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AUTHOR Local, John; Lodge, Ken
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ABSTRACT

The Kalenjin group of languages, spoken mainly in western Kenya, displays a harmony system involving the phonological feature Advanced Tongue Root ([ATR]). The study reported here addresses issues of the phonological representation of the [ATR] in Kalenjin and its phonetic interpretation. Specifically, it is shown that (1) the harmony system encompasses the consonant system as well as the vowel system; (2) [ATR] is best characterized as a phonological unit that has a syllabic domain; (3) there are harmony constraints on the constituents of monomorphemic polysyllables; and (4) the phonetic exponents of [ATR] harmony provide evidence for the need to maintain a strict demarcation between an abstract, relational phonology and interpretive phonetic exponents. It is argued that a straightforward way of handling the [ATR] harmony system is in terms of underspecification, and it is proposed that a formal implementation of the analysis can be constructed in terms of constraints on structured hierarchies of features that permit partial specification and structure sharing, combined with a phonetic interpretation function. Contains 95 references. (MSE)

ANOTHER TRAVESTY OF REPRESENTATION: PHONOLOGICAL REPRESENTATION AND PHONETIC INTERPRETATION OF ATR HARMONY IN KALENJIN*

John Local and Ken Lodge

ANOTHER TRAVESTY OF REPRESENTATION: PHONOLOGICAL REPRESENTATION AND PHONETIC INTERPRETATION OF ATR HARMONY IN KALENJIN*

John Local and Ken Lodge

Department of Language and Linguistic Science
University of York

1. Introduction

The Kalenjin group of languages, part of the Southern Nilotic or Chari Nile family (Greenberg 1964) are spoken mainly in western Kenya. One of their characteristics is that they display a harmony system which is said to involve the phonological feature Advanced Tongue Root ([ATR]) (Creider and Creider 1989; Hall et al. 1974; Halle and Vergnaud 1981).

In this paper we address issues of the phonological representation of [ATR] in Kalenjin and its phonetic interpretation. Specifically we will show:

- that the harmony system encompasses the C-system as well as the V-system
- that [ATR] is best characterised as a phonological unit which has a syllabic domain
- that there are harmony constraints on the constituents of monomorphemic polysyllables
- that the phonetic exponents of [ATR] harmony provide evidence for the need to maintain a strict demarcation between an abstract, relational phonology and interpretative phonetic exponents (Pierrehumbert 1990; Kelly and Local 1989)

We will argue that one straightforward way of handling the [ATR] harmony system is in terms of underspecification (cf. Lodge 1993b). On

* Authors' correspondence addresses: John Local, Department of Language and Linguistic Science, University of York. Ken Lodge, School of Modern Languages and European Studies, UEA, Norwich. NR4 7TJ

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the assumption that only unpredictable values/features are specified in the lexical entry forms of morphemes (cf. Archangeli 1984, 1988) we will show that

- it is necessary to specify lexically [+ATR] for the dominant morphemes and [-ATR] for the opaque ones.
- the adaptive morphemes are unspecified for lexical [ATR] value.
- [+ATR] harmony domains are immediately adjacent. (There is no evidence that harmony patterns can or do 'skip' over adjacent morphemes.)
- [+ATR] harmony domains encompass immediately adjacent unspecified adaptive morphemes or the default value, [-ATR], applies.

We will propose that a formal implementation of our analysis can be constructed in terms of constraints on structured hierarchies of features which permit partial specification and structure sharing, combined with a phonetic interpretation function (Coleman 1992a; Local 1992; Ogden 1992; see also Bird 1990; Broe 1993; Scobbie 1991).

2. Phonetic interpretation of [ATR]

We begin with a consideration of some of the phonetic characteristics of the [ATR] harmony system in Kalenjin[1]. We will, in the manner of Firthian Prosodic Analysis, refer to these as 'phonetic exponents' (Carnochan 1957; Firth 1948;.Henderson 1949; Sprigg 1957). Importantly our investigations reveal that the phonetic exponents of the [ATR] feature in Kalenjin are varied and not simply confined to the V-system (a detailed discussion is presented in Local and Lodge (forthcoming)). The transcriptions in (1) give an impression of some of these characteristics:

[1] The data we discuss is drawn from observations and recordings of a female and male speaker of the Tugen dialect. Both speakers are in their mid 30's.

(1)

+ATR words		−ATR words	
[kʰɐ̰ːβɪ̰tʲʰ]	{TO SPRINKLE}[2]	[kʰˑɐːβɪtʏʰ]	{TO GROW}
[kʰɐ̰ʔgʊ̰tʲʰ]	{TO SCRAPE UP}	[kʰˑɐːɣ̰ʊ̰tʏʰ]	{TO BLOW}
[kʰɐ̰ːβɑ̰l̰]	{TO DIG UP}	[kʰˑɛʔβ̰a̰l]	{TO DIG}
[pʰɐ̰ˑɲ]	{MEAT}	[pʰˑɛɲ]	{HARDSHIP}
[lɔ̰]	{FAR}	[lʏɔ̰]	{SIX}

2.1 Phonetic differences between words of the [±ATR] categories

There are a number of phonetic differences between words in the two categories which can be observed not only in vocalic portions but also in the consonantal portions of such words. These differences include phonatory quality, vocalic and consonantal quality and articulation and durational differences.

2.1.1 Phonatory differences

The two sets of words exhibit different kinds of phonatory activity. This is audible in terms of voice quality. Words of the [-ATR] set have audible breathy phonation as compared with words in the [+ATR] set. This breathy voice quality is especially noticeable in the rime of the words. Measurements of the open quotient (OQ) of the glottal cycle made from electrolaryngographic recordings (Davies et al. 1986; Howard et al. 1990; Lindsey et al. 1988) and inverse filtering (Karlsson 1988; Wong et al. 1979) show statistically significant differences can be taken

[2] We adopt the following notational conventions in presenting the Kalenjin material: [phonetic font] for phonetic material; **bold** for phonology; lower case for syntactico-morphological categories; {**bold in braces**} for morphemes expressed in terms of phonology; {CAPITALS IN BRACES} for meanings and glosses. These conventions are based on those employed by Carnochan, 1957. Thanks to Richard Ogden for comments and suggestions concerning notation.

to confirm breathiness of phonation (typically, larger OQ values are found for [-ATR] words). Examination of voice source measurements also suggests different kinds of laryngeal behaviour in moving from voice to voicelessness in the two sets of [ATR] words. In [+ATR] voicing dies away slowly and continues at low level (often noticeably overlapping with friction if present). In contrast, in [-ATR] words, voicing drops off rapidly.

Examination of the spectral characteristics of vocalic portions of the two classes also reveals differences commensurate with breathy versus non-breathy phonation (Local and Lodge, forthcoming). There is, for example, a tendency for words of the [-ATR] set to display a greater amplitude of the fundamental in respect of the first harmonic.

2.1.2 Vocalic differences

There are striking auditory differences in vocalic quality between words in the two sets. Vocalic portions in [-ATR] words are noticeably more central (and frequently more open) than those in [+ATR] words. (Note the open [+ATR] vocoid has a *back* quality in the region of CV5 [ɑ] while the open [-ATR] vocoid has a noticeably *front* quality in the region of CV4 [a]. These harmonize with appropriate tokens from the [ATR] sets: [sɳmʲiʂʲ] ~ [ʂa̱.mʸɪʂʸ] [tʰɳŋgusʲ] ~ [tʰ·aŋ̈g̈uʂʸ].) Examination of plots of F1/F2 for tokens each of the [±ATR] vocoids in the data confirms the results of impressionistic listening (for example, [+ATR] vocoids show lower F1 values than their congeners [-ATR]). For purposes of broad transcription we represent the vowels of Kalenjin thus: [+ATR] [i e ɑ o u], [-ATR] [ɪ ɛ a ɔ ʊ].

2.1.3 Consonantal differences

Words of the two categories exhibit differences in types of consonantal stricture and their ranges of variation. In [+ATR] words we final labial, apical and velar closure with burst release, or with close approximation; in comparable [-ATR] words closure with burst release is not found. In such words lax fricative portions occur but so do portions with open approximation.

There are also noticeable variations in terms of place of articulation. 'Coronals' in [+ATR] words are exponed with apico-alveolar strictures whereas they may be exponed with either apico-alveolar or dental strictures in [-ATR] words. Generally consonantal pieces in [+ATR] words are tenser than their [-ATR] equivalents. This can give rise to the percept of stop-like release of laterals and nasals in [+ATR] words.

2.1.4 Durational differences

Consonantal and vocalic portions are durationally different in [±ATR] words. Typically consonantal portions are shorter in [+ATR] words than in [-ATR] words. This is particularly noticeable in the closure and release phases of initial and final plosive portions. Averages of vocalic duration reveal a tendency for [-ATR] vocoids to be shorter than [+ATR] vocoids but there is some overlap in terms of the ranges of duration. However, [+ATR] words are routinely longer (measured from beginning to end of voicing) than are [-ATR] words.

3. Phonological preliminaries: some characteristics of [ATR] domains

Having provided a brief characterisation of the phonetic exponents of [ATR] we now provide an outline of the main aspects of the organisation of the [ATR] harmony system in Kalenjin. There are three different types of morpheme: *adaptive*, *dominant* and *opaque* whose behaviour can be described as in (2) below:

(2)

(i) dominant morphemes are always [+ATR]; any immediately adjacent adaptive morpheme(s) will share this value: **{MORPH}$_D$**.

(ii) adaptive morphemes vary their [ATR] value according to the specification of [ATR] in their neighbouring morpheme(s): **{MORPH}$_A$**.

(iii) opaque morphemes are always [-ATR] and do not vary the value, even next to a dominant morpheme. They delimit the domain of dominant morphemes: **{MORPH}$_O$**.

3.1 Examples of ATR patterning

In (3) - (8) below we give examples of each of these possibilities with accompanying broad phonetic transcriptions.

(3)

{KE:R}$_D$	{-UN}$_A$	[ke:run]
{SEE} root	directional suffix	{SEE IT FROM HERE}

(4)

{KU:T}$_A$	{-UN}$_A$	[kʊ:tʊn]
{BLOW} root	directional suffix	{BLOW IT HERE} (imperative)

(5)

{KA-}$_A$	{A-}$_A$	{KU:T}$_A$	{-E}$_D$	[kɑ:yʊ:te]
recent-past prefix	1sg subject prefix	{BLOW} root	continuous suffix	{I WAS BLOWING}

(6)

{KA-}$_A$	{A-}$_A$	{KU:T}$_A$	{-UN}$_A$	[kɑ:yʊ:tʊn]
recent-past prefix	1sg subject prefix	{BLOW} root	directional suffix	{I BLEW IT}

(7)

{KI-}$_A$	{A-}$_A$	{UN}$_D$	{-KEJ}$_O$	[kiɑungɛɪ]
far-past prefix	1sg subject prefix	{WASH} root	reflexive suffix	{I WASHED MYSELF}

(8)

{KA-}$_A$	{KA:-}$_O$	{KO-}$_A$	{KE:R}$_D$	{-ʌ}$_A$
recent-past prefix	perfective prefix	aspect prefix	{SEE} root	1sg object suffix

[kaɣa:ɣoɣe:rɑ]

{HE HAD SEEN ME}

Evidence for the three types of morpheme is as follows. Sentences (3) and (4) show that the directional suffix {-UN}$_A$ is an adaptive morpheme; in (3) it appears in [+ATR] form and [-ATR] in (4). Similarly comparison of (4) and (5) show that the verbal root {KU:T}$_A$ may also vary in terms of [±ATR] characteristics and can therefore be treated as adaptive. In (4) we see that any such adaptive morphemes not in the domain of dominant ones exhibit the exponents of [-ATR]. Comparison of the characteristics of the structures in (5) and (6) shows that the continuous suffix {-E}$_D$ is dominant (therefore [+ATR]) and that all the other morphemes in its left domain share its [+ATR] characteristics. In (7) the final suffix is opaque and so it does not share the [ATR] characteristic of the preceding dominant ([+ATR]) root {UN}$_D$, while the two adaptive prefixes in the left domain of the root share its [+ATR] properties. In (8) the perfective prefix {KA:-}$_O$ is opaque and thus the adaptive recent-past prefix {KA-}$_A$ at the beginning of the construction is outside the domain of the dominant root {KE:R}$_D$. As expected from the behaviour of the adaptive suffix in (4) this initial prefix is [-ATR]. However, the adaptive morphemes in the immediate left and right domains of the dominant root share its [+ATR] characteristics. Note that roots (nominal and verbal) and affixes may be dominant or adaptive. Affixes may be opaque but roots are not.

[ATR] functions in a variety of ways in Kalenjin. In addition to the harmony patternings in (3) - (8) and the lexical pairs given in (1) above, it participates, for instance, in some singular/plural distinctions: [sǫmʲɪ̟sʲ] {AWFUL} (plural) is [+ATR]; [ʂa̟ mᵛɪʂᵛ] {AWFUL} (singular) is [-ATR]; [mʔ.ǫ̟ː.i̟] {CALVES} is [+ATR] ~ [mᵛɔ̟ː.ɪ] {CALF} is [-ATR] (see also Tucker and Bryan 1964).

4. Abstractness of phonological categories: [ATR] and the inadequacy of intrinsic phonetic interpretation

[ATR] harmony is canonically the kind of phonological organisation which has been seen as a candidate for autosegmental status[3] (Clements 1976, 1981; Kaye 1982). We will discuss one such treatment of Kalenjin [ATR] below. However, it is appropriate here to consider

[3] Or within the Firthian tradition as 'prosodic'.

briefly one issue which [ATR] harmony in Kalenjin raises for an autosegmental analysis - that of the phonetic implementation or interpretation of the phonological feature [ATR]. While conventional non-linear approaches may be able to characterise graphically the long-domain implications of [ATR], it is not immediately clear how such phonological approaches could deal in any coherent way with the phonetic implementation of an [ATR] autosegment in Kalenjin given the range of different phonetic exponents we have outlined above. The problem arises because in contemporary autosegmental approaches phonological features are deemed to have intrinsic (or intuitive) interpretation — the IPI hypothesis (see eg Clements (on IPI in feature geometry) 1985[4]; Durand 1990; Goldsmith 1990; Pulleyblank 1989). The intrinsic approach to phonetic interpretation represents a continuity of practice from traditional generative phonologies. In the generative tradition phonetic interpretation is merely the end point of a process which maps strings to strings. Phonological representations are constructed from features taking binary values; phonetic representations employ the same features with the difference that they usually take scalar values. In the *locus classicus* of generative phonology, Chomsky and Halle explicitly embrace this view of a phonetics-phonology continuum and write 'We take 'distinctive features' to be the minimal elements of which phonetic, lexical and phonological transcriptions are composed' (1968: 64). This undefended position is only made possible in SPE, as in more recent autosegmental approaches, because there is no attempt at an explicit formulation of phonetic interpretation. In the present case it would require a certain amount of ingenuity to postulate an [ATR] autosegment and find what there is in common between devoicing of coda approximants, breathy voice quality, front or back secondary articulation, consonantal length, particular ranges of consonantal variability and any putative advanced position of the tongue root.

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4 Although Clements argues that the geometric organisation of features 'depends upon phonological, rather than physiological criteria' (1985: 240) it would appear that the categories he discusses are deemed to have an intrinsic phonetic interpretation.

4.1 Getting the exponents of [ATR] to 'fall out'

It has been suggested to us (van der Hulst, personal communication) that there might be some kind of phonetic/perceptual relationship even in this case which might serve to rescue a conventional autosegmental treatment of [ATR] in Kalenjin in respect of the IPI hypothesis. The suggested solution would be to propose that [±ATR] is exponed by degrees of vocal tract tension with [-ATR] exponed by a generalised 'lax' articulatory setting and [+ATR] by a 'tense' setting (cf. also the description in Hall et al.. 1974: 244, without reference, and Schachter and Fromkin. 1968, on Akan). This might then allow the consonantal and vocalic features we are concerned with to 'fall out' of the categories set up by the analysis.

However, such an analysis merely sidesteps the issue in replacing 'the feature [ATR]' with some other intrinsically interpreted feature [lax]. In itself this begs the question as to why precisely it should be this combination of phonetic features (not universally 'lax') rather than some other that is implicated in the interpretation of [±ATR] (see also the discussion of cross-language differences in the phonetic interpretation of [ATR] harmony in Lindau and Ladefoged 1986). Moreover, such a proposal would not provide a readily accessible account of the durational characteristics of vowels and consonants or the observed variability in the 'coronal' consonants in the two sets. Nor, as far as we can discern, would it give us any analytic leverage on the counter-intuitive phonetic implementation of the open [+ATR] vowel as [ɑ] and the open [-ATR] vowel as [a].

However, the central problem with postulating universal features like [ATR] is that the phonetic and phonological levels are confounded, phonological categories amount to little more than 'rounded up' phonetics and phonetic detail is constantly being made to fit the phonology (e.g. Lindau on 'r-sounds', 1985). Since the phonetic exponents of the harmony system in Kalenjin do not seem to have been investigated thoroughly until our recent paper (Local & Lodge 1994), it is of particular concern that a number of analyses have chosen [ATR] as the phonological designation of the relationships involved.

4.2 Definitions of [ATR]

Harmony systems are of central phonological importance in a large number of languages. They typically involve two sets of phonetic exponents which alternate in some way, though not always in the same way across languages. Let us call these sets A and B; thus far there can be little disagreement. In the case of [ATR], however, a search has been made for a common phonetic parameter for the set of exponents of the phonological category by investigating some, but not all, such languages. This search has been limited from the outset by the unwarranted assumption that the commonality resided solely in vowel phoneme inventories.

Research by Stewart (1967), Lindau (1975, 1978), Ladefoged (1964 (on Igbo), 1971, 1972), Lindau et al. (1973) and Painter (1973) on the [ATR] harmony systems in languages of the West African Akan family establishes a connection between the vowel qualities in the two such sets and the position of the tongue root. Lindau et al. (1973) show that advancing of the tongue root may also be used as a mechanism to alter tongue height, as in German and some English speakers, without there being any justification for giving the mechanism phonological status (87)[5]. They thus distinguish between those languages which use tongue root position as the basis of a phonological vowel harmony system and those that use it as an articulatory mechanism for raising the tongue body. Lindau (1978) suggests that the important articulatory effect of advancing or retracting the tongue root in general is to change the shape of the pharyngeal cavity and labels the phenomenon [expanded]. This is an elaboration of Ladefoged's (1971, 1972) suggestion that there is a phonological (sic) feature [wide] covering three states of the pharynx: wide, as in advanced tongue root articulations, neutral, where the tongue root is in its 'normal' position (which may or may not be the position for [-ATR], depending on the language), and narrow, where the tongue root is retracted. The last state may be the equivalent of [-ATR], but Ladefoged exemplifies it with Arabic [ʕ]. Lindau (1978: 553) also suggests that neutral versus narrow is employed in Arabic to

5 Kenstowicz (1994: 20,22) provides a clear instance of the unwarranted elevation of tongue root to phonological status in his discussion of vowel symbols.

differentiate between non-emphatic and emphatic consonants respectively. This is the only reference to consonants in relation to the position of the tongue root.

With the basic groundwork set up in this way it is easy to see how phonologists (who have not necessarily investigated the so-called [ATR] languages directly) find the [ATR] feature attractive as a generic binary label for the two sets A and B. There is apparently a simple intrinsic phonetic interpretation of the phonological phenomenon, a convenient isomorphism: an advanced tongue root produces a wide pharynx, which equates with [+ATR] in the phonology (see, for instance, Hall and Hall 1980 who, in discussing [ATR] harmony in Nez Perce, comment that [+ATR] [ɯ] 'follow(s) naturally if the tongue root is in advanced position when /u/ is articulated' (214)). However, if, as might be expected, a phonological contrast is exponed by a constellation of phonetic exponents, it has been traditionally deemed necessary to have a way of determining the choice of which the (single) exponent should be. For example, in Gimson (1962: 90) we are told that with regard to RP pairs of long and short vowels 'the opposition between the members of the pairs is a complex of quality and quantity', but he decides to take length as the phonologically relevant characteristic (ibid.: 93). In Gimson (1945-49) he demonstrates that for native RP speakers vowel quality and the duration of voicing in the rime are the important cues for vowel 'length'; the criteria used to come to a decision in Gimson (1962) seem to be 'tradition' and a language-teaching expedient (cf. 90-93 for the full discussion). These hardly represent substantive criteria for a motivated *phonological analysis.*

In the context of the present paper we need to be convinced that a single cover term is appropriate for the phenomena under discussion. But even if this position is adopted, it is important that the phonological analysis must at least make reference to the wider phonological and grammatical context of the language concerned, rather than relying on the discovery of some common physical denominator (cf Firth 1948).

5. The abstractness of phonological categories

We will start with a matter that concerns the phonetic interpretation of only the vocalic part of the syllable in Kalenjin: namely, the exponents of the open V's. First of all, it is striking to note that in the investigations of those languages which have an open V distinction in [+ATR] and [-ATR] sets e.g. Akan, (see, for instance, Lindau 1975, 1978, Lindau et al. 1973), little is said about their qualities, the non-open vowels being the focus of attention. The pharyngeal cross-sections for the latter show clear distinctions in the position of the tongue root, but there are no such cross-sections for the low vowels, transcribed in Lindau (1975) as [ə] for [+ATR] and [a] for [-ATR], but in Lindau (1978) as [a] and [ʌ], respectively, without any comment, though on the formant chart (Fig.7, Lindau 1978: 552) [a] appears in a relatively back position near to [ɔ], [ʌ] being omitted. In their transcription of Kalenjin Halle and Vergnaud use [a] and [a], respectively, again without elaboration (unfortunately misinterpreted by Carr 1993a: 260-262, as [a] and [ɑ], respectively)[6]. The important point about the Kalenjin realizations of the two harmonic sets, as far as the low vowels are concerned, is that we find the counter-intuitive occurrence of [ɑ] for the [+ATR] open V and [a] for the [-ATR] open V (cf. the relatively detailed transcriptions given at the beginning of this paper). Careful impressionistic observation and acoustic analysis indicates that the backer of the two vocalics co-occurs with vocalic and consonantal portions which typify [+ATR]. In other words, the expected tongue body position on the front-back axis in relation to the assumed position of the tongue root does not occur. Whatever the facts of Akan, in Kalenjin the tongue body position is clearly not *determined* by the size of the pharynx, so, even if we restricted the phonological domain of the harmony system to the vowels, for the low vowels we would need the contrary interpretation of [±ATR] to their interpretation for the non-low

[6] Whether [-ATR] is equivalent to a neutral or retracted tongue root is not a question we concern ourselves with in this paper, but the issue has led to the introduction of another feature [RTR] in the analysis of some languages; see Carr, 1993b and references therein.

vowels - not a happy conclusion for universals of phonetic implementation.

As far as consonantal articulations are concerned, the available literature does not provide much in the way of indication of what happens to them when the pharynx is wide (see, for example, Ladefoged 1972, or Lindau 1978). A narrow pharynx, as we have already noted, has been implicated in the production of Arabic emphatic consonants. This is of no help in explaining the consonantal articulations we have observed in Kalenjin, nor in explaining the difference in phonation types. It is Stewart (1967: 199) who assumes a relationship between [+ATR] and breathy voice, for which we find no evidence; on the contrary, in our data breathy voice in the sonorants goes with [-ATR]. (Halle and Stevens (1969) also offer a tentative determinate account of the relationship between tongue-root retraction, larynx lowering and phonatory difference, but the work of Lindau and her associates indicates that such an association is casual rather than causal). Similarly, the lenition phenomena and the length phenomena referred to in §2 above and discussed in detail in Local and Lodge (1994) seem to us to have no obvious connection with pharynx width, any more than the fact that in Kalenjin 'coronality' in [+ATR] words has exclusively alveolar exponents whereas in [-ATR] words it varies between alveolar and dental exponents. The only conclusion we can draw is that [ATR] can have no 'basic intrinsic' phonetic interpretation that will allow us to apply it in any meaningful way to the Kalenjin material under discussion here. Rather the interpretation of the abstract phonological relationship designated [±ATR] must be accounted for in explicit statements of temporal and parametric phonetic exponency (Carnochan 1957; Ogden and Local 1995; Sprigg 1957); we cannot appeal to some kind of free-ride intrinsic phonetic interpretation principle.[7] If we adopt

[7] Compare the statement of Gazdar et al (1985) concerning similar practices in syntax. 'Unlike much theroetical linguistics, it [the GPSG exposition] lays considerable stress on detailed specifications of the theory and of the descriptions of parts of English grammar ... We do not believe that the working out of such details can be dismissed as 'a matter of execution ... In serious work, one cannot 'assume some version of the X-bar theory' or conjecture that a 'suitable' set of interpretative rules will do something as desired ...' (ix)

this position, of course, it has considerable ramifications for all aspects of the relationship between phonological categories and their phonetic exponents.

Rejection of the IPI hypothesis is, of course, aligned with the position of Firthian Prosodic Analysis wherein phonological representations are entirely relational, encoding no information about temporal or parametric events (Carnochan 1958; Firth 1948; Ogden 1993; Ogden and Local 1993, 1995; Sprigg 1957). Under this view the phonological representations are abstract relational structures and are treated as having no intrinsic phonetic denotation. This is different from the view we highlighted earlier which is propounded in a number of contemporary 'non-segmental' approaches where features in the phonology are deemed to embody a transparent phonetic interpretation - typically cued by the featural *name* (e.g. Browman and Goldstein 1986; 1989; Bird and Klein 1990; Sagey 1986. See also the discussion in Keating 1988).

The position we take does not mean that we see no interesting or 'explanatory' links between phonetic phenomena and phonological structures. Rather our claim is that if we wish to develop a sophisticated understanding of the relationships between the meaning systems of a language and their exponents in speech, being forced to provide an explicit statement of the detailed parametric phonetic exponents of phonological structure is an essential prerequisite. The feature labels for phonological units we employ may be given mnemonic labels (e.g. `[ATR]`), but their relation to the phonic substance need not be simple. Because they are distributed over different parts of the syllabic structure, their interpretation is essentially polysystemic (Firth 1948; Henderson 1949; Carnochan 1957). For example, the interpretation of the contrast given the feature label `[+ATR]` or the label `[+nasal]` at a syllable onset need not necessarily be the same as the interpretation of the contrast given the feature label `[+ATR]` or `[+nasal]` at a rime (see also the comments by Manuel et al. 1992 on the phonetic interpretation of 'alveolarity and plosion' in codas of English words). Moreover, the occurrence of the phonologically contrastive feature `[+nasal]` at some point in the phonological structure may generalize over many more phonetic parameters than those having to do simply with lowering of the soft palate. Similarly the absence of a feature such as `[+voice]`

does not necessarily mean that the representation generalizes over tokens where there is no activity involving vocal fold vibration - vocalic, nasal and liquid portions typically have regular vocal fold activity, though the phonological representation to which such portions may be referred does not necessarily involve the *feature* [+voice] (cf Ladefoged 1977; Local 1992).

The consequence of this argument is that nothing at all hangs on the *name* of a phonological feature (eg [ATR]) provided that the canonical naive view of the relationship between phonological categories and phonetic ones is eschewed. That is provided the semantics of the phonological categories is explicitly and formally stated then it really doesn't matter what they are called. All that the 'naming of parts' achieves is some kind of mnemonic shorthand that can, in the worst cases, lead to analytical infelicities. There are two aspects to specifying the semantics: (i) it is necessary to know how the phonological category(ies) in question relate to other phonological categories - that is provide a semantic statement of their place within the phonological systems and structures and (ii) it is necessary to provide an explicit statement of the phonetic interpretation of the phonological categories - this is crucial because, in Firthian terms, it 'renews the connection' (Firth 1957). For instance, Sprigg (1957:107) writes

> '... it is clear that the phonological symbols are purely formulaic, and in themselves without precise articulatory implications. In order therefore to secure 'renewal of connection' with utterances, it becomes nesessary to cite abstractions at another level of analysis, the Phonetic level: abstractions at the Phonetic level are stated as criteria for setting up the phonological categories concerned, and as exponents of phonological categories and terms.'

We return, therefore, to our initial labels A and B. As cover terms for the categories that enter into the phonological system, they are as good as anything else in that they are abstractions from the data without any phonetic content or implication. It seems to us that this is not dissimilar to a much simpler example that relates to the phonological

status of a feature [alveolar] or a binary equivalent [+cor, +ant], as a definition of English /t d n/. As is well known, these three putative phonological units are subject to (at least) place of articulation assimilation with a following obstruent or nasal (cf. Gimson 1962, and more recent discussions in Local 1992; Lodge 1984, 1992; Nolan 1992); in other words, their exponents, in this respect vary in terms of articulatory place: bilabial, labiodental, dental, palato-alveolar, palatal and velar, as well as alveolar. The only thing these features have in common is that they are all indeed place specifications. Clearly, in such cases as this the alveolar articulatory place descriptor cannot be equated with the phonological category [alveolar]. The proposals made by Local (1992) and Lodge (1981, 1984, 1992) involve non-specification of the place feature for such consonants; in addition, in Local (1992) and Lodge (1992) feature-changing rules are excluded entirely from the grammar, as proposed in §8 below, so by having no lexical specification of a place feature for /t d n/ the necessary level of abstraction is achieved: these particular sounds are not defined as alveolar at all, but as those that have no specific place. (For a proposal that this may be a universal feature of coronals, see Paradis and Prunet 1991.) The appropriate place features are supplied by sharing the following obstruent or nasal in particular structural domains, with alveolarity as the default.

However, the case of Kalenjin is more complicated than this, since the phonetic exponents of the terms of the harmony system cannot easily be subsumed under a general heading such as 'place of articulation'.

Fudge (1967) is an early attempt within the framework of generative phonology to introduce phonological primes with no implicit phonetic content (with a reference to Firthian Prosodic Analysis). He states: 'It is ... dangerous and misleading to say that either articulatory or auditory features ARE the phonological elements, unless they correlate so closely that no facts of language are obscured by treating them as if they were the same' (4, original emphasis). The two reasons he gives to support his claim that facts are obscured if one assumes identity of phonetic and phonological features are the matter of biuniquness (discussed also by Chomsky 1964: 75-95) and morphophonemic patterns, some of which are counter-phonetic. The

first of these Fudge exemplifies with tone-sandhi in Mandarin, in which Tone 2 followed by Tone 3, and Tone 3 followed by Tone 3 are both realized as a high rising followed by a low rising pitch (1967: 4-7). (There is evidence that such claims trade on less than compelling phonetic observation - and an innocence about interrelationships between levels of analysis. See, for example, Chuenkongchoo 1956, on Thai and Henderson 1960, on Bwe Karen.) The second is exemplified by the Hungarian vowel system, in which phonetic [ɒ] pairs with phonetic [a:] in a harmony system partly determined by lip-rounding or lack of it; they are phonemicized as /a/ and /a:/, respectively. As Chomsky points out (1964: 74; quoted by Fudge 1967: 10), /a/ is 'functionally unrounded but phonetically rounded.' Fudge sees this as a convenient shorthand, but argues that 'it is surely the task of phonology to make classifications on its own terms, to state explicitly what these phonetic-sounding labels ('Rounded' and 'Unrounded', 'Long' and 'Short', etc.) are a 'shorthand' for' (1967: 10). The Hungarian system also contains a situation parallel to the Mandarin tone-sandhi: [i] and [i:] function phonologically as both front and back, another pair of features involved in harmony relations. He then goes on to show how abstract labels - he uses A, B, 1, 2, a, b, (i), (ii) - can be used to define the phonological relations involved, and then interpreted in four ways, by means of four different sets of rules: articulatory, acoustic, auditory and recognitional. We do not want to go into any further details of Fudge's proposals (which are segmentally based), but would like to note in particular what Fudge considers one serious disadvantage of distinctive feature notation, namely that 'systematic phonemic elements and their systematic phonetic counterparts are treated in terms which are formally indistinguishable, and this often forces us to imply that one systematic phonemic element has been changed into another (Tone 3 HAS BECOME Tone 2 in our [Mandarin] example). This is not only undesirable, but also unnecessary, since we do not require complete biuniqueness in our phonology' (1967: 6). We applaud such cautionary remarks, but we find it extraordinary that after nearly thirty years only a few phonologists have started to pay any attention to them.

4.2 Maintaining strict demarcation: Compositional Phonetic Interpretation

We have argued that the IPI hypothesis for phonological categories is, in the general case, untenable and, in the particular case of [ATR] harmony in Kalenjin, demonstrably inadequate. In the light of this we have suggested that it is not only desirable but necessary to adopt an analysis in which a strict demarcation between the abstract phonological and physical phonetic levels is maintained as in Firthain prosodic analysis. In order to do this, as we indicated, it is necessary to solve the issue of the phonetic interpretation of phonological categories. To accomplish this we adopt the proposal of Coleman and Local (1992) for a compositional phonetic interpretation (CPI) function for partial phonological descriptions. We sketch only the broad outlines of the CPI here. Fuller, more technical descriptions, of the phonological theory and the formal treatment of the CPI function, as formally implemented in the YorkTalk speech generation system, can be found in Coleman 1992a; Local 1992; Ogden 1992).

In the CPI function adopted here, phonological structures and features are associated with phonetic exponents. The phonological descriptions being interpreted are here taken to be unordered acyclical graph structures with complex attribute-value node labels (cf structures found in GPSG or HPSG). The statement of phonetic exponents in CPI has two formally distinct parts: temporal interpretation and parametric phonetic interpretation. Temporal interpretation establishes timing relationships which hold across constituents of a phonological graph while parametric interpretation instantiates interpreted 'parameter strips' for any given piece of structure (any feature or bundle of features at any particular node in the phonological graph). The resulting 'parameter strips' are sequences of ordered pairs where any pair denotes the value of a particular parameter at a particular (linguistically relevant) time. Thus in the general case:

{(node: partial_phonological_description),(Time_start, Time_2, ... Time_end), parameter section}

where the node represents any phonologically relevant contrast domain. (Ladefoged 1980, argues for a similar formulation of the mapping from

phonological categories to phonetic parameters.) The time values may be absolute or relative, fixed or proportional. The precise physical domain of the parameter strips (eg articulatory, acoustic, aerodynamic) is not of immediate relevance here.

Under CPI, phonetic interpretation of the phonological descriptions is constrained by the principle of compositionality (Partee 1984) which requires that the 'meaning' of a complex expression is a function of the form and meaning of its parts and the rules whereby the parts are combined. Under the present proposal, the phonological 'meaning' of a syllable equals the 'meaning' of its constituents (for a similar approach see Bach and Wheeler 1981; Wheeler 1981; 1988). The compositional principle is instantiated by requiring any given feature or bundle of features at a given place in the phonological structure to have only one possible phonetic interpretation. So, for instance, in the present case the Kalenjin words (i) [kʰʷo.l], 'good planters' and (ii) [kʰʷo.l] 'plant!' can be given the following Firthian-like, partial representations (similar representations can be found in Albrow 1975; Carnochan 1960):

(i) $^{[ATR+]}$ (κoλ) (ii) $^{[ATR-]}$ (κoλ)

Here the syllable-domain [ATR] unit as well as being semantically distinctive serves to integrate the other syllabic material (paradigmatically contrastive 'phonematic units' (Firth 1948)) with consequences for their phonetic exponency as we illustrated above). Given this, then the interpretation of (i) is of the form:

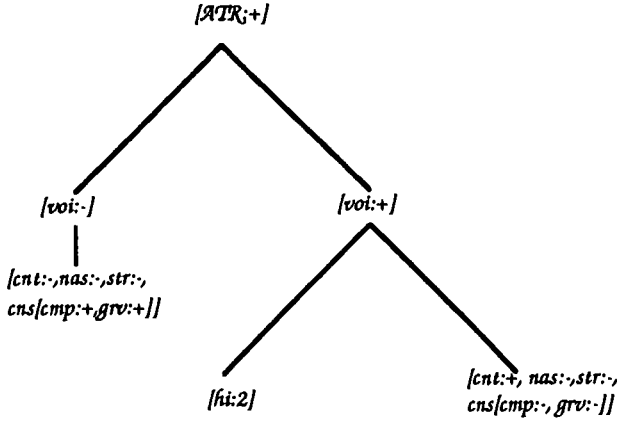
CPI([ATR:+] (κoλ)) = {phonetic exponents of 'kol'}

where *CPI* is a phonetic interpretation function (cf Coleman and Local 1992). A more fully specified representation of (i) might be given as:

(i) $^{[ATR+]}$ ($^{\hbar}$(κ), $^{\neg\hbar}$ (o,λ))

In this representation the units *within* the syllable are treated as separate entities or sequences of entities; the superscript symbols $\hbar/\neg\hbar$ placed before the units (κ) and (oλ) serve to indicate onset/rime domain

phonation prosodies (*h* 'voicelessness'; ¬*h* 'voice'). Such a representation can be reconstructed as a graph with attribute-value node labels, thus:



The compositional interpretation of this schematic representation can be determined in the following quasi-articulatory fashion:[8]

1. *CPI*([*cnt:-, nas:-, str:-, cns*[*cmp:+, grv:+*]]) = {contact of tongue back with soft palate, closure of soft palate ...}
2. *CPI*([*hi:2*])={relatively mid tongue-height...}
3. *CPI*([*cnt:+, nas:-, str:-, cns*[*cmp:-, grv:-*]]) = {contact of tongue apex with alveolar ridge...}
4. *CPI*([*voi:+*]([*hi:2*], [*cnt:+, nas:-, str:-, cns*[*cmp:-, grv:-*]])) = {succession of *CPI*([*cnt:+, nas:-, str:-, cns*[*cmp:-, grv:-*]]) to *CPI*([*hi:2*]), relative length of *CPI*([*hi:2*]), relative slow decay of voicing of *CPI* ([*hi:2*])...}
5. *CPI*([*voi:-*]([*cnt:-, nas:-, str:-, cns*[*cmp:+,grv:+*]])) = {voicelessness, aspiration of *CPI*([*cnt:-, nas:-, str:-, cns*[*cmp:+,grv:+*]])...}

---

[8] In a more complete representation backness and roundedness of the nucleus would be accounted for at the syllable level, thus providing, *inter alia*, for an appropriate phonetic interpretation of consonant-vowel coarticulation (see Local, 1992).

6. *CPI*(/*atr:+*/(/*voi:-*/(/*cnt:-, nas:-, str:-, cns/cmp:+, grv:+*//), /*voi:+*/(/*hi:2*/, /*cnt:+, nas:-, str:-, cns/cmp:-, grv:-*//))) = {succession of *CPI*(/*voi:-*/(/*cnt:-, nas:-, str:-, cns/cmp:+,grv:+*//)) to *CPI*(/*voi:+*/(/*hi:2*/, /*cnt:+, nas:-, str:-, cns/cmp:-, grv:-*//)), non-maximal backness of *CPI*(/*voi:-*/(/*cnt:-, nas:-, str:-, cns/cmp:+,grv:+*//)) and *CPI*(/*voi:+*/(/*hi:2*/, /*cnt:+, nas:-, str:-, cns/cmp:-, grv:-*//)), relative palatality of *CPI*(/*cnt:+, nas:-, str:-, cns/cmp:-, grv:-*//), relative shortness of closure and release of *CPI*(/*voi:-*/(/*cnt:-, nas:-, str:-, cns/cmp:+,grv:+*//)), tense phonatory quality and slow decay of voicing of *CPI*(/*voi:+*/(/*hi:2*/, /*cnt:+, nas:-, str:-, cns/cmp:-, grv:-*//)), ...}

We have formally tested and verified a CPI for Kalenjin within the YorkTalk declarative speech generation system employing acoustic parameters. Discussion and illustration of this and quantitative details of the phonetic exponents of [ATR] in Kalenjin are given in Local and Lodge (forthcoming).

6. Phonological analysis

In order to develop our phonological analysis we shall now consider Halle and Vergnaud's (1981) analysis of Kalenjin [ATR] harmony, the contribution of underspecification and then return to a consideration of the phonetic interpretation of [ATR].

6.1. Halle and Vergnaud's analysis

Halle and Vergnaud's (1981) paper was one of the first to argue for an autosegmental account of the Kalenjin harmony system. In it they make a number of substantive claims:

- [ATR] autosegments can be linked only to vowel slots in the core (CV anchor tier), (which they claim is 'obvious').
- [ATR] can also be part of the core specifications, but autosegmental specification overrides core specification.

• Autosegments are either linked to the core in the lexical representations or they are floating, i.e. not linked to the core slots. Linking is subject to the following conditions (= their (1f)):

(9)

i. Each (vowel) slot is linked to at *most* one (harmony) autosegment.
ii. Floating autosegments are linked automatically to all accessible vowel slots.
iii. Unlinked autosegments are deleted at the end of the derivation. (Emphasis original.)

In order to make their analysis work Halle and Vergnaud also find it necessary to invoke the No Crossing Constraint (for a critique of this constraint, see Coleman and Local 1989). To account for the facts in (2) above, as exemplified in (3)-(8), they claim that all vowel slots are (redundantly) specified [-ATR] and that dominant morphemes have a floating [+ATR] autosegmental specification in their lexical entry form. Opaque morphemes are specified with a [-ATR] autosegment. On the basis of this analysis they give the lexical representations in (10a,b,c) (= their (1g); we use Halle and Vergnaud's conventions for representing Kalenjin morphophonology but additionally give broad phonetic transcriptions).

(10a)

kI-a-gɛr	[kɪaɣɛr]	{I SHUT IT}

(10b)

	[+ATR]		
kI-a-gɛr	-ɛ	[kiaɣere]	{I WAS SHUTTING IT}

(10c)

[-ATR]	[+ATR]			
ka-ma-a	-gɛːr	-ak	[kamaaɣeːrak]	{I DIDN'T SEE YOU (pl)}

In the first case (10a), where all the morphemes are adaptive, Halle and Vergnaud state that the form is 'subject to no modifications and surfaces in its underlying form as far as [ATR] harmony is concerned' (1981: 4), giving [-ATR], the redundant specification of all morphemes. In (10b) all vowels are [+ATR] because (9ii) links the autosegment accordingly. In the third example (10c), which is parallel to (8) above, the last three vowels are linked to [+ATR] by (9ii), but the No Crossing Constraint prevents it from being linked to the first morpheme; given the linking of $\{MA\}_O$ with [-ATR] $\{KA\}_A$ surfaces as [-ATR] (= 'is subject to no modifications').

Since they operate with fully specified underlying forms, the association of the floating [+ATR] autosegment necessarily has the effect of changing the value of the redundant [-ATR] specification of the lexical entry form. It is also the case that the 'blocking effect' of the autosegmental [-ATR] specification of the opaque morphemes is arbitrary, in that in other cases (though not in Halle andVergnaud's paper) spreading can delink such associations (cf. Broe 1992: 153-154). That is to say, whether spreading can delink or not has to be indicated in a language-specific way, and possibly even a phenomenon-specific way.

Halle and Vergnaud's analysis highlights three problems. The first two are of some generality within conventional autosegmental treatments of languages with [ATR] harmony. First there is an unwarranted assumption that [ATR] associates with vocalic slots only. Second there is a reliance on procedural, feature-changing rules (see, for example, the extensive appeal to 'delinking' and 'deletion' in Goldsmith 1990 and papers cited therein). The third problem concerns Halle and Vergnaud's arbitrary account of the blocking effect of the opaque morphemes. We will deal with the first of these problems in the following section and with the other two when we give a declarative analysis of Kalenjin [ATR] harmony.

7. The syllable domain of [ATR]

It is now appropriate to take a closer look at our earlier claim that [ATR] harmony in Kalenjin is of syllabic domain. Halle and Vergnaud, in conventional manner, associate [ATR] autosegments with vowels (in this way they define dominant morphemes 'those with [=ATR] (sic)

Given that [ATR] harmony systems are conventionally dealt with under the rubric 'vowel harmony' it may seem somewhat bizarre to suggest that there is anything odd about this analytic claim. However, as we indicated at the outset of this paper, the phonetic characteristics of consonantal portions in Kalenjin also show marked differences depending on their occurrence in [±ATR] domains. For example, initial voicelessness and plosion have short voice onset times in [+ATR] domains, but relatively long voice onset times with relatively greater amplitude of burst in [-ATR] domains. In [+ATR] words such as [porpor] ({CRUMBLY}, plural) the apical portion is typically a palatalized trill; in contrast in the [-ATR] form [pɔrpɔr] ({CRUMBLY}, singular), we typically find a velarized tap or a lax apical approximant.

That consonantal portions should be implicated in the exponency of 'vowel harmony' should not be regarded as odd. There is evidence that in other 'vowel harmony' languages consonantal portions may also be different. For example, Kelly and Local (1989: 180) show that in Igbo comparable intervocalic consonant portions vary in a number of ways (e.g. in degree of stricture) according to the harmonic V-system they occur with; Waterson (1956) similarly demonstrates that consonantal portions in Turkish exhibit harmonic properties which go around with the so-called vowel harmony in that language. (Dick Hayward (personal communication) confirms noticeable consonantal differences, particularly in duration, co-incident with the vowel harmony systems in Dinka.)

It is important to stress here that the phonetic characteristics of consonants which we have described are not to be attributed to low-level 'co-articulatory effects' (as might, for instance, be argued in the case of 'emphatic consonant harmony' in Arabic (van der Hulst and Smith 1982)[9]. We therefore contest Halle and Vergnaud's assumption about [±ATR] association. It arises simply because the authors have paid insufficient attention to the phonetic facts of the language.[10]

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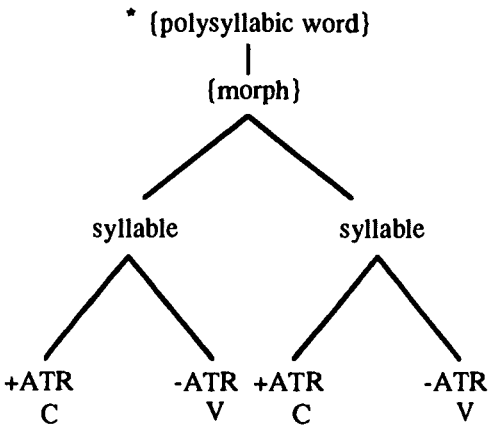
[9] Given Whalen's (1990) disscussion concerning the 'planned' nature of so-called low-level 'phonetic coarticulation effects' it is probably dangerous to propose such an account in any case.

[10] This may be a problem of some generality - wherein particular analytic concerns or 'hunches' focus, in an unwarranted and potentially damaging

The situation we have described for Kalenjin is one in which it would be arbitrary to assign the harmony feature [±ATR] to either vowels or consonants. We note, for example, that structural configurations of the kind in (11) are not permitted:

(11)



That is, we do not find cross-combinations of these [+ATR] consonantal portions with [-ATR] vocalic portions or vice versa. We refer to this cohesiveness of [ATR] within syllables as the Syllable Integrity Constraint.

Second, we note here that there are syntagmatic dependencies between onset and rimal constituents and within the rime between nucleus and coda constituents. That is, while we find V, CV, VC as autonomously occurring structures we do not find C (without the implication of a following or preceding V). Taken along with our observations about the integrity of [ATR] in CV(C) structures this suggests that we need to formulate a constraint on the *syllabic* association of [±ATR].

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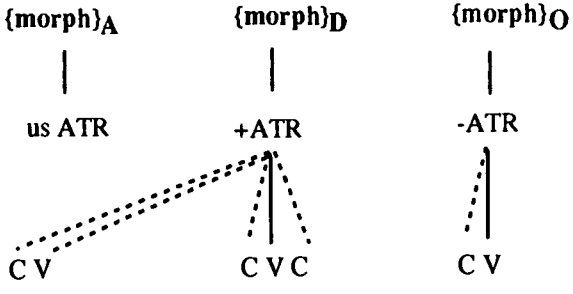
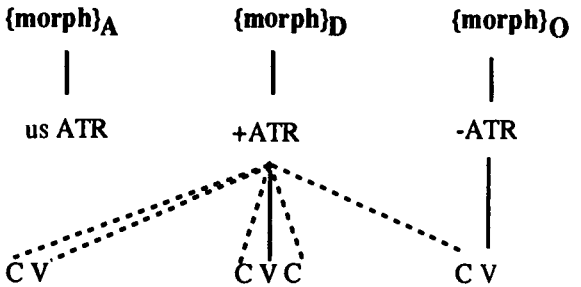
manner, phonetic observation (cf Kelly and Local, 1989). This problem is compounded by the willingness of many current phonologists to 're-work' the *analyses* of others.

We have just proposed that the simplest analysis for the phenomena we have described would be to propose the syllable as the minimal domain of association for [ATR]. We now consider some of the implications of this claim for autosegmental accounts. A conventional non-linear analysis would, like Halle and Vergnaud's, propose association of the [ATR] feature with V-slots and then to allow spreading (cf. also Archangeli 1985; Clements and Sezer 1982; Goldsmith 1990, for example). Notice, though, that we need to deal with two kinds of spreading. While both [+ATR] and [-ATR] spread to all material within syllables only [+ATR] spreads between syllables. Given the inclusion of consonantal material in the 'harmonic spreading' and the Syllable Integrity Constraint, if we adopt the conventional V-association approach, it is clear that we need to invoke a more complex architecture of association precedence and/or blocking to ensure that spreading works in the appropriate fashion. For instance we desire 12(a) but not 12(b).

(12a)



(12b)



In 12(a) we have appropriate spreading of [+ATR] to the C's in the dominant morpheme and to the V and C in the adaptive morpheme (usATR = unspecified [ATR]). This is in line with our observations that it is necessary to spread [±ATR] to any onset and coda consonants as well as vowels, and that dominant [+ATR] harmony spreads to all adaptive morphemes in its domain.

In 12(b), however, although we have spreading of [+ATR] as in (a) to the C's in the dominant morpheme and to the C and V in the adaptive morpheme, it also spreads to the C in the [-ATR] opaque morpheme in violation of the Syllable Integrity Constraint. Clearly we need a way of blocking the spread of dominant [+ATR] harmony to the C's of adjacent opaque [-ATR] syllables. It would be possible to propose a function which would allow morphemic information to percolate to the C and V material in such syllables. However, there is a simpler way of prohibiting this association by ordering the spreading of [±ATR] to C's *within* syllables before spreading between syllables. Once the parochial within-syllable spreading had been accomplished, between syllable spreading would ensure that [+ATR] only associated with V slots which were unspecified for [ATR] and in its immediate left or right domain. This, of course, is tantamount to associating [±ATR] with complete syllables in the first place. As we will show now, it is possible to avoid these somewhat baroque extrinsically ordered association rules if we treat [ATR] as having a syllabic domain and adopt a constraint-based feature-sharing analysis of the harmony system.

8. A declarative underspecification analysis of [ATR] in Kalenjin

One way of avoiding destructive phonological rules, in which features or values are changed or deleted from lexical or, in a derivational framework, intermediate representations, whilst maintaining a single lexical representation for each morpheme, is to employ underspecified lexical representations. Radical underspecification has been developed by Archangeli (1984 1988) and applied to the [ATR] harmony system in Yoruba by Pulleyblank (1988) and Archangeli and Pulleyblank (1989). The Yoruba system that they describe is different in several respects from that of Kalenjin, but the same principles of analysis apply in each case. (In Yoruba, for instance, the vowel /i/ is opaque to the harmony system, whereas in Kalenjin certain *morphemes* are opaque.)

In general, in those cases where alternant realizations are involved, the appropriate feature(s) or feature-value(s) must be unspecified lexically (cf. Lodge 1992 and 1993a). (Whether one refers to features or values is to some extent a matter of whether one uses unary or binary features, respectively; see also the discussion in Calder and Bird 1991. Under these assumptions, then, in Kalenjin the adaptive morphemes are appropriately represented without a lexically specified value for the [ATR] feature underlyingly. Dominant morphemes are specified as [+ATR] (let us say, for the time being, associated with their syllable head (vowel) slot(s), i.e. not floating as in Halle and Vergnaud's analysis). [+ATR], being the non-default value, will have in its domain any adjacent syllables whose head features are not specified for [ATR], i.e. those of the adaptive morphemes. In those words that involve no dominant morphemes, as in (4) and (6) above, a language-specific default rule will supply the redundant specification [-ATR]. (Which value of [ATR] might be the universal default is unclear; in Yoruba, for instance, [+ATR] is the redundant value, though the rule is described as a language-specific complement rule by Pulleyblank 1988: 238, and Archangeli and Pulleyblank 1989: 180, footnote 11.) The opaque morphemes are lexically specified as [-ATR], as in Halle and Vergnaud's account, but given that we have ruled out destructive rules a priori as a means of restricting phonological theory, such lexical specifications will automatically serve to 'block' the 'spread' of any feature, since delinking of any kind is not permitted. Thus, in an underspecification

account opaque morphemes are lexically specified for [ATR], whereas adaptive ones are not. This will yield lexical representations of the kind given in (13) for example (8).

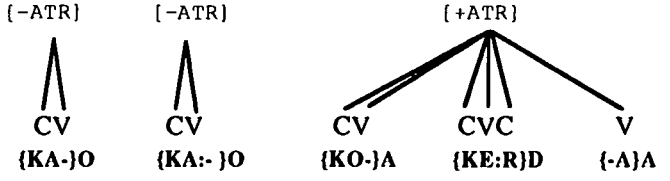
(13)

	[-ATR]		[+ATR]	
	|		|	
KA-	KA:-	KO-	KE:R	-A

The unspecified **{KO-}** and **{-A}** are in the domain of $\{KE:R\}_D$ and share its [+ATR] specification. The initial $\{KA-\}_A$ has the default value [-ATR]. As we demonstrated earlier, this is because the presence of [-ATR] in the lexical representation of the second prefix delimits the inheritance domain of [+ATR].

Since, in the case of Kalenjin, we are dealing with constellations of interacting phonetic parameters which also affect consonantal quality, our analyis above is equivalent to extending the Ladefoged/Lindau proposal to any appropriate consonants, as they do for Arabic. The result is that in Kalenjin the whole syllable is [±ATR] covering both consonants and vowels; our representation in (13) would then be easily modified as in (14), as a representation of the results of spreading and default specification.

(14)



(We do not concern ourselves here with the difference between long and short vowels here, labelling both as V.)

7.1 Structure-sharing,and [ATR] harmony.

In §4.2 we proposed a Compositional Phonetic Interpretation function to allow us a formal means of relating abstract phonological categories

to their phonetic exponents. Here we outline a declarative structure-sharing account for [ATR] harmony which is consonant with this CPI.

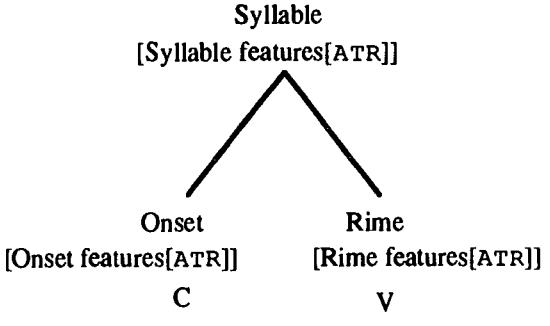
The syntagmatic dependencies outlined above in §7 above imply that V is the head of the syllable rime and that the rime is the head of the whole syllabic structure. This provides us with an obvious solution to the formulation of syllabic association of [±ATR]. In recognising V-system units as *heads* of rimes, rimes as heads of syllables and C-system units as dependents we are able to employ a version of the familiar feature sharing constraints of the GPSG framework (Gazdar et al. 1985). By designating a daughter of a particular category to be the head we identify the relationship between that daughter and the mother as a distinguished one. This allows us to encode the apparent 'feature-spreading' of [±ATR] within a CV(C) structure as a declarative feature-agreement constraint. What we require is to be able to say: OnsetFeatures[ATR] = RimeFeatures[ATR] (and NucleusFeatures[ATR] = CodaFeatures[ATR]). This can be accomplished by employing versions of Gazdar et al's Head Feature Convention (HFC) and Foot Feature Principle (FFP) (Gazdar et al. 1985: 50ff; 70ff). These two constraints may be phrased informally thus for a given fragment of graph representation:

- HFC: The head features of the mother must be an extension of the head features of the head daughter.

- FFP: The foot features of the mother must be identical to the foot features of every daughter.

Combining the HFC and FFP with the structure in (15) below constrains [SyllableFeatures[ATR]] and [OnsetFeatures[ATR]] to be identical.

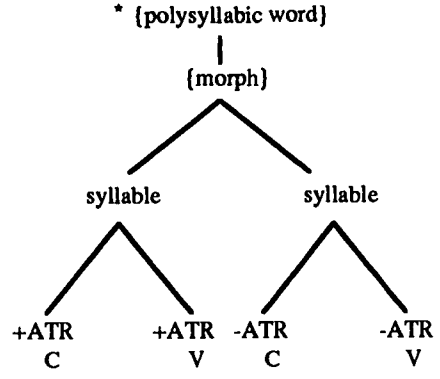
(15)



There are two things to notice here. First observe that it does not matter which of the nodes has its [ATR] value determined or when. The effect is identical (cf Coleman 1992b). Second, notice that the 'spreading' of dominant [+ATR] harmony to immediately adjacent syllables can, by extension, be handled by a similar feature-agreement technique in which the domain of sharing is the word. In Kalenjin a 'word' consists of a monomorphemic root monosyllable or polysyllable. These roots include nominal, verbal, temporal-demonstrative and possessive morphemes (see Lodge 1993b). Roots combine with other morphemes (prefixes and suffixes of various kinds) to form larger word-pieces and these provide the domain of application for the harmony.

Evidence for a word-domain harmony can be illustrated by considering the constraint on the mixing of [+ATR] and [-ATR] vocalic and consonantal portions in monomorphemic polysyllabic structures. Although it is possible, as we have seen in (3) - (8) above, to have polysyllabic utterances in which [+ATR] and [-ATR] properties may be mixed, this is prohibited just in the case where the polysyllabic structure is monomorphemic. So, for instance we find [tɑriːt] {BIRDS} and [tarɪːt] {BIRDS} where the structures as a whole exhibit [+ATR] or [-ATR] harmonic characteristics. Structures of the following kind are prohibited:

(16)



The ill-formedness of such structure is a natural consequence of the contraint-based analysis we have proposed. Though the syllables respect the Syllabic Integrity Constraint the HFC cannot be satisfied for the {morph} node.

Lodge (1993b) provides further evidence of [ATR] harmony encompassing word-domains. He shows that apparent failures of [+ATR] harmony in some pieces can be attributed to the presence of a word boundary within the piece. For instance, in [kwɛsɑ:ɣɑɲɑ:] in (17), where the syllables are (elsewhere) demonstrably adaptive, dominant, adaptive, dominant, the first syllable would be expected to exhibit [+ATR] harmony features; it does not.

(17a)

{KWES}$_A$	##	{NA:}$_D$	{KA}$_A$	{-NYA:}$_D$
{GOAT} root		temporal demonstrative	recent-past	possessive suffix

[kwɛsɑ:ɣɑɲɑ:][11]

{OUR GOAT (OF YESTERDAY) }

11 Most sequences of two consonants are not allowed, hence the interpretation of {KWES}+{NA:} as [kwɛsɑ:].

(17b)

{TUKA}$_A$	##	{CA:K}$_D$	{-ET}$_A$	[tʊɣatʃɑ:ɣet]
{COW} root		possessive	recent-past suffix	{THOSE COWS OF OURS }

(17c)

{TUKA}$_A$	##	{-CA:}$_D$	{-KAJ}$_O$	{-KA}$_O$	{-CA:K}$_D$
{COW} root		temporal demonstrative	recent-past suffix		possessive suffix

[tʊɣatʃɑ:ɣaɪɣɑtʃɑ:k]
{THOSE COWS OF OURS YESTERDAY}

Similarly in 17(b), [tʊɣatʃɑ:ɣet], where the syllables are adaptive, adaptive, dominant, adaptive, we would expect the first two syllables to harmonise with the dominant syllable, whereas only the last, adaptive syllable harmonizes with the dominant [tʃɑ:ɣ]. If these pieces are analysed as consisting of two words (the second coinciding with the start of the temporal demonstrative in two cases and the possessive in the other), we see that this is exactly the point where the harmony ceases to operate. Once this word division is recognized we find that the harmony operates exactly as it does in (3) -(8).

9. Conclusion

Current work in phonological theory is moving away from procedural, rule-ordered analyses to non-procedural, non-derivational analyses in which phonological representations are incrementally constructed. The phonological representations so constructed cannot be destructively modified - there can be no deletion, 'delinking' or feature-changing rules. The information in the phonological representation must be preserved.

In part, this work represents a research effort to elaborate grammars which favour neither production nor recognition and which allow for a felicitous interaction with contemporary declarative theories of syntax. To this extent, the declarative research program in phonology is a direct descendent of Firthian prosodic analysis (Coleman and Local 1992; Broe 1993; Local 1992; Ogden and Local 1995). The underspecification, feature-agreement analysis we have provided of [ATR] harmony in Kalenjin is intentionally undertaken as part of this research program. Taken together with the Compositional Phonetic Interpretation function which we have described, it provides a more felicitous account of the phenomenon than the mechanisms discussed earlier in the paper and the one offered by Halle and Vergnaud. Unlike the Halle and Vergnaud analysis, underspecification with feature-agreement avoids the need to invoke destructive, structure changing rules. Moreover, in constrast to a conventional V-association account with procedural 'spreading', the feature-sharing constraint offers a computationally tractable mechanism of some generality (Bird 1990; Broe 1993; Coleman 1992b; Local 1992; Scobbie 1991) being more constrained and more comprehensive than a standard analysis in not trading on a naive assumption that the harmony is simply vocalic. In addition to proposing a computationally tractable declarative approach to phonological representation we have also described an explicit declarative, compositional approach to phonetic interpretation which provides the 'renewal of connection' (Firth 1948) between the abstract categories of the phonology and their parametric phonetic exponents.

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