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- (4) I follow McCarthy (1979) in all the details of representation and association principles.
- (5) Forms that are affixed with a vowel initial suffix are subject to a syncope rule and subsequently to an epenthesis rule. For example *tu-ktubi* will surface as *tukutbi*. The interaction of these two rules with the vowel harmony phenomenon will be the topic for a separate paper. However, for the sake of clarity, the effect of these two rules will be ignored in this paper.

### Bibliography

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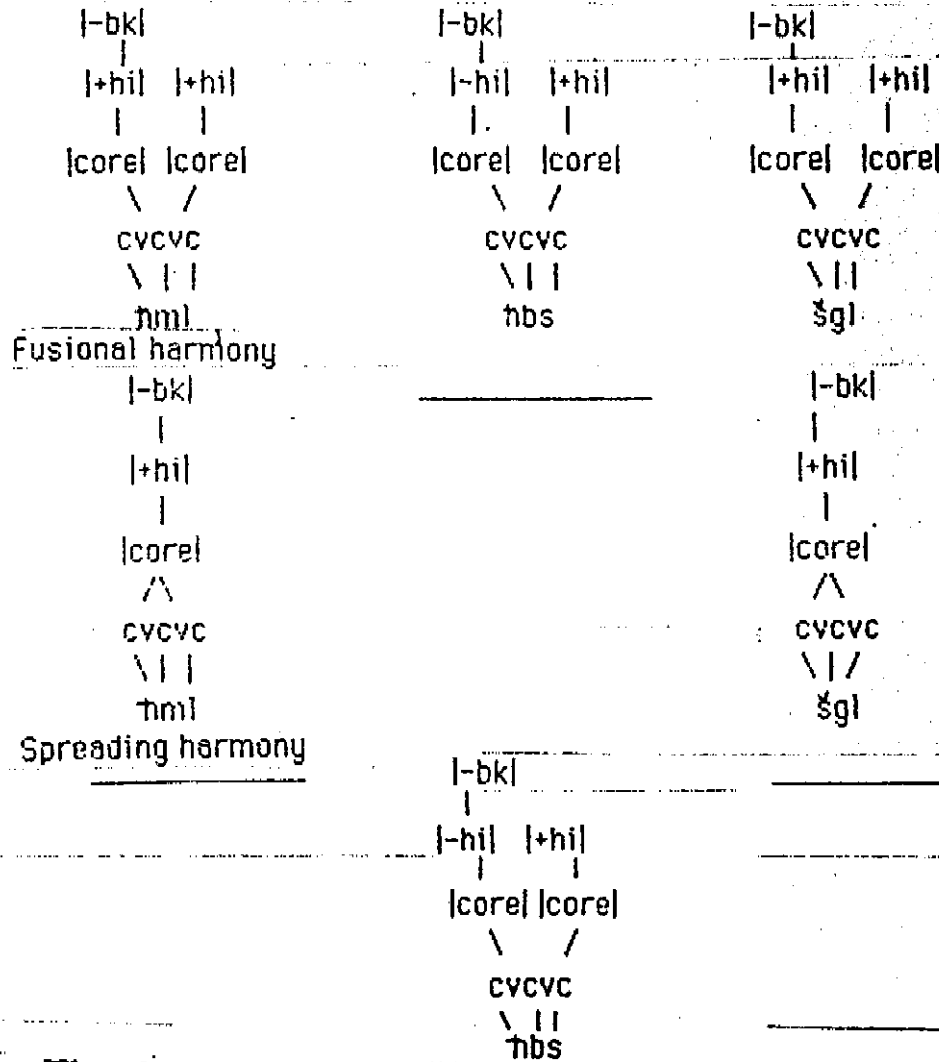
In summary, we have seen that the JA short high vowel cooccurrence restriction needs to be excluded by a special stipulation within a theory of phonology in which vowels are represented as bundles of features that are collectively subject to the OCP. However, such a stipulation is not needed if features are distributed on separate tiers, each of which is independently subject to the OCP, as proposed by Mester (1936). We have also seen that dependent tier ordering representations are superior to direct core linking representations because the former but not the latter captures certain obvious cooccurrence generalizations. In addition, dependent tier ordering receives interesting support from vowel harmony in prefix vowels and epenthetic vowels.

### NOTES

- (1) The term Jordanian Arabic is used loosely to refer to many of the Arabic dialects used by the greatest majority of Jordanians and Palestinians. I would like to express my appreciation to Mr. Al-Ghazo for his valuable comments. The transcription of exotic consonants will be as follows:
1. A dot under a symbol means that the consonant is emphatic.
  2. *g* stands for a voiced uvular fricative.
  3. *h* stands for a voiceless pharyngeal fricative.
  4. *c* stands for a voiced pharyngeal fricative.
- The rest of the symbols have their familiar values.
- (2) In addition to these three pairs of underlying vowels, JA has two long mid vowels *ee* and *aa*. These two vowels are derived from *ay* & *ow* sequences respectively.
- (3) There are a few exceptions to this cooccurrence restriction. These exceptions include some loan-words such as *burgi* 'a screw' and *kursi* 'a chair', some proper names formed by the addition of the suffix - *i* (which are probably originally Turkish), to *cvcc* nouns such as *luffi*, *subhi*, *Husni*, and a few words borrowed from classical Arabic such as *mutrib* 'singer' *muxbir* 'informant' etc. It is worth while to mention here that *ui* vocalic melodies of words borrowed from classical Arabic are changed to *ii* melodies in JA; *mislmi* *muslim* 'moslem', *abdilmihsin* *abdilmuhsin* 'Abdulmuhsin' (a proper name).

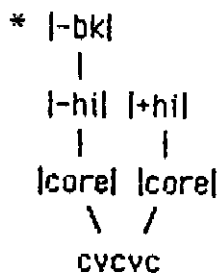
The derivation of the nouns in (39) is given in (41).

(41) underlying representation after Epenthesis

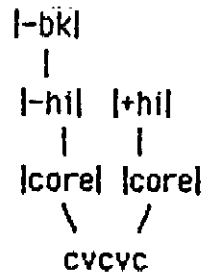


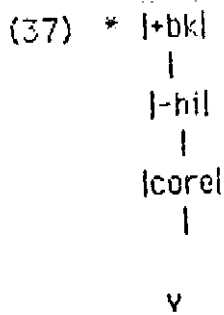
The absence of forms where the stem vowel is *a* and the epenthetic vowel *u* also finds an explanation in this analysis. The missing features of the epenthetic vowel in such forms has to be derived either by fusional harmony which will be blocked because of the opposite values of the feature [ hi ] in (42) a, or by spreading harmony which spreads the feature [- bk] to the epenthetic vowel which results in forms like *habis* (42)b, with the high front vowel.

(42) a.



b.

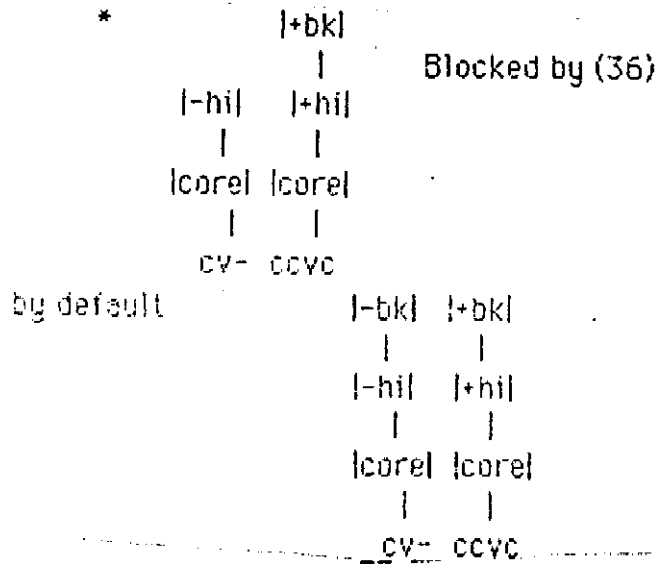




Except in emphatic environment

Therefore, the default value of |-bkl| will be assigned to the prefix vowel

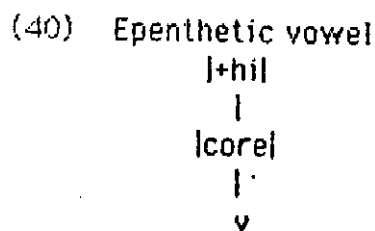
(38) ?a - ktub



JA has a rule of epenthesis that breaks a word final biconsonantal cluster by inserting a high short vowel between the two members of such a cluster. The quality of the epenthetic vowels is determined by the stem vowel. Thus, the epenthetic vowels of nouns of the canonical shape cvcc is realised as *i* if the stem vowel is either *i* or *a*, but as *u* if the stem vowel is *u*.

- (39) |\* nimit < niml 'load'  
 |\* nabis < nabs 'jail'  
 |\* šuḡul < šuḡl 'work'

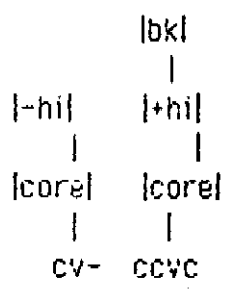
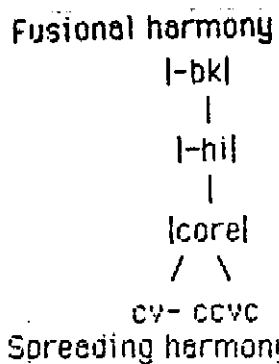
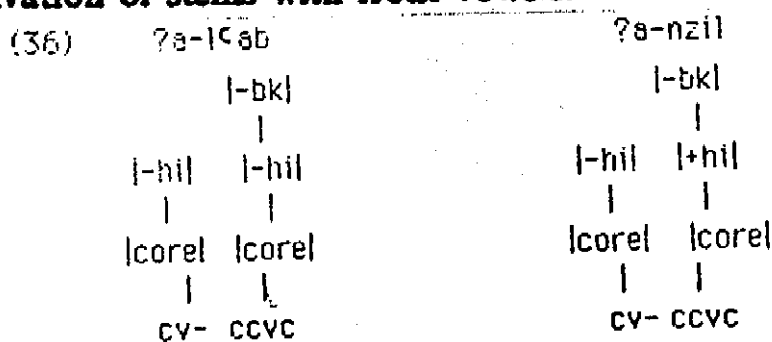
Once again, this vowel harmony can be accounted for by assuming that the epenthetic vowel is specified as |+hil| but unspecified for the feature |bk|. The default value for |bk| is +|bk|.



Mester (1986, 73-74) distinguishes between fusional harmony and spreading harmony as follows:

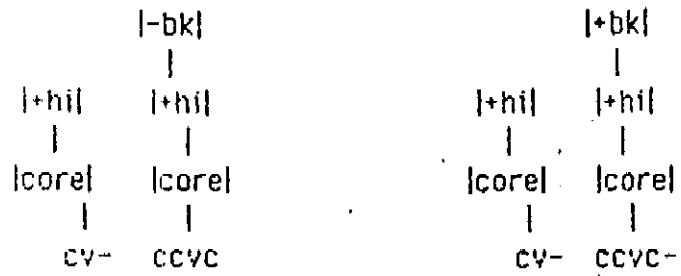
"fusional harmony is involved whenever harmony triggers and harmony undergoers are governed by specific conditions like the equal height requirement ..... spreading harmony is involved if there are no such stratificational restrictions"

Forms affixed with the first person sg prefix can be derived the same way except that the prefix vowel is specified as  $[-hi]$  and unspecified for the feature  $[bk]$ . The feature  $[-bk]$  is the default value for  $[bk]$ . I show in (36) the derivation of stems with front vowels.



As for first person sg forms with the back stem vowel, both the fusional harmony and the spreading harmony are blocked. The former is blocked because the prefix vowel and the stem vowel differ with respect to the values of  $hi$ . The latter is blocked because, even with no TC effects, under normal circumstances, an underlying vowel in JA cannot have a  $|\text{+bk}|$  and  $|\text{-hi}|$  specification at the same time. This can be expressed in terms of a well-formedness condition as in (37).

T-C

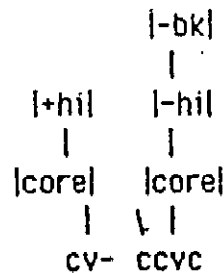


(Geminate) Fusion

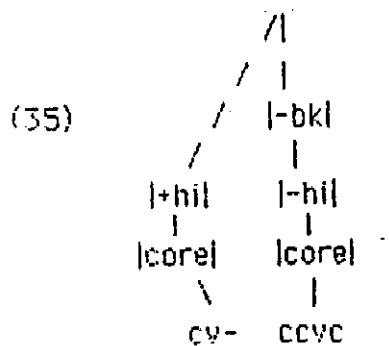


In the form *ti-leab* 'you masc sg play', where the stem vowel is [-hi], fusional harmony cannot apply, since the prefix vowel and the stem vowel will have opposite values for the feature [hi]. The representation of this form after TC is shown in (34).

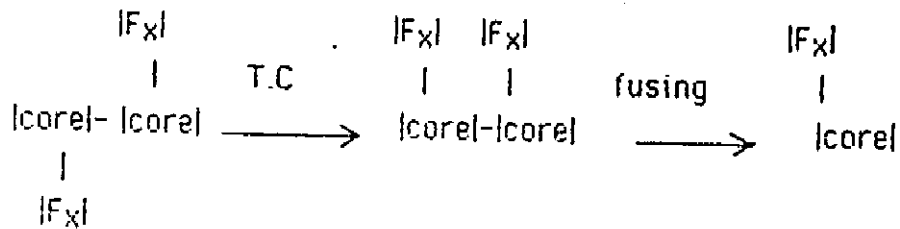
(34) ti-leab



Such a form is subject to a different kind of harmony, i.e., spreading harmony. This kind of harmony spreads the feature [-bk] to the vowel of the prefix.

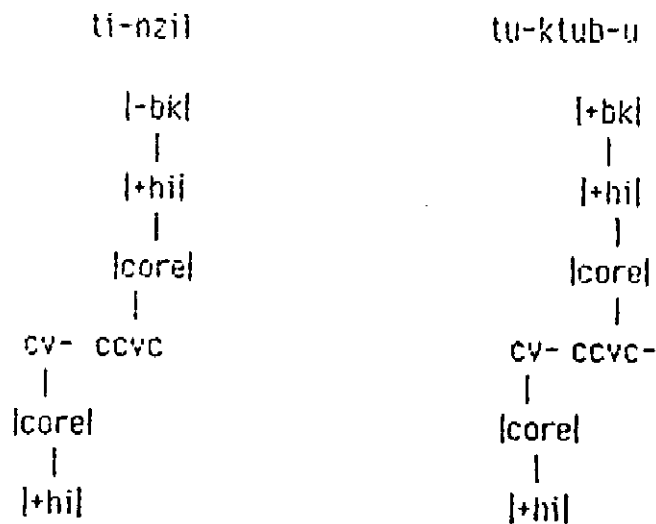


(32)



I follow Mester (1986) in assuming that this fusion is a separate parameter set by individual languages rather than a universal concomitant of TC. The derivations of *ti-nzil* 'you masc sg descend' and *tu-ktub-u* 'you masc pl write' illustrate this point. For the purpose of clarity, we will ignore the association of the suffix vowels.

(33)

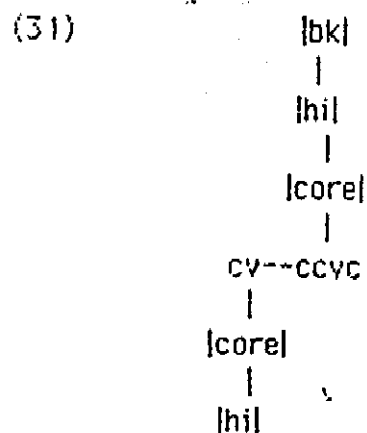




(30)	'play'	'descend' <sup>c</sup>	'write'
1st sg	?a-1ʕab	?a-nzil	?a-ktub
1st pl	ni-1ʕab	ni-nzil	nu-ktub
2nd sg masc	ti-1ʕab	ti-nzil	tu-ktub
2nd sg fem	ti-1ʕab-i	ti-nzil-i	tu-ktub-i
3rd masc sg	yi-1ʕab	yi-nzil	yu-ktub
3rd masc pl	yi-1ʕab-u	yi-nzil-u	yu-ktub-u
3rd fem pl	yi-1ʕab-in	yi-nzil-in	yu-ktub-in

I assume that, except for the 1st sg prefix, the prefix vowels in (30) are underlyingly [+hi] but unmarked for the feature [bk] (see Archangeli 1984, 1985, Mester 1986 for a similar analysis of suffix vowels in Yawelmani Yokuts). The unmarked value for the feature [bk] is [-bk]. This is the value which is assigned by default to vowels underlyingly unspecified for [bk], unless they receive a specification in some way in the phonological derivation. The underlying representation of the forms with high prefix vowels in (30) after affixation of the imperfective prefixes will be illustrated in (31) with stem vowels specified for both [hi] and [bk] but with no [bk] specification for the prefix vowel.

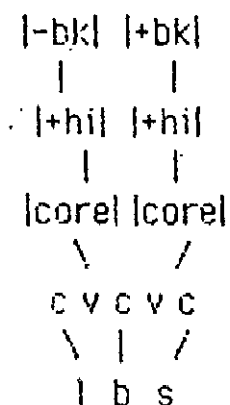
(31)



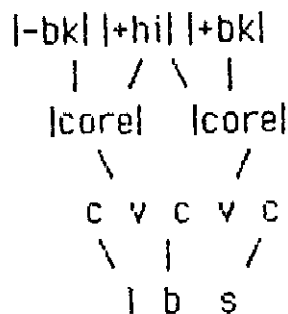
I suggest that the only way in which a vowel unspecified for [bk] receives [bk] specification is through tier conflation (TC). McCarthy (1986) suggests that, as a part of Tier Conflation, heteromorphemic identicals (i.e. geminates) are fused into a single melody element.

(29)

a. \*libus



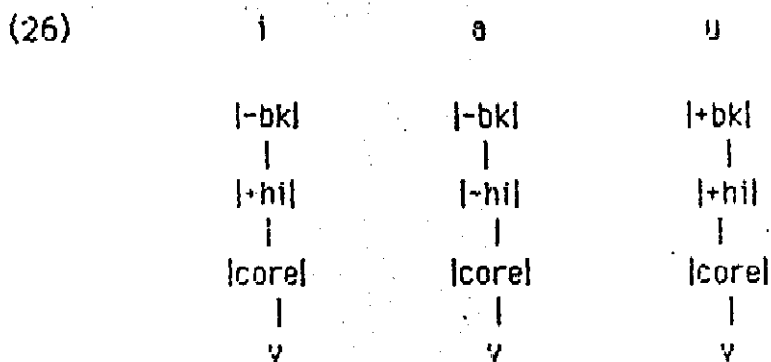
b. \*libus



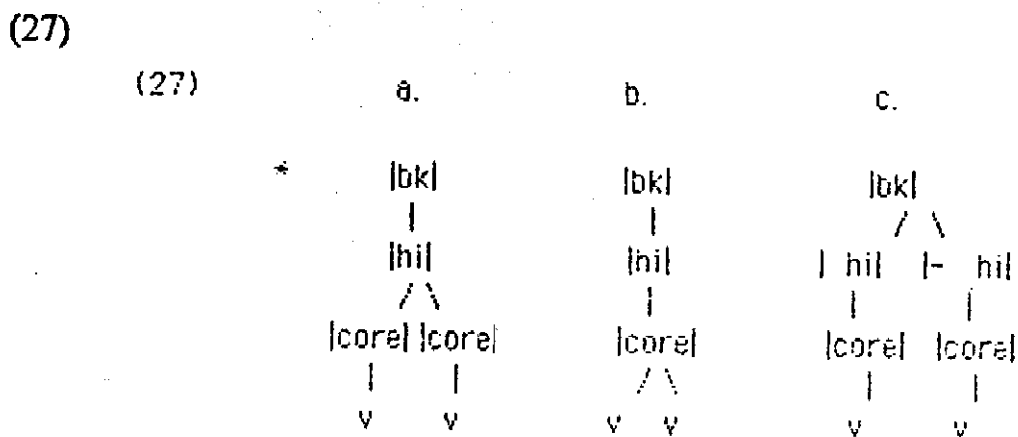
Note that representations such as (29)a escape the Geminata Minimization Principle since the identical cores do not share the same values for the feature [bkl]. It is interesting to note here that the Branching Prohibition Condition (17) and the dependent tier ordering representation are both needed to account for the facts of JA. This analysis supports Mester's (1986, 61-62) argument that dependent tier ordering cannot be given up in favor of direct core linking plus branching prohibitions. Nor can branching prohibitions be entirely abolished as a part of the theory. They are both necessary ingredients of the theory.

We have argued so far that the JA vowel harmony facts can be accounted for in terms of the OCP if vowels are represented with features occupying separate tiers which are individually subject to the OCP. We also argued that the h tier is the head tier and the [bkl] tier is dependent on the head tier.

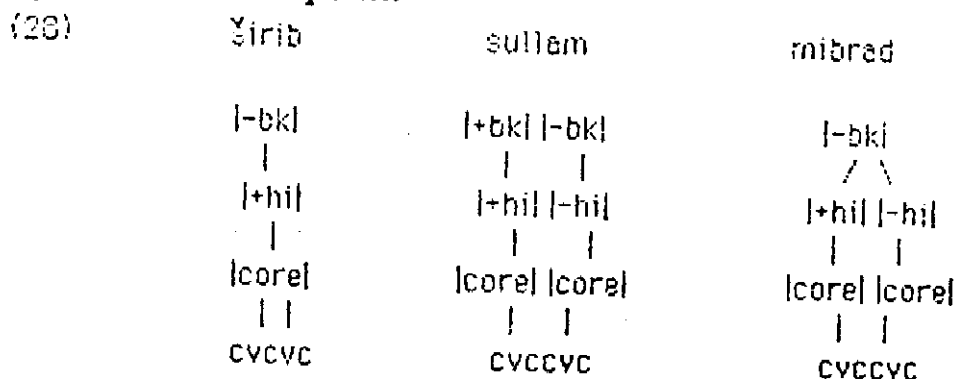
In JA a measure imperfective verb has a cv-prefix whose consonant is determined by the person and number of the subject S. Except for the first person singular prefix whose vowel is always 6, the vowel of all the other imperfective prefixes surfaces as i if the stem vowel is either a or I and U if the stem vowel is U.



In (26) the feature [bk] is dependent on the feature [hi]. This dependency relationship along with the Geminate Minimization Principle (23) entails that representations such as the one in (27) a are prohibited while those like the ones in (27) b-c are allowed.

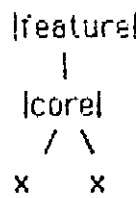


The forms in (1) and (3) are well-formed because they can be derived from (27b) and (27c) respectively but never from (27a). The representations in (28) illustrate this point.

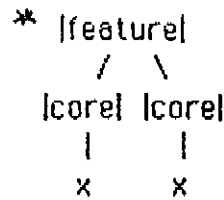


The forms in (2), on the other hand, are ill-formed because they will have representations that either violate the OCP in a dependent tier or dering representation as in (29) a or the condition (17) in a direct core linking representation as in (16) repeated here as (29)b.

(23) a.

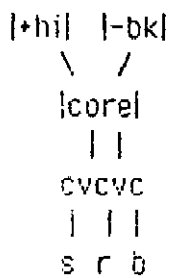


b.

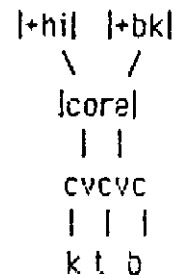


Principle (22) requires the forms in (1) to be represented as in (24).

(24) širib

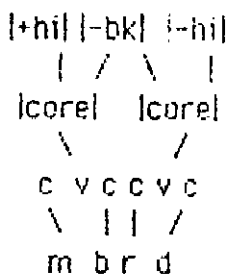


kutub



The representations in (24), coupled with the representation in (18) repeated here as (25), involve a generalization; the feature [bk] branches only if the [hi] tier has two opposite values for the feature [hi], otherwise, i.e. if the feature [hi] is linked to one core, it does not branch.

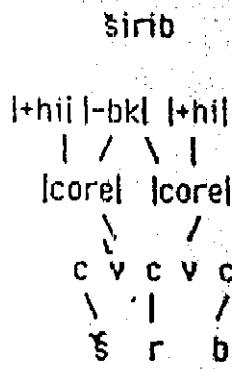
(25) mibrad



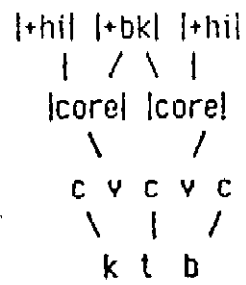
Direct core linking configurations do not capture this generalization. Such generalization is captured, however, in a dependent tier ordering configuration (Mester 1986).

Let us assume that the feature [hi] is more central to the core and that the feature [bk] has access to the core only through the feature [hi]. The underlying representation of JAvowels in (13) will be as in (26).

(20)



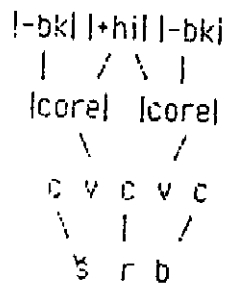
kutub



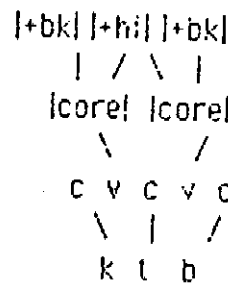
If the above analysis is correct, then the representation in (19) entails that, unlike the feature /hi/, the feature /bk/ has no branching prohibition condition. The above analysis is still incomplete. Forms having two identical high vowels will violate either the OCP as in (20) or both the OCP and the condition (17) as in (21).

(21)

širib



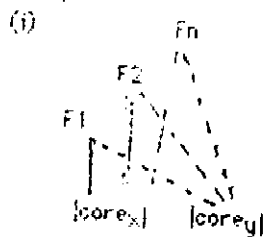
kutub



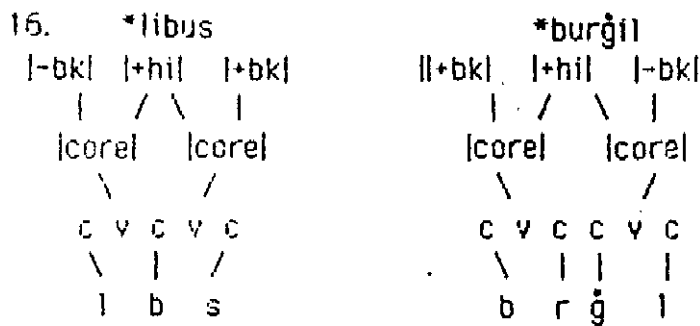
Mester's (1986) model solves such a problem by means of an independently motivated principle called the Geminata Minimization Principle.

(22) Geminata Minimization Principle

"Melodic structures of the form (i) are ill-formed, where core<sub>x</sub> and [ core<sub>y</sub>] are identical core configurations sharing all external feature specifications" (116)

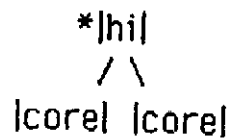


Mester (1986) states that this principle allows branching from the core, but prohibits branching from other features to identical core units. Thus, the representation in (23) a is well-formed, whereas that in (23) b is ill-formed since the cores are identical.



The representations in (16) require that a branching prohibition condition be imposed on the feature /hi/ (see McCarthy 1985 for a similar treatment of the feature /labial/ in Semitic morphology and Ito and Mester 1986 for a similar treatment of the feature /voice/ in Japanese). The JA branching prohibition condition can be formalized as in (17).

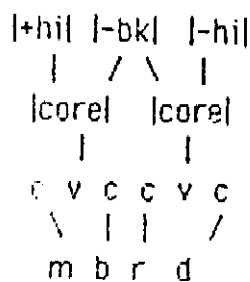
(17) Branching Prohibition Condition



The forms in (2) are ill-formed because they violate either the OCP as in (15) or the condition (17) as in (16).

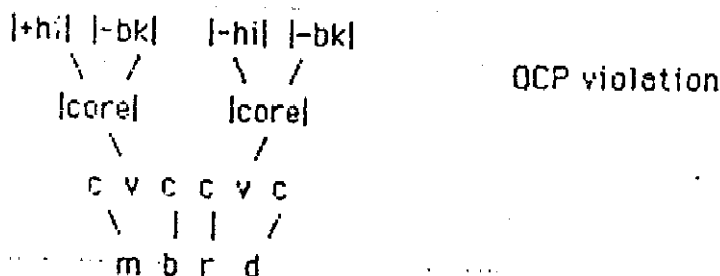
The configurations of the vowels in (13) require that well-formed stems containing the two short front vowels *i* and *a* be represented with a branching /bk/ feature. I illustrate this point by giving the representation for *mibradin* (18).

(18) mibrad



If this form is represented with a non-branching /bk/, the OCP will be violated.

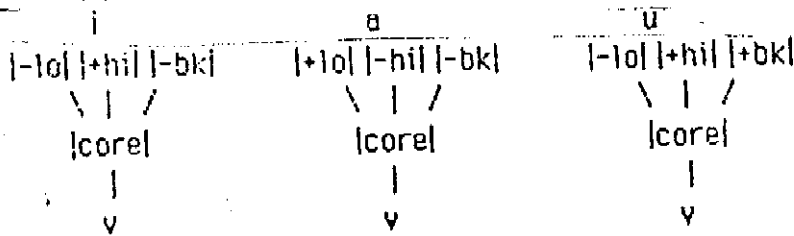
(19) mibrad



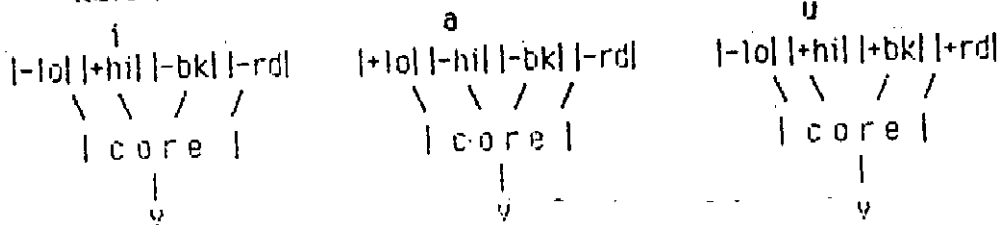
signed to these features. The representation of these vowels after the assignment of the default values of the two features is given in (14).

(14)

Rule (9)

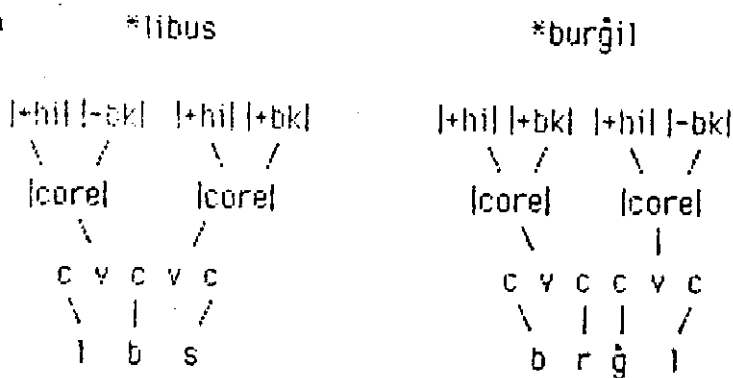


Rule (10)



The representations of vowels in (13) allow the interpretation of the ill-formedness of the forms in (2) as a direct consequence of the OCP, thus, eliminating the need for a special stipulation. Such forms will have the representations in (15).

(15)



Both of the representations in (15) violate the OCP because each one of them has the same value for /hi/ on the |hi| tier.

This analysis, however, has a problem. The OCP alone cannot account for the illformedness of the forms in (2), since they can be alternatively represented as in (16) where the feature |hi| is doubly linked to two cores, thus, evading the effect of the OCP.

$$(9) \quad \begin{array}{c} | -hi | \\ | \\ v \longrightarrow | +lo | \end{array}$$

Rule (9) would apply only to *a*, since the other two short vowels are specified | -hi |. Similarly, the feature | rd | can be excluded from the underlying representation, to be introduced later by means of a redundancy rule as in (10).

$$(10) \quad \begin{array}{c} | +bk | \\ | \\ v \longrightarrow | +rd | \end{array}$$

The exclusion of the features | lo | and | rd | results in the chart in (11).

(11)	i	a	u
	hi	+ -	+
	bk	- -	+

Having established the underlying representation of JA vowels in terms of an underspecification theory, we can return to the treatment of the cooccurrence restrictions of the JA vowels. Let us tentatively assume that each of the two features | hi | and | bk | occupies a separate tier with no dependency relationship between them.

$$(12) \quad \begin{array}{cc} |hi| & |bk| \\ \backslash & / \\ |core| \\ | \\ v \end{array}$$

The underlying representation of the three short vowels will be as in (13).

(13)	i	a	u
	+hi    -bk	-hi    -bk	+hi    +bk
	\ /	\ /	\ /
	core	core	core
	v	v	v

We assume that the redundancy rules (9) and (10) will respectively introduce the default values for | lo | and | rd | which we assume to be | -lo | and | -rd | if in the course of the derivation no other specification is as-



The ordering of these tiers with respect to one another is assumed to be governed by universal as well as language specific rules. Their presentation in (7) allows individual features to occupy separate tiers, but at the same time imposes dependency relationships among tiers.

Returning to the JA data in (1)–(3), I hypothesize that the short high vowel cooccurrence restriction can be accounted for in terms of the OCP if we follow Mester's (1986) model. The JA vowels must be represented with separate tiers for individual features. These tiers exhibit dependency relationships and are individually subject to the OCP.

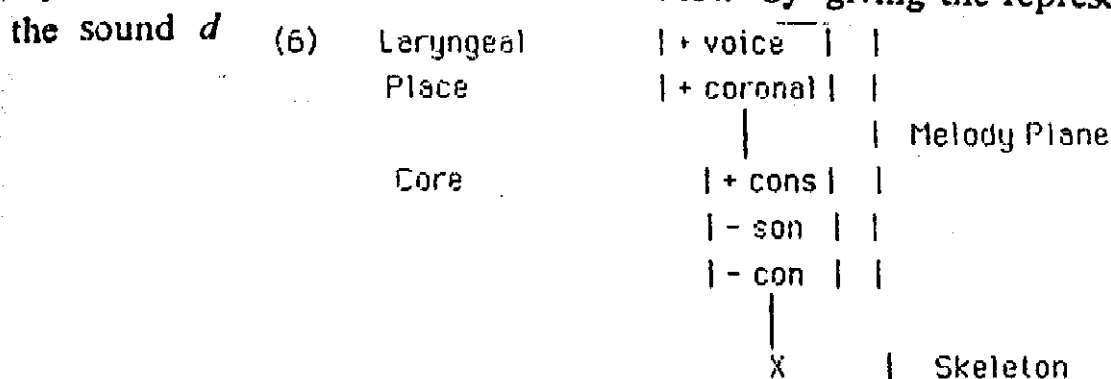
Before investigating the consequences of this model, the JA vowel system must be briefly described. In (8) below I show the JA vowels specified for the features high, low, back and round.

(8)	i	a	u
hi	+	-	+
lo	-	+	-
bk	-	-	+
rd	-	-	+

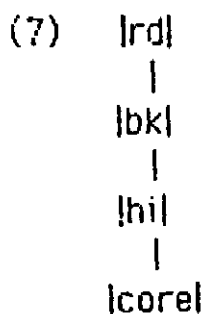
Obviously, the system in (8) includes some redundancy. Both  $|hi|$  and  $|lo|$  serve the same function, i.e., they distinguish  $a$  from the other two short vowels. Along the lines of the Feature Minimization Principle of an underspecification theory, one would like to eliminate one of these two features. An underspecification theory regards as most highly valued a grammar with underlying representations including the minimal number of features necessary to make different the phonemes of the language (Archangeli 1984). Besides, Chomsky and Halle (1958, 410) state: "No vowel segment can be marked for the feature 'round' unless some vowel segment in the system is marked for the feature 'high'". Since we need the feature  $|rd|$  to distinguish between  $u$  and  $i$ , we will retain the feature  $|hi|$  in the underlying representation of the JA vowels and exclude the feature  $|lo|$ . Another motivation for the elimination of the feature  $|lo|$  in favour of  $|hi|$  is that JA does not have underlying mid vowels which would require the presence of the feature  $|lo|$ , since such vowels would have to be specified  $| - lo |$  and  $| - hi |$  [ see note (2) ]. If the grammar requires that the feature  $| lo |$  be present in intermediate representations, it can be introduced by a redundancy rule such as the one in (9).

superior to a direct core linking approach. Then, further support for Mester's (1986) model will be presented by analysing vowel harmony facts exhibited by forms that have undergone prefixation and epenthesis.

Mester's (1986) model embodies several assumptions that need to be briefly reviewed. All features of a sound are assumed to occupy a common melody plane the basis of which is the core. Individual features occupy separate tiers which are individually visible to the OCP. The tiers occupied by features other than those occupying the core tier are linked to the skeleton through the core tier. Mester (1986) illustrates the type of representation such a model would allow by giving the representation



The representation in (6) enables us to analyse some morpheme-internal restrictions in terms of features. Such cooccurrence restriction will be derived from the OCP applying to feature tiers rather than to melody tiers. Crucial to Mester's model is the assumption that there is a hierarchical organization imposed on the set of features of each sound. Some features are more basic and directly linked to the core, while other features depend on the basic ones and have no direct linking to the core. For example, the vocalic features could be arranged as in (7).



In a theory of phonology where a sound is represented as a bundle of features that exist on one tier with no internal organization, the well-formedness of the forms in both (1) and (3) can be accounted for in terms of the Obligatory Contour Principle (OCP). This principle does not allow adjacent elements on an autosegmental tier to be identical (Leben 1973, McCarthy 1979, 1981). The OCP requires forms with two identical vowels to be underlyingly represented with a single vocalic melody, but those with two different vowels to be represented with two vocalic melody elements 4.

(4)	širib	burġul	mibrad	sullam
	i	u	i a	u a
	^	^		
	CVCV	CVCCVC	CVCCVC	CVCCVC
	š r b	b r ġ l	m b r d	s l m

None of the representations in (4) violates the OCP since none has two adjacent identical bundles of features on any autosegmental tier.

In such a theory, however, the ill-formedness of the forms in (2) cannot be accounted for in terms of the OCP. These forms will be represented with two different bundles of features on the vocalic melody tier.

(5)	*širib	*burġil	*kitub
	u i	u i	i u
	CVCV	CVCCVC	CVCV
	š r b	b r ġ l	k t b

Since the forms in (5) are ill-formed, their representations must be ruled out by means of a special stipulation. On the other hand, the OCP explanation of the ill-formedness of these forms can be maintained if we adopt Mester's (1986) model of their structure which is a version of the Melody Plane Hypothesis argued for Steriade (1982), Archangeli (1984), Clements (1985) and McCarthy (1985). The rest of the paper is organized as follows. First, Mester's (1986) dependent tier ordering model will be briefly described. It will be compared to a direct core linking model. It will be shown that the dependent tier ordering approach to vowel harmony is

# VOWEL HARMONY IN JORDANIAN ARABIC: A DEPENDENT TIER ORDERING ANALYSIS

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## Abstract

The paper discusses vowel harmony found in bisyllabic words in Jordanian Arabic. It is argued that the correct analysis requires the Jordanian Arabic vowels to be represented underlyingly with a separate tier for the feature [back] that is dependent on a head tier for the feature [high] directly linked to the [core] tier. This representation makes possible the interpretation of the vowel harmony facts in Jordanian Arabic as direct consequences of general principles of phonological theory such as the Obligatory Contour Principle and the Tier Conflation Principle. It is concluded that the Jordanian Arabic data provide interesting support for a dependent tier ordering analysis of vowel harmony along the lines developed in Mester (1986).

Like many Levantine Arabic dialects, Jordanian Arabic (JA) has a very simple vowel inventory. It has a system consisting of three short vowels: i u a, and their long counterparts ii uu aa<sup>2</sup>. In JA the two short high vowels i and u do not co-occur within a stem (Kenstowicz 1981). Thus stems of the canonical shape cicic, cucuc, ciccic, and cuccuc are well-formed, whereas stems of the canonical shape cicuc, cucic, ciccuc, and cuccic are ill-formed<sup>3</sup>.

- |     |            |             |         |          |
|-----|------------|-------------|---------|----------|
| (1) | sirib      | libis       | kutub   | burgul   |
|     | 'to drink' | 'to put on' | 'books' | 'bulgur' |
| (2) | *sarib     | *libus      | *kitub  | *burgil  |

The short vowel a cooccurs freely with the short high vowels as well as with itself.

- |     |          |            |            |
|-----|----------|------------|------------|
| (3) | mibrad   | sullam     | daras      |
|     | 'a file' | 'a ladder' | 'to study' |