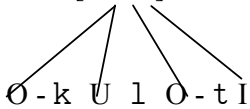
The effects of these assumptions are illustrated below using the same hypothetical roots /kulo/ and /kulɔ/ in (12) and (13) and two hypothetical harmonizing affixes: a prefix that alternates between /o/ and /ɔ/, and a suffix that alternates between /ti/ and /tɪ/. (It is assumed here that both prefix and suffix are attached to the same root simultaneously. The dotted lines indicate association lines that are added in the course of the derivation as the [ATR] value of the root spreads outward onto the affixes.)

(14) [+ATR]



O-k U l O-t I = o-kulo-ti

(15) [-ATR]



O-k U l O-t I = ɔ-kulɔ-tɪ

Although more recent theoretical treatments of ATR harmony have adopted somewhat different mechanisms to account for root-controlled harmony, this early autosegmental model of bi-directional spreading onto affixes having no inherent [ATR] value of their

own remains a useful way of conceptualizing root-controlled harmony. Moreover, even phonologists working in theories (such as the currently-popular model of optimality theory) which no longer make use of actual feature spreading rules or processes talk informally (and metaphorically) about harmony in terms of "spreading" because of the descriptive usefulness of this concept.

3. Dominant harmony

A rather striking departure from this simple and symmetric picture of ATR harmony involves what is commonly known as *dominant* ATR harmony. In the literature on ATR harmony, a distinction is commonly made between *root-controlled* and *dominant* (or "dominant-recessive") harmony systems (cf. Kutsch Lojenga 1986). Essentially, an ideal root-controlled system is one which is characterized by (11e), i.e. a language in which affixes generally agree in their value of [ATR] with that of the root. (If the language has both prefixes and suffixes, then we might ideally expect (11c) to hold true as well.) What is important is that the two values of [ATR] (plus and minus) behave symmetrically as far as the system is concerned. In a prototypical root-controlled system, there is no evidence that either value is in any sense special.

On the other hand, although root-controlled systems are symmetric as far as the two values of [ATR] are concerned, there is another obvious respect in which they are asymmetric. This is that roots behave differently from affixes; the former have their own inherent (and in the ideal case unchangeable) [ATR] values, while the latter behave as though they were inherently neither [+ATR] nor [-ATR], but simply take whatever [ATR] value the root they are attached to happens to have. (You may find it helpful here to review the behavior of the harmonizing affixes in section 2 above.)

Note that both the symmetric behavior of the two values of [ATR] and the asymmetric behavior of roots and affixes are reflected in the autosegmental description of root-controlled harmony presented at the end of the preceding section. The former is manifested in the fact that both [+ATR] and [-ATR] are represented in the underlying forms of some morphemes (though of course the two values generally do not appear with the *same* morpheme), while the latter shows up in the fact that roots, but not affixes, have underlying [ATR] values associated with them.

Whereas root-controlled systems can thus be described as featurally symmetric but morphologically asymmetric (i.e., as far as the distinction between roots and affixes is concerned), dominant harmony systems can be described as morphologically symmetric but featurally asymmetric. The morphological symmetry shows up in that affixes as well as roots can have their own inherent [ATR] value. The featural asymmetry manifests itself in that the two values of [ATR] do not have equal status: one value is *dominant*, and the other *recessive*. A dominant feature value is one that:

- Does not itself change to the opposite value.
- Can cause the opposite value to change through assimilation to the dominant value.

A recessive feature is one that:

- Can become assimilated to the opposite value.
- Does not cause the other feature value to assimilate to itself.

In most of the well-known dominant harmony systems it is [+ATR] which is dominant and [-ATR] which is recessive. (We will consider the possible existence of languages

in which [-ATR] is dominant below.) In such a system, both roots and affixes may be inherently either [+ATR] or [-ATR]. Morphemes (whether roots or affixes) which are inherently [+ATR] will never change to become [-ATR]; however morphemes (whether roots or affixes which are inherently [-ATR] may assimilate to a neighboring [+ATR] morpheme.

In considering the behavior of such a system in detail, there are four possibilities to consider:

(16) Possible root + affix combinations in a dominant harmony system

a. A root and attached affix are both inherently [-ATR].

b. A root and attached affix are both inherently [+ATR].

c. A [-ATR] affix is attached to a [+ATR] root.

d. A [+ATR] affix is attached to a [-ATR] root.

Not surprisingly, the outcome of the situation described in (16a) is that both root and affix surface phonetically as [-ATR], since there is no dominant [+ATR] morpheme to cause them to change. The result of combining two [+ATR] morphemes, as in (16b) is, again not surprisingly, that both morphemes surface phonetically as [+ATR]. The outcome in (16c) is that the affix changes to become [+ATR] in agreement with the root. Taken by itself, this could however be viewed as an instance of the same root-controlled phenomenon we looked at in the preceding section. In fact, if we had only the three cases in (16a-c) to look at, there would be no real basis for assuming that affixes have an inherent [ATR] value at all; since, in all three cases, the affix ends up phonetically with the same [ATR] value as the root. Thus, these cases do not show any difference from what would be expected in a root-controlled harmony.

The really interesting case is (16d). The outcome in this situation contrasts sharply with what would be expected in a root-controlled language: rather than the [+ATR] affix changing its value to agree with the [-ATR] root, it is the [-ATR] root which becomes [+ATR] in agreement with the affix. Lest we should be tempted to think, focusing on this one case, in terms of "affix-control," it needs to be stressed that the pattern in general is not one of roots changing their [ATR] value to agree with affixes. Rather, the true generalization is that "[+ATR] always wins," that is, a [+ATR] morpheme (whether root or affix) anywhere in the word causes the whole word (i.e. all the vowels in the word) to become [+ATR].

The four cases in (16) are illustrated in (17) with examples from Baka, a Central Sudanic language described in Parker (1985).[6]

(17) a. /tɑrɑ-mɑ/ → [tɑrɑmɑ] 'my mouth'
mouth-1sg

b. /sili-ji/ → [siliji] 'your hand'
hand-2sg

c. /lemi-mɑ/ → [lemimə] 'my sister'
sister-1sg

[6] Example (17b) is not actually found in Parker's article, but is inferred from his description.

d. /lʊndʊ-ji/ → [lunduji] ‘your brother’
brother-2sg

(17a) shows a [-ATR] suffix attached to a [-ATR] root, while (17b) shows a [+ATR] suffix attached to a [+ATR] root; as expected, there is no change to the underlying form in either case. In (17c), the underlying [-ATR] suffix /-mɑ/ becomes [+ATR] [mə] when attached to a [+ATR] root, while in (17d) the [+ATR] suffix /-ji/ causes the preceding [-ATR] root /lʊndʊ/ to surface with [+ATR] vowels as [lundu]. These latter two examples together illustrate the generalization, typical of dominant [+ATR] harmony systems, that [-ATR] morphemes, whether roots or affixes, assimilate to [+ATR] morphemes, rather than vice-versa. Thus, [+ATR] can be regarded as dominant while [-ATR] is recessive.

The suffix second person singular suffix /-ji/ in (17b,d) is an example of what is known as a *dominant affix*. Dominant affixes have the following two properties:

- They themselves never undergo [ATR] changes in harmony with root morphemes.
- The vowels in other morphemes (including root morphemes!) that occur in the same word as a dominant affix may change their value of [ATR] to agree with the [ATR] value of the vowel(s) in the dominant morpheme.

Dominant [ATR] harmony is extremely widespread among Nilo-Saharan languages of East Africa. Reference has often been made in the literature in fact to a kind of geographic and genetic division, such that dominant [ATR] harmony (with [+ATR] dominant) is characteristic of East African Nilo-Saharan languages, whereas root-controlled harmony is more characteristic of West African Niger-Congo languages.

Notwithstanding the general tendency for dominant harmony to occur primarily in East African languages, there are also some West African Niger-Congo languages which have dominant [+ATR] affixes. (Moreover, East African languages with “dominant” harmony also exhibit some of the characteristics of root-controlled harmony.)

Example: Nawuri (Kwa, Ghana) has a diminutive suffix /-bi/ that causes a preceding vowel in a [-ATR] root to become [+ATR]:[7,8]

(18) a. [ɔ-bʊŋ] [gɑ-bum-bi]
‘river’ ‘stream’

---

[7] Etymologically, /-bi/ is undoubtedly from the root /bi/ meaning ‘seed’ or ‘child’, which still exists in the language. Synchronically, however, it is functioning in these (and many other) examples as a (fairly productive) diminutive suffix.

[8] In order to simplify the presentation, certain allophonic processes have been ignored in the phonetic forms in (18). The vowels transcribed [ɐ] and [ɨ] in (18b,c) are actually quite centralized phonetically, being realized respectively as vowels that might be better transcribed [ə] and [ɨ̈]. This is due to an entirely regular and independent process that centralizes all short front vowels in the language when they occur between consonants. In the same context, the vowel /ɑ/ is regularly raised to a somewhat higher position, so that the vowel /ɑ/ in (18a,b) might, in a more narrow transcription, be more appropriately transcribed [ʌ]. These details do not affect the essential fact being illustrated in (18), which is simply that vowels in underlyingly [-ATR] roots become [+ATR] when followed by the /-bi/ suffix.

b.	[gɑ-wɛ]	[gɑ-we-bi]
	'calabash'	'small calabash'
c.	[ɔ-fɔlɪ]	[o-foli-bi]
	'crop bed'	'small crop bed'

In all three examples, the vowel(s) of the noun root become [+ATR] when the suffix /-bi/ follows. The fact that the noun class prefix /ɔ/ is also affected in (18c) (surfacing phonetically as [o], while the noun class prefix /gɑ/ has not become [+ATR] in (18a,b), may be due to the fact that the low vowel /ɑ/ is more resistant to [+ATR] assimilation than the mid vowel /ɔ/. However, it is also true that the extent of leftward [+ATR] spreading in Nawuri is extremely variable in general, and depends considerably on rate and style of speech. Thus, although the prefix vowels are transcribed as [-ATR] /ɑ/ in the examples (taken from my own field notes) (18a,b), I expect (based on analogous examples) that these vowels could, in some speech styles, be realized with a [+ATR] quality, in which case they would be expected to surface phonetically as a vowel [ə] which is phonetically identical to a strongly centralized allophone of /e/ found between consonants. (See note 8.)

Other possible cases of West African Niger-Congo languages with dominant [+ATR] suffixes:

- Dagara (Gur; Pénou-Achille 1982)
- Diola-Fogny (Atlantic; Hall et. al. 1974, citing Sapir 1965)
- Nkonya (Kwa; Peacock & Lear 1997)
- Foodo (Kwa; Plunkett 1991)

Dominant suffixes are cross-linguistically much more common than dominant prefixes, although the latter are attested in Budu (Bantu; Kutsch Lojenga 1994b). This *may* be related to more general tendency of [ATR] to spread more readily to the left than to the right.

In almost all known cases, dominant affixes are [+ATR] rather than [-ATR]. The exceptions I am aware of are as follows:

- Toposa (Schröeder & Schröeder 1987) and Turkana (Dimmendaal 1983, Noske 1990), two closely related Eastern Nilotic languages, are reported to have both [+ATR] and [-ATR] dominant affixes, although in Toposa at least it is [+ATR] dominance which represents the more usual case.
- Puguli (Gur; data from Kevin Warfel) has a dominant [-ATR] noun class suffix /ɑ/ which apparently causes preceding root vowels to become [-ATR]. A similar pattern apparently occurs in Ninkare (also Gur; Connie Kutsch Lojenga, personal communication) as well.
- Lika (Bantu; Kutsch Lojenga 1999a) appears to have limited [-ATR] spreading from dominant [-ATR] suffixes.

Dominant +ATR harmony as systematic underspecification of [-ATR]

We saw in section 2 above that root-controlled ATR harmony can be modeled autosegmentally as a spreading process in which affixes which are inherently unspecified for [ATR] assimilate to the [+ATR] or [-ATR] value of a root to which they

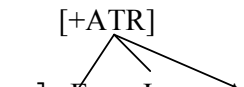
are attached. In the case of dominant harmony, a different theoretically-inspired metaphor may be helpful. Some autosegmental analyses have captured the asymmetry between the two values of [ATR] by assuming that

- Only one value, the dominant one, is underlyingly specified. The recessive value is simply absent in phonological representations.
- This specified [ATR] value can be underlyingly present in both roots and affixes.

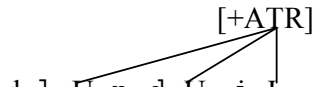
Since, as we have seen, the vast majority of dominant harmony systems have [+ATR] as the dominant value, we may consider how these assumptions play themselves out in the case of a dominant [+ATR] system. In such a system, we will have only [+ATR] underlyingly, and the four logical possibilities described and illustrated in (16) and (17) above will be represented autosegmentally as in (19). (Here the symbol A is introduced stand for the set of features common to [ɑ] and [ə], i.e. to represent a non-high central vowel that will be realized phonetically as [ə] if associated with a [+ATR] autosegment and as [ɑ] otherwise.)

(19) a. t A ɾ A - m A → [tɑɾɑmɑ] 'my mouth'

b. s I l I - j I → [siliji] 'your hand'



c. l E m I - m A → [lemimə] 'my sister'



d. l U n d U - j I → [lunduji] 'your brother'

Here a dotted line is used once again to represent an association line that is not present underlyingly but is added during the course of the derivation by an assimilation or spreading rule. Thus, (19c) shows [+ATR] spreading from an underlyingly [+ATR] root onto a suffix, while (19d) shows [+ATR] spreading from an underlyingly [+ATR] suffix onto a preceding root. It is assumed, under this approach, that vowels which lack an [ATR] association are simply interpreted phonetically as [-ATR] by default; thus (19a) is interpreted phonetically as [tɑɾɑmɑ]. (Alternatively, some analyses of this basic type would assume a late phonological rule that applies to insert [-ATR] onto any vowel that lacks an [ATR] specification.)

Dominant and root-controlled harmony revisited

Although the commonly-assumed generalization that West African (Niger-Congo) languages have root-controlled ATR harmony while East African (Nilo-Saharan) languages have dominant ATR harmony has its usefulness, there is a point at which this distinction begins to break down. As we have already seen, there are cases of West African Niger-Congo languages with dominant [+ATR] affixes. More fundamentally, however, both root-controlled and dominant harmony systems as described above represent idealized behavior patterns to which real languages often do not entirely correspond. That is, many real languages fall "somewhere in the middle," in that they

share some characteristics of both root-controlled and dominant harmony. In addition to having dominant [+ATR] affixes, most, perhaps all, East African ATR harmony languages also have affixes which simply alternate to agree in their [ATR] value with that of the root vowels. This kind of simple harmonization, which looks exactly like the phenomenon of "root-control" commonly found in West African languages, appears in fact be the normal mode of behavior for prefixes in those East African languages which have both suffixes and prefixes. Of even greater interest, perhaps, is the fact that the two values of [ATR] very often do not behave as though they were fully symmetric ("equal and opposite") in real West African languages, as they would be expected to within a classic root-controlled system. Even in those (numerous) West African languages which do not have dominant affixes, there are often telltale clues which indicate that one value of [ATR] is in some sense dominant over the others. In a number of nine- or ten-vowel West African languages, for example, [-ATR] root vowels may assimilate to neighboring [+ATR] vowels under some circumstances, e.g. across word boundaries or in compound words combining both [+ATR] and [-ATR] roots. In these same languages, [+ATR] vowels never assimilate to [-ATR] vowels on the other hand.

These and other common asymmetries involving the two values of [ATR] will be discussed in more detail in section 13 below. What is important for our present purposes is simply the realization that the ideal distinction between dominant and root-controlled harmony is to some extent an oversimplification, which, though it can provide a useful way of viewing things if flexibly applied, should not be used as a rigid classification scheme into which all languages must neatly fit.

4. Vowel systems in which ATR harmony is commonly found

Ten-vowel systems

(20) Ten-vowel system

i		u	[+ATR] vowels: i u e o ə
ɪ		ʊ	
e	ə	o	
ɛ		ɔ	[-ATR] vowels: ɪ ʊ ɛ ɔ ɑ
	ɑ		

Although less common than some other types of vowel system, this system is not exceedingly rare. It occurs in between 30 to 40 languages (about 9 %) out of slightly over 400 currently in my survey.[9]

- Gur languages with a ten-vowel system include Nuni, Lobiri, Kasem, Deg, Vagala, Kusaal, Chakali, Koromfe(?).
- Kwa languages with ten-vowel systems include Abron(?), Akposso, Abbey(?).
- The only Mande language with a ten-vowel system known to me is Bisa, according to Hartell (1993).

[9] Note: The frequency figures in this section are based on database of vowel systems in African languages that currently contains slightly over 400 languages, mainly from the Niger-Congo and Nilo-Saharan families. The current sample is skewed in favor of West and East Africa; Central and Southern Africa are rather under-represented.

- Other language families in which the ten-vowel system occurs include Atlantic (Diola-Fogny), Benue-Congo (in several branches found in Nigeria), and quite a few Nilotic (Nilo-Saharan) languages.

The phonetic identity of the "10th" vowel, symbolized as [ə] in (20), varies considerably; Depending on the language, it may be a mid central vowel, a high central vowel, a relatively low central vowel, a relatively low front vowel, or a low back vowel. In West Africa, it is usually front or central, and non-high.

It is important to note that, whatever its precise phonetic realization, this 10th vowel is a full vowel phoneme, and not an epenthetic or transitional vowel of the type often symbolized as [ə]. Its duration is comparable to that of other vowel phonemes, it is not optionally omitted, and it does not have the variable and indeterminate quality of the unstressed [ə] in English.

Descriptive issues for 10 V systems: phonemic status, phonetic quality of 10th V.

Descriptions of ten-vowel languages have unfortunately not always been explicit about the phonemic or allophonic status of the 10th vowel, nor about its exact phonetic quality.

Ten-vowel systems almost always have cross-height ATR harmony! (No clear exceptions are known to me.)

Nine-vowel systems

(21) Nine-vowel system

i	u	[+ATR] vowels: i u e o
ɪ	ʊ	
e	o	
ɛ	ɔ	[-ATR] vowels: ɪ ʊ ɛ ɔ ɑ
ɑ		

Survey frequency: about 22%

Both some recent theoretical work on the markedness of nine-vowel systems and also some older introductory works on African languages (cf. Westermann & Ward 1933:33) tend to give the impression that this vowel system is relatively rare.

In fact, it is extremely common and widespread. It occurs in virtually all major branches of Niger-Congo (except possibly Ubangi and Kordofanian) and in a large number of Nilo-Saharan languages in the Central Sudanic and Nilotic families. In West Africa, it is not inconceivable that it could turn out to be the single most common vowel system.

There is currently a widespread view (cf. Archangeli & Pulleyblank 1994, Calabrese 1995, Stewart 1999) among phonologists that this nine-vowel system (and also the ten-vowel system) is rather marked, in virtue of possessing the high [-ATR] vowels /ɪ/ and /ʊ/, which are alleged to involve a challenging combination of articulatory gestures.

Descriptive issue for nine- and ten-vowel systems: relative frequency of vowels.

A possible problem for the view that /ɪ/ and /ʊ/ are highly marked vowels is the fact that these are very often among the most common vowels in nine-vowel languages, and sometimes function as epenthetic vowels.

A considerable number of nine-vowel systems in African languages, in both East and West Africa, have at one time or another been incorrectly analyzed as seven-vowel

systems (Rennison 1986, Casali 1995a, Dakubu 1997). In virtually every case, the incorrect analysis resulted from inaccurate phonetic transcriptions resulting from a failure to hear the difference between the high [-ATR] vowels [ɪ] and [ʊ] and (depending on the language) either high [+ATR] vowels [i] and [u], or (perhaps more commonly) the mid [+ATR] vowels [e] and [o].

This difficulty, which has posed considerable problems for both analysis and orthographies in African languages, will be discussed in more detail below. The fact that so many nine-vowel systems have been incorrectly analyzed as seven-vowel systems may be part of the reason why the nine-vowel system has not always been recognized in the literature as being as common as it is.

Like ten-vowel systems, nine-vowel systems almost always have cross-height ATR harmony. (No clear known exceptions.)

Seven-vowel systems - common type

(22) Seven-vowel system (common type)

i	u	[+ATR] vowels: i u e o
e	o	
ɛ	ɔ	[-ATR] vowels: ɛ ɔ ɑ
	ɑ	

Survey frequency: about 27%

This vowel system is also extremely common. It may well be the most common system in African languages on the whole, though not by such an overwhelming margin as is sometime supposed. In West Africa, it is difficult to say whether this system is more common in overall terms than the nine-vowel system.

This seven-vowel system often has ATR vowel harmony involving at least the mid vowels /e/, /o/, /ɛ/, /ɔ/.

A sketch of an African language with a seven-vowel system needs to make it clear whether or not there is ATR vowel harmony.

It is difficult to say how common it is for seven-vowel systems to have ATR vowel harmony, in part because many descriptions of languages with this language are not explicit on this point. This is no doubt due to some extent due to the fact that harmony is often a less striking phenomena in such systems, as it frequently involves only the mid vowels. The high vowels /i/ and /u/ and the low vowel /ɑ/ are often neutral to ATR harmony, a behavior we will consider in more detail below.

Seven-vowel systems - less common type

There is a second type of seven-vowel system, which, though less common than the system /iɛɑɔou/, occurs in a number of African languages from a variety of families.

(23) Seven-vowel system (less common type)

i	u	[+ATR] vowels: i u
ɪ	ʊ	
ɛ	ɔ	[-ATR] vowels: ɪ ʊ ɛ ɔ ɑ
	ɑ	

Survey frequency: about 6%

Like the nine- and ten-vowel systems, this vowel system is also regarded as highly marked by some current theories.[10] It is nevertheless not vanishingly rare in Africa as a whole.

In West Africa, however, this system *is* rare. Although it has been reconstructed for Proto-Guang by Keith Snider and some other proto families by John Stewart, the only examples I am aware of in present-day West African languages are one dialect of Nawdm (Jacques Nicole, personal communication), and probably Daza (Connie Kutsch Lojenga, Kevin Walters, personal communication).

Seven-vowel systems: terminology

The two types of seven-vowel system just presented exhibit rather different behavior (discussed below) as far as ATR harmony is concerned. It will therefore be important to have some convenient terminological means for distinguishing them.

Notice that the only difference between these two systems lies in the identity of the second highest ("height 2") vowels, which are /e/ and /o/ in the more common type of system in (22), but /ɪ/ and /ʊ/ in the less common type of system in (23). Since the height 2 vowels are phonologically lower in the system in (22) than the one in (23) (i.e. /e/ and /o/ are [-high] while /ɪ/ and /ʊ/ are [+high]), we might designate the former as the *lower* seven-vowel system and the latter as the *higher* seven-vowel system. To further aid keeping the difference clear in mind, we will generally add the identities of the height 2 vowels in parentheses after the labels *lower* and *higher*. Thus we will speak of a "lower (eo) seven-vowel system," consisting of the vowels /ieɛɑɔou/, and a "higher (ɪʊ) seven-vowel system," consisting of the vowels /iɪɛɑɔʊu/.

A further important point to keep in mind is that these designations, as well as the labels "nine-vowel system" and "ten-vowel system," will be used throughout to refer to the *underlying* inventory of a language and not its *surface* inventory. Many languages have more vowels phonetically than underlyingly, due to various kinds of allophonic processes (a few of which are fairly common and will be discussed below). These additional, allophonic vowels, though they are not without interest, will be ignored for purposes of classifying vowel systems in this paper.

Systems with additional central vowels

A number of languages have vowel systems that are nearly identical to one of the four systems above but with one or more additional central vowels:

- Some Kru languages (e.g. Godie, Kpokolo) are reported to have 13 vowel systems which consist of the vowels of the nine-vowel system plus four non-low central vowels.
- Some languages, found in several families, have vowel systems containing a non-low [+ATR] central vowel /ə/ (and/or /ɨ/, in some languages) in addition to the usual vowels of the lower (eo) seven-vowel system. (Examples: Attie (Kwa), C'Lela (Benue-Congo), Tongu dialect of Ewe (Kwa), Wurukun (Chadic), Akoose (Bantu), Omotik (Southern Nilotic).)

[10] Under one theory, that of Calabrese (1995), it ought to be virtually non-existent.

- Some languages, found in several families, have eight vowel systems containing a [+ATR] central vowel /ə/ (or /ɨ/, in some languages) in addition to the usual vowels of the higher (ɪʊ) seven-vowel system. (Examples: Burun (Western Nilotic), Kuche(?) (Benue-Congo), Lendu (Central Sudanic), Mayogo (Ubangi), Zande (Ubangi).)

Other systems, with different combinations of central vowels, are found in other languages, for example some languages have the vowels of the lower (eo) seven-vowel system plus *two* additional central vowels, /ə/ and /ɨ/.

As far as [ATR] harmony is concerned, the systems with additional central vowels behave in most important respects very much like the corresponding systems without the non-low central vowels.

Generalized system types based on heights

For comparative and typological purposes (as far as ATR harmony is concerned), it is sometimes useful to ignore the presence or absence of non-low central vowels and focus on the number (and nature) of the vowel heights that are present. It is convenient to distinguish the following three general types of systems that commonly have ATR harmony:

(24) Five-height system

i	(ɨ)	u	[+ATR] vowels: i u e o (ə) (ɨ)
ɪ	(ɪ̈)	ʊ	
e	(ə)	o	
ɛ	(ʌ)	ɔ	[-ATR] vowels: ɪ ʊ ɛ ɔ ɑ (ɪ̈) (ʌ)
	ɑ		

Here the parentheses indicate (optional) vowels which may or may not be present, without changing the overall type of the system.

(25) Four-height system - lower (eo) type

i	(ɨ)	u	[+ATR] vowels: i u e o (ə) (ɨ)
e	(ɑ)	o	
ɛ	(ʌ)	ɔ	[-ATR] vowels: ɛ ɔ ɑ (ʌ)
	ɑ		

(26) Four-height system - higher (ɪʊ) type

i	(ɨ)	u	[+ATR] vowels: i u (ə) (ɨ)
ɪ	(ɪ̈)	ʊ	
ɛ	(ʌ/ə)	ɔ	[-ATR] vowels: ɛ ɔ ɑ ɪ ʊ (ʌ) (ɪ̈)
	ɑ		

Terminology: The highest vowels in a vowel system are often referred to as the "height 1" or "degree 1" vowels, the next highest as the "height 2" or "degree 2" vowels, etc.[11]

[11] As with almost anything in linguistics, alternative systems of terminological reckoning exist. Some linguists prefer to number the height levels starting from the bottom, so that /ɑ/ is height 1. The system which starts from the top seems to be the most commonly used, however, and we will follow it here.

Asymmetric systems

Although all of the systems discussed so far have equal numbers of front and back vowels, there are also systems which are asymmetric in having fewer front or back vowels.

Although some of these systems are very rare, it is not all that uncommon to find systems which are otherwise of the lower (eo) four-height type but which lack the front [-ATR] vowel /ɛ/. Examples in my survey: Konkomba, Bassari, Bimoba, Ibibio, Karan, Moba, Obolo, Ewe (some dialects), Ewondo, Metta, and Mono.

Three-height systems

Also very common in African languages of some families (e.g. Bantu, Chadic) are three-height systems of the types in (27).

(27) Three-height triangular systems[12]

a.
i	(ɨ)	u
ɛ	(ʌ)	ɔ
	ɑ	

b.
i	(ɨ)	u
e	(ə)	o
	ɑ	

In these systems, the feature [ATR] is not contrastive (being predictable from the features [high] and [low]), and so one would normally not expect to find ATR harmony in such languages.

There are however some languages with the system in (27b) (e.g. Fufulde; Archangeli & Pulleyblank 1994) which have a form of ATR harmony as an allophonic process in which /ɛ/ and /ɔ/ are realized as [e] and [o] in the vicinity of /i/ and /u/.

5. Exceptions to ATR vowel harmony

Types of exceptions

ATR harmony is rarely completely exceptionless at the level of the grammatical word.

Some exceptions are *idiosyncratic*, and involve the failure of some morphemes to obey harmony.

- Particular lexical roots may violate harmony.
- Certain affixes may fail to harmonize.

Other exceptions are *systematic*: ATR harmony holds in a wide range of environments, but regularly fails to apply under certain well-defined conditions. "Exceptions" of this

[12] There is some question as to whether there really are two categorically different types of three-height systems, as in (27), or whether it is simply the case that the quality of the mid vowels is free to fluctuate more in a system in which there is no contrast between [e] and [ɛ] or between [o] and [ɔ]. If there is a lot of fluctuation, it may not always be possible to identify a particular language as having one or the other system. (See Casali 1996b for discussion.)

type need not necessarily be viewed as exceptions at all, but can generally be regarded simply as limitations on the domain in which harmony applies.

- In many ATR harmony languages, harmony often does not apply between two roots in a compound.

This is not always the case, however. In Nawuri, [-ATR] roots sometimes change their vowels to [+ATR] when they co-occur in a compound word with a [+ATR] root.

- Neutral vowels present a systematic type of exception (discussed below) in many languages.

Some phonological theories also lead us to expect the possibility of exceptions (discussed in more detail below) arising through the need to avoid certain "marked" vowels in particular positions.

Exceptional roots

It is not uncommon for a few particular lexical items to violate vowel harmony in a language with otherwise regular harmony. In Nawuri, for example, the word dʒoonɔ 'dog' does not obey the regular ATR harmony pattern of the language under which the vowels [o] and [ɔ] are ordinarily excluded from occurring in the same morpheme. (The word dʒoonɔ is not a compound but consists of a single morpheme.) This is one of only two or three words I have discovered in the language in which such a vowel harmony violation occurs. The fact that cognate forms, listed in (28) (from Snider 1989a), in related North Guang languages do obey vowel harmony, suggests that the disharmonic status of this word in Nawuri may be a relatively recent historical development. The ultimate reasons for the exceptional behavior of this word remain a mystery at present however.

(28)	a. dʒono	Chumburung, Gichode
	b. dʒoɾo	Krachi
	c. dʒɔnɔ	Gonja

One might speculate that loan words would be more likely to violate vowel harmony than native words, especially where many speakers of an ATR harmony language are fluent in a language such as English or French in which ATR harmony does not hold. However, I am not aware of any studies showing that this is the case, and it is equally conceivable that native speakers would regularly adjust the phonological structure of loans to conform to ATR harmony. The behavior of loanwords with respect to ATR harmony is a topic that could make for an interesting study in a harmony language.

Given that many ATR harmony languages have at least some morphemes which violate harmony, you should not be overly concerned about discovering a few such cases in a language you are working on. In particular, the discovery of small number of exceptions does not justify the conclusion that a language does not have vowel harmony. To draw such a conclusion would be, in effect, to make the exception the rule.

Exceptional affixes

Some languages also have affixes which fail to harmonize but which, unlike dominant affixes, do not induce any [ATR] changes in a root to which they are attached.

There are two sub-cases:

- Affixes containing neutral vowels (see below), which never harmonize at all in the language.

Example: The low vowel /ɑ/ is often "neutral" (neutrality will be discussed below) in nine-vowel languages. In such languages, affixes containing /ɑ/ may be phonetically invariant.

- Affixes which do not contain neutral vowels but are simply idiosyncratic in their failure to harmonize.

Example: the agentive suffix /-pʊ/ is invariantly [pʊ] in Chumburung; it does not become [pu] following [+ATR] roots, as one might have expected.

Data from Snider (1989a):

(29) With [-ATR] roots

a. bwɑjɪ-pʊ	'blacksmith'
b. ɔ-tʃɑ-pʊ	'healer'
c. ɔ-lʊ-pʊ	'weaver'

(30) With [+ATR] roots[13]

o-kɨsɨ-pʊ	'fetish priest' (lit. 'one who taboos')

In some other Guang languages, the cognate agentive suffix *does* harmonize. The word corresponding to (30) in closely-related Nawuri, for example, is o-kɨsɨ-pu. (Following [-ATR] roots, the suffix is phonetically [pʊ] in Nawuri, just as in Chumburung.)

Foodo, a Guang language related to Chumburung and Nawuri, is also said to have some invariantly [-ATR] suffixes (Plunkett 1991).

Markedness-driven harmony exceptions

Most current phonological theories predict the possibility of exceptions to vowel harmony due to the tendency in some languages to avoid certain "marked" vowels in certain environments. Because a meaningful treatment of this type of exception requires an understanding of the theoretical notion of *markedness*, I postpone discussion until section 11, "Vowel systems and markedness."

Practical implications

ATR vowel harmony systems are typically *not* exceptionless. Therefore, it would be a mistake to conclude from the discovery of some words which do not obey vowel harmony that the language does not have vowel harmony.

Rather, if your language has more than three-heights, it would be safer to start out assuming that it does have some form of ATR harmony and systematically investigate to what extent this harmony holds. (This of course needs to be discussed in a written description.)

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[13] Although the example in (30) is the only completely straightforward example I found in Snider's data, I am fairly certain that the failure of this suffix to harmonize is a general property of Chumburung.

Descriptive issue: Describe vowel co-occurrence possibilities in detail.

In particular, any claim to the effect that a four- or five-height Niger-Congo or Nilo-Saharan language lacks ATR harmony altogether needs to be carefully documented. Even if a language does not have regular ATR harmony affecting all of the language, it may well more limited harmony affecting a subset of the vowels. (See section 7 below.) Many lower (eo) four-height languages for example have a limited form of ATR harmony affecting only the mid vowels: mid [+ATR] vowels /e/ and /o/ do not co-occur with mid [-ATR] vowels /ɛ/ and /ɔ/. The non-mid (high or low) vowels on the other hand are often (depending on the language) relatively free to co-occur both with each other and with mid vowels of either harmony set. Four- or five-height African languages which have no ATR harmony requirements whatsoever, i.e. languages in which all [+ATR] vowels can freely co-occur with all [-ATR] vowels, appear to be relatively rare. Indeed, it would probably not be a gross exaggeration to say that the vast majority of such languages divide into three groups as far as the existence of vowel harmony is concerned: those for which no phonological description exists, those which are described as having some form of ATR harmony, and those for which existing descriptive sources are simply silent about the existence of vowel harmony. A fourth logically expected group, four- or five-height African languages for which descriptive sources explicitly (and convincingly) demonstrate an absence of ATR harmony are surprisingly difficult to come by.

An obvious answer to this is that a linguist writing a phonological description of a language should hardly be expected to explicitly mention every phenomenon which does *not* occur in the language. This sounds reasonable, and indeed fifty or sixty years ago there may have been no compelling reason, based on what was known about the distribution of ATR harmony at the time, why it should have been thought necessary to mention the absence of vowel harmony in a phonological description, except perhaps in cases (relatively small in number at that time) of languages belonging to families in which vowel harmony was known to be widespread. Based however on what is known today about the extremely wide distribution of languages with some form of ATR harmony, it would appear that there are few if any African language families commonly having four- or five-height systems in which ATR harmony is not a strong possibility. This being the case, the discovery that a (four- or five-height) language lacks ATR harmony altogether is a fact of significant import that it generally deserves careful and explicit documentation.

6. Phonetics of [ATR]

The articulatory basis of [ATR] in Akan and <u>some</u> other languages

The existence of [ATR] harmony systems was widely known long before the phonetic basis of the contrast [ATR] (Advanced Tongue Root) was well-understood.

Early descriptions of the phonetic contrast invoked descriptive labels like the following:

- tense vs. lax
- relative tongue height
- “hollow” vs. creaky” (or other, similar impressionistic labels) voice quality

Phonetic studies on Akan (a Kwa language of Ghana) beginning in the mid 1960’s (Ladefoged 1964, Pike 1967, Stewart 1967, Painter 1973, Lindau 1976, 1979, 1987)

revealed that the primary phonetic basis of the contrast is advancement/retraction of the tongue root.

On this basis, Stewart (1967) and others proposed that the phonological feature underlying these contrasts be described in terms of Advanced Tongue Root (ATR). Use of [ATR] to describe such contrasts both in Akan and in languages with similar vowel harmony systems quickly became widespread.

For some Akan speakers (there is apparently some variation), advancement of the tongue root is also accompanied by lowering of the larynx. Because both larynx lowering and tongue root advancement enlarge the pharynx, Lindau (1979) argued that it would be more appropriate to define the phonological feature in terms of pharyngeal expansion rather than tongue root advancement alone. She proposed replacing the feature [ATR] with the feature [EXP], or Expanded Pharynx.

While Lindau's arguments were widely accepted, only a few phonologists have actually used [EXP] in their work. Most have preferred to retain the more familiar label [ATR], with the understanding that this actually refers to pharyngeal cavity expansion and not just tongue root advancement alone.

Articulatory phonetics of [ATR] in other languages

Very few other five-height nine- or ten-vowel languages with [ATR] harmony have been subject to instrumental articulatory studies (e.g. X-ray or MRI) of the type carried out in Akan.

Among the few which have been investigated, some languages appear to use essentially the same articulatory mechanisms (tongue root advancement and larynx lowering, leading to expansion of the pharynx) used in Akan, while others use somewhat different mechanisms, e.g. tongue body raising or both tongue body raising and tongue root advancement (cf. Jacobean 1980, Lindau et. al. 1972, and Lindau & Ladefoged 1986). These studies also reveal that there can be a significant amount of variation as to the mechanisms used even by different speakers of a single language.

Tongue root advancement versus tongue root retraction: Are there two types of languages?

It has been suggested by some phonologists (cf. Painter 1971, Steriade 1995) that in some languages the [ATR] contrast is manifested phonetically in that the [+ATR] vowels are produced with a tongue root that is actively advanced from a more-or-less neutral position, while the [-ATR] vowels are articulated with the tongue root in a relatively neutral (rather than actively retracted) position. It is assumed that in other languages the situation is exactly the opposite: the [-ATR] vowels are articulated with the tongue root actively retracted, while the [+ATR] vowels are produced with a relatively neutral tongue root position.

While there are theoretical considerations that make this view attractive (see Steriade 1995 for discussion), there seems to be relatively little empirical evidence at present to support it. Although Painter (1971:243) suggests that Akan and Anum, both Kwa languages of Ghana, represent languages of the first and second type respectively, this claim ultimately rests on impressionistic observations that have not so far been substantiated instrumentally. Moreover, as will be discussed in more detail below, the [+ATR] and [-ATR] vowels in many ATR harmony languages have been described as having very different voice qualities, the former set sounding "breathy" or "hollow" (among other descriptive labels which have been applied--see below), while the latter

sound (among other labels) “creaky” or “choked.” It has generally been assumed that the former voice quality is caused (for reasons that may not yet be entirely understood) by active fronting of the tongue root and/or lowering of the larynx, while the latter quality results in one way or another from retraction of the tongue root and possibly other accompanying gestures. The fact that most reports of voice quality distinctions in ATR harmony languages commonly cite abnormal voice qualities accompanying *both* [ATR] sets would appear, if taken at face value, to suggest that [+ATR] vowels are typically produced with active advancement and [-ATR] vowels with active retraction. It would not be surprising to find, however, that different languages, and even different speakers of the same language, may differ with respect to which gesture (tongue root advancement in the case of [+ATR] vowels, tongue root retraction in the case of [-ATR] vowels) involves the greatest degree of active displacement. (One thing that has become quite clear from instrumental work on ATR harmony systems done so far is that not all speakers of a language use exactly the same mechanisms in articulating either the “[ATR]” contrasts of African languages or the “tense-lax” contrasts of European languages.)

Acoustics of [ATR]

The primary acoustic correlate of [+ATR] is a lowered first formant frequency, which in auditory terms translates into a higher sounding vowel. It is generally the case that a [+ATR] vowel will be acoustically higher than its [-ATR] counterpart. This auditory raising effect holds not only in languages in which [+ATR] is implemented articulatorily by advancing the tongue root and/or lowering the larynx, but also in languages (e.g. Ateso; Lindau & Ladefoged 1986) in which the difference between [+ATR] and [-ATR] vowels involves the height of the body of the tongue. On the basis of this invariant acoustic effect (and for other reasons) [ATR] might be regarded as essentially a secondary acoustic height feature which functions to distinguish height contrasts which cannot be distinguished by means of the feature [high] alone (Casali 1996b, 1998a,b, Goad 1993, Hyman 1988).

It needs to be emphasized however that under this view the acoustic effect of a [+ATR] specification is an *incremental* or *relative* one. There is no absolute acoustic threshold between [+ATR] and [-ATR] vowels. The only certain effect of a [+ATR] specification is that it will cause a vowel which bears it to be acoustically higher than it would have been otherwise. Thus /i/ and /u/ will be acoustically higher than /ɪ/ and /ʊ/ respectively, while /e/ and /o/ will be higher than /ɛ/ and /ɔ/ respectively. Notice however that no prediction is made about the acoustic height of /e/ and /o/ relative to /ɪ/ and /ʊ/. The *degree* of acoustic raising supplied by a [+ATR] association can be assumed to be language-specific. If this degree is great enough, the [-high] vowels /e/ and /o/ will be raised far enough above /ɛ/ and /ɔ/ (the height they would have had without their [+ATR] specification) that they may “overtake” the level of the high [-ATR] vowels /ɪ/ and /ʊ/.

To put it differently, this view which treats [ATR] as an acoustic height feature assumes that the absolute acoustic height level of a given vowel is computed by combining the height level appropriate to its value of [high] with the height increment appropriate to any specification it possesses for [+ATR]. To make things concrete (at the risk of oversimplifying considerably), imagine that vowel height is computed using some acoustic scale. In principle, this could be based on first formant frequency, but for simplicity we will just assume a numeric scale ranging from 1 to 10, with 1 being at the

low extreme of the vowel space (i.e. a maximally low vowel) and 10 being at the upper extreme of the vowel space (i.e. a maximally high vowel). In any given language, the feature specifications [+high] and [-high] will have particular values associated with them along this scale. Assume that in some language the normal values are 7 for [+high] and 4 for [-high]. The feature [ATR] will not have an absolute value associated with it, but rather an incremental value associated with [+ATR] and/or a decremental value associated with [-ATR]. For simplicity, we will imagine that "[-ATR]" vowels are simply unspecified for [ATR], so that we need only concern ourselves with the former. Let us assume that in some language the acoustic increment associated with [+ATR] is +2. In such a language, the absolute height levels of the vowels /i/ (or /u/), /ɪ/ (or /ʊ/), /e/ (or /o/) and /ɛ/ (or /ɔ/) would be computed as follows.[14]

(31) Height of /i/: 7 + 2 = 9
Height of /ɪ/: 7 + 0 = 7
Height of /e/: 4 + 2 = 6
Height of /ɛ/: 4 + 0 = 4

The values assumed in this example ([+high] = 7, [-high] = 4, [+ATR] = +2) yield the kind of classic well-behaved picture of a vowel system one might expect, in which the [+high] vowels are all higher than the [-high] vowels. With slightly different values, it is possible to have a situation in which the [-high,+ATR] vowel /e/ is acoustically as high as or higher than the [+high,-ATR] vowel /ɪ/. This will be the case for example (as the reader may verify) if the same values are used for plus and minus [high] and the acoustic increment associated with [+ATR] is increased to +3 (or more). As noted previously, such situations do occur. In the model presented here, however, whether or not /e/ is acoustically higher than /ɪ/ (and/or /o/ is higher than /ʊ/) is a very low-level matter, as it depends simply on the *degrees* that are assigned to the binary feature values for high and [ATR] in their phonetic interpretation. It is thus not something that should be expected to have consequences for other areas of the phonology, but is an issue on a par with the question of how strongly rounded the lips are for round vowels in a particular language. And in fact, no systematic differences in phonological patterning have been reported between languages (e.g. Ateso, Dho-Luo; Lindau & Ladefoged 1986) in which /ɪ/ and /ʊ/ are consistently higher than /e/ and /o/ and languages (e.g. Akposso; Anderson 1999, Akan, Okrika Ijo; Lindau & Ladefoged 1986) in which /e/ and/or /o/ are as high or higher than /ɪ/ and/or /ʊ/.

Note moreover that just as different speakers of a single language might have more or less strongly rounded vowels, or more or less nasal vowels, we might also expect, under the model presented here, that different speakers of a language could have somewhat different degrees of acoustic raising associated with [+ATR], or could have somewhat different acoustic "baseline" values for [+high] and [-high]. This being the case, we might expect that speakers of the same language could differ with respect to whether the high [-ATR] or mid [+ATR] vowels are acoustically higher. And this appears in

[14] We will ignore the vowel /ɑ/ here for simplicity. One way of incorporating this vowel into the present model might be to assign some acoustic decrement (e.g. -2) to the feature value [+low] carried by this vowel.

fact to be the case. A study (Casali 1999) of four Nawuri speakers, for example, showed considerable inter-speaker variation as follows:

(32)	Speaker	Front vowels e & ɪ	Back vowels o & ʊ
	1	ɪ significantly higher than e	ʊ significantly lower than o
	2	ɪ significantly lower than e	ʊ significantly lower than o
	3	ɪ, e approximately the same height	ʊ, o approximately the same height
	4	ɪ, e approximately the same height	ʊ significantly lower than o

No two of the four speakers have exactly the same pattern.

Another possible pattern which the model predicts is one in which the vowels /ɪ/ and /ʊ/ are acoustically close to (though not quite as high as) the vowels /i/ and /u/ rather than the vowels /e/ and /o/. This pattern is also attested, for example in Koromfe (Rennison 1986). (What kinds of acoustic values for the features [high] and [ATR] might give rise to this pattern? To what extent is it expected, under this model, that /e/ and /o/ will be acoustically close to /ɛ/ and /ɔ/ in some languages?)

The model presented above has been oversimplified in a number of respects. Although most of these need not concern us for our present purposes, there is one simplification that should be mentioned. This is that the model ignores the possibility that front and back vowels may behave differently in a language. In fact, there are languages in which /e/ is acoustically higher than /ɪ/, but /o/ is not higher than /ʊ/. This is the case for example for at least some speakers of Akan (Lindau & Ladefoged 1986). There are also languages in which the reverse pattern holds, i.e. in which /e/ is not higher than /ɪ/, but /o/ is higher than /ʊ/. This pattern holds for the first Nawuri speaker in table (32) above.

Relevance to field work (expectations)

This acoustic model is not intended to be something that can be taken and applied *directly* to a language for descriptive purposes (for example there would seem to be no advantage for descriptive purposes to using numbers to indicate vowel height in place of conventional labels such as high, low, and [ATR]). Rather, it is intended to be helpful in suggesting (and perhaps partly making sense of) the acoustic patterns you might expect to find in a language with [ATR] contrasts. In particular:

- Expect that the high [-ATR] vowel /ɪ/ may be acoustically close to either /i/ or /e/, and that /ʊ/ may be acoustically close to either /u/ or /o/.
- You should not be surprised or concerned to find that the "mid" [-ATR] vowels are actually as high or higher than the "high" [+ATR] vowels. If you do find (either by instrumental speech analysis or simply on the basis of your own auditory impressions) that /e/ and/or /o/ are acoustically higher than /ɪ/ and/or /ʊ/, this is not a reason to refrain from using the traditional label "mid" (or some equivalent) to describe the former and "high" to describe the latter.

Acoustic merger?

A very serious question which the acoustic model presented above does not address is the following. If the vowels /e/ and /o/ can have the same acoustic height (= first formant value) in some languages as /ɪ/ and /ʊ/ respectively, how is that native speakers can tell these vowels apart?

- Possible Answer 1: There could be a slight difference of frontness/backness (measured in terms of the second formant) which would render them distinct. That is, although both /ɪ/ and /e/ are front vowels, for example, one could be slightly (but audibly) more front than the other.

Discussion: Although such a situation might exist in some languages, this kind of cue is not invariably present. In some languages, neither the height nor the frontness/backness dimensions serves to distinguish the relevant vowels; as far as the conventional dimensions of the acoustic vowel space are concerned, they overlap entirely. There is little if any evidence that it is acoustic frontness/backness differences which are primarily responsible for rendering /ɪ/ and /e/ (and/or /ʊ/ and /o/) perceptually distinct in languages in which their acoustic heights coincide.

- Possible Answer 2: One might imagine that the high [-ATR] and mid [+ATR] vowels are *not* in fact phonetically distinct in languages in which their acoustic heights coincide. That is, one might propose that native speakers cannot actually hear a difference between the vowels *in isolation*, but that they are able to tell them apart based on vowel harmony and other contextual cues.

Discussion: This has been claimed for a number of languages, of which perhaps the best known case is Okpe, an Edoid language of Nigeria. Hoffman (1973) describes Okpe as having a lower (eo) seven-vowel system phonetically:

(33)

i	u
e	o
ɛ	ɔ
ɑ	

According to Hoffman, roots like [sɔ́] 'steal' and [sɔ́] 'sing' are homophonous, both having a vowel which he transcribes as [o]. However, the vowels in these two words differ in their behavior with respect to ATR harmony. Whereas the former takes [+ATR] forms of harmonizing affixes, as would be expected with a [+ATR] root vowel like, the latter unexpectedly takes [-ATR] affixes:

(34)

a. o-so		'he is stealing'
b. ɔ-so-ɑ	([ɔswɑ])	'he is singing'[15]

[15] The presence of suffix /-ɑ/ in (34b) but not (34a) is due to the fact that, quite generally, such suffixes appear only with roots that have phonologically high vowels; this in itself is further evidence that the root vowel in (34b) is underlyingly high. Realization of the underlying root vowel in this example as a semivowel is due to a very general process of glide formation in Okpe (see Hoffman 1973, Omamor 1988, Casali 1996b.)

Thus, the root 'sing', though phonetically [o] according to Hoffman, behaves phonologically like a [-ATR] vowel. Hoffman accounts for this behavior by proposing that the vowel of this root is underlyingly the high [-ATR] vowel /ʊ/, but that it is realized on the surface as a [+ATR] mid vowel [o], merging phonetically with the underlying [+ATR] mid vowel /o/ in 'steal'. This same proposal is adopted and formalized by Pulleyblank (1986) in his underspecification analysis of Okpe.

It is not clear however that the claim that /ʊ/ and /o/ are auditorily indistinguishable to native speakers in Okpe is factually correct. Another study, Omamor (1973), provides acoustic formant measurements of the vowels in Okpe which indicate that these vowels have distinct first formant frequencies; this would suggest that it should be possible to tell them apart.

Whatever the facts may be in Okpe, it seems fairly clear that even complete overlap of acoustic height values of high [-ATR] and mid [+ATR] vowels does not necessarily result in auditory merger. In Akan, for example, native speakers are able to reliably distinguish the vowels /ɪ/ and /e/ in isolation contexts (Hess 1992), even though the first formant values of these vowels closely coincide. In Nawuri, the acoustic heights of the vowels /ɪ/ and /e/ are in general fairly close, and coincide more or less exactly for some (but not all) speakers. The same is true of /ʊ/ and /o/. The high [-ATR] and mid [+ATR] vowels are nevertheless auditorily distinct (presumably for all speakers), even in monosyllabic words spoken in isolation. (Compare the Nawuri examples in (35c,e) below.)

Neither of the two possible answers discussed above appears to be correct in general. Acoustic height (i.e. first formant frequency) merger does not entail auditory merger (possible answer 2) nor does some acoustic difference along the frontness/backness dimension appear to be what is rendering the high [-ATR] and mid [+ATR] vowels distinct in the relevant languages (possible answer 1). Something else must be responsible. Although vowel harmony undoubtedly plays a role in facilitating accurate identification of root vowels, the fact that the vowel remain distinguishable even in isolation shows that this cannot be the whole story. Rather, the answer appears to be related to what have often been described in the literature as *voice quality* differences between the two harmony sets.

Voice quality differences

Five-height languages with ATR harmony have sometimes been described as having a different voice quality associated with each set of vowels (cf. Fulop et. al. 1998, Hall et. al. 1975, Larsen 1984, Noonan 1992, Tucker 1971). This has been reported more commonly in Nilotic languages of East Africa, but has also been noted in some West African languages, e.g. Akan (Dolphyne 1988), Ahanta and Nzema (Berry 1955), Degema (Fulop et. al. 1998), and Nawuri (Casali 1999). Based on my experiences in listening to a number of West African ATR harmony languages, I think it is quite likely that voice quality differences exist in many more West African languages than have so far been reported.

Voice quality in this case does not refer to one of the more familiar auditory properties like backness or height, but rather to a more subtle quality difference, as though the person's overall voice changes somewhat when pronouncing vowels from the different sets (or as though, if one were to exaggerate considerably, a different person were

speaking). Various impressionistic labels have been used to describe the difference. [+ATR] vowels have been described as "breathy," "dull," "full," "deep" or "hollow," while [-ATR] vowels have been described as "bright," "tight," "creaky," or "choked."

All of these terms are subjective labels designed to capture a phenomenon which has proven somewhat difficult to characterize, is subtle enough that it has often been overlooked, and whose underlying acoustic correlates are still not entirely understood (see Fulop et. al. 1998 for some detailed discussion). Ultimately, the best way to become familiar with the voice quality difference is by listening carefully for it in a language in which it is reportedly found.

It should be noted that the "creaky" quality of the [-ATR] vowels is not, at least in West African languages, laryngealization, although in terms of what it sounds like it is not altogether dissimilar to it. There is however none of the characteristic low pitch associated with laryngealization; the "creaky" quality has its source in a pharyngeal constriction, rather than from some abnormal mode of vocal fold vibration.

Similarly, in West African languages, the "breathy" quality of the [+ATR] vowels is apparently not, in most cases, the classic "breathy voice" phenomenon associated with an abnormal mode of vibration of the vocal folds. (Descriptions of East African Nilotic languages suggest however the possibility that in some languages of this family the voice quality difference may involve, at least in part, a genuine difference in vocal fold vibration. In some extreme cases, in fact, it has been suggested the distinction is better characterized as fundamentally one of breathiness rather than [ATR] (cf. Reh 1996, Yigezu 1995).)[16]

An auditory analogy which I have also found helpful is to characterize the [+ATR] vowel quality as sounding a bit more "bassy," like the effect of turning up the bass knob on a stereo, and the [-ATR] vowels as sounding a bit more "trebly," as though one had turned up the treble knob. Or, to put it just a bit differently, the [+ATR] vowels sound like they were spoken in a slightly deeper voice than the [-ATR] vowels.

(35) Puguli examples: [+ATR] vowels

a.	[luo]	'francolin'	
b.	[lugoʔ]	'mortar'	

[16] Compare in this regard the statement of Fulop et. al. (1998:84), who do not however note any significant difference between West African and East African languages: "In many ATR languages, the timbral contrast seems to be at least partly caused by a genuine variation in phonation type. Lax (or breathy) voice quality often accompanies [+ATR], while tense (or creaky) voice quality often accompanies [-ATR]. This covariation is not observed in all languages with ATR harmony, however [Kingston et. al. 1997.] In Degema, for example, there is no impressionistic indication of a phonation type distinction."

(36) Puguli examples with [-ATR] vowels

a.	[lʊɔʔ]	'fatigue'	
b.	[lʊlɑʔ]	'little stalks beside the main stalk'	

Some native speakers of French produce (at least) the high French vowels with a voice quality that is not unlike the [+ATR] voice quality found in ATR harmony languages.

This voice quality difference is, in at least some languages, not so strikingly obvious as to be instantly noticeable if one is not looking for it. I had been working with Nawuri for a couple years before a first became aware of a voice quality difference. Once I became attuned to the difference however, I began to notice it in other West African languages, and I have found it to be an extremely useful cue to distinguishing the two sets of vowels from each other, particularly in the case of pairs of vowels (e.g. [ɪ] and [e], [o] and [ʊ] in languages like Nawuri or Akan, or [i] and [ɪ], [u] and [ʊ] in some other languages) which are very similar in other respects and seem to have roughly the same auditory height.

Because the voice quality distinction can be helpful in distinguishing pairs of vowels which otherwise sound very similar, it is something that is worth trying to pay attention to. As Larsen (1984:38) points out, such differences are easily overlooked, native speakers of European languages being naturally more prone to focus on differences in the perceived height of vowels:

> *"Someone who has not grown up in, or extensively studied a language with +ATR vowels, will automatically focus on the difference in vowel height qualities rather than more important difference in resonance quality (hollowness)."*

As we have already noted, however, it is precisely the height quality differences between some pairs of vowels which are often small or non-existent in languages with ATR harmony. In such cases, the voice quality difference may be provide the only really effective clue to distinguishing these vowels, and the investigator would do well to pay close attention to it.

A question which naturally arises is whether such voice quality distinctions might show up through acoustic speech analysis in a program like WinCECIL or Speech Analyzer. While this might be possible in principle (since the voice quality difference is audible, it must presumably be encoded in the speech signal by some means or other, and should in principle be detectable instrumentally), there have been relatively few studies that bear on the matter of an acoustic correlate of this voice quality distinction in particular languages. Among the relevant studies that do exist are Fulop et. al. (1998), Hess (1992), and McCord (1989). Although these studies succeed to varying degrees in identifying measurable correlates of [ATR] that might be presumed to correspond to voice quality differences, the kinds of measures that were used are not in general things that are easily measured using a tool like WinCECIL or Speech Analyzer. (There is certainly no type of display in the present set of speech analysis tools which would

allow you to see at a glance whether a particular vowel was produced with advanced or retracted tongue root, nor is such a tool likely to be developed in the foreseeable future.)

There is a strong need for further research into the acoustic properties of the [+/-ATR] distinction and accompanying voice quality differences in individual languages. At present, instrumental techniques are certainly no substitute for a researcher's ability to hear different vowel distinctions, though they can be a helpful supplement in particular cases. Where CECIL and other programs can help considerably at present is in facilitating the listening process by allowing one to easily play back utterances, syllables, and even individual vowel sounds and compare one against another (e.g. by putting them in separate windows) to hear whether they are the same or different.

While reports of a voice quality difference in five-height African languages are not uncommon, there have been relatively few such reports of a similar quality distinction in four-height languages (see however Armstrong 1985 on Yoruba). This should not be taken however as a clear indication that such voice quality distinctions are lacking in languages with fewer than five heights, or as evidence that the phonetic basis of the vowel contrasts in these languages is fundamentally different from that found in four-height languages.[17]

Listen for voice quality differences between [+ATR] and [-ATR] vowels and note any such differences in a description.

There are several reasons why a voice quality difference in a four-height languages is more likely to go unnoticed than in a five-height language. For one thing, the incentive for an investigator to pay close attention to such cues is considerably less in most four-height languages,[18] since the vowel qualities are generally quite easily distinguished apart from such cues simply in terms of their acoustic height. The extent to which voice quality differences of the type reported in five-height languages are at work in languages with fewer heights is an interesting and open question.[19] Linguists doing field work in four-height languages are in a position to help answer this question by carefully reporting their impressions as to the presence or absence of these quality differences.

Visual/tactile clues

A few researchers have reported visual cues, involving either the jaw/chin or Adam's apple, accompanying the different harmony sets in five-height languages. Thus in the case of Igede, a Benue-Congo language of Nigeria, Bergman (1968:22) notes a significant difference in jaw position for the [+ATR] and [-ATR] vowels:

> *"When observing an Igede informant pronounce wû 'to catch' and wô 'to harvest groundnuts' in sequence, his jaw is noticeably moved back for wô."*

In Bari (Eastern Nilotic), Hall & Yokwe (1981:56) note a similar difference in jaw position, accompanied by movement of the lips as well:

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[17] For a suggestion to the contrary, see Kenstowicz (1994:476).

[18] This is true at least of the lower (eo) four-height language, though it may be less true of higher (ɪʊ) four-height languages, in which the height 2 vowels /ɪ/ and /ʊ/ have sometimes been described as being quite close acoustically to the height 1 vowels /i/ and /u/.

[19] My own impression based on exposure to a few four-height languages spoken in Ghana, e.g. Ewe and Lelemi, is that these languages (at least in the case of those speakers I have listened too) have voice quality differences that are virtually identical to those found in four-height languages like Akan.

"Fortunately for the beginner, there does exist a visual cue in Bari: as a concomitant of the advancement of the tongue root there is also a noticeable jutting forward of the jaw and lips. This is most visible with the high back vowel of set 1 [the [+ATR] vowels--RC] where the lips are markedly pursed and pushed forward as though in position to whistle; while less pronounced with the other non-low set 1 vowels, the same general forward motion can be seen."

A visual difference has also been described in Akan by Stewart (1967:197), who states that for the [-ATR] vowels "the angle formed by the front of the neck and the under side of the chin was sharp," whereas for the [+ATR] vowels "it was considerably straightened out."

In the same passage, Stewart also quotes Pike (1947:21-22) as noting that the gesture of larynx lowering (which instrumental studies have found to accompany [+ATR] vowels in many languages--recall that, larynx lowering, like advancing the tongue root, serves to expand the overall volume of the pharyngeal cavity) can be observed visually as a lowering of the Adam's apple.

Stewart (1967:197) also describes how the [ATR] difference in Akan can be discerned by touch, quoting the following passage by Hockett (1958:78-79):

"Hold the fingers on the bundle of muscles above and in front of the glottis within the frame of the lower jaw, and say bit, beat, bit, beat. For beat, one can feel a bunching and tension in the muscles which is either lacking or at least much less prominent for bit...Just what this bunching of muscles accomplishes is not clear; presumably it has some effect on the precise positioning of the upper surface of the tongue, and thus bears on the shape of the oral cavity."

Although the exercise described by Hockett applies in its original context to the "tense-lax" distinction in English, Stewart found that it also appropriately characterized the [ATR] distinction in Akan:

"This exercise, when applied to Twi [=Akan--RC], produced the most gratifying results: the muscles to which Hockett refers were pushed markedly downwards for all 5 of the raised [i.e. +ATR--RC] vowels and for none of the unraised [i.e. -ATR--RC] vowels." -- Stewart (1967:197)

7. Characteristic ATR harmony behavior in different vowel systems

Ten-vowel systems

Ten-vowel languages generally exhibit the most regular and symmetric vowel harmony. In general, non-compound words will contain all [+ATR] or all [-ATR] vowels.

Normally, ten-vowel languages do not have neutral vowels (vowels which can co-occur with either ATR harmony set--see below). (An exception is Akposso, in which the vowel /ɑ/ can occur in [+ATR] words under certain conditions.)

As in all other types of systems, the possibility exists of having morphemes which idiosyncratically fail to obey harmony. There is also the possibility that harmony may fail to apply in certain grammatical or morphological contexts. Markedness-driven exceptions to ATR harmony (see section 11) are also a possibility.

Perhaps the most significant descriptive issues that are unique to ten-vowel systems concern the nature of the tenth vowel.

Questions:

- What is its phonetic quality? Is it phonetically low?

Where acoustic measurements are not available, it might help to describe its quality with reference to some other vowels in the system, e.g. "of the same height as /ɛ/, but slightly more central and with a voice quality more characteristic of [+ATR] vowels." In some cases, it might also be appropriate to describe its quality with reference to some vowel in a well-studied language, e.g. "somewhat similar to the vowel in English *cup*." Or, if you are familiar with the cardinal vowel system, that might be a useful frame of reference also. (Unfortunately, choice of an appropriate IPA symbol alone will not generally suffice; there is too little consensus about how these symbols should be used to represent various "tenth" vowel qualities.)

- What is the distribution of the tenth vowel? Can it occur in all positions in which other vowels can occur? Does it occur in (non-harmonizing) function words?
- How common is this vowel?

Ten-vowel systems are likely to show an asymmetry in which [+ATR] rather than [-ATR] behaves as the active value, e.g. undergoes spreading across word and/or morpheme boundaries. (See section 13 for more discussion.)

Neutral vowels

Before discussing systems with fewer than ten vowels, it will be beneficial to discuss the behavior of neutral vowels, which often figure prominently in such systems.

In a classic ten-vowel system, the vowels of the language are exhaustively divided into two sets [ATR] harmony sets, each with five vowels:

(37)

+ATR vowels:		-ATR vowels:	
i	u	ɪ	ʊ
e	o	ɛ	ɔ
ə		ɑ	

In prototypical systems of this type, vowels from the two sets never mix; a non-compound word will either contain all [+ATR] vowels or all [-ATR] vowels. There are no [+ATR] vowels which can co-occur with [-ATR] vowels, and no [-ATR] vowels which can co-occur with [+ATR] vowels.

Many actual ATR harmony languages with fewer than ten vowels (as well as a few languages that have all ten vowels!) depart from this prototypical pattern in that they have at least one vowel which can co-occur with either [+ATR] or [-ATR] vowels. Such vowels are called *neutral*.

The behavior of neutral vowels can be illustrated using nine-vowel systems. Such languages have unequal numbers of [+ATR] and [-ATR] vowels: four of the former, but five of the latter:

(38)

+ATR vowels:		-ATR vowels:	
i	u	ɪ	ʊ
e	o	ɛ	ɔ
		ɑ	

The vowel responsible for the asymmetry here is the vowel /ɑ/, which lacks a low [+ATR] counterpart. In many, though not all, languages of this type, the vowel /ɑ/ performs a kind of "double duty," in that while it is phonetically (and phonologically) [-ATR], it can co-occur with [+ATR] vowels, as in the following examples from Nawuri:

(39) /ɑ/ in roots with [-ATR] vowels

a.	kɑɑpʊ	'show'
b.	sʊlɑ	'carry'
c.	kɪtɑ	'catch'
d.	sɑɑlɪ	'insult'
e.	tɔɔmɑɑ	'neighbor'
f.	lɑpɛ	'plate'
g.	gɑ-tʃɑɑpɛɛ	(type of fish)
h.	sɑgɑ	'hang'

(40) /ɑ/ in roots with [+ATR] vowels

a.	bɑɑrii	'embrace'
b.	busɑɑ	'yam slices'
c.	dɑɑmu	'controversy'
d.	kinɑ	'refuse'
e.	gi-diilɑɑ	(type of grass)
f.	pulɑ	'bury'
g.	tiyɑŋkoŋ	'hornbill'
h.	kɑɑke	(type of dance)

Because the vowel /ɑ/ can co-occur with both [+ATR] and [-ATR] vowels in Nawuri, it can be described as neutral. Some linguists have represented this type of neutrality (which is extremely common in nine-vowel languages) by listing /ɑ/ as a member of both harmony sets:

(41)

+ATR vowels:		-ATR vowels:	
i	u	ɪ	ʊ
e	o	ɛ	ɔ
ɑ		ɑ	

Do not represent neutral vowels as belonging equally to both harmony sets.

This kind of representation, though justified to a point, is unfortunately misleading (and is best avoided in a description) in that it tends to obscure the fact that /ɑ/ does not function as a genuinely [+ATR] vowel in the language; it is still clearly a [-ATR] vowel in a number of crucial respects:

- It is phonetically [-ATR]; for example, it has the voice quality characteristic of other [-ATR] vowels.
- Roots containing only /ɑ/ take [-ATR] rather than [+ATR] forms of harmonizing affixes. This is true not only in Nawuri, as shown in the examples in (42), but in every known nine-vowel language with ATR harmony.

(42) a. ɔ-tɛ ‘he/she sat’
b. o-kpe ‘he/she went’

c. ɔ-bɑ (*o-bɑ) ‘he/she came’

Neutral vowels subdivide into two types: *opaque* and *transparent* (Hulst & Smith 1986, Polgárdi 1998). Both types are attested in ATR harmony systems.

Opaque neutral vowel behavior in a nine-vowel system can be illustrated once again with the vowel /ɑ/ in Nawuri. When this vowel intervenes between a [+ATR] vowel and a harmonizing affix, it can block the spread of [+ATR] from the [+ATR] vowel onto the affix, i.e. it will prevent harmonization of the affix with the [+ATR] vowel:

(43) a. o-dɔɔ-pʊ 'farmer'
b. o-suŋ-pu 'messenger'

c. o-kulɑɑ-pʊ 'widow' (*o-kulɑɑ-pu)

The examples in (43) contain an agentive suffix /-pʊ/ ~ /-pu/ which harmonizes for [ATR] with roots containing only non-low vowels, as in (43a,b). In (43c), the presence of the low vowel /ɑɑ/ prevents the agentive suffix from surfacing as [pu] in agreement with the [+ATR] root vowel /u/. Rather, the suffix surfaces as [pʊ], in agreement with the [-ATR] value of /ɑɑ/. Intuitively, we might speak of the low vowel as somehow “blocking” the normal [ATR] agreement between root and suffix.

This description in terms of a blocking effect becomes especially appropriate if normal harmonization of affixes is viewed, as it has been within many phonological theories, as a process in which the [+ATR] value of the root vowel(s) “spreads” onto the affix, causing the latter to surface in its [+ATR] form. Using the graphic devices of autosegmental phonology, normal harmonization via spreading might be represented as in (44).

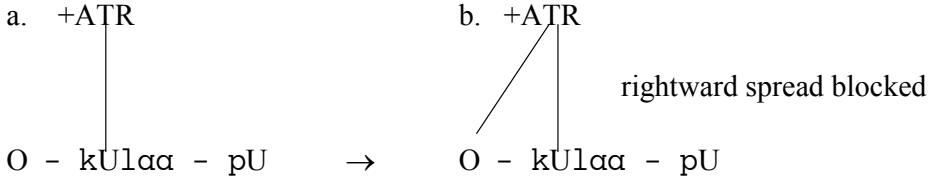
(44) a. +ATR b. +ATR

O - sUŋ - pU → O - sUŋ - pU

Here the [+ATR] root /suŋ/ is underlyingly associated with a [+ATR] autosegment in (44a). This [+ATR] autosegment spreads (either by rule or by automatic convention, depending on the particular version of autosegmental phonology being used), in (44b), both leftward onto the prefix and rightward onto the suffix. (Recall that spreading is commonly indicated in work on autosegmental phonology by means of a dotted line.)

Adopting this perspective, we would then say that the failure of [+ATR] to spread from the root vowel /u/ in an example like (43c) is due to the fact that the [-ATR] vowel /ɑ/ intervenes between this [+ATR] vowel and the affix, and that [+ATR] is unable to spread onto or over this vowel.

(45) a. +ATR b. +ATR



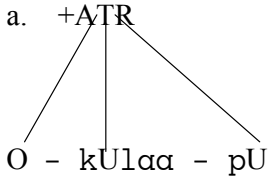
The inability of [+ATR] to spread onto the vowel has most often been attributed to a constraint against low [+ATR] vowels:

(46) *[+low,+ATR]

Such a constraint is well-motivated in Nawuri (though not in all languages!), since the language does not in fact have low [+ATR] vowels in its underlying inventory.

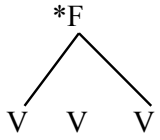
It must still be explained however why it is that rightward spreading of [+ATR] is unable to simply skip right over the vowel /ɑɑ/ onto the suffix, as in (47):

(47) a. +ATR



This is generally assumed to violate a constraint (cf. Hulst & Smith 1986, Archangeli & Pulleyblank 1994, Polgárdi 1998) that prohibits "gapped" representations in which an autosegment is linked to two vowels without being linked to a vowel (in the case of (47), the vowel /ɑɑ/) that comes between them:[20]

(48) No Gap constraint



(F = autosegment, V = vowel)

In most nine-vowel languages in which /ɑ/ can co-occur with [+ATR] vowels, it behaves opaquely, as in the Nawuri example (43c).[21] This is not the only possible behavior a neutral vowel can exhibit. Suppose that the agentive suffix in (43c) had surfaced as [pu] rather than [pʊ] (either in Nawuri or some other, hypothetical, language):

(49) o-kulɑɑ-pu

In this case, it would have appeared that the [+ATR] value of the root vowel /u/ had spread right through the low vowel /ɑ/ onto the suffix. That is, the harmonizing suffix in this case agrees with the [+ATR] value of the first vowel of the root, just as though the vowel /ɑ/ were not even present. In such a situation, we would still describe /ɑ/ as

[20] Most recent theoretical treatments of vowel harmony have taken this constraint to be universally inviolable, a position which faces an apparent difficulty with cases we shall see below in which /ɑ/ appears to behave transparently rather than opaquely.

[21] Although the vowel /ɑ/ is normally opaque in Nawuri, as seen above, there are also some circumstances in which it appears to behave transparently in this language (Casali 1999).

a neutral vowel, but rather than being a neutral vowel that is opaque, we would refer to it as *transparent*.

Transparent behavior of /ɑ/ in nine-vowel ATR harmony systems is quite rare. Perhaps the best attested case is Budu, a Bantu language of East Africa described in Kutsch Lojenga (1994b). The transparency of /ɑ/ in Budu is illustrated in examples like the following (where /mʊ-/ ~ /mu-/ is a noun class prefix):

(50)	a.	mʊ-nɔnɔ	'descendant'
	b.	mʊ-gyɛndɔ	'village'
	c.	mʊ-kɑnɪ	'stone'
	d.	mu-kpekpe	'seed'
	e.	mu-nenu	'daughter-in-law'
	f.	mu-sinɑ	(type of wild animal)
	g.	mu-tɑnji	(type of tree)
	h.	mu-yɑyo	'nursemaid'

The crucial examples are those in (50g,h), which show the prefix assimilating to a [+ATR] vowel in the second syllable of the root, even though the first syllable contains the low [-ATR] vowel /ɑ/. (Example (50c), as well as many other examples in the language, make it clear that /ɑ/ is not simply functioning as a [+ATR] vowel.)

Limited transparency of /ɑ/ to [+ATR] spreading is also reported in Kinande (Mutaka 1995, Hyman 1989), a Bantu language with a higher (ɪʊ) four-height system, and Ngiti (Kutsch Lojenga 1994c), a Central Sudanic language with a nine-vowel five-height system.

The extent to which transparency of /ɑ/ to [+ATR] spreading occurs in languages is an important an interesting question in view of the fact that a number of recent theories (e.g. Polgárdi 1998) predict that such behavior should not occur. Such theories generally claim that apparent cases of transparency are only superficial, and that what really happens in such cases is that the vowel /ɑ/ actually undergoes [+ATR] spreading, i.e. it becomes [+ATR] and transmits this [+ATR] value in turn to an adjacent affix.

Nine-vowel systems

Whereas much that is of descriptive interest in ten-vowel systems concerns the tenth vowel /ə/, it is the behavior of the low vowel /ɑ/ that needs to be thoroughly investigated in nine-vowel systems, in view of the interesting typological variation it exhibits. There is a connection here; it is precisely the absence of /ə/ in a nine-vowel system which gives the vowel /ɑ/ a unique status, in that it is the only vowel in the nine-vowel system to lack its own harmonic counterpart (which should have been /ə/).

In addressing the status of /ɑ/ in a nine-vowel language, the first question to ask is whether this vowel is neutral, i.e. can it co-occur in words with [+ATR] as well as [-ATR] vowels. (While it is logically possible to have a nine-vowel language in which /ɑ/ occurs *only in words with [+ATR] vowels*, there are no known examples, and such a situation would be highly unexpected in terms of phonological naturalness.) If the

answer is yes, then the next question to ask is whether /ɑ/ is opaque (the most common case) or transparent. (The answer to this question should be clearly presented in a description.)

Although nine-vowel languages do not have a phonemic [+ATR] low vowel, the vowel /ɑ/ sometimes has a [+ATR] allophone that occurs in words with [+ATR] vowels. This is the case for example in Anum, as discussed in (90) above. Other nine-vowel language in which /ɑ/ has a [+ATR] allophone include Ahanta (Kwa; Ntumy 1997a,b), Akan (Kwa; Clements 1981, Dolphyne 1988), Nawuri (Kwa; Casali 1995b, 1999), and Waja (Adamawa; Kleinewillinghöfer 1990). In some of these languages, the [+ATR] allophone of /ɑ/ if found only to the left or only to the right of [+ATR] vowels, i.e. linear order is important.

Although the vowel /ɑ/ is frequently neutral in nine-vowel languages, this is by no means always the case. In some languages, /ɑ/ is entirely excluded from co-occurring with [+ATR] vowels. This generally means that:

- [+ATR] words never contain low vowels.
- If a harmonizing affix has the vowel /ɑ/ with [-ATR] roots, it will show up with some non-low [+ATR] vowel (generally /e/ or /o/) when it occurs with [+ATR] roots.

In Kɔnni (Gur, Ghana; Cahill 1992), for example, suffixes that surface with /ɑ/ following [-ATR] roots appear with /e/ when they follow [+ATR] roots:

(51)	a. ʊ-sɪɪ-jɑ	'he has bathed'
	b. ʊ-jɪ-jɑ	'he has given'
	c. ʊ-tʊn-jɑ	'he has worked'
	d. u-sii-je	'he has danced'
	e. u-je-je	'he has seen'
	f. u-tuu-je	'he has dug'

It would seem that /e/ is the vowel most commonly co-opted to serve as the [+ATR] counterpart of /ɑ/ in nine-vowel languages in West African. Other West African languages of this sort include Avatime (Kwa; Maddieson 1995),[22] Ebira (Benue-Congo; Adive 1984), Ega (Kwa; Bole-Richard 1981), Okpe (Benue-Congo; Hoffman 1973, Omamor 1973, 1988), and possibly Lokpa (Gur; Akawe 1999) and Sisaala-Pasale (Gur; Toupin 1995).

In some East African languages with nine vowels, on the other hand, the regular counterpart of /ɑ/ is usually /o/. This is illustrated below with examples (taken from Polgárdi 1998; original source is Tucker & Mpaayei 1955) from Massai (Eastern Nilotic) involving a suffix /tɑ/ ~ /to/:

[22] Although /e/ generally functions as the harmonic counterpart of /ɑ/ in Avatime, there is at least one prefix, a future marker /tɑ/, that fails to harmonize with a following [+ATR] root, surfacing invariantly as [tɑ].

(52) a. ɑɑ-rɪk-ɪ-tɑ-ɪ ‘I am being nauseated’
b. ɑ-tɛ-pɛ-tɑ ‘I kept close to it’
c. ɑɑ-ipot-i-to-i ‘I am being called’
d. ɑɑ-tɑ-pe-to ‘I smeared it’

Other East African languages in which /o/ functions as the harmonic counterpart of /ɑ/ include the Eastern Nilotic language Turkana (Dimmendaal 1983) and the Bantu languages Bila (Kutsch Lojenga 1994a) and Budu (Kutsch Lojenga 1994b, Koehler 1995). In some other East African languages, for example Alur (Western Nilotic; Kutsch Lojenga 1986), the [+ATR] counterpart of /ɑ/ is /e/, as in the West African languages cited above.

If some non-central vowel /e/ or /o/ functions as the harmonic counterpart of /ɑ/ in a language, either in general or in particular contexts or morphemes, this should be carefully described.

An interesting question to ask at this point is whether, in nine-vowel ATR harmony languages in which /ɑ/ is prohibited from co-occurring with [+ATR] vowels (i.e. is not neutral), it is always the case that some other vowel such as /e/ or /o/ will function as the [+ATR] counterpart of this vowel. At first glance, it might seem that this is almost a logical necessity. Assuming, as is usually the case, that such a language has affixes that take /ɑ/ when attached to [-ATR] roots, the requirements of vowel harmony will presumably dictate that these affixes must surface with some other, [+ATR], vowel when attached to [+ATR] roots. (If they surfaced with [ɑ] in such cases, then we would be talking about a different type of language altogether, i.e. one in which /ɑ/ is neutral. While such languages exist, they are not the kind we are interested in at the moment.) Logically, there are however at least two possible exceptions to consider. First, it could be the case that such a language lacks affixes with /ɑ/ altogether, or that such affixes happen never to occur with [+ATR] roots. (We might imagine, for example, that the only affix with /ɑ/ in a language is a certain noun class prefix, and that none of the noun roots which happen to take that prefix have [+ATR] vowels.) Although this is a logical possibility, I know of no real examples.

The second possibility, which *is* attested, would be a case in which attaching an affix with /ɑ/ to an underlying [+ATR] root caused the root, rather than affix to change, becoming [+ATR] so as to maintain vowel harmony without changing the /ɑ/ into some [+ATR] vowel. This would appear to be, in essence, a case of dominant [-ATR] harmony. Exactly this situation is attested in two Gur languages of Burkina Faso, Pugili (Kevin Warfel, personal communication) and (apparently) Ninkare (Gur; Connie Kutsch Lojenga, personal communication). In Puguli, there is a singular noun class suffix which surfaces as [e] following [+ATR] roots and as [ɛ] following [-ATR] roots, as shown in the examples in (53) ([+ATR] roots) and (54) ([-ATR] roots).

(53) a. dol-e ‘beam’
b. kom-e ‘field’
c. som-e (type of fruit)
(54) a. khʊl-ɛ ‘mound’
b. dɪl-ɛ ‘ear’
c. zɪl-ɛ ‘ladder’

There is nothing particularly unusual about this kind of behavior, which is just the familiar phenomenon of root-control found in a great many nine-vowel West African languages. Nor is there even anything irregular about the relationship between the [+ATR] and [-ATR] forms; it is entirely normal for [ɛ] and [e] to be paired as harmonic counterparts in nine-vowel systems.

What is unusual about these nouns however about some of these nouns is the way they form their plurals. Nouns in the class which takes the /e/ ~ /ɛ/ suffix in the singular generally form their plurals by means of a suffix /ɑ/. When this suffix is added to the [-ATR] roots in (54), nothing surprising happens; both root and suffix surface unchanged in their [-ATR] forms, as might be expected:

(55)	a. khʊl-ɑ	'mounds'
	b. dɪl-ɑ	'ears'
	c. zɪl-ɑ	'ladders'

Things become interesting however when the same plural suffix /ɑ/ is added to the [+ATR] roots in (53). In this case, it is evident that something must change, given the very strong prohibition in Puguli against co-occurrence of /ɑ/ with [+ATR] vowels.[23] What is most interesting about Puguli is that, in contrast to the very common situation in which the vowel /ɑ/ is replaced by a [+ATR] vowel phoneme /e/ or /o/, Puguli resolves the situation by keeping /ɑ/ unchanged and changing the root vowel to its [-ATR] counterpart:

(56)	a. dɔl-ɑ	'beams'
	b. kɔm-ɑ	'fields'
	c. sɔm-ɑ	(type of fruit--pl.)

This seemingly extreme solution can be viewed as arising from the strong prohibition in Puguli against co-occurrence of /ɑ/ with [+ATR] vowels together with an equally strong reluctance for /ɑ/ to alternate harmonically with some other vowel.[24]

Finally, rare cases have also been reported of a rather bizarre kind of behavior in which a phonetically [-ATR] vowel /ɛ/ or /ɔ/ functions phonologically as the [+ATR] counterpart of /ɑ/. This is said to be the case for example in the Nigerian language Okpe (Pulleyblank 1986), in which /ɛ/ behaves as the [+ATR] counterpart of /ɑ/, and in the Nilotic languages Koony (Larsen 1984, Kutsch Lojenga 1986), Sabaot (Kutsch Lojenga 1986) and Toposa (Schröder & Schröder 1987), which show /ɔ/ functioning as the [+ATR] counterpart of /ɑ/. (Note that here again there seems to be a general

[23] This prohibition is nearly, but not completely exceptionless. There is one morpheme with /ɑ/ that can co-occur with [+ATR] vowels in the language.

[24] This kind of view of processes as arising from competing prohibitions or pressures within a language is readily expressed within the framework of optimality theory (Cahill 1999, Archangeli & Langendoen 1997.)

tendency for /ɑ/ to alternate with a front vowel in West African languages and with a back vowel in East African languages.)[25]

The discussion so far implies the following typology of the ways in which /ɑ/ may interact with [+ATR] vowels in nine-vowel systems:

(57) Does /ɑ/ co-occur with [+ATR] vowels?
- Yes (/ɑ/ neutral):
  - Is /ɑ/ transparent, or opaque?
    - Transparent (e.g. Budu)
    - Opaque (e.g. Akan)
- No (/ɑ/ not neutral):
  - Does some other vowel fill in as the [+ATR] counterpart of /ɑ/??
    - No (e.g. Puguli)
    - Yes
      - What other vowel phoneme fills in as the [+ATR] counterpart of /ɑ/?
        - /ɐ/ (e.g. Kɔnni)
        - /o/ (e.g. Massai)

The most common types in West African languages appear to be the Akan and Kɔnni types.

In reality, however, the variation found among real languages is more complex than this simple typology would imply. The main reason for this is that it is common for languages to exhibit different behaviors in different positions.

Examples:

- In Nawuri /ɑ/ behaves opaquely in root-final syllables, but is superficially transparent in root-initial syllables. (Nawuri exhibits a further complication that short /ɑ/ behaves quite differently from long /ɑɑ/--see Casali (1995b).)
- In Ega (Kwa; Bole-Richard 1981), /ɑ/ alternates with /ɐ/ in suffixes (i.e. a suffix will contain [ɑ] following [-ATR] roots but [ɐ] following [+ATR] roots), while prefixes containing /ɑ/ will occur with both [+ATR] and [-ATR] roots.
- In Massai, /ɑ/ alternates harmonically with /o/ in suffixes (and thus presumably does not follow [+ATR] roots), whereas in prefixes /ɑ/ co-occurs with both [-ATR] and [+ATR] roots (cf. (52c) above). Moreover, /ɑ/'s which occur in roots are opaque to leftward spread of [+ATR] from a dominant suffix.
- In Budu, /ɑ/ is neutral and transparent in roots but alternates harmonically with /o/ (and hence is non-neutral) in suffixes.

[25] In light of the fact that the [+ATR] vowel /ə/ in ten-vowel systems is sometimes auditorily quite close to either /ɛ/ (as in Kasem) or /ɔ/ (as in Nandi; Tucker 1964), what alternative interpretation of such patterns might need to be checked out in some cases?

- In Waja (Adamawa, Nigeria; Kleinewillinghöfer 1990), /ɑ/ alternates harmonically with /o/ in suffixes as in Massai and Budu. In prefixes, /ɑ/ occurs with both [+ATR] and [-ATR] roots, as in Ega and Massai. However, unlike these two languages, prefixal /ɑ/'s which occur with [+ATR] roots surface phonetically as a vowel which Kleinewillinghöfer transcribes as [ʌ]. (This vowel is not an independent phoneme in Waja, but a predictable allophonic realization of /ɑ/ when it precedes a [+ATR] vowel.)

[ATR] activity:

As in ten-vowel systems, [+ATR] rather than [-ATR] is likely to behave as the active or dominant value, e.g. undergoes spreading across word and/or morpheme boundaries, in nine-vowel languages. Where coalescence occurs, [+ATR] is expected to be preserved in sequences involving a [+ATR] and [-ATR] vowel, e.g. a sequence like /ɑ+i/ is more likely to coalesce to a [+ATR] mid vowel [e] than to a [-ATR] mid vowel [ɛ]. (See section 13.)

Lower (eo) seven-vowel languages

The lower (eo) seven-vowel system differs from the nine-vowel system discussed in the preceding section in that it lacks the high [-ATR] vowels /ɪ/ and /ʊ/. If we were to simply divide the remaining seven vowels into two groups based on their phonetic qualities, we might expect this system to manifest the following harmony sets shown:

(58) +ATR vowels: -ATR vowels:

i	u		
e	o	ɛ	ɔ
		ɑ	

In this system, the feature [ATR] is contrastive only for the mid vowels. High vowels are redundantly [+ATR] (that is, there are no [-ATR] high vowels), and the low vowel /ɑ/ is redundantly [-ATR] (that is, there are no [+ATR] low vowels).

Since [ATR] is contrastive only for mid vowels, it is only the mid vowels which have a harmonic counterpart; /ɛ/ and /e/ are harmonic counterparts of each other, as are /ɔ/ and /o/.

Since it is only the mid vowels which have harmonic counterparts, we would expect that if a language with this system has ATR harmony at all, it will involve the mid vowels. For this reason, an important thing to establish early on in investigating a language with a lower (eo) seven-vowel system is whether or not the [+ATR] mid vowels /e/ and /o/ can freely co-occur with the [-ATR] mid vowels /ɛ/ and /ɔ/.

Possibilities:

- [-ATR] /ɛ/, /ɔ/ and [+ATR] /e/, /o/ are always mutually exclusive within the word.
- The two sets of mid vowels can co-occur in some contexts but not others. (Example: [-ATR] mid vowels may occur to the right of [+ATR] mid vowels but not to their left.)

- The two sets of mid vowels can freely co-occur with no restrictions.

Clear and well-documented instances of the third scenario in African languages are somewhat hard to come by.

The extent to which the high vowels /i/ and /u/ and the low vowel /ɑ/ participate in ATR harmony is expected to vary from language to language, just as the way in which /ɑ/ acts harmonically varies considerably in nine-vowel languages. However, in this case there are more possibilities to consider, because the high vowels /i/ and /u/ and the low vowel /ɑ/ might behave differently from each other.

Assuming we are dealing with a language which does have ATR harmony with the mid vowels, one would expect that the following questions would need to be addressed:

- Can the high vowels /i/ and /u/ co-occur with the low vowel /ɑ/?
- Can the high vowels /i/ and /u/ co-occur with the mid [-ATR] vowels /ɛ/ and /ɔ/?
- Can the low vowel /ɑ/ co-occur with the mid [+ATR] vowels /e/ and /o/?

We might further expect that in any case where vowels of opposite [ATR] value can co-occur (e.g. co-occurrence of /i/& /u/ with /ɑ/ and/or /ɛ/ & /ɔ/, co-occurrence of /ɑ/ with /e/ and /o/), the co-occurrence (neutrality) might involve either transparency or opacity. It would seem, therefore, that the overall number of possible patterns could be quite large.

Not enough is known at this point to give a detailed discussion of the extent to which the various logically expected patterns are actually attested. There seems to have been very little empirical cross-linguistic study so far of the typological behavior of vowel neutrality in seven-vowel systems. The only significant exception I am aware of is Leitch (1996), a typological study of [ATR] vowel harmony in Bantu C.[26] A few general observations can however be made.

- It appears that the high vowels /i/ and /u/ are usually neutral, and can co-occur with all other vowels. (Partial exception: In some Bantu C languages, discussed in Leitch (1996), the high vowels may not precede the mid [-ATR] vowels within the same word, though they may follow them.)
- The high vowels /i/ and /u/ are often opaque to spreading of [-ATR]. This is the case for example in Standard Yoruba (Ola Orie 2001, Polgárdi 1998) and (generally) in Bantu C (Leitch 1996). However, /i/ and /u/ are transparent to spreading of [-ATR] in the Ife dialect of Yoruba (Ola Orie 2001) and behave transparently under some conditions in Ntomba, a Bantu C language discussed by Leitch.
- The low vowel /ɑ/ may be either opaque or transparent. Leitch (1996) gives examples of both types of behavior in Bantu C. /ɑ/ is opaque in Yoruba.

[26] Because it is a one-of-a-kind study, Leitch's work may be of interest to those working on seven-vowel languages in other families. Other typologically oriented work dealing with neutral vowels in seven-vowel languages includes Archangeli & Pulleybank (1994) and Polgárdi (1998). (Note however that these works are theoretical in focus and deal with only a few languages.)

- I know of no languages in which the vowel /ɑ/ is prohibited altogether from co-occurring with the mid [+ATR] vowels /e/ and /o/.
- Surprisingly, /ɑ/ *is* prohibited from co-occurring with the [-ATR] vowels /ɛ/ and /ɔ/ in many Bantu C languages! Although this would appear to be a type of *dis*harmony it might, perhaps, also be analyzed as due to a frontness and roundness harmony, such as is found in a number of other seven-vowel languages--see below. (See Leitch (1996) however for a different explanation.)

In contrast to five-height languages, languages with the lower (eo) seven-vowel system typically have [-ATR] as the dominant [ATR] value. Coalescence patterns involving preferential preservation of [-ATR] (see section 13), e.g. /ɑ+e/ > [ɛ], /ɑ+i/ > [ɛ], /ɑ+o/ > [ɔ], /ɑ+u/ > [ɔ], /ɔ+e/ > [ɛ], /ɛ+o/ > [ɔ], etc., are common in such languages (though apparently unattested in five-height languages).

A few languages with lower (eo) seven-vowel systems have a process in which /i/ and /u/ are realized allophonically as [ɪ] and [ʊ] in the vicinity of underlying [-ATR] vowels. Since the auditory differences between [i] and [ɪ] and between [u] and [ʊ] are typically not as striking as between [e] and [ɛ] and between [o] and [ɔ], this is the kind of process that might easily be overlooked in a descriptive study. Hence, it is possible that this process occurs more commonly than it would presently appear based on existing sources. It is something that should be watched out for in any case: do the high vowels have an invariantly [+ATR] quality to them, or do they sometimes sound more lax, closer to [ɪ] and [ʊ]?

For reasons that are not entirely clear, it seems to be very common (more so than in other types of systems) for the lower (eo) type of seven-vowel system to have fronting and/or rounding processes in which /ɑ/ becomes [ɛ] in the vicinity of a front vowel(s) and/or /ɑ/ becomes [ɔ] in the vicinity of a round vowel(s).

An open and interesting question concerns the extent to which the articulatory basis of the [ATR] contrast in lower (eo) four-height systems is the same as in (some? many? most? all?) five-height languages, i.e. tongue root advancement / retraction. (Some theories appear to assume that the contrasts in four-height systems are generally based on tongue height.) While this is not the kind of question that can, at present, be definitively answered without recourse to instrumental articulatory studies (e.g. MRI), it would at least be a step in the right direction to discuss your subjective impressions of how the contrast is made, based on your own attempts at imitations, reports of native speakers, and any voice quality differences accompanying the two harmony sets, as well as any evidence from visual or tactile clues (cf. section 6 above).

Higher (ɪʊ) seven-vowel languages

It seems to be quite common for languages with the seven-vowel system /iɪɛɑɔʊu/ (or comparable systems with an additional central vowel) to have an allophonic process in which [e] and [o] are derived from [ɛ] and [ɔ] in the vicinity of the underlying [+ATR] vowels /i/ and /u/. This occurs for example in Burun (Western Nilotic; Andersen 1993), Lese-Mvuba (Central Sudanic; Connie Kutsch Lojenga, personal communication), LuBwisi (Bantu; Waller & Mary Tabb, personal communication), Lugbara (Central Sudanic; Andersen 1986), Mayogo (Ubangi; McCord 1989), Teda-

Daza (Saharan; Connie Kutsch Lojenga, personal communication), and Zande (Ubangi; Boyd 1997).

Some higher (ɪʊ) seven-vowel languages (e.g. LuBwisi; Waller Tabb, Connie Kutsch Lojenga, personal communication) have other instances of [-ATR] vowels assimilating to [+ATR] vowels as well. In general, to the extent that evidence is available, [+ATR], rather than [-ATR], is likely to behave as the dominant [ATR] value. (See section 13 below.)

Phonetics:

It seems to be quite common in languages with the higher (ɪʊ) type of seven-vowel system for the height 2 vowels /ɪ/ and /ʊ/ to be auditorily quite close to the height 1 vowels /i/ and /u/. To the extent that this is the case, it is worth noting. In some languages, the two heights are close enough together that researchers have reported some difficulty in reliably distinguishing them.

As discussed above for the lower (eo) four-height system, any observations that can be made in a description about the articulatory basis of the [ATR] contrasts (and/or about the quality of [+ATR] allophones [e] and [o], if these exist) are potentially helpful.

8. Postlexical [ATR] spreading

In some languages, [+ATR] can spread across word boundaries (this is known as "postlexical" spreading) under certain circumstances, causing underlying [-ATR] vowels to become [+ATR]. Languages with this type of spreading include Akan (Clements 1981), Nawuri (Casali 1995b), and Chumburung (Snider 1985), all of which are Kwa languages of Ghana. Some examples from Nawuri are shown below.

(59)

a.	/ɔsɪ wijɑ/ 'father owner'	→ [osuwijɑ]	'person whose father is living'
b.	/ɪsɪ bʊ obu-to/ sand be room-in	→ [isiboobuto]	'sand is in the room'
c.	/ɛ-kɔɔlɪ ɑ-fulee/ he_PROG-receive money	→ [ekoolɑɑfulee]	'he is collecting money'

In Nawuri and Akan, and probably other languages which have [+ATR] spreading across word boundaries as well, the number of syllables affected by spreading can be quite variable, depending on speech rate and style. In casual speech, however, [+ATR] can affect several underlying [-ATR] syllables to the left of an underlying [+ATR] syllable, as in the Nawuri examples in above.

[+ATR] spreading in Akan and Nawuri is also *gradient*, both in the sense that the assimilation process frequently gives rise to vowels which are somewhat intermediate in quality between that of an underlying [-ATR] vowel and its [+ATR] counterpart, and in the sense that vowels which are further to the left of the underlying [+ATR] syllable (often referred to as the "trigger") from which spreading occurs are likely to assimilate

less fully. That is, there is a tendency for the assimilation process to "die out with distance."[27]

The examples in (59) above all involve *leftward* spreading of [+ATR]. Leftward spreading of [+ATR] across word boundaries does seem to be much more common than rightward spreading. Other languages with leftward [+ATR] spreading across word boundaries include Anum (Kwa; Obeng 1995), Deg (Gur; Crouch & Herbert 1997), Ebira (Nupoid; Scholz 1976), Kinande (Bantu; Mutaka 1995), and Vata (Kru; Kaye 1982, Kiparsky 1985). Cases of rightward spreading across word boundaries are also reported however, in Chumburung (Kwa; Snider 1985), Nawuri (Kwa; Casali 1995b), and Ebira (Nupoid; Scholz 1976). (Note that each of these languages also has leftward [+ATR] spreading across word boundaries as well.)

Spreading of [-ATR] across word boundaries appears to be less common. One language in which this does occur however is Mbosi Oléé (Leitch 1996, citing Fontaney 1989).

An obvious way of testing to see whether [+ATR] or [-ATR] spreading across word boundaries occurs in a language is to construct phrases in which [+ATR] and [-ATR] words occur in sequence (examples of both [-ATR] [+ATR] and [+ATR] [-ATR] orders should be used), ask native speakers to pronounce them, and note whether any [ATR] changes occur relative to the ways in which the words are pronounced in isolation. This should be tried with several speakers.

While this procedure might yield some useful results, it is not necessarily without drawbacks. An alternative approach that may yield better results is to listen carefully to naturally recorded text; in a language in which [ATR] spreading does take place across word boundaries, you will almost certainly begin to notice cases where one or more vowels in a word surface with the opposite [ATR] value of what they normally take, under the influence of a neighboring word whose vowel have this opposite value. I found in my work with Nawuri that significant [+ATR] spreading, often covering several syllables, was much easier to observe in natural, casual speech than in the artificial case in which native speakers were asked to pronounce artificially constructed phrases in which such spreading might be expected to occur. (Contrary to what one might have expected, asking people to pronounce the artificial phrases more quickly did not generally result in more significant spreading. My assumption is that *rate* of speech was a much less significant factor than *casualness*, meaning, roughly, a frame of mind in which a speaker is not attending carefully to their own speech in an effort to carefully control their pronunciation. Asking people who are keenly aware that you are listening closely to their pronunciation to pronounce constructed phrases is hardly likely to give rise to casual speech in this sense!)

[27] In practice, it is very difficult to be sure that one is hearing an intermediate degree of a feature such as [ATR], which can often be difficult to adequately identify even when it is fully present. If however you find you are having difficulty assigning a particular vowel in an utterance to one of two vowel qualities (e.g. [ɔ] and [o]) which you can usually tell apart quite reliably, this should cause you to wonder whether the vowel in question (assuming it occurs in an environment where [+ATR] spreading might be expected) is actually of intermediate quality.

9. [ATR] as a "floating" grammatical morpheme

A few languages have been reported in which a morphological change may be signaled purely by a change in the [ATR] categories of the vowels in a word. This is illustrated in the Päri (Western Nilotic) examples in (60), from Andersen (1989).[28]

(60)

verb root		centripital stem	
a. lɪm	'collect'	lim	'collect in this direction'
b. jab	'open'	jəb	'open in this direction'
c. ŋɔd	'cut'	ŋud	'cut in this direction'

Here the only difference between the forms in (60a,b) is that the former contain [-ATR] vowels, whereas the latter contain the [+ATR] counterparts of the same vowels. (60c) involves an additional change in that the vowel /ɔ/ in the simple verb root becomes not only [+ATR] but [+high] in the centripetal. Andersen explains this additional complexity by suggesting that the vowel /ɔ/ in this root (and others like it) was originally */ʊ/ (which would normally be the vowel we would expect to alternate harmonically with the [+ATR] vowel /u/.

In autosegmental terms, the centripetal morpheme in Päri might be analyzed (cf. Roberts 1994) as consisting simply of a [+ATR] autosegment morpheme. This analysis is reminiscent of the common autosegmental treatment of grammatical tone as involving morphemes that consist entirely of a floating tone(s) lacking any segmental content.

Other possible cases of floating [+ATR] morphemes are found in Anywak (Western Nilotic; Reh 1996), Gouro (Le Saout 1979), Kalenjin (Southern Nilotic; Rottland 1980) Kanembu (Western Saharan; Roberts 1994), Tem(?) (Gur; Tchagbale 1976), and Toposa (Schröeder & Schröeder 1987).

10. Analyzing and describing ATR harmony: some practical suggestions

Looking at the relatively neat and systematic behavior displayed by many ATR vowel systems on paper, it would be easy to conclude that such striking patterns would be difficult to miss in doing field work on such a language. In fact, however, the presence of ATR harmony has been missed in a large number of African languages. Among other things, a considerable number of five-height, nine- or ten-vowel ATR harmony systems have been incorrectly analyzed as four-height lower (eo) seven-vowel systems. In nearly all cases, the underlying source of the problems would seem to lie in incorrect phonetic transcriptions. These in turn can be largely attributed to the auditory similarity of certain pairs of vowels in these languages. It is clear that however straightforward such systems may look on paper, they often present considerable difficulties in practice.

In this section I make some practical suggestions for doing field work in a language in which ATR harmony is a likely possibility. A number of these suggestions, to be sure,

[28] Some phonetic symbols have been changed in the examples in (60) to agree with those used elsewhere in this paper.

involve steps that ideally ought to be carried out in any case. In the case of ATR harmony languages, however, it would seem particularly important to ensure that they are carefully followed.

The suggestions in this section are divided into three types: suggestions for advance preparation, methodological suggestions, and possible clues to the presence and or typology of ATR harmony which should be watched for.

Advance preparation

Reading

It ought to go without saying that before beginning linguistic field work in a language, it is important to become familiar with any previous linguistic studies that have been done on the same or closely related languages, as well as the general typological characteristics of the language family to which the language belongs. Often, however, this kind of review of the existing literature is not carried out to the degree it could be. While most people do at least consult readily-available material on the same language, a literature review often fails to take adequate account of material on closely-related languages, or to look closely at topical studies on particular features known to be present in a language family. Also, there is often material on a language which, while not easily accessible (unpublished theses and dissertations fall into this category) could be tracked down with some effort, perhaps with the aid of a research service like that provided to SIL members by Wycliffe Associates, U.K. Of course, before one can try to obtain such material, one must be aware of its existence. Once good place to start a literature search on a language is by looking in the references found in some work that is readily accessible on a language (or, where this is not available, on a related language). Then, every time another work on a language is found, the references cited in that work are examined for possible further material of interest, and so on. This will often lead to an expanding trail of references that may yield a number of useful items. Another useful place to begin such a trail is in an article or book on a particular language family or geographic regions, e.g. the Niger-Congo volume edited by John Bendor-Samuel (1989).

As far as preparation for dealing with vowel systems is concerned, there are several things that merit special attention when it comes to a literature review. Perhaps the most obvious is to carefully examine any existing descriptive material on the vowel system of the language itself. Beyond simply taking note of the vowel system which is claimed for the language, it is also important to make some assessment of the overall reliability of the description and especially of the credibility of the analysis of the vowel system. In forming such an opinion, one is of course initially at a disadvantage, since there is no way to tell with any degree of certainty whether a particular transcription of an utterance is accurate.

Nevertheless, there are a number of things that can be looked for. First, and perhaps most obviously, one should take note of any gross inconsistencies in the data or text, as for example when a number of words are transcribed differently in different places (in the same context, so that the differences could not be due to changes brought about by the phonetic environment). One should equally be suspicious of proposed generalizations which do not agree with the data, for example a case where a particular sound is claimed not to occur in a particular environment, despite the fact the data contains examples of the sound in that context.

Beyond gross inconsistencies of this sort, one should also look at whether or not the vowel system proposed in a description is of a type that is known to be well-attested in the particular language family. (This presumes that one has become familiar with the characteristic vowel systems found in the language family, and this of course is another type of initial research that is essential before beginning field work on a language, yet one which has unfortunately sometimes been neglected.) Usually, this kind of information is well-known and not difficult to come by, and your expectations should be shaped accordingly. A few examples:

- In Bantu C languages, few if any languages have so far been found to have anything other than a standard three-height system (Leitch 1996).
- Most Tano (Kwa) languages have nine-vowel systems.
- Most Nilotic languages have nine- or ten-vowel systems.

Of course, the vowel system in a language will not always be the same as those of its closest relatives. Although I have stated that most Tano languages have nine-vowel systems, for example, a few such languages, e.g. Anufɔ and Baule, have lower (eo) seven-vowel standard three-height systems. There are of course many other examples of this. The point here is not that one should form *rigid* a priori expectations. Nevertheless, it is equally ill-advised to proceed with no expectations whatsoever. Thus, in cases where a description of a language's vowel system conforms entirely to what has been found to occur in most of the other languages in a family, one is naturally justified in assuming that the description stands a good chance of being essentially correct. If, at the other extreme, the vowel system posited in a description departs quite radically from all vowel systems previously reported in a language family, one is entitled to be suspicious, especially if the description does not discuss the surprising departure from the patterns found in related languages in explicit detail. In such a situation, it is strongly advisable to actually check some of the relevant phonetic data in the description very early on, to make some first hand assessment of its reliability.

Phonetic practice

As noted above, most incorrect analyses of languages with ATR harmony systems have arisen as a result of faulty phonetic transcriptions. It is significant that problems of this type have most often occurred in languages (five-height languages or languages with higher (ɪʊ) systems) which have /ɪ/ and /ʊ/ as phonemes. These vowels tend in some five-height languages to sound very similar to /e/ and /o/ respectively, while in other languages they sound very similar to /i/ and /u/. (They often sound very similar to the latter in higher (ɪʊ) systems as well.) Not surprisingly, most errors of transcription have tended to involve confusion of these high [-ATR] vowels with neighboring vowels.

Because of this difficulty, it would be a good idea, if you are preparing to work in a language family in which /ɪ/ and /ʊ/ are known to occur (i.e. a language family with five-height or higher (ɪʊ) four-height systems), to spend some time beforehand familiarizing yourself with what these vowels sound like in other, preferably related languages. Even if you feel you are generally quite good at hearing and transcribing sounds phonetically, it is asking for trouble (or at least a certain amount of time wasted) to begin transcribing data without the benefit of some reference point based on previous experience listening to the relevant sounds.

There are various practical ways you might go about trying to gain such experience. If you have colleagues working in such languages, you might ask them to prepares some recordings you could listen to for this purpose. It would also not be a bad idea for an SIL / NBTO entity in whose language projects such sounds are likely to be encountered to prepare standard listening exercises based on languages that have been well-studied. Such listening exercises, which might be distributed as .wav files (perhaps embedded in a word processor document, as in the case of the Nawuri recordings in section 6 above), should ideally be constructed around several levels of difficulty, beginning with contrasts in contexts where they are most easily perceived (typically word-initially or word-finally) and only later progressing contexts where the contrasts are more difficult to hear (often word-medially, especially in closed syllables).

Methodological suggestions

Phonetics

- Aim for *consistency* in phonetic transcriptions.

Adopt a conservative transcription in cases where you are not sure about something. Where you are not sure that two sounds (e.g. two vowels in the same position in different words) are the same or different, transcribe them provisionally with the same symbol, but note your uncertainty. Eventually, you may find that there are some sounds which you know to be instances of a particular sound (let's say the vowel [ɪ] for concreteness), and others which you have doubts about. If you find this happening regularly, adopt one symbol (where possible, an appropriate IPA symbol, e.g. [ɪ] in the hypothetical case we are considering here) for the ones you are sure about, and some other symbol (e.g. an unused IPA symbol) for the ones you are not sure about.

- Get help from colleagues.

We seek help from colleagues in all kinds of practical areas: computer problems, car problems, schooling options, advice on where to spend holidays. And yet one area where I have hardly ever seen anyone seek help from colleagues is with phonetic transcription. I believe that to a regrettable extent our training has largely prepared us to believe that we have to "go it alone" in this area. There is nothing wrong with asking someone else to lend an ear!

- Spend time practicing and listening. Many people have found that it takes considerable time to learn to distinguish the vowels /ɪ/ and /ʊ/ from all other vowels. You may need to construct listening drills for this. Tools like WinCECIL or Speech Manager / Analyzer can be a big help here. If you wished to focus on the difference between /o/ and /ʊ/, for example, you could put examples of each sound in adjacent windows, and then play them back in different orders until you are confident you can hear the difference. If you cannot find real minimal pairs to use, it is also possible to use computer speech tools to construct artificial minimal pairs by editing out the parts that differ in near-minimal pairs. If for example your closest near-minimal pair for /o/ and /ʊ/ were a pair [ko], [gʊ] (let us assume that the tones are the same), you could remove the initial consonants from both words so that only the vowels remained. Or, if the best near-minimal pair opposed [ito] and [ɑtʊ], you could remove the initial vowels to contrast [to] and [tʊ] (again, it would be most helpful if the tones on these remaining syllables were the same).

Analytical procedures

- If you see a plausible phonological analysis that doesn't quite work, consider the possibility that your data may be wrong. Avoid a strictly linear, inductive approach to phonological analysis that takes your phonetic data as established fact and proceeds from there. Maintain a healthy distrust of your data and work both ends toward the middle.

A hypothetical example: Imagine you are working with a language that appears, based on the forms transcribed in your data, to have seven phonetic vowel qualities as in (7).

(61)
i	u
e	o
ɛ	ɔ
ɑ	

Suppose you find a prefix that generally harmonizes for [ATR] with the vowels of the root to which it is attached, surfacing as [o] with roots that contain [+ATR] vowels but as [ɔ] with roots that contain [-ATR] vowels, as in the following hypothetical examples:

(62)

With [+ATR] roots:	With [-ATR] roots:
a. o-bi	e. ɔ-bɛ
b. o-su	f. ɔ-lɔ
c. o-ke	g. ɔ-ta
d. o-fo	

Suppose you find however that there are a few roots containing [e], and others containing [o], that unexpectedly take the [ɔ] form of the prefix:

(63)
a. ɔ-te
b. ɔ-ke
c. ɔ-lo
d. ɔ-go

What possible problem with the phonetic data does this pattern suggest? How would you proceed to check it out?

- Make appropriate use of native speaker intuition.

Although it will generally not do to simply ask native speakers without linguistic training to list the sounds in their language, native speaker intuitions are generally very reliable as to whether two sounds are the same or different, in cases where the difference is a contrastive one. This means for example that in languages in which linguists have found it difficult to distinguish /ɪ/ and /i/, native speakers can often tell these vowels apart with little or no difficulty. (They may not necessarily write them differently, however, if they have not been previously exposed to an orthography that distinguishes them. For this reason, one has to be careful in phrasing questions about the sameness or difference of two sounds, for example by asking whether they are *exactly* the same, not whether they should be written the same. In some cases native speakers have described the difference between /ɪ/ and /i/ as one between an "i" which

is a little "heavier" or "stronger" and one which is a bit "weaker" or "lighter." In other cases, native speakers have talked in terms of a "true i" and a "false i.")

Once native speakers have become aware of a contrastive difference in their language to the point of having some appropriate terms and symbols for representing it, they will in many (though not all) cases be able to transcribe the relevant difference with close to 100% accuracy. For this reason, it is usually a good idea to invest significant effort early in a language project to helping native speakers become aware of the vowel sounds in their language. At the same time of course, you will want to be consulting native speakers about whether various instances of similar vowels are the same or different. Since linguists and native speakers typically bring different skills and abilities to the task, the ideal is a closely cooperative effort. One such approach that has been used with considerable success is described in Kutsch Lojenga (1996).

A special case where native speaker judgments should by all means be consulted involves pairs of words which are thought to be completely identical except perhaps for two sounds (one in each word, in the same position) whose identity is not clear. For example, suppose you have a word [to] 'cup' with high tone and a second word meaning 'arrow' which you would be inclined to transcribe in exactly the same way, however you are not completely sure that the two words are completely homophonous. In this case, you should enlist the help of two (or more) native speakers, and ask one speaker to choose one of the words and pronounce it without letting the other speaker know in advance which word is to be pronounced. If the other speaker can tell with certainty, upon hearing the word spoken, which word was intended, then the two words must be different; otherwise, the most likely hypothesis is that they are the same.[29] (In addition to having another native speaker(s) listen, you should of course listen yourself as well, to see whether you can tell which word is being pronounced.) Of course, this test does not by itself tell you exactly *where* the difference lies in cases where the two words are found to be different. It might be the vowel, the consonant, the tone, or even the presence of a weak final glottal stop (which is easily overlooked, even though it is surface-contrastive in many West African languages). Presumably, however, you would usually be able to eliminate some of these possibilities and through carefully listening combined with the suggestions of native speakers determine where the difference lies.

It is also important to pay close attention to places where native speakers transcriptions differ systematically from your own. Although it would be a mistake to assume automatically that a native speaker's transcription is correct and your own is wrong, systematic differences may provide valuable clues to something you have been overlooking.

The classic case of this kind of clue as far as ATR harmony is concerned involves a situation (which has occurred very commonly) in which a linguist working on a language tends to mistranscribe /ɪ/ and /ʊ/ as [e] and [o] respectively. In every such case I am aware of, native speakers who are not already familiar with special symbols for /ɪ/ and /ʊ/ (which are absent from the vast majority of orthographies of African languages, as well of course as most/all non-African languages widely spoken on the continent) have preferred to write these vowels as "i" and "u" rather than "e" and "o,"

[29] A variant of this test would be to record both words in WinCECIL or Speech Analyzer and put them in adjacent windows to be played back in either order.

except in situations (and sometimes even in such situations!) where established orthographic conventions require use of the latter. Generally, in fact, the widespread tendency of native speakers to use "i" and "u" to write vowels which the linguist hears as [e] and [o] can be taken as a very strong clue that the vowels in question may actually be [ɪ] and [ʊ].

- Recognize that absence of minimal pairs does not mean that two sounds are not separate phonemes.

In many five-height languages, one or more of the vowels is likely to be relatively rare. /ə/ is often rare in ten-vowel languages, for example, while /e/ and /o/ are rare in many nine-vowel West African languages. Where a vowel is relatively rare, it would not be surprising if there are few if any minimal pairs to demonstrate contrast with a certain other vowel(s), and it may even be difficult to find good near-minimal pairs. While such a state of affairs might warrant the statement that the uncommon vowel(s) in question is a rather marginal phoneme, it does not justify the assumption that it is simply an allophone of some other phoneme, unless a clear and plausible statement of complementary distribution can be given. It will not do, for example in a (potentially) nine-vowel language in which minimal pairs involving [e] and [ɪ] cannot (due to the rarity of the former) be found to treat (as may have been done in some actual cases) [ɪ] as an allophone of /e/, invoking a vague claim to the effect that the two vowels "do not appear to contrast." Given the sheer typological unexpectedness that [ɪ] would be an allophone of /e/ in a Niger-Congo or Nilo-Saharan language and the difficulty in imaging what a plausible conditioning environment might be, such an analysis would only be tenable in the face of clear and strong evidence of complementary distribution (of a sort that could not plausibly be treated to a combination of chance and the rarity of the vowel [e]).

- Keep the distinction between phonology and orthography in mind.

Although the goal of developing a practical orthography provides what is probably the primary motivation for most SIL and NBTO teams to do a phonological analysis of a language, it is important to keep in mind that analyzing a phoneme inventory is not exactly the same thing as developing an orthography. In particular, one should not let one's orthographic choices or preferences (some of which, being based on non-linguistic factors such as government policy or popular opinion, may be partly decided before the phonemic inventory has been determined) influence the analysis of the vowel system. The vowel inventory should be determined on the basis of standard (relatively) objective criteria, without regard to which vowels you ultimately intend to write in an orthography. To put it differently, the direction of influence between phonological analysis and orthographic choices should be one way: phonological analysis can (and presumably should) influence orthographic choices, but orthographic choices should not influence phonological analysis. (This principle may seem fairly obvious, but I point it out because there have been cases where it has not been followed in practice.)

Part 2: Additional Topics for Consultants & Specialists

11. Vowel systems and markedness

Markedness described

An important concept in phonology is that of *markedness*. This concept relates to a distinction between unmarked segments, which are expected to display the properties in (64), and marked segments which are expected to display the properties in (65).

(64) Typical properties of unmarked segments

a. They are found in many languages.
b. In languages in which they exist, they occur frequently in lexical items.
c. They are among the earlier sounds acquired by children.
d. They have a wide distribution in a language; they can occur in most/all phonological environments.
e. They often result from phonological processes that eliminate more marked segments.

(65) Typical properties of marked segments

a. They are relatively rare in languages.
b. In languages in which they exist, they tend to occur less frequently.
c. They are acquired relatively late by children.
d. They often have a restricted distribution in a language and can occur only in certain environments.
e. They are often eliminated through historical processes.
f. Languages generally do not have marked segments unless they also have less marked segments of the same type.

Segments generally regarded as relatively unmarked include common consonants and vowels such as /t/, /l/, /k/, /n/, /p/, /s/, /f/, /ɑ/, /i/, /u/. Examples of segments usually assumed to be more marked include /kp/, /gb/, /ŋm/, /ʒ/, /ð/, /ɓ/, /ɥ/, /ɬ/, /œ/, /y/, /ɨ̃/.

Markedness is assumed to be *relative*. It is not a question of some segments being unmarked and others marked in absolute terms; rather, there is a scale or hierarchy from very unmarked segments, to slightly marked segments, to very marked segments.

Some phonologists have proposed universal markedness hierarchies for various types of segments (or positions within the syllable).

The reasons *why* a particular marked segment is marked could in principle be either related to articulatory difficulty or auditory non-salience. In practice, articulatory reasons have more commonly been invoked.

A widespread view of [ATR] and markedness in vowel systems

A fairly widespread view has developed during the past few years about the relative markedness of the vowels found in African languages with ATR harmony.

According to this view (Calabrese 1995, Archangeli & Pulleyblank 1994, Bakovic 1999), the least marked vowels are those which combine a relatively high position of the tongue body ([+high]) with an advanced tongue root ([+ATR]), or which combine a low position of the tongue body ([-ATR]) with a non-advanced tongue root ([-ATR]).

(66) Vowels commonly assumed to be least marked

a. [+high,+ATR] vowels: /i/, /u/

b. [-high,-ATR] vowels: /ɑ/

The most marked vowels are said to be those which combine a high tongue body position with a non-advanced tongue root, or a low tongue body with an advanced tongue root.

(67) Vowels commonly assumed to be most marked

a. [+high,-ATR] vowels: /ɪ/, /ʊ/

b. [-high,+ATR] vowels: /ə/ (Where /ə/ is assumed to be phonetically low.)

These assumptions about markedness are based on an oft-cited articulatory connection between the tongue root and the tongue body:

> *"the root of the tongue naturally tends to be pushed backwards (as for unadvanced vowels) when the dorsum is low (as for open vowels) and pulled forwards (as for advanced vowels) when the dorsum is high (as for close vowels)" -- Stewart (1970:350)*

Given this connection, it is alleged to be more difficult to make a high vowel with the tongue root retracted or a low vowel with the tongue root advanced.

What about the mid vowels /e/, /o/, /ɛ/, and /ɔ/?

Opinions differ about the relative markedness of these vowels, even among phonologists who subscribe to the general view that the markedness of vowels in ATR harmony languages is related to the articulatory connection between [high] and [ATR].

- Archangeli & Pulleyblank (1994) do not regard any of these mid vowels as marked; for them, markedness conditions refer only to high and low vowels. (Note however that they appear to assume that vowels transcribed /ə/ in [ATR] harmony systems are low.)
- Calabrese (1995) adopts a very specific markedness hierarchy in which the most marked vowel is the "low" [+ATR] vowel /ə/, followed by the [+high,-ATR] vowels /ɪ/ and /ʊ/, followed by the [-high,+ATR] vowels /e/ and /o/, followed by the unmarked vowels /i/, /u/, /ɛ/, /ɔ/, and /ɑ/.

Calabrese claims moreover that more marked vowels will generally only be possible in a language if all less marked types of vowels in this hierarchy also occur. (Which of the vowel system types described in section 4 ought to be ruled out by this proposal?)

- Bakovic (1999) assumes that all of the non-low [-ATR] vowels /ɪ/, /ʊ/, /ɛ/, /ɔ/ are marked, as are low [+ATR] vowels. Unmarked vowels, for him, are the low [-ATR] vowel /ɑ/ and the non-low [+ATR] vowels /i/, /u/, /e/, and /o/.

Critique of this view (see also Casali 1995a)

The main arguments in favor of the claim that the vowels in (65) are highly marked are first, the phonetic plausibility of the connection between tongue body height and tongue root position, and second, the observation that the vowels in (65) are generally the first to be lost historically in the reduction of ten-vowel systems (Elugbe 1983, Ford 1973,

Painter 1972, Stewart 1970, Williamson 1983). (The claim is that /ə/ is generally the first to be lost, followed by /ɪ/ and /ʊ/.)

Phonetic plausibility alone constitutes only weak support for the presumed markedness of the vowels /ə/, /ɪ/, and /ʊ/. There is little if any direct phonetic evidence to suggest that these segments are particularly difficult to articulate. Even if raising the tongue body would *tend* to pull the tongue root forward, for example, it does not follow that this tendency is particularly difficult to overcome. Moreover, the fact that some sound can be identified as involving some articulatory challenge does not entail that it will be phonologically marked. Not all identifiable phonetic tendencies appear to be strongly reflected in phonological behavior. The fact that rather different conclusions (i.e. the particular markedness hierarchies of Archangeli & Pulleyblank, Calabrese, and Bakovic) can be drawn from the same articulatory considerations also illustrates the tenuous nature of this type of reasoning.

It is also very unclear to what extent the central [+ATR] vowel (here transcribed /ə/) in ten-vowel systems is in fact a low vowel to begin with. There appear to be some, perhaps many, ten-vowel languages in which this vowel is phonetically mid. But if the vowel is not in fact low, then the argument that it is marked because of the relative articulatory incompatibility of lowness and advanced tongue root does not apply. There is, moreover, no evidence so far that the tenth vowel behaves as less marked in languages in which it is phonetically mid (as we might expect if the combination of low tongue position and [+ATR] were responsible for the marked status of this vowel). In Akposso (Anderson 1999), for example, in which /ə/ is acoustically higher than both /ɛ/ and /ɔ/ (though not as high as /e/ and /o/), this vowel is nevertheless the rarest of the ten vowels in the language. Although the quantity of available evidence bearing on the question is not all that great, such evidence as is available at present does not seem to show any correlation between the markedness of /ə/ (at least as measured by its relative frequency) in a language and a low articulation. Rather /ə/ seems to be a highly marked vowel in most if not all ten-vowel systems, regardless of its low or non-low articulation.

Claims to the effect that /ə/, /ɪ/, /ʊ/ are commonly lost historically appear to be based in part on a picture of the facts which is not always fully complete and accurate. It is true that African languages with /ə/ are relatively (though by no means extremely) uncommon, and this, combined with other facts about the behavior of this vowel (e.g. the fact that it appears to be less common than other vowels in languages in which it occurs), might be used as an argument in favor of the markedness of this vowel. Languages with /ɪ/ and /ʊ/, on the other hand, are extremely common, a fact which has not received sufficient attention from proponents of the view that these vowels are highly marked. Nor is it necessarily the case that these vowels are always lost before allegedly less-marked vowels such as /e/ and /o/; vowel systems (e.g. /iɪɛɑɔʊu/) which have /ɪ/ and /ʊ/ but not /e/ and /o/ are not extremely rare.

/ɪ/ and /ʊ/ also tend to be extremely common in languages in which they occur,[30] which is not what one would expect if these were highly marked vowels. In at least

[30] Languages in which /ɪ/ and/or /ʊ/ are among the most frequent vowels include Akposso (Kwa; Anderson 1999), Chumburung (Kwa; Cahill 1991), Dagaari (Gur; Cahill 1991), Bete (Kru; Werle &

some languages, including Nawuri and Kabiyè (Delord 1976), they are also commonly found in positions of neutralization, in which only a subset of the vowels can regularly occur, e.g. in grammatical morphemes. That is, they have a wider distribution than some other, allegedly less-marked segments. In at least some languages, including Nawuri (Kwa; Casali 1999), Kabiyè (Delord 1976), Chumburung (Hansford & Hansford (1989), Kɔnni (Gur; Cahill 1996), and Kalabari Ijo (Ijoid; Jenewari 1973), they also function as epenthetic segments to break up impermissible syllable structures in loan words. (Epenthetic segments are typically among the least marked segments. Consonants commonly used epenthetically include segments like [t], [l], or [ʔ], for example, and not more complex or unusual segments like [ŋm] or [ɗ].)

Conclusion:

Although /ə/ might plausibly be regarded as a marked segment, /ɪ/ and /ʊ/ do not exhibit the kind of behavior typical of articulatorily marked segments. Cases where these vowels have been lost historically can be better understood in terms of auditory and acoustic factors (cf., Casali 1995a, Stewart 1971, Lindblom 1986), as arising due to the difficulty in distinguishing these vowels from those immediately below (i.e. /e/ and /o/) or above (i.e. /i/ and /u/) them. An advantage of this account lies in the fact that whereas the claim that /ɪ/ and /ʊ/ are difficult to articulate remains at best a conjecture, the acoustic similarity of /ɪ/ and /ʊ/ to other vowels has been documented in many ATR harmony languages.

It is likely that auditory-acoustic factors are also at the root of the tendency for /ə/ to be lost historically. This vowel is known to be acoustically quite similar to some other vowel in at least some ten-vowel languages.

Beyond all this, it would seem that the markedness of different types of vowel systems is not a simple function of the markedness of the individual vowels the system contains. Other functional factors, notably the degree of overall acoustic separation of the vowels in the system, may well play a more important role (Flemming 1995, Lindblom 1986, Lindblom & Liljencrants 1972).

Markedness-driven harmony exceptions

Though actual examples are a bit hard to come by, current phonological theories predict the possibility of exceptions to vowel harmony due to phonotactic constraints prohibiting the occurrence of certain marked vowels in certain positions, or of certain marked feature combinations.

A hypothetical (but very plausible example):

Imagine a language (language X) with the phonemic oral and nasal vowel inventories below:

Gbalehi 1976), Kabiye (Delord 1976), Nafara (Aglo 1989-1990), Wali (Gur; Cahill 1991), and Kɔnni (Gur; Cahill 1991).

In a phonological description, it is generally best to present the oral and nasal vowel inventories separately. In referring to the number of vowels in the system, use the number of oral vowels, e.g. the language described here would be referred to as having a ten-vowel system, and not a seventeen-vowel system.

(68) Oral vowel inventory of language X

i		u	[+ATR] vowels: i u e o ə
ɪ		ʊ	
e	ə	o	
ɛ		ɔ	[-ATR] vowels: ɪ ʊ ɛ ɔ ɑ
	ɑ		

(69) Nasal vowel inventory of language X

ĩ		ũ	[+ATR] nasal vowels: ĩ ũ
ɪ̃		ʊ̃	
ɛ̃		ɔ̃	[-ATR] nasal vowels: ɪ̃ ʊ̃ ɛ̃ ɔ̃ ɑ̃
	ɑ̃		

Opinion: Formal rules or constraints (i.e. rules or constraints expressed in the symbolic notation of some theory) should be used sparingly if at all in a written phonology description. However, they can provide a useful conceptual basis for trying to make sense of phonological patterns.

Although formal constraints need not be used in a description, it is important to explicitly note (in ordinary prose) any systematic gaps in phonological inventories, e.g. "mid [+ATR] nasal vowels do not occur in language X."

Language X lacks mid [+ATR] nasal vowels, a situation which is extremely common in real life. These vowels can, accordingly, be regarded as more marked than other, more common nasal vowels such as /ɑ̃/, /ĩ/, and /ɔ̃/. Many phonological theories would account for this "gap" in terms of a constraint against this type of vowel

(70) "Nasal ATR" constraint: No mid [+ATR] nasal vowels.

Imagine that language X also has a general ATR harmony rule/constraint that requires vowels in a word to agree in their value of [ATR]:

(71) "ATR Harmony" constraint: Vowels in a word must agree for [ATR].

Finally, we will assume that language X has a further requirement that only nasal vowels can occur immediately following a nasal consonant:

(72) "Nasal Agreement" constraint: Vowels following nasal consonants must be nasal.

Note that each of these constraints could also be expressed in formal notation as either a rule or constraint. For example, Nasal Agreement could be expressed as an autosegmental rule spreading [+nasal] from a consonant onto a following vowel. Our interest here is not in formal notation however, nor on the relative merits, from a theoretical perspective, of rules or constraints. What is important is that, however it is to be analyzed in theoretical terms, languages often do show certain requirements or pressures similar to those listed above, which they tend to obey. Another important observation that has been made about how languages function is that these different requirements or pressures sometimes conflict. That is, a situation may arise in which it is logically impossible to simultaneously satisfy all of the requirements that the language otherwise conforms to. Under such circumstances, some requirement or other must be sacrificed so that one or more other requirements can be satisfied. We will now consider a case of this type.

Suppose that language X has a harmonizing suffix with a mid front vowel. In keeping with ATR Harmony, this vowel surfaces as [e] following [+ATR] roots and as [ɛ] following [-ATR] roots:

(73) a. kol-e
b. kɑl-ɛ

Following roots that end in a nasal consonant, the Nasal Agreement constraint also comes into play, requiring that the suffix vowel be nasal:

(74) sɔn-ɛ̃

Realization of the suffix as a [-ATR] nasal vowel [ɛ̃] in this example satisfies both ATR harmony and Nasal Agreement. There is also no problem with the third constraint, Nasal ATR, since the suffix is not a mid [+ATR] vowel.

Problem case: What happens when the suffix occurs with a [+ATR] root that ends in a nasal consonant, e.g. /kon/?

The problem here is that the ATR Harmony, Nasal Agreement, and Nasal ATR constraints potentially conflict.

Possible realizations:

(75) a.	kon-ẽ	satisfies: ATR Harmony, Nasal Agreement violates: Nasal ATR
b.	kon-e	satisfies: ATR Harmony, Nasal ATR violates: Nasal Agreement
c.	kon-ɛ̃	satisfies: Nasal ATR, NasalAgreement violates: ATR Harmony

There are yet other imaginable possibilities that satisfy all three constraints, for example those shown in (76):

(76) a. kon-ĩ
b. kon

(There are still other possibilities as well.)

However, these possibilities are not without a price, as they involve adding or deleting features or segments (which might be thought of as violating other "constraints").

Current phonological theories predict that a language might select any one of the possibilities in (75) or (76) as the "optimal" solution, depend on which of the phonological constraints or requirements it treats as most important.

Since we are talking about exceptions to ATR harmony, the possibility which is of most interest to us here is the one in (75c), which sacrifices the ATR harmony requirement in order to satisfy Nasal Agreement and Nasal ATR.

Although the example is hypothetical, all three of the phonological constraints or pressures (ATR harmony, Nasal Agreement, Nasal ATR) are not only attested but relatively common. There is also ample evidence to show that languages commonly do override some otherwise general constraint (such as ATR harmony) in response to some conflicting constraint(s). Consequently, patterns somewhat similar to this are not unlikely to occur.

Whether or not this particular pattern exists in some languages, it illustrates a general type of exception to ATR harmony which is fully expected to occur under virtually all phonological theories. This type of exception conforms to the following scenario:

- A vowel which would occur in some environment if ATR harmony were satisfied is prohibited, either in general in the language or in that particular environment.
- Consequently, the prohibited vowel is replaced by some other vowel.
- The vowel used as a replacement has the opposite [ATR] value from the vowel it replaces. Since the vowel being replace is the one would have satisfied vowel harmony, it follows that the vowel actually used as a replacement will normally violate vowel harmony.

The expectation of most current theories is that the vowel being replaced in such cases will normally be one that is particularly *marked*. Usually, one would not expect replacement of a less marked vowel by a more marked vowel.

To the extent that this is true, we might refer to these kinds of exceptions as *markedness-driven exceptions* to ATR harmony.

Possible real-life examples of markedness-driven exceptions to ATR harmony

Example 1: Akposso (Kwa; Ghana & Togo; Anderson 1999)

Akposso has a ten-vowel system with regular and productive ATR harmony.

(77)

i		u	[+ATR] vowels: i u e o ə
ɪ		ʊ	
e	ə	o	
ɛ		ɔ	[-ATR] vowels: ɪ ʊ ɛ ɔ ɑ
	ɑ		

In a typical ten-vowel system, an affix which has [ɑ] as its vowel with [-ATR] roots will surface with the [+ATR] central vowel [ə] with [+ATR] roots. That is, [ə] is normally the *harmonic counterpart* of [ɑ].

Because [ə] is generally considered to be a marked vowel (as discussed above), however, we might also expect to find ten-vowel languages in which this vowel is prohibited from occurring in certain environments.

This is the case in Akposso. The vowel [ə] cannot occur in affixes in Akposso, but only in roots (and only in non-initial position). Consequently, an affix which has [ɑ] in its [-ATR] form must take some vowel other than [ə] in its [+ATR] form.

There are two different substitution strategies which Akposso employs for avoiding [ə] in affixes in contexts where this vowel would normally be expected.

- Strategy 1: A different [+ATR] vowel is substituted. The vowel that is used is the mid front [+ATR] vowel [e]. (We might speculate that that this is the [+ATR] vowel to which [ə] is acoustically most similar in Akposso, though not necessarily in all languages.)

(78) Plural noun class prefix [e] ~ [ɑ] with [-ATR] roots[31]

a. ɑ-gbɑ	'gorillas'
b. ɑ-kpɑ	'people of a same age group'

(79) Same prefix with [+ATR] roots

a. e-mloo	'children'
b. e-kpi	'dogs'
c. e-luvi	'males'

This strategy does not lead to any violation of ATR harmony, although it does require substituting a front vowel for a central vowel in the [+ATR] forms.

A second strategy, which is used with a different noun class, does lead to ATR harmony violations.

- Strategy 2: The vowel [ɑ] is used as the affix form with [+ATR] vowels as well as [-ATR] vowels, even though this violates vowel harmony.

(80) Plural noun class [ɑ] with [-ATR] roots

a. ɑ-lʊ	'people'	(singular = ɔ-lʊ)
b. ɑ-sɪ	'women'	(singular = ɔ-sɪ)

(81) Plural noun class [ɑ] with [+ATR] roots

a. ɑ-levi	'young man'	(singular = o-levi)
b. ɑ-sjetʃu	'young woman'	(singular = o-sjetʃu)

It is the examples in (81) that involve vowel harmony exceptions, since a [-ATR] prefix occurs with a [+ATR] root.

Practical implications

Although it is not completely clear which vowels should be regarded as most marked in different types of systems, current theories all give the expectation that some vowel(s) in a system might exhibit the kinds of behavior (listed in (65)) typical of marked vowels. Be alert to (and call attention to) any such behavior in your language.

Because of their potential relevance to questions which phonologists are trying to answer about markedness, the following kinds of information are useful in a phonological descriptions:

---

[31] The corresponding singular forms of this noun class prefix are [u] (with [+ATR] roots) and [ʊ] (with [-ATR] roots). Akposso has only a couple genuine noun classes synchronically. (See Anderson 1999 for discussion.)

Descriptive issues concerning markedness: relative frequencies of vowels, epenthetic vowel, vowels occurring in positions of neutralization.

- Information about the relative frequencies of the different vowels (see for example Anderson 1999, Bonvini 1974, Casali 1999, Hérault 1982b, Yago 1984)
- Which vowel(s) function epenthetically in the language?
- Note any "positions of neutralization" in which only a subset of the vowels (which ones?) can occur.

It is also good to be alert to the possibility that some exceptions to ATR harmony in a language might be motivated by a pressure to avoid marked vowels in certain positions.

12. The fundamental nature of ATR

Although much of the phonological literature (especially introductory work) gives the impression that [ATR] is a well-understood feature, it has been used in several different senses in the literature, and there is in fact no clear consensus concerning its fundamental nature.

It is possible however to distinguish two main types of view concerning [ATR]:

- *Minimalist* views, which would restrict [ATR] to languages in which the relevant contrast is known or strongly suspected to be based on actual advancement of the tongue root. This view is cited advocated by Parkinson (1996:9), who proposes that [ATR] should be

  > *"reserved only for those languages exhibiting the phenomena Stewart (1967) originally intended the feature to describe [i.e., contrasts based on tongue root advancement--RC]."*

- *Maximalist* views, which employ [ATR] as essentially a secondary vowel height feature. These views allow use of [ATR] to distinguish just about any vowel "height" contrasts which cannot be distinguished in terms of [high] and [low] alone (e.g. contrasts between /i/ and /ɪ/, /u/ and /ʊ/, /e/ and /ɛ/, /o/ and /ɔ/).

  > *"In some circles, [ATR] has replaced completely the feature [tense], and it is used to describe any and all contrasts involving [e]:[ɛ] and [o]:[ɔ]." -- Schane (1990)*
  >
  > *"In fact, it is likely that [ATR] should be viewed as a more general cover feature possibly involving different gestures in different languages (height, quality, pharyngealisation, centralising, flattening, etc.). Thus, while [ATR] is exploited only for vowel height in Esimbi, this feature may have additional phonetic consequences in other languages." (Hyman 1989)*

Some of those who hold maximalist views of [ATR] have been willing to apply this feature not only to African languages with and without ATR harmony (whether or not tongue root is known to play a role) but also non-African languages including European languages such as English.

Regardless of which position is to be preferred on theoretical grounds (see Casali 1998b for discussion), the maximalist position is may be the most useful to assume for descriptive purposes, since it corresponds most closely to the way in which [ATR] has been widely employed in practice.

Practical suggestions

- Use [ATR] for descriptive purposes, regardless of whether or not tongue root advancement seems to be involved.

Descriptive issue (all vowel systems with more than three heights): How does the [ATR] contrast seem to be implemented articulatorily?

- Clearly describe the extent to which, as best you can tell, tongue root mechanisms seem to be involved. This information must generally be based on auditory impressions and attempts at imitation (more on this below). CECIL is very unlikely to help resolve such questions. (Equipment such as x-ray or MRI machines which in principle might provide an answer is not usually available to field linguists!)
- If you are not sure that tongue root advancement is at work, it would be helpful to clearly state in a description that while you are using the feature [ATR] to describe the relevant vowel contrasts, you have no clear evidence that tongue root advancement is actually at work.
- The fact that a description of a language describes a vowel contrast in terms of the feature [ATR] does not by itself justify the inference that the author has any reason to believe that the contrast is based on tongue root displacement. [ATR] is widely used in practice in cases where the role, if any, of tongue root displacement in a contrast is not clearly known.

13. Active and inert [ATR] values, underspecification

In languages with [ATR] harmony, it is often the case that the two values of [ATR] ([+ATR] and [-ATR]) do not behave symmetrically. Rather, one value is clearly active in a way that the other is not.

Probably the most striking cases of this type involve the dominant harmony systems found in many Nilo-Saharan languages, in which there is widespread assimilation of underlying [-ATR] vowels to [+ATR] vowels (as for example when a [-ATR] root changes its vowels to [+ATR] when it takes a [+ATR] suffix), but no assimilation of underlying [+ATR] vowels to [-ATR] vowels.

Limited instances of dominant suffix behavior are also found in some Niger-Congo languages, as in the Nawuri examples given previously in (18) and repeated here as (82).

(82)

a. [ɔ-bʊŋ]	[gɑ-bum-bi]	
‘river’	‘stream’	
b. [gɑ-wɛ]	[gɑ-we-bi]	
‘calabash’	‘small calabash’	
c. [ɔ-fɔlɪ]	[o-foli-bi]	
‘crop bed’	‘small crop bed’	

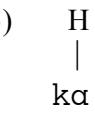
This kind of asymmetry has often expressed by saying that the [+ATR] vowels in such languages are “dominant” or “marked” or “active” and that the [-ATR] vowels are “recessive” or “unmarked” or “inert.”

Underspecification

Inert/recessive/unmarked feature values often behave for all intents and purposes as if they were simply not there. In languages with dominant [+ATR] harmony, for example, [-ATR] has often been regarded as simply the absence of any [ATR]

specification whatsoever. A somewhat analogous example comes from tone; a number of analyses of two tone languages have proposed that low tone is in reality simply the absence of a tonal specification (cf. Pulleyblank 1983, Odden 1995).

Underspecification theories (Abaglo & Archangeli 1989, Archangeli 1984, 1988, Archangeli & Pulleyblank 1989, Clements 1987, Pulleyblank 1983, 1986, 1988, Steriade 1987), popular in the 1980's, sought to account for such asymmetries by assuming that only the active or dominant value of a feature is underlyingly specified. Since it is underlyingly present, it can be referred to by phonological rules, and hence can "spread" its influence to other segments. The opposite value, which is recessive or inert, is not underlyingly specified, but is either "filled in" by default at some late stage of a derivation or else (under some theories) is never supplied at all, but is viewed as simply the absence of the opposite (specified) feature specification. Under this latter approach, for example, one might imagine (as has in fact been proposed by a number of tonologists) that the low tones in a two-tone language are in reality simply the way in which syllables which lack a tone specification altogether are realized phonetically. From this point of view, for example, a hypothetical high-toned word like [kά] in a two-tone language would be represented autosegmentally as in (83), while a low-toned word like [kὰ] would be represented autosegmentally as in (84):

(83)


(84) kα

It would then be necessary to assume a convention that syllables which lack a specification for tone are realized phonetically with relatively low pitch.[32]

Our primary focus here is on describing some widespread phenomena in ATR harmony systems and not on theoretically-based analyses. It should also be noted that underspecification theories have been largely abandoned in more recent work. Nevertheless, you may find that underspecification theory provides a useful way of thinking about active (dominant) versus inert (recessive) feature values. In particular, we can think of the active value of [ATR] in a language as the one that would need to be specified underlyingly in order to yield the most straightforward underspecification analysis. An inert feature value is one that would not need to be specified underlyingly, but could, because it does not need to be directly referred to by any phonological rules, be viewed as the absence of an [ATR] specification.

It will not always be the case that there is clear evidence in a language for deciding which value of [ATR] would need to be underlyingly specified. In a large number of languages, however, there is such evidence. We can illustrate this using the Nawuri examples in (82c) above. An underspecification analysis for this form is given below. This analysis takes [+ATR] as the underlyingly specified value and assumes that vowels which lack an [ATR] specification are interpreted phonetically as [-ATR]. [ATR] is assumed to be an autosegmental feature; it appears on its own separate tier and is linked to vowels by association lines. Following fairly standard conventions, upper case

[32] Given that the actual surface pitch of a syllable in the context of any real utterance depends on a variety of factors, the full story to this kind of analysis would presumably have to be more complicated. However, this example should suffice to communicate the basic idea.

letters are used to indicate vowels which are specified for all features except [ATR]. For example, "I" is used to represent a vowel which is high, front, and non-round, but is unspecified for [ATR]. It will be interpreted phonetically as [i] if it is associated with a [+ATR] autosegment and as [ɪ] otherwise.

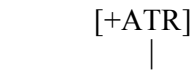
(85) Underspecification analysis of the forms in (82c)

a. Analysis of [ɔ-fɔlɪ] 'crop bed'

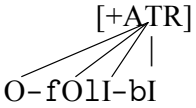
Underling form:	O-fOlI
phonetic interpretation:	ɔ-fɔlɪ

b. Analysis of [o-foli-bi] 'small crop bed'

Underling form:



[+ATR] spreading leftward:



Phonetic interpretation: o-foli-bi

What would be wrong with an analysis of these examples which took [-ATR] as the underlyingly specified one?

Descriptive issue: Does one value of [ATR] show evidence of being active in a way that the other does not?

Many languages show this kind of asymmetry in which one value of [ATR] (either [+ATR] or [-ATR], depending on the language) would *need* to be specified under the most straightforward phonological analysis (e.g. one which accounts for assimilation in terms of feature spreading), whereas the other *could* be left unspecified. The "could" is important here; it is generally difficult or impossible to show that a value *must* be unspecified. (And in fact the most widespread theoretical position in the year 2000 may be that both values of every feature are fully specified underlyingly.) However, the mere fact that only one value of [ATR] *must* be specified in some particular language is evidence of an interesting asymmetry (referred to as "activity") that ought to be discussed in a description and must ultimately be accounted for (whether by underspecification or some other means) by theories.

Evidence of [+ATR] or [-ATR] activity

In order to diagnose one or the other value of [ATR] as being the active value, it is generally necessary to have two things. First, there must be some alternations or processes involving [ATR], that is there must be some morpheme(s) with a vowel(s) which is sometimes [+ATR] and sometimes [-ATR]. Second, there must be some way of telling which of the two forms of the morpheme(s) is the underlying or basic one.

Not all [ATR] alternations allow the second condition to be met. In an ideal root-controlled harmony system in which the only [ATR] alternations involve harmonizing

affixes, for example, there may be no basis for regarding either the [+ATR] or the [-ATR] form of the affix as the basic or neutral one.

Consider for example the following hypothetical forms involving a harmonizing prefix that surfaces as [o] with [+ATR] roots but as [ɔ] with [-ATR] roots:

(86) With [+ATR] roots

a. o-te	'horse'
b. o-sili	'paper'
c. o-ku	'tree'

(87) With [-ATR] roots

a. ɔ-tɛ	'boat'
b. ɔ-nɛlɪ	'sky'
c. ɔ-fɔ	'light'

The pattern here is entirely symmetric; there is no way of telling from examples like these which of the two forms of the affix constitutes the more "basic" or "neutral" or "underlying" form. In underspecification terms, one might assume either the analysis in (88), which takes [+ATR] to be the underlyingly specified (active) feature, or the analysis in (89), which takes [-ATR] to be the underlyingly specified feature. (Note the different phonetic interpretation conventions that the two analyses assume.)

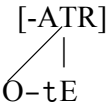
(88) Underspecification analysis 1: Only [+ATR] specified

a. O-tE	=	[o-te]	'horse'
b. O-tE	=	[ɔ-tɛ]	'boat'

Phonetic convention: Absence of [ATR] specification is interpreted as [-ATR].

(89) Underspecification analysis 2: Only [-ATR] specified

a. O-tE	=	[o-te]	'horse'



b. O-tE	=	[ɔ-tɛ]	'boat'

Phonetic convention: Absence of [ATR] specification is interpreted as [+ATR].

What we have in the hypothetical examples in (86) and (87) is essentially the classic picture of "root-controlled" harmony that is commonly assumed to be characteristic of West African languages. What has not often been noted in the literature however is that while many West African languages do have root-controlled alternations of the type in (86) and (87), it is fairly common for them to also have other types of [ATR] alternations where it *is* possible to tell which form of an alternating morpheme is basic and which is derived. At least the following cases arise in some languages:

- Dominant affixes (cf. (82) above)

In almost all cases known to me at present, dominant affixes are [+ATR]. Exceptions: Puguli (Gur; data from Kevin Warfel, personal communication) appears to have a dominant [-ATR] noun class suffix /ɑ/ (cf. section 7 above). Ninkare (Gur; Connie Kutsch Lojenga, personal communication) may exhibit somewhat similar patterns.

Dominant affixes are almost always suffixes. Exception: Dominant [+ATR] prefixes are found in Budu (Bantu; Kutsch Lojenga 1994b).

In contrast to harmonizing affixes, dominant affixes do not themselves show alternations for [ATR]. Rather, they may trigger alternations in the form of a root to which they are attached. Thus, the dominant [+ATR] suffix /-bi/ in Nawuri causes a preceding [-ATR] noun root to become [+ATR], e.g. /ɔ-fɔlɪ-bi/ becomes [o-foli-bi]. In such cases, it is easy to tell what the basic or underlying form of an alternating noun root is; this is simply the form it normally has when there is no dominant suffix attached to it. Thus, the fact that the root 'crop' in Nawuri surfaces with a [-ATR] form [ɔfɔlɪ] when it bears no suffix shows that it is underlyingly [-ATR].

- Allophonic [ATR] alternations

This refers to situations in which a vowel has both a [+ATR] and a [-ATR] allophone.

Examples:

(90) a. In Anum (Kwa, /iɪeɛɑɔouu/; Obeng 1995), the vowel /ɑ/ has the following allophones:

[æ] occurs preceding a syllable with an underlying [+ATR] vowel.
[ɑ] occurs elsewhere.

b. In Lugbara (Central Sudanic, /iɪɛɑɔuu/; Andersen 1986), the vowels /ɛ/ and /ɔ/ have the following allophones:

[e], [o] occur in words with the [+ATR] vowels /i/ and /u/.
[ɛ], [ɔ] occur elsewhere.

c. In the Ekiti dialect of Yoruba (/ieɛɑɔou/, Oyelaran 1973) /i/ and /u/ have the following allophones:

[ɪ], [ʊ] occur before a [-ATR] vowel /ɛ/, /ɑ/, or /ɔ/ in the following syllable.
[i], [u] occurs elsewhere.

Which value of [ATR] would we assume to be active in each case?

The "elsewhere" case is the one that would be assumed, under virtually all theories to constitute the underlying form. The allophone which occurs in the more specific context would be derived (in rule-based generative phonology) by a rule. In each of these three cases, the rule is clearly an assimilatory one which would spread or copy a feature value found on some neighboring segment(s). In order for the rule to spread or copy a feature value, this feature value must of course be present.

- Assimilation across word and/or morpheme boundaries.

(91) Leftward spreading of [+ATR] across word and morepheme boundaries in Nawuri

a. /ɔsɪ wijɑ/ father owner	[ɔsuwijɑ]	'father owner' (non-orphan)
b. /ɪsɪ bʊ obu-to/ sand be room-in	[isiboobuto]	'sand is in the room'
c. /ɔ-dɪ-bi/ NC-village-child	[ɔdɨbi]	'villager'

In each of these examples, the underlying forms of the root words and morphemes are known, because they are the forms which show up in neutral contexts, e.g. the word 'sand' (91b) is normally [ɪsɪ]; it only shows up as [isi] when a [+ATR] word follows. (Note that the vowel [ɨ] in example (91c) is a centralized allophone of /i/ that occurs in interconsonantal environments.)

In other languages, it is [-ATR] which spreads, as in the Yoruba compound example below:

(92) /ogbo-ɛni/ → ɔgbɛni 'sir'
old-person

- Systematic preservation of [+ATR] under vowel fusion (coalescence)

Many languages have a vowel coalescence process in which a sequence of two different vowels undergoes fusion or merger to form a vowel different from the two originals:

(93) Vowel coalescence: $V_1 + V_2 \rightarrow V_3$

A very common example is coalescence of /ɑ+i/ to form either [e] or [ɛ], depending on the language.

The cases of interest as far as [ATR] activity are concerned are those in which the two input vowels have opposite values of [ATR], i.e. one vowel is [-ATR] and the other is [+ATR]. The question to ask in such cases is which value of [ATR] survives. Under most analyses of coalescence that have been proposed (cf. Aoki 1974, Haas 1987, 1988, Casali 1996a,b, Snider 1989b) the value that survives must be assumed to have been present underlyingly (hence active). (The other value need not, under many analyses, have been present underlyingly.)

Coalescence in Nawuri (Casali 1995, 1996b):

Coalescence applies only in cases where V_1 (the first vowel) is [-high] and V_2 (the second vowel) is [+high] /i/ or /ɪ/. (The other high vowels, /u/ and /ʊ/, do not occur word-initially in Nawuri.) The result of coalescence is always a mid vowel that preserves (at a minimum) the [-high] value of V_1 and the frontness or backness (and roundness) of V_2. Thus for example an underlying sequence /ɑ+ɪ/ is realized as [ɛ] (combining the [-high] value of /ɑ/ with the frontness of /ɪ/), while an underlying

sequence /o+i/ is realized as [ʷe] (where the [ʷ] indicates labialization of a preceding consonant).

In cases in which the two input vowel have opposite [ATR] vowels, the phonetic output is always a [+ATR], rather than a [-ATR] vowel:

(94) V_1 [+ATR] + V_2 [-ATR] → V_3 [+ATR] e.g. o+ɪ>ʷe

(95) V_1 [-ATR] + V_2 [+ATR] → V_3 [+ATR] e.g. ɑ+i>e, ɔ+i>ʷe, ɛ+i>e

On the basis of this evidence, [+ATR] is diagnosed as phonologically active in Nawuri. Note that this agrees with other types of evidence for [+ATR] activity in Nawuri discussed earlier.

Whereas [+ATR] is preserved under coalescence in Nawuri, [-ATR] is preserved under coalescence in some other languages. In such languages, the result of coalescence a [+ATR] and [-ATR] vowel is always a [-ATR] vowel. Common patterns of this type include /ɑ+e/ > [ɛ], /ɑ+o/ > [ɔ], /ɑ+i/ > [ɛ], /ɑ+o/ > [ɔ], /ɛ+o/ > [ɔ], /ɔ+e/ > [ɛ].[33]

(96) Kisi examples (Atlantic; Causley & Smallwood 1997)

a. /ɑ+e/ > [ɛ]	kel-e	→	kelɛ	'ring'
b. /ɛ+o/ > [ɔ]	fɛfɛ-o	→	fɛfɔ:	'eave'

These examples provide evidence that [-ATR] is active in Kisi, just as coalescence patterns in Nawuri provide evidence that [+ATR] is active in that language.

ATR activity and frequency

Which [ATR] set occurs most frequently?

There is some evidence of a correlation between the active value of [ATR] in a language and the frequency of the two harmony sets. In many five-height languages with active [+ATR], the [+ATR] vowels occur much less frequently than [-ATR] vowels.

This is what is expected under theories which equate markedness (of which frequency is one diagnostic) with phonological activity. [+ATR] is marked (hence less frequent) and shows phonological activity. [-ATR] is unmarked (hence more frequent) and phonologically inert.

Frequency statistics for four-height languages are harder to come by.

Can the active value of [ATR] be predicted from a language's vowel inventory?

Based on diagnostic criteria of the sort discussed above [+ATR] appears to be active or dominant in some languages (e.g. Akan, Nawuri, Massai), while [-ATR] appears to be active in others (e.g. Yoruba, Bantu C, Kisi).

[33] Which, if any of these patterns occurs will vary from language to language. It is rare for a language to have all of them.

Because of this, phonologists have generally assumed that the active value of [ATR] is simply a language-specific option: some languages happen to employ [+ATR] as the dominant value, while others employ [-ATR].

Claim: The selection of one or the other [ATR] value as active is not random, but is strongly correlated with the type of inventory found in a language (Goad 1993, Casali 1993, 1996, 1998a,b, 1999).

To the extent that evidence is available, [+ATR] activity is normally found in languages of both the Nilo-Saharan and Niger-Congo families with underlying five-height systems.

(97) Five-height languages with dominant [+ATR] (48 total)

Abouré (Kwa; Burmeister 1982), Acholi (Western Nilotic; Hall et. al. 1974, Tucker & Bryan 1957), Ahanta (Kwa; Ntumy 1997a,b), Akan (Kwa; Clements 1981, 1984, Stewart 1967), Akposso (Kwa; Anderson 1999), Alur (Western Nilotic; Kutsch Lojenga 1986), Anum (Kwa; Obeng 1995), Baka (Central Sudanic; Parker 1985), Bari (Eastern Nilotic; Hall & Yokwe 1981), Bete (Kru; Werle & Dagou 1976), Bila (Bantu; Kutsch Lojenga 1994a), Bongo (Chari-Nile; Kilpatrick 1985), Budu (Bantu; Kutsch Lojenga 1994b), Chumburung (Kwa; Snider 1985, 1989b), Dagara (Gur; Pénou-Achille 1982), Deg (Gur; Crouch & Herbert 1997), Didinga (Eastern Sudanic; Odden 1983), Dilo (Gur; Jones 1987), Diola-Fogny (Atlantic; Hall et. al. 1974, citing Sapir 1965), Ega (Kwa; Bole-Richard 1981), Foodo (Kwa; Plunkett 1991), Gichode (Kwa; Keith Snider field notes), Igbira (Nupoid; Scholz 1976), Igbo (Igboid; Stewart 1967), Izi (Benue-Congo, Igboid; Meier et. al. 1975), Kɔnni (Gur; Cahill 1993, 1996), Kabiyè (Gur; Lébikaza 1998), Kinande (Bantu; Mutaka 1995), Kalenjin (Southern Nilotic; Hall et. al. 1974, Lodge 1995, Local & Lodge 1996), Koony (Sabaot) (Southern Nilotic; Kutsch Lojenga 1986, Larsen 1984), Kpokolo (Kru; Kaye et. al. 1985), Krachi (Kwa; Keith Snider field notes), Kusuntu (Gur; Kleinewillinghöfer 1999), Lama (Gur; Ourso 1989a,b), LuBwisi (Bantu; Waller Tabb, personal communication), Lotuko (Eastern Nilotic; Hall et. al. 1974), Mayogo (Ubangi; Connie Kutsch Lojenga, personal communication, McCord 1989), Maasai (Eastern Nilotic; Hall et. al. 1974, Hamaya 1997), Ngiti (Central Sudanic; Kutsch Lojenga 1994c), Nkonya (Kwa; Peacock & Lear 1997), Nzema (Kwa; Alabi Achini, personal communication), Otuho (Eastern Nilotic; Coates 1985, Dick Watson, personal communication), Päkot (Southern Nilotic; Tucker 1964), Tem (Gur; Tchagbale 1976, De Craene 1986), Tepo (Kru; Dawson 1975), Vata (Kru; Kiparsky 1985, Kaye 1982), Waja (Adamawa; Kleinewillinghöfer 1990)

Known exceptions: Turkana, Toposa (Schröeder & Schröeder 1987), and some dialects of Akan (John Stewart, personal communication) have limited instances of dominant [-ATR] activity, in addition to the regular pattern in five-height languages of dominant [+ATR] activity. Puguli (Kevin Warfel, personal communication) and Ninkare (Connie Kutsch Lojenga, personal communication) have limited apparent instances of dominant [-ATR] suffixes. (Beyond this, there are of course many five-height languages for which there is simply no evidence available to determine which, if either value of [ATR] is dominant. These languages are not regarded as counterexamples to the general pattern that [+ATR] is the dominant value in five-height languages, but rather as simply having no bearing on the issue.)

I do not know of a single example of a five-height system in which [-ATR] is regularly the active/dominant value.

[+ATR] activity also appears to be the norm in higher (ɪʊ) four-height systems, although the fact that this system is less common to begin with makes this result perhaps somewhat less certain.[34]

(98) Higher (ɪʊ) four-height languages with dominant [+ATR] (8 total)

Burun (Western Nilotic; Andersen 1993), Kinande (Bantu; Mutaka 1995), Lese-Mvuba (Central Sudanic; Connie Kutsch Lojenga, personal communication), LuBwisi (Bantu; Waller & Mary Tabb, personal communication), Lugbara (Nilo-Saharan; Andersen 1986), Mayogo (Ubangi; McCord 1989), Daza (Saharan; Connie Kutsch Lojenga, personal communication), Zande (Ubangi; Boyd 1997)

The only possible (and somewhat marginal) example of an upper four-height language with dominant [-ATR] I am aware of is Kimatuumbi (Odden 1996).

In contrast, [-ATR] activity is the norm in the lower (eo) type of four-height system (/iɛɛɑ(ə)ɔɔu/).

(99) Lower (eo) four-height languages with dominant [-ATR] (31 total)

Akɔɔse (Bantu; Hedinger & Hedinger 1977), Anufɔ (Kwa; Adjekum et. al. 1993), Attie (Kwa; examples from Connie Kutsch Lojenga personal communication), Bera (Bantu; Kutsch Lojenga 1994a), Bhele (Bantu; Kutsch Lojenga 1994a), Bini (Edoid; Wescott 1962), Bolia (Bantu; Mamet 1960, Leitch 1996), Dangme (Kwa; Dakubu 1987), Efik (Cross River; Cook 1969, Ward 1933, Welmers 1968), Ewe (Kwa; Westermann 1930, Clements 1974), Ewe (Tongu) (Kwa; Mensah 1977), Ga (Kwa; Mensah 1992), Kaba (Central Sudanic; Jim Roberts, personal communication), Kisi (Atlantic; Causley & Smallwood 1997), Komo (Bantu; Thomas 1992, Kutsch Lojenga 1994a), Koyo (Bantu C; Hyman 1999), Lobala (Bantu C; Morgan 1993), Lwankamba (Bantu C; Leitch 1996, Hulstaert 1977), Mbosi Oléé (Bantu C; Leitch 1996, citing Fontaney 1989), Moba (Gur; Jan Russell, personal communication, Russell 1985), Mongo-Nkundo (Bantu C; Hyman 1999), Nkengo (Bantu C; Hulstaert 1970), Owon Afa (Defoid; Awobuluyi 1972), Tetela (Bantu C; Leitch 1996, citing Jacobs 1964), Yakata (Bantu; Motingéa 1993), Yengé (Bantu C; Hulstaert n.d.), Yoruba--Standard (Defoid; Archangeli &

[34] Some higher (ɪʊ) seven-vowel languages (e.g. Kinande, LuBwisi) have coalescence patterns in which the [+ATR] vowels /i/ and/or /u/ coalescence with the [-ATR] vowel /ɑ/ to form [ɛ] and/or [ɔ] respectively. Since [-ATR] is preserved in such cases, this type of coalescence might appear to pose a problem for the generalization that higher (ɪʊ) seven-vowel languages have active [+ATR] and not active [-ATR]. Note however that if /ɑ+i/ and /ɑ+u/ were to coalesce (respectively) to [e] and [o], preserving [+ATR] (along with [-high], whose preservation in the output is a hallmark of this common type of height coalescence--see Casali 1996a,b), this would result in sounds which are not part of the underling inventory. Hence, the realization of these sequences instead as [ɛ] and [ɔ] can be viewed as an example of the very common *structure preservation* effect, in which sounds that would otherwise result from some process are replaced by sounds that are part of the underlying inventory. (Note that the ATR assimilation process referred to in the immediately preceding paragraph, which realizes /ɛ/ and /ɔ/ as [e] and [o] in [+ATR] contexts, does *not* obey structure preservation. This is not necessarily problematic, however, as it is common to find that some processes in a language are structure preserving while others are not.)

Pulleyblank 1989), Yoruba--Ekiti (Defoid; Oyelaran 1973), Yoruba--Ifaki (Defoid; Fresco 1970 as cited in George 1973), Yoruba--Ijesa (Defoid; Oyelaran 1973)

The evidence for [-ATR] dominance in many of these languages is limited to cases (numerous in some languages, not so numerous in others) of [-ATR] preservation under coalescence. However, the fact that these kinds of coalescence patterns (e.g. ɑ+ɐ > ɛ, ɛ+o > ɔ, ɑ+ɔ > ɔ, etc.) are extremely common in lower four-height languages but (as far as I can tell) completely unattested in five-height systems, makes it likely that this evidence is significant.

I know of no examples of lower (eo) four-height systems with clear evidence of dominant [+ATR].

Summary:

- [+ATR] is normally the active value in five-height languages and languages with the higher (ɪu) four-height system (/iɪɛɑ(ə)ɔʊu/).
- [-ATR] is normally the active value in languages with the lower (eo) type of four-height system (/ieɛɑ(ə)ɔou/).

Comments:

- These generalizations refer to the *underlying* system of a language and not its *surface* system. (It is possible to find surface systems which violate them.)
- There may very well be languages in which everything is fully symmetric so that it is impossible to tell which value of [ATR] is active. However, in languages in which there *is* evidence that one value of [ATR] is active, the generalizations above are normally expected to hold.
- It is not possible to know at this point whether these generalizations constitute absolute or merely statistical universals; at the very least there are some apparent counterexamples which need to be accounted for. It is safe to assume however that these correlations are not coincidental and need to be explained by phonological theory. They can also serve as useful guidelines for what to expect in working with a particular type of systems.

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Appendix A: Four- and five-height languages in African language families

Listed in this appendix are the examples of four- and five-height African languages (in which ATR harmony is a priori a likely possibility) in different language families currently in my database. I have grouped these first by language families and then by vowel system type in the hope that this will allow the appendix to be useful in getting a feel for the types of vowel systems that are likely to be encountered in a given family. It must be cautioned however that this usefulness is limited not only by the fact that some language families (e.g. Kordofanian) which may commonly have vowel systems of these types are greatly underrepresented in my database, but also by the fact that the selection of languages from a particular family (even in the case of families with a reasonable number of languages in my database) is not guaranteed to be representative of what occurs in the family as a whole. Despite these limitations, it is hoped that the information of these lists will still be of use in many cases; at the very least, they serve to establish that certain types of systems clearly occur with some frequency in some families; there can be no doubt that five-height systems are widely attested in families like Kwa, Gur, and Nilotic, or that lower (eo) four-height systems are extremely common in Bantu for example.

The lists below contain about 300 four- and five-height languages. Although this is a significant number, it seems clear that it does not come close to the total number of languages with such systems in Africa. I would be very grateful for information about additional languages which can be added to these lists, and also for any reports of factual errors in the information below.

As might be expected in a work dealing with ATR harmony, an effort is made to specify which languages exhibit this phenomenon. This is done by means of the designation (y) following languages in which ATR harmony has been reported, and the designation (n) following languages for which a descriptive sources explicitly states that ATR harmony does not occur. In (the very large number of) cases where neither designation appears, this indicates that the sources consulted do not state whether or not ATR harmony occurs in the language.

Afro-Asiatic, Chadic

Five-height, 9 vowels: Tangale (y) (Hall et. al. 1974, Kleinewillinghöfer 1990)

Lower (eo) four-height system, 8 vowels (7 vowels + /ə/): Pero (Jungraithmayr 1971), Wurkun (Jungraithmayr 1971)

Afro-Asiatic, Cushitic

Five-height system, 11 vowels: Boni (y) (Heine 1980)

Five-height system, 10 vowels: Somali (y) (Halle et. al. 1974, Heine 1980)

Niger-Congo, Adamawa

Lower (eo) four-height system, 7 vowels: Nzakanbay (y) (Jim Roberts, personal communication), Doayo (Hartell 1993)

Niger-Congo, Atlantic

Five-height system, 10 vowels: Diola-Fogny (y) (Hall et. al. 1974, citing Sapir 1965, Gero & Levinsohn 1993)

Lower (eo) four-height system, 7 vowels: Kisi (Causley & Carolyn Smallwood 1997)

Niger-Congo, Benue-Congo, Bantu (Grassfields)

Lower (eo) four-height system, 9 vowels (7 + 2 additional central vowels): Bafut (Hartell 1993)

Four-height system, 8 vowels (/ieɑɔou/ + 2 additional central vowels, missing /ɛ/): Metta (Hartell 1993)

Niger-Congo, Benue-Congo, Bantu (Narrow)

Five-height system, 12 vowels: Kɔɔzime (Hartell 1993)

Five-height system, 9 vowels: Bali (y) (Kutsch Lojenga 1994a), Bila (y-limited) (Kutsch Lojenga 1994a), Budu (y) (Koehler 1995, Kutsch Lojenga 1994b), Mbo (y) (Kutsch Lojenga 1994a), Ndaka (y) (Kutsch Lojenga 1994a), Nyali (y) (Kutsch Lojenga 1994a), Tswana(?) (Hyman 1999), Sotho(?) (Hyman 1999)

Five-height system, 9 vowels or higher (ɪʊ) four-height system, 7 vowels (sources disagree): Vanuma (y) (Kutsch Lojenga 1994a)

Higher (ɪʊ) four-height system, 7 vowels: Sukuma (Tucker & Bryan 1957, Hyman 1999, Stewart 1983), Bwisi (y) (Tucker & Bryan 1957, Waller Tabb, personal communication, Connie Kutsch Lojenga, personal communication), Kikuyu (Leakey 1959, Tucker & Bryan 1957), Nilyamba (Tucker & Bryan 1957), Rangi (Oliver Stegen, personal communication), Londo(?) (Hyman 1999), Konzo(?) (Hyman 1999), LuGungu(?) (y) (Kutsch Lojenga 1999b), Logoli(?) (Hyman 1999), Gusii(?) (Tucker & Bryan 1957, Hyman 1999), Rimi(?) (Hyman 1999), Nyamwezi (Hyman 1999), Kinga(?) (Hyman 1999), Kimatuumbi (Odden 1996), Amba (Tucker & Bryan 1957), Kinande (y) (Mutaka 1995), Kamba (Whitely & Muli 1962, Roberts-Kohno 1994), Ibuon (Dawson & Dawson 1996)

Lower (eo) four-height system, 8 vowels (/ieɛɑəɔou/): Akɔɔse (Hedinger & Hedinger 1977)

Lower(eo) four-height system, 7 vowels: Amba (y-limited) (Kutsch Lojenga 1994a), Bera (y-limited) (Kutsch Lojenga 1994a), Bhele (y-limited) (Kutsch Lojenga 1994a), Komo (y-limited) (Thomas 1992, Kutsch Lojenga 1994a), Kuria (Tucker & Bryan 1957), Nata (Tucker & Bryan 1957), Yakata (Motingéa 1993), Basaa (Hartell 1993, Hyman 1999), Kakɔ (Hartell 1993), Mboo (Hartell 1993), Bakweri(?) (Hyman 1999), Duala (Hartell 1993, Hyman 1999), Nugunu (Orwig 1989, Hyman 1999), Seki(?) (Hyman 1999), Kota(?) (Hyman 1999), Bia(?) (Hyman 1999), Bobe(?) (Hyman 1999), Himba(?) (Hyman 1999), Pinzi(?) (Hyman 1999), Tsogo (Hyman 1999), Kande(?) (Hyman 1999), Nzebi(?) (Hyman 1999), Tiene(?) (Hyman 1999), Boma (Hyman 1999), Babole (y) (Leitch 1996), Bolia (y) (Mamet 1960), Lobala (y) (Morgan 1993), Lwankamba (y) (Leitch 1996, Hulstaert 1977), Mbosi Oléé (y) (Leitch 1996, citing Fontaney 1989), Nkengo (Hulstaert 1970), Tetela (y) (Leitch 1996, citing Jacobs 1964), Yengé (Hulstaert n.d.), Leke (Hyman 1999), Koyo (y) (Hyman 1999), Mboshi (Hyman 1999), Doko (Hyman 1999), Bobangi (Hyman 1999), Lingala (Hyman 1999), Ngombe (Hyman 1999), Bango (Hyman 1999), Leku

(Hyman 1999), Mongo (Hyman 1999), Mongo-Nkundo (y) (Hyman 1999), Tetela (Hyman 1999), Kela (Hyman 1999), Wongo (Hyman 1999), Lega (Hyman 1999), Nilamba (Hyman 1999)

Four-height system, 7 vowel system (/ieɑəɔou/): Ewondo (Hartell 1993)

Niger-Congo, Benue-Congo, Central Delta

Five-height system, 10 vowels: Abua (y) (Williamson 1983), Kugbo (y) (Williamson 1983), Odual (y) (Williamson 1983), Ogbia (y) (Williamson 1983)

Niger-Congo, Benue-Congo, Cross River

Five-height system, 10 vowels: KoHumono (Cook 1968, as cited in Williamson 1973)

Five-height system, 9 vowels: Agwagwune (y-limited) (Williamson 1973)

Lower (eo) four-height system, 7 vowels: Efik(?) (Cook 1969, Ward 1933, Welmers 1968), Kana (Williamson 1973), Mbembe (Barnwell 1969), DuRop (y) (Kastlelein 1994)

Four-height system, 6 vowels (/ieɑɔou/): Ibibio (Williamson 1973, citing Cook 1969), Obolo (Williamson 1973)

Niger-Congo, Benue-Congo, Defoid

Lower (eo) four-height system, 7 vowels: Yoruba (y) (Archangeli & Pulleyblank 1989), Owon Afa (Awobuluyi 1972), Isekiri (Dunstan 1969), Ife (Coleen Anderson, personal communication)

Niger-Congo, Benue-Congo, Edoid

Five-height system, 10 vowels: Engenni (y) (Thomas 1978, Savage 1987), Degema (y) (Fulop et. al. 1998, Elugbe 1983)

Five-height system, 9 vowels: Isoko (Donwa-Ifode 1985), Okpe (y) (Omamor 1973, 1988), Uvwie (y) (Omamor 1973, 1988), Emalhe (y) (Laniran 1985)

Lower (eo) four-height system, 7 vowels: Etsako (Elimelech 1976), Emai (Folarin-Schleicher 1992, Schaefer 1987), Bini (Wescott 1962)

Niger-Congo, Benue-Congo, Idomoid

Five-height system, 10 vowels: Igede (y) (Armstrong 1985, Abiodun 1989, 1991 Bergman 1968, 1971)

Niger-Congo, Benue-Congo, Igboid

Five-height system, 9 vowels: Ikwere (y?) (Clark 1971), Ogba (y?) (Clark 1971), (y?) Ekpeje (Clark 1971), Izi (y) (Meier et. al. 1975)

Five-height system, 8 vowels (/iɪeɑɔouu/): Igbo (y) (Williamson 1973)

Niger-Congo, Benue-Congo, Ijoid

Five-height system, 9 vowels: Ibani (Williamson 1973), Kalabari Ijo (y) (Jenewari 1973, 1989, Akinlabi 1997)

Niger-Congo, Benue-Congo, Kainji

Lower (eo) four-height system, 8 vowels (/ieɛɑɨɔou/) C'Lela (n) (Dettweiler 1997, 1998)

Niger-Congo, Benue-Congo, Mambiloid

Lower (eo) four-height system, 10 vowels (7 + 3 additional central vowels): Kwanja (Blench 1993), Nizaa (Blench 1993)

Four-height system, 6 vowels (/ieɑɔou/), existence of ATR harmony not known: Mambila (Hartell 1993, Perrin & Hill 1969)

Niger-Congo, Benue-Congo, Nupoid

Five-height system, 9 vowels: Ebira (y) (Adive 1984, Scholz 1976), Gade (y?) (Sterk 1990)

Niger-Congo, Benue-Congo, Oko

Lower (eo) four-height system, 7 vowels: Ogori (y) (Chumbow 1982a, b)

Niger-Congo, Benue-Congo, Platoid

Higher (ɪu) four-height system, 8 vowels (/iɪɛɑəɔʊu/): Kuche(?) (Wilson 1996a,b)

Niger-Congo, Gur

Five-height system, 11 vowels (9 + 2 additional central vowels): Lama (y) (Ourso 1989a,b)

Five-height system, 10 vowels: Deg (y) (Crouch & Herbert 1997), Kasem (y) (Awedoba 1992, Bonvini 1974, Adongo 1976), Lobiri (y) (Audrey Joslin, personal communication), Nuni (y) (Kurrle 1988, Yago 1984), Koromfe (y) (Rennison 1984, Chris Ladish, personal communication)

Five-height system, 9 vowels: Dagaari (y) (Cahill 1991, Bodomo 1997), Dagara (y) (Pénou-Achille 1982), Dilo (y) (Jones 1987), Dɔgɔsɛ (y?) (Ouattara n.d.), Frafra (y) (Azennaba 1979, Ephraim 1999), Kaansa (y) (Stuart Showalter, personal communication), Kabiyè (y) (Kézié Lébikaza, personal communication, Lébikaza 1998, Delord 1976), Kɔnni (y) (Cahill 1993, 1996), Kusuntu (y) (Kleinewillinghöfer 1999), Lokpa (y) (Hartell 1993, Akawe 1999), Loron (y) (Leenhouts & Person 1977), Nafara (Aglo 1989-1990), Nankani (y) (Azennaba 1979, Azagsiba 1977), Pasaale (y) (Toupin 1995), Puguli (y) (Kevin Warfel, personal communication), Safaliba (Paul Schaefer, personal communication), Sisaala (y) (Hartell 1993), Tem (y) (Tchagbale 1976, De Craene 1986), Wali (y) (Cahill 1991), Winye (y) (Zerbo 1994), Yom (Hartell 1993)

Higher (ɪu) four-height system, 7 vowels: Nawdm (some dialect(s)) (Jacques Nicole, personal communication)

Lower (eo) four-height system, 8 vowels (7 + /ə/): Nateni (Coleen Anderson, personal communication)

Lower (eo) four-height system, 7 vowels: Bariba (Hartell 1993), Bwanmu (Bolli et. al. 1981, Sharyn Thompson, personal communication), Cerma (Hartell 1993), Ditammari (Zürcher 1983, Hartell 1993), Djimini (Inge Egner, personal

communication), Gangam (Coleen Anderson, personal communication), Karaboro (Hartell 1993), Kolia (y) (Rongier 1999), Nawdm (some dialect(s)) (Jacques Nicole, personal communication), Pana(?) (Beyer 1999), Tyébara (Soro 1999), Waama (Hartell 1993)

Four-height system, 7 vowels (/iɛɑəɔou/): Lyele (Bassole 1982, Kutsch Lojenga 1986, Hartell 1993)

Four-height system, 6 vowels (/ieɑəɔou/): Moba (Jan Russell, personal communication, Russell 1985)

Niger-Congo, Kordofanian

Higher (ɪu) four-height system, 7 vowels: Tira (y) (Kathie Watters, personal communication)

Niger-Congo, Kru

Five-height system, 13 vowels (9 + 4 additional central vowels): Bete (y) (Inge Egner, personal communication, Werle & Dagou 1976, Marchese 1983), Godie (y) (Inge Egner, personal communication, Marchese 1983), Kpokolo (y) (Kaye et. al. 1985)

Five-height system, 12 vowels (9 + 3 additional central vowels): Koyo (Marchese 1983)

Five-height system, 10 vowels: Vata (y) (Kiparsky 1985, Kaye 1982)

Five-height system, 9 vowels: Dida (Inge Egner, personal communication, Marchese 1983), Aizi (y) (Marchese 1983), Cedepo (y-limited) (Marchese 1983), Grebo (y-limited) (Marchese 1983), Krahn (y-limited) (Marchese 1983), Néyo (y) (Marchese 1983), Tepo (y) (Dawson 1975), Guere (y) (Paradis & Prunet 1990), Klao (Marchese 1983, Singler l983), Niaboua (y) (Inge Egner, personal communication, Marchese 1983), Wobe (Bearth & Hofer 1975, Marchese 1983)

Lower (eo) four-height system, 10 vowels (7 + 3 additional central vowels): Sɛmɛ (Marchese 1983)

Lower (eo) four-height system, 7 vowels: Bassa (Marchese 1983), Dewoin (Marchese 1983), Kuwaa (Marchese 1983)

Niger-Congo, Kwa

Five-height system, 10 vowels: Abron(?) (y) (Ravenhill 1982), Akposso (y) (Anderson 1999), Abbey(?) (Nguessan 1982), Anyi-Sanvi(?) (y) (Retford 1971, Burmeister 1982), Anyi (y) (Burmeister 1988)

Five-height system, 9 vowels: Abidji (y) (Tresbarats 1982), Abouré (y) (Burmeister 1982), Akan (y) (Clements 1981, 1984, Stewart 1967, Berry 1957), Anum (y) (Obeng 1995, Painter 1971), Avatime (y) (Schuh 1995, Maddieson 1995), Chumburung (y) (Snider l985, Snider 1989b), Ega (y) (Bole-Richard 1981, 1982), Eotile (y) (Hérault 1982), Foodo (y) (Plunkett 1991), Gichode (y) (Lenwah 1979, Snider 1989), Gonja (y?) (Snider 1989), Cherepon (y) (Bransom 1981), Larteh (y) (Banchi n.d.), Ikposo (y) (Ring & Numuley n.d.), Krachi (y) (Snider 1989), Nawuri (y) (Casali 1988, 1995, 1999), Nkonya (y) (Peacock &

Lear 1997), Nzema (y) (Berry 1955), Anyi (Indenie) (Retford 1971), Ahanta (y) (Ntumy 1997a,b), Anyi (Moronou, Tiassale dialects) (Retford 1971)

Lower (eo) four-height system, 9 vowels (7 + /ə/, /ɨ/): Attie (Kutsch Lojenga & Hood 1982)

Lower (eo) four-height system, 8 vowels (7 vowels + additional central vowel /ə/ or /ɨ/): Ewe (Tongu dialect) (Mensah 1977), Alladian (y-limited) (Duponchel & Bertin 1982)

Lower (eo) four-height system, 7 vowels: Adja (Hartell 1993), Anufɔ (y) (Adjekum et. al. 1993), Baoule (Nguessan 1982), Betibe (Stewart 1983), Dangme (Dakubu 1987), Ebrie (Bole-Richard 1982), Ewe (Kpandu dialect) (Mensah 1977), Ewe (Peki dialect) (Mensah 1977), Fɔn (Hartell 1993), Ga (Mensah 1992), Gɛn-Mina (Hartell 1993), M'batto (n) (Grassias & Bole-Richard 1982, Robert Hale, personal communication), Maxi (n) (Gbéto 1997), Sele (y) (Allen 1974, Harflett 1999), Siwu (Iddah 1972), Tɔfin (Hartell 1993), Adioukrou (y) (Hérault 1982b), Avikam(?) (y) (Hérault 1982c), Krobou(?) (y-limited) (Mensah 1982), Bowiri (y) (Ian Maddieson, personal communication)

Four-height system, 7 vowels (/ieɑəɔou/): Ewe (Anglɔ dialect) (Mensah 1977)

Niger-Congo, Mande

Five-height system, 10 vowels: Bisa (Hartell 1993)

Five-height system, 9 vowels: Beng (Inge Egner, personal communication), Gouro (y) (Le Saout 1979), Yaouré (y-limited) (Hopkins 1987)

Lower (eo) system, 7 vowels: Boussa (Hartell 1993), Jula (Tourville 1993), Jo (Djilla 1999)

Niger-Congo, Ubangi

Higher (ɪʊ) four-height system, 8 vowels (7 + 1 additional central vowel): Mayogo (y?) (Connie Kutsch Lojenga, personal communication, McCord 1989), Zande (y) (Boyd 1997)

Lower (eo) four-height system, 7 vowels: Ngbaka (y) (Jim Roberts, personal communication)

Nilo-Saharan, Central Sudanic

Five-height, 10 vowels: Baka (y) (Parker 1985), Moru (y) (Andersen 1986), Bongo (y) (Kilpatrick 1985)

Five-height system, 9 vowels: Ma'di (y) (Kilpatrick 1985, Andersen 1986), Ngiti (y) (Kutsch Lojenga 1994c), Mangbetu (Connie Kutsch Lojenga, personal communication., Demolin 1992), Lulobo (Andersen 1986)

Four-height system, ieauoɔ (and possibly ɨ): Kaba (y) (Jim Roberts, personal communication)

Higher (ɪʊ) four-height system, 7 vowels: Lugbara (y) (Andersen 1986), Lese-Mvuba (Connie Kutsch Lojenga, personal communication)

Higher (ɪʊ) four-height system, 8 vowels (iɪɛɑəɔʊu): Lendu (n) (Kutsch Lojenga 1989)

Four-height system, 7 vowels (iɪɛɑʌɔu): Omiti (Kaliko) (Connie Kutsch Lojenga, personal communication)

Four-height system, 7 vowels (iɪɛɑɨɔu): Avokaya (y?) (Eileen Kilpatrick, personal communication, Andersen 1986)

Nilo-Saharan, Eastern Sudanic, Eastern Nilotic

Five-height system, 10 vowels: Otuho (y) (Coates 1985, Dick Watson, personal communication), Bari (y) (Hall & Yokwe 1981), Lotuko (y) (Hall et. al. 1974)

Five-height system, 9 or 10 vowels (sources disagree), Turkana (y) (Noske 1990, Wedekind 1989, Dimmendaal 1983, Heine 1980)

Five-height system, 9 vowels: Maasai (y) (Hall et. al. 1974, Hamaya 1997), Toposa (y) (Schröder & Schröder 1987)

Nilo-Saharan, Eastern Sudanic, Southern Nilotic

Five-height system, 10 vowels: Kalenjin (y) (Hall et. al. 1974, Lodge 1995, Local & Lodge 1996, Creider & Creider 1989, Rottland 1980), Nandi (y) (Tucker 1964), Päkot (y) (Tucker 1964)

Five-height system, 9 or 10 vowels (sources appear to disagree): Sabaot (y) (Larsen 1984, Kutsch Lojenga 1986)

Five-height system, 9 vowels: Akie (y) (Rottland 1980)

Lower (eo) four-height system, 8 vowels (7 + low central [+ATR]): Omotik (y) (Rottland 1980)

Lower (eo) four-height system, 7 vowels: Datooga(?) (Rottland 1980)

Nilo-Saharan, Eastern Sudanic, Surma

Five-height system, 9 vowels: Didinga (y) (Wedekind 1989, Odden 1983, De Jong 1999)

Lower (eo) four-height system, 7 vowels: Me'en (Wedekind 1989)

Nilo-Saharan, Eastern Sudanic, Western Nilotic

Five-height system, 10 vowels: Acholi (y) (Hall et. al. 1974, Tucker & Bryan 1957), Anywak (y) (Dick Watson, personal communication, Reh 1996), Luo (y) (Hall et. al. 1974, Tucker & Bryan 1957), Päri (y) (Andersen 1989), Adhola (Tucker & Bryan 1957), Dinka (Dick Watson, personal communication), Lango (Tucker & Bryan 1957, Noonan 1992)

Five-height, 9 vowel: Alur (y-limited) (Kutsch Lojenga 1986)

Higher (ɪʊ) four-height system, 8 vowels (iɪɛɑʌɔʊu): Burun (Andersen 1993)

Lower (eo) four-height system, 7 vowels: Nuer (Yigezu 1995)

Nilo-Saharan, Mabang

Five-height system, 10 vowels: Massalit (y) (Jim Roberts, personal communication)

Lower (eo) four-height system, 7 vowels: Aiki (Nougayrol 1989)

Nilo-Saharan, Saharan

Five-height system, 11 vowels (9 + 2 additional central vowels): Kanembu (y) (Roberts 1994, citing Jouannet 1982)

Five-height system, 9 vowels (or, higher (IU) four-height system, 7 vowels--not yet clear): Teda (Kevin Walters, personal communication, Connie Kutsch Lojenga, personal communication)

Higher (IU) four-height system, 7 vowels (or possibly five-vowel system, 9 vowels): Daza (Kevin Walters, personal communication, Connie Kutsch Lojenga, personal communication)

Appendix B: Suggested additional reading on ATR harmony in African languages

Note: A good place to obtain copies of almost any of the published articles (even those in relatively obscure books / journals) listed below is through Wycliffe Associates U.K., who have access to the British Library (and other libraries) and will mail copies to SIL members/entities in overseas locations, charging their accounts directly. (Typically the total cost, including shipping, is not more than about five U.S. dollars.) For help in obtaining copies of other items, such as unpublished manuscripts, contact the Africa Area linguistics coordinator.

List 1: General introductory reading for language teams working in areas with vowel harmony

1. Hall, B.L.; R.M.R. Hall; M.D. Pam; A. Myers; S.A. Antell; and G. Cherono. 1974. African vowel harmony systems from the vantage point of Kalenjin. Afrika und Übersee 57.241-267.
2. Ladefoged, Peter & Ian Maddieson. 1995. Sounds of the world's languages. Oxford: Blackwell. *Read the material on vowel features, especially ATR.*
3. Pike, Kenneth L. 1967. Tongue-root position in practical phonetics. Phonetica 17.129-140.
4. Stewart, John M. 1967. Tongue root position in Akan vowel harmony. Phonetica l6:l85-204.
5. Clements, G. N. 1981. Akan vowel harmony: A nonlinear analysis. Harvard Studies in Phonology 2.108-177.
6. Jacobson, Leon C. 1980. Voice-quality harmony in Western Nilotic languages. In Issues in Vowel Harmony, ed. by R. Vago, 183-200. Amsterdam: John Benjamins.
7. Larsen, Iver A. 1984. Vowel harmony in Koony. Occasional papers in the study of Sudanese languages 3:29-45.
8. Bole-Richard, Rémy. 1981. Une autre approche de l'harmonie vocalique: le mot phonologique en Ega. Cahiers Ivoriens de Recherche Linguistique 10:31-51. Abidjan: Institut de Linguistique Appliquée, Université Nationale de Côte d'Ivoire.
9. Boyd, Raymond. 1997. Les harmonies vocaliques du zande. Lingua 101:1-19.

Item 1 is a highly readable discussion of ATR harmony, which while it focuses primarily on East African languages, contains material which will be of interest to those working on West African languages as well. It is in some sense a landmark study, which is often cited by later writers.

Items 2-4 have useful and accessible discussions of the phonetics of ATR vowel systems. Item 4 also contains interesting and relevant discussion (much of which is potentially relevant to Nilo-Saharan as well as Niger-Congo) of the phonological behavior of ATR and orthographic issues, and is therefore highly recommended.

Item 5 contains one of the earliest and most extensive applications of autosegmental theory to ATR vowel harmony. Although its orientation is theoretical, it contains a very clear factual description of Akan vowel harmony, drawing on a number of earlier studies but also going beyond them in a number of respects in the descriptive generalizations which it presents. Because the Akan system is typical of many other West African vowel harmony systems, it is highly recommended for people planning to work in this part of the world. (It is also a clear and useful introduction to certain aspects of autosegmental phonology, although those with no previous background in

the theory might do well to consult an introductory textbook first, or the first chapter of Keith Snider's book on tone.)

Items 6 and 7 will be of interest primarily to people working in Nilo-Saharan languages (especially Nilotic), but have some general discussion of the phonetics of ATR that may be useful to those working in Niger-Congo also. Item 7 has a very thorough and helpful discussion of the impressionistic phonetic quality of ATR contrasts which, though based on one language, are very applicable to what has been described in other Nilo-Saharan (and even Niger-Congo) languages also. It also contains some helpful practical suggestions for dealing with the difficulties that arise in many ATR harmony languages (of both major families) in hearing some of the vowel contrasts. It could serve, moreover, as a very good model of information to include in a description of an ATR harmony system and should probably be considered "must" reading for those planning to do descriptive fieldwork on ATR harmony systems in Nilo-Saharan languages.

Item 8 is a clear and insightful description, in French, of vowel harmony in Ega, a Kwa language with a harmony system typical of a great many West African languages. Though arguably superseded to some extent by later autosegmental approaches, the theoretical analysis Bole-Richard proposes for ATR vowel harmony is also of interest.

Item 9, also in French, will be of interest primarily to those working in languages with vowel systems of the form /iɪɛaɔʊu/ (with or without an additional central vowel /ə/ or /ɨ/).

List 2: Suggested additional reading for phonology consultants and specialists, and those who intend to do further study involving (or who simply want to develop a deeper knowledge of) ATR harmony

A. Historical/typological/comparative studies

Read those which seem most relevant, based on the language family/families you are working in.

Casali, Roderic F. 1995. On the reduction of vowel systems in Volta-Congo. African Languages and Cultures 8, 2:109-121.

Casali, Roderic F. 1997. ATR harmony systems: Some issues for research. Handout of paper presented at the 28th Annual Conference on African Linguistics, Cornell University, July 11-13, 1997.

Dakubu, M. E. Kropp. 1997?. Oti-Volta vowel harmony and Dagbani. MS, University of Ghana.

Donwa-Ifode, Shirley. 1989. Prefix vowel reduction and loss of noun class distinctions: The Edoid case. Afrika und Übersee 72:229-253.

Elugbe, Ben Ohi. 1983. The vowels of Proto-Edoid. Journal of West African Languages 13(1).79-89.

Ford, K.C. 1973. On the loss of cross-height vowel harmony. Research Review, Supplement 4.50-80. Legon: University of Ghana, Institute of African Studies.

Hall, Beatrice L & Eluzai M. Yokwe. 1981. Bari vowel harmony: The evolution of a cross-height vowel harmony system. Occasional papers in the study of Sudanese languages 1:55-63. Juba: College of Education, University of Juba.

Hyman, Larry. M. To appear (1999). The historical interpretation of vowel harmony in Bantu. To appear in Recent Advances in Bantu Historical Linguistics, ed. by Jean-Marie Hombert & Larry M. Hyman. C.S.L.I.
Painter, Colin. 1972. Phonological features underlying vowel harmony loss in certain West African languages. In Fourteen Papers on Gwa and Fifty-two Texts in Gwa, by Colin Painter, 30-33. (Collected language notes, 12.) Legon: Institute of African Studies, University of Ghana.
Rottland, Franz. 1980. Vowel harmony in Southern Nilotic. MS, University of Nairobi.
Snider, Keith L. 1989. The vowels of proto-Guang. Journal of West African Languages XIX, 2:29-50.
Academy of Sciences.
Stewart, John M. 1983. The high unadvanced vowels of proto-Tano-Congo. Journal of West African Languages 13(1).19-50.
Wedekind, Klaus. 1989. Status and dynamics of Ethiopian vowel systems. Journal of Ethiopian Studies 22:105-172.
Williamson, Kay. 1983. Vowel merger in harmony languages. Journal of the Linguistic Association of Nigeria 2.61-82.

B. Descriptive studies, by language area or family

Where possible, up to six have been included under each language family. It is recommended that each person read those from the language family/families they intend to focus on, although it might be helpful to become somewhat familiar with ATR patterns in other language families also. Further examples of works on ATR harmony in languages in most of these families can be found in my more extensive "Bibliography on ATR/RTR Harmony in African Languages."

1. Niger-Congo, Adamawa-Ubangi

Boyd, Ginger. 1997. A phonology and grammar of Mbodɔmɔ. University of Texas at Arlington MA thesis.
Boyd, Raymond. 1997. Les harmonies vocaliques du zande. Lingua 101:1-19.
Kleinewillinghöfer, Ulrich. 1990. Aspects of vowel harmony in Waja and Tangale-Waja common vocabulary. Frankfurter Afrikanistische Blätter 2:93-106.
McCord, Michael Steven. 1989. Acoustical and autosegmental analyses of the Mayogo vowel system. Arlington, TX: University of Texas at Arlington MA thesis.

2. Niger-Congo, Atlantic

Ka, Omar. 1987/8. Wolof phonology and morphology: A non-linear approach. Ph.D. dissertation, University of Illinois.
Sapir, David J. 1965. A grammar of Diola-Fogny. (West African Language Monographs, 3.) Cambridge: Cambridge University Press.

3. Niger-Congo, Bantu

Hyman, Larry. M. To appear (1999). The historical interpretation of vowel harmony in Bantu. To appear in Recent Advances in Bantu Historical Linguistics, ed. by Jean-Marie Hombert & Larry M. Hyman. C.S.L.I.

Leitch, Myles. 1996. Vowel harmonies of the Congo basin: An optimality theory analysis of variation in the Bantu zone C. Vancouver, B.C.: University of British Columbia dissertation.
Koehler, Loren Scott. 1995. An underspecification approach to Budu vowel harmony. Arlington, TX: University of Texas at Arlington MA thesis.
Kutsch Lojenga, Constance. 1991. KiBudu: A Bantu language with nine vowels. Paper presented at the 22nd Annual Conference on African Linguistics, Nairobi.
Kutsch Lojenga, Constance. 1994. The vowel system of BILA, a Bantu language of the northern Bantu borderland in Zaire. Paper presented at the Leiden University annual African Linguistics Colloquium.
Mutaka, Ngessimo M. 1995. Vowel harmony in Kinande. Journal of West African Languages 25(2).42-55.
Thomas, John Paul. 1992. A morphophonology of Komo: Non-tonal phonology. Grand Forks, ND: University of North Dakota MA thesis.

4. Niger-Congo, Benue-Congo (non-Bantu)

Abiodun, Michael. 1991. Vowel harmony in Igede. Studies in African Linguistics 22.157-169.
Chumbow, Beban Sammy. 1982. Ogori vowel harmony: An autosegmental perspective. Linguistic Analysis 10(1).61-93.
Dettweiler, Stephen. 1997. Syllabification and vowel harmony in c'Lela. MS, Nigeria Bible Translation Trust.
Omamor, Phil. Augusta. 1988. Okpe and Uvwie: A case of vowel harmony galore. Journal of West African Languages 18(1).47-64.
Runsewe, Oluremi I. 1988. Vowel Harmony in Lòkə́ə. Journal of West African Languages 18(1).41-46.
Wilson, Janet. 1996. Acoustic properties of vowels and glides in Kuche. MS, University of Texas at Arlington.

5. Niger-Congo, Gur

Cahill, Mike. 1996. ATR harmony in Kɔnni. Ohio State University Working Papers in Linguistics 48:13-30.
Dakubu, M. E. Kropp. 1997?. Oti-Volta vowel harmony and Dagbani. MS, University of Ghana, Legon.
Ouattara, Balagassina. n.d. Esquisse phonologigue du Dɔgɔsɛ: Variété Klamaasısɛ. Ouagadougou: MS, Société Internationale de Linguistique.
Rennison, John. 1984. On the vowel harmonies of Koromfe (Burkina Faso, West Africa). In Phonologica 1984: Proceedings of the Fifth International Phonology Meeting Eisensdadt, 25 -- 28 June 1984, ed. by Wolfgang U. Dressler, Hans C. Luschützky, Oskar E. Pfeiffer, and John R. Rennison, 239-246. London: Cambridge University Press.
Tchagbale, Zakari. 1976. Phonologie et tonologie du tem. Paris: Université de la Sorbonne Nouvelle dissertation.
Zerbo, Mamina Marie-Thérèse. 1994. Esquisse phonologique du Wine. Memoire de Maitrise, Universite de Ouagadougou.

6. Niger-Congo, Ijo

Akinlabi, Akinbiyi. 1997. Kalabari vowel harmony. To appear in The Linguistic Review, volume 14.

Jenewari, Charles. 1973. Vowel harmony in Kalabari Ijo. Research Notes from the Department of Linguistics and Nigerian Languages, University of Ibadan, 6.59-78.

7. Niger-Congo, Kwa

Anderson, Coleen G. 1999. ATR vowel harmony in Akposso. Studies in African Linguistics 28:186-214.

Bole-Richard, Rémy. 1981. Une autre approche de l'harmonie vocalique: le mot phonologique en Ega. Cahiers Ivoriens de Recherche Linguistique 10:31-51. Abidjan: Institut de Linguistique Appliquée, Université Nationale de Côte d'Ivoire.

Clements, G. N. 1974. Vowel harmony in Ewe. Studies in African Linguistics 5.281-301.

Clements, G. N. 1981. Akan vowel harmony: A nonlinear analysis. Harvard Studies in Phonology 2.108-177.

Obeng, Samuel Gyasi. 1995. Vowel harmony in Gwa Nmle. MS, Indiana University.

Schuh, Russell. 1995. Aspects of Avatime phonology. Studies in African Linguistics 24.31-67.

8. Niger-Congo, Kru

Dawson, Keith. 1975. L'accord vocalique en Tépo. Annales de l'Université d'Abidjan, série H (Linguistique), 8.15-26.

Kaye, Jonathan D. 1982. Harmony processes in Vata. The structure of phonological representations part 2, ed. by Harry van der Hulst & Norval Smith, 385-452. Dordrecht: Foris Publications.

Werle, Johannes-Martin, and Dagou Justin Gbalehi. 1976. Phonologie & morphonologie du Bete de la region de Guiberoua. Abidjan: Institute de Linguistique Appliquée and Société Internationale de Linguistique.

Singler, John V. 1983. Vowel harmony in Klao: Linear and nonlinear analyses. Studies in African Linguistics l4:1-33.

9. Niger-Congo, Mande

Le Saout, J. 1979. Notes sur la phonologie du Gouro. Nice: Centre d'Etude sur le Phonétisme des Langues Africaines.

10. Nilo-Saharan, Eastern Nilotic

Coates, Heather. 1985. Otuho phonology and orthography. Occasional Papers in the Study of Sudanese Languages 4:86-118. Juba: Summer Institute of Linguistics, Institute of Regional Languages, and University of Juba.

Dimmendaal, Gerrit. 1983. Topics in a grammar of Turkana. Nilo-Saharan Language Studies, ed. by M. Lionel Bender, 239-271. East Lansing: African Studies Center, Michigan State University.

Hall, Beatrice L & Eluzai M. Yokwe. 1981. Bari vowel harmony: The evolution of a cross-height vowel harmony system. Occasional papers in the study of Sudanese languages 1:55-63. Juba: College of Education, University of Juba.

Schröeder, Helga, and Martin Schröeder. 1987. Vowel harmony in Toposa. Afrikanistische Arbeitspapiere 12:27-35.

11. Nilo-Saharan, Southern Nilotic

Creider, Chet A. & Jane Tabsubei Creider. 1989. A grammar of Nandi. Hamburg: Buske.

Larsen, Iver A. 1984. Vowel harmony in Koony. Occasional papers in the study of Sudanese languages 3:29-45.

Local, John, and Ken Lodge. 1996. Another travesty of representation: Phonological representation and phonetic interpretation of [ATR] harmony in Kalenjin. York Papers in Linguistics 17.77-117.

Lodge, Ken. 1995. Kalenjin morphology: A further exemplification of underspecification and non-destructive phonology. Lingua 96.29-43.

Tucker, A.N. 1964. Kalenjin phonetics. In In Honour of Daniel Jones, ed. by D. Abercrombie, D.B. Fry, P.A.D. MacCarthy, N.C. Scott & J.L. Trim, 445-470. London: Longmans.

12, Nilo-Saharan, Western Nilotic

Andersen, Torben. 1989. The Päri vowel system with an internal reconstruction of its historical development. Journal of African Languages and Linguistics 11:1-20.

Kutsch Lojenga, Constance. 1986. Vowel harmony in Alur: On the crossroads of two systems. Proceedings of the Third Nilo-Saharan Linguistics Colloquium (Nilo-Saharan, 6), 131-141.

13. Nilo-Saharan, Central-Sudanic

Kilpatrick, Eileen. 1985. Bongo phonology. Occasional Papers in the Study of Sudanese Languages 4.1-62. Juba: Summer Institute of Linguistics, Institute of Regional Languages, and University of Juba.

Kutsch Lojenga, Constance. 1994. Ngiti: A Central-Sudanic language of Zaire. (Nilo-Saharan, 9.) Köln: Köppe.

Parker, Kirk. 1985. Baka phonology. Occasional Papers in the Study of Sudanese Languages 4.63-85. Juba: Summer Institute of Linguistics, Institute of Regional Languages, and University of Juba.

14. Nilo-Saharan, Eastern Sudanic

Odden, David. 1983. Aspects of Didinga phonology and morphology. In Nilo-Saharan Language Studies, ed. by M. Lionel Bender, pp. 148-176. East Lansing: African Studies Center, Michigan State University.

C. ATR and orthography

Cahill, Michael. 1991. The vowels Æ and Û in Ghanaian orthographies. MS, Ghana Institute of Linguistics, Literacy, and Bible Translation.

Ring, J.A., and W. Kwami Numuley. n.d. Writing vowels in Ikposo. MS. [Available from Africa Area Linguistics Coordinator.]

Stewart, John M. 1967. Tongue root position in Akan vowel harmony. Phonetica l6:l85-204.

D. Phonetic studies

Suggested minimum reading for phonology specialists: 9, and either 1 or 8 (these three deal with acoustic correlates of ATR), 2 (especially for those working in Nilo-Saharan, but others will profit as well), 3 (if possible read 5 first), 7.

1. Hess, Susan. 1992. Assimilatory effects in a vowel harmony system: an acoustic analysis of advanced tongue root in Akan. Journal of Phonetics 20:475-492.
2. Jacobson, Leon C. 1980. Voice-quality harmony in Western Nilotic languages. In Issues in Vowel Harmony, ed. by R. Vago, 183-200. Amsterdam: John Benjamins.
3. Lindau, Mona, and Peter Ladefoged. 1986. Variability of feature specifications. Invariance and variability in speech processes, ed. by J.S. Perkell and D.H. Klatt, 464-479. Hillsdale, New Jersey: Lawrence Erlbaum Associates.
4. Lindau, Mona. 1979. The feature expanded. Journal of Phonetics 7.163-176.
5. Lindau, Mona. 1987. Tongue mechanisms in Akan and Luo. UCLA Working Papers in Phonetics 68.46-57.
6. Lindau, Mona; Leon Jacobson; and Peter Ladefoged. 1972. The feature Advanced Tongue Root. UCLA Working Papers in Phonetics 22.76-94.
7. Local, John, and Ken Lodge. 1996. Another travesty of representation: Phonological representation and phonetic interpretation of [ATR] harmony in Kalenjin. York Papers in Linguistics 17.77-117.
8. McCord, Michael Steven. 1989. Acoustical and autosegmental analyses of the Mayogo vowel system. Arlington, TX: University of Texas at Arlington MA thesis.
9. Fulop, Sean, Ethelbert Kari & Peter Ladefoged. 1998. An acoustic study of the tongue root contrast in Degema vowels. Phonetica 55:80-98.
10. Tiede, Mark K. 1996. An MRI-based study of pharyngeal volume contrasts in Akan and English. Journal of Phonetics 24:399-421.

E. ATR harmony and phonological theory

1. Recommended background reading

Most of the studies listed in the further sections below assume a high level of familiarity with developments in generative phonological theory since the mid 1970's. Those whose background in generative phonology is not reasonably current may wish to brush up by reading relevant material in one or more introductory phonology texts/articles before plunging into the primary literature. It is also useful to have some background on certain related topics, such as acoustic phonetics. The following sources are recommended as background reading.

<u>General introductory material</u>

Goldsmith, John. 1990. Autosegmental and metrical phonology. Oxford: Blackwell.
Kenstowicz, Michael. 1994. Phonology in generative grammar. Oxford: Blackwell.
Goldsmith, John. 1995. Phonological theory. In The Handbook of Phonological Theory, ed. by John Goldsmith, 1-23. Oxford: Basil Blackwell.

<u>Lexical phonology</u>

Kroeger, Paul. 1990. Lexical phonology and the rebirth of the phoneme. Notes on Linguistics 50:11-24.

Feature theory

Parker, Steve. 1994. On the motivation for feature geometry. Notes on Linguistics 65:26-33.

Pulleyblank, Douglas. 1995. Feature geometry and underspecification. In *Frontiers of Phonology*, ed. by Jacques Durand & Francis Katamba. Harlow, England: Longman Group.

Cahill, Michael. 1998. Phonological Features, their Organization, and Assimilatory Processes: A Review. MS, Ohio State University.

The Cahill paper, though written at a more advanced level, provides a useful and comprehensive overview of the way in which feature theory has developed within generative phonology. It should be read only after the other works cited under E-1.

Optimality theory

Archangeli, Diana and D. Terence Langendoen, eds. 1997. Optimality Theory: An overview. Oxford, England and Malden, Massachusetts: Blackwell.

Note that only a few of the works listed below (basically those in section E-9 require a knowledge of optimality theory.

Acoustic phonetics

Ladefoged, Peter. 1996. Elements of acoustic phonetics. Second edition. Chicago: University of Chicago Press.

A basic knowledge of acoustic phonetics, especially the concept of vowel formants, is essential background for some of the material listed below, e.g. Archangeli & Pulleyblank (1994), Goad (1993).

Vowel systems - general

Goldsmith, John. 1987. Vowel Systems. Papers from the 23rd annual regional meeting of the Chicago Linguistic Society, Part Two, 116-133.

Although not concerned exclusively with ATR, Goldsmith's paper presents some important ideas concerning the feature specification of vowels and discusses concepts that will be useful in understanding some subsequent work on ATR.

Anyone doing extensive work on vowel systems (whether or not they involve ATR harmony) would benefit from familiarity with work on the dispersion theory of vowel systems by Lindblom and others. Thus, it would be worth reading one of the following:

Lindblom, Björn. 1986. Phonetic universals in vowel systems. In Experimental Phonology, ed. by J.J. Ohala and J.J. Jaeger, 13-44. Orlando: Academic Press.

Lindblom, Björn. 1990. Models of phonetic variation and selection. Phonetic Experimental Research 9:65-100. Institute of Linguistics, University of Stockholm.

Lindblom, Björn, & Johan Liljencrants. 1972. Numerical simulation of vowel quality systems: The role of perceptual contrast. Language 48:839-862.

(Lindblom's functional approach toward explaining vowel inventory phenomena also provides what may be a useful counterbalance to the predominantly formal orientation of most theoretical work on ATR harmony within generative phonology.)

Vowel harmony and phonological theory - suggested early readings

Clements, G. N. 1976. Vowel harmony in nonlinear generative phonology. Bloomington: Indiana University Linguistics Club.

Hulst, Harry van der & Jeroen van de Weijer. 1995. Vowel Harmony. In The Handbook of Phonological Theory, ed. by John A. Goldsmith, pp. 495-534. Oxford: Basil Blackwell.

2. Work dealing with the fundamental definition/nature of ATR and/or the relationship of ATR to other features (especially vowel height features)

Archangeli, Diana, and Douglas Pulleyblank. 1994. Grounded Phonology. (Current Studies in Linguistics, 25.) Cambridge: MIT Press.

Casali, Roderic F. 1993. On some uses of ATR. MS, UCLA.

Casali, Roderic F. 1996. Vowel Coalescence in Niger-Congo: Implications for height-feature theory. Paper presented at the 27th Annual Conference on African Linguistics, University of Florida, Gainesville, March 29, 1996.

Casali, Roderic F. 1996. Resolving hiatus. Los Angeles, CA: UCLA dissertation. (To be published by Garland Publishing, New York.)

Casali, Roderic F. 1998. Predicting ATR Activity. CLS 34, 1:55-68.

Clements, George N. 1989. On the representation of vowel height. MS, Cornell University.

Clements, George N. 1991. Vowel height assimilation in Bantu languages. Working Papers of the Cornell Phonetics Laboratory 5:37-76.

Clements (1989, 1991) actually says very little about [ATR] directly. Indirectly, however, his work has potentially important implications for theoretical treatments of [ATR], in that he analyzes a number of phenomena that might be (or have been) treated in terms of [ATR] using an alternative framework for capturing "vowel height" distinctions. In fact, although Clements does not do so, one could imagine extending his theory so as to do away with [ATR] altogether.

Goad, Heather. 1993. On the configuration of height features. Los Angeles, CA: USC dissertation.

Goldsmith, John. 1987. Vowel Systems. Papers from the 23rd annual regional meeting of the Chicago Linguistic Society, Part Two, 116-133.

Hulst, Harry van der. 1988. The geometry of vocalic features. Features, Segmental Structure and Harmony Processes, vol. 2, ed. by Harry van der Hulst and Norval Smith, 77-125. Dordrecht: Foris.

Hulst, Harry van der. 1989. Atoms of segmental structure: Components, gestures, and dependency. Phonology 6:235-284.

Hyman, Larry M. 1988. Underspecification and vowel height transfer in Esimbi. Phonology 5.255-273.

Kaye, Jonathan D.; Jean Lowenstamm; and Jean-Roger Vergnaud. 1985. The internal structure of phonological elements: a theory of charm and government. Phonology Yearbook 2.305-328.

Lodge, Ken. 1995. Kalenjin morphology: A further exemplification of underspecification and non-destructive phonology. Lingua 96.29-43.
Local, John, and Ken Lodge. 1996. Another travesty of representation: Phonological representation and phonetic interpretation of [ATR] harmony in Kalenjin. York Papers in Linguistics 17.77-117.
Odden, David. 1991. Vowel Geometry. Phonology 8:261-289.
Parkinson, Frederick. 1996. The representation of vowel height in phonology. Ohio State University dissertation.
Polgárdi, Krisztina. 1998. Vowel harmony: An account in terms of government and optimality. The Hague: Holland Academic Graphics.
Pulleyblank, Douglas. 1997. Towards deriving distinctive features, with a focus on cross-height harmony. Paper presented at a UCLA colloquium, April 25 1997.
Schane, Sanford A. 1990. Lowered height, laxness, and retracted tongue root: Different manifestations of phonological aperture. Word 41(1).1-16.
Steriade, Donca. 1995. Underspecification and markedness. The Handbook of Phonological Theory, ed. by John Goldsmith, 114-174. Oxford: Basil Blackwell.
Trigo, Loren. 1991. On pharynx-larynx interactions. Phonology 8:113-136.
Vaux, Bert. 1996. The status of ATR in feature geometry. Linguistic Inquiry. 27:175-182.

3. ATR and feature geometry

Cahill, Mike. 1996. ATR harmony in Kɔnni. OSU Working Papers in Linguistics 48:13-30.
Clements, George N. 1991. Vowel height assimilation in Bantu languages. Working Papers of the Cornell Phonetics Laboratory 5:37-76.
Goad, Heather. 1993. On the configuration of height features. Los Angeles, CA: USC dissertation.
Hulst, Harry van der. 1988. The geometry of vocalic features. Features, Segmental Structure and Harmony Processes, vol. 2, ed. by Harry van der Hulst and Norval Smith, 77-125. Dordrecht: Foris.
Hulst, Harry van der. 1989. Atoms of segmental structure: Components, gestures, and dependency. Phonology 6:235-284.
Kaye, Jonathan D.; Jean Lowenstamm; and Jean-Roger Vergnaud. 1985. The internal structure of phonological elements: a theory of charm and government. Phonology Yearbook 2.305-328.
Odden, David. 1991. Vowel Geometry. Phonology 8:261-289.
Parkinson, Frederick. [Ohio State University dissertation, 1996?]
Pulleyblank, Douglas. 1995. Feature geometry and underspecification. In *Frontiers of Phonology*, ed. by Jacques Durand & Francis Katamba. Harlow, England: Longman Group.
Rennison, John. 1984. On the vowel harmonies of Koromfe (Burkina Faso, West Africa). In Phonologica 1984: Proceedings of the Fifth International Phonology Meeting Eisensdadt, 25 -- 28 June 1984, ed. by Wolfgang U. Dressler, Hans C. Luschützky, Oskar E. Pfeiffer, and John R. Rennison, 239-246. London: Cambridge University Press.
?Trigo, Loren. 1991. On pharynx-larynx interactions. Phonology 8:113-136.
Vaux, Bert. 1996. The status of ATR in feature geometry. Linguistic Inquiry. 27:175-182.

4. ATR and markedness

Archangeli, Diana, and Douglas Pulleyblank. 1994. Grounded Phonology. (Current Studies in Linguistics, 25.) Cambridge: MIT Press.

Bakovic, Eric. 2000?. Harmony, dominance and control. Rutgers University dissertation.

Calabrese, Andrea. 1995. A constraint-based theory of phonological markedness and simplification procedures. Linguistic Inquiry 26.373-463.

Casali, Roderic F. 1997. ATR harmony systems: Some issues for research. Paper presented at the 28th Annual Conference on African Linguistics, Cornell University, July 11-13, 1997.

Casali, Roderic F. 1998. Predicting ATR Activity. CLS 34, 1:55-68.

Kaye, Jonathan D.; Jean Lowenstamm; and Jean-Roger Vergnaud. 1985. The internal structure of phonological elements: a theory of charm and government. Phonology Yearbook 2.305-328.

Kiparsky, Paul. 1985. Some consequences of Lexical Phonology. Phonology Yearbook 2.83-138.

Leitch, Myles. 1996. Vowel harmonies of the Congo basin: An optimality theory analysis of variation in the Bantu zone C. Vancouver, B.C.: University of British Columbia dissertation.

Pulleyblank, Douglas. 1986. Underspecification and low vowel harmony in Okpe. Studies in African Linguistics 17.119-153.

Pulleyblank, Douglas. 1997. Towards deriving distinctive features, with a focus on cross-height harmony. Paper presented at a UCLA colloquium, April 25 1997.

Pulleyblank, Douglas, Ping Jiang-King, Myles Leitch, and Ola Nike. 199?. Typological variation through constraint rankings: low vowels in tongue root harmony. MS, University of British Columbia.

Smolensky, Paul. 1993. Harmony, markedness, and phonological activity. Paper presented at Rutgers Optimality Workshop 1, October 23, 1993. (Available from the Rutgers Optimality Archive.)

Steriade, Donca. 1995. Underspecification and markedness. The Handbook of Phonological Theory, ed. by John Goldsmith, 114-174. Oxford: Basil Blackwell.

Stewart, John M. 1967. Tongue root position in Akan vowel harmony. Phonetica l6:l85-204.

5. Typology of ATR harmony systems

Archangeli, Diana, and Douglas Pulleyblank. 1994. Grounded Phonology. (Current Studies in Linguistics, 25.) Cambridge: MIT Press.

Calabrese, Andrea. 1995. A constraint-based theory of phonological markedness and simplification procedures. Linguistic Inquiry 26.373-463.

Casali, Roderic F. 1996. Resolving hiatus. Los Angeles, CA: UCLA dissertation. (To be published by Garland Publishing, New York.)

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Goad, Heather. 1993. On the configuration of height features. Los Angeles, CA: USC dissertation.

Gorecka, Alicja. 1996. Vowel harmony vs. vowel reduction in Optimality Theory. Paper presented at the 2nd Southwest Optimality Theory Workshop, University of California Irvine, May 11, 1996. [Appears in UC Irvine Working Papers in Linguistics vol. 2?]

Leitch, Myles. 1996. Vowel harmonies of the Congo basin: An optimality theory analysis of variation in the Bantu zone C. Vancouver, B.C.: University of British Columbia dissertation.

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Steriade, Donca. 1995. Underspecification and markedness. The Handbook of Phonological Theory, ed. by John Goldsmith, 114-174. Oxford: Basil Blackwell.

6. Behavior of neutral vowels with respect to ATR harmony

Akinlabi, Akinbiyi. 1997. Kalabari vowel harmony. To appear in The Linguistic Review, volume 14.

Archangeli, Diana, and Douglas Pulleyblank. 1994. Grounded Phonology. (Current Studies in Linguistics, 25.) Cambridge: MIT Press.

Bakovic, Eric. 2000?. Harmony, dominance and control. Rutgers University dissertation.

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Hyman, Larry M. 1989. Advanced tongue root in Kinande. MS, University of California, Berkeley.

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Ola Orie, Olanike. 2001. Two harmony theories and high vowels in comparative Yoruba. Paper presented at the 2001 LSA meeting, Washington, D.C., January 4-7, 2001.

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7. (Under)specification of ATR

Archangeli, Diana, and Douglas Pulleyblank. 1989. Yoruba vowel harmony. Linguistic Inquiry 20.173-217.

Archangeli, Diana, and Douglas Pulleyblank. 1994. Grounded Phonology. (Current Studies in Linguistics, 25.) Cambridge: MIT Press.

Bakovic, Eric. 2000?. Harmony, dominance and control. Rutgers University dissertation.

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Ewen, Colin, and Harry van der Hulst. 1985. Single-valued features and the non-linear analysis of vowel harmony. In Linguistics in the Netherlands 1985, ed. by H. Bennis and F. Beukma, 317-36. Dordrecht: Foris.

Ewen, Colin, and Harry van der Hulst. 1987. Single-valued features and the distinction between [-F] and [0F]. In Linguistics in the Netherlands 1987, ed. by F. Beukema and P. Coopmans, 51-60. Dordrecht: Foris.

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Hulst, Harry van der. 1988. The geometry of vocalic features. Features, Segmental Structure and Harmony Processes, vol. 2, ed. by Harry van der Hulst and Norval Smith, 77-125. Dordrecht: Foris.

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Rennison, John. 1984. On the vowel harmonies of Koromfe (Burkina Faso, West Africa). In Phonologica 1984: Proceedings of the Fifth International Phonology Meeting Eisensdadt, 25 -- 28 June 1984, ed. by Wolfgang U. Dressler, Hans C. Luschützky, Oskar E. Pfeiffer, and John R. Rennison, 239-246. London: Cambridge University Press.
Ringen, Catherine O. 1984. Vowel harmony: Linear or non-linear? In Phonologica 1984: Proceedings of the Fifth International Phonology Meeting Eisensdadt, 25 -- 28 June 1984, ed. by Wolfgang U. Dressler, Hans C. Luschützky, Oskar E. Pfeiffer, and John R. Rennison, 248-251.. London: Cambridge University Press.
Roberts, James. 1994. Nontonal floating features as grammatical morphemes. MS, Summer Institute of Linguistics.
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Steriade, Donca. 1995. Underspecification and markedness. The Handbook of Phonological Theory, ed. by John Goldsmith, 114-174. Oxford: Basil Blackwell.
Stewart, John M. 1967. Tongue root position in Akan vowel harmony. Phonetica 16:185-204.

8. Rule-based autosegmental/metrical analysis of [ATR] harmony processes

Clements, G. N. 1981. Akan vowel harmony: A nonlinear analysis. Harvard Studies in Phonology 2.108-177.
Cahill, Mike. 1996. ATR harmony in Kɔnni. OSU Working Papers in Linguistics 48:13-30.
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Hulst, Harry van der, and Norval Smith. 1986. On neutral vowels. The phonological representation of suprasegmentals (Part II), ed. by Koen Bogers, Harry van der Hulst & Maarten Mous, 233-279. Dordrecht: Foris Publications.
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10. A “short list” of strongly recommended items

The list below represents an attempt to select from among the references in 1-9 above a smaller set of items which I believe are likely to be of the most enduring usefulness to a consultant or phonology specialist who on the one hand has a certain inherent interest in phonological theory but at the same time is primarily interested in the contribution which phonological theory can make to an understanding of ATR vowel harmony. Preference has generally been given to work embodying theoretical proposals which are not yet outdated. (Thus, they do not necessarily provide a good picture of the historical progression of important theoretical work on ATR, for which other items would have served better at a number of points.) Most of these items have been included because they bear on (at least) one theoretical issue which is of fairly general interest as far as the behavior of ATR harmony is concerned. Inevitably, these selections are to some extent reflective of my own biases and interests; another phonologist would undoubtedly have compiled a somewhat different list.

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Appendix D: Listening exercise: [+ATR] and [-ATR] vowels in Puguli (Gur, Burkina Faso)

Puguli has a nine-vowel system with four [+ATR] vowels (/ieou/) and five [-ATR] vowels (/ɪɛɔʊ/). Five examples of each vowel in word-final positions are given below, with glosses in French. To hear each word on a Windows computer, double click on the speaker icon in the right column. (This may take a few seconds on a slower computer.)

Note that some of the words end in a final glottal stop; this has been ignored in the transcriptions, as have certain other details.

[Sound files omitted from this short version.]

/i/

bili	'poser à plat'
luri	'enlever'
pheli	'blaguer'
luɤi	'vider'
tili	'se courber'

/ɪ/

fɪɪɾɪ	'attraper fort'
bɪlɪ	'être malin'
fɪɾɪɤɪ	'se serrer'
bɪɾɪ	'verser'
ɓɔɾɪ	'durer'

/e/

bule	'bouillie' (sg.)
hwele	'écureuil terrestre'
keɾe	'croire'
kheeɤe	'aubergines africaines'
kpile	'front'

/ɛ/

bɑɑɾɛ	‘varans d’eau’
bɔɔɾɛ	‘sacs’
hɑlɛ	‘oeuf’
hɔlɛ	‘charbon’ (sg.)
dɑɑɾɛ	‘bois’ (pl.)

/ɑ/

bɑɾɑ	‘varan d’eau’
bɛɾɑ	‘rois’
bʊʊɾɑ	‘pierres’
fɛlɑ	‘humidité’ (pl.)
hala	‘oeufs’

/ɔ/

bʊɾɔ	‘python’
dɪɾɔ	‘lutte’
dɔɔɾɔ	‘savon’
mɛlɔ	‘rosée’
lɔ	‘tomber’

/o/

bulo	‘bouillie’
diɾo	‘nourriture’
huuɾo	‘cuisses’
kiɾo	‘chose’
loɾo	‘ventre’

/ʊ/

khʊlʊ	‘brûme’
phɑlʊ	‘montagne’
vɑɑɾʊ	‘bras’ (pl.)
lʊ	‘fatiguer’
sɑɾʊ	‘piege à poissons’

/u/

dunu	‘grand’
su	‘remplir’
cumu	‘lapin’
dɑʔju[35]	‘rat voleur’
lemuɾu	‘agrume’

[35] What do you notice about the quality of the vowel /ɑ/ in this example? What hypothesis does this suggest?