Issues in the Phonology and Morphology of the Modern Hebrew Verbal System: Alignment Constraints in Verb Formation

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1. Introduction

The purpose of this paper is to examine the role of alignment in the verbal system of Modern Hebrew (MH). Certain phenomena within the verbal system of MH involve interaction between morphological and phonological processes. I will show that two seemingly unrelated phenomena, namely the shape of the outputs of verb formation processes on the one hand, and stress alternations on the other hand, are both subject to a number of alignment constraints (as discussed in McCarthy & Prince, 1993b) which impose a certain relation between phonological elements and morphological elements.

I propose an OT account of verb formation in MH, following the Optimality Theory outlined in Prince & Smolensky (1993) and McCarthy & Prince (1993a,b). I show that verb formation is subject to a series of syllabic well-formedness constraints, and alignment constraints: Align(foot,R,root,R) - which requires the Root to be right aligned with a foot, and Align(root,L,foot,L) - which requires the Root to be left aligned with a foot. These constraints will be shown to play a major role in explaining reduplication facts. I also show that interaction between alignment constraints govern stress alternations in the inflectional system.

The structure of the paper is as follows: In section 2, I mention briefly the problems which arise with the root-to-template association theory (McCarthy 1979, 1981), and argue in favor of a syllabification theory (Bat-El, 1989) for languages such as MH. In section 3, I lay out my proposal for simple (non-suffixed) forms, in the OT framework of Prince & Smolensky, 1993, and McCarthy & Prince, 1993a,b). In section 4, I discuss the role of OT in denominal verb formation. Section 5 deals with stress alternations due to suffixation, which are also accounted for as a result of the interaction between alignment constraints.

2. Root-to-template Association vs. Syllabification

In a theory of root-to-template association (McCarthy, 1981), the morphology of the Hebrew verbal system, like that of other Semitic verbal systems, is analyzed as partly nonconcatenative: the base of each verb consists of two morphemes: one identified by the consonantal tier, and the other identified by the vocalic tier. The consonantal tier (the root) is said to convey the core meaning, and the vocalic tier (the verbal pattern) marks things such as aspect, reflexivity, (un)accusativity, reciprocality, etc. Some verbal patterns come with a prefix. Five of the seven vocalic patterns ("binyanim") are illustrated in (1) (excluding the two passive binyanim):

(1)

Past		Future		
CaCaC	- katab	yi-CCoC/CCaC	- yiktob	'write'
Ci(C)CeC	- kibel	ye-Ca(C)CeC	- yekabel	'receive'
hi-(C)CCiC	- hiktib	ya-(C)CCiC	- yaktib	'dictate'
ni-CCaC	- niSbar	yi-CaCeC	- yiSaber	'break'
hit-Ca(C)CeC	- hitkateb	yit-Ca(C)CeC	- yitkateb	'correspond'

(The forms in (1) are cited in the 3rd person singular masculine form, which is an unsuffixed form. Gender, person and number specifications are done via suffixation to the forms in (1) (with variation in the consonantal prefix, in the Imperfective case). These cases are discussed in section 5.)

In McCarthy's (1981) theory of root-to-template association, the binyan specification contains templatic information, and the paradigm in (1) is accounted for in the following way: each root is mapped onto a specific template to form a stem. The binyan-specific vowels and prefixes are then added. Two problems arise with this kind of analysis (discussed in Bat-El 1986, 1989, 1994a; Dor ,1993): (1) in MH, the templates seem to be a by-product of syllabification, rather than being part of the specification of each binyan; and (2) such an analysis fails to account for denominal verbs. Let us consider the template issue first.

The template theory accounts for the verbal system in languages such as Classical Arabic and Tiberian Hebrew, where there is a distinction between long and short vowels, and where gemination is allowed. So, for example, the fact that in Tiberian Hebrew, the second consonant of any tri-consonantal root is geminated when this root is mapped to a CVCCVC template (e.g., <g,d,l> --> giddel), is explained as a satisfaction of the templatic requirement which is part of the binyan specification. However, in MH, where geminates[1] and long vowels do not exist, there is no phonological motivation for specifying a template in the word formation process. Rather, the interdigitation of the vowels is a by-product of syllabification, and therefore the template

[1]Spirantization effects are not discussed here. See Adam (1993) for an analysis of stop/fricati
ernations in MH, based on a re-examination of the feature composition of the segmental inventory
rather than on gemination (but see Sheffer (1994) for a gemination-based approach).

specification is redundant (for a detailed discussion of this issue, and also of the lack of morphological motivation for the templates, see Bat-El, 1989). Assuming that this is correct, and that the template is not be part of the binyan specification, the question which arises is how proper syllabification can be derived from universal (rather than language specific) principles of syllabification. In particular, we want a theory which will explain why certain syllabically well-formed forms are excluded:

a. Why can't the vocalic pattern "escape" the root boundaries? Why is the syllabically well-formed kible (from <k,b,l> and <i,e> ungrammatical?

b. If a vowel can, in principle, occupy more than one position, (e.g. katab from <k,t,b and <a>), why doesn't the first consonant always begin a foot? Why is hi[kitib] ungrammatical?

c. When the first consonant does not begin a foot, why is it always a coda of some syllable, and not an onset of an unfooted syllable? Why is ki[resem] ungrammatical?

As for the denominal verbs issue, it is argued in Bat-El's (1989) discussion of Hebrew verb formation, and in McCarthy & Prince's (1990) discussion of the Arabic broken plural, that the theory of root-to-template association in these root-based languages cannot account for all morphological processes. In some cases of MH denominalization, clusters in the input form (the noun) are preserved in the output form (the verb). This effect is illustrated in (2a). In other cases, consonants in the input form are reduplicated in the output. This effect is illustrated in (2b,c):

(2) Nouns Verbs Nouns Verbs

a. di-syllabic (complex onset)
praklit --> priklet ('lawyer' --> act as a lawyer') smartut --> smirtet ('rag' --> 'make ragged')

b. mono-syllabic (bi-consonantal)
kod --> kided ('code' ---> 'encode)
kav --> kivkev ('line' ---> 'draw a line')

c. mono-syllabic (multi-consonantal: complex onsets and/or codas)
blof --> bilef ('bluff' ---> 'bluff')
xrop --> xarap ('sleep' ---> 'sleep')
flirt --> flirtet ('flirt' ---> 'flirt')

faks --> fikses ('fax' ---> 'fax')
(Data mostly from Bat-El (1989), (1994a))

These phenomena are problematic for the root-to-template theory as well as for the syllabification theory for the following reasons. If we assume that Hebrew imposes a consonantal root on each verb, then by extracting the consonantal tier from, for example, praklit and mapping it onto a CVCCVC template, both the well-formed priklet and the ill-formed *pirklet are possible output (assuming, of course, that a complex onst or coda fills one C position). Postulating a new template, such as CCVCCVC, overlooks the fact that the preservation of the /pr/ cluster is dictated by the input, and not by the template. On the other hand, from the point of view of the syllabification theory, *pirklet is predicted to be the grammatical form since the vowel, in the usual case, is preceded by the first consonant. Since /pr/ of praklit is preserved as a cluster in the disyllabic output forms, we might be led to conclude that clusters are extracted as one segment (and syllabified accordingly). However, as Bat-El (1994a) observes[2], this is not the case, judging from bilef and xarap, where the clusters /bl/ and /xr/ in the mono-syllabic input forms are not preserved. The reason they are not preserved in bilef and xarap is that the input forms have "just enough" consonantal material to satisfy the "template" of the target binyan (which is: two syllables, the second one a closed syllable). On the other hand, forms such as kided "supply" the consonantal material (missing from the input form) needed to satisfy the "template" of the target binyan by reduplicating the rightmost member of the root. The syllabification facts, as well as the cluster preservation facts, will be shown to follow from a series of ranked constraints.

I address the syllabification issue first. In section 3, I outline my proposal for an OT account of the verbal system. I begin with root-based (non-denominal) verbs, showing that their shape is determined by constraints on syllable and foot structure, and by alignment constraints which require that some morphological element (the root) align with a phonological element (the foot). This analysis predicts the exclusion of some syllabically well-formed forms, as well as all syllabically ill-formed forms. However, I do not discuss irregular roots, i.e. roots containing elements which are forced to be unparsed in the output form (e.g. <b,n,y>, whose output form is bana). (This kind

[2]This fact, among others, led Bat-El (1985, 1986) to conclude that all words are derived from ds, and in Bat-El (1994a) - to abandon the concept of the root entirely. It is argued there that phological or phonological process ever refers to the root, and therefore it has no morphemic tus in MH (see also Horvath, 1981). Here I adopt the traditional view according to which the roo s have morphemic status. For arguments in favor of the morphemic status of the root, see Berman 90). For a different root-based approach to the MH verbal system, see Dor (1993).

of phenomena should be dealt with in terms of segmental constraints, and is a topic for further research). The cluster preservation issue is addressed in section 4.

3. Syllabification - An OT Account

I assume Optimality Theory as outlined in Prince & Smolensky (1993) and McCarthy & Prince (1993a,b), where the input of each process is associated, via the function Gen, with a set of output candidates which are evaluated against a set of ranked constraints. The candidate which best satisfies the constraint system is the optimal form (see Prince & Smolensky (1993), Ch.5, and McCarthy & Prince (1993a), Ch. 2, for discussion of the evaluation algorithm). Gen is restricted by Containment: it cannot remove elements from the input form. As a result, all the information present in the input form is present in the output form as well.

I also assume the theory of Generalized Alignment, as outlined in McCarthy and Prince (1993b), according to which certain morpho-phonological processes are accounted for by a series of constraints which require alignment of an edge of a certain phonological or morphological element with that of another phonological or morphological element. The general schema of the theory is presented in (3):

(3) Align (Cat1,Edge1,Cat2,Edge2) =
$\forall$Cat1 $\exists$Cat2 such that Edge1 of Cat1 and Edge2 of Cat2 coincide.

Edge1 and Edge2 range over Right and Left. Cat1 and Cat2 range over all morphological and phonological categories.

In the formation of root-based (non-denominal) verbs, I adopt the view that the input consists of an ordered set of consonants (the consonantal root = Root) and, following Bat-El, an ordered set of vowels (the vocalic pattern = Bin). The output of Gen provides all the possible linear combinations of Root and Bin. I assume that the morphological structure of the output form is:

```
(4)                  Verb
               /       |      \
         (PREFIX)     Root   Bin  (= vocalic pattern)
                        \\ \
                            /
          hi-              /CCiC
```

(e.g. hi-gdil - 'he enlarged')

Since not all the verbal patterns have prefixes, PREFIX may be empty. The representation of suffixed (inflected) forms, however, requires an additional level:

```
(5)             Verb'
               /        \
             Verb        SUFFIX
        /      |    \
     PREFIX  Root   Bin
```

The hierarchical relation represented in (5), where SUFFIX is hierarchically higher than PREFIX, follows from the fact that the presence of the prefix is always required by the binyan (and therefore is part of the basic form), whereas the suffix is required only by person-gender-number, as illustrated in (6):

(6)

Past	Future	
higdál-ti	egdál	- 1st sing.
higdál-ta	tigdál	- 2nd sing. masc.
higdál-t	tigdel-í	- 2nd sing. fem.
higdíl	yigdál	- 3rd sing. masc.
higdíl-a	tigdál	- 3rd sing. fem.
higdál-nu	nigdál	- 1st pl.
higdál-tem	tigdel-ú	- 2nd pl.
higdíl-u	yigdel-ú	- 3rd pl.

Since the suffix is not required by the binyan, I will assume that the Verb' level is not present if no suffix is present (see Section 5 for analysis of Verb' forms).

The uninflected forms (whose structure is (4)) are constrained by two alignment constraints which require that the right edge of Root coincide with the right edge of a foot, and that the left edge of Root coincide with the left edge of a foot. The first constraint is given in (7):

(7) ALIGN-FT-rt-R: Align(foot,R,root,R)
For every foot, there is a root such that the right edge of the foot coincides with the right edge of the root.

Lower case "root" stands for Root or Identified Root (= "denominal" root, see section 4). Since (in the usual case) there is one root per word, this constraint, when satisfied, has the effect that each word contains one foot, and one foot only, and that the foot ends on the rightmost member of the root. Furthermore, satisfaction of (7) has the effect that Verb ends on the last member of Root:

(8)
```
                   Verb
         /           |       \
      PREFIX      Root     Bin
                  \ \ \   /  |
                         /   |
                      g a d a l
                              /
                        FOOT
```

Constraint (7) is satisfied in forms such as gadal, gidel, egdal, etc. (see (1)). It is violated in suffixed forms such as tigdeli (see (6)). A form such as *gidle, which is syllabically well-formed, is rejected due to a violation of (7). The second constraint is given in (9):

(9) ALIGN-rt-FT-L: Align(root,L,foot,L)

For every root, there is a foot, such that the left edge of the root coincides with the left edge of the foot.

This constraint, when satisfied, has the effect that the root (since there is only one) is the onset of the first syllable of the foot. In the usual case, this results in that the left edge of the Verb coincides with the left edge of a foot:

(10)

```
                 Verb

        /          |       \
     PREFIX       Root      Bin
                   \ \ \ /   |
                         /   |
                     g a d a l
                     \
                       FOOT
```

Constraint (9) is satisfied in gadal, hitgadel, and yegadel (see (1)). It is violated in egdal and tigdal (see (1) and (6)).

(In the usual case, there is one root per word, so the fact that (9) is formulated in such a way that the root is universally quantified and the foot is existentially quantified has no special consequence. However, in the reduplication cases to be discussed in 4.2, this particular choice of quantifiers is crucial, and makes the right predictions.)

Other constraints are constraints on syllable and foot structure, taken from Prince & Smolensky (1993):

(11)	ONS:	A syllable has an onset.
	NO-CODA:	A syllable does not end on a coda.
	*COMPLEX:	No complex onsets or codas.
	PARSE-Seg:	Every segment must be parsed.
	PARSE-SYLL	A syllable is parsed by a foot.
	FOOT-BIN	A foot is bisyllabic or bimoraic. (undominated)

I propose that "PARSE-Seg" stands for two constraints: PARSE-MSEG ("every morphologically licensed segment must be parsed"), and PARSE-SEG ("every segment must be parsed"). In this section, the relevant constraint is the more specific PARSE-MSEG. The issue of morphological licensing is addressed in section 4. All the segments discussed in this section are morphologically licensed.

The following generalizations hold for simple (uninflected) verb forms:

(12) a. If the input contains no prefix, then the Root is left and right aligned with a foot in the output, regardless of the number of vowels in Bin.

b. If the input contains a prefix, and Bin consists of one vowel, then in the output, the prefix is left-aligned with the foot and the Root is right aligned with the foot.

c. If the input contains a prefix, and Bin consists of two vowels, then Root is left and right aligned with the foot in the output.

The constraint ranking which predicts the observations in (12) is the following:[3]

```
(13)              PARSE-MSEG    ALIGN-FT-rt-R      ONS
                      |        /
                  PARSE-SYLL
                      |        \_
                ALIGN-rt-FT-L  \_   *COMPLEX
                                  \      |
                                     NO-CODA
```

The idea behind the ranking in (13) is this: in an optimal form, unparsing of a syllable is forced if otherwise either not every foot is right aligned with the root, or not every (morphologically licensed) segment is parsed. Also, the presence of an extra coda is forced if otherwise not all syllables are parsed (and/or some additional constraint is violated).

Let us see how this ranking predicts the observations in (12). If there is no prefix in the input, the winning candidate obeys all the above constraints (apart for NO-CODA, which is violated by the entire candidate set). For example, an input consisting of the root <t,d,l,k> and the vocalic pattern <i,e>, will generate, via Gen, the following candidates: [tid.lek], [tid][lek], ti[de.lek], [ti.de]lek, [ti.de][lek], [ti.dlek], [tidl.ke], i[ted.lek], and [tidl.ek] (other possible candidates have the same violations, or more violations of the same constraint). This set shows that, in principle, every vowel may appear more than once, but the appearance of a vowel in more than one position may

[3]I assume that ONS is ranked relatively high, but since here it never plays a deciding role, I l mostly ignore it, and will not provide any evidence for its relative ranking.

result in one or more constraint violation.

Apart from [tid.lek], all the candidates violate one or more constraints in addition to NO-CODA: ti[de.lek] violates PARSE-SYLL (.ti. is not parsed by a foot) and ALGIN-rt-FT-L (/t/, the left edge of Root, does not coincide with the left edge of the foot). [ti.de]lek violates PARSE-SYLL (.lek. is not parsed by a foot) and ALIGN-FT-rt-R (/k/ - the right edge of Root, is not right aligned with the foot). [tidl.ke] violates ALIGN-FT-rt-R and *COMPLEX. i[ted.lek] violates PARSE-SYLL and ONS, and [tidl.ek] violates ONS and *COMPLEX. [tid][lek] fatally violates ALIGN-FT-rt-R (as does [ti.de][lek]), because it has two feet, and the constraint requires that every foot be right aligned with Root. Note that [tid.lek] crucially competes with [ti.dlek]: the former has two violations of NO-CODA and the latter just one, but the latter has also one violation of *COMPLEX which the former respects. [tid.lek] also crucially competes with [ti.de][lek], because the former has two violations of NO-CODA and the latter one, but the latter also violates ALIGN-FT-rt-R.

The fact that [tid.lek] wins follows from the ranking in (11), namely, *COMPLEX >> NO-CODA. The constraint interaction is summarized in (14):

(14) Input: / <t,d,l,k>, <i,e>/ ('fuel')

([] indicate Foot boundaries, dots indicate syllable boundaries)

Candidates	ONS	ALG-FT-rt-R	PARSE-SYLL	ALG-rt-FT-L	*COMPL	NO-CODA
a.☞ [tid.lek]						**
b. [tid][lek]		*!				**
c. [ti.dlek]					*!	*
d. ti[de.lek]			*!	*		*
e. [ti.de]lek		*!	*			*
f. [ti.de][lek]		*!				*
g. [tidl.ke]		*!			*	*
h. i[ted.lek]	*!		*			**
i. [tidl.ek]	*!				*	**

If the vocalic pattern in the input is <a>, the result is the same (the optimal form satisfies all the constraints except for

NO-CODA). The only difference is that /a/ of <a> occupies two positions instead of one. If it occupies one position, as in gadl, the result is a *COMPLEX violation (in addition to the NO-CODA violation). The winning candidate is [ga.dal]: all the syllables have onsets, all the syllables are parsed, the right and left edges of the root are aligned with the right and left edges of the foot, and there are no complex onsets or codas. Once again, the lowest ranking NO-CODA is violated in the optimal form (as it is in all the other forms). The competition is summarized in (15):

(15) Input: /<g,d,l> , <a>/

Candidates	ONS	ALIGN-FT-rt-R	PARSE-SYLL	ALIGN-rt-FT-L	*COMPLEX
a. ☞ [ga.dal]					
b. ga[dal]			*!	*	
c. [gadl]					*!
d. [gdal]					*!
e. [gad.al]	*!				
f. [gad.la]		*!			

In what follows, I will ignore candidates which violate ONS, since this constraint does not participate in any crucial ranking, and I will consider only crucial violations of *COMPLEX and NO-CODA.

The shape of prefixed forms is determined by the number of vowels in Bin: if Bin consists of one vowel, the first member of the root becomes the coda of the first syllable. For example, yigdal (see (1)).
The input consists of a vocalic set <a>, and /a/ may fill one or more positions, yielding the following candidate set: [yig.dal], [yig][dal, yi[ga.dal], [yi.ga][dal], and [yi.ga]dal. The reason yigdal is the optimal form is that it satisfies ALIGN-FT-rt-R and PARSE-SYLL. [yig][dal] fatally violates ALIGN-FT-rt-R because it has two feet, and therefore not every foot is right aligned with the root. yi[ga.dal] loses, because although it satisfies ALIGN-rt-FT-L, it violates PARSE-SYLL. This establishes the ranking relation between PARSE-SYLL and ALIGN-rt-FT-L, namely: PARSE-SYLL >> ALIGN-rt-FT-L.

The form [yi.ga][dal] fatally violates ALIGN-FT-rt-R (since there are two feet in the word), and so does [yi.ga]dal.:

(16) Input: /yi-, <g,d,l> , <a>/

Candidates	ALIGN-FT-Rt-R	PARSE-SYLL	ALIGN-Rt-FT-L
a. ☞ [yi|g.dal]			*
b. [yig][dal]	*!		*
c. yi|[ga.dal]		*!	
d. [yi|.ga][dal]	*!		*
e. [yi|.ga]dal	*!	*	*

("|" indicates a morphological boundary.)

The morphlogical structures of (16a-d) are shown in (17):

```
(17) 17a.      Verb     16b/c/d.          Verb
           /    |   \                   /    |    \
         PREFIX  Root Bin             PREF   Root   Bin

         yi        gdal               yi       gadal
```

Let us now look at the tri-syllabic <u>yegadel</u> (see (1)), where the last two syllables form an iambic foot. The input form consists of the same root, the vocalic pattern <a,e>, and the prefix <u>ye-</u>. When the entire vocalic set <a,e> is parsed, the result is a tri-syllabic structure. This may be footed, without violating FOOT-BIN, in three possible ways: ye[ga.del], [ye.ga][del], and [yega]del. If not all members of the vocalic set are parsed, the resultant form violates PARSE-MSEG. The winning candidate is ye[ga.del], which violates PARSE-SYLL, but satisfies ALIGN-FT-rt-R and ALIGN-rt-FT-L. It crucially competes with the form [ye.ga][del], which satisfies PARSE-SYLL but violates ALIGN-FT-rt-R (it contains two feet). Since we know that PARSE-SYLL dominates ALIGN-Rt-FT-L (see (16)), the fact that ye[ga.del] wins establishes the ranking between ALIGN-FT-rt-R and PARSE-SYLL, namely:
ALIGN-FT-rt-R >> PARSE-SYLL. The fact that [yeg<<a>>.del] loses, establishes the ranking PARSE-MSEG >> PARSE-SYLL, since although all its syllables are parsed, it loses to ye[ga.del] (which has an unparsed syllable):

(18) Input: /ye-, <g,d,l> , <a,e>/

(<<>> indicates an unparsed segment)

Candidates	PARSE -MSEG	ALIGN-FT-rt-R	PARSE-SYLL	ALIGN-rt-FT-L
a. ☞ ye|[ga.del]			*	
b. [ye|.ga][del]		*!		*
c. [ye|.ga]del		*!	*	*
d. [ye|g.<<a>>del]	*!			*

The morphological structure of the candidates in (18) is:

```
(19)              Verb
                /   |    \
            PREFIX  Root  Bin

              ye      gadel
```

The difference between (16) and (18), is that in (16) the vocalic pattern is <a>, and therefore the output can be bi-syllabic, whereas in (18) the vocalic pattern is <a,e>, and therefore the output can be bisyllabic only at the expense of violating PARSE-MSEG.

When the prefix is bi-moraic, the winning candidate is again the one which respects all the constraints but PARSE-SYLL. For exmaple, hit[ga.del] wins over hi[tag.del], which apart from violating PARSE-SYLL, also violates ALIGN-FT-rt-R:

```
(20)  21a:           Verb           21b:          Verb
                   /    |    \                  /       |       \
              PREFIX  Root  Bin          PREFIX   Root    Bin

              hit      gadel                 hit     agdel
```

Other candidates fatally violate ALIGN-FT-rt-R or PARSE-MSEG:

(21) Input: /hit-, <g,d,l> , <a,e>

Candidates	PARSE -MSEG	ALIGN-FT-rt-R	PARSE-SYLL	ALIGN-rt-FT-L
a. ☞ hit|[ga.del]			*	
b. hi[tag.del]			*	*!
c. [hit<<a>>.gdel]	*!			*

d. [hit.gad<<e>>l]	*!			*
e. [hit]|[ga.del]		*!		
f. [hit.|ga][del]		*!		*
g. [hi.t|ag][del]		*!		*

Under the assumptions made above, hit[gadel], and not [hit][gadel], is the optimal form. The theory of secondary stress (which presumably applies at a further level) will then have to explain how stress is assigned to the unfooted hit-. Secondary stress is not discussed here, however, if it turns out, that -hit- must form a foot, for secondary stress assignment, then it must be the case that PARSE-SYLL is ranked relatively high, which will predict [hit][gadel] to be the grammatical form. However, _hitgadel_ and _yegadel_ have exactly the same stress pattern (in which the head of PrWd is final, and the first syllable is unstressed), and the fact that ye[gadel] is the optimal form is a welcome result, since -ye- is mono-moraic, and cannot form a foot. I leave this question open, and assume that the optimal forms predicted by (19) and (21) are correct.[4]

We have shown how the ranking in (13) predicts the observations made in (12): unprefixed forms obey both alignment constraints, since the vocalic pattern never consists of more than two vowels, therefore a bisyllabic foot which aligns with the root left and right can be formed.

Prefixed forms (regardless of whether the prefix is monomoraic or bi-moraic) depend on the number of vowels which the vocalic pattern consists of. If it consists of one member, the winning candidate is the one where all syllables are parsed, and the root is right aligned with the foot. If the vocalic pattern consists of two members, the winning candidate is the one where a bisyllabic foot is right and left aligned with the root, and the first syllable is unparsed.

The next section deals with the role of ALIGN-FT-rt-R, ALIGN-rt-FT-L, PARSE-SYLL and PARSE-Seg in denominal verb formation. I will present an analysis of reduplication which utilizes the two Root alignment constraints. This discussion will lead to the cluster preservation problem raised in Section 2.

4. Denominal Verbs

[4]It is argued in Bat-El (1989) that syllables in MH are always mono-moraic. Under such an lysis it follows that [hit][gadel] is not a possible form. However, it requires the stipulation t consonants are not moraic in MH. Here I assume that consonants can, in principle, be moraic (e _kam_), and that proper syllabification follows from the constraints.

As demonstrated in section 2, the behavior of denominal verbs poses a problem for the root-to-template association theory and for the syllabification theory, because of the difficulty to predict cluster preservation. It was also demonstrated, that on the one hand clusters are not always preserved, and on the other hand, in some cases consonants are reduplicated in the output in order to satisfy the templatic restrictions of the target binyan. I show that the same constraints which determine the shape of root-based verbs, underly the cluster preservation and reduplication phenomena as well: all verbal forms are required to satisfy ALIGN-FT-rt-R and PARSE-MSEG, and when possible, also the lower ranking PARSE-SYLL and ALIGN-rt-FT-L. An additional constraint (namely, CONTIGUITY, which is satisfied vacuously in non-denominals) is needed. First I present my view of the morphological and phonological processes involving denominalization.

4.1 Morphological licensing

In section 2, I mentioned that PARSE-Seg stands for two constraints: PARSE-MSEG and PARSE-SEG. PARSE-MSEG requires that every morphologically licensed segment be parsed. The definition of a morphologically licensed segment is as follows:

(22) A segment is morphologically licensed iff parsed by a morphologically parsed morpheme.

In the process of denominalization (N ---> V), the entire noun serves as input. The derivation itself involves morphological unparsing of the noun, in favor of parsing the verb. It also involves identification of the consonantal tier of the noun as a root (Identified Root). This explains the fact that when the input consists of a prefixed noun (e.g. me-rkaz 'center'), the consonant of the prefix occupies a root-consonant position in the output (mirkez). So, for example, the representation of the verb mirkez is the following:

(23)
```
                    V
                  /       \
                IR         Bin
                | \ \\ _ _/  |
                      /      |
                 m  i  r  k  e  z

                      <<N>>
```

The IRoot <m,r,k,z> and <i,e> are parsed morphemes, therefore each segment is morphologically licensed. Moreover, the vowels /i/ and /e/ fill already existing vowel positions (/e/ and /a/)

of the source noun (a mapping which involves changing the feature matrix of the vowel), therefore there is no violation of either PARSE-MSEG or PARSE-SEG. However, if one of the Bin vowels creates a new vowel position which does not exist in the input, this may result in a PARSE-SEG violation:

```
(24)          V
         IR        Bin
                    |   \
        m <<e>>  r  i  k  e  z

                <<N>>
```

The form in (24) violates PARSE-SEG and not PARSE-MSEG because all the morphologically licenced segments are parsed. The ranking between PARSE-MSEG, PARSE-SYLL and PARSE-SEG is as follows:

(25) PARSE-MSEG >> PARSE-SYLL >> PARSE-SEG

This explains why verbs derived from nouns consisting of more than two syllables are bi-syllabic.[5] For example <u>telefon</u> --> <u>tilfen</u> ('telephone'). The competing candidates are: [til.fen], ti[le.fen], and [tli.fen]. ti[le.fen] loses, because although all its segments are parsed (/e/ of <i,e> fills two position), it has a PARSE-SYLL violation. [tli.fen] loses due to a violation of *COMPLEX. [til.fen] is the winning candidate since all its morphologically licensed segments are parsed:

(26) Input: /telefon, <i,e>/

Candidates	PARSE-MSEG	PARSE-SYLL	PARSE-SEG	*COMPLEX
a.☞ [til.<<e>>fen]			*	
b. ti[le.fen]		*!		
c. [t<<e>>li.fen]			*	*!

The IRoot is subject to ALIGN-FT-root-R and ALIGN-root-FT-L. In 4.2, I show what role these alignment constraints play in reduplication. In particular, I argue that they for the "ban" on leftward "spreading" (i.e., the fact that the initial root consonant is never reduplicated alone) in reduplicated forms.

4.2 <u>The role of ALIGN-FT-rt-R and ALIGN-rt-FT-L in Reduplication</u>

[5] See Bat-El (1994b) for an alternative analysis, based on the constraint STEM-BINARITY.

Some denominal verbs manifest the following behavior: they reduplicate one or more input consonants. This was demonstrated in (2) (section 2). Additional examples (from Bat-El, 1994a) are given below:

(27)

Noun	Verb	
kod	kided	('code')
cad	cided	('side')
kav	kivkev	('line')
dal	dilel/dildel	('thin')
flirt	flirtet	('flirt')
faks	fikses	('fax')

As noted in Bat-El (1994a), not only bi-consonantal inputs result in reduplication in the output (e.g., faks --> fikses). In other words, it is not the existence of two consonants in the input which triggers reduplication in order to satisfy a bi-syllabic template in the output. Also, there is no way to predict how many consonants will be reduplicated (since kivkev from kav exists alongside kided from kod).[6] Also, the initial root consonant is never reduplicated alone (i.e., forms such as *kiked are ungrammatical).

I leave the problem of fikses for 4.3, and focus on bi-consonantal roots. As for the number of consonants reduplicated, I assume that for an input such as kod, both kided and kidked are grammatical outputs, and that the choice between them is determined by extragrammatical factors. In other words, we need a grammar which predicts both these forms to be grammatical.

As for the copying process, assume that Gen supplies for each root an infinite number of roots, where any subset of the root may be reduplicated an infinite number of times via adjunction (just like a vowel which belongs to a vocalic set may fill more than one position). So, for any root in the language, Gen supplies the following associated roots:

(28) <g,d,l>, <g,d,l,l'>, <g',g,d,l>, <g,d,l,g',d',l'>, etc.

As suggested to me by Alan Prince, the process of reduplication illustrated in (28) can be analyzed as adjunction of the reduplicated consonant to the root. So, for example the root

[6] I treat reduplication as the default process. However, there are cases in which an monosyllabi ut yields an output with an epenthetic consonant (e.g., xov --> xiyev). This may be treated as a ondary default strategy. See Bat-El (1994a,b) and Bolozky, Lederman and Schwarzwald (1993) for sible analyses. Cases in which /W/ surfaces in the output form (e.g., sug --> siveg), the /W/ is bably part of the consonantal root, which is not parsed the input.

<g,d,l,l'>, where adjunction has taken place, is represented as follows:

```
(29)              Root
                 /    \
              Root      Red
             g d l      l'
```

The fact that we never get a form such as *gidlel from an input which consists of <g,d,l> is due to the existence of a candidate (namely, gidel) which violates NO-CODA once, compared to gidlel which violates it twice.[7] However, if the input contains just two consonants, reduplicating one of them is one way to satisfy ALIGN-FT-rt-R.

So, in the case under discussion (exemplified by kod), Gen supplies at least six competing candidates:

[a] one candidate which reduplicates the second member of the consonantal root and adjoins it to the right,

[b] one which reduplicates the first member of the consonantal root and adjoins it to the left,

[c] one which reduplicates the entire set,

[d] one which reduplicates the first and the second members separately,

[e] one which reduplicates the first consonant and adjoins it to the right, and

[f] one which reduplicates the second consonant and adjoins it to the left.

The forms are given in (30), and their respective representations are given in (31):

(30) a. kided'
b. k'iked
c. kidk'ed'
d. k'ikded'
e. kidek'
f. d'iked

```
(31)  a.      Verb                 b.      Verb
             /     \                        /     \
          IRoot    Bin               IRoot        Bin
          /     \                     /   \
       IRoot     Red                Red  IRoot
       /   \      |                  |      |   \
       k  i  d  e  d                 k   i  k  e  d
```

[7]There is another instance of reduplication (templatic reduplication), in which a reduplicative pheme is suffixed to a verb resulting in a new verb (e.g., ?iSer ('confirm') ---> ?iSrer econfirm")). In this case (unlike *gidlel), extra violation of NO-CODA results from the need to se the reduplicative morpheme.

```
     \          /              \           /
        FOOT                       FOOT


c.            Verb              d.        Verb
            /       \                  /          \
     IRoot           Bin            IRoot          Bin
    /      \                        /     \
  IRoot      Red                 Red    IRoot
                                   |     /     \
  |    \    /    |                 |  IRoot    Red
  |     \  /     |                 |      | \     |
  k  i  d  k  e  d                 k  i  k  d e d
  \            /                   \           /
     FOOT                             FOOT


e.            Verb            f.        Verb
            /      \                   /      \
        IRoot       Bin          IRoot       Bin
        /    \                   /    \
     IRoot    Red                 Red     IRoot
      |  \     |                 |       /   \
      k i d  e k                 d  i  k  e  d
      \        /                  \           /
       FOOT                         FOOT
```

All the forms in (31) have one thing in common: they all satisfy ALIGN-FT-rt-R. Gen also supplies a candidate with an epenthetic consonant (namely, kiCed)[8], which satisfies ALIGN-FT-rt-R, and a coda-less candidate (namely, kide), which satisfies NO-CODA, but because of that, it violates ALIGN-FT-rt-R. A candidate such as kik'ded', where the adjoined k' is adjoined to /k/ is not generated because adjunction is only possible to a morpheme, not to a segment. (Recall also that onsetless candidates are not considered).

In order to evaluate this candidate set three more constraints need to be introduced. The first one is CONTIGUITY, taken from Prince & Smolensky (1993), which states the following:

(32) CONTIGUITY: A contiguous string in the input is contiguous in
the output.

---

[8]This candidate should not be confused with with the xov/xiyev case (see Footnote 6), which is result of a different process.

Two additional constraints are adapted from McCarthy & Prince's (1993a) analysis of Axininca Campa reduplication: MAXIMALITY (which requires the reduplication of the entire consonantal set), and ANCHORING (which disallows, for example, adjunction to the right of the leftmost consonant). Both constraints are formulated as follows:

(33) MAXIMALITY: Red = root

(34) ANCHORING:
a. In root+Red, the final element in Red is identical to the final element in "root".
b. In Red+root, the initial element in Red is identical to the initial element in "root".

(35a) is a structure which satisfies (34a), and (35b) is a structure which satisfies (34b):

```
(35)          a.        IRoot          b.   IRoot
                       /      \               /     \
                  IRoot     Red          Red      IRoot
              <C1...<..Cn>>  <..Cn>      <C1..>   <<C1..>...Cn>
```

The ranking which predicts kided and kidked to be grammatical is the following:

```
(36)            ALIGN-FT-rt-R     CONTIGUITY    ANCHORING
                          \            /
                           ALIGN-rt-FT-L
                                |
                            MAX, NO-CODA
```

Furthermore, the ranking between MAX and NO-CODA is not crucial.

Let us assess each candidate. (31a) violates MAXIMALITY and NO-CODA. It satisfies ALIGN-FT-rt-R, because every foot (and there is one) is right aligned with a root. (31b) violates ALIGN-rt-FT-L, because not every root (and there are two) is left aligned with a foot, and therefore it loses. (31c) satisfies both alignment constraints, but has two NO-CODA violations. The reason it does not lose to (31a) is that MAXIMALITY and NO-CODA are not crucially ranked with respect to each other. (31d) loses for the same reason (31b) does: violation of ALIGN-rt-FT-L (due to the existence of more than one root). (31e) and (31f) both fatally violate ANCHORING.

The form kide, although it satisfies NO-CODA, fatally violates ALIGN-FT-rt-R, and kiCed, the candidate with the epenthetic vowel violates CONTIGUITY (since, if the input /o/ corresponds to the /i/ position in the output, it does form a contiguous string with /d/ in the output).

The constraint interaction is summarized in (37):

(37) Input: /kod, <i,e>/

Candidates	ANCHOR	ALIGN-FT-IR-R	ALIGN-IR-FT-L	CONTIG	MAX	N0-CODA
a.☞ kided'					*	*
b. k'iked			*!		*	*
c.☞ kidk'ed'						**
d. k'ikded'			*!			**
e. kidek'	*!				*	*
f. d'iked	*!		*		*	*
g. kide		*!				
h. kiCed				*!		*

The reduplication analysis I presented aims to capture McCarthy's (1981) observation that the first member of the root is never reduplicated, due to a ban on leftward spreading:

```
(38)     a.   C V C  V  C        b.  *  C  V  C  V  C
               |   |    .                .     |     |
               |   |  .                    .   |     |
               |   |.                        . |     |
               g   l                           g     l
```

My proposal captures the rightward spreading effect with the constraint ALIGN-rt-FT-L, which requires that every root be aligned with a foot. It crucially relies on the assumption that in every reduplicated form there is more than one root (the extra roots are adjoined to the original root via Gen).

To summarize, the alignment constraints which underly proper syllabification also underly reduplication phenomena. In the cases discussed in this subsection, reduplication is triggered by the need to satisfy ALIGN-FT-rt-R. I also propose that the need to satisfy ALIGN-rt-FT-L solves the puzzle of the ban on leftward "spreading". The constraint CONTIGUITY was introduced to exclude a candidate with an epenthetic consonant. CONTIGUITY turns out to play a deciding role in some cases of cluster preservation.

4.3 The role of CONTIGUITY in cluster preservation and reduplication

As shown in 4.2, CONTIGUITY is the constraint responisble for the exclusion of a candidate with an epenthetic segment, since that segment appears in the output between two segments which are contiguous in the input. CONTIGUITY is therefore the constraint (in some cases, together with other constraints) which underlies cluster preservation. The phenomenon of cluster preservation was illustrated by the forms in (2), repeated here:

(2) Nouns Verbs Nouns Verbs

a. di-syllabic (complex onset)
praklit --> priklet ('lawyer' --> 'act as a lawyer')
smartut --> smirtet ('rag' --> 'make ragged')

b. mono-syllabic (bi-consonantal)
kod --> kided ('code' ---> 'encode)
kis --> kiyes ('pocked' ---> 'pickpocket')

c. mono-syllabic (complex onset)
blof --> bilef ('bluff' ---> 'bluff')
xrop --> xarap ('sleep' ---> 'sleep')
flirt --> flirtet ('flirt' ---> 'flirt')
faks --> fikses ('fax' ---> 'fax')

The observations (due to Bat-El, 1989, 1994a) are summarized in (39):

(39) a. Consonant clusters are not always preserved (compare (2a) with (2c)).
b. Not every monosyllabic input results in reduplication in the output (e.g. xarap), but only monosyllabic inputs may do so.
c. A monosyllabic input with a cluster in final position, results in reduplication together with cluster preservation in the output (e.g. fikses). A cluster in initial position does not trigger reduplication.

In the reduplication cases discussed in 4.2, the input was always bi-consonantal (e.g. kod). However, as observed by Bat-El, reduplication is not automatic when the input is monosyllabic. On the other hand, the existence of more than two consonants in the root does not automatically block reduplication. The fact that in flirtet ((2c)) there is both cluster preservation (/rt/) and reduplication (of /t/) suggests that these two phenomena are related. As we shall see, CONTIGUITY triggers reduplication when there is a cluster in initial position, provided that the input is monosyllabic. However, since reduplication is costly, if the input has more than one syllable, CONTIGUITY is satisfied without redpulication. These generalizations are predicted by the following ranking:

(40) PARSE-MSEG >> PARSE-SYLL >> PARSE-SEG >> *COMPLEX, ALIGN-rt-FT-L
>> CONTIGUITY >> NO-CODA

As argued in 4.1, the input to denominal verb formation is the entire noun, where the consonantal set is identified as a root - identified, not extracted. In this way, the information regarding the clusters is not lost. Recall also that we argued in 4.2 that Gen allows reduplication freely, so that for each root (Root or IRoot), Gen supplies roots with reduplicated consonants via adjunction. So, for an input consisting of the noun blof (where the cluster is an initial complex onset), Gen supplies the following candidates: bilef, blifef, bilfef, biblef. bilef violates CONTIGUITY (since /bl/ is a contiguous string in the input but not in the output) and NO-CODA. blifef violates *COMPLEX and NO-CODA. Since *COMPLEX dominates CONTIGUITY, bilef wins over blifef. biblef violates ALIGN-rt-FL-L, and bilfef[9] violates NO-CODA twice, therefore although it violates CONTIGUITY and respects *COMPLEX just like bilef, it still loses. The constraint interaction is summarized in (41):

```
(41) Input:   /blof , <i,e>/
                ||  |
                bl f   -   IRoot
```

Candidates	*COMPLEX	ALIGN-rt-FT-L	CONTIGUITY	NO-CODA
a. ☞ bi.lef			*	*
b. bli.fef	!*			*

[9] bilfef is possible as an output of templatic reduplication, see Footnote 7.

c. biblef		*!		**
c. bil.fef			*	*!*

If the input has a cluster in final position, as in faks, the candidate set generated by Gen is the following: fikses, fikes, and fifkes. fikses violates NO-CODA twice, but satisfies *COMPLEX, ALIGN-rt-FT-L and CONTIGUITY and *COMPLEX. fikes violates CONTIGUITY, and fifkes violates ALIGN-rt-FT-L. Out of the three candidates which satisfy *COMPLEX, the one which also satisfies CONTIGUITY wins:

(42) Input: / faks, <i,e> /
                 | ||
                 f   ks   =   IRoot

Candidates	*COMPLEX	ALIGN-rt-FT-L	CONTIGUITY	NO-CODA
a. ☞ fikses				**
b. fikes			*!	*
c. fifkes		*!	*	**
d. fkises	*!		*	*

The difference between blof and faks is this: faks has a complex coda in final position. Reduplication of /s/ results in breaking up the complex coda. In blof, this is not possible since reduplication of /b/ also results in a violation of ALIGN-rt-FT-L.

If there is a cluster both in initial and final positions, the optimal form flir.tet is again the one which reduplicates the final consonant, thus breaking up the complex coda, and satisfying CONTIGUITY. Breaking up the complex onset by inserting a vowel, as in fil<<i>>ret results in a PARSE-SEG (not PARSE-MSEG) violation. The other candidates violate both *COMPLEX and CONTIGUITY:

(43) Input: /flirt, <i,e>/
              || ||
              fl rt   = IRoot

Candidates	PARSE-SEG	*COMPLEX	CONTIGUITY
a.☞ flir.tet		*	

b. fil<<i>>ret	*!		**
c. fi.lert		*	*!
d. fli.ret		*	*!

To sum up, if the input is monosyllabic, reduplication takes place in two cases: (a) if there are two consonants in the input, to satisfy ALIGN-FT-rt-R; and (b) if there is a consonant cluster in final position, to satisfy CONTIGUITY and *COMPLEX.

However, if the input is bi-syllabic, as in praklit, CONTIGUITY is satisfied in the optimal form without reduplication. However, the higher ranking *COMPLEX is violated in the optimal form, since the other candidates violate the higher ranking PARSE constraints, or have more violations of *COMPLEX.[10] Any candidate, in which the Bin vowels are not mapped to existing vowel positions, violates PARSE-SEG or PARSE-SYLL (both of which rank higher than CONTIGUITY).

```
(44) Input:    / praklit, <i,e> /
                 || || |
                 pr kl t -    IRoot
```

Candidates	PARSE-MSEG	PARSE-SYLL	PARSE-SEG	*COMPLEX	CONTIG
a. ☞ [prik.let]				*	
b. pi[rek.let]		*!			*
c. [pir<<a>>k.let]			*!	*	*
d. [pri.klet]				*!*	
e. [pir<<a>>.klet]			*!	*	*
f. [pir<<a<><<k>>.let]	*!		*		*

CONTIGUITY, then, plays the following role in cases with complex onsets or codas: it is satisfied in the optimal form either when

[10] This does not explain why tilgref and not tligref is the verbal form from the tri-syllabic egraf, since both of them satisfy CONTIGUITY and equally violate *COMPLEX. Clearly, another straint (possibly TOTAL-CORRESPONDENCE, which would require that the complex onset /gr/ be a plex onset in the output) is at play. See Bat-El (1994b) for another possible analysis, involvin constraint ALIGN-AFFIX, which requires the members of the vocalic set to be as close to the edg possible.

its satisfaction does not cause violation of the higher ranking *COMPLEX, or when its satisfaction does cause violation of *COMPLEX, but the other candidates violate the higher ranked PARSE constraints or ALIGN-rt-FT-L.

I have shown that the same grammar which underlies proper syllabification of verbs, also underlies reduplication and cluster preservation in denominal verb formation. Constraints such as CONTIGUITY, which are not "active" in root-based forms, are satisfied vacuously.[11] Reduplication was shown to be the result of satisfying ALIGN-FT-rt-R and/or CONTIGUITY.

In the following section I will discuss stress alternations which occur as a result of suffixation. This process is also governed by an interaction between alignment constraints, which can account for stress shift, vowel reduction and vowel deletion.

5. Root-based verbs - more complex forms

Affixation of inflectional suffixes to the forms discussed in 3.1 sometimes results in stress shift, accompanied by vowel deletion or vowel change, as shown in (45):

(45) Past:

Basic form: gadál (3-sg-m)

No Change	Stress Shift	
	Vowel Deletion	Vowel change
gadál-ti (1-sg)	gadl-á (3-sg-f)	
gadál-ta (2-sg-m)	gadl-ú (3-pl)	
gadál-t (2-sg-f)		
gadál-nu (1-pl)		
gadál-tem (2-pl)		

Future:

Basic form: Ci+gdál

No Change	Stress Shift	
	Vowel Deletion	Vowel Change
		tigdel-í (2-sg-f)
		tigdel-ú (2-pl)
		yigdel-ú (3-pl)

Basic form: Ce-gadél

	te-gadl-í (2-sg-f)	
	te-gadl-ú (3-pl)	

In (46) is a summary of the observations to be made based on this

[11]A form like gidel does not violate CONTIGUITY, since <g,d,l> does not contain contiguous ings. The set notation implies precedence relations, not contiguity.

data:

(46) a. A "no-change" situation occurs when the suffix is consonant initial (e.g. gadálti).

b. Stress shift occurs when the suffix is vowel initial, and then, if the first member of the root is an onset of some syllable, then the result, in some cases, is vowel deletion in the suffixed form (e.g. gadlá). If the first member of the root is not an onset of some syllable, this in some cases results in vowel reduction in the suffixed form (e.g. tigdelí).

The data in (45), together with the forms discussed in section 3, suggest two things: (a) the basic foot form in MH is iambic, as is shown by the behavior of the non-suffixed forms (gadál, and yigdál, where the last syllable is stressed); and (b) MH is a quantity-insensitive language, as is illustrated by the fact that in gadlá, for example, the light syllable is stressed, and not the heavy one. In Optimality theoretic terms these observations are captured as follows: (a) the relevant foot form constraint is FT-FRM-IAMBIC, i.e. the foot final syllable is stressed; and (b) the WEIGHT-TO-STRESS Principle (WSP) is ranked very low with respect to other constraints, in other words it is vastly violated. In fact, we made this assumption implicitly in the analysis of forms such as yigdál in 3.1, where the Prosodic Word was analyzed as one foot, and the foot was of the form HH. Such feet are disallowed in a language where the WSP is ranked relatively high. In the following tableaux WSP is missing simply because it never plays any deciding role in the evaluation of the cadidates, and FT-FORM-IAMBIC is assumed to be ranked above all the other constraints.

I assume that the structure of suffixed forms is the following:

```
(47)         Verb'
            /     \
          Verb     Suffix
```

I also assume, that the metrical structure of Verb is part of the input, and therefore, by Containment, must be present in the output. This metrical information is stored in the output on a separate plane:

(48) PrWd - Output plane

```
            /         \
            ga  dal  ti
            \     /                -      Verb plane (stored)
             PrWd
```

I assume two more alignment constraints in addition to ALIGN-FT-rt-L. The first one requires that every foot in the output be left aligned with a stored foot (that is to say, with a foot in the Verb plane). The second constraint is RIGHTMOST (Prince & Smolensky, 1993), which requires that the Prosodic Word end on a foot. The formulation of these constraints is given in (49):

(49) ALIGN-FT-VbFT-L: Align(Foot,L,VbFT,L)
RIGHTMOST: Align(PrWd,R,Foot,R)

In addition, I assume that a reduced vowel (e.g., /e/ in <u>tiqdeli</u>, which results from suffixation of -i to <u>tiqdal</u>), is a vowel with an unparsed feature. It projects a reduced syllable (s-) which does not dominate any mora nodes (and is therefore codaless):

```
(50)              s-
                  |
                 RV
                <low>
```

I further assume, that a reduced syllable can only be incorporated into metrical structure by adjunction to a syllable, thus causing a PARSE-SYLL violation, because the lower s in (51) is not parsed by a foot:

```
(51)          s
           /     \
         s-        s
```

However, a reduced syllable cannot adjoin to a bimoraic syllable, because although the reduced syllable does not parse a mora, it does have weight, and its adjunction to a bi-moraic syllable would make the upper syllable too "heavy". In other words, only in a sequence of two light syllables, one of them can be reduced. The requirement that a reduced syllable may only be adjoin to a mono-moraic syllable has the status of an unviolable constraint (or a principle of Gen).

Since /a/ parses the feature [low], it appears reduced when [low] is unparsed (resulting in a PARSE-LOW violation). Similarly /i/, which parses [hi], is reduced when [hi] is unparsed (resulting in a PARSE-HI violation). The vowel /e/ which does not parse any features cannot be reduced.

The following ranking predicts the observations in (46):

```
(52) ALIGN-FT-rt-R  ALIGN-FT-VbFT-L   PARSE-HI
                \__      |     _______/
                   \     |    /
                    RIGHTMOST
                    /       \
             PARSE-MSEG     PARSE-LOW
                  |
             PARSE-SYLL
```

The idea behind this ranking is the following: since PARSE-MSEG is dominated by the alignment constraints, segments may be unparsed in order to satisfy one or more of these constraints. Likewise, syllables are reduced if by doing so, RIGHTMOST, for example, is satisfied (i.e., if the structure [s s] s becomes [s s- s], where the reduced syllable is adjoined to a light syllable). However, since vowel reduction is costly, this does not always happen. /a/ reduces to /e/ in order to satisfy RIGHTMOST ([tigdal] ---> [tig.de.li]), because PARSE-LOW is dominated by RIGHTMOST, but /i/ does not reduce to /e/, because RIGHTMOST is dominated by PARSE-HI.

Let us begin by examining a "no-change" situation, i.e., where the suffix is consonant initial, and that consonant begins a syllable. Such a case is exemplified by suffixation of -ti to gadal. Two footings are possible: [gadal]ti, ga[dalti] (a footing such as [ge.dal.ti] where either .ga. or .dal. are reduced, is impossible since .dal. is bi-moraic). Another candidate is one with an unparsed vowel (e.g. [g<<a>>dal.ti]). The winning candidate satisfies ALIGN-FT-rt-R and ALIGN-FT-VbFT-L but violates RIGHTMOST. ga[dal.ti] and [g<<a>>dal.ti] fatally violate ALIGN-FT-rt-R:

(53) Input: /[ga.dal], -ti/

Candidates	ALIGN-FT-rt-R	ALIGN-FT-VbFT-L	RIGHTMOST
a.☞ [ga dal]ti			*
b. ga[dal.ti]	*!	*	
b. [g<<a>>dal.ti]	*!		

In the case of hit[ga.dal]ti (where the input contains also a prefix), the winning candidate is again the one which satisfies ALIGN-FT-rt-R and ALIGN-FT-Vb-FT-L.

Stress shift occurs when the suffix is vowel initial. In such cases the rightmost root consonant becomes the onset of the syllable projected by the suffix (e.g., tig.dal. --> tig.de.li), and therefore ALIGN-FT-rt-R is violated by all the candidates (excluding the ones which fatally violate ONS). If the vowel can be reduced, we get a reduced syllable. For example, in [tig.de.li] /a/ is reduced to /e/, since only by reducing the syllable can both ALIGN-FT-VbFT-L and RIGHTMOST be satisfied. An input consisting of tigdal + -i, generates the following candidate set: [tig.de.li], where the reduced syllable .de. is adjoined to the syllable .li.; tig[da.li] which violates ALIGN-FT-VbFT-L; [tig][dali] also violates ALIGN-FT-VbFT-L since there are two feet, and one of them is not left aligned with the stored foot; and [tig.da]li which violates RIGHTMOST. [tig.d<<a>>li], where the vowel is unparsed, is not part of the candidate set. I assume this is due to an independent principle of Gen, which requires that for a morpheme to be (morphologically) parsed, at least one of its segments has to be phonologically parsed. Since in tigdal Bin consists of <a>, this single vowel cannot be unparsed. tigdeli, with the reduced syllable, is correctly predicted to be the optimal form, although it violates PARSE-SYLL and PARSE-LOW.

(54) Input: /[tigdal] , -i /

Candidates	ALIGN-FT-VbFT-L	RIGHTMOST	PARSE-SYLL	PARSE-LOW
a. ☞ [tig.da.li] <low>			*	*
b. [tig][dali]	*!			
c. tig[da.li]	*!		*	
d. [tig.da] li		*!	*	

Stress shift with vowel deletion occurs when the suffix is again vowel initial, but none of the vowels can project a reduced syllable. Such a case is exemplified by gidla, which is the result of suffixing -a to gidel. Since the vowel /e/ parses no features it cannot be reduced. However, it can be unparsed, since Bin consists of two vowels (/i/ and /e/). The candidate set includes [gid<<e>>la], which violates PARSE-MSEG; [gi.de]la, which fatally violates RIGHTMOST; gi[de.la], which fatally violates ALIGN-FT-VbFT-L; and [g<<i>>de.la], which violates *COMPLEX. [gid.<<e>>la] is correctly predicted to be the optimal form:

(55) Input: /[gidel] , -a/

Candidates	ALIGN-FT-VbFT-L	RIGHTMOST	PARSE-MSEG	*COMPLEX
a. ☞ [gid.<<e>>la]			*	
b. [gi. de] la		*!		
c. gi [de. la]	*!			
d. [g<<i>>de.la]			*	*!

In the case of te[gadel] + -i, where the input includes a prefix, the winning candidate is again the one which satisfies both ALIGN-FT-Vb-FT-L and RIGHTMOST: te[gad<<e>>li].

The fact that PARSE-HI ranks higher than RIGHTMOST explains why vowel reduction does not take place in the case of <u>higdila</u> (from <u>higdil</u> + -a), where the vowel /i/ of .di. is not reduced. Vowel deletion does not occur either, due to the principle discussed before, which requires that at least one segment of a morpheme be parsed (in this case, /i/ of <i>). Therefore, [hig.di]la is correctly predicted to be the optimal form:

(56) Input: / [higdil] , -a /

Candidates	ALIGN-FT-VbFT-L	PARSE-HI	RIGHTMOST
a. ☞ [hig.di] la			*
b. [hig][dila]	*!		
c. hig [di. la]	*!		
d. [hig .di. la] <hi>		*!	

The ranking in (52) reflects the fact ALIGN-FT-rt-R is the highest ranking constraint, and whenever the rightmost member of the Root can be a coda, this constraint is satisfied. It also reflects two distinct tendencies in suffixed forms: preservation of the metrical structure of the input (which is dictated by ALIGN-FT-VbFT-L), and left aligning the prosodic word with a foot (dictated by RIGHTMOST). These two constraints may conflict, when suffixation results in a form whose size is more than two syllables. Simultaneous satisfaction of these constraints is done at the cost of violating PARSE-MSEG and PARSE-LOW.

In this section I analyzed the stress shift, vowel reduction, and vowel deletion as resulting from an interaction between the alignment constraints ALIGN-FT-VbFT-L and RIGHTMOST, and the familiar PARSE-MSEG, PARSE-SYLL and *COMPLEX. This analysis relies on the assumption that the input to suffixed forms includes the metrical representation of the basic verbal form, and that reduced vowels project reduced syllables, which are in some sense defective syllables, and are never directly parsed by feet.

6. Conclusion

I have explored the role of alignment in word formation. I have shown how the different "templates" in the verbal system of Modern Hebrew are predicted by a series of alignment constraints, which, when satisfied, result in aligning the right edge of the root with a foot, and in aligning the left edge of the root with the left edge of a foot. In particular, I have shown that the ranking between ALIGN-FT-rt-R, PARSE-SEG, PARSE-SYLL, and ALIGN-rt-FT-L accounts for the difference in the metrical structure between forms with open syllable prefixes, and forms with closed syllable prefixes.

I provided additional evidence for the existence of ALIGN-FT-rt-R and ALIGN-rt-FT-L by showing that they predict the fact that the first consonant of the root is never reduplicated, thus deriving the ban of leftward spreading from alignment (which is needed independently). ALIGN-FT-rt-R was also shown to play a crucial role in determing the stress pattern of suffixed forms, together with ALIGN-FT-VbFT-L and RIGHTMOST.

Summary of the constraint rankings presented:

```
(57)      ALIGN-FT-rt-R  ALIGN-FT-VbFT-L    PARSE-HI
                       \_        |         _/
                         \_      |      __/
                           \     |     /
                            RIGHTMOST
                         __/     |
                        /        |
                       /         |
            PARSE-MSEG       PARSE-LOW
               |
            PARSE-SYLL
               |
            PARSE-SEG
               |    \__
               |       \
           *COMPLEX     ALIGN-rt-FT-L
               |       /
           CONTIGUITY /
               |     /
         NO-CODA, MAX
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