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**RELINEARIZING PHONOLOGY :
AN EDGE FEATURE ACCOUNT OF SHONA ¹**

ABSTRACT

In this paper, a new system of description of register tone is presented wherein the characteristic of the melody which is described is the location of edges between tonal plateaus. This is contrasted with the standard non-linear autosegmental account wherein the characteristic described is the tone expressed on syllable nuclei. The two systems of description are each applied to a set of problems in Shona tonology : Meeussen's rule, Stevick's rule, and some of the tonology of the verb stem. The edge feature account is more like linear analyses in that it does not involve multiple linking of tones to syllables. It is formally simpler in the number of stipulations it requires. It is less powerful in that its rules are more restricted in the features they can affect and how and where they can affect them: they all reset the pitch to the default tone at morphological junctures. In this, it better reveals patterns in the tonology of Shona. Moreover, its rules are functionally motivated and applicable on-line, unlike the rules of the autosegmental account.

KEYWORDS

Shona, tone, autosegment, linearity, edge-feature.

Non-linear feature systems have become a standard tool of linguistic description. The fundamental elements of such systems are autosegmental features which stand in many-to-many relations to feature-bearing units. This paper will examine a methodology which is something of an alternative to non-linear feature systems : edge features. Edge features mark distinctive boundaries between constant percepts. If we conceive of putatively non-linear phenomena in terms of edges rather than the percepts bounded, we can produce descriptions without feature spreading or the linking of multiple feature-bearing units to single features. Such a description is not fully non-linear, inasmuch as it may involve the linking of multiple features to single feature-bearing units ; but in that the branches of its phonological trees do not grow back together, it is 'more linear' than the structures of non-linear phonology.

In this paper I seek merely to demonstrate a technique. I do not seek to provide a full-fledged edge feature analysis of a language or a class of phenomena. I will take a circumscribed set of phenomena previously selected to demonstrate the advantage of non-linear analyses and develop an edge feature analysis for them. The study I will use is that fragment of Shona ² tonology presented in Kenstowicz (1994), whose analysis in turn is based on that of Odden (1980) and Myers (1987). The strategy of my argument is simple : if the edge feature analysis shows some advantage to the non-linear one at handling data thought to demonstrate the superiority of the latter, then the edge feature analysis deserves further exploration. I will seek to show that the edge feature account has two advantages : it is functionally motivated and it is formally simpler.

The layout of the paper is as follows. In §1 I will explore briefly the nature of edge features, their conceptual and psychological basis. In § 2 I will present an edge feature analysis of a fragment of Shona tonology. The phenomena I will examine are Meeussen's rule, Stevick's rule, and the tonology of Shona verb stems. In § 3 I will present an autosegmental account of the same data. In § 4 I will compare the formal properties of the two accounts. In § 5 I will compare their functional motivations. And in § 6 I will conclude.

1. The nature of edge features



Fig. 1 : An image and its edges


Edge features are phonological features marking perceptually salient edges between two areas of relatively constant percepts. I take inspiration for such features from perceptual studies of vision, in particular, Marr (1982). The retina is so constructed as to compute the second derivative of intensity over the visual field, and this results in the extraction of edges between regions of constant intensity. There is much utility in this. The interior of a field is reconstructable from knowledge of its edges, as are the edges from knowledge of the interior, but edges require much less data to represent – compare how much ink it took to print the two images above. The edges, therefore, have a much higher information density than points in the interior ; by paying special attention to edges, one pays attention to what is the richest part of an image informationally.

There is a respect in which the preceding description is inaccurate, and in which a description of a description in edges is more complicated than a description of a description in interiors : from a set of edges alone one may reconstruct two images, both the intended image and its negative. This is because an edge by itself does not tell you to which side it is darker and to which side lighter. From the edges in figure 1, for instance, one cannot tell whether one is looking at white furniture on a black background or black furniture on a white background. A single bit of information however is all that is needed to distinguish between these two cases.

2. An edge feature account of certain phenomena in Shona

2.1. The basics

Let us translate these insights from vision to phonology. To begin, let us use the visual model as a metaphor : different pitches³ will correspond to different degrees of brightness ; we will arbitrarily represent high pitch as black. We thus will represent « murúme » ‘man’ as in (1).

(1) 
murume

There is an edge between « mu » and « rúme ». We need two pieces of data to determine the representation of « murúme », that there is an edge after the first syllable and that this edge separates a region of high pitch from a region of low. In principle, we could represent all tonal melodies with these two types of information. The second variety of information, whether the word begins high or low, can in turn be conceived of in two different ways : either the distinction is equipollent or privative. In the first case, the lexical representation of a word always must begin with a ‘feature’ setting the starting tone either low or high. In the second case, some such feature need only be present if the word does not begin on the default tone. Representations are simpler in the second case, so there are metatheoretical reasons to prefer this analysis. Furthermore, Myers has argued

and it has been accepted by Kenstowicz (*op cit.*) that the low tone is the default in Shona, so we will provide an analysis assuming default tones. We will assume that a rule of Shona morphophonology resets the phonological pitch of the utterance to low before every phonological word. A word which begins high, therefore, must have an edge immediately after this reset and before the first syllabic nucleus of the word. A complete representation of « murúmé » thus might be something like,

- (2) L |
 murume

The symbol 'L' indicates that the pitch on the word begins low and the line shows that there is an edge separating regions of different pitch between the first and second syllables. The tonal melody is thus LH... Because there are three syllables, this is equivalent to LHH. Since the reset is inserted by default, a complete lexical representation of « murúmé » is,

- (3) |
 murume

This system of notation for tone is further demonstrated in (4) and (5).

- (4) L |
 hove hóvé 'fish'
(5) L
 sadza sadza 'porridge'

Again, in each of these cases, the initial reset to the default low tone, the 'L', is assigned by a morphophonological rule and is not part of the lexical representation of the word. We might represent this rule as in (6) ⁴.

- (6) WORD (RESET INTRODUCTION) RULE : ## → #L#

In this ad hoc notation, '#' represents a word boundary and '##' represents the boundary between words (for simplicity, I am ignoring sentence initial words). It might seem strange to have a feature between two words. One may think of this rule as introducing an unassociated autosegment. We will consider what becomes of this autosegment in the discussion of Stevick's rule below.

One should note about the edge feature representations presented so far that they involve fewer lexical features than there are apparent tones in the surface phonology of the word and yet there is no feature spreading. An aspect of edge features which may strike the reader as peculiar is that they occur in the domain of consonants between syllable nuclei rather than suprasegmentally to the vowel ⁵. Though this aspect may be unusual, note that it accords with the well-established

theory of tonogenesis which posits that tones originate in the differential effects of consonants on adjacent vowels (*q.v.* Halle and Stevens, 1971; Hombert, Ohala, and Ewan, 1976 ; Maddieson, 1984 ; among others).

We now have a means of describing the tonal melody of a word in terms of edge features. What remains is for us to capture the rules of tonal ‘composition’, how the melody of a complex word is derived from the melodies of its parts. The problems in Shona tonal composition that we will consider may be classified under three headings : Meeussen’s rule, Stevick’s rule, and stem tones.

2.2. Meeussen’s rule

Meeussen’s rule governs tone alternation at the juncture between a clitic and its host. The linear description of this rule is,

$$(7) \quad H \rightarrow L/H\#_.$$

This is only a rough description, as it fails to capture the fact that all of the consecutive high tones after such a juncture become low. Meeussen’s rule is illustrated by (8).

$$(8) \quad \text{né ‘with’\# hóvé ‘fish’} \rightarrow \text{néhove ‘with a fish’}$$

Meeussen’s rule falls out of our edge feature representation without any further stipulations. Consider the edge feature representation in (9).

$$(9) \quad \begin{array}{|c|c|c|c|} \hline | & | & & | & | \\ \hline \end{array} \\ \text{ne \# hove} \rightarrow \text{nehove}$$

The reset associated with the whole complex (not represented in (9) but introduced by the word reset introduction rule) first sets the starting pitch to low. Immediately at the beginning of the clitic, the first edge takes this low to high, giving a high tone on the first syllable. At the margin of the host word, another edge occurs, taking the high back to low. There are no more edge features in the word, so the final two syllables are both realized with low tones.

There could not be a more elegant treatment of Meeussen’s rule than the edge feature account, because the edge feature account requires no additional rules to produce the pattern Meeussen observed. Meeussen’s rule does illustrate one potential drawback with the edge feature account, however : there are two possible sources for a low tone ; it could be derived from either a reset or an edge following another edge. Are there lexical resets, or are non-initial low tones always produced by edges as in (9) ? One way to compare these two cases is to see how far tone alternations spread in a word : change propagates through an edge, as illustrated in (9) ; resets block alternations. The word « hákáta »,

‘diviner’s bones’, provides the test case we require. If the final low tone is produced by an edge, the proclitic « sé », ‘like’, will combine with it to produce « séhakatÁ ». If it is produced by a lexical reset, « sé » will produce « séhakata ». The latter is the correct result, thus we have the derivation shown in (10) ; the word reset is not represented.

- (10) | | | | | |
 se # hakata → sehakata

This example does not resolve how to represent second or third lexical low tones but I will assume they all follow the same pattern ; all are produced by resets.

The only complication to the edge feature account of Meeussen’s rule involves cliticization onto words which do not begin with a high tone. We might expect the initial tone of these to be made high by the edge on the clitic, but they are not. Thus, « né », ‘with’ plus « badzá », ‘hoe’, produces « nébadzá » rather than « *nébádza ». Examples such as this require a new reset introduction rule, described in (11).

- (11) CLITIC (RESET INTRODUCTION) RULE ⁶ : #^lσ₁#⁰σ₂ → #^lσ₁#^lσ₂

In the notation I am adopting, ‘#’ represents the edge of a word, so ‘##’ represents a word-word juncture and ‘#’ sandwiched between other symbols represents a word-clitic or clitic-clitic juncture. ‘σ’ represents a syllable ; ‘⁰σ’ represents a syllable having no edge features associated to its onset ; ‘^lσ’ represents a syllable to the onset of which is associated an edge ; ‘^lσ’ represents a syllable to the onset of which is associated a reset. ‘^lσ₁’ represents a syllable identical to ‘σ₁’ except for the initial edge and likewise for ‘^lσ₁’. A ‘σ’ without any prefixed superscript is unspecified as to whether any edge feature is associated to its onset.

The clitic rule in (11) says that an unassociated syllable following a clitic syllable marked with an edge is itself marked with a reset. That it is a reset which is introduced and not an edge is illustrated by examples such as « sénebadzá » – Meeussen’s rule does not propagate past this low tone. The operation of the clitic reset introduction rule is illustrated in (12a). (12b) shows what would result if this rule introduced an edge rather than a reset. The word resets are not shown.

- (12) | | | | | |
 a. se # ne # badza → senebadza sénebadzá ‘like with a hoe’
 | | | | | |
 b. se # ne # badza → senebadza *sénebádza

2.3. Stevick’s rule

A distinct problem of tonal composition is presented by Stevick’s rule. By this rule, the last tone in a series of high tones becomes low before a word beginning with a high tone. Stevick’s rule is illustrated in (13).

- (13) hóvé ‘fish’## húrú ‘big’ → hóvé húrú ‘big fish’

The tonal edge account already provides the mechanism to produce Stevick’s rule : the word reset. The rule introducing the word reset leaves it hanging between words as an unassociated autosegment. Stevick’s rule suggests that this autosegment may become associated with an adjacent syllable. (14) and (15) are association rules for unassociated autosegments.

- (14) ASSOCIATION RULE 1 : $\lfloor \#^{\text{H}}\sigma_1 \rightarrow \#^{\text{H}}\sigma_1$
 (15) ASSOCIATION RULE 2 : $^{\text{H}}\sigma_1 \# \lfloor \rightarrow \lfloor \sigma_1 \#$

The first rule says that an unassociated reset feature at a word boundary which immediately precedes a syllable bearing no edge feature becomes associated to that syllable. The second rule differs only in that the feature follows the syllable. The two rules ordered in this way produce Stevick’s rule. The first ensures that Stevick’s rule does not apply if the following word does not begin in a high syllable – in this case, the word reset is absorbed by the following word, bleeding the second rule. The second rule, if it applies, assigns the word reset to the last syllable of the preceding word, ensuring that it will be low. These association rules are illustrated in (16).

- (16) $\begin{array}{|c|c|c|c|} \hline | & | & | & | \\ \hline \end{array}$
 hove ## huru → hove huru hóvé húrú (from (6) and (15))

In the course of the derivation represented in (16) two word resets are introduced. The association rules do not say what becomes of the first reset. The first association rule does not apply to the second reset, since it is followed by an associated syllable. The second one does apply, however ; the preceding syllable is unassociated. The second reset ends up associated with the final syllable of the first word, therefore.

There are eight possible word junctures depending on whether the final syllable of the first word is high or low, whether it is one of a series or single, and whether the first syllable of the second word is high or low. The two association rules get the results right in all cases, but they do not clarify what happens in the cases where both the syllable before the juncture and the syllable after the juncture are already associated with some tonal edge feature. As long as the tone is reset to low, it can make no descriptive difference where precisely the word reset resides, but for theoretical tidiness we might postulate a third association rule.

- (17) ASSOCIATION RULE 3 : $\lfloor \# \sigma_1 \rightarrow \# \sigma_1$

The third association rule says that an unassociated reset becomes associated to the onset of a following syllable. It is bled by rules 1 and 2.

Example (18) shows Stevick's rule applying at a clitic juncture.

- (18) mukúró 'large' # sá 'too' → mukúrusá 'too large'

In these instances, its basis is a clitic reset rather than the reset at word juncture, but the mechanism is the same. In order to account for these we must rewrite the clitic rule so that it applies to enclitics as well as proclitics :

- (19) THE CLITIC (RESET INTRODUCTION) RULE :

- a. $\# \downarrow \sigma_1 \# \sigma_2 \rightarrow \# \downarrow \sigma_1 \downarrow \sigma_2$
- b. $\sigma_2 \# \downarrow \sigma_1 \# \rightarrow \sigma_2 \downarrow \sigma_1 \#$

The effect of this modification is to make the rule symmetrical, so all high-toned clitics introduce resets onto adjacent unassociated syllables on their hosts. We also must rewrite the association rules so that the boundary marker is not obligatory :

- (20) THE ASSOCIATION RULES :

1. $\downarrow (\#) \sigma_1 \rightarrow (\#) \downarrow \sigma_1$
2. $\sigma_1 (\#) \downarrow \rightarrow \downarrow \sigma_1 (\#)$
3. $\downarrow (\#) \sigma_1 \rightarrow (\#) \downarrow \sigma_1$

This will give us the derivation shown in (21).

- (21) $\begin{array}{ccc} | & | & | \downarrow | \\ \text{mukuru} & \# \text{sa} & \rightarrow \text{mukurusa} \text{ mukúrusá} \end{array}$ [from (19.b) and (20.2)]

The word reset is not represented. The resets which is present is introduced by part b of the clitic rule and is associated by the second association rule.

Our edge feature analysis of tone in Shona so far includes a rule introducing a word reset, a set of rules introducing a clitic reset, and an ordered block of rules governing the association of the resets introduced by the first two sets of rules. All that remains to account for is the tonology of verbal stems. For this, we will require one more rule, a rule introducing a stem reset.

2.4. Verb stems

In Shona, verbal roots only ever carry a single tone, high or low. This tone then spreads across all the syllables of the stem. This is illustrated in (22).

- (22) kuténgá 'to buy'
 kuténgésá 'to sell'
 kuténgésérá 'to sell to'
 kuténgéséráná 'to sell to each other'

So far, verbs present no special challenge to the edge feature account. All that is at issue in (22) is tonal spreading, which falls out trivially from the nature of edge features. Even when the tone is apparently more dynamic, verb stems present no challenge. In particular, there is a reduplication construction which exhibits tonal alternation reminiscent of Meeussen's rule :

(23) kuténgésá → kuténgésátengesa 'to keep selling'

This alternation follows naturally in the edge feature account if the stem is duplicated completely, including the lexical edge feature associated to the onset of the first syllable.

(24) | | |
ku-tengesa → kutengesa-tengesa kuténgésátengesa

The same mechanism, *i. e.* no mechanism, produces the alternation in (24) as produced the alternation in Meeussen's rule. The initial word reset is not represented.

Verbal stems only behave strangely when we add a high-toned prefix. When we add a high-toned prefix to a low-toned stem, rather than spreading across the entire stem the high tone stops on the penultimate syllable. Thus from « kuerengera » 'to read to' we have « kumúéréngéra » 'to read to him' rather than « *kumúéréngérá ». When we add a high-toned prefix to a high-toned stem, there is no tone-reversal, no Meeussen's rule. Rather, both the prefix and the stem keep their high tones. So when we take « kuténgésá », 'to sell', and add the third person object prefix « -rí- », we get « kuríténgésá », 'to sell it' rather than « *kurítengesa ». What could block the spread of the high tone in the first case and separate the two edges in the second case ? Another reset. This reset is introduced by the rules in (25).

(25) THE STEM (RESET INTRODUCTION) RULES ⁷ :

1. $-(\langle^0\sigma^*\rangle_1)^0\sigma_2\# \rightarrow \langle^0\sigma^*\rangle_1\downarrow\sigma_2\#$
2. $-\sigma_1 \rightarrow \downarrow\sigma_1$

In these rules, '↓' represents a stem juncture. Identically indexed identical subformulas in angle brackets represent identical substrings. The rules together ensure that every stem juncture introduces a reset to the stem. The first rule says that this reset should be assigned to the rightmost syllable in the word, provided that no syllable associated with an edge feature intervenes between it and the stem juncture. This rule bleeds the second, which says that in all other cases a reset should be associated to the onset of the syllable immediately following the juncture. The first rule applies in low-toned stems and the second, in high-toned stems. In effect, the stem reset floats as far rightward in the word as it can go ; the only things that can block its movement are the end of the word and another edge feature. The application of this rule block is illustrated in (26-27).

- (26) $\begin{array}{c} | \qquad \qquad \qquad | \qquad \qquad \qquad \text{L} \\ \text{kumu} - \text{erengera} \rightarrow \text{kumuerengera kumuéréngéra [from (25.1)] \\ | \quad | \qquad \qquad ||| \\ \text{(27) } \text{kuri} - \text{tengesa} \rightarrow \text{kurítengesa kuríténgésá [from (25.2)] \end{array}$

Again, for simplicity I have not represented the word reset, which sets the initial tone in both examples to low. In (26), the stem juncture introduces a reset on the final syllable of the word according to stem rule 1. In (27), the stem juncture appends a reset to the beginning of the following syllable. This feature has to share space with the edge feature already there. The initial low tone carries across the first syllable, is brought high by the edge on the onset of the second syllable, and at the onset of the third syllable the tone is reset to low by the stem reset and then immediately returned to high by the lexical edge on that syllable.

2.5. Summary

That completes the edge feature account of this fragment of Shona tonology. To recapitulate, we have two edge features, a simple edge and a reset. The first represents the boundary between a region of high tone and a region of low tone. The second represents a point after which the tone is returned to some default, whatever it was before. The edge features occur between syllable nuclei, and this means in the case of Shona that they are associated with syllable onsets; Shona, according to Myers (1987), can be analyzed without reference to syllable codas. The edge features may occur lexically and one of them, the reset, may be introduced by rules. The complete set of rules postulated for the edge feature account is presented below.

THE RESET INTRODUCTION RULES :

THE WORD RULE :

$$\#\# \rightarrow \# \text{L} \#$$

THE CLITIC RULES :

$$\text{a. } \# \text{L} \sigma_1 \# \sigma_2 \rightarrow \# \text{L} \sigma_1 \text{L} \sigma_2$$

$$\text{b. } \sigma_2 \# \text{L} \sigma_1 \# \rightarrow \sigma_2 \text{L} \text{L} \sigma_1 \#$$

THE STEM RULES :

$$1. - \langle \sigma^* \rangle_1 \sigma_2 \# \rightarrow \langle \sigma^* \rangle_1 \text{L} \sigma_2 \#$$

$$2. - \sigma_1 \rightarrow \text{L} \sigma_1$$

THE ASSOCIATION RULES :

$$1. \text{L} (\#) \sigma_1 \rightarrow (\#) \text{L} \sigma_1$$

$$2. \sigma_1 (\#) \text{L} \rightarrow \text{L} \sigma_1 (\#)$$

$$3. \text{L} (\#) \sigma_1 \rightarrow (\#) \text{L} \sigma_1$$

These rules describe how the underlying representation of a complex surface form is derived from the lexical representations of its parts. Within these rules lexical features are immutable and there is no rule which deletes, moves, or modifies any feature associated with a syllable. The stem rules and the association rules are

ordered among themselves, but considered as four separate blocks the rules are not ordered in any way. As far as tone is concerned, a string is well-formed as the underlying representation of a surface form in Shona if it does not contain the conditioning environment for any rule in any one of these blocks. Every rule is 'self-bleeding': its application removes its conditioning environment.

There is much more to Shona tonology than I have presented here. As I have said, the present paper is meant only to demonstrate a new methodology and reveal some of its potential. For yet thornier problems I refer the reader to Kenstowicz (1994 ; p. 372-375), Odden (1986), Myers (1987), Hewitt and Prince (1989).

3. An autosegmental account of certain phenomena in Shona

Let us now consider how we may describe the same phenomena in a standard autosegmental framework ⁸. The account I will give is based on Kenstowicz (1994), which in turn is based on Myers (1987) and Odden (1980). For further explanations and elaboration, I urge the reader to consult Kenstowicz (1994).

Autosegmental phonology provides a way to describe multiple instances of a phonological feature as reflecting single instances underlyingly : the surface instances are linked together to a common tone in the underlying form. So for instance, the autosegmental representation of « murúmé » 'man' is,

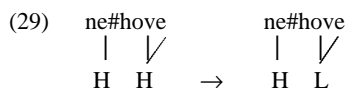
$$(28) \quad \begin{array}{c} \text{murume} \\ | \quad \diagup \\ \text{L} \quad \text{H} \end{array}$$

This example illustrates the basic mechanics of the autosegmental account. TONES and TONE-BEARING UNITS (TBUs) exist on separate TIERS. Every TBU must ultimately come to be associated with a tone. The association of tones to TBUs is mediated by a separate entity, the ASSOCIATION LINE ; these link tones to TBUs. If the tones are unlinked, they first become linked to TBUs via the UNIVERSAL ASSOCIATION CONVENTION (UAC), which joins them up to unassociated TBUs one at a time, left to right. Afterwards, if any TBUs remain, they are linked to the final tone by a rule of RIGHTWARD SPREADING. An important constraint in autosegmental morphology is that ASSOCIATION LINES CANNOT CROSS.

Meeussen's rule is not an inevitable consequence of the autosegmental account of Shona, but only one rule is required to produce it. This is the linear rule presented in (7), repeated here.

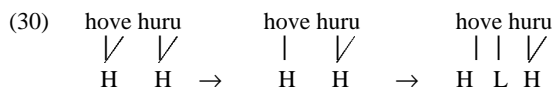
$$(7) \quad \text{H} \rightarrow \text{L/H\#}__.$$

The operation of this rule is illustrated in (29).



A possible alternative formulation has it that the lexical high tone of « hóvé » is not converted to a low tone but that it is deleted and a DEFAULT TONE INSERTION rule, which is necessary in any case, supplies the TBUs now bereft of any tone with the default low tone. Note that in the autosegmental account a special explanation is given for why Meeussen's rule does occur, whereas in the edge feature account a special explanation is given for why it fails to occur in some instances.

Stevick's rule describes the apparent insertion of a low tone between plateaus of high tone in adjoining words. The edge feature account is that the word reset of the second word is becoming associated with the final syllable of the preceding word. The autosegmental account, informally stated, is that a TBU linked to a multiply-linked tone becomes delinked from this tone when it occurs immediately before another TBU linked to a different high tone, and the Default Tone Insertion rule then supplies this TBU with a low tone. This derivation is represented in (30).

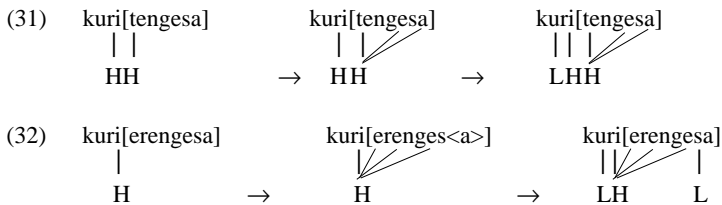


The edge feature account of Stevick's rule relies entirely on mechanisms independently required by the theory : the word reset and some set of rules for associating unassociated edge features. Neither element of the autosegmental account of this rule is necessarily required independently, though Default Tone Insertion, if we posit it, can serve a role in many independent processes and does so in this autosegmental account of Shona.

The element of Shona tonology which requires the most independent stipulations in the autosegmental account is the tonology of the verb stem. Kenstowicz presents no account of the Meeussen's rule-like tonal alternation presented in the reduplication construction illustrated in (25), though he argues that the autosegmental implementation of Meeussen's rule cannot do double duty to explain it. In this respect the autosegmental account differs from the edge feature account : in the latter, both phenomena are automatic consequences of the mechanics of the theory. Kenstowicz does present an account of the interaction of the verb stem with high-toned prefixes. I will present this account in summary.

In the autosegmental account, the phenomenon to account for in the tonology of the verb stem is why the high tone from a prefix spreads into the verb stem but only as far as the penultimate syllable ; why « kuerengesa » becomes « kuriéréngésA » rather than « *kuriéréngésÁ ». Kenstowicz argues that the stem presents a distinct TONAL DOMAIN from the word and hence undergoes an

independent CYCLE of autosegmental rules. In the stem cycle, the UAC applies, then Rightward Spreading. This is illustrated with some abbreviation in the first two representations in (31). These two steps account for why high-toned stems have high tones on every syllable. The final syllable in the stem is then made EXTRATONAL. This status is represented by the angle brackets in the second representation in (32). The word cycle then begins. The UAC applies again, then Rightward Spreading, which ignores any extratonal syllables. This step is illustrated in the second representation in (32). Extratonicity is then removed and any remaining syllables still unassociated are given the default low tone by Default Tone Insertion. This final step is illustrated by the third representations in (31) and (32).



Thus the autosegmental account of the interaction of verb stems with high-toned prefixes involves two cycles with seven steps between them. The edge feature account, similarly informally stated, would be : 1) insert a stem reset ; 2) move it as far rightward as it can go ; 3) associate it to the onset of the next syllable – this is a paraphrase of the description presented in footnote 7.

4. A comparison of the formal properties of the edge feature and autosegmental accounts

How does the edge feature account of Shona compare to the autosegmental account, then, considering only their formal properties ? First let us consider how the two diverge from earlier linear phonological theories.

Linear features are comparable to edge features which are comparable to autosegmental tones. Linear segments are comparable to edge feature onsets which are comparable to tone-bearing units. The relations of features to segments are one-to-one. Those of edge features to onsets are many-to-one. Those of tones to TBUs are many-to-many. Because edge features bear a many-to-one relation to onsets, they are more like traditional features than are autosegmental tones. This is also the respect in which they are ‘more linear’ than autosegmental tones : there is no multiple-linking of edge features to onsets. Because of this, there is also no need to stipulate a convention of Rightward Spreading or a prohibition against crossing lines. There is one respect in which the edge feature account is less stipulative than either the linear or the autosegmental account. In both of the latter, every segment or TBU must be associated to a feature or autosegment. There is

no corresponding stipulation in the edge feature account : any onset may be but need not be associated to some number of edge features. Altogether, considering the necessary features of the edge feature and autosegmental accounts, the former is arguably less stipulative and more like the linear account.

Considering next the elements of each theory necessary to account for the Shona data, the edge feature account is again less stipulative and arguably less powerful. It is less stipulative in that it makes no appeal to extratonicity and it requires no novel stipulations to explain Stevick's rule and tonal alternation in verb stem reduplication. Further, its account of Meeussen's rule is not obviously more stipulative than the autosegmental account. It is less powerful than the autosegmental account in that the rules one must stipulate to provide the edge feature account, unlike those in the autosegmental one, are restricted from modifying associated features in any way, which means lexical features are never altered and features introduced by rules cannot be modified once they are associated. Furthermore, the only type of feature added by any rule is a reset and these are only added at junctures between morphological units. It is also less powerful in that it makes no appeal to extratonicity.

Finally, the formal properties of the edge feature account reveal a structure in the tonology of Shona which is not apparent in the autosegmental account. All of the problems of tonal composition in Shona as framed in the edge feature account involve the placement of resets associated with morphological junctures. In the autosegmental account, too, all of these problems involve morphological junctures, and Kenstowicz suggests, following Myers, that they all conspire to produce compliance with the Obligatory Contour Principle. But since it is debatable whether this principle holds for polymorphemic forms, even assuming it holds as an arbitrary constraint on single morphemes, Kenstowicz's proposal is less than obvious. On the other hand, that the edge feature rules all concern the introduction of resets is an empirical observation.

I conclude that the edge feature account of this fragment of Shona tonology when considered formally is preferable to the autosegmental account on the grounds that it is less stipulative, less powerful, and better reveals generalizations in the phenomena in question.

5. Functional motivations

Though this may be obscured by the formalism I have used, one of the chief advantages of the edge feature analysis is that it has some functional motivation. Assuming hearers of Shona recognize linguistic signs by their tonal cues, three sorts of constraints on the rules manipulating these cues will assist them in doing this :

1. The rules should tend to preserve the melodies of particular forms.
2. The rules should tend to preserve the salience of particular melodies by preserving the edges between tones.

3. The rules should allow the hearer to reconstruct the derivational history of particular tones.

These three constraints do not always harmonize. In particular, constraints (1) and (2) may clash. If two melodies abut with the same tone, the beginning of the second melody will be considerably less salient – it will be imperceptible ; but if some rule changes one of the tones at the edge of one of the melodies to keep their juncture salient, the changed melody will become less recognizable. The two sorts of edge features in the analysis reflect these two constraints. Edges preserve their salience, as per (2), at the sacrifice of the particular tones in the melody, contra (1), because they allow changes in the melody to propagate. Resets do not allow changes in the melody to propagate, thereby potentially sacrificing their own salience, contra (2), but also preserving the particular tones of the following melody, as per (1). Constraints (1) and (3) are linked : anything which preserves a melody in its most recognizable form by blocking changes simplifies its reconstruction from whatever melody is ultimately expressed.

This reasoning also allows us to understand the functionality of the particular rules we have postulated. Melodies are associated with morphosyntactic units ; therefore barriers to changes in these melodies should be found at the junctures between these units, and this is where we find the derived resets. It explains as well why the only edge features associated with these junctures are resets : independently salient junctures need not respect constraint (2), the constraint which resets ignore while respecting (1) and (3) ; and besides, the resets are derived, they do not carry lexical information, so it matters little that they themselves are not salient – their function is to keep the melodies to either side of them distinct. The distinctive behaviors of the different juncture resets can be understood by consideration of the length and morphological independence of the units they demarcate. Unpredictable change is salient, and better so, because it is also informative. The juncture between words is more salient than that between morphologically dependent units, because variation at this juncture is less predictable on either semantic or morphosyntactic grounds. Thus, at word junctures constraint (2) should have less force and word resets should consequently be less mutable than those at clitic and stem junctures, and indeed they are : clitic resets are not always present and stem resets may move, while word resets are always present and remain at the word juncture. There is no motivation for edges and resets within morphemes to change in respect of constraints (1-3), and so they are utterly immutable.

These considerations do not predict Shonas tonology ; they only show its functional motivation. They do lead one to predict that if the edge feature account is correct, one should find that other register tone languages also may be described in terms of edges and resets, where resets are onsets to plateaus of the default tone, additional resets are introduced at the junctures between morphological units, and juncture resets vary in mutability in accordance with the morphological independence of the constituents on either side of their juncture. Moreover, these

predictions do not apply merely to register tone, but to any phenomena which may be described with edge features, *mutatis mutandis* ; which means any phenomena which have been explained with autosegments multiply-linked to tone-bearing units.

It may be that I simply am not sufficiently imaginative, but I can conceive of no such functional motivation for the autosegmental account. And even if I am wrong regarding the functional motivation of autosegmental phonology by the three functional principles listed above, there is a distinct functional motivation for the edge feature account which cannot apply to the autosegmental one : the edge feature account is suited to on-line production. The only anticipatory rule in the edge feature account is the association rule which produces Stevick's rule, and this rule requires the speaker to look ahead only one syllable. Other than this, to pronounce any syllable of a word one need not concern oneself with later morphological constituents. In the autosegmental account of the verb stem, on the other hand, one derives the underlying representation of the word from the lexical representations of its morphological constituents via two cycles, the first over only the verb stem and the second over the entire word including prefixes. Because of this, one cannot compute the autosegmental representation of a Shona verb on-line. One must compute the representation of the entire word and then utter it. When one considers that this includes verbs such as « kuténgéséránátengeserana », 'to keep selling to each other', and that verbs in Shona can be still more complex, this becomes a strong reason to prefer the edge feature approach.

6. Conclusion

I have presented the edge feature analysis of certain tonological phenomena in the register tone language Shona. The edge feature account is based on the observation that one may succinctly represent regions of steady percepts by representing only their edges. I have shown how one may write a set of simple, functionally motivated rules to account for Meeussen's rule, Stevick's rule, and certain features of verb stem tonology in Shona using edge features, and I have compared this to the autosegmental analysis of the same phenomena presented by Kenstowicz. I have adduced a variety of evidence arguing that the edge feature account is simpler than the autosegmental approach, requires a less powerful formal apparatus, and is more revealing of the patterns in Shona tonology. In that the edge feature account does not involve the multiple linking of edge features to syllable onsets, it is more like earlier, linear approaches to tonology, and thus is in a sense more linear than the autosegmental approach. It also has the advantage over the autosegmental approach that it is clearly functionally motivated, among its functional motivations being that the representations it generates may be produced and uttered on-line. For all of these reasons I argue that the edge feature account is to be preferred.

The chief drawback of the edge feature approach as I see it is that it has only been tested on this fragment of Shona tonology. I chose this fragment because others have chosen it to demonstrate the superiority of the autosegmental account. The autosegmental account has also been used on a large and typologically varied array of other register tone languages, not to mention contour tone languages and non-tonal phenomena. There is no reason that I know of that should prohibit an edge feature account from being extended to these other phenomena as well. The argument for the edge feature as a theoretical entity will not have been fully made until this has been done.

NOTES

1. I would like to thank Jean-Pierre Koenig, Colleen Fitzgerald, Karin Michelson, and the anonymous reviewer for *Recherches Linguistique de Vincennes* for their criticisms and editorial advice. Any remaining errors and infelicities are entirely my own.
2. Shona is a Southern Bantu language spoken in Zimbabwe.
3. It is phonological pitch rather than phonetic pitch that is relevant in this paper. In particular, it is irrelevant that constant phonological tones do not correspond to constant phonetic tones.
4. The rules I will present presuppose a distinction between underlying representations and a surface form. All of the strings of symbols related in the rules concern underlying representations.
5. At least this is the case in Shona, which has no contour tones. One might analyze contour tones, in register tone languages at any rate, as tonal edges which occur in the course of pronunciation of a vowel. I will not explore this possibility in this paper, however.
6. This rule works on the assumption that any syllable between two clitic boundaries or a clitic boundary and a word boundary is itself a clitic. This assumption might not be accurate and in any case this is not the most perspicuous formulation of this rule, but it is concise and it will suffice for our purposes.
7. The Kleene star in the first rule below makes its effect non-local. There is a variety of ways of rewriting these rules so that they are strictly local. For instance, the effect of (25) could be achieved by the three rules: 1) $-\sigma_1 \rightarrow \lfloor \sigma_1 ; 2) \lfloor^0 \sigma_1^0 \sigma_2 \rightarrow^0 \sigma_1 \lfloor^0 \sigma_2 ; 3) \lfloor \sigma_1 \rightarrow \lfloor \sigma_1$. The second rule would have to be iterated and there are further complications which would require discussion. For the sake of brevity, I have chosen the non-local formulation in (25), but ultimately some strictly local formulation might be preferable.
8. I say standard because the edge feature account could also be construed as autosegmental. Nonetheless, henceforth I will refer to more standard autosegmental accounts merely as autosegmental and I will identify the edge feature account as edge feature.

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RÉSUMÉ

Dans cet article, un nouveau système de description des tons est présenté dans lequel la mélodie tonale est caractérisée en termes de frontières de plateau. On compare cette analyse avec l'analyse autosegmentale dans laquelle ce qui est décrit ce sont les tons exprimés sur les noyaux syllabiques. Les deux systèmes sont appliqués chacun à un ensemble de problèmes dans la tonologie de la langue Shona : la règle de Meeussen's, la règle de Stevick, et un sous-ensemble de la tonologie du radical verbal. L'analyse en termes de frontières de plateau est plus semblable aux analyses linéaires dans la mesure où il ne contient pas de liaisons multiples des tons aux syllabes. Il est plus simple formellement dans la mesure où il a besoin de moins de stipulations. Il est moins puissant dans la mesure où les règles peuvent affecter moins de traits et de moins de façons: toute règle remet le ton au niveau de défaut aux jointures morphologiques. Ainsi, cette analyse révèle plus clairement la présence de schèmes tonals en Shona. De plus, ses règles sont motivées fonctionnellement et on peut les appliquer lors de la production du discours, contrairement aux règles de l'analyse autosegmentale.

MOTS-CLÉS

Shona, ton, autosegment, linéarité, trait de bord.