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# Positionally Determined [ATR] Vowel Harmony in Wolof

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## I. What this paper is about

It is often believed that harmony features must be unassociated or "floating" in underlying representation because harmony features are morphemic in nature and because lexically linked autosegments may not spread in cyclic phonology. This paper[1] argues that this is not true for vowel harmony in Wolof. In this West African language, vowels which are transparent or opaque with respect to [ATR] harmony when in root-medial position determine the [ATR] value of all following mid vowels when in root-initial position. Theories that are based on the linking and spreading of lexically floating autosegments have to resort to stipulations to be compatible with these facts. The analysis proposed below avoids this problem by assuming that Wolof vowel harmony is "positionally determined" in a sense familiar from Steriade (1979): The harmony feature is lexically specified on the root-initial vowel and spreads in cyclic phonology.

## II. The facts

Wolof is a West Atlantic Niger-Congo language (cf. Greenberg (1966)) that is spoken in the Gambia and Senegal, serving as the lingua franca in the latter country. The data in this paper come from the Senegalese Kayoor-Bawol dialect as described in Ka (1988).

I will assume that Wolof has the vowel system depicted in (1). [ATR] stands for the feature [advanced tongue root], which is used following the general literature on this topic (but see Lindau (1979) for arguments favouring the feature [expanded (pharynx)]). As is usual, the colon marks long vowels.

(1) Wolof Vowel System

| | [-back,-round] | [+back,-round] | [+back,+round] | |
|---|---|---|---|---|
| [+high,-low] | i(:) | | u(:) | [+ATR] |
| [-high,-low] | e(:) | ə | o(:) | [+ATR] |
| [-high,-low] | ɛ(:) | ʌ | ɔ(:) | [-ATR] |
| [-high,+low] | | a(:) | | [-ATR] |

The correct analysis of Wolof [-ATR] central vowels is a controversial issue.

First, Ka (1988) claims that the vowel represented above as low and short (i.e. /a/) is in fact phonetically long (cf. also Ka (1990)). However, this vowel is found only in front of geminates and clusters of nasal and oral stops, contexts from which long vowels are otherwise banned in the language. This fact suggests that /a/ stands for an underlyingly long vowel that is phonetically shortened in order to obey Wolof syllable constraints. My own preliminary phonetic study of Wolof vowels supports this conclusion: /a/ is only insignificantly longer than short vowels and significantly shorter than /a:/.[2]

Second, Ka (1988) argues that the vowel represented above as mid central (i.e. /ʌ/) is in fact low. But Sambou (1984) characterizes /ʌ/ as relatively more "closed" and "muffled" than /a(:)/ which he calls relatively more "open" and "clear". Similar statements can be found in Dialo (1981:17, 1983) and an anonymous review of this paper. The upshot is that /ʌ/ is a mid vowel whereas /a(:)/ is a low vowel, a conclusion that is also argued for in Stewart et al. (1966), Kane (1974) and Ka (1985). Calvet (1965) however found no significant difference between the first formants of /ʌ/ and /a:/, a result that was duplicated in my own study.[3] Inasmuch as the first formant is a reliable indicator of vowel height, this suggests that /ʌ/ and /a(:)/ are both low vowels. But phonetic evidence of this kind has to be taken with a grain of salt. Perkell (1971) for example records exactly the same value (800hz) for the first formants of English /ʌ/ and /a/, vowels which are nevertheless usually taken to be mid and low, respectively. One reason to stick to the classification in (1) comes from vowel harmony. We will see below that in Wolof, the [+ATR] high vowels /i/ and /u/ do not participate in this process. [-ATR] /ʌ/ on the other hand fully participates in vowel harmony and alternates with [+ATR] /ə/. If /ʌ/ was indeed low, the phonology of Wolof would be unique: To the best of my knowledge, no other language has harmonic [ATR] contrasts in its low vowels while at the same time lacking such contrasts in its high vowels.

Within certain domains, [-ATR] and [+ATR] vowels are restricted in their cooccurrence. The following subsections introduce and exemplify the relevant generalizations.

II.1. Harmony in roots containing mid vowels only

In Wolof lexical roots (i.e. roots of open-class items) that contain only mid vowels (i.e. vowels that are [-high,-low]), all vowels are either [+ATR] (cf. (2a)) or [-ATR] (cf. (2b)). There are no native Wolof roots of the form in (3), where all vowels are mid but differ in their [ATR] specification.

| | | | | | |
|---|---|---|---|---|---|
| (2) a. | je:go | "step" | b. | jʌfɛ | "to be expensive" |
| | bereb | "place" | | nɛlʌw | "to sleep" |
| | getən | "to bother" | | dɔ:lɛ | "strength" |
| | testən | "sole" | | jʌrgoñ | "spider" |
| | bəccəg | "daytime" | | bɔldɛ | "big stick" |

(3) *C V C V

$$\begin{bmatrix} \alpha ATR \\ -high \\ -low \end{bmatrix} \qquad \begin{bmatrix} -\alpha ATR \\ -high \\ -low \end{bmatrix}$$

II.2. Harmony in roots containing high or low vowels

As indicated in (1), high vowels are always [+ATR] and low vowels are always [-ATR] in Wolof; the language does not have [-ATR] high vowels or [+ATR] low vowels. Roots containing high or low vowels exhibit the following cooccurrence patterns.

In root-medial position, high vowels can be surrounded by vowels that are either all [+ATR] (cf. (4a)) or all [-ATR] (cf. (4b)), but not by vowels that disagree in their [ATR] specification and the second of which is mid (cf. (5)). In other words, root-medial high vowels are transparent with respect to [ATR] harmony.

| | | | | | |
|---|---|---|---|---|---|
| (4) a. | fidiwəl | "string" | b. | kankurʌñ | (dance) |
| | xulune | (vegetable) | | ka:ritɛ | "butter" |
| | sururə | "respect" | | wʌrugʌr | "obligation" |
| | | | | kʌmisɔl | "robe" |
| | | | | kʌstilɔr | "pan" |

(5) *C V C V C V

$$[\alpha ATR] \qquad [+high] \qquad \begin{bmatrix} -\alpha ATR \\ -high \\ -low \end{bmatrix}$$

Note that there seem to be no native trisyllabic roots with a medial high vowel preceded by a [+ATR] mid vowel. Since [+ATR] mid vowels may precede high vowels in disyllabic roots (cf. (6a)) and since native trisyllabic roots are rare in Wolof, I take this gap to be accidental. The examples in (6b) show that in disyllabic roots, high vowels may also be preceded by [-ATR] mid and low vowels.

| (6) a. | yo:xu | "to shout" | b. | mandi | "to be drunk" |
|---|---|---|---|---|---|
| | wəsin | "to give birth" | | ba:si | "couscous" |
| | ndekki | "to have breakfast" | | tɔntu | "to reply" |
| | wundu | "cat" | | rɛndi | "to slaughter" |
| | dəwlin | "cooking oil" | | tʌli | "pavement" |

In root-initial position, high vowels behave quite differently: Following mid vowels are invariantly [+ATR] (cf. (7)) and never [-ATR] (cf. (8)). Unlike root-medial high vowels, root-initial high vowels are not transparent with respect to [ATR] harmony but instead serve as a harmonic trigger.

(7) jige:n "woman"
gune "infant"
guro "cola nut"
dibe:r "Sunday"
fitnə "hardship"

(8) *C V C V

$$[+\text{high}] \qquad \begin{bmatrix} -\text{ATR} \\ -\text{low} \\ -\text{high} \end{bmatrix}$$

The first two examples in (4b) and (6b) show that [+ATR] high vowels may follow [-ATR] low vowels. The reverse order is also allowed (cf. (9)). This is to say that high and low vowels cooccur freely within the root.

| (9) | tuba:b | "European" |
|---|---|---|
| | bijja:w | "grey hair" |
| | muswa:r | "handkerchief" |
| | ginna:w | "back" |
| | cu:ra:y | "incense" |

The [+ATR]-[-ATR] sequence exhibited in (9) is impossible when the first vowel is mid instead of high: A root-initial mid vowel that is followed by a [-ATR] low vowel is always [-ATR] (cf. (10)) and never [+ATR] (cf. (11)).

| (10) | fʌna:n | "to spend the night" |
|---|---|---|
| | jʌxa:y | "eagle" |
| | tɛnga:dɛ | "hat" |
| | cɔsa:n | "origin" |
| | mbɔna:t | "turtle" |

(11) *C V C V

$$\begin{bmatrix} +\text{ATR} \\ -\text{high} \\ -\text{low} \end{bmatrix} \qquad [+\text{low}]$$

Mid vowels that follow a [-ATR] low vowel are also always [-ATR] (cf. (12a)). This is true even if the low vowel follows itself a root-initial high vowel (cf.

(12b). Due to the rarity of native trisyllabic roots, no other examples are available). Except for borrowings, roots containing a low vowel followed by a [+ATR] mid vowel are unattested in Wolof (cf. (13)).

(12) a. a:wɔ "first wife"
fa:lɛ "to pay attention"
la:lɔ "starch"
ma:fɛ "peanut dish"
pa:kʌ "knife"

b. mbura:kɛ "millet powder"

(13) *(CV)$_0$ C V C V
[+low] [+ATR, -high, -low]

Since regardless of the [ATR] specification on preceding vowels, Wolof low vowels initiate a sequence of [-ATR] vowels, they may be called opaque with respect to [ATR] harmony.

II.3. Harmony beyond the root

Wolof [ATR] harmony is not restricted to lexical roots. Derived words exhibit exactly the same cooccurrence patterns that were illustrated above. Suffixes containing only mid vowels harmonize with the initial vowel of their host (cf. (14a, b)), unless that host contains a low vowel, in which case the suffix always surfaces with [-ATR] vowels (cf. (14c)).

(14) -Æm "3rd sg possessive"[4]

a. kər-əm "his/her house"
seng-əm "his/her palm wine"
dəwlin-əm "his/her cooking oil"

b. xʌndɔ:r-ʌm "his/her snore"
gʌn-ʌm "his/her guest"
kʌyit-ʌm "his/her paper"

c. mbura:k -ʌm "his/her millet powder"
tuba:b-ʌm "his/her European"
bijja:w-ʌm "his/her grey hair"

In a similar fashion, pronouns, focus markers, inflectional morphemes and other non-lexical roots (i.e. roots of closed-class items) containing only mid vowels agree in their [ATR] value with the first vowel of a preceding lexical root (cf. (15a, b) and (16a, b)), unless that lexical root contains a low vowel. In the latter case, the non-lexical root always surfaces with [-ATR] mid vowels (cf. (15c, 16c).

(15) a. mo:du mo: ko xʌm
M. 3rd sg s-foc 3rd sg obj know
"It is Modu who knows it"

b. ʌbdu: mɔ: kɔ jəl
A. 3rd sg s-foc 3rd sg obj take
"It is Abdu who took it"

c. tuba:b mɔ: kɔ jəl
European 3rd sg s-foc 3rd sg obj take
"It is the European who took it"

(16) a. mo:du dəfə fə xʌm
M. 3rd sg v-focus there know
"Modu knows there"

b. ʌbdu: dʌfʌ fʌ genn
A. 3rd sg v-focus there go out'
"Abdu went out there"

c. tuba:b dʌfʌ fʌ genn
European 3rd sg v-focus there go out'
"The European went out there"

The same non-lexical items always surface with [-ATR] mid vowels when not preceded by a lexical root, i.e. utterance-initial.

(17) a. mɔ: jəl
3rd sg s-foc take
"It is he/she who took"

b. dʌfʌ genn
3rd sg v-foc go out
"He/she went out"

A different pattern is exhibited by non-lexical items whose first vowel is high. When the inflectional morpheme dinÆñu "third person plural future" occurs utterance-medial, the [ATR] specification on the mid vowel is determined in the way just described (cf. (18a, b)). But when the same inflectional morpheme occurs utterance-initial, the mid vowel is produced with an advanced tongue root (cf. (18c)), in contrast to the examples in (17). We will see below that this fact remains problematic for both approaches to Wolof vowel harmony discussed in this paper.

(18) a. jige:n ña dinəñu dɛm
woman def 3rd pl fut leave
"The women (away) will leave"

b. xʌlɛ yʌ dinʌñu ñow
child def 3rd pl fut come'
"The children (away) will come"

c. dinəñu dɛm
3rd pl fut go
"They will leave"

## III. Floating Feature Harmony

In order to capture the morphemic nature of harmony features, it is often assumed that in the lexical entries of roots, such features are floating and not associated with any particular segments. This view, which I will call Floating

Feature Harmony, holds that harmony features link and spread only in the phonology. Ka (1988) seems to propose such an account for the case of Wolof [ATR] vowel harmony. I have reconstructed this account in (19), where language specific rules and presumably universal conventions appear in the order in which they are applied.

(19) a. Underlying Representation: Lexical roots may contain a floating [+ATR] autosegment. Low vowels are linked to [-ATR].

b. Morpheme Structure Constraint: Lexical root-initial high vowels are linked to [+ATR].

c. Linking Convention: Link a floating [+ATR] auto-segment to the leftmost vowel of its root unless that vowel is associated with [-ATR].

d. Prosodic Word Formation: Exhaustively parse the utterance into prosodic words delimited by the left syntactic boundary of lexical roots.

e. [+ATR] Spread: Within the prosodic word, spread [+ATR].

f. Redundancy Rule: High vowels are linked to [+ATR].

g. Default Rule: Vowels that are associated neither to [+ATR] nor to [-ATR] are linked to [-ATR].

Floating Feature Harmony correctly predicts that roots containing only mid vowels are always harmonic (cf. (2-3)): If such a root contains a lexically floating [+ATR] autosegment, the latter will link to the first vowel (cf. (20b)) and spread to all following vowels (cf. (20c)). If such a root lacks a lexically floating [+ATR] autosegment, all vowels are assigned [-ATR] by default (cf. (21d)).

(20) a. Underlying Representation
[+ATR]
jE:gO

b. Linking Convention
[+ATR]
|
jE:gO

c. [+ATR] Spread
[+ATR]
| \
jE:gO

d. Default Rule

(d.n.a)

je:go "step"

(21) a. Underlying Representation

jÆfE

b. Linking Convention

(does not apply)

c. [+ATR] Spread

(d.n.a.)

d. Default Rule
[-ATR]
| |
jÆfE

jʌfɛ "to be expensive"

Floating Feature Harmony also correctly predicts that high vowels that are not root-initial are transparent with respect to [ATR] harmony (cf. (4-6), (15a, b) and (16ab)): These high vowels receive their [+ATR] specification either via

[+ATR] Spread from a preceding vowel (cf. (22d)) or via the Redundancy Rule (cf. (23e)). In the first case, [+ATR] continues to spread to all mid vowels that consecutively follow the high vowel within the same prosodic word. In the second case, the [+ATR] specification is assigned to the high vowel only after [+ATR] Spread has ceased to operate. This [+ATR] specification can therefore not spread and all mid vowels that follow the high vowel within the same prosodic word are assigned [-ATR] by default (cf. (23f)).

(22) a. Underlying Representation

```
[+ATR]
 mO:dU mO: kO xÆm
```

b. Linking Convention

```
[+ATR]
   |
mO:dU mO: kO xÆm
```

c. Prosodic Word Formation

```
[+ATR]
   |
mO:dU mO: kO   xÆm
[N°  ] [PR] [PR] [V° ]
(PW           ) (PW  )
```

d. [+ATR] Spread

```
    [ +ATR ]
   /  /   \   \
mO:dU mO: kO   xÆm
(PW           ) (PW  )
```

e. Redundancy Rule

(d.n.a.)

f. Default Rule

```
    [ +ATR ]   [-ATR]
   /  /   \   \     |
mO:dU mO: kO   xÆm
```

mo:du mo: ko xʌm

"It is Modu who knows it"

(23) a. Underlying Representation

```
                [+ATR]
ÆbdU   mO: kO   jEl
```

b. Linking Convention

```
                [+ATR]
                  |
ÆbdU   mO: kO   jEl
```

c. Linking Convention

```
                [+ATR]
                  |
ÆbdU  mO:   kO   jEl
[N°  ] [PR]  [PR] [V° ]
(PW          ) (PW  )
```

d. [+ATR] Spread

(d.n.a.)

e. Redundancy Rule

```
 [+ATR]        [+ATR]
   |             |
ÆbdU  mO:   kO   jEl
```

f. Default Rule

```
[-ATR] [+ATR] [-ATR] [+ATR]
    \    /      /   \    |
     ÆbdU     mO:  kO   jEl
```

ʌbdu: mɔ: kɔ jəl

"It is Abdu who took it"

The derivations in (22, 23) illustrate how Wolof vowel harmony works in examples where the prosodic word and hence the domain of [+ATR] Spread is larger than the root. Note that non-lexical roots in utterance-initial position are in prosodic words of their own and hence inaccessible to [+ATR] Spread from following lexical roots. Since the underlying representations of non-lexical roots never have floating [+ATR] autosegments, mid vowels in utterance-initial non-lexical roots should always be assigned [-ATR] by default. This prediction is borne out if the item in question does not start with a high vowel (cf. (17)). As mentioned earlier, the behavior of non-lexical roots that begin with a high vowel is more complicated (cf. (18c)) and will be discussed in section IV.

Floating Feature Harmony maintains that low vowels are underlyingly linked to [-ATR] (cf. (19a)). The Line Crossing Constraint (cf. Goldsmith (1976)

and Bagemihl (1989)) as formulated in (24) prevents the spreading of [+ATR] over a root-medial low vowel (cf. (25c)). Instead, mid vowels following a low vowel within the same prosodic word are always assigned [-ATR] by default and independently of the question whether that low vowel is or is not preceded by an otherwise spreadable [+ATR] autosegment (cf. (25d, 26d)).[5] This accounts for the fact that low vowels are opaque with respect to [ATR] harmony (cf. (12b, 13, 14c, 15c) and (16c)).

(24) Line Crossing Constraint


(25) a. Underlying Representation
[-ATR]
|
mbUrA:kE

b. Morpheme Structure Constraint
[+ATR] [-ATR]
\ /
mbUrA:kE

c. [+ATR] Spread
(d.n.a.)

d. Default Rule
[+ATR] [-ATR]
\ / |
mbUrA:kE

mbura:kɛ "millet powder"

(26) a. Underlying Representation
[-ATR]
|
tEngA:dE

b. Morpheme Structure Constraint
(d.n.a.)

c. [+ATR] Spread
(d.n.a.)

d. Default Rule
[-ATR]
/ | \
tEngA:dE

tɛŋga:dɛ "hat"

It is when we turn to root-initial high and low vowels that the problems with Floating Feature Harmony become apparent. In order to ensure that lexical roots containing an initial high vowel followed by mid vowels always surface with a [+ATR] specification on all vowels (cf. (7-8)), the Morpheme Structure Constraint must link the high vowel to [+ATR] before [+ATR] Spread applies (cf. (27b, c)). Without the Morpheme Structure Constraint, the initial high vowel of a lexical root that has no floating [+ATR] autosegment in its underlying representation would receive its [+ATR] specification via the Redundancy Rule after [+ATR] Spread has been switched off (cf. (28d)) and the Default Rule would wrongly assign [-ATR] to all following mid vowels (cf. (28e)).

(27) a. Underlying Representation
jIgE:n

b. Morpheme Structure Constraint
[+ATR]
|
jIgE:n

c. [+ATR] spread
[+ATR]
/ \
jIgE:n

(28) a. Underlying Representation
jIgEn

b. (No Morpheme Structure Constraint)

c. [+ATR] spread
(d.n.a.)

| | |
|---|---|
| d. Redundancy Rule | d. Redundancy Rule |
| | [+ATR] |
| | \| |
| | jIgE:n |
| (d.n.a.) | |
| e. Default Rule | e. Default Rule |
| | [+ATR] [-ATR] |
| | \ / |
| | jIgE:n |
| (d.n.a.) | |
| jige:n "woman" | *jigɛ:n |

The problem with the Morpheme Structure Constraint is that it restricts that part of the expressive power of Floating Feature Harmony that motivates this approach in the first place: It curtails the possibilities that arise through the assumption of a lexically floating autosegment on the one hand and underlying underspecification of most vowels on the other hand. This point is important enough to warrant a restatement from a slightly different angle. According to Floating Feature Harmony, surface [+ATR] specifications are on most segments the reflection of morphemic (as opposed to segmental[6]) [+ATR] specifications. But with respect to lexical roots containing initial high vowels, the opposite seems to be true: Here the morphemic [+ATR] specification is the reflection of the redundant [+ATR] surface specification on the first vowel. This contradiction suggests that the Floating Feature approach to Wolof vowel harmony is on the wrong track.

A look at roots containing initial low vowels will support this conclusion. But notice first that in Khalkha Mongolian [+ATR] harmony, /i/ behaves exactly like /i/ and /u/ in Wolof (see Chinchor (1979), Rialland and Djamouri (1984), Steriade (1979) and Svantesson (1986)). Root-medial /i/ is transparent (cf. (29a)). Only [+ATR] vowels may follow root-initial /i/ (cf. (29b)).

(29) Khalkha Mongolian[7]

| a. | | | b. | | |
|---|---|---|---|---|---|
| | onciro | "to become orphaned" | | sire:-ge:ɾ | "table" |
| | tusimel | "official" | | bicig-e:ɾ | "letter" |
| | erbe:xi:nu:d | "butterflies" | | bilu:d-le: | "whetted" |
| | cocgi:-go:ɾ | "cream" | | id-le: | "ate" |
| | vs. | | | | |
| | mɔrilɑn | "towards the horse" | | | |
| | ɔrxiyɔ: | "let's throw it away" | | | |
| | tɑ:lai-ga:ɾ | "hare" | | | |
| | ɔird-ɑ:l | "approach" | | | |

Steriade (1979), who claims that Khalkha Mongolian vowel harmony affects frontness instead of tongue root position, observes that "the fact that words beginning with j are exclusively front should suggest immediately ... that F[ront] H[armony] is run off the first vowel of the word" (p. 27) which in contrast to all other vowels may and "must always be fully specified underlyingly" (p. 35. See also Goldsmith (1985)). In section IV, I will develop a very similar theory for [ATR] vowel harmony in Wolof.

Next, recall that mid vowels that follow a root-initial low vowel are never produced with an advanced tongue root (cf. (12a, 13)). To guarantee this result, Floating Feature Harmony has to restrict the linking of underlyingly floating autosegments to the root-initial vowel (cf. (19c)). Given this restriction, the hypothetical floating [+ATR] autosegment of a root containing an initial low vowel remains unlinked and the Default Rule correctly assigns [-ATR] to the mid vowels of that root (cf. (31c)). Without this restriction (i.e. assuming the version of the Linking Convention in (30)), the floating [+ATR] autosegment would skip the inaccessible root-initial low vowel and link to the leftmost non-low vowel (cf. (32b)), resulting in a surface patter that is unattested in Wolof.

(30) Linking Convention: Link a floating [+ATR] auto-segment to the leftmost possible (i.e. underspecified) anchor of its root.

(31) a. Underlying Representation




b. Linking Convention (19c)

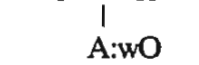
(d.n.a.)

c. Default Rule

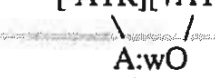



a:wɔ "first wife"

(32) a. Underlying Representation




b. Linking Convention (30)




c. Default Rule

(d.n.a.)

*a:wo

Ka (1988: 81) assumes that the restrictive version of the Linking Convention follows from the universal Association Conventions proposed in Pulleyblank (1983: 31).

(33) Association Conventions: Map a sequence of tones onto a sequence of tone bearing units, a. from left to right
b. in a one-to-one relation.

Harmony processes in other languages provide counter-examples against this strict interpretation of the universal Association Conventions. In Yoruba vowel harmony (cf. Archangeli and Pulleyblank (1989)), a lexically floating [-ATR] autosegment links to the rightmost possible anchor and spreads to consecutive mid vowels to the left of that anchor. Yoruba high vowels always surface with a [+ATR] specification and are opaque with respect to [-ATR] harmony. As indicated in derivation (36), linking skips an inaccessible root final high vowel, a fact that accounts for the disharmonic roots in (34). In Akan vowel harmony (cf. Clements (1981)) a lexically floating [+ATR] autosegment links to the leftmost possible anchor and spreads to consecutive non-low vowels to the right of that anchor. Note that Akan high vowels fully participate in [+ATR] harmony and surface with either a [+ATR] or a [-ATR] specification. Akan low vowel are underlyingly [-ATR] and opaque with respect to [+ATR] harmony. Derivation (37) shows that linking skips an inaccessible root-initial low vowel, with the by now familiar result of disharmonic roots (cf. (35)).

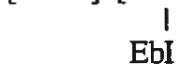
(34) Yoruba[8]

| | |
|---|---|
| ɛ̀bi | "guilt" |
| ɔ̀kín | "egret" |
| ɛ̀wù | "clothing" |
| ɔ̀run | "heaven" |
| ɔ̀jɛun | "glutton" |

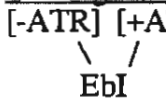
(35) Akan[9]

| | |
|---|---|
| a̰-ko | "parrot" |
| ka̰ri | "to weigh" |
| ya̰funu | "belly" |
| $k^w$a̰ɟo | (proper name) |
| a̰-go | "velvet" |

(36) a. Underlying representation



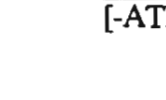

b. Linking Convention




ɛ̀bi "guilt"

(37) a. Underlying representation


b. Linking Convention




a̰-ko "parrot"

Both Yoruba and Akan use the more permissive instead of the more restrictive formulation of the Linking Convention (i.e. (30) instead of (19c)). It is particularly striking that Akan allows the very derivation that has to be excluded in Wolof (compare (37) with (32)). The prohibition against Wolof roots containing an initial [-ATR] low vowel followed by [+ATR] mid vowels therefore cannot follow from universal conventions or principles such as Pulleyblank's Association Conventions. It has to be stipulated language specifically.

The need for this language specific stipulation poses a problem for Floating Feature Harmony that is very similar to the one discussed above in connection with root-initial high vowels. According to Floating Feature Harmony, the absence of a surface [+ATR] specifications is on most segments the reflection of the absence of a floating [+ATR] autosegment in the lexical entry of the root. But in roots containing initial low vowels, the absence of a morphemic [+ATR] autosegment and hence the absence of [+ATR] specifications on root-medial mid vowels is the reflection of the redundant [-ATR] surface specification on the first vowel. This contradiction again calls into question the appropriateness of a Floating Feature Harmony analysis of Wolof vowel harmony.

In the next section, I will develop a theory of [+ATR] vowel harmony in Wolof whose expressive power is defined (and not, as in the case of Floating Feature Harmony, curtailed) by the special role of root-initial vowels.

## IV. Positionally Determined Harmony

We just saw that lexical root-initial high and low vowels play a decisive role in Wolof vowel harmony: Their segmental [ATR] specification determines the [ATR] specification on following mid vowels and hence the morphemic [ATR] specification on the root. This observation is incompatible with Floating Feature Theory which identifies the morphemic [ATR] specification with a lexically floating

autosegment that is not dependent on any particular root-segment in underlying representation. Root-initial mid vowels do not provide any evidence in this respect: Since all mid vowels may surface with either the positive or the negative value for [ATR], harmony in roots containing an initial mid vowels could be produced by linking a lexically floating [ATR] autosegment to the first vowel of the root and spreading it to the right. But harmony in these roots is equally compatible with the view (motivated by the behavior of root-initial high and low vowels) that it is caused by the segmental [ATR] specification on the first vowel. Wolof vowel harmony can therefore be described in the following, maximally simple terms:

(38) The [ATR] specification on the first vowel of a lexical root determines the [ATR] specification on all consecutive mid vowels before the next low vowel or the next lexical root.

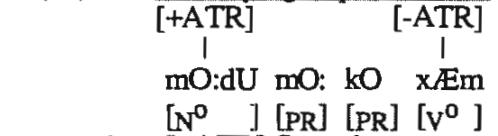
This descriptive generalization is the basis for a theory that I will call Positionally Determined Harmony. In Positionally Determined Harmony, a certain anchor position (the first vowel of lexical roots in the case of Wolof) is designated as the harmony trigger and is underlyingly specified for the harmony feature (e.g. [±ATR]). Usually, all other anchors remain unspecified for the harmony feature, although I will show below that there is reason to believe that in Wolof, all low vowels are underlyingly marked [-ATR]. In the phonology, one or possibly both values of the harmony feature spread. I will assume that Wolof chooses the first option and spreads only [+ATR] (But see the discussion at the end of this section). Default and Redundancy rules take care of those anchors which remain unspecified after spreading. The ordered rules of Positionally Determined [ATR] vowel harmony in Wolof are summarized in (39).

(39) a. Underlying Representation: i. All low vowels are linked to [-ATR].
ii. The first vowel of each lexical root is specified for [ATR], except where this leads to a violation of iv.
iii. All other vowels are unspecified for [ATR]
iv. *[$X_{lex^0}$ [αATR][-αATR]]
b. [+ATR] Spread: Spread [+ATR] from left to right.
c. Redundancy Rule: Link all high vowels to [+ATR].
d. Default Rule: Link all vowels that are unspecified for [ATR] to [-ATR].

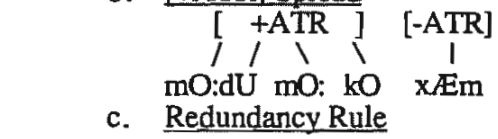
The derivations in (40) and (41) illustrate how Positionally Determined Harmony works in examples that do not contain opaque low vowels. All and only lexical root-initial vowels are marked either [+ATR] or [-ATR] in underlying representation. (cf. (40a, 41a)). [+ATR] spreads to the right (cf. (40b)), but not to the left (cf. (41b)). Vowels that are neither underlyingly specified nor affected by [+ATR] Spread receive their [ATR] specification via the Redundancy Rule (cf. (41c)) or the Default Rule (cf. (41d)). Note that unlike Floating Feature Harmony, Positionally Determined Harmony does not have to refer to the prosodic word or any other domain in order to explain the range of [+ATR] Spread: The applicability of [+ATR] Spread is restricted on the one side by the directionality of spreading and on the other side by the fact that the initial vowel of lexical (but not non-lexical)

roots is always linked to either [+ATR] (which is spread itself) or [-ATR] (which, by the Line Crossing Constraint, stops [+ATR] Spread).

(40) a. Underlying Representation




b. [+ATR] Spread




c. Redundancy Rule

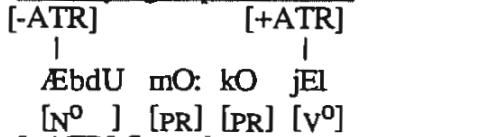
(d.n.a.)

d. Default Rule

(d.n.a.)

mo:du mo: ko xʌm
"It is Modu who knows it"

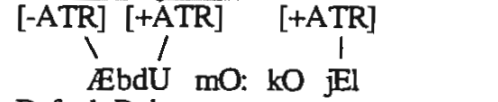
(41) a. Underlying Representation



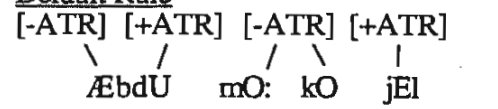

d. [+ATR] Spread

(d.n.a.)

c. Redundancy Rule




d. Default Rule



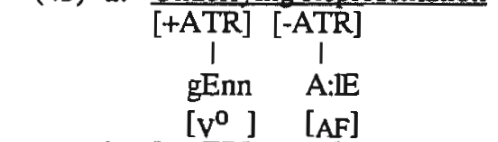

ʌbdu: mɔ: kɔ jəl
"It is Abdu who took it"

High vowels can be linked only to [+ATR]. In fact, this restriction does not have to be stipulated: A high vowel underlyingly linked to [-ATR] would also be linked to [+ATR] by the Redundancy Rule and surface with the structure in (42), which is ruled out on independent grounds. The prohibition against such "double specifications" also correctly prevents [+ATR] Spread from applying to low vowels. Compare the derivations in (43) and (44) for the [+ATR] verb genn "to go out" followed by the [-ATR] associative marker a:lɛ.

(42) *[+ATR] [-ATR]



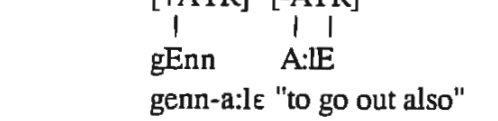
(43) a. Underlying Representation




b. [+ATR] spread

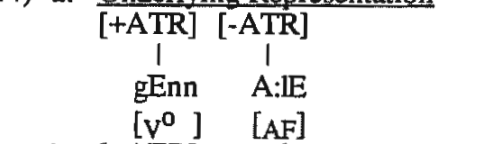
(d.n.a.)

c. Default Rule

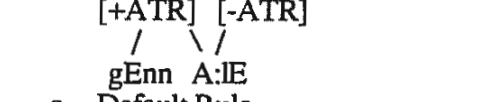



genn-a:lɛ "to go out also"

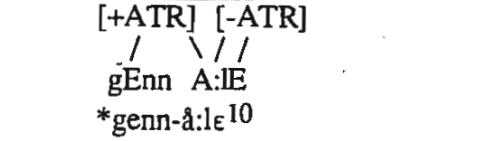
(44) a. Underlying Representation




b. [+ATR] spread




c. Default Rule

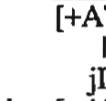



*genn-å:lɛ[10]

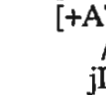
 

Lexical root-initial high vowels are hence underlyingly linked to [+ATR] (cf. (45a)) unless the root also contains a low vowel (cf. the discussion of (49, 50) below). [+ATR] Spread links this specification to all following non-opaque vowels (cf. (45b)). Lexical root-initial low vowels, on the other hand, are underlyingly linked to [-ATR] (cf. (46a)), as are in fact all low vowels (cf. the discussion of (47, 48)). The Redundancy and Default Rules assign all following non-opaque vowels their respective [ATR] values (cf. (46c, d)).

(45) a. Underlying Representation




b. [+ATR] spread




c. Redundancy Rule

(d.n.a.)

d. Default Rule

(d.n.a.)

jige:n "woman"

(46) a. Underlying Representation



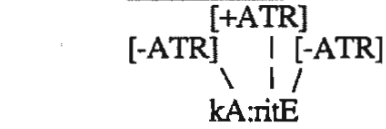

b. [+ATR] spread

(d.n.a.)

c. Redundancy Rule




d. Default Rule




ka:ritɛ "butter"

As shown in (46a), Positionally Determined Harmony assumes that low vowels are underlyingly linked to [-ATR]. The examples discussed so far do not require this assumption. Suppose instead that a feature cooccurrence constraint rules out [+ATR] on low vowels and that [+ATR] Spread is strictly local in that it cannot skip any vowels. Low vowels (including lexical root-initial ones) are underlyingly unspecified for [ATR] and receive their [-ATR] specification late in the derivation via the Default Rule. They nevertheless stop [+ATR] Spread by virtue of the locality restriction on this rule.

Remember however that within the same root, mid vowels that precede low vowels are always [-ATR] (cf. (10)) and never [+ATR] (cf. (11)). This cannot be due to a surface prohibition against root-internal disharmony, since [+ATR] high vowels may freely precede (cf. (9)) or follow (cf. the first two examples in (4b) and (6b)) low vowels. It is hard to see how an illicit derivation like the one in (47) could be ruled out by the theory sketched in the preceding paragraph. Note in particular that the apparently problematic underlying representation (47a) is identical in all relevant aspects to the unproblematic underlying representation of the first lexical root in (40a). But under the assumption that low vowels are underlyingly linked to [-ATR] (cf. (39a-i)) and that underlyingly disharmonic roots are prohibited (cf. (39a-iv)), lexical root-initial mid vowels must be underlyingly linked to [-ATR] before low vowels (cf. (48a)) and the correct results ensue.

(47) a. Underlying Representation
[+ATR]
|
tEngA:dE

b. Default Rule
[+ATR] [-ATR]
\ / |
tEngA:dE

*tenga:dɛ

(48) a. Underlying Representation
[-ATR]
/ \
tEngA:dE

b. Default Rule
[-ATR]
/ | \
tEngA:dE

tɛnga:dɛ "hat"

If the above reasoning is on the right track, Positionally Determined Harmony makes an interesting prediction: In lexical roots with an initial high vowel followed by a mid and a low vowel, the mid vowel should always surface with a [-ATR] specification. We saw above that high vowels may not be linked to [-ATR]. In the root type under discussion, lexical linking of the high vowel to [+ATR] creates an underlyingly disharmonic root if low vowels are underlyingly linked to [-ATR]. Under the assumption that underlyingly disharmonic roots are impossible, the high vowel has to remain unspecified in the lexicon (cf. (49a)). As a consequence, [+ATR] Spread cannot apply (cf. (49b)) and the mid vowel becomes [-ATR] by default (cf. (49d)). As a matter of fact, this seems to be exactly what is happening in Wolof. If on the other hand the assumptions above were wrong and the high vowel was underlyingly marked [+ATR] in these roots (cf. (50a)), we would expect this feature to spread to the mid vowel (cf. (50b)), regardless of whether low vowels are, as assumed in (50a) for the sake of concreteness, or are not underlyingly unspecified. As indicated, the output of this derivation is illformed.

(49) a. Underlying Representation
[-ATR]
|
sInEmA:

b. [+ATR] Spread

(d.n.a.)

c. Redundancy Rule
[+ATR] [-ATR]
\ |
sInEmA:

d. Default Rule
[+ATR] [-ATR]
\ / |
sInEmA:

sinɛma: "movie theater"

(50) a. Underlying Representation
[+ATR]
|
sInEmA:

b. [+ATR] Spread
[+ATR]
| |
sInEmA:

c. Redundancy Rule

(d.n.a.)

d. Default Rule
[+ATR] [-ATR]
| \ /
sInEmA:

*sinema:

While this example suggests that Wolof low vowels are indeed underlyingly linked to [-ATR], it constitutes only inconclusive evidence. As mentioned in section II, there are few trisyllabic roots in Wolof. Of these, the example above is to my knowledge the only one with the vowel sequence high-mid-low. Unfortunately, it is obviously a borrowing from French and loans may violate the rules of Wolof

vowel harmony. But note that unlike its Wolof counterpart, the mid vowel in the French cinéma is, at least in careful pronunciation, produced with an advanced tongue root. That the [ATR] specification on this vowel was changed during borrowing and that it conforms to the prohibition against underlyingly disharmonic roots only after this change remains suggestive.

In summary, the absence of lexical roots with an [+ATR] mid vowel followed by a low vowel leads me to conclude that low vowels are underlyingly linked to [-ATR]. This conclusion is at odds with the theories of Radical Underspecification (cf. Archangeli (1988)) and Redundant Value Underspecification (cf. Steriade (1987)). Let me briefly address this question.[11]

First, it seems necessary to lexically specify redundant [-ATR] on low vowels in Esimbi in order to account for vowel height transfer in this language (cf. Hyman (1988)). It might therefore simply be empirically wrong to exclude this option.

Second, Perkell (1971) argues that [+constricted pharynx] or, in our terms, [-ATR] instead of [+low] is the feature which defines /a(:)/. It is then reasonable and in accordance with underspecification theory to assume that [ATR], far from being lexically unspecified, is in fact the only feature present in the underlying representation of /a(:)/.

In the remainder of this paper, I would like to touch on two other problems. While the first of them concerns only Positionally Determined Harmony, the second is relevant for Floating Feature Harmony as well. First, note that Positionally Determined Harmony crucially involves the spreading of a lexically linked autosegment. Archangeli and Pulleyblank (1989) claim that the Strict Cycle Condition prohibits such spreading.

(51) Strict Cycle Condition
If W is derived from a lexical entry W', where W' is nondistinct from XPAQY and distinct from XPBQY, then a rule A → B / XP_QY cannot apply to W until the word level. Kiparsky (1985:89)

The Strict Cycle Condition prohibits the application of structure changing rules to underived structures in cyclical phonology (cf Kiparsky (1985)). The claim is that roots with lexically linked autosegments constitute such underived structures and that spreading can therefore not apply in these roots before Default and Redundancy Rules have fixed the specifications on all targets. The linking of a lexically floating autosegment on the other hand creates a derived structure to which spreading can apply already in cyclically phonology, i.e. before Default and Redundancy Rules. But structure building rules are, unlike structure changing rules, not affected by the Strict Cycle Condition. Since Wolof [+ATR] Spread is structure building instead of structure changing, it should not be subject to the Strict Cycle Condition and spreading of lexically linked [+ATR] should, as assumed in this study, be possible.[12]

Let me finally return to non-lexical roots containing an initial high vowel followed by a mid vowel (cf. (18)). In utterance-medial position, these roots

behave as predicted by Positionally Determined Harmony (and Floating Feature Harmony, as the reader may verify on her own). Since these roots are non-lexical, their initial vowel is not underlyingly specified for [ATR] (cf. (52a, 53a)) and all their non-opaque vowels receive their [ATR] specification either via [+ATR] Spread from the closest lexical root (cf. (52b)) or via the Redundancy and Default Rules (cf. (53c, d)).

(52) a. Underlying Representation

[+ATR] [-ATR]

jIgE:n ñÆ dInÆñU dEm

[N$^0$ ] [def] [I$^0$ ] [V$^0$ ]

b. [+ATR] Spread

[ +ATR ] [-ATR]

jIgE:n ñÆ dInÆñU dEm

c. Redundancy Rule

(d.n.a.)

d. Default Rule

(d.n.a.)

jige:n ñə dinəñu dɛm "The women (away) will leave"

(53) a. Underlying Representation

[-ATR] [+ATR]

xÆlE yÆ dInÆñU ñOw

[N$^0$ ] [def] [I$^0$ ] [V$^0$ ]

b. [+ATR] Spread

(d.n.a.)

c. Redundancy Rule

[-ATR] [ +ATR ]

xÆlE yÆ dInÆñU ñOw

d. Default Rule

[-ATR]

[-ATR] [+ATR] [+ATR]

xÆlE yÆ dInÆñU ñOw

xʌlɛ yʌ dinʌñu ñow "The children (away) will come"

In utterance-initial position, however, the roots under discussion are predicted by both Floating Feature Harmony and Positionally Determined Harmony to surface with [-ATR] mid vowels, contrary to the facts (cf. (18c)). Again, no [+ATR] autosegment is available for spreading, and the mid vowel should receive [-ATR] by default (cf. (54d)). The correct form seems to require that non-lexical and lexical root-initial high vowels alike be underlyingly (or, in Floating Feature Harmony, via a reformulated Morpheme Structure Constraint) linked to [+ATR] (cf. (55a)). But this feature should then always spread to a following mid vowel, regardless of whether the root containing both vowels is in utterance-initial or utterance-medial position. As a consequence, the derivation in (53) is no longer possible and we now expect the non-lexical roots in question to show up with a [+ATR] mid vowels after [-ATR] lexical roots, too, which they do not (cf. (18b)).

(54) a. Underlying Representation

[-ATR]

dInÆñU dEm

[I$^0$ ] [V$^0$ ]

b. [+ATR] Spread

(d.n.a.)

(55) a. Underlying Representation

[+ATR] [-ATR]

dInÆñU dEm

[I$^0$ ] [V$^0$ ]

b. [+ATR] Spread

[+ATR] [-ATR]

dInÆñU dEm

c. Redundancy Rule

```
[+ATR]  [-ATR]
  /  \     |
dInÆñU   dEm
```

d. Default Rule

```
        [-ATR]
[+ATR]  |  [+ATR]  [-ATR]
   \    |   /        |
    dInÆñU          dEm
```

*dinʌñu dɛm

c. Redundancy Rule

(d.n.a.)

d. Default Rule

(d.n.a.)

dinəñu dɛm
"They will leave"

I see no easy way to solve this paradox in either of the two theoretic frameworks discussed in this paper. One might be tempted to reconsider the choice of the feature value that spreads in Wolof vowel harmony, but it is at least doubtful that [-ATR] Spread alone can account for all the data described in section II.[13] Another, more promising solution involves [-ATR] Spread as a second, structure changing harmony rule in addition to structure building [+ATR] Spread. In this approach, [-ATR] would apply post-cyclically as dictated by the Strict Cycle Condition and hence after [+ATR] Spread. Provided that [-ATR] Spread can be restricted to the prosodic word, that all stem-initial high vowels are underlyingly linked to [+ATR], and that [-ATR] Spread can cross high vowels (i.e. that high vowels that are affected by [-ATR] Spread are switched back to [+ATR] by a phonetic implementation rule), just the right facts can be derived. Limitations of space prevent me from exploring this or other avenues that come to mind in this paper. I will have to leave this issue for future research.

## V. Conclusion

In this paper, I have argued that there are at least two types of autosegmental, stress-unrelated harmony systems. Languages like Akan or Yoruba employ Floating Feature Harmony, where the harmonic feature is underlyingly independent from the segments of the morpheme that contains it in its lexical entry. Languages like Wolof or Khalkha Mongolian employ Positionally Determined Harmony, where the harmonic feature is lexically specified on a positionally determined trigger. This second system requires that the Strict Cycle Condition allows the spreading of underlyingly linked autosegments in cyclic phonology. I have argued that since the rules involved are structure building instead of structure changing, this is indeed the case. The behavior of domain-peripheral neutral and opaque segments decides between the two analyses: Only where the surface specification on these invariable segments determines the specification on the variable segments in the rest of the domain do we have reason to believe that Positionally Determined Harmony is at work.

Footnotes

1 The paper was written in 1990 and presented at the 21st Annual Conference on African Linguistics at the University of Georgia at Athens, GA in April 1990. I am indebted to the participants at this conference and in particular to Larry Hyman, Omar Ka and Claude Timmons. I also thank John McCarthy, Harry van der Hulst, Sam Rosenthal, Russell G. Schuh, Lisa Selkirk and three anonymous reviewers for helpful comments on various drafts of this paper. Finally, I am especially grateful for the time and insights shared with me by my Wolof informants: Ndeye Nene Fall, Binta Racine Ly and an anonymous informant. All mistakes are mine.

2 The mean lengths of /ʌ/, /a/ and /a:/ were 0.061sec, 0.075sec and 0.171sec, respectively. The mean ratios of length of the target vowels /ʌ/, /a/ and /a:/ versus length of the reference vowel /a/ were 1.031, 1.335 and 3.309, respectively. Scheffe's test determined both the difference between the mean lengths of /ʌ/ and /a/ and the difference between the mean target/reference ratios of /ʌ/ and /a/ to be statistically insignificant (P-values .6004 and .5906). The corresponding differences between /ʌ/ and /a:/ on the one hand and /a/ and /a:/ on the other hand were deemed statistically significant (P-values .0001).

3 In the speech of my informant, the mean heights of the first formants of /ʌ/, /a/ and /a:/ were 927hz (Calvet (1965): 565hz), 877hz and 924hz (Calvet (1965): 610hz), respectively. Neither the difference bewteen /ʌ/ and /a/ nor the difference between /ʌ/ and /a:/ were statistically significant according to Scheffe's test (P-values .5092 and .9944).

4 I will use the capital letters I, E, Æ, A, U and O for high front, mid front, mid central, low central, high back and mid back archi-vowels without [ATR] specification. In addition, the following abbreviations are used throughout the paper:

| | | | |
|---|---|---|---|
| 1st | first person | fut | future |
| 2nd | second person | inj | injunctive |
| 3rd | third person | def | definite marker indicating remoteness |
| sg | singular | | |
| pl | plural | PR | pronoun |
| subj | subject | $N^0$ | nominal root |
| obj | object | $V^0$ | verbal root |
| s-foc | subject focus | $Xlex^0$ | lexical root |
| v-foc | verb focus | $I^0$ | inflection |
| S-foc | sentence focus | AF | affix |
| | | PW | prosodic word |

5 Ka (1988) does not address the question why low vowels are never preceded by [+ATR] mid vowels in the same root (cf. (11)). Below I propose that this systematic gap is effected by a prohibition against underlyingly disharmonic

roots (i.e. *[X]$_{lex}^{0}$ [αATR][-αATR]]). This solution is also available within Floating Feature Harmony.

6 A feature is segmental insofar as it is associated with an individual segment of the root (e.g. it is part of a particular vowel) and morphemic insofar as it is associated with the root as a whole. Note that an instantiation of a feature may be both segmental and morphemic. I will continue to assume that segmental and morphemic [ATR] specifications are both autosegmental insofar as they are represented on a different tier than other features or the skeleton.

7 /ɷ/ represents a high back rounded [-ATR] vowel

8 In the Yoruba examples, ` represents a low tone, ´ represents a high tone, and vowels without a diacritic bear a mid tone.

9 In the Akan examples, /ạ/ stands for "a raised and fronted low vowel (often transcribed [ɜ]) which approaches [ɛ] in articulation" (Clements (1981: 114)).

10 /a̰/ represents a (universally unattested) low vowel with both [+ATR] and [-ATR] specifications.

11 The assumption that lexical root-initial high vowels are underlyingly marked [+ATR] except when followed by a low vowel is also incompatible with all current versions of underspecification theory. I will say nothing on this issue.

12 The only example cited in the literature as direct evidence for the prohibition against spreading of lexically linked features, [ATR] harmony in Massai (cf. Levergood (1984)), is based on misleading notational conventions in the data source and hence not conclusive, to say the least (Barbara Levergood (p.c.)).

13 The behavior of utterance-initial non-lexical roots containing only mid vowels (cf. (17)) requires a negative default value for [ATR]. To my knowledge, it is a crosslinguistic fact that spreading and default rules never involve the same value of the harmony feature.

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