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# Vowel Reduction in Tiberian Biblical Hebrew as Evidence for a Sub-foot Level of Maximally Trimoraic Metrical Constituents

## 0. The Problem

Biblical Hebrew, as transmitted in the Tiberian pronunciation tradition, has a vowel reduction rule which weakens short vowels in light (CV) syllables that precede a word's main-stressed syllable. The vowels which are affected by this process can appear on the surface as non-centralized prosodically-weakened vowels, or can undergo further processes of weak-vowel centralization and syncope, as shown in the following examples:

| 1) | underlying: | | surface: | |
|---|---|---|---|---|
| | ’ohalay | -> | ’ohŏlée | ’tents of’ |
| | dabariim | -> | dəbaaríim | ’words’ |
| (diachronic proto-form) | *ladabarikím | -> | lidbarkém | ’your (masc.pl.) word (ind.obj.)’ |

(Here "V̆" is a notation for a prosodically weakened vowel.)

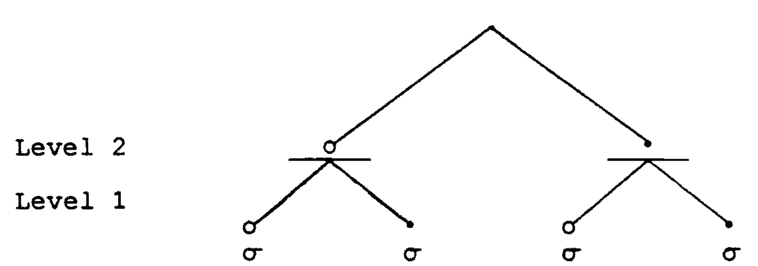
Since Prince (1975), this vowel reduction process has been analyzed in generative phonology as a rule which creates prosodic structures; other accounts are McCarthy (1979), Hayes (1981), Rappaport (1984), and Prince (1985). The prosodic structures created by vowel reduction do not seem to be stress feet. The questions which then arise are, what is the nature of these reduction structures, and what is their relation to stress-feet in metrical representations?

In earlier (pre-1980) metrical theory, reduction structures could be described as simply lower-level branchings in the (relatively undifferentiated) overall prosodic tree. However, metrical theory has moved toward categorizing prosodic constituents as belonging to various discrete levels of metrical representation, and towards placing constraints on the constituents which can occur at each of these discrete levels. Reduction structures do not fit neatly into any of the established levels, so that various ad-hoc and/or principled weakenings of metrical theory have been proposed in order to accommodate them.

## 0.1. Metrical Coherence

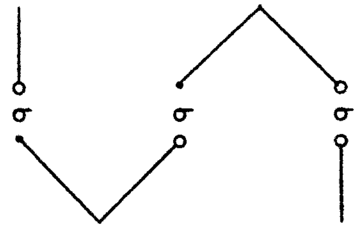
In particular, Rappaport (1984) has claimed that the constraint that different levels of metrical representation should be related in a strictly hierarchical way, as in (2) below, should be weakened in order to explain Biblical Hebrew vowel reduction. To accommodate reduction structures, she proposes that metrical representations can be composed of independent, non-hierarchical "stress planes" or metrical tiers (1984:135ff), as in (3):

2)



3) Level 1, Plane A

Level 1, Plane B




Here reduction structures would be on a separate plane from stress-feet and other metrical structures. Unfortunately, this "multiplanar" analysis results in a serious weakening of metrical theory. For example, two planes of metrical representation can assign conflicting constituency and relative prominence, as shown in (3) above (as in Rappaport 1984:160, Halle and Vergnaud 1987:68), and there can be complex interactions between constituents of the two planes.

A related problem is that in multiplanar analyses it is frequently postulated that metrical constituent structure is created temporarily, being used only for the purpose of counting positions for some specific phonological process (e.g. vowel reduction), and is then completely eliminated shortly afterwards (perhaps automatically, as the result of some general convention). In this respect reduction structures would be treated quite differently from all other types of structure (i.e. stress-assigning metrical structure, syllable structure, and autosegmental linking), which are assumed to persist unchanged unless affected by some specific process during the course of the derivation.

Analyses where a non-hierarchical (non-coplanar), temporarily created, level of metrical structure is claimed to be necessary to explain a vowel reduction process exist for Biblical Hebrew (Rappaport 1984:135ff,160 and Halle and Vergnaud 1987:68), Yawelmani (Archangeli 1984:194), and Old English (Keyser and O'Neill 1985:12).

## 0.2. Goals

This paper will attempt to show that Biblical Hebrew vowel reduction can be accounted for within a more restrictive metrical theory, where each level of metrical constituency in a metrical representation is in a simple hierarchical relationship with the levels immediately above and immediately below, and where all metrical structures, once created, persist until modified by a specific rule (and the general destruction of an entire layer of metrical structure is not a permitted rule type). (In other words, metrical structure cannot be created as a rule-particular position-counting device that can ignore the already-established metrical structure.) Dresher and Lahiri (1987) call such theories "metrically coherent".

The claim will be that the device of temporary multiplanar metrical representations is unnecessary in the case of Biblical Hebrew vowel reduction. Since this is the main case in the recent literature (e.g. Halle and Vergnaud 1987) which has been analyzed using the full power of non-"metrically coherent" theory, the results of this paper may cast doubt on whether multiplanar representations should be allowed as part of metrical theory.

Another goal of this paper will be to find a concrete phonological interpretation for reduction structures (which have tended to remain purely abstract entities in previous analyses), in order to explain the differences between reduction structures and stress feet. The analysis of Hebrew reduction structures adopted here will also apply in many respects to the similar sub-foot, moraic, non-stress-assigning constituents which have been postulated for certain other languages.

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## 1. Clues to the Nature of Hebrew Vowel Reduction

### 1.0. Preliminaries

"Tiberian Biblical Hebrew" refers to the state of the Hebrew language attested in the Tiberian masoretic orthography, representing the best pronunciation tradition of ca. the eighth century A.D. A quantitative interpretation of the vowel symbols of the Tiberian orthography is followed here, differentiating long qaamees (long aa) from short qaamees (short ɔ). The orthographic sign šəwaa (used to mark both consonants not followed by a vowel, and consonants followed by the central reduced vowel), will be interpreted here basically as in Chomsky (1971). As for secondary stress, and its relation to the meteg grapheme, I will basically follow the interpretation of Dresher (1981). Finally, the symbol "ʿ" is used here to transcribe the voiced pharyngeal.

### 1.1. Effects of Vowel Reduction on Syllable Structure

One clue as to the nature of reduction structures in Biblical Hebrew comes from the fact that the process of vowel reduction complicates the system of syllable structure. Hebrew surface representations, and intermediate representations after vowel reduction, have a number of highly specific constraints on syllable types and syllable sequences, which should be explained as a consequence of vowel reduction.

#### 1.1.1. Syllable Structure of the Input to Vowel Reduction

Vowel reduction takes place in the the last, non-cyclic, stratum of the lexical phonology, after main-stress assignment. The syllable structure of the representations which are the input to the process of vowel reduction is rather simple. There is a contrast between two degrees of vowel length, short vowels (V), and quantitatively long vowels (VV). There are no reduced vowels, as such, before vowel reduction; there are some vowels which are lexically unspecified for vowel features (Rappaport 1981), but this underlying lack of specification is unconnected synchronically with vowel reduction (such underlyingly unspecified vowels do not necessarily become prosodically weakened on the surface).

In non-word-final position, two syllable weights, light (CV) and heavy (CVC or CVV) can occur. These syllable types can occur in any order (there are no syllable sequence constraints, as in post-vowel-reduction representations). In word-final position, heavy and superheavy (CVVC) syllables can occur; light syllables do not occur finally (*CV#). Note that all syllables have an onset, and no onset consists of more than one consonant.

#### 1.1.2. Syllable Structure of Post-Vowel-Reduction Representations:

After vowel reduction has occurred, syllable structure is more complex. Reduced vowels exist, and can never be long, so that there is an apparent contrast between three distinct degrees of vowel prominence: prosodically-weakened or reduced short vowels (informally symbolized here as "ə"), unreduced short vowels (V), and long vowels (VV).

Reduced vowels also do not occur before a tautosyllabic consonant ($*əC]_{\sigma}$), so that only light syllables can contain reduced vowels (Cə). This means that there is an apparent contrast between four different syllable weights: reduced light syllables (Cə), unreduced light syllables (CV), heavy syllables (CVV and CVC), and superheavy syllables (CVVC, and later on also CVCC).

Post-vowel-reduction representations are subject to the following syllable constraints:

Reduced light syllables cannot be main-stressed (*Cə́) and cannot occur word-finally (*Cə#). Also, two light syllables both containing unreduced short vowels may not occur in succession (*CVCV). And a light syllable containing an unreduced short vowel may not occur immediately preceding the main-stressed syllable (*CVσ́).[1]

Another constraint must be stated relative to a late rule which has the effect of changing CV.Cə.Cə sequences to CV.CVC. Before the CV.Cə.Cə > CV.CVC rule takes place, a non-main-stressed unreduced light syllable can occur only if the following syllable is a reduced light syllable (non-main-stressed CV only before Cə). After the CV.Cə.Cə > CV.CVC rule has taken place, two reduced light syllables may not occur in succession (*CəCə).[2]

In addition to being subject to many of the above constraints, unreduced light syllables are relatively less frequent overall after vowel reduction; also, those light syllables which were initially assigned the main-stress tend to lose this stress later on, after vowel reduction (see section 2.1.1 below). This seems to lead to the conclusion that light syllables are a distinctly marked syllable type in post-vowel reduction representations (along with superheavy syllables), while heavy syllables, which are not subject to any restrictions, are the unmarked syllable type (see Cantineau 1932:134).

Since all the above syllable constraints are a result of vowel reduction, clearly they should be accounted for by any adequate theory of vowel reduction. A goal of this paper will be to develop a theory in which most of these constraints will follow directly from the nature of the phonological process of vowel reduction.

## 1.2. Evidence for a Sub-Foot Metrical Constituent

There are several reasons for supposing here that reduction structures are different from stress feet. For one thing, no one has ever been able to collapse the assignment of main stress and the reduction of pre-main-stress vowels in light syllables into a single phonological process which creates a single kind of metrical structure. Also, secondary-stress stress assignment is a very "surfacy" phenomenon, which applies after vowel reduction. Very roughly speaking, secondary-stress assignment stresses alternate unreduced vowels, suggesting that there is a difference between the prosodic relationship between a syllable containing a reduced vowel and a syllable containing an unreduced vowel (i.e., a reduction structure) and the prosodic relationship between an unstressed syllable and a stressed syllable (i.e. a stress foot).

An indication as to the nature of reduction structures comes from the fact that several of the post-vowel-reduction syllable constraints appear to be prosodic in nature. For example, the *CVCV and *CəCə constraints ensure that if two light syllables are adjacent, then there is an alternation in prominence; one of them is relatively strong (unreduced) and the other is relatively weak (reduced). The requirement that a non-main-stressed CV syllable must be followed by a Cə syllable also has some prosodic characteristics. This constraint has the effect that, after vowel reduction, an unreduced short vowel in a non-main-stressed syllable must be followed either by a coda consonant (resulting in a CVC syllable), or by a reduced syllable (resulting in a CV.Cə sequence).

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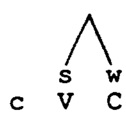
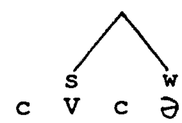
1 Ignoring a late rule which degeminates gutturals without compensatory lengthening (e.g. 'aḥḥím 'brothers' > 'aḥím); see Joüon 1923:60-61 and Prince 1975:231. (These consonants cannot be geminated on the surface.)
2 Note that in the long version of this paper, Churchyard 1988, it was shown that these CV.Cə.Cə/CV.CVC sequences turn out to form special ternary/trimoraic constituents. If ternary constituents of this type are excluded, then both the *CəCə filter, and the requirement that non-main-stressed CV be before Cə, will always be true at every stage of the derivation after vowel reduction.

Thus it seems that a reduced vowel is in some way metrically equivalent to a coda consonant, but differs metrically from a full short vowel. Intuitively, what coda consonants and reduced vowels have in common, as compared to full short vowels, is that they are both in some sense "weak moras" (cf. Selkirk 1978:149).

Suppose we create a metrical structure with moras as terminal nodes (i.e. on the rhyme projection), and assign strong terminal nodes to full short vowels, and weak terminal nodes to coda consonants and reduced vowels (taking further certain ideas implicit in McCarthy's representations of Hebrew; see McCarthy 1979:24, etc.).

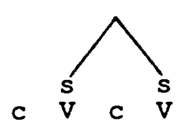
Then the similarity between the following two mora-relating representations would express some kind of equivalence in prosodic structure:

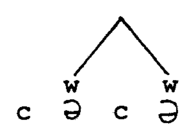
4) 

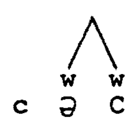

5) 

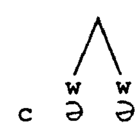

(Here "c" expresses a [non-moraic] onset consonant, "C" a coda consonant, and the schwa symbol stands for any reduced [prosodically weakened] vowel.)

If reduced vowels and coda consonants must be represented as "weak moras", while unreduced short vowels are "strong moras", then the impossibility of *CVCV or *CəCə sequences, and of *CəC syllables, would follow immediately from the inherent ill-formedness of the following three structures which would have to be created:

6) * 


7) * 


8) * 


9) * 


Similarly, if one says that the second mora of a quantitatively long vowel must be a "weak mora" (as a coda consonant is), then the impossibility of long reduced vowels follows from the inherent ill-formedness of structure (9).

So a number of the peculiar syllable constraints are explained by postulating structures which assign relative prominence to moras, with the restriction that certain types of moraic (rhyme) segments in Hebrew must be dominated by strong terminal nodes and other types of moraic segments must be dominated by weak terminal nodes. Since these syllable constraints are created by vowel reduction, I postulate that these mora-relating structures are the prosodic structures responsible for vowel reduction.

Thus reduction structures are mora-relating structures that form a level of metrical constituency which is below the level of stress-feet, and above the syllable level. These sub-foot structures are in some sense projections of syllable-internal mora-relating (rhyme) structure, thus explaining how reduction structures can be inter-syllabic metrical structures that are not stress-assigning. The process of pre-main-stress vowel reduction can be expressed as the iterative right-to-left formation of these structures.

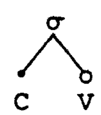
Of course, constraints must be placed on any proposed new level of structure, so that the resulting theory does not have too much expressive power, and in fact it seems that only a very tightly-constrained theory of the nature of mora-relating reduction structures is able to make correct predictions about Hebrew.

## 1.3.The Definition of the Sub-Foot

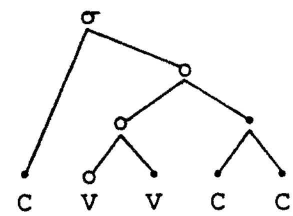
If the sub-foot structures responsible for vowel reduction are in some way projections of syllable rhyme-structure, then the way in which syllable-internal structure is represented will be relevant to the definition of the sub-foot.

Here the minimally elaborate syllable representations necessary are assumed. Major syllable constituency is respected (i.e., onset vs. rhyme, and nucleus vs. coda). All information associated with the nodes of syllable structure is ignored, except for information about overall syllable headship. Finally, there is "tree pruning" of non-branching nodes (exhaustive domination), resulting in simple syllable representations of the following type:

10)




11)

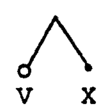



(These representations are similar to those of Archangeli 1984:171-73; see also Levin 1985.)

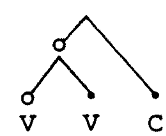
If syllable onsets are ignored as metrically irrelevant, then we have the following representations for the rhymes of the syllable types in existence at the stage of the derivation when vowel reduction applies (monomoraic CV, bimoraic CVX, where "X" is either C or V, and trimoraic CVVC):

12)


13)




14)



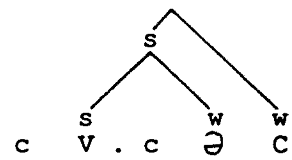

These minimal rhyme representations express the metrical aspect of syllable structure, and are postulated to be the only syllable-internal information that sub-feet have access to (thus sub-foot formation cannot be sensitive to purely segmental features of moraic segments, or fine sonority distinctions).

### 1.3.1.Constraints on the Sub-Foot

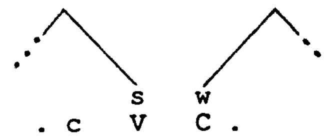
There are several sets of constraints that will serve to define the sub-foot formally. Each moraic segment (i.e., rhyme segment) in a word is linked to a terminal node of the prosodic structure of a sub-foot (with the single possible exception that a reduced vowel in a word-initial syllable will be left unaffiliated to any sub-foot, and will therefore dangle directly from the word tree). No non-moraic segments (onset consonants) are linked to terminal nodes of a sub-foot.

The first constraint on the sub-foot is the Rhyme-Structure Inalterability constraint. The process of sub-foot formation cannot rearrange syllable-internal structure, but rather incorporates already-existing syllable-internal structure. Thus the syllable-internal mora-relating structure of sub-feet cannot conflict with the rhyme-internal constituency previously established by syllabification, (12)-(14) above. Also, the moraic segments in a single syllable cannot be divided between two sub-feet, nor can a proper subset of the moras in one syllable be grouped together with moras in another syllable. (This is the "syllable integrity" constraint of Prince 1980:529 and Rice 1988.) Therefore any branching which is a part of sub-foot structure will either be contained entirely within a single rhyme, or will relate two whole syllable rhymes (only the branchings between syllables are actually created by the process of sub-foot construction). Rhyme-structure inalterability rules out the following as sub-foot structures (where a period indicates a syllable-boundary):

15) *

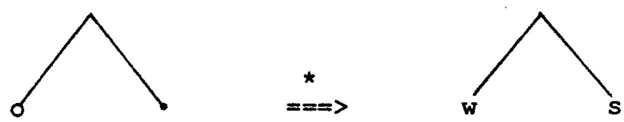



16) *



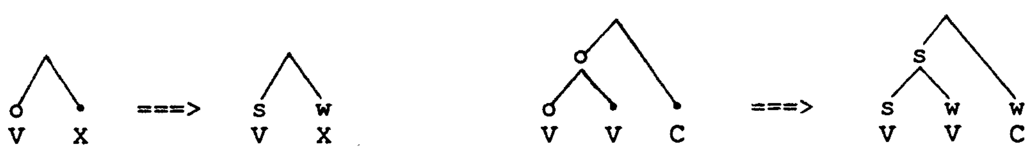

As a corollary to this requirement that sub-foot constituency cannot actually conflict with previously-established rhyme-internal constituency, there is also a requirement that the strong/weak prominence relations between nodes of sub-foot structure should not actually conflict with the previously-established rhyme-internal head/non-head prominence relations between the nodes of syllable representations. In other words, a syllable non-head which is a sister of a syllable head cannot be labeled as relatively stronger in sub-foot structure. This constraint can be expressed as follows (where "===>" stands for the operation of labeling rhyme structure as a part of sub-foot structure):

17)




The rhyme-structure inalterability constraint, and its labeling corollary, determine that bimoraic and trimoraic rhymes must have the following labelings as part of mora-relating sub-foot structure:

18)

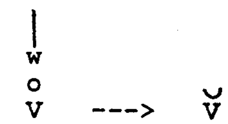


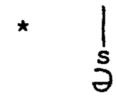

Thus while it may seem dangerous to postulate an inter-syllabic constituent which has access to individual moras in a syllable, the requirement that sub-foot structure may not conflict with previously-established syllable structure provides a strong constraint on interaction between the sub-foot and syllable.

Note that the above general requirements against conflicting with previously-established rhyme-internal structure allow the vowel of a light syllable (i.e., the single moraic segment of a monomoraic rhyme) to be dominated by either a strong terminal node or a weak terminal node of sub-foot structure. Also, these general constraints do not determine which vowels will become interpreted as prosodically-weakened, as a result of being made part of sub-foot structure.

Hebrew vowel reduction is expressed by a prosodic-weakening convention, (19) below, that a syllable-head segment dominated by a weak terminal node of prosodic structure is interpreted as a reduced vowel. This kind of convention seems to be fairly common in languages which have metrical weakenings of various types. Only vowels in light syllables can be reduced by this process, since syllable-head segments in bimoraic and trimoraic syllables must be dominated by a strong terminal node of sub-foot structure, as seen in (18).

Biblical Hebrew has another (language-particular) restriction that reduced vowels can only appear in this position; a segment dominated by a strong terminal prosodic node cannot be a reduced vowel, (20) below (as was assumed in section 1.2 above). This means that the rhymes of unreduced light syllables will always be dominated by a strong terminal node of sub-foot structure, while reduced light syllables will be dominated by a weak terminal node.

19) 

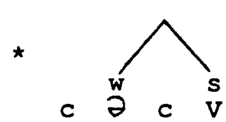

20) 


(In convention (19) I am using the symbol "V̆" to informally express a reduced or prosodically-weakened vowel, rather than "ə" as elsewhere in section 1, so as to avoid giving the impression that (19) affects segmental features.)

The requirements that sub-foot structure should not conflict with syllable rhyme structure (i.e., the rhyme-structure inalterability constraint and its labeling corollary), when combined with the restriction on prosodic weakening (20), yield the result that in bimoraic and trimoraic rhymes (13-14) a full short vowel or the first mora of a long vowel must be dominated by a strong terminal node of sub-foot prosodic structure, while a coda consonant or the second mora of a long vowel must be dominated by a weak terminal node.

Similarly, when restriction (20) and the prosodic weakening convention (19) are applied to monomoraic rhymes (12), we get the result that reduced vowels must be dominated by a weak terminal node of the sub-foot, while full short vowels in a light syllable must be dominated bya strong terminal node (just as full short vowels in CVC syllables are). Thus if the various constraints on the sub-foot which have been discussed above are applied to the inventory of syllable rhymes that exist in the input to vowel reduction (12-14), this gives the distinction between segment-types that are "weak moras" and "strong moras" in post-vowel-reduction representations, as discussed above in section 1.2.

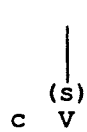
Finally, sub-feet are also subject to another constraint, that the overall mora-relating structure of a sub-foot must be identical in branching pattern to the mora-relating structure (i.e., rhyme branching) of some individual existing syllable type (12-14), with strong nodes of sub-foot structure corresponding to the syllable-head nodes of rhyme representations. This, the Rhyme-Structure Parallelism Constraint, can be viewed as a kind of "structure preservation" constraint; if sub-feet are in some sense projections of syllable rhymes, then it seems only plausible that the kinds of sub-foot structure which are allowed should be constrained by the kinds of rhyme structure which are allowed by the syllabification rules. The following structure is ruled out as a possible sub-foot by the rhyme-structure parallelism constraint:

21) 

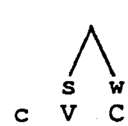

1.3.2.Possible Sub-Feet

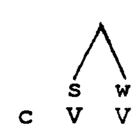
The following structures are possible sub-feet within the constraints outlined above:

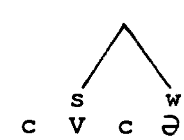
Unary:

22) 

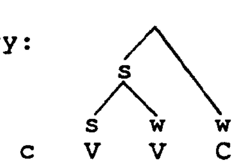

Binary:

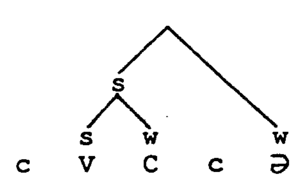
23) 

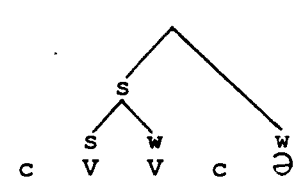

24) 


25) 


Ternary:

26) 


27) 


28) 

Sub-feet are maximally trimoraic, since Hebrew syllables are maximally trimoraic. Due to the rhyme-structure parallelism constraint, the bisyllabic sub-feet are projections of rhyme-internal mora-relating structure onto two syllables. Also, note the equivalence of inter-syllabic and rhyme-internal branchings as a part of sub-foot structure.

*  *  *

## 2. Reduction as Structure Assignment

In this analysis, Hebrew vowel reduction is accomplished by the iterative right-to-left creation of maximal sub-foot constituents, starting from the right edge of the word. The following is a schematic example of this process (here sub-foot formation is shown only in the pre-main stress domain, where vowel reduction occurs, and sub-foot boundaries are indicated by parentheses):

29)

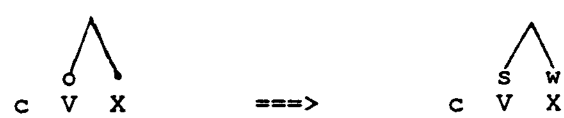
#cV.cVX.cV.cV.cVX.cV.cV.cV.cVX.cV.cV.cV.cV.cVX.cV.[σ́

⇓

#cV̆(cVX) (cVcV̆) (cVXcV̆) (cVcV̆) (cVX) (cVcV̆) (cVcV̆) (cVXcV̆) [σ́

There are several sub-cases to the process of construction of sub-feet of maximal size. As one proceeds from right to left in the word, if the rightmost syllable yet unassigned to a sub-foot is an underlying heavy syllable, then that syllable is made into a monosyllabic bimoraic sub-foot:

30a)

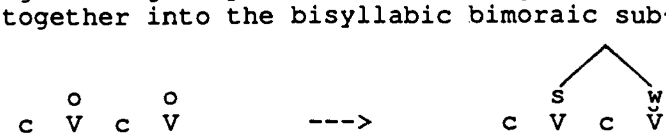



A monosyllabic trimoraic sub-foot is constructed over an underlying super-heavy syllable (these exist only at the end of a word):

30b)

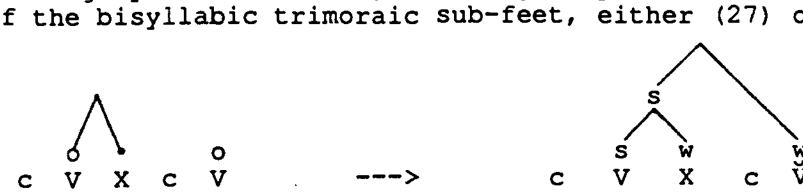

But if after assigning sub-foot structure to part of a word, the rightmost syllable that remains unassigned to a sub-foot is a light syllable, then the vowel of this light (cV) syllable will be prosodically weakened. If the syllable preceding the light syllable is also light, then the two syllables will be grouped together into the bisyllabic bimoraic sub-foot (25):

30c)




If the preceding syllable is heavy, the light syllable will be grouped with it into one of the bisyllabic trimoraic sub-feet, either (27) or (28):

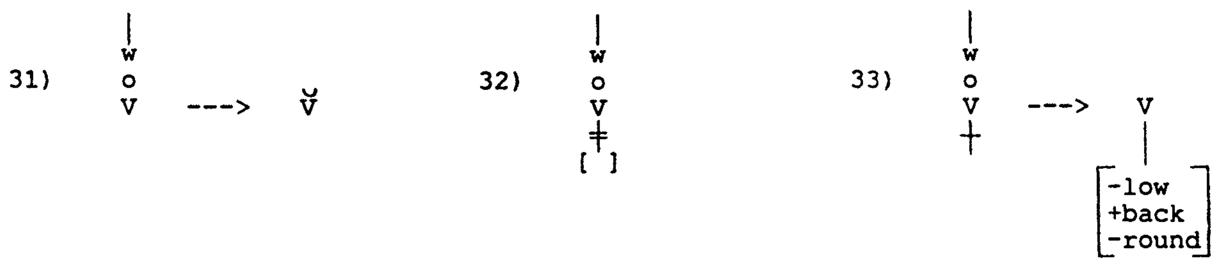
30d)



But if the rightmost unassigned syllable is a word-initial light syllable, so that there is no preceding syllable, then it cannot be assigned to any sub-foot, and remains unaffiliated at the left edge of the word.

Syllable-head segments, and any rhyme constituency structure, are indicated on the left-hand side of each sub-case of (30) above. Note that sub-case (30a) and sub-case (30b) merely label already-existing rhyme-structure as part of sub-foot structure, while sub-cases (30c) and (30d) actually create new inter-syllabic prosodic branchings.

A syllable-head segment dominated by a weak terminal node of prosodic structure (here the terminal node of a sub-foot) is interpreted as a prosodically weakened (reduced) vowel by convention (19), repeated here as (31). Such reduced vowels are subject to further changes.



A prosodically weakened vowel generally loses its distinctive feature specifications (the "melody removal" of Rappaport 1984, expressed in (32) above). (Note that this process does not always apply to reduced vowels in word-initial syllables, as will be discussed below.) Prosodically weakened vowels which have been made featureless by melody removal will receive new (non-central) vowel features if they are directly after a guttural consonant, by the processes of "cross-guttural harmony" (to be discussed below as 53) and post-guttural a-insertion. Those vowels affected by (32) which are not preceded by a guttural eventually become central vowels by a late-applying (default) process of feature insertion, (33) above. Note that (33) must be a post-lexical process, since it is not "structure-preserving" (there are no underlying non-low central vowels). Finally, central reduced vowels in doubly-open syllables are deleted by a syncope rule.

Below are some examples of the process of the right-to-left iterative creation of maximal sub-foot constituents. The input representation to vowel reduction shows the effects of main-stress assignment and pretonic lengthening. Sub-foot constituency is again indicated by parentheses, and the boundary of the main-stress foot by a left bracket. The symbol "Ø" is used for unspecified vowels, whether they are underlying or created by melody removal, and "Ø̆" is used to represent a prosodically-weakened featureless vowel (instead of Rappaport's "V̆" symbol).

| | | |
|---|---|---|
| 34) | mamla[kóot | 'kingdoms of' |
| | mamla[(kóot) | (30b) |
| | (mamlă)[(kóot) | (30d) |
| | (mamlØ̆)[(kóot) | (32) |
| Surface: | (mamlə)[(kóot) | (33) |

| | | |
|---|---|---|
| 35) | 'oha[léy | 'tents of' |
| | 'oha[(léy) | (30a) |
| | ('ohă)[(léy) | (30c) |
| | ('ohØ̆)[(léy) | (32) |
| | ('ohŏ)[(léy) | (53) |
| | ----- | (33) |
| Surface: | ('ohŏ)[(lée) | (other rules) |

| | | |
|---|---|---|
| 36) | lØdabarØ[kém | 'your (masc.pl.) word (indir.obj.)' |
| | lØdabarØ̆[(kém) | (30a) |
| | lØda(barØ̆)[(kém) | (30c) |
| | (lØdă)(barØ̆)[(kém) | (30c) |
| | (lØdØ̆)(barØ̆)[(kém) | (32) |
| | (lØdə)(barə)[(kém) | (33) |
| Surface: | (lid)(bar)[(kém) | (other rules) |

(The schwa symbol is used here only for actual central vowels; note that central vowels are generally always prosodically weak, so that the breve symbol would be redundant in this case.)

Note how (33) does not apply in derivation (35), since the vowel affected by (32) is after a guttural. Derivation (36) shows that underlyingly unspecified vowels are not necessarily the same as the vowels which are prosodically weakened by vowel reduction. The second of the underlyingly unspecified vowels in the underived representation of (36) happens to be assigned to the weak position of a sub-foot, and so is treated in the same way as reduced vowels affected by (32); the first underlying unspecified vowel is not prosodically weakened, and so receives distinctive features through a completely separate process (by which an unreduced unspecified vowel in a closed syllable, i.e., not before a guttural, becomes i).

## 2.1. Potential Problems

The analysis of Hebrew vowel reduction outlined above is incomplete in several respects.

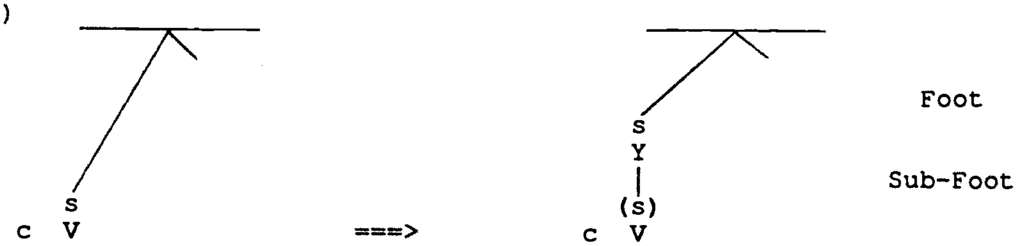
### 2.1.1. Monomoraic Sub-Feet and the Stress Shift off a Light Penult

The first situation that was not considered above is what happens when there is a potential conflict between maximal sub-foot assignment and the already existing stress-foot constituency. It turns out that sub-foot assignment does not change the position of the previously-assigned main-stress (i.e., does not affect the single, maximally binary, left-strong foot which has been constructed at the right edge of the word).

If a word ends in a stressed heavy or superheavy syllable, or in a sequence of a penultimate stressed heavy syllable followed by a word-final heavy syllable, then there is no conflict between sub-foot constituency and stress-foot constituency. But a word can also end in a sequence of a penultimate stressed light syllable followed by a word-final heavy syllable, and in this case the foot constituency is ...[CVCVX#, while the right-to-left creation of sub-foot constituents of maximal size would produce the constituency ...CV)(CVX)#, where the vowel of the light syllable would be subject to reduction.

If vowel reduction cannot change the location of the main stress, then sub-foot construction will run into the foot boundary, and the maximal sub-foot constituent that can be assigned in this case will be monomoraic (note that this is the only situation in which a monomoraic sub-foot is created):

30e)



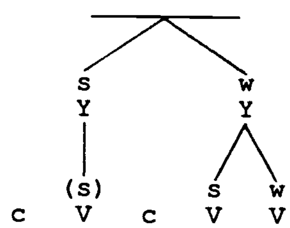
(If Prince's formalism (1980:527) is used, in which exhaustive domination is notationally equivalent to a node with multiple, ordered annotations, then one can say that no new structure as such is actually being built in (30e); rather, a syllable rhyme is simply labeled as being a sub-foot.)

The following derivation illustrates monomoraic sub-foot creation:

| | | |
|---|---|---|
| 37) | kaa[tábuu | 'they wrote' |
| | kaa[tá(buu) | (30a) |
| | kaa[(tá)(buu) | (30e) |
| | (kaa)[(tá)(buu) | (30a) |

According to this account, the fact that main-stressed penultimate light syllables frequently destress is because they are part of a highly marked configuration: The only situation in which monomoraic sub-feet occur is also the only situation in which a main-stressed syllable is lighter in metrical weight than the following weak syllable in the same foot!

38)




(foot structure)

(sub-foot structure)

(rhymes/skeleton)

The stress shift off a light penult can now be analyzed as the deletion of a monomoraic sub-foot's prosodic constituent structure. As a consequence of this deletion, the formerly stressed syllable no longer belongs to a sub-foot, so that (30) can reapply, as seen in the derivation below:

| | | |
|---|---|---|
| 39) | (kaa)[(tá)(buu) | (37) |
| | (kaa)ta[(búu) | (1-μ sub-foot deletion) |
| | (kaată)[(búu) | (30d) |
| | (kaatØ̆)[(búu) | (32) |
| | (kaatə)[(búu) | (33) |
| Surface: | (kaat)[(búu) | (other rules) |

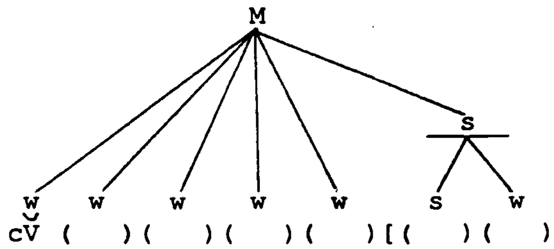
In previous accounts, the stress shift off a light penult has been analyzed as reduction-structure formation actually overwriting the previously existing foot structure (Prince 1975:29,145, McCarthy 1979:24, Rappaport 1984:139, Prince 1985:18). However there are a number of morphemes which are exceptions to this stress shift, and it also does not apply in the final word of a phonological/intonational phrase. So one reason for not analyzing the stress shift off a light penult as vowel reduction is that this would complicate the statement of vowel reduction, which otherwise is exceptionless and automatic, as in (30). (In my theory, by contrast, reduction structure formation creates the conditions for the stress-shift to apply, but does not directly cause it.)

### 2.1.2.Word-Initial Reduced Syllables

Another potential problem with the account of Hebrew vowel reduction given above is that word-initial light syllables can be prosodically weakened. But my sub-foot formation rule, (30), leaves the word-initial light syllables which are to be reduced unaffiliated to any sub-foot (rather than dominated by a weak terminal node of a sub-foot); thus it does not say why these syllables should be affected by vowel reduction.

To explain reduction of word-initial syllables, I assume that stray sub-feet (not dominated by the foot) and stray word-initial light syllables (not dominated by a sub-foot) are adjoined as weak terminals to an _n_-ary word tree:

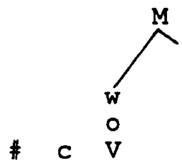
40)




(Here "M" is the node which dominates the word tree.)

Thus a word-initial light syllable unaffiliated to a sub-foot is in the correct configuration to be interpreted as reduced by convention (31); given the metrical irrelevance of onsets, the vowel of the syllable will be dominated directly by a weak terminal node of prosodic structure (in this case of the word-tree, rather than of a sub-foot):

41)




So there are derivations such as the following one:

| 42) | | |
|---|---|---|
| | dabaa[ríim | 'words' |
| | dabaa[(ríim) | (30b) |
| | da(baa)[(ríim) | (30a) |
| | dǎ(baa)[(ríim) | (40;31) |
| | dØ̌(baa)[(ríim) | (32) |
| Surface: | də(baa)[(ríim) | (33) |

In this analysis, there is a structural difference between reduced vowels which are weak moras of a sub-foot, and reduced vowels in word-initial light syllables, unaffiliated to a sub-foot. This result seems to be the correct one, since there are several independent processes which treat word-initial reduced syllables differently from word-internal reduced syllables.

2.1.2.1.Distinctive Quality of Reduced Vowels

In Hebrew surface representations the quality of a reduced vowel in a non-initial syllable can almost always be predicted from the surface segments which immediately precede it (as a result of melody removal, (32) above). However (32) frequently does not apply to reduced vowels in word-initial syllables, so that these vowels can have surface "independent color" or distinctive quality (Rappaport 1984:211):

| 43) | | |
|---|---|---|
| | 'e[mét | 'truth' |
| | 'e[(mét) | (30a) |
| | 'ĕ[(mét) | (40;31) |
| Surface: | ----- | (32) |

2.1.2.2.Secondary-Stress Assignment

Secondary-stress assignment in Hebrew is a very late-applying rule; Dresher (1981) has shown that Hebrew secondary stress is entirely determined by the surface syllable structure of forms to which post-lexical processes, subsequent to vowel reduction, have applied (Rappaport 1984:143). (Also, there are many processes in Hebrew which are sensitive to the distinction between main stress and lack of main stress, but there is no Tiberian Biblical Hebrew segmental phonological process which is sensitive to the distinction between secondary stress and lack of stress; this seems to confirm that secondary stress is not present in the phonology until very late.)

The secondary-stress assignment algorithm ignores word-internal reduced syllables (i.e. syllables in the weak position of a sub-foot). Generally speaking, sub-feet whose head is a trimoraic syllable are stressed, and also alternate sub-feet to the left of the main-stressed syllable, or to the left of a trimoraic-syllable sub-foot (thus only trimoraic syllables are counted as "heavy" for purposes of quantity sensitivity, while bimoraic syllables, of the unmarked syllable weight, are treated as relatively "light"). In the following examples, Dresher's results have been reformulated in terms of the grid theory of Prince (1983):

```
44)  'they wrote'

     (kàat)[(búu)
        x     x
        x     x
              x

45)  'the person'

     (hàa)('aa)[(dáam)
        x    x     x      sub-foot level
        x          x      foot level
                   x      word level

46)  'I will soil
       them (masc.)'

     'ă(ṭannə)[(péem)
        x         x
                  x
                  x

47)  'and they
       (masc.) spoke'

     (wàyyə)(dabbə)[(rúu)
        x      x       x
        x              x
                       x

48)  'the border'

     (hàm)(mis)[(géret)
        x    x      x
        x           x
                    x

49)  'to the woman
       (Gen. 3:4)'

     ('el)#(hàa)('iš̌)[(šáa)
        x     x     x      x
              x            x
                           x

50)  'to the woman
       (Gen. 3:16)'

     ('èl)#(haa)('iš̌)[(šáa)
        x     x     x      x
        x                  x
                           x

51)  'and you (masc.
       sg.) visited him'

     (wàt)(tipqə)[(dén)(nuu)
        x     x      x     x
        x            x
                     x
```

(Note that (45) and (47) have the same stress pattern despite the difference in number of syllables, while (44) has greater secondary stress than (46), despite having half as many syllables.)

While word-internal reduced syllables are not even counted for the purposes of secondary stress assignment, word-initial reduced syllables can sporadically actually receive secondary stress (!), as shown in (52) below, resulting in stressed reduced vowels (<u>šəwaa gaʻyaa</u>) which are otherwise impossible in Hebrew. (This mainly happens when a word is the most prominent in an intonational phrase, or "disjunctively accented"; see Blake 1912:79-80.)

```
52)    'and Patrusim (acc.)'
              (Gen. 10:14)

     wə̀('et)#(pàt)(ruu)[(síim)
     x  x      x     x     x      sub-foot level
     x         x           x      foot level
                           x      word level
```

This tends to confirm that word-initial reduced syllables are in a different structural position (and that secondary-stress assignment is a late process).

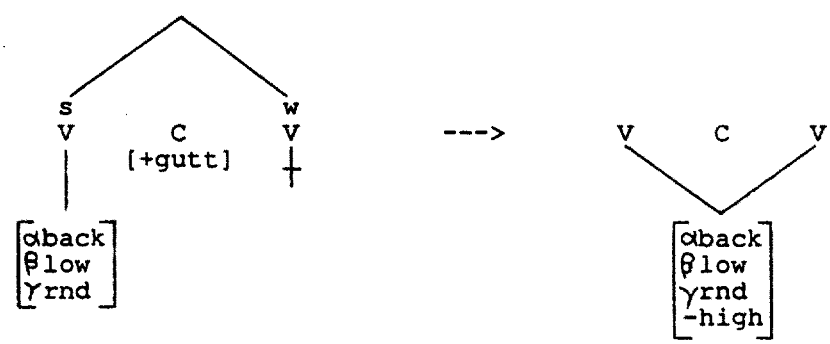
### 2.1.2.3."Cross-Guttural Harmony"

The reason why word-initial reduced syllables are isolated in my analysis is that sub-feet (reduction structures) are left-strong, so that a reduced syllable is grouped together with a preceding syllable. Thus any independent evidence for left-strong reduction structures will support the analysis under which word-initial reduced syllables are not part of any reduction structure.

One piece of evidence for grouping a reduced syllable together with the preceding syllable (and thus for left-strong reduction structures) is the syllable constraint (discussed in section 1.1.2 above) that a non-main stressed unreduced light syllable (CV) must always be followed by a reduced light syllable (CV̆). (In terms of the theory being developed here, this constraint follows from the fact that among the originally-created sub-feet, unreduced light syllables occur only in (22) and (25), and (22) is only built over a main-stressed syllable.)

Another piece of evidence for left-strong reduction structures comes from the change of "cross-guttural harmony", in which a featureless reduced vowel preceded by a guttural onset consonant takes on the features of the vowel in the preceding light syllable (thus the change <u>'ohØ̆léy</u> --> <u>'ohŏléy</u> in derivation 35). In the present theory, cross-guttural harmony will always apply within a sub-foot (recapturing the original insight of McCarthy 1979:107 that it always applies within the metrical domain of a reduction structure):

53)




(Here "[+gutt]" is an ad hoc feature used to express the natural class of pharyngeals and laryngeals.)

By contrast, in Rappaport (1984), where reduction structures are right-strong, cross-guttural harmony will always apply <u>across</u> a constituent boundary (1984:197), which is somewhat less elegant. Thus the left-strong reduction-structure analysis, according to which word-initial reduced syllables do not belong to any reduction structure, seems to be correct.

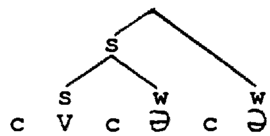
### 2.1.3.Trisyllabic Sub-Feet

Another potential problem with the analysis of vowel reduction as sub-foot formation outlined above is that nothing in the constraints on the sub-foot in section 1.3 excludes the tri-syllabic sub-foot of type (54) below as a well-formed sub-foot. But the process of vowel reduction does not create sequences of two reduced vowels (as can be seen from the account of vowel reduction given at the beginning of section 2).

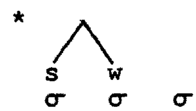
The answer to this problem is to postulate a derivational constraint on the process of sub-foot formation (in addition to the static well-formedness constraints of section 1.3). Sub-feet must be built up one inter-syllabic branching at a time ("bottom up"), and syllables must be assigned to sub-feet in a strictly sequential right-to-left manner (i.e. it is forbidden to "skip over" a syllable at any stage in the course of the derivation).

Therefore (54) cannot be constructed by the rule which initially parses a word into sub-feet, since the impermissible structure (55) would be an intermediate stage of the derivation (where all the syllables in the word to the right have already been parsed into sub-feet):

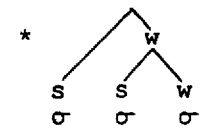
54)




55)




56)




The only trisyllabic binary-branching metrical structure which does not conflict with the derivational constraint, (56), is ill-formed by Rhyme-Structure Parallelism, so that the process of vowel reduction cannot create trisyllabic sub-feet. (However, later processes, which modify rather than create sub-foot structure, and so are not subject to the initial derivational constraint, do create sub-feet of type (54), as discussed in Churchyard 1988.)

* * *

## 3.Conclusion

In the theory presented here, reduction structures (sub-feet) are always in a simple hierarchical constituent relationship with syllables below and feet above, and they are not temporary, but persist to become part of surface metrical representations (i.e.,they are integrated into overall metrical structure in a "metrically coherent" way). Sub-feet are prosodic structures which assign relative prominence to moras, and can be interpreted as projections of syllable rhyme-internal prominence relations (thus explaining how they can be inter-syllabic prosodic structures that are not stress-assigning).

Note that the process of vowel reduction might be given something of a functional/"teleological" explanation, in that it takes representations (the input to vowel reduction) in which light (monomoraic) and heavy (bimoraic) syllables are approximately equally likely to occur, and transforms them into representations (the output of vowel reduction) where bimoraic sub-feet are heavily favored (though trimoraic sub-feet also occur). Thus a random alternation of syllable types, which differ in weight (number of moras) by a ratio of 2:1, is replaced by a more even succession of constituents largely of the same weight (the bimoraic sub-feet), with the occasional intrusion of heavier constituents (the trimoraic sub-feet, which differ in weight by the less extreme ratio of 3:2). So there is a more even distribution of moras among phonological constituents after vowel reduction applies (ignoring monomoraic sub-feet, which are only created at a foot boundary and are often deleted); see Cantineau 1932:125. (The later rule of schwa syncope changes CV.C sequences to CVC syllables, effectively making heavy syllables the unmarked syllable weight, just as bimoraic sub-feet are the unmarked sub-foot type.)

### 3.1.Analogues to the Sub-Foot in other Languages

Analyses of other languages have postulated the existence of mora-relating, sub-foot, non-stress assigning structures; thus the Hebrew sub-foot may be a particular case of a type of structure that has several possible parameters, which are partly determined by the nature of syllabification in a language.

Hayes (1987) has described Palestinian Arabic and Latin as having a sub-foot level of maximally bimoraic mora-relating metrical constituents; these structures consist of either a single heavy syllable, or two light syllables, and in each case the first mora is relatively stronger. Similarly, Stowell (1979) and Selkirk (1978) have described Passamaquoddy and French, respectively, as having a level of metrical constituency composed of non-stress-assigning structures which are either monosyllabic or bisyllabic, and if bisyllabic must have a syllable with a reduced vowel as the weak syllable.

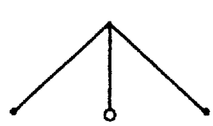
These structures are subject to differing combinations of the Hebrew sub-foot constraints listed in section 1.3.1 above. All of the structures obey the rhyme-structure inalterability constraint, while the French, Latin, and Palestinian Arabic structures also obey the rhyme-structure parallelism constraint. French and Passamaquoddy differ from Hebrew in that strong moras can have the vowel quality which is specially associated with reduced vowels, so that (20) does not apply (while Palestinian Arabic and Latin simply do not have vowel reduction as such). None of these languages appears to have trimoraicity.

Hayes (1987) has included the Palestinian Arabic/Latin maximally bimoraic left-strong constituent (the "moraic trochee") within a supposedly exhaustive typology of metrical constituents. Since the other members of this typology are syllable-relating constituents, rather than mora-relating constituents, Hebrew vowel reduction would have to be done with the moraic trochee. However there would be several problems with analyzing vowel reduction as bimoraic trochee formation. Such an analysis would predict that a word-internal "stressless foot" (an unstressed syllable which forms a maximally monomoraic weak constituent, constructed when it is not possible to construct a moraic trochee) would be created wherever rule (30d) above applies. However, headless monomoraic constituents, such as my word-initial reduced syllables in 2.1.2 above, should probably be confined to word-peripheral positions. Also, trimoraic syllables behave differently from bimoraic syllables (as can be seen from the secondary stress assignment facts in section 2.1.2.2 above); this would be impossible to represent in a strict bimoraic trochee account. Similarly, there are rules of Biblical Hebrew phonology that will have to refer to ternary sub-feet of various types (see Churchyard 1988).

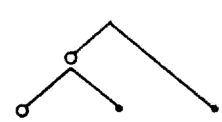
So while the Hebrew sub-foot and the bimoraic trochee are differing instances of the same general type of mora-relating sub-foot prosodic structure, Hebrew vowel reduction shows that the bimoraic trochee is only one special case of this category of constituents. Depending on syllabification and language-particular constraints it can have other, somewhat different manifestations, such as the Hebrew sub-foot.

A final potential problem with the sub-foot is that Levin (1988) and Halle and Vergnaud (1987:10,27) require ternary metrical constituents to be center-headed and "flat" (non-hierarchically branching), as in (57), whereas trimoraic sub-feet are peripherally-headed and hierarchically branching, as in (58):

57)



58)



However, if (57) is understood as applying only to stress-assigning metrical structures, then the sub-foot, as a non-stress-assigning prosodic constituent, is not a counter-example. Trimoraic syllable rhymes are arguably represented appropriately by hierarchically-branching constituency structure, and sub-feet are projections of the prosodic aspects of syllable rhyme structure onto the between-syllables domain.

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