

## STRESS IN THE MODERN HEBREW VERBAL SYSTEM: THE OPTIMALITY OF A MORPHOLOGICALLY LIMITED GENERALIZATION

Lise M. Dobrin

The University of Chicago

### 0. Overview.

The problem of accounting for the placement of stress in the Hebrew verbal paradigms has posed a lasting challenge to analysts working within the generative tradition (cf., e.g., Prince 1975, Bolozky 1978, McCarthy 1979, Rappaport 1984, Bat-El 1989, Dobrin 1994). Modern Hebrew inherited from its Biblical predecessor a stress pattern that interacts with segmental alternations in a morphologically conditioned yet regular way. A cyclic account within the theoretical framework of Lexical Phonology suffers from formal and conceptual inadequacies, however, which motivate another approach. More recently the morphologically limited nature of the verb stress generalization has been captured by referring to a foot-sized template anchored at the edge of an explicitly morphological constituent of the verb. But such a template is ultimately too rigid to accommodate the full range of verbal patterns, and it is furthermore prosodically redundant. In this paper, the Modern Hebrew stress patterns are interpreted as the product of constraints, formulated according to the principles of Optimality Theory (McCarthy and Prince 1993a,b, Prince and Smolensky 1993). Under the Optimality account, a subset of the Modern Hebrew constraints are elevated from an ineffectually low position in the language's general evaluation hierarchy to a much higher position in the hierarchy for the purpose of evaluating specifically verbal candidates. The analysis obviates the need for an otherwise anomalous stress template and raises critical issues for the Optimality framework including (1) the precise formulation of constraints on the alignment of morphological and prosodic constituents, (2) the possible need for multiple phonological levels, contrary to the parallel evaluation procedure so highly valued within the Optimality model, and (3) the nature of the relationship between a morphologically specific constraint hierarchy and the macro-level generalizations it aims to describe.

### 1. The Modern Hebrew Data.

In (1) below are listed the full verb paradigms for regular (CCC) roots in Modern Hebrew. The central (underlined) cases are most clearly represented in the Pa'al past paradigm. On the unsuffixed verb stem (3.m.sg.), stress is simultaneously stem- and word-final (*katáv*). Where a consonant-initial suffix follows, stress is retained on the stem (*katáv-ti*), but with a vowel-initial suffix the stem-final vowel usually deletes, and stress falls on the suffix (*katv-á*). A schwa appears in verbs whenever

deletion creates a tri-consonantal cluster, such as in certain Pa'al future (*tixtəv-i*) and Nif'al past forms (*nixnəs-á*).

(1)	Binyan:	Pa'al	Nif'al	Hitpa'el	Pi'el	Hif'il
	<b>Past</b>					
	1.sg. -ti	<u>katávti</u>	nixnásti	hitlabášti	cilámti	higdálti
	2.m.sg. -ta	katávta	nixnásta	hitlabášta	cilámta	higdálta
	2.f.sg. -t	katávt	nixnást	hitlabášt	cilámt	higdált
	3.m.sg. Ø	<u>katáv</u>	nixnás	hitlabéš	cilémt	higdíl
	3.f.sg. -a	<u>katvá</u>	<u>nixnəsá</u>	hitlabšá	cilmá	higdíla
	1.pl. -nu	katávnu	nixnásnu	hitlabášnu	cilámtu	higdálnu
	2.m.pl.-tem	katávtem	nixnástem	hitlabáštem	cilámtem	higdáltem
	2.f.pl. -ten	katávten	nixnástem	hitlabášten	cilámten	higdálten
	3.pl. -u	katvú	nixnəsú	hitlabšú	cilmú	higdílu
	<b>Future</b>					
	1.sg. e-/a-	extóv	ekánés	etlabéš	ecalém	agdíl
	2.m.sg. tV-	tixtóv	tikanés	titlabéš	tecalém	tagdíl
	2.f.sg. tV- i	<u>tixtəví</u>	tikánš	titlabší	tecalmí	tagdíli
	3.m.sg. yV-	yixtóv	yikanés	yitlabéš	yecalém	yagdíl
	3.f.sg. tV-	tixtóv	tikanés	titlabéš	tecalém	tagdíl
	1.pl. nV-	nixtóv	nikanés	nitlabéš	necalém	nagdíl
	2.pl. tV- -u	tixtəvú	tikánšú	titlabšú	tecalmú	tagdílu
	3.pl. yV- -u	yixtəvú	yikánšú	yitlabšú	yecalmú	yagdílu
	<b>Participle</b>					
	m.sg. Ø	kotév	nixnás	mitlabéš	mecalém	magdíl
	f.sg. -et/-a	kotévet	nixnéset	mitlabéšet	mecalémet	magdíla
	m.pl. -im	kotvím	nixnasím	mitlabším	mecalmím	magdílim
	f.pl. -ot	kotvót	nixnasót	mitlabšót	mecalmót	magdílot
	Gloss:	'write'		'dress' (refl.)	'photograph' (trans.)	'increase, enlarge'
	Root(√):	(k-x).t.v	(k-x).n.s	l.b.š	c.l.m	g.d.l

In contrast to mid and low vowels, high stem-final vowels do not delete, and so they retain stress, as in (2). The environment where this configuration arises most regularly is in the Hif'il binyan (2a).

- (2) a. *tagdíli* 'enlarge' 2.f.sg.fut  
*higdílu* 'enlarge' 3.pl.past  
 b. *taširi* 'sing' 2.f.sg.fut.  
*yakúm-u* 'rise' 3.pl.fut.

Monosyllabic and vowel-final stem also bear stress, presumably because they do not undergo deletion; see (3) and (4), respectively.

- (3) *kám-u* 'rise' 3.pl.past  
*gár-a* 'live' 3.f.sg.past  
*ta-šir-u* 'sing' 2.pl.fut  
 (4) *nehené-ti* 'enjoy' 1.sg.past  
*niglé-nu* 'emerge' 1.pl.past

In the participles, as shown by (5) below, only stem-final *e* is subject to deletion, and like unmarked nouns, participles always take word-final stress (except when followed by the feminine singular suffix *-et*, which is never stressed).

- |     |                       |                             |                          |
|-----|-----------------------|-----------------------------|--------------------------|
| (5) | stem-final <i>e</i> : | <i>kotév ~ kotv-ím</i>      | 'write' m.sg. ~ m.pl.    |
|     |                       | <i>mesarév ~ mesarv-ót</i>  | 'refuse' m.sg. ~ f.pl.   |
|     | stem-final <i>a</i> : | <i>nixnás ~ nixnas-ím</i>   | 'enter' m.sg. ~ m.pl.    |
|     |                       | <i>mekubál ~ mekubal-ím</i> | 'accepted' m.sg. ~ m.pl. |
|     | stem-final <i>i</i> : | <i>magdíl ~ magdil-á</i>    | 'enlarge' m.sg. ~ f.sg.  |

As opposed to verbs, nominals (nouns and adjectives) are assumed to take word-final stress as a rule; cf. (6). Vowel deletion in nominals is either lexically specified or subject to a distinct set of conditions. The near-minimal pairs in (6c) demonstrate the independence of stress from deletion in nominals.

- |     |    |                         |                       |
|-----|----|-------------------------|-----------------------|
| (6) | a. | <i>kélev ~ klaví-m</i>  | 'dog' sg. ~ pl.       |
|     |    | <i>davár ~ dvar-ím</i>  | 'thing' sg. ~ pl.     |
|     | b. | <i>gadól ~ gdol-ót</i>  | 'big' m.sg. ~ f.pl.   |
|     |    | <i>šákét ~ šket-á</i>   | 'quiet' m.sg. ~ f.sg. |
|     | c. | <i>gamál ~ gmal-ím</i>  | 'camel' sg. ~ pl.     |
|     |    | <i>gamád ~ gamad-ím</i> | 'dwarf' sg. ~ pl.     |

Following Bat-El 1989, I will treat schwa as epenthetic, inserted in the environment CC\_C. Epenthesis cannot be treated as an exceptionless phonetic rule, however, since the type of cluster it serves to break up is not always unacceptable; compare (7a) and (7b). A constraint against tri-consonantal sequences does appear to hold in the native vocabulary, with strategies for dealing with it differing along morphological lines. The typical nominal pattern of vowel deletion two syllables preceding the stress is blocked when it would create an illicit tri-consonantal cluster (Bolzky 1972); cf. (7c). The phonetic quality of schwa is often identical to that of the mid front vowel *e*, which is also the hesitation vowel in Israeli speech. The epenthesized vowel is denoted here as *ə* in order to clearly distinguish it from the underlying *e* which also exists in the language.

- |     |                     |  |                                 |
|-----|---------------------|--|---------------------------------|
| (7) | a. Native Verbs     | <i>yintərú</i>   | 'guard' 3.pl.fut.               |
|     |                     | ( <i>yintor-u</i> → <i>yintr-u</i> → <i>yintər-u</i> ) |                                 |
|     |                     | <i>tišpəri</i>   | 'be good, pleasing' 2.f.sg.fut. |
|     |                     | ( <i>tišpor-i</i> → <i>tišpr-i</i> → <i>tišpər-i</i> ) |                                 |
|     | b. Non-native Verbs | <i>xintréš</i>   | 'talk nonsense' 3.m.sg.past     |
|     |                     | <i>mašpríc</i>   | 'spray' m.sg.pres.              |
|     | c. Nominals         | <i>kamcán ~ kamcanít</i>                               | 'stingy' m.sg. ~ f.sg.          |
|     |                     | <i>taclíl ~ taclilím</i>                               | 'chord' ~ 'chords'              |
|     |                     | <i>marpék ~ marpekím</i>                               | 'elbow' ~ 'elbows'              |

## 2. Cyclic Inflection: A Derivational Analysis.

In this section I consider in some detail the cyclic solution proposed by Bat-El 1989 within the theory of Lexical Phonology. Her generalization for Modern Hebrew verbs is that stress is stem-final, but with the addition of a vowel-initial suffix, the stressed vowel deletes unless it is [+high], and with the loss of the stressed vowel stress shifts onto the suffix. Default stress in the language is assumed to be domain-final, implemented in a grid-based notation by the Right-End Rule (Prince 1983), which adds a beat to the rightmost grid position at the highest level. The stem-final stress generalization for verbs is thus Modern Hebrew's general domain-final default rule maintained from its original application to the stem. As for the resilience of high vowels, Bat-El reasons (p. 185) that "stress shift is triggered by vowel deletion and not vice versa. Deletion rules, unlike stress rules, are often sensitive to segmental quality." That is, she finds it most natural to assign stress regularly and then simply not delete the high vowel, so that stress shift is not motivated in such forms. Bat-El's vowel deletion rule is given in (8):

$$(8) \acute{V}_{[-\text{high}]} \rightarrow \emptyset / \sigma C \_ \sigma$$

This Vowel Deletion rule must be conditioned so as to apply very selectively. The 'non-high' condition exempts forms with stem-final *u* and *i*, such as the Hif'il *higdíl-u* and *tagdíl-i*. The initial syllable of the environment excludes deletion in monosyllabic stems, such as *kám-u*. Finally, a stipulated limitation to derived prosodic contexts (p. 186) renders the rule inapplicable to stem-final open syllables which were underlyingly open as well, such as in the word *niglél-nu*, which does not undergo deletion as predicted by rule (8) (\**niglél-nú*).

- (9) a. (i) Syllabification  
 (ii) Right-End Rule (& Tier Conflation)  
 (iii) Vowel Deletion (& Stress Shift)

b.	level 2		*		*				
	level 1		*				*		*
	level 0	*	*		*	*	*		*
		$\sigma$	$\sigma$		$\sigma$	$\sigma$	$\sigma$		
		[k̂ â t̂ â v̂]		[[k̂ â t̂ â v̂] â]		[k̂ â t̂ v̂ â]		katv́a	
				*					
	c. level 2								
	level 1		*		*				
	level 0	*	*		*	*			
		$\sigma$	$\sigma$		$\sigma$	$\sigma$	$\sigma$		
		[k̂ â t̂ â v̂]		[[k̂ â t̂ â v̂] t̂ ê m̂]				katávtem	

The derivation of verbs proceeds through the ordered rule block in (9a) as follows. The input to stress is first syllabified, since syllables are the stress-bearing units of the language. In the initial representations of both (9b) and (9c), the Right-End Rule applies at level 1, yielding stem-final stress. Verbal suffixes are then

added, the material is resyllabified, and the Right-End Rule applies again on level 2, now reinforcing the previously assigned beat (since the rule always scans the highest grid level). Vowel deletion applies in (9b) and not in (9c) because only in the former is its environment met.

Bat-El accounts for the participial forms differently. Stress does appear to shift in words like *magdil-á*, even though the stem-final vowel is retained and should be capable of carrying stress; similarly for *nixnas-ím*, where Vowel Deletion would seem to be called for but does not apply. Bat-El's solution here is actually bipartite: First, Modern Hebrew participles are not verbs morphologically. And second, non-verbal suffixes are not added cyclically; i.e., an entire word is available to the original assignment of stress. The first claim is easily defensible, since the participles are peripheral to the verbal system in several ways: morphosyntactically, they do not inflect for person, like nominals and unlike other verbs, and they can be used either as nouns or verbs syntactically. The participle *šomer* 'watch, guard', for example, functions verbally in (10a) below, taking a PP complement. In (10b), by contrast, the same word acts as subject, and is incorporated into a possessive construction.

- (10) a.     *hi*     *šomeret*             *al*     *ha-yeladim*  
           she watches F.SG.       PREP. DEF.-children  
           'She's watching after the children.'
- b.     *šomre-ha-yeled*             *lo*     *daagu*     *alav*  
           watchers(POSS.)-DEF.-child   NEG. worried(PL.) about-him  
           'Those watching after the child didn't worry about him.'

In terms of formal realization, the participles regularly inflect with the feminine singular suffix *-et*, which is otherwise only a nominal suffix. Finally, as exemplified in (5) above, vowel deletion is more restricted in participles than it is in verbs.

But the second part of Bat-El's account is what really drives her analysis. Since cyclic affixation is what enables verbs to retain stem-final stress despite the presence of a suffix, it must be assumed that non-verbal suffixes are by contrast *not* added cyclically, so that the original assignment of stress applies to an entire word. Note, however, that this partitioning of suffixes into cyclic and non-cyclic does not follow in any way from their regularity, obligatoriness, or phonological character. In fact one suffix, feminine singular *-a*, is homophonous, occurring on both nouns and verbs.

Furthermore, the cyclic interaction between stress and deletion in verbs actually founders in its details. The shift of stress precisely onto the word-final syllable in forms like (9b) follows from nothing in the analysis: the Right-End Rule applies twice, once on each cycle, and since Bat-El denies the existence of foot structure in Modern Hebrew, there is no basis for shifting the stress within its foot. It might be suggested that stress is deleted along with the vowel and the Right-End Rule reapplied, so that Stress Shift is eliminated altogether, but in that case the systematic connection between the application of the stress rule and independently motivated morphological domains is lost.

### 3. The Verb Stress Template: A Morphological Analysis.

The analysis described in this section is an explicitly morphological approach to the Modern Hebrew verb stress problem (Dobrin 1994). The solution is of interest in the present context to the extent that it identifies the primary element of the stress constraints to be formalized in the next section (a quantity insensitive iambic foot), and targets the precise level of representation at which the stress facts are appropriately described. Referring again to the data in (1), the following generalization emerges: there is a pattern of *columnar stress* in the past and future (the morphologically verbal) paradigms. That is, within each of the tense-binyan paradigms, stress always aligns on the same syllable, counting from the left edge of the word. The phenomenon of columnar stress is preceded in the literature on Spanish, in works such as Reyes 1972, Hooper and Terrell 1976, and Janda 1992. In these analyses the emphasis is on the autonomy and priority of a coherent local stress pattern within the Spanish verbal paradigms, rather than on the divergence of verb stress from the essentially phonological penultimate default pattern characteristic of the language at large.

To capture the notion of columnarity Dobrin 1994 proposes a disyllabic stress template accented on its second syllable, as exemplified in (11). The template appears to hold at a level subsequent to vowel deletion, since it aligns stress to the suffix vowel whenever the stem-final vowel is deleted; cf., e.g., (11b). Furthermore, as in (11c), the template is completely oblivious to any syllable containing schwa, implying that the schwa generalization holds of a subsequent level of representation.

- (11)
- |              |            |             |
|--------------|------------|-------------|
| *            | *          | *           |
| [σ σ]        | [σ σ]      | [σ σ]       |
| a. ká.táv.ti | b. kát.Øvā | c. tix.tØvi |

The left-edge orientation of template alignment is detectable from alternations between ultimate and penultimate stress, which are found throughout the verb paradigms. The constant point of reference is the leftmost syllable containing root material, whether the root-initial consonant syllabifies as its onset, as in *hit.la.báš.ta* 'you (m.pl.) got dressed ( $\sqrt{1.b.š}$ ), or as a coda after a CV preformative, as in, e.g., *nix.nás.ti* 'I entered' ( $\sqrt{(k-x).n.s}$ ). It is thus necessary to identify both morphological and phonological structures in order to correctly align the template. The representation over which the template holds is problematic from most derivational perspectives, since it must be phonologically adjusted to the inflectional endings via vowel deletion, yet still retain its stem-internal composition so that the appropriate anchoring syllable can be identified. This is unexpected if bracket erasure takes place between strata of morphological derivation, as in, e.g., McCarthy 1986; it is equally intractable according to the a-morphous cyclic framework of Anderson 1992. Interestingly, Modern Hebrew poses several instances of this problem; i.e., reference to presumably inaccessible morphological structure; cf. Bat-El 1989. The problem is not nearly so pressing, however, if rules are

interpreted as static generalizations which hold over words, rather than as procedures for composing them. From this non-derivational point of view, vowel deletion can be formulated as a morphophonological rule relating inflected verbs to their unsuffixed counterparts. The stress template can be conceived as a simultaneous condition holding over verbs at the same level of representation (cf. Goldsmith 1993 and Lakoff 1993 on the topic of simultaneous rule application).

There are cases which a columnar account is simply too rigid to handle, however; cf., e.g., (12). Verbs with an assimilated initial root consonant appear to violate the anchoring rule, since the first root C is phonologically absent. Monosyllabic stems such as those in (3) above likewise cause descriptive trouble. In such cases, the suffix is never stressed in the way that the template structure and alignment generalizations predict, e.g., *tašir-u*, \**tašir-ú* ( $\sqrt{\text{š.}(i).r}$ ). While there is some consolation in the fact that neither of these categories is a productive member of Modern Hebrew verb morphology, the columnar stress generalization does hold for them as well. The descriptive behavior of these verbs is indeed columnar; it is the templatic explanation for it which is amiss.

- |      |               |   |
|------|---------------|---|
| (12) | <i>yi.gáš</i> | 'approach' 3.m.sg.fut. ( $\sqrt{n.g.š}$ ) |
|      | <i>ti.pól</i> | 'fall' 2.pl.fut. ( $\sqrt{n.p.l}$ )       |
|      | <i>e.léx</i>  | 'go' 1.sg.fut. ( $\sqrt{h.l.x}$ )         |

#### 4. Competing General and Verb-Specific Constraints: An Optimality Analysis.

##### 4.1. Optimality Theory.

Optimality Theory (McCarthy and Prince 1993a,b, Prince and Smolensky 1993) treats the phonological form of words as a function of interacting constraints. Constraints or well-formedness conditions have come to play an increasingly central role in recent years, as the burden of explanation in phonology has shifted off of rules and onto representations (Anderson 1985). The Optimality position stands at the extreme end of the representational side of the scale in that it employs no rules whatsoever. Instead, Optimality Theory uses only constraints to narrow a potentially infinite set of candidates to a unique grammatical output form.

The candidates posited by the generative component GEN are interpretations of the phonological information introduced by the morphology. The range of candidates is limited by a set of principles ensuring that the distinctive structure provided by the input is maintained in the output. One such principle, Consistency of Exponence, requires that the morphological composition of an input be preserved in the output, regardless of its phonological realization. Consistency of Exponence will be crucial to the analysis developed below.

The evaluation component EVAL tends to constitute the focus of Optimality analyses, since that is the component responsible for choosing the optimal candidate from among the possibilities supplied by GEN. The constraints in EVAL are all in principle violable, and though violation will always be minimal, many constraints

turn out in fact to be violated frequently, so that constraints may be interpreted as a language's preferences when all else is equal. Since constraints are ranked on a language-specific basis in order of priority, what can make all else equal for purposes of a given constraint is for the higher ranked constraints all to be satisfied or violated equally, so that the determination of optimality falls to the constraint in question.

There is one particular subtheory of constraints within Optimality Theory which one would expect a priori to play a role in an analysis of Modern Hebrew verb stress, the family of ALIGN constraints schematized in (13). ALIGN constraints demand coincidence of various morphological and prosodic edges. It is this formal vocabulary for aligning the parts of a representation that makes the theory attractive for explaining Modern Hebrew verb stress, since determining the alignment of the stress unit lies at the heart of the problem.

(13) ALIGN (CATEGORY<sub>1</sub>, EDGE<sub>1</sub>; CATEGORY<sub>2</sub>, EDGE<sub>2</sub>)

#### 4.2. Prosodic Assumptions.

In this section basic assumptions about prosodic structure are articulated as a preface to the Optimality analysis. The prosodic hierarchy incorporating moras, syllables, feet and prosodic words is assumed following earlier Prosodic Morphology (McCarthy and Prince 1986, 1990, 1991, 1993a). Modern Hebrew has no distinctive vowel length or syllable weight, so only the last three of the four prosodic levels are relevant here. Some outlying forms will be analyzed as violating FTBIN, (14), a highly-ranked constraint. It will also be necessary to consider violations of FTFORM (15), a constraint requiring Modern Hebrew feet to be right-headed.

(14) Constraint: FTBIN

Feet are binary under syllabic or moraic analysis.

(15) Constraint: FTFORM (IAMBIC)

Feet are right-headed (iambic): [ σ σ´ ]

The analysis deals only with main stress, and makes no assertions about the prosodic status of those segments unparsed by the main stress foot. Presumably, however, all syllables are ultimately footed, since secondary stress on alternating syllables is characteristic of the language (Boložky 1982). For purposes of the constraint ranking arguments, it is assumed that VCCV sequences syllabify as VC.CV, though eventual restructuring based on relative sonority is not excluded. Finally, it will be assumed that 'schwa insertion' is governed by a constraint ranking subsequent to the one attributed here to EVAL. This is admittedly a contentious assumption, since as mentioned earlier the appearance of schwa is not an obviously phonetic phenomenon. I will return to this issue later in the exposition.

## 4.3 The Optimality Analysis of Modern Hebrew Verb Stress.

Having assumed a quantity-insensitive iambic foot, the next step is to determine its alignment in words. The constraint deriving the default final stress pattern is ALIGN-PRWD (16), which aligns the right edge of the foot to the right edge of the prosodic word. Since stress is not always word-final, this constraint must be crucially dominated in the hierarchy.

- (16) **Constraint:** ALIGN (FT,R; PRWD,R)  
Align the right edge of the foot to the right edge of the prosodic word.

Vowel deletion in verbs derives from the interaction of two constraints. The first, \*LL (17), disprefers sequences of two open syllables, referred to as 'light' in order to tie in with the very similar constraint proposed for the vowel syncope pattern of the Bedouin Arabic dialect described by McCarthy 1993. \*LL violations are reckoned step-wise over two syllable windows, so that a sequence LLL incurs two separate violations. The second, lower-ranked constraint is PARSEV (18), which wants simply for vowels to be parsed into prosodic structure. In Tableau (1) form (c) wins even though it violates PARSEV because it does not contain any sequences of two open syllables. Form (b) violates PARSEV as well, but it does not make the word any better for it and so loses out to (c). The interaction of these constraints can be held responsible for the classic 'V → ∅ in a two-sided open syllable' effects familiar from generative phonology.

- (17) **Constraint:** \*LL  
Sequences of two open syllables are not permitted.

- (18) **Constraint:** PARSEV  
Parse vowels into prosodic structure.

T(1) *katau-u* 'wrote' 3.pl (√k.t.v)

Candidates	*LL	PARSEV
a. ka.ta.v-u	**!	
b. k(a)ta.v-u	*!	*
c. <del>ka</del> kat.(a)v-u		*

Tableau (2) shows how the site of deletion is determined by its function. The vowel deletes in the only place where doing so avoids violation of the higher ranked constraint. Underparsing the initial vowel does not affect syllabic structure at all, and underparsing the *a* still leaves the final LL sequence intact. The possibility that suffixes are left unparsed is not being considered here, since it would always result in a loss of distinctive morphological structure. Similarly unrepresented are forms which would be ruled out by the basic syllable structure constraints. The possibility that LL sequences are so to speak 'repaired' by epenthesis is excluded by the high ranking of FILL (or its more recent incarnation MSEG, cf. McCarthy 1993),

which prohibits surface material with no morphological affiliation. Finally, \*LL is not active in nouns at the same point in the constraint ranking that it is in verbs, as can be seen from the common nominal pattern *ma.ta.rá* 'goal', *ha.la.xá* 'way', and derived LL sequences: *ša.két* ~ *ške.t-á*.

T(2) *tecalem-i* 'photograph' 2.f.sg.fut. ( $\sqrt{c.l.m}$ )

Candidates	*LL	PARSE V
te.ca.le.m-i	***!	
t(e)ca.le.m-i	**!	*
tec.(a)le.m-i	*!	*
☞ te.cal.(e)m-i		*

Violations of \*LL must be answering to higher constraints. The word *tecalém* in Tableau (3) provides an example. The optimal form retains the middle vowel in deference to ALIGN-ROOT (19), which demands that the left edge of the foot align to the left edge of the root, the innermost constituent of the Modern Hebrew verb stem. A similar sort of explanation holds for the word analyzed in Tableau (4), *hekímu*, which contains the resilient high vowel. There \*LL is violated in deference to the higher ranked PARSEHiV (20).

(19) Constraint: ALIGN (Ft,L; ROOT,L)  
Align the left edge of the foot to the left edge of the root.

T(3) *tecalem* 'photograph' 2.m./3.f. sg.fut. ( $\sqrt{c.l.m}$ )

Candidates	ALIGN-ROOT	*LL	PARSE V
☞ te.[ca.lém]		*	
[tec.(a)lém]	*!		*

(20) Constraint: PARSEHiV  
Parse high vowels into prosodic structure.

T(4) *hekim-u* 'cause to arise' 3.pl.past.

Candidates	PARSEHiV	*LL	PARSE V
☞ he.ki.m-u		*	
hek.(i)m-u	*!		*

Tableau (5) demonstrates the effects of ALIGN-RIGHT (21), a well-established constraint in the Optimality literature (McCarthy and Prince 1993a,b, 1994). ALIGN-RIGHT demands that stems end cleanly on the end of a syllable, i.e., it militates against prosodically obscuring a stem-suffix boundary. The word *niglénu* is built on an underlyingly vowel-final stem, *niglé-*, and since the suffix begins with a consonant, deleting the vowel would throw off that otherwise optimal alignment.

- (21) **Constraint:** ALIGN (STEM,R;  $\sigma$ ,R)  
Align the right edge of the stem to the right edge of a syllable.

T(5) *nigle-nu* 'emerge' 1.pl.past

Candidates	ALIGN-RIGHT	*LL	PARSEV
$\text{c}\text{c}$ nig.le-nu		*	
nig.l(e)-nu	*!		*

Stem-final stress in verbs is a challenge to formulate under the align schema, since it does not refer directly to edges. As defined in (22) the verb-specific constraint ALIGN-STEMV aligns the head of the foot (i.e., the stressed syllable) to the rightmost vowel of the verb stem. By virtue of the priority of \*LL in the constraint ranking, ALIGN-STEMV is only visibly active when the stem-final vowel survives deletion. If the stem-final vowel is unparsed in deference to \*LL, then ALIGN-STEMV cannot be satisfied, and the decision falls to ALIGN-PRWD. Note that the introduction of ALIGN-STEMV into the constraint hierarchy does not supplant the need for ALIGN-ROOT (19) because of cases like *tecalém* in Tableau (3) above, where ALIGN-STEMV is satisfied in both candidates. A \*LL violation must thus be induced by other pressures.

- (22) **Constraint:** ALIGN (H(Ft); R,STEMV) H(Ft) = head of foot  
Align the head of the foot to the rightmost stem vowel.

T(6) *higdil-a* 'increase' 3.f.sg.past ( $\sqrt{g.d.l}$ )

Candidates	ALIGN-Rt	ALIGN-ROOT	ALIGN-STEMV	ALIGN-PRWD
hig.[di.l-á]	*	*	*!	
$\text{c}\text{c}$ [hig.dí.l]-a	*	*		*

The decision made for the word *hitlabšú* in Tableau (7) underscores the importance of the morphology-conserving principle Consistency of Exponence mentioned above to the proper functioning of ALIGN-STEMV. All the candidates that satisfy the higher-ranked \*LL fail on ALIGN-STEMV because the constraint refers to the rightmost morphological, i.e., underlying vowel, and not to whatever vowel happens to surface as the last vowel in the stem.

T(7) *hitlabeš-u* 'get dressed' 3.pl.past ( $\sqrt{l.b.š}$ )

Candidates	ALIGN-ROOT	*LL	ALIGN-STEMV	ALIGN-PRWD
a. hit.[la.bé.]š-u		**!		*
b. [hit.lá.]b(e)š-u	*!		*	*
$\text{c}\text{c}$ hit.[lab.(e)š-ú]			*	

Tableau (8) shows how stem stress is achieved in monosyllabic stems. The \*LL violation is tolerated because the higher ranking of FTBIN and FILL/MSEG prevents either deleted or augmented forms from superceding it. Such a ranking is supported by the realization of monosyllabic forms like *kam*, which surface true to their underlying forms instead of augmenting to satisfy FTBIN. Since the stem vowel is parsed, ALIGN-STEMV demands that it be stressed. As a result, the foot is reversed in violation of FTFORM. FTFORM must thus be a lower-ranked constraint.

T(8) *kam-u* 'get up' 3.pl.past

Candidates	*LL	ALIGN-STEMV	FTFORM
a. [ka.m-ú]	*	*!	
b. <del>ka</del> [ká.m-u]	*		*
c. [ká.]m-u	*FTBIN!		
d. [k(a)m-ú]	*FTBIN!		

Such a low ranking of FTFORM is certainly counter-intuitive, since up to this point the question of its violability has never arisen. But consider what other possible circumstances might motivate a violation of FTFORM. In forms like *higdíl-a* and *nixnás-tem*, which have stem-final stress and root misalignment, reversing the headedness of the foot would derive stem-final stress without violating ALIGN-PRWD, since ALIGN constraints only target *edges* and make no demands on the internal structure of the units they align. Allowing violations of FTFORM thus makes the correct parse for such forms ambiguous: if FTFORM dominates ALIGN-PRWD, as assumed above, then the parse is [*nix.nás*].-tem; however, if FTFORM ranks below ALIGN-PRWD, then the correct parse is actually *nix*.[*nás*.-tem].

Choosing between these two analyses is not an empirical necessity, though the decision intersects with other considerations which make the matter worth pursuing. One possibility is that the indeterminacy is an artifact of the precise formulation of the constraint aligning stress to the end of the prosodic word. That is, it may not be literal identification of an edge, but instead orientation towards an edge that actually underlies word-final stress, just as in the ALIGN-STEMV constraint posited for verbs in (22). This possibility can be implemented by revising the constraint to one aligning the heads of feet rather than their edges, as in (23).

(23) Constraint: ALIGN (H(FT); R,PRWD)

Align the head of the foot to the rightmost vowel in the prosodic word.

What makes (23) (which I will refer to as ALIGN-PRWD') especially interesting is that it moves the analysis of Modern Hebrew stress entirely out of the arena of the ALIGN schema, since with this revision neither of the main stress constraints refers to an edge proper. ALIGN-PRWD' might be construed as an EDMOST constraint (24), the conceptual predecessor of ALIGN from Prince and Smolensky 1993, though not without loosening the restriction on the EDMOST schema that requires a relation of hierarchical dominance to hold between the aligned categories. As is evident

from the preceding discussion of stem-final stress, it is necessary in Modern Hebrew to align units belonging to distinct linguistic components (e.g., stems and syllables).

(24) EDGEMOST( $\varphi$ ; E,D)

The item  $\varphi$  is situated at edge E of domain D.

McCarthy and Prince 1993b propose the constraint ALIGNHEAD, schematized under (25), which reformats the End Rule as a constraint. However, ALIGNHEAD differs in certain respects from the head-aligning constraints posited here. ALIGNHEAD is motivated in the context of a discussion of main stress in Garawa, a language with potentially long prosodic words and an independently determined foot pattern. The constraint thus picks out one 'pre-existing' constituent as strongest, and accessing its literal edge is sufficient to access its head as well. In contrast, the superficially similar ALIGN-PRWD' determines both foot placement and word-level prominence simultaneously. If the head end of the main stress foot were allowed to vary in Hebrew's generally two- to four-syllable words, i.e., if violations of FTFORM such as in *nix.[nás.tem]* were allowed to satisfy the language's constraint on alignment to the prosodic word, the notion of the stress foot would be significantly weakened. The revision in (23) thus appears justified, whatever its ultimate formal derivation.

(25) ALIGN(CAT,EDGE; HEAD(CAT),EDGE)

Align the prosodic word with the foot heading the prosodic word.

This discussion would be incomplete without considering the possibility that Modern Hebrew stress has nothing to do with foot alignment at all. It should be recalled that the existence of foot structure was inferred from the prosodic hierarchy assumed at the outset. But as the fact emerges that both the stem-final and word-final stress generalizations actually target not the edges but the heads of feet, that assumption becomes much less tenable. A constraint referring to the head of a foot refers to the stressed syllable itself. Though an alternative account unmediated by foot structure is beyond the scope of this paper, relaxing the strictures of foot-level prosody is certainly an option worthy of future probing.

Returning now to the analysis developed here, the constraint ranking which has been established is summarized in (26). What is special about verb stress in Modern Hebrew is that it answers to the three hierarchically contiguous constraints highlighted in (26), namely ALIGN-ROOT, \*LL, and ALIGN-STEMV, which play no role in the evaluation of nominals.

- (26) PARSE SUFFIXES >> PARSE HiV >> \*LL >>  
 FILL/MSEG > FTBIN ALIGN-ROOT  
 ALIGN-R
- >> PARSE V >> FTFORM  
 ALIGN-STEMV ALIGN-PRWD'

The strongest position within Optimality Theory is that the inventory of constraints is universal, with constraint ranking organized on a language-particular basis. The interpretation of the Modern Hebrew hierarchy which is compatible with this attributes all of the language's constraints to a common pool, with a subset of them ranked so low outside the verb-specific hierarchy that they are not visibly active. For nominal forms, the highest-ranked constraint pertaining to foot alignment is ALIGN-PRWD'. The contrast between, e.g., the past tense verb *higdila* and the participial form of the same verb *magdila*, is thus accounted for by a rearrangement of the EVAL hierarchy to which two major morphological classes are subject.

## 5. Conclusions and Consequences.

In summary, Optimality Theory provides a way to express the morphological limitation on stem-final verb stress in Modern Hebrew, while simultaneously recognizing that those verbal forms which lack a stem-final vowel to carry the stress simply default to the language's general word-final stress rule. This notion is formalized by way of a set of verb-specific constraints which compete to determine foot placement, their effectiveness derived from their high ranking in the component evaluating verbs. Vowel deletion and stress are separate generalizations, subject to different constraints in the system. Deletion is a response to the high ranking of \*LL for verbs, while stem-final stress results from a separate but lower priority constraint on foot alignment, the effects of which emerge whenever the stem-final vowel is parsed.

While the elevation of constraints particular to verbs has to be stipulated for that morphological class, such a stipulation is not inappropriate, since the verbal system is the most highly constrained sector of Modern Hebrew morphology in other ways as well. When new words are borrowed into the language they must be adapted to an existing Modern Hebrew prosodic template in order to be well-formed as verbs, whereas they can normally be taken over wholesale for use as nouns. To cite just one example, the English noun 'telephone' is incorporated directly into Modern Hebrew as *télefon* ~ *telefónim* sg. ~ pl., whereas the verb 'to telephone' is assimilated to the Pi'el conjugation class as *tilfén* ~ *metalfén* ~ *yetalfén* 3.m.sg. past ~ part. ~ fut.

There is one important problem inherent in the Optimality analysis which remains to be addressed, namely the derived schwa mentioned earlier. As the analysis stands, it is not possible to regulate the appearance of schwa by the same constraint hierarchy that accomplishes vowel deletion, since the two hierarchies make conflicting demands on exactly the same aspect of the representation. The grammar takes a CCCV. input and syllabifies it as CCə.CV., i.e., into a sequence of two open syllables, precisely the configuration which is disallowed by the \*LL constraint. Though the significance of schwa was minimized throughout the exposition above so as not to muddy the more central arguments, that element does present a challenge. One possibility for dealing with it is to leave the deleted vowel's features unparsed, assuming that a featureless root node or vowel slot is

default-realized as schwa in the course of phonetic implementation. Still more needs to be said, however: even in the absence of associated features, there remains a prosodic position, and this is just the aspect of the representation which needs to be ignored for purposes of stress assignment. It would thus be necessary first to recast the units of prosody so that syllables headed by vowels lacking features do not project onto feet, and second, to rewrite the \*LL constraint so that such prosodically inert syllables do not violate it.

However, an equally plausible option for the Modern Hebrew facts would be to give explicit recognition to multiple levels of analysis. Such levels are not defined morphologically, as are the levels distinguishing verbs and nominals in the foregoing discussion. Instead, they capture the different phonotactic requirements that induce deletion and schwa, respectively. This amounts to what is called 'serialism' in the Optimality literature (Prince and Smolensky 1993, McCarthy 1994) and constitutes a retreat from the Optimality ideal that candidate evaluation proceeds monostratally. But it is significant that when coupled with a limitation on the number of levels to those motivated by phonotactic necessity, this slightly more permissive form of Optimality strongly resembles the theory of Harmonic Phonology as developed by Goldsmith 1990, 1993. An interpretation of the focal verb generalizations within Harmonic Phonology is presented in (27) below, which shows that it is still possible to limit the description of the phonotactics at each level to constraints on the representations at each individual level.

(27)	M-Level: Vowel Deletion (*LL) Stress (ALIGN-STEMV>>ALIGN-PRWD')	tixtov-i (UR) tix.t(o)v-i (M-output)
	W-Level: Epenthesis (*CCC)	tix.t(ə)v-i (W-output)

Finally, a few retrospective words on the previous analyses are in order. Bat-El's 1989 cyclic account fails to satisfactorily explain what makes Modern Hebrew verb stress special, since it attributes the different stress patterns of the major lexical categories to a difference in the lexical strata at which their affixes attach, whereas the same basic stem-suffix structure is exhibited in both cases. Furthermore, cyclic application of a unitary stress rule fails to represent the important differences between stem-level and word-level applications of stress. The Optimality analysis eliminates this problem by introducing a single special stress constraint for verbs, distinct from the general constraint which holds in the default case.

The columnar stress generalization discussed above might seem to be completely epiphenomenal under an Optimality account. However, the constraint hierarchy and stress-template analyses can be superimposed and construed as simultaneous micro- and macro-level views of the same system. Strong resemblances between the two analyses are readily apparent: both target a foot-sized constituent, and both determine its position in the word via morphological alignment. The columnar stress pattern provides a perceptual motivation for the special arrangement of verb constraints, and the fact that formally deviant cases have been regularized over time supports this idea. Hebrew verbs (unlike nominals, cf. Aronoff 1994) are related

paradigmatically. The retraction of word-final stress in the Hebrew second person plural past forms, which has changed historical (now prescriptive) *kətav-tém* (masc.)/*kətav-tén* (fem.) to *katáv-tem/katáv-ten* in the modern colloquial language, is a classic case of analogy within a paradigm. The constraint hierarchy and the columnar stress pattern provide alternative ways of viewing such analogical change, since they both identify, at different analytical levels, the location of stress, one of the most important unifying features of the Modern Hebrew verbal paradigms.

#### References.

- Anderson, Stephen. 1985. *Phonology in the Twentieth Century*. Chicago: University of Chicago Press.
- Anderson, Stephen. 1992. *A-Morphous Morphology*. Cambridge: Cambridge University Press.
- Aronoff, Mark. 1994. *Morphology by Itself: Stems and Inflectional Classes*. LI Monograph 22. Cambridge: MIT Press.
- Bat-El, Outi. 1989. *Phonology and Word-Structure in Modern Hebrew*. UCLA dissertation.
- Bolozky, Shmuel. 1972. On Morphological and Phonetic Constraints in Modern Hebrew. *Hebrew Computational Linguistics Bulletin* 6: 1-12.
- Bolozky, Shmuel. 1978. Some Aspects of Modern Hebrew Phonology. In Ruth A. Berman, *Modern Hebrew Structure*. Tel Aviv: University Publishing.
- Bolozky, Shmuel. 1982. Remarks on Rhythmic Stress in Modern Hebrew. *J. Linguistics* 18: 275-289.
- Dobrin, Lise M. *Columnar Stress in the Modern Hebrew Verbal System*. Presented at the 22nd Meeting of the North American Conference on Afroasiatic Linguistics. Madison, WI, March 1994.
- Goldsmith, John. 1990. *Autosegmental and Metrical Phonology*. Oxford: Blackwells Publishers.
- Goldsmith, John. 1993. Harmonic Phonology. In John Goldsmith (ed.). *The Last Phonological Rule: Reflections on Constraints and Derivations*. 21-60. Chicago: The University of Chicago Press.
- Hooper, Joan and Tracy Terrell. 1976. Stress Assignment in Spanish: A Natural Generative Analysis. *Glossa* 10.1: 64-110.
- Janda, Richard. 1992. Metrical Phonology and the "Columnar" Morphology of Spanish Verb Stress. In A. Crochetière et al. (eds.). *Proceedings of the 15th International Congress of Linguists*. Université Laval, Quebec.
- Lakoff, George. 1993. Cognitive Phonology. In John Goldsmith (ed.). *The Last Phonological Rule: Reflections on Constraints and Derivations*. 117-145. Chicago: University of Chicago Press.
- McCarthy, John. 1979. *Formal Problems in Semitic Phonology and Morphology*. MIT dissertation.
- McCarthy, John. 1986. OCP Effects: Gemination and Antigemination. *LI* 17: 207-263.

- McCarthy, John. 1993. *The Parallel Advantage: Containment, Consistency, and Alignment*. Handout from presentation at the Rutgers Optimality Workshop, Rutgers University, New Brunswick, NJ.
- McCarthy, John, and Alan Prince. 1986. *Prosodic Morphology*. ms., University of Massachusetts, Amherst, and Brandeis University.
- McCarthy, John, and Alan Prince. 1990. Root and Word in Prosodic Morphology: The Arabic Broken Plurals. *NLLT* 8: 209-282.
- McCarthy, John, and Alan Prince. 1991. *Linguistics 240: Prosodic Morphology*. Lectures and handouts from 1991 Linguistic Institute Course, University of California, Santa Cruz.
- McCarthy, John, and Alan Prince. 1993a. *Prosodic Morphology I: Constraint Interaction and Satisfaction*, ms., University of Massachusetts, Amherst, and Rutgers University.
- McCarthy, John, and Alan Prince. 1993b. *Generalized Alignment*. Rutgers Technical Report #7.
- McCarthy, John, and Alan Prince. 1994. *The Emergence of the Unmarked: Optimality in Prosodic Morphology*. ms. University of Massachusetts, Amherst, and Rutgers University.
- Prince, Alan. 1975. *The Phonology and Morphology of Tiberian Hebrew*. MIT dissertation.
- Prince, Alan. 1983. Relating to the Grid. *LI* 14: 19-100.
- Prince, Alan, and Paul Smolensky. 1993. *Optimality Theory: Constraint Interaction in Generative Grammar*. ms., Rutgers University and University of Colorado, Boulder.
- Rappaport, Malka. 1984. *Issues in the Phonology of Tiberian Hebrew*. MIT dissertation.
- Reyes, Rogelio. 1972. *Studies in Chicano Spanish*. Harvard dissertation.



This work is licensed under a [Creative Commons Attribution 4.0 International License](https://creativecommons.org/licenses/by/4.0/).