Tutrugbu Partial ATR (Dis)harmony in Search

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Using its property of checking the presence of a given configuration, Search is employed to analyze Tutrugbu ATR harmony. The phenomenon in question is partially disrupted if the high vowel which is the string-first vowel is followed by (a) non-high vowel(s). The proposal uses the result of an independent search, determining whether the first vocalic is high, to condition the change of the other independent one, making -ATR the non-high vowels whose tongue root movement has not yet been specified, which transpires before the otherwise systematic ±ATR agreement between prefix and stem.

keywords: Search; Tutrugbu ATR harmony

The peculiarity that the string-first vowel can have a say on the ATR harmony in Tutrugbu (a Ghana-Togo Mountain language of Niger-Congo [Heine 2017: 277]) is examined from the perspective of (substance-free) Search (Mailhot and Reiss 2007, Dabbous et al. 2022). In the following, the description of this framework will be interspersed with the illustration of the phenomenon in question.

The plain Tutrugbu ATR harmony is shown in (1): the ATR value of the (alternating) prefix vowel(s) is determined by that of the first stem vowel (Essegbey 2009: 39, Essegbey 2019: 32).[1]

(1) simplex ATR harmony (McCollum et al. 2020: 219, 220; tones omitted)[2]

a.	ɔ-da ‘CL3-copper’	b.	ka-tɪ-ba-ba ‘CL7-NEG-FUT-come’
	o-pete ‘CL3-vulture’		ke-ti-be-ʃe ‘CL7-NEG-FUT-grow’

When the respective two items in (1a) and (1b) are contrasted with each other, the prefixes are known to alternate. Since the first stem vowel is -ATR for the upper item in both columns, the prefix vowels are realized as -ATR. The +ATR realization happens for the same reason in the lower part. For these alternating prefix vowels, I will assume that they are underspecified for the feature ATR, though specified for the features Syllabic, High, Low, Back, and Round: I for i~ɪ; U for u~ʊ; O for o~ɔ. For the pairing e~a, in addition to the aforementioned non-specification, Low and Back are not specified, either. So, the capital digraph *Æ* for e~a means the set {+syllabic, -high, -round}.

The ATR agreement is then formalized with a Search-based rule below:

[1] The emphasis on the first stem vowel is due to the existence of the disharmonic stems like hɔ̃litsa ‘chameleon’ (Essegbey 2019: 35).

[2] On the surface, ɪ and ʊ are realized as ɛ and ɔ, respectively (McCollum et al. 2020: 218, McCollum and Essegbey 2020: 3, 27).

(2) ATR agreement
Search INR: [+syllabic]; DIR: right; TRM: [+syllabic, αATR]
Change INR ⊔ {αATR}
'Unify a vowel with the ATR value of the first ATR-specified vowel to its right.'

Search identifies if a given configuration is present. It consists of three parameters: i) the initiators (INRs) are *all* the segments which are compatible with a given feature specification; ii) the direction (DIR) instructs Search to proceed either leftward or rightward from an INR; iii) the terminator (TRM) is the *first* segment whose feature composition matches with what is specified to the designated side of an INR. This operation of seeking stops when either the TRM is found or one of the two end domains is reached. In (2), every vowel is asked to look for the first vowel with an ATR value to its right. If not specified otherwise, Change only happens to those INRs which each successfully found their corresponding TRM. In (2), an INR is unified with the ATR value of the found vowel from Search. Unification, as defined in Bale et al. (2014: 245), is like union. But, when an INR contains a valued feature which is opposite to what is to be unified with, the INR remains unchanged after the application of unification. For instance, when a -ATR vowel is unified with +ATR, the vowel is still -ATR afterwards. As for a +ATR or ATR-underspecified vowel, the unification with +ATR results in the vowel with +ATR specification.

The straightforwardness of the ATR agreement, however, is complicated: if both i) the first vowel of a given string is a high vowel, and ii) there exists a prefixal non-high vowel, it is -ATR-exponents that appear (McCollum et al. 2020: 220, 221). The first two examples below all have +ATR vowel in the stem, but, instead of the predicted +ATR realization, it is -ATR realization that shows up.

(3) disharmony under the specified conditions (McCollum et al. 2020: 219, 220, 221)
a. bʊ-ba-ʃe '1PL-FUT-grow' (cf. bu-ti-ʃe '1PL-NEG-grow')
b. ɪ-tɪ-ka-a-ba-ba-wu '1SG-NEG-PFV-PROG-VENTIVE-VENTIVE-climb'
c. bʊ-ba-di-wu '1PL-FUT-ITIVE-climb' (cf. ɪ-dɪ-tɔ '1SG-ITIVE-cook')

(Notice that the comparison at the end of (3a) tells us that the first person plural prefix does alternate.) The disharmony, nonetheless, is partial. When the aforementioned conditions are met, but, there remain prefixal high vowels which follow the rightmost non-high vowel, the ATR harmony applies as usual. For the portion of 1PL-FUT in (3c), the disharmony conditions are met and -ATR exponency occurs; as for the other half, the itive prefix vowel is +ATR due to the verb's +ATR vowel.

To account for the conditioned disharmony, I let the rule -ATR-specification (4) apply before the ATR agreement (2):

(4) -ATR-specification

Search INR-i: [+syllabic, -high]

INR-j: [+syllabic, +high]; DIR-j: left; TRM-j: [+syllabic]

Change INR-i ⊔ {-ATR}, if |INR-j| ≠ |TRM-j|[3]

'Unify a non-high vowel with -ATR, if the number of high vowels which look leftward for another vowel is not equal to the number of the vowels thus found.'

The Search-i lacks DIR and TRM since it is a (semi-)context-free rule. The unification of -ATR with any non-high vowels is further qualified with the condition which is calculated through the Search-j. By letting each high vowel look leftward for another vowel, the purpose is to check whether the string-first vowel is high or not. And the three possible scenarios are deliberated:

scenario i: there does not exist a high vowel

Since no qualified initiator can start the Search-j, neither can there be any corresponding terminator. Therefore, the cardinality of the set containing the initiators |INR-j| and that of the set containing the terminators |TRM-j| are both zero and the same. The if-condition is thus not met, so the unification does not take place.

scenario ii: all the high vowels are not the first vowel of the string

Because the high vowels can be the second or any of the following vowels of the string, they are always preceded by another vowel. Each initiator thus successfully finds its terminator, so the cardinality number of both sets is the same as the number of the initiators/terminators. The if-condition is thus not met, so the unification does not take place.

scenario iii: one of the high vowels is the first vowel of the string

Due to the unsuccessful search initiated by the string-first high vowel, the cardinality of the set containing the terminators is always one less than that of the set containing the initiators. Hence, the if-condition is met, so all the non-high vowels are unified with -ATR.

Up to this point, with the underlying representation assumption and the rules (4) and (2) (in that order), I, U, and O are no longer present. Nonetheless, Æ has only become either A ({+syllabic, -high, -round, -ATR} with no specification for Low and Back) or E ({+syllabic, -high, -round, +ATR} with no specification for Low and Back). In order to complete the current analysis, a context-free rule is proposed:

[3] I abuse the notations INR-j and TRM-j here for them to stand for the parameters of the Search-j and the sets which contain the qualified INRs and TRMs of the Search-j.

(5) non-high unrounded vowel height and backness specification

Search INR: [+syllabic, -high, -round, αATR]

Change INR ⊔ {-αlow, -αback}

'Unify an ATR-specified non-high unrounded vowel with the opposite value to that of ATR for the features Low and Back.'

The application of the above rule (non-vacuously) results in a from A and ɐ from E.

To make concrete the foregoing discussion, the derivation of bʊ-ba-di-wu '1PL-FUT-ITIVE-climb' from (3c) is given:

(6) a sample derivation

underlying form: bU-bÆ-dI-wu

-ATR-specification (4)

Search	INR-i: [+syllabic, -high]—Æ		
	INR-j: [+syllabic, +high]		TRM-j: [+syllabic]
	u	leftward	I
	I	finds	Æ
	U		nothing
Change	|INR-j| (=3) ≠ |TRM-j| (=2), so INR-i ⊔ {-ATR}		
	Æ becomes A		

intermediate form: bU-bA-dI-wu

ATR agreement (2)

Search	INR: [+syllabic]		TRM: [+syllabic, αATR]
	U	rightward finds	A
	A		u
	I		u
	u		nothing
Change	INR ⊔ {αATR}		
	U becomes ʊ (A is -ATR)		
	A does not change (-ATR of A and +ATR of u are incompatible)		
	I becomes i (u is +ATR)		
	u does not change		

intermediate form: bʊ-bA-di-wu

non-high unrounded vowel height and backness specification (5)

Search	INR: [+syllabic, -high, -round, αATR]—A
Change	INR ⊔ {-αlow, -αback}
	A (is unified with {+low, +back} and) becomes a (A is -ATR)

surface form: bʊ-ba-di-wu

It is common to see that multiple searches within a rule are connected (i.e. the *x*-ors of a search as the *x*-ors of another).[4] The above analysis, nevertheless, shows that it needs not to be the case. On the other hand, what remains constant is seeking for it is this property that enables us to detect the presence of a given configuration before a change may take place.

References

Bale, Alan, Maxime Papillon, and Charles Reiss. 2014. Targeting underspecified segment: A formal analysis of feature-changing and feature-filling rules. *Lingua* 148: 240-253.

Dabbous, Rim, Marjorie Leduc, Fatemeh Mousavi, Charles Reiss, and David Ta-Chun Shen. 2022. Satisfying long-distance relationships (without tiers): A strictly anti-local approach to phonology. Ms., Concordia University and Rutgers University.

Essegbey, James. 2009. Noun classes in Tutrugbu. *Journal of West African Languages* 36.1-2: 37-56.

Essegbey, James. 2019. *Tutrugbu (Nyangbo) Language and Culture*. Leiden: Brill.

Heine, Bernd. 2017. Some reflections on genetic relationship in a group of West African Niger-Congo languages. *Language Typology and Universals* 70.2: 273-281.

Mailhot, Frédéric, and Charles Reiss. 2007. Computing long-distance dependencies in vowel harmony. *Biolinguistics* 1: 28-48.

McCollum, Adam G., Eric Baković, Anna Mai, and Eric Meinhardt. 2020. Unbounded circumambient patterns in segmental phonology. *Phonology* 37.2: 215-255.

McCollum, Adam G., and James Essegbey. 2020. Initial prominence and progressive vowel harmony in Tutrugbu. *Phonological Data and Analysis* 2.3: 1-37.

[4] For a toy rule which neutralizes the height to mid when a vowel is preceded by a nasal and followed by a rhotic, one possible formalization of the search portion is as follows:

Search	INR-i: [+syllabic]; DIR-i: left; TRM: [+consonantal, +sonorant, +nasal]
	INR-j: INR-i; DIR-j: right; TRM: [+consonantal, +sonorant, -nasal, -lateral]

If INR-j is simply set to be [+syllabic], the vowels referred to by INR-i and those by INR-j need not be the same, which is not exactly what the toy rule requires.