Edge-In Association

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Non-linear phonology associates melodies (tones, phonemes, feature bundles) with skeletal slots (syllable positions) one to one in some direction. Two main candidates for the unmarked direction of association have been suggested. Either association proceeds from left-to-right, or from the outside in. Left-to-right has been assumed in analyses of tone (Goldsmith 1976, Clements 1985, Yip 1980, Pulleyblank 1986,) and template morphology (McCarthy 1981, Archangeli 1984). Outside-in has been suggested by research on reduplication (Marantz 1982, McCarthy and Prince 1986) to account for the correlation between affix position and direction of association : left-to-right in prefixes, versus right-to-left in suffixes.

I shall argue that association works from the edges inwards in stems as well as in affixes, and that in the case of a root or stem this involves association first to <u>both</u> edges of the domain, and then filling in of the center. If this is right one general principle will cover both reduplication (and other affixation) and initial stem association, a surely desirable result. It is not possible here to re-analyze all cases of alleged left-to-right association as edge-in association: I shall limit myself to one prominent example, Semitic morphology, and then suggest the predictions made for other cases.

1. <u>Theoretical Assumptions and Background</u>

The theory I shall assume has the following properties:

a. Phoneme melodies associate to templates one-to-one.
b. Spreading, if any, is by rule.
c. Templates consist of syllabic positions (Levin 1985), and are probably prosodic in the sense of McCarthy and Prince (1986,1987). For convenience they will be referred to as C, V here, since the issue of their precise nature is orthogonal to the issue of directionality.
d. Only unpredictable information is present in lexical entries. Predictable values are supplied by redundancy rules (Kiparsky 1982, Archangeli 1984, Pulleyblank 1986).

The theory must also specify the direction of association, and I will argue that the unmarked case is association from the edges inwards, both in stems and in affixes. First, let me give some background on the origins of the idea that association must proceed from the edges inwards in some cases. It was noticed that in reduplication prefixing reduplication copied material from the beginning of the word, and suffixing reduplication copied material from the end of the word. In a theory like that of Marantz (1982) in which the entire word melody is copied this requires LR association in prefixes and RL association in suffixes, and since this is overwhelmingly the normal situation he suggests that a general principle of outside -in association is at work.

In the case of affixation (including reduplication) only one edge is free for association, the already-associated stem occupying the other edge. In stems themselves, however, both edges are free, so a natural extension of this idea would give rise to a system in which initial and final melodic elements first anchored to initial and final slots, then medial elements associated to medial slots in some way. [1] The aim of this paper is to show that there is evidence for just such a process of outside-in association in stems, and that such an account is superior to a LR association account.

Let me briefly review the parallel but contrasting properties of left-to-right (LR) association, and then of edge-in (EI) association.

(1) Excess Skeletal Slots:
Excess slots will be on the right edge in LR association, medial in EI association. Three logical possibilities arise: spreading by rule, assignment of default values, and loss of excess slots. The last posssibility is rare or non-existent, suggesting a principle of template satisfaction (McCarthy and Prince 1986). LR association thus predicts spreading of the rightmost element, or default values on the right edge. EI association predicts spreading of medial elements, or medial default values.

(2) Excess Melodic Elements:
Excess melodic elements will also be on the right edge in LR

association, and medial in EI association. Three possibilities again arise: association by rule to create contours, loss of excess melodic material, and provision of extra skeletal slots. LR association thus predicts contours on the right edge, and loss of rightmost melodic material. EI association predicts medial contours, and loss of medial melodic material. The provision of extra skeletal slots would imply a principle of Melody Satisfaction, and we shall see later that such a principle exists in Classical Arabic.

A few comments are in order. First, note that when spreading was thought to be automatic the existence of rightward spreading was taken as striking evidence for LR association, but ever since it was shown that spreading is by rule only (Pulleyblank 1986:80-89) this pattern of rightmost spreading no longer falls out automatically from LR association, but rather requires the addition of a language-particular rule. [2] Medial spreading, by contrast, has apparently escaped notice, but I shall argue below that it not only exists, but is the normal case in Classical Arabic and can only be simply accounted for in an EI association theory. At the same time apparent rightward spreading in Classical Arabic turns out to have more complex origins, invalidating it as the basis of an argument for LR association in this case.

A second contrast noted in (1), the occurrence of default values on the right edge versus medially, is one of the most interesting. Tonal systems such as Tiv (Pulleyblank 1986) show evidence of default L tones on the right edge (cf yévèsè) . Segments, however, show evidence of default values in the middle (cf mutakaatib, see section 2.2). Whether this is a real difference between tone and segments, or a language specific difference, I am not yet able to say, but the existence of medial default values in Classical Arabic argues strongly for EI association in that case.

The contrasts in (2) (loss of final/medial melodies, or creation of final/medial contours) are less useful as diagnostics for LR versus EI asociation than at first appears, because melody loss is rather rare in stem association, and may have quite different underlying causes, as I shall show. As for contours, many languages, such as Chinese, show contours freely on any syllable, while others never allow them at all. What is more, although tonal systems often create contours on final syllables only, segmental systems rarely do.[3] I conclude that the distribution of contour tones cannot be used as evidence for LR association pending a fuller understanding of their nature (see Yip 1987b). Instead, I would suggest that extrametricality may play a role here, reserving a final tone until the end of the lexical phonology for later attachment.

In the remainder of this paper I shall show that Classical Arabic

morphology is best explained by edge-in association. My analysis will depend heavily on McCarthy (1981), and I accept without argument what he showed so clearly: Semitic languages derive words by the non-concatenative method of associating three morphemes: a template, supplied by the binyan; a consonant melody which is the verb root; and a vocalic melody, which is the aspectual and tense marker. I differ from him in the details of how these three elements associate: I shall argue that association is not IR, but EI.

2. Classical Arabic Association

2.1 Consonant Association

2.1.1 1-1 Matches

EI association will associate the initial and final melodic elements with the initial and final free slots, anchoring the two ends. Remaining slots and melodic elements will then be associated in the same way, moving inwards, until all slots are associated. The results of this procedure in the case of identical numbers of vowels and consonants are shown in (3):

(3)

Edge Assoc	C V C | | s m	C V C V C | | k t b	C V C C V C | | d ḥ r j
Filling In		C V C V C | | | k t b	C V C C V C | | | | d ḥ r j

Clearly, identical results are obtained for IR association, so nothing distinguishes the two procedures for these forms.

2.1.2 Excess slots:

There are several binyanim with more slots than consonants, and they are listed in (4):

(4) Biliteral roots: all binyanim, eg

I	samam
II	sammam

Triliteral roots:

(a)		(b)	
II	kattab	IX	ktabab
V	takattab	XI	ktaabab
XII	ktawtab	XIV	ktanbab

Quadriliteral roots:

QIV dḥarjaj

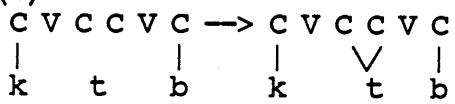
Biliteral roots always spread the final consonant; triliterals spread either the medial or the final consonant, and quadriliterals spread the final consonant. We have, then, an apparently mixed

system, with rightward spreading suggesting LR association, and medial spreading suggesting EI association. I shall first give an account that makes use of EI association throughout, then I shall contrast it with a LR association analysis.

2.1.2.1 Medial Spreading

EI association predicts that if there are excess slots the medial consonant is likely to spread , since after anchoring the ends the association procedure is one of "filling-in", and the medial consonant will if necessary fill more than one slot [4]. This is what happens in the forms in (4)a, typified by the second binyan, kattab, as shown in (5). (The fifth binyan, takattab, , and the twelfth, ktawtab are identical except for the prefixed /t/ and infixed /w/).

(5)



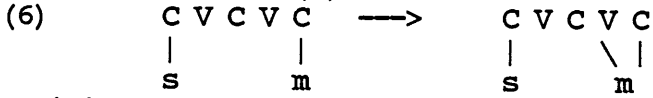
These common binyanim can thus be accounted for simply and directly under an EI association account. The LR association account will be discussed at the end of the next section.

2.1.2.2 "Rightward Spreading"

The remaining forms in (4) show apparent rightward spreading, which I have suggested may be diagnostic of LR association. If, as the previous section claims, EI association is the norm, how do we explain the rightward spreading cases?

First, I postulate a leftward spreading rule for the biliterals like samam. This is descriptively adequate, and on a par with the LR account, which requires a rightward spreading rule. [5] The derivation is shown in (6):

(6)



The remaining cases, 9th,11th, and 14th, and QIV binyanim, have a different explanation. I will argue that these binyanim require that the last two consonant slots be jointly linked, and that this precedes or otherwise overrides general association, leaving exactly the right number of slots for the remaining consonants to link to. In order to argue this I need to digress and consider the quadriliteral binyanim in more detail.

The most noticeable thing about the quadriliteral roots is that they only occur with templates that have at least four slots, thus ensuring that no melodic elements are lost. [6] This suggests that in addition to a principle of template satisfaction Semitic has a principle of Root Realization.

Given this fact, and the additional fact that the triliterals are the morphological norm, one might suppose that quadriliteral roots would make use of the subset of triliteral templates that have space for four or more consonants. In (7) I give the candidate triliteral binyanim, and alongside them quadriliterals that appear to be their counterparts.

(7)

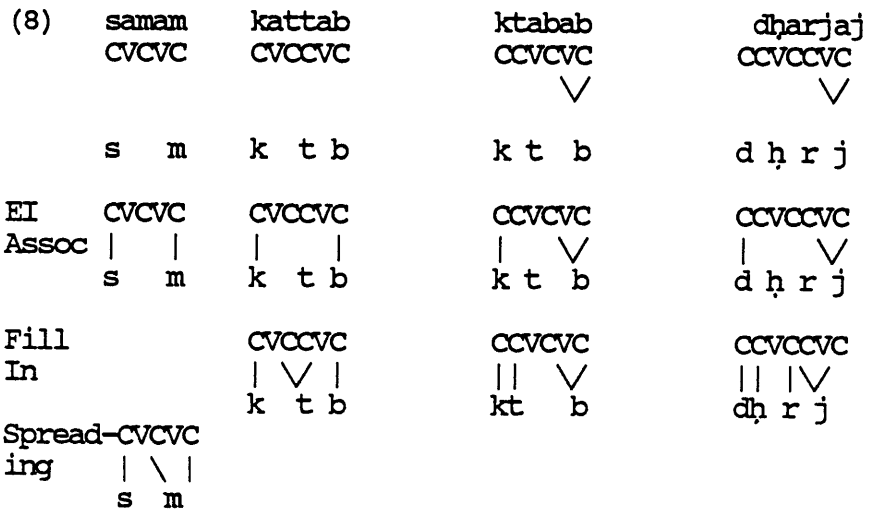
II	kattab	QI	daḥraj	
V	takattab	QII	tadaḥraj	
IX	ktabab		*dḥaraj	BUT QIV dḥarjaj
XI	ktaabab		*dḥaaraj	
XII	ktawtab		*dḥawraj	
XIV	ktanbab	QIII	dḥanraj	

The parallellism is far from perfect, and one might wonder why. Notice particularly that two of the triliteral binyanim with no obvious quadriliteral counterparts , IX, XI, ktabab and ktaabab, have doubling of the final consonant, whereas their putative but non-existent quadriliteral versions, *dharaj and *dḥaaraj, do not. Suppose that this doubling is a fundamental requirement of these binyanim.[7] Then there is no way to realize a complete quadriliteral root on these binyanim while simultaneously achieving the double linking; dḥarar or dḥajaj would involve melody loss. To satisfy both requirements we need a template with five slots, and since none exists among the triliteral inventory, a new one is created by addition of a C slot to IX, giving QIV ,CCVCCVC, dharjaj, which satisfies both requirments. [8]

This line of argument also explains our earlier problem: why are the triliteral IX and XI binyanim, ktabab and ktaabab realized with spreading of the final rather than the medial consonant? Because they require double linking of the final consonant, and this overrides the general association principles. [9]

The same double linking requirement is presumably at work in ktanbab and ktaabab, but the heavy first syllable makes deriving an appropriate quadriliteral binyan difficult. Any attempt to add an extra slot so as to meet both Root Realization and double linking requirements would require addition of an entire syllable, since dḥanrjaj, dḥaarjaj, dḥanrajj or dḥaarajj would be out on other grounds. Apparently, then, Root Realization is more important than the double linking requirement, and we get plain QIII dḥanraj with no double linking. The absence of a quadriliteral equivalent of XI ktaabab and XII ktawtab is presumably accidental: XI and XII are rare anyway, and so are quadriliteral roots.

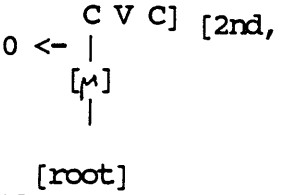
A summary of the derivation of selected forms from (4) is given in (8):



I have tried to explain both the cases of apparent rightward spreading, and the forms of the quadriliteral binyanim, as the result of EI association, a leftward spreading rule, Root Realization, and a double linking requirment. To the extent that I have succeeded, rightward spreading cannot be used as an argument for IR association. Let me therefore end this section with a summary of McCarthy's IR account of these facts.

The first problem encountered in a IR association account is how to deal with the existence of the binyanim with medial spreading, like II and V, and the surprising absence of the expected forms with rightward spreading, like *[katbab], since initial association will inevitably create a tb cluster in medial position. McCarthy assumes that [kattab] is derived from the intermediate */katbab/ by a special rule which erases the association lines, given in (9) (McCarthy 1981:392):

(9) Second, Fifth Binyan Erasure (=McCarthy's (24))

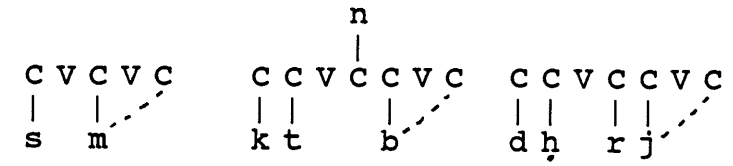


Subsequently the melody to the left spreads onto the now free C slot, giving [kattab] from [katbab]. This rule must either be restricted to triliteral roots, or allowed to apply to the quadriliterals like dahraj as well, but its effects are then immediately undone by reassociation of the now free consonant by the general association principles.[10] The IR account, although descriptively adequate, treats these binyanim as exceptional. The EI account, however, treats them straightforwardly: there is medial spreading in kattab as a result of normal fill-in procedures, and the quadriliterals like dahraj show no spreading simply because

there are equal numbers of consonants and slots.

In contrast to the problem presented by the forms with medial spreading, the forms in (4) in which the rightmost consonant spreads onto the excess slots fall out simply from LR one-to-one association, followed by a rightward spreading rule. Notice that the rule is still required, since the alternatives would be loss of unfilled slots, or provision of default values (such as ?, t, or w). Typical derivations are shown in (10):

(10)



The second problem for the LR account is that it fails to provide any explanation for the array of quadriliteral binyanim, and instead wrongly predicts quadriliteral counterparts for all six triliteral binyanim with four consonant slots, and cannot explain the addition of QIV with five consonant slots.

2.1.3 Excess Melodic elements: Right-end Loss

A second difference between EI and LR association lies in the fate of excess melodic elements: EI predicts medial loss, LR predicts right-end loss. In Classical Arabic melody loss is limited to quinquiliteral roots: as we have seen, quadriliteral roots always appear with quadriliteral templates. McCarthy (1981) claims that the rightmost consonant is lost when matching a quinquiliteral root to a quadriliteral template, giving magnat from /mgntš/, and that this argues in favor of LR association, but I shall argue that these forms do not bear on the issue of direction of association, since what is happening is that roots of five or more consonants are being reanalyzed to conform to the canons of the language, and that those canons have a maximum of four consonants per root. The reanalysis drops off one consonant in a variety of ways which are not fully predictable. Another version of this argument can be found in McCarthy and Prince (1987), which includes a careful and elegant analysis of the Classical Arabic broken plural. For a different view, see Hammond (1986).

The two circumstances under which this root reanalysis is necessary involve the broken plurals of nouns, and the diminutive (Wright 1951:167). Note particularly that broken plural formation is no longer productive for quinquiliteral roots, suggesting that something other than the normal association process is needed in such cases.

The broken plural template has room for only four consonants, so the quinquiliteral roots are reanalyzed in a variety of ways. Typical data is given in (11):[11]

(11)a.		safarjal	safaarij	'quince'
b.		farazdaq	faraaziq	'burnt cake'
c.	/w/:	?ustuwaanat	?asaatiin	'pillar'
	/n/:	qalansuwat	qalaasiyu	'sort of cap'
	/m/:	batlamiyuus	bataalisat	'Ptolemy'
	/t/:	dumustuq	damaasiq	'Byzantine governor'

(11a) shows reanalysis by loss of the final consonant, and McCarthy and Prince, citing Dieterici (tr.) (1852:353) state that this is the preferred method. I shall assume that this is the result of making the final root consonant extrametrical. SInce extrametricality is only possible at edges, only the initial or final consonant can be excluded from association in this way. Why it is always the final consonant I do not know.

(11b) shows loss of a medial consonant, contra the predictions of IR association. (11c) shows loss of what Wright (1951:231) calls a "servile consonant". These are consonants which resemble affixes, even though they are not necessarily real affixes. The consonants chosen include /w,t,n,m,/, and they are frequently medial, not on the right edge. I shall call them pseudo-infixes.

Reanalysis of these consonants as infixes allows a sort of spurious conformity to the Root Realization principle referred to earlier.

I conclude from these facts that simple IR association, with excess consonants dropping off the right edge, does not account for the broken plurals of quinquiliterals. Since the lost consonant may be final or medial, simple EI association will also not account for the facts. Instead, a process of root regularization is at work, resulting in quadriliteral "roots" which associate to the broken plural template without further loss.

2.2 Vocalism

Turning to the vocalism, I shall show that EI association together with underspecification allows for a very simple statement about vowel melodies in Classical Arabic verbs. The melodies can be given as (u(i)), and their surface realization is the result of edge-in association, and default insertion of the features for /a/ on any unassociated vowel(s).

McCarthy (1981) gives the melodies in (12) (the groupings and base melodies are mine):

(12)		Surface	Base melody
(a)	Perfective Active	a^4_2	∅
	Imperfective Passive	u a^4_2	u
	Active Participle	u a^3_1 i	u i
	Passive Participle	u a^4_2	u
(b)	Perfective Passive	u^3_1 i	u i

Leaving (b), the Perfective Passive, aside for a moment, notice that the only vowel which appears more than once in a surface melody is /a/, and that the other vowels, u,i appear only at the edges of the melody. This pattern can be derived immediately if the underlying melodies are those shown on the right in (12), that is (u (i)), and they associate to the edges , with all unassociated vowels surfacing as [a] by default. As an illustration, consider the vocalism of the Active Participle, such as VI binyan mutakaatib:

(13)

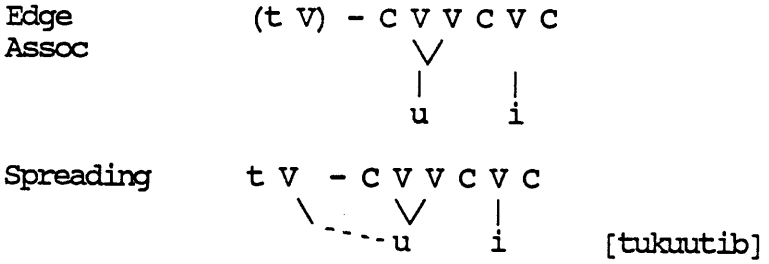
```
          C V C V C V V C V C
                    u   i

Edge      C V C V C V V C V C
Assoc.      \           /
             u         i

Default   C V C V C V V C V C
Rules      |    \  | /   |
           u       a     i          [mutakaatib]
```

Note particuarly that there is no spreading of either underlying vowel, /u/ or /i/.[12] If there is no melody, as in the Perfective Active, then all the vowels surface as /a/ as the result of the Default Rules. If the melody consists of a single vowel, /u/, as in the Imperfective Passive and the Passive Participle, the /u/ associates to the left edge only, and all the other vowels surface as /a/ by default. This last case requires a slight addition to the principles of EI association: apparently the left edge has some sort of priority, at least in Classical Arabic, so that a single vowel associates there and not to the right edge (or to both edges).

I have left the data in (12b), the Perfective Passive, till last since it apparently spreads /u/ onto up to three vowels. Inspection of the forms, however, shows that more than one [u] is found in only two cases. First, if both [u] are tautosyllabic, as in kuutib. Any account will need a principle requiring that tautosyllabic vowels are identical, so as to rule out forms like *kuatib. This is

a general fact about Classical Arabic syllables, so let us assume that /u/ associates to some superordinate syllable node, say the nucleus, and that if this nucleus is complex it is realized on both slots. The second case is if the prefix /tV/ is present, as in tukuttib, tukuutib. (V and VI binyanim). I suggest that this prefix is extrametrical, so association begins on the following nucleus; at the end of the cycle, when /tV/ ceases to be extrametrical, /u/ spreads leftward onto the prefix vowel slot. [13] The derivation is given in (14):

(14)



The superficially different vocalisms of the perfective passive, [u u u i] , and the active participle, [u a a a i], can now be reduced to one melody, /u i/, general EI association, and extrametricality of the prefix tV. [14]

A LR association account, by contrast, needs a special rule. McCarthy (1981:401) proposes an analysis in which the /i/ anchors to the rightmost V slot, then the other vowels anchor one-to-one left to right, with spreading. He thus effectively makes use of edge association, since both ends are associated before the middle; however, he has recourse to a language specific and domain specific rule , Vowel Association, whereas I would claim that it is only an instance of general edge association.[15]

The vocalism provides striking evidence in favor of an EA approach, since no special association rules are needed, and a maximally simple statement of the possible melodies is made possible.

There is some independent evidence for the status of /a/ as the default vowel in Classical Arabic morphophonology. Brame (1970) discusses some interesting alternations that provide suggestive evidence supporting the analysis of /a/ as the default vowel. The relevant fact is that /a/ appears to be the epenthetic vowel in the lexical phonology of Classical Arabic, and Archangeli (1984) , Yip (1987a) have argued that epenthesis usually inserts an empty V slot which then surfaces as the default vowel. The epenthetic /a/ shows up in the first syllable of the first binyan, in the 'hollow' nouns, and in the definite article. In all these cases one or more vowels are needed to fill the nuclei of syllabic templates, and these vowels then surface as /a/. For a detailed analysis see Yip (to appear).

3. Conclusion

I have argued here that one particular set of data, Classical Arabic verbal morphology, is an example of edge-in association in stems. Several other templatic morphology languages appear to exhibit EI association. Tigrinya for example, shows widespread medial gemination as exemplified by the frequentatives sababara, masakakara (Leslau (1941)). Tigre (Palmer 1962:18ff) shows medial gemination in the broken plurals such as damamm@l, tanakk@l. Languages of this kind lend themselves naturally to an EI association analysis. See also Takelma (Goodman 1983), Syriac Arabic (Hoberman 1987), Wuxi tone (Yip 1987b).

The obvious question to ask is whether all association operates in an edge-in fashion, or whether it is just an additional option to be added to the LR and RL choices. A full answer involves a careful look at all the cases of LR and RL association to see if they can be reanalyzed as EI association. If this turned out to be possible, it would resolve an odd inconsistency in the literature. Marantz (1982) and McCarthy and Prince (1986) argue that reduplication is a kind of affixation, and that association works from the ends in. In suffixes, then, association should normally be RL. In contrast, tonal analyses of suffixing languages have quite generally assumed that association is LR throughout the phonology, both in roots and in suffixes. Pulleyblank (1986) is a particularly careful example of such an analysis. We must thus conclude that either tone and segmental phonology associate by different principles, or reduplication is not affixation at all (see McCarthy and Prince (1987) for a view along these lines) or that these analyses must be reconsidered.

Footnotes
This paper has benefited from the comments of a number of people, including the participants in the MIT Linguistics Colloquium, Brandeis University Phonology classes, and particularly Diana Archangeli, Michael Hammond, John McCarthy, and Alan Prince. All errors are of course my own.

1.The process is thus one of pattern matching, as can be seen particularly clearly in tonal systems (see Rialland 1987, Yip 1987).

2.The apparent assymetry between rightward and leftward spreading, however, is still accounted for by LR association: if there is spreading, it can only be to the right, since this is where there will be empty slots.

3. Rotuman (Saito 1981) creates short diphthongs on final vowel slots (cf pure / puer), but, like the tonal cases, this is arguably post-cyclic. See also Odden (1987:525, fn2) on Gta?.

4. Another way to think of this procedure is that the remaining consonant associates to both ends of the unassociated domain, continuing the process of associating from the edges inwards. This would predict slightly different results in other cases.

5.Both accounts also allow for the existence of a language with only forms like sasam: either it is RL association, or EA with rightward spreading.

6.I know of one exception: the quadriliteral root /xlbs/ has a related triliteral form [xalab]. Presumably the root has been reanalyzed as a triliteral (see section 2.1.3).

7.Broselow (1984) argues that Amharic has a Perfective template which require a double linking in this way, giving forms like labbasa. See section 3 on Tigrinya.

8.Wright (1951:49) says that IX and XI show intensiveness of colour or of defects, (IX is permanent, XI transitory) and that this is shown by doubling of the last consonant. Note that Wright (p49) equates QIV with IX on semantic grounds, since QIV is also intransitive and intensive.

9.It is possible that this double linking is the result of a later reduplication rule and spreading of the rightmost melodic element. How the double linking is established is not my main concern in this paper, but the requirement of double linking has its syntactic counterpart in requirements for case identity (see Yip, Maling and Jackendoff 1987).

10.Other researchers (eg Pulleyblank 1986:115) have argued that automatic reassociation cannot undo the effects of a rule that specifically disassociates the same two elements. If this is so, McCarthy's rule must be restricted to the triliteral roots.

11.-at is a suffix in both singular and plural. The w/y alternation is the result of a glide insertion rule.

12.Whether the default rules insert one instance of /a/, as required by the OCP, or several, does not bear on the issues here.

13.Note too that the spreading is leftward, like in the consonants.

14.Note that when this prefix occurs with the active participle it is no longer extramterical because it is preceded by another prefix, mu, and thus no longer at an edge. We thus get mutakaatib, but tukuutib.

15. The fact that only /a/ spreads is a result of its being the rightmost unanchored vowel in his analysis. However, he could also make use of underspecification to achieve this result.

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