

Ultra Long-Distance ATR Agreement in Wolof

MARIAME SY

University of California, Los Angeles

0. Introduction

Wolof (West Atlantic) exhibits a pattern of vowel harmony which involves the categorization of all the vowels in the language into two harmonic sets with regard to the feature [ATR] (advanced tongue root). Though the domain of harmony is usually described as being the word, in Wolof this domain extends to syntactic phrases. This fact, in and of itself, is neither unusual nor particularly exciting. Indeed, there are many African languages in which phonological processes apply at the phrasal level. What is exceptionally interesting about Wolof is that in some cases the process of vowel harmony appears to apply across syntactic phrases, showing patterns to which we refer as “ultra-long distance [ATR] agreement” (henceforth ULDA), as shown in (1).

- (1) a. $\overbrace{[-ATR] \quad [-ATR] \quad [-ATR]}^{\downarrow}$
 xaj b- u weex **b- ale**
 dog CL-REL be.white CL-DEM.DIST
 ‘that white dog’
- b. $\overbrace{[+ATR] \quad [+ATR] \quad [+ATR]}^{\downarrow}$
 béy w- u réy **w- ëlé**
 goat CL-REL be.big CL-DEM.DIST
 ‘that big goat’

Although it seems reasonable to assume that the final demonstratives in the examples in (1) harmonize with the head nouns which they modify, nothing tells us that the trigger of harmony is not the immediately preceding adjectival verbs. In fact, since these verbs are specified for the [ATR] feature and thus cannot incur any harmony effects from the noun, it seems more reasonable, from a phonological point of view, to assume that the verbs are the actual triggers of harmony on the demonstratives. Then, the question immediately arises as to which of these assumptions is in actual fact correct. The first part of this article reports on the findings of an experimental study designed to answer this question.

Given the fact that nouns and adjectival lexemes carrying opposite [ATR] values may combine within the same structure, such disharmonic strings naturally come to mind as the perfect testing ground. Examples of this type of disharmonic DP are given in (2) below.

medial position, the two types vowels behave differently. High vowels in this position display typical transparent behavior, i.e. they neither incur harmony from vowels located to their left, nor do they trigger harmony on those located to their right.

- (5) a. bind-óón-ně ‘wrote-3sg.’ b. soppi-woon-na ‘changed-3sg.’
 tuur-óón-ně ‘spilled-3sg.’ teeru-woon-na ‘welcomed-3sg.’

The examples in (5a) show that the past and perfective affixes surface respectively as [+ATR] *-óón* and *-ně*, harmonizing with the initial high vowel stems with which they occur. Yet in (5b), where the stems contain medial high vowels and [-ATR] initial vowels, these same affixes surface as [-ATR] *-oon* and *-na*, incurring no harmony effects from the immediately preceding high vowels.

Medial low vowels, on the other hand, never allow spreading of the opposite tongue root feature across their own, but instead initiate their own harmony domain to their right, thus showing typical opaque behavior, as evidenced in (6); the past and perfective affixes surface as [-ATR] in both (6a) and (6b), although the stems in (6b) contain [+ATR] initial vowels.

- (6) a. tàkk-oon-na ‘caught fire’ b. liyaar-oon-na ‘hand-gestured’
 laal-oon-na ‘touched’ nguufaan-oon-na ‘carried in arms’
 sang-oon-na ‘covered’ misaal-oon-na ‘gave examples’

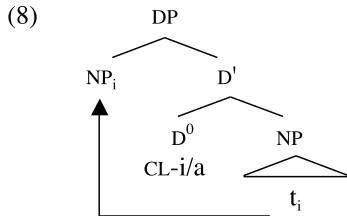
1.2. DP Structure

Wolof is, in the general case, a head-initial (SVO) language. However, within DP heads can be either initial or final; that is, indefinite determiners occur pre-nominally while definite determiners and demonstratives appear in post-nominal position. All of these elements agree with the class and/or [ATR] feature of the noun, as illustrated in (7).⁴

- (7) a. (a- w) fas b. fas w- i c. fas w- a
 INDEF-CL horse horse CL-DEF.PROX horse CL-DEF.DIST
 ‘a horse’ ‘the horse’(proximal) ‘the horse’ (distal)
 d. (w-enn) fas e. fas w- ii f. fas w- ale
 CL-one horse horse CL-DEM.PROX horse CL-DEF.DIST
 ‘a/one horse’ ‘this horse’ ‘that horse’

Given these facts, we assume that definite DPs are derived as in (8).

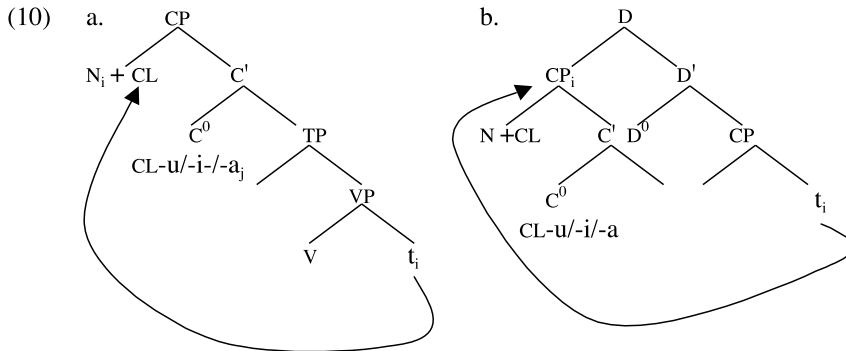
⁴ Wolof nouns are invariant; class and number are marked on the dependents of the noun. Interestingly, the noun class marker, which appears as the initial consonant of the nominal modifier, is often a copy of the initial consonant of the noun. Though other criteria may determine class agreement, it is worth noting that elements that show phonological class agreement (including less-than-perfect copying) are the same ones that show ATR agreement. For more details on noun classification, see Sy (2003, 2004).



Other nominal modifiers include relative clauses and genitive phrases. Relative clauses comprise two types which have very similar structures: Wolof adjectives are verbs which are introduced by the same type of relativizer used in non-adjectival clauses. These relativizers, as well as the determiners that may occur in such DPs, agree in noun class, [ATR] feature, and other deictic features with the head noun, as shown in (9).

- (9) a. **góór g- u** njool **gële** b. **xale b- i** toog **bale**
 man CL-REL.INDEF tall DEM.DIST child CL-REL.DEF sit DEM.DIST
 ‘that (distal) man who is tall ‘ ‘that (distal) child who is seated’
 c. **góór g- ë** wex- oon **g- ë** ca ndaw- am
 man CL-REL.DIST bitter-PAST CL-DEF.DIST PREP youth-his
 ‘the (distal) man who was disagreeable in his youth’

Following Torrence (2005), who, based on the dependencies discussed above, argues for a raising promotion analysis (as in Kayne 1994) of Wolof relatives, we assume the following structure.



2. The Experiment

2.1. Method

The data for this experiment was recorded in the UCLA phonetics lab sound booth. The speakers are two male Senegalese natives in their thirties: one a speaker of the dialect of Dakar, the other a speaker of the dialect of St.-Louis. The

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collected data consist of 108 tokens distributed among three different sets of 36 tokens as follows.

Set 1 contains 36 minimal or near-minimal pairs in single root form in the carrier sentence ‘say X also’, where X stands for the target token. These are exemplified in (11).

- | | |
|-------------------------------------------------------------------|--------------------------------------------------------------|
| (11) a. [-ATR] root
waxal <i>kër</i> itam
‘Say house also.’ | b. [+ATR] root
waxal <i>ker</i> itam
‘Say shade also.’ |
|-------------------------------------------------------------------|--------------------------------------------------------------|

Set 2 consists of nouns which minimally contrast with respect to tongue root value only, combined with different harmonizing determiners that contain front, central, and back mid vowels as shown in (12). The nouns were put in a carrier sentence of the type ‘I saw X yesterday’, where X stands for the target structure.

- | | |
|--------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------|
| (12) a. [-ATR] noun
gis naa <i>ker ga</i> démb
see 1sg. shade the yesterday
‘I saw that shade yesterday.’ | b. [+ATR] noun
gis naa <i>kër gë</i> démb
see 1sg. house the yesterday
‘I saw that house yesterday.’ |
|--------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------|

Set 3 contains the same pair of nouns as Set 2, but here the nouns are combined with two types of adjectival relative clauses, one [+ATR], the other [-ATR], so as to produce both harmonic and disharmonic DPs, as illustrated in (13).

- | | |
|---------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------|
| (13) a. [-ATR] N, [+ATR] ADJ CP
gis naa [<i>ker gu réy ga</i>] démb
see 1sg. [shade REL big the] yesterday
‘I saw that big shade yesterday.’ | b. [+ATR] N, [-ATR] ADJ CP
... [<i>kër gu weex gë</i>]...
... [house REL white the]...
‘...that white house...’ |
| c. [-ATR] N, [-ATR] ADJ CP
gis naa [<i>ker gu weex ga</i>] démb
see 1sg. [shade REL white the] yesterday
‘I saw that white shade yesterday.’ | d. [+ATR] N, [+ATR] ADJ CP
... [<i>kër gu réy gë</i>]...
...[house REL big the]...
‘...that big house...’ |

The recording was digitized using PCQuirer with a sample rate of 11 KHz. Waveforms and spectrograms were generated from the same program and combined to measure the target vowels’ first and second formant frequency.⁵ These formant values were then used to calculate mean and standard deviation, as well as to perform statistical comparisons pairwise (t-tests, two sample, assuming equal variance).

The formant values of the target vowels in fully harmonic simplex DPs (Set 2) were compared to those of the vowels in the disharmonic complex DPs (Set 3).

⁵ In the interest of space, some details about vowel measurement as well as statistical data will be left out.

The range of formant values in these two sets was also compared to that of the base forms (Set 1).

3. The Results

3.1. Base Forms

The results show a two-way split between the front and central vowels on the one hand, and the back vowels on the other. As apparent in (14) below, the average F₁ frequency value for [+ATR] mid front vowels (360.1 Hz) is lower than that of their [-ATR] counterparts (553.8 Hz). Similar facts can be observed in mid central vowels; [+ATR] central vowels have lower average F₁ frequency values at 486.8 Hz, as opposed to 643.6 Hz for their [-ATR] counterparts. The results of the two-way analysis performed on this data set show a highly significant difference with regard to F₁ frequency (p<0.006). F₂ frequency values, on the other hand, though consistently higher in the [+ATR] set for both front and central vowels, showed no significant difference between the two opposite sets (p>0.5).

(14)

	FRONT		CENTRAL		BACK	
	[+ATR]	[-ATR]	[+ ATR]	[-ATR]	[+ATR]	[-ATR]
Avg. F ₁ value (Hz)	360.1	553.8	486.83	643.6	357.5	541.5
Avg. F ₂ value (Hz)	1872.8	1854.3	1403.3	1344.3	944	1055
Std Dev F ₁	35.8	17.8	22.1	79.7	9.57	46.06
Std Dev F ₂	46.8	77.8	15.77	51.2	44.8	69.89

Turning to back vowels, the data in (14) shows the same correlation between low first formant frequency and tongue root advancement found in front and central vowels. The average F₁ frequency value for [+ATR] vowels is 357.5 Hz while that of [-ATR] vowels is 541.5 Hz. As far as F₂ values are concerned, back vowels indicate the reverse correlation of that found in front and central vowels: the average F₂ frequency value for mid back vowels is higher in the [-ATR] set. This reverse effect may be the result of different degrees of lip rounding; the advanced vowel, which is produced with a noticeably higher degree of lip rounding, incurs a higher degree of second formant lowering. The results of the t-test performed on back vowels show that there is a significant difference between the [+ATR] set and the [-ATR] set for both F₁ and F₂.

In summary, we may conclude from these results that in Wolof, [+ATR] front and central vowels have higher and fronter tongue position than their [-ATR] counterparts, and [+ATR] back vowels have a higher and backer tongue position. Overall, the results also indicate that F₁ is the most important acoustic correlate of [ATR] vowels, a fact which confirms the findings of earlier studies on the acoustic properties of [ATR] vowels (Lindau 1974, 1979).

3.2. DPs

The vowels of the determiners in all DP types display the same acoustic properties as those in base forms.

(15) Average [+ATR] formant values in all DP types (Hz)

Type	Front		Central		Back	
	F ₁	F ₂	F ₁	F ₂	F ₁	F ₂
Base forms	360.1	1872	486.8	1403.3	357.5	944
Simplex DPs	370.3	1865	432	1399.6	474	962
Harmonic complex DPs	369.66	1793	422.1	1463.1	478	1059
Disharm. complex DPs	380.5	1844	442	1419.8	492	960.5

(16) Average [-ATR] formant values in all DP types (Hz)

Type	Front		Central		Back	
	F ₁	F ₂	F ₁	F ₂	F ₁	F ₂
Base forms	553.8	1854.3	643.6	1344.3	541.5	1055
Simplex DPs	465	1858.5	506	1447	525.6	995.8
Harmonic complex DPs	451	1793	557.6	1530	537	1059
Disharm. complex DPs	480	837.3	523.6	1511	551.5	1019

As can be noted from (15) and (16) above, in front and central vowels the average F₁ frequency value is lower in the [+ATR] set, ranging between 360 and 380 Hz in front vowels, and 422 and 486 Hz in central vowels in all DP types, as compared to their [-ATR] counterparts, whose average F₁ values range between 450 and 550 Hz in front vowels, and 500 and 650 Hz in central vowels. Just as in base forms, F₂ frequency values in both classes of vowels are higher in the [+ATR] set, but again not significantly different.

Back vowels in all DP types also exhibit the same properties as their analogs in root forms; both F₁ and F₂ frequency values are lower in the [+ATR] set, though in this case the t-test results indicate that there is a significant difference with regard to F₁ as in root forms, but not F₂, unlike in root forms.

The results of the two-way analysis comparing all DP types show that there is no significant difference between any two sets of vowels in the three types of DP (simplex, harmonic, and disharmonic) with the same head noun. Importantly, the t-test performed on sets of DPs with heads of opposite values shows that there is a significant difference between the determiner vowels occurring with [+ATR] head nouns and those occurring with [-ATR] head nouns.

Considering the data in (15) and (16) more closely, one may find slight differences in average formant values between vowels in root forms and alternating vowels in DPs. These differences seem to represent a stronger tendency in root vowels toward the observed correlations: average first formant frequencies are lowest in root vowels in the [+ATR] and highest in root vowels in the [-ATR] set, as compared to DP vowels. However, the differences are quite minimal, as the range

of variability appears limited; for example, frequency values in front vowels remain characteristically under 400 Hz in the [+ATR] set, while they are consistently above 450 Hz in the [-ATR] set with low standard deviation numbers.

In conclusion, the overall result of this experiment reveals that the relationship between tongue root advancement/retraction and first and second formant frequency values observed in root forms holds in alternating determiner vowels as well. This relationship holds whether or not there is intervening material between the head noun and the determiner.

4. The Quest for an Account

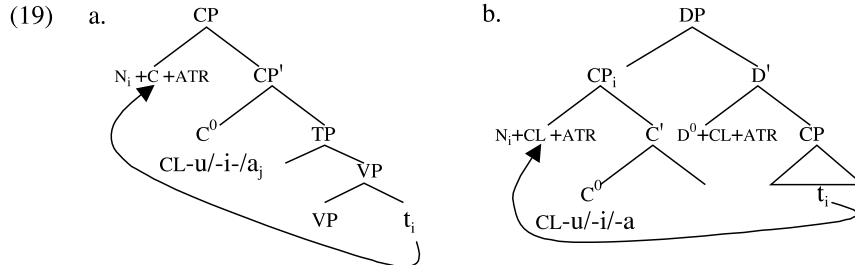
Given the evidence for the occurrence of ULDA in Wolof, we must now confront the problem of accounting for this phenomenon. Considering the fact that we are dealing with a phonological process, it is only natural to seek an answer in the phonology. In the following section we discuss various ways of approaching the problem from a phonological point of view.

4.1. The Phonology Can Do Half the Job

Setting aside the evidence presented above, let us assume for the sake of argument that phrase level harmony proceeds in exactly the same way as word-internal harmony (i.e. locally from left to right), and consider the data in (17) below.

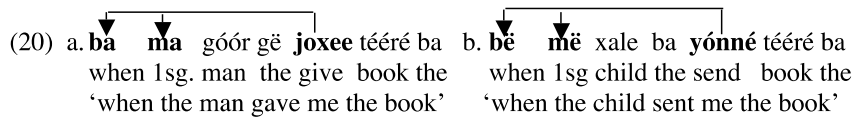
- (17) a. kër gu réy gë
house REL big the
'the big house'
- b. ker gu réy ga
shade REL big the
'the big shade'
- c. kër gu réy gA
[+ATR]
[réy | gA]
[+ATR]
kër gu réy gë
- d. ker gu réy gA
[+ATR]
[réy | gA]
[+ATR]
* ker gu réy gë

The example in (17a) is not a problem because the two potential triggers in the structure bear the same [+ATR] feature, but the one in (17b) is. In this case, letting harmony apply in the usual manner forces us to choose the trigger which is most linearly adjacent to the target, namely the [+ATR] adjectival verb *réy*, as schematized in (17c-d). As evidenced by the ungrammaticality of (17d), such an approach only works if the head noun and the verb bear the same harmonic feature as in (17a).



This approach straightforwardly captures at once the dependencies between the relativizing element, the determiner, and the head noun with regards to noun class agreement, vowel harmony, and other feature dependencies such as deixis.

Be that as it may, syntactic locality runs into problems in other cases of ULDA. Consider (20) below.



In the temporal clause in (20), the trigger (the verb) and the targets (the complementizer and the object clitic) are separated by the DP subject of the clause. Although it can be argued that the object pronoun is generated in post-verbal position, and thus has been in a local relationship with the verb at some point in the derivation before moving to its surface preverbal position, in the case of the complementizer, it would be hard to make such a case using only the usual syntactic mechanisms available in the derivation of such structures. What seems to be relevant in these cases and the ones previously discussed is the relation between trigger and target. In all these cases, harmony applies between a head and its complement within the XP that contains them. Any adequate account of these patterns must therefore allow the phonology to refer to syntactic structure and syntactic relations.

5. Optimality Theory

Because it is an output oriented theory, OT seems suitable to resolve the problem. Archangeli and Pulleyblank (2002), in a study of Kinande [ATR] harmony, found that some vowel sequences behave differently in different morphological structures. In such cases, a purely phonological analysis leads to a paradox. The authors argue that this paradox points to the necessity of incorporating morpho-syntactic domains distinguishing between root, stem and macro-stem. The general idea behind this proposal is that morphological domains determine the range of prosodic constituents (the Domain Qualification Hypothesis).

Extending this idea to the Wolof data, we might construe the role of syntax in Wolof phrasal harmony to be the same as that of morphology in DQH; that is,

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syntactic bracketing may determine the range of harmony domains. In addition, syntactic relations determine trigger-target mapping.

Given the patterns observed in the data under consideration and the basic facts of Wolof vowel harmony, we can isolate the relevant conditions. Since lexical items always trigger harmony and never undergo harmony, there must be a faithfulness condition preserving their harmonic feature, and one ensuring that they trigger harmony on functional elements with which they co-occur. These two conditions are formalized in (21) and (22).

(21) IDENT [ATR] LEX: The [ATR] feature specification of a lexical item is preserved in the output.

(22) AGREE [ATR] LEX: Only lexical items may trigger harmony.

Furthermore, harmonizing elements agree with the lexical items in head position, not those in specifier position. This constraint is notated as in (23).

(23) AGREE [ATR] HD: functional heads harmonize with lexical heads, not lexical specifiers.

Finally, lexical heads do not induce harmony on dependents of other heads: there is a requirement that every XP be a harmonic domain, as formalized in (24).

(24) AGREE [ATR] XP: Every XP is a harmonic domain.

These constraints must crucially rank lower than the grounding harmony conditions HI/ATR, AND LO/RTR to ensure that high vowels remain advanced, and low vowels remain retracted. Then IDENT [ATR] LEX must dominate all other phrase level harmony constraints, since it is never violated. The remaining constraints interact with each other as follows.

AGREE [ATR] HD >> AGREE [ATR] LEX: In adjectival clauses the determiner agrees with the lexical head of the phrase which contains it, not the lexical item closest to it; similarly, in temporal clauses the complementizer and the object clitic do not harmonize with the subject DP closest to them, but with the head of the VP.

(25) a. *_{[DP ker [CP gu réy] gë]} b. *_{[CP bë [VP më [DP góór] gë [V joxee]]]}

AGREE [ATR] XP >> AGREE [ATR] LEX : Lexical heads trigger harmony on their own dependents; the determiner inside DP cannot agree with any lexical item outside that DP.

(26) a. *_{[CP bë [VP më [CP góór ga [V joxee]]]} b. *_{[DP tànkú [NP béy] D bélé]}

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These rankings generate the following hierarchy.

- (27) HI/ATR, LO/RTR >> IDENT [ATR] LEX >> AGREE [ATR] HD >> AGREE [ATR] XP
>> AGREE [ATR] LEX

6. Conclusion

The Wolof data has provided evidence that the domain of word-external harmony is subject to syntactic restrictions. One of the effects of such restrictions is what we have called ultra-long distance ATR agreement (ULDAA). Such non-local phonological agreement representations have been shown to resist a purely phonological as well as a purely syntactic account, arguing for the need to allow freer interaction of the two components. Within an optimality theoretic framework, it is possible to allow such interaction in a single ranked hierarchy.

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Mariame Sy
Columbia University Institute of African Studies
1103 International Affairs Building
420 West 118th Street
NY, NY 10027-3331

sms2168@columbia.edu