THE FATE OF THE CONSONANTAL ROOT AND THE BINYAN IN OPTIMALITY THEORY

Outi Bat-El
Tel-Aviv University

The paper provides an Optimality Theoretic account to Modern Hebrew non-concatenative morphology. It argues that the base of derivation is the word/stem, modified by constraints assigning the prosodic structure, the vocalic pattern, and the affixes (if any). The notion of the binyan is viewed as a configuration of the structures assigned by these constraints. The consonantal root is entirely eliminated from the grammar. The latter is supported by arguments from historical change and learnability.

0. Introduction

Linguistic generalizations can be formally expressed in different ways, depending on the theoretical framework in which the analysis is couched. Consequently, the grammatical units assumed can be quite dissimilar as well. In this paper I provide an analysis of Modern Hebrew non-concatenative morphology within the framework of Optimality Theory (briefly reviewed in §1). In particular, I reconsider the status of the consonantal root and the binyan in the grammar as grammatical units, within a word-based morphology.[1]

Bat-El (1994a) and Ussishkin (1999, 2000) argue for a word-based view of Hebrew morphology (termed output-output correspondence in Optimality Theory) that does not give place to the consonantal root (here after C-root) in the grammar (see §3). Further support to this view is given here, on the basis of evidence from historical change (§3.1), as well as the learnability principles of Optimality Theory (§3.2). It is argued that historical changes affect words, rather than C-roots, and that the learning process leads to the construction of a word as an input, rather than a C-root.

The structural status of binyanim (for verbs, as well as mishkalim for nouns) is, of course, not dispensed with like that of the C-root. As in McCarthy (1979, 1981), I view the binyan as a configuration, composed of independent structural properties:

[1] While I concentrate here on Modern Hebrew morphology, the general principles are by no means specific to this language. Other Semitic languages displaying a certain degree of non-concatenative morphology, as well as non-Semitic languages displaying some characteristics of non-concatenative morphology (see Bat-El 2003a), can be reconsidered under this approach.

prosodic structure, vocalic pattern (hereafter V-pattern), and in some cases also a prefix. Each of these properties is represented in the grammar by constraints or constraint schema. Prosodic structure (§2.1) is expressed by universal constraints independently motivated for in other languages. Prefixes (§2.3), as well, are introduced by the general alignment constraint schema (McCarthy and Prince 1993b), which may interact with the prosodic structure constraints (§2.4). The V-patterns (§2.2), although viewed as affixes in the sense that they are imposed on the base (at the cost of losing the base vowels), have an independent constraint schema, as alignment can never be surface true due to restrictions on syllable structure. Before concluding (§5), a sample of tableaux is presented, showing the formal account of Optimality Theory for relations between words in non-concatenative morphology (§4).

1. The Basics of Optimality Theory

Optimality Theory, first introduced in Prince and Smolensky (1993) and McCarthy and Prince (1993a), is an output oriented constraint-based framework.[2] The architecture of Optimality Theory consists of a generator (GEN), an evaluator (EVAL), and a set of universal constraints (CON).[3] GEN produces all possible output candidates for a given input (out of which only the relevant ones are usually considered), and EVAL evaluates the candidates with respect to a language-specific ranking of CON. The optimal candidate is the one that minimally violates the constraint ranking.

Evaluation procedures (as well as the linguist's ranking arguments) are presented in tableaux, like the one in (1) below. For illustration, let us assume a language whose CON consists of $\text{C}{\scriptsize\text{ON}}_1$ >> $\text{C}{\scriptsize\text{ON}}_2$ >> $\text{C}{\scriptsize\text{ON}}_3$ >> $\text{C}{\scriptsize\text{ON}}_4$ (where "X >> Y" denotes "X is ranked above Y"), and the relevant candidates produced by GEN for an input INP are cand-a, cand-b, and cand-c. The input is placed in the leftmost top cell in the tableau,

[2] See Archangeli and Langendoen (1997), Kager (1999), and McCarthy (2002a) for detailed reviews of the theory.

[3] See, however, Boersma (2000) and Carr (2000) for arguments against universality in phonology.

the candidates are given in a random order in the leftmost column, and the constraints are listed, left-to-right high-to-low ranking, in the top row.

(1) A schematic example of an evaluation procedure

INP	CON_1	CON_2	CON_3	CON_4
☞ cand-a		**	*	*
cand-b	*!		*	
cand-c		**	**!*	

The top ranked constraint CON_1 is violated by cand-b; constraint violation is marked with an asterisk (*). As there are candidates that do not violate CON_1, CON_1violation by cand-b is fatal; a fatal violation is marked with an exclamation mark (!) after the asterisk. A fatal violation throws the candidate out of the competition, and its performance with respect to lower ranked constraints is no longer relevant; irrelevant performance is indicated by shaded cells. Cand-a and cand-c tie with respect to CON_2, as both violate it to the same degree (two violations each). Therefore CON_2 cannot select the optimal candidate in this case. Both cand-a and cand-c also violate CON_3. However, cand-c has more violations of CON_2 than cand-a. The second violation of cand-c is fatal (thus followed by !), since cand-a has only one violation, and therefore cand-a is selected as the optimal candidate, as indicated by the pointing hand (☞) in the candidates column. Notice that the optimal candidate violates CON_4. However, this is irrelevant, since CON_4 is ranked low in the hierarchy such that its effect does not emerge in the evaluation of the candidates of INP (though it may emerge with respect to other inputs). The optimal candidate is selected when all other competing candidates have been eliminated, and thus any further violations are insignificant (thus shaded). The optimal candidate, i.e. the output form, is not absolutely wellformed, as it violates some constraints; however, the violation is minimal given the language specific constraint hierarchy.

As made explicit in McCarthy and Prince’s (1995b) theory of correspondence, there are two basic types of constraints, markedness and faithfulness. Markedness constraints require the output (without reference to the input) to include a certain structure (e.g. ONSET: a syllable has an onset), or not to have a certain structure (e.g.

*CODA: a syllable does not have a coda). Faithfulness constraints require identity between the input and the output, or alternatively, as argued in Struijke (2000), require the output to preserve the structural properties of the input. The input to which faithfulness constraints refer can be an (abstract) underlying form (in which case input - output correspondence is involved) or a surface form (in which case output - output correspondence is involved).

In this paper, I reject the notion of an abstract underlying representation in Hebrew morphology (though I do not make any general claims against underlying representations in grammar), arguing that the relation between words is a case of output - output correspondence (McCarthy and Prince 1995b, Benua 1997). I adhere to the principle of "paradigm optimization" (Tesar and Smolensky 2000), showing that although, by "richness of the base" (Prince and Smolensky 1993), any input is possible (whether an abstract or a surface form), Hebrew learners can arrive only at a surface form when selecting the base for another surface form (I use the terms base and input interchangeably, where in both cases I refer to a surface form).

2. The Binyan

Traditional studies in Semitic morphology view the binyan (or mishkal) as a unit composed of vowels, affixal consonants, and slots for the root consonants. This view is couched within a linear approach to phonology, where the structural distinctions between prosodic and segmental elements and between segmental elements of different types (i.e. vowels and consonants) are not available. There is, however, a concealed multi-leveled representation in such an approach, which is inevitable given the non-concatenative nature of Semitic morphology. For example, Gesenius (1910) refers to the function of the vowels in a stem, the strengthening of the consonants (gemination), and the affixes as independent morphological characteristics of surface forms.

With the development of non-linear phonology in the study of tonal systems, McCarthy (1979, 1981) presented the binyan as two (and sometimes three) morphemes, the V-pattern and the prosodic template (and in some cases also a derivational affix). Later studies in prosodic morphology (McCarthy and Prince 1986, 1995a), showed that prosodic templates could be derived from more general constraints, not necessarily specific to Semitic morphology, and thus need not be specifically associated with the binyanim or mishkalim (see §2.1 below).

Within the constraint-based framework of Optimality Theory, all structural properties can be represented by constraints. In the following subsections I introduce the constraints responsible for the configuration of the binyanim in Hebrew: the prosodic structure (§2.1, 2.4), the V- patterns (§2.2), and the prefixes (§2.3).[4]

2.1. Prosodic Structure: Words

Many Semitic languages exhibit preference for disyllabic words. For example, most Hebrew verbs are disyllabic and so are many of the nouns and adjectives (e.g. *diber* 'to talk', *tirgem* 'to translate', *h-ixnis* 'to put in', *cayar* 'painter', *ʔaxbar* 'mouse', *m-igdal* 'tower', *xiver* 'pale'). As argued in McCarthy and Prince's (1986, 1995a) study of prosodic morphology, the disyllabicity preference found in Semitic morphology reflects the universal preference for a binary foot, either syllabic or moraic. Indeed, the foot plays a role in the morphology of non-Semitic languages as well, where it often limits the minimal size of content words (function words are often sub-minimal). For example, English content words are minimally bimoraic, CVV or CVC (Goldston 1991), thus allowing *ti:k* 'teak', *tɪk* 'tick', *ti:* 'tea' but no **tɪ*. Lardil (an Australian language) actively rejects words smaller than a disyllabic foot, by inserting segments to a subminimal root and blocking vowel deletion in a disyllabic word (see examples at the end of this section).

The minimal word restriction is imposed by two constraints, one ensuring that the word consists of only one foot (2a) and the other that the foot is binary (2b).

---

[4] Here are the V-patterns, prosodic structure and prefixes (specified consonants) of the five binyanim in Hebrew, as they appear in regular verbs (throughout the paper, stress is final unless otherwise specified). C^n indicates a possible cluster: B1: CaCaC (*gadal* 'to grow'); B2: niCCaC (*nixnas* 'to enter'); B3: hiCC^{n}iC (*higdil* 'to enlarge');B4: CiC^{n}eC (*kibel* 'to receive');B5: hitCaC^{n}eC (*hitraxec* 'to shower').

(2) Minimal Word constraints (WordMin)

a. All Feet Right/Left (AllFtR/L) (McCarthy and Prince 1993b)
The right (left) edge of every foot is aligned with the right (left) edge of the prosodic word

b. Foot Binarity (FtBin) (Prince and Smolensky 1993)
Feet are binary on the moraic or syllabic level

The constraints in (2) assume the prosodic hierarchy (Selkirk 1980), where the prosodic word dominates the foot, and the foot dominates syllables or moras. Thus, when the edges of all feet in a word align with the edges of the prosodic word (2a) there can only be one foot in a prosodic word, and when this foot is binary (2b), the prosodic word consists of a single binary foot. In the structures below, only (3a) respects the two WordMin constraints. The structure in (3b) respects FtBin, but violates AllFtR/L, since the inner edges of both feet do not align with an edge of the prosodic word. The structure in (3c) violates both FtBin (in the leftmost foot) and AllFtR/L (see §2.4 for the prosodic structure within the syllables).

(3)

	a. $[[\square\ \square]_F]_{PrWd}$	b. $[[\square\ \square]_F[\square\ \square]_F]_{PrWd}$	c. $[[\square\ ]_F[\square\ \square]_F]_{PrWd}$	
	√	√	*	FtBin
	√	*	*	AllFtR/L

While in most languages WordMin defines the minimal size of stems, in many Semitic languages it also restricts the maximal size of stems.[5] It might seem that in Hebrew WordMin is redundant, as the V-pattern consists of two vowels, thus imposing disyllabicity (assuming that no vowel can be added to or deleted from the V-pattern; see §2.2). However, we can see the effect of WordMin in the formation of Hebrew acronym words, where there is no specific V-pattern; rather, a default *a* (in most cases) appears in every nuclear position (Bat-El 1994b and Zadok 2002). Acronym words are in most cases disyllabic, regardless of the number of words in the input.[6] For example, both the two word base *matbéa xuc* 'foreign currency' and the three word base *merkaz texnologia xinuxit* 'educational technology center' surface as

[5] Minimal and maximal demarcation by WordMin is also found in reduplicative affixes (McCarthy and Prince 1995a,b), hypochoristics (Poser 1990, Itô 1990), and some stages of language acquisition (Demuth 1996).

[6] There are also a few monosyllabic acronym words (e.g. *xak* from *xaver kneset* 'parliament member') as well as trisyllabic (e.g. *samankal* from *sgan menahel klali* 'deputy manager').

the acronym word *matax*.[7] Note that bases with four words also give rise to disyllabic acronym words, as in *mamram*, whose base is *merkaz mexaʃvim (ve-)riʃum memuxan* ‘automated computer center’. Moreover, there are hardly any acronym words whose base consists of five consonants, due to the prohibition on complex syllable margins (*CCVCCVC) and WORDMIN (*CVCVCVC). It should be noted that the structure of acronym words in Hebrew is identical to that of basic stems (cf. *matax* vs. *matar* ‘rain’, *mamram* vs. *sarbal* ‘overalls (garment)’), though prosodically they are more limited (by not allowing complex syllable margins) and segmentally more permissive (by having plenty of forms with identical consonants in the stem).

WORDMIN demarcates not only the size of the stem but also the size of a suffixed form, especially in verbs. Ussishkin (2000) and Adam (2002) argue that vowel deletion in verbs, which occurs before vowel initial suffixes, is due to WORDMIN (e.g. *gadal-a* ---> *gadla* ‘she grew’, *kibel-u* ---> *kiblu* ‘they accepted’). There are, however, cases where WORDMIN cannot be fully respected, due to higher ranked constraints. When the penultimate syllable in the verb is closed, the vowel cannot be deleted since verbs do not allow complex onsets (unless it appears throughout the paradigm, as in *sinxren – sinxranti - sinxrenu* ‘he - I - they synchronized); in this case the vowel changes to *e*, a matter that I will not discuss here (e.g. *yigmor-u* ---> *yigmeru* ‘they will finish’, *tigdal-i* ---> *tigdeli* ‘you fm. will grow’). *COMPLEX, which prohibits complex syllable margins, has to be ranked above WORDMIN in order to account for the failure of vowel deletion in the latter cases. MAXV, which prohibits vowel deletion, is, of course, ranked below WORDMIN (square brackets indicate foot structure).[8]

[7] As argued in Zadok (2002), these are not pure acronym words, where only the first segment of each word in the base is selected, but rather clipped compounds. This distinction is not relevant here.

[8] Notice that *COMPLEX also determines which vowel would delete, as deletion of the vowel in the first syllable (*gadal-a* ---> **gdala*) results in an initial complex onset. In some nouns and most adjectives, however, where a complex onset is not prohibited, *a* is deleted in the first syllable (e.g. *gamal-im* ---> *gmalim* ‘camels’, *kaxol-im* ---> *kxulim* ‘blue sg.-pl.’) and *e* in the second (e.g. *xiver-im* ---> *xivrim* ‘pale pl.’). I do not dwell here on the distinction between nouns and verbs in this respect; see Bat-El (2001a).

(4) a. Vowel deletion: *gadal-a* ---> *gadla* 'she grew'

gadal-a[9]	*COMPLEX	WORDMIN	MAXV
a. [ga.da][la]		*!	
b. [gad.la]			*

b. Vowel retention: *tigdal-i* ---> *tigdeli* 'you fm. will grow'

tigdal-i	*COMPLEX	WORDMIN	MAXV
a. [tig.de][li]		*	
b. [tig.dli]	*! (*dl*)		*

To conclude this section, the prosodic template of the binyan is not viewed as a primitive unit specific to Semitic morphology. Rather, it results from the joint effect of universal constraints, the WORDMIN constraints, enforced outside of Semitic morphology as well. When WORDMIN is fully respected, the word consists of no more and no less than two syllables (or moras). However, higher ranked constraints may force violation of one or both of the WORDMIN constraints, resulting, as in the above example, in a trisyllabic word. In languages where WORDMIN restricts only the minimal size of the word, WORDMIN is outranked by faithfulness constraints against deletion (i.e. words consisting of more than a foot cannot be shortened) but not against insertion (i.e. words consisting of less than a foot can be expanded). For example, as shown in Kenstowicz and Kisseberth (1979) and McCarthy and Prince (1993a,b), among others, subminimal roots in Lardil undergo epenthesis in order to respect WORDMIN (e.g. */wun/* - *wun<u>ta</u>* - *wun-in* 'rain Uninflected - Nonfuture', where the *t* and the *a* are arguably epenthetic). However, roots exceeding the minimal word size do not undergo deletion (e.g. *yaraman* 'horse' **yara*). Furthermore, final vowel deletion (e.g. */wuluna/* - *wulun* - *wulunka-n* 'fruit Uninflected - Nonfuture') is blocked when the root is disyllabic, to avoid violation of WORDMIN (e.g. *pape* 'father's mother').

[9] In §2.3 I argue that affixes are presented by constraints. But for the time being I use the more common presentation, where affixes are given in the input.

2.2. The Vocalic Pattern

Not every possible pair of vowels can appear in a (disyllabic) stem in Hebrew. For example, there is no Hebrew verb form with the V-pattern *ei*. The V-patterns are an arbitrary subset of all possible pairs of the language's vowels. There are no independently motivated phonological constraints that rule out the non-existing pairs.[10] The V-patterns must then be structural morphological units.

The V-pattern can be viewed as an affix, whose position within the stem is determined by prosodic restrictions (Ussishkin 2000). There are two views, within the rule-based approach, as to the status of affixes in the grammar (Hockett 1954). The syntactic-oriented view adheres to the Item-and-Arrangement model, where affixes are listed lexical items, which differ from roots (not in the Semitic sense) in being bound (Selkirk 1980 Lieber 1992). The other view, advocated in Aronoff (1976), Kiparsky (1982), and Anderson (1992), among others, adopts the Item-and-Process model, where affixes are included in the morphological rule, and the input is only the root or the stem.

If we view constraints as the analogue of rules in the sense that both trigger processes (though in a very different way), then most studies in Optimality Theory may be said to adopt a mix of the two models. On the one hand, affixes, just as roots/bases, are introduced as lexical items in the input, and on the other hand an alignment constraint places the affix in its position with respect to the base/root (i.e. as prefix or a suffix). Russell (1995, 1999), however, eliminates this duality, arguing that affixes should be introduced as constraints only, as in the Item-and-Process model (see also Yip 1998, Adam and Bat-El 2000, Adam 2002, Bat-El 2003b). I adopt here the constraint-based view of affixation, presenting a case where it has stronger explanatory power.

I assume a constraint schema V-PATTERN (hereafter VP), specified for the set of V-patterns associated with the binyanim; e.g. VP4{ie}, VP5{ae}, etc. (see fn. 4 for the

[10] See, however, Guerssel and Lowenstamm's (1990, 1996) analysis of Classical Arabic verbs, where the vowel in a derived stem can be predicted on the basis of the quality of the lexically specified vowel of the base.

other vocalic patterns).[11] An input has to be specified for the binyan required in the output, and the specification on the VP constraint has to match this requirement. There are two situations under which a candidate incurs a violation mark for a VP constraint: (i) V-pattern mismatch - when the V-pattern of the candidate differs from that required by the VP constraint, and (ii) binyan mismatch - when the V-pattern of the candidate does not match the V-pattern specification required from the output. The VP constraints of the different binyanim (only two are given below for illustration) are not ranked with respect to each other (as indicated in the tableau by the dotted line).

(5) V-pattern selection: *sabon* 'soap' ---> *siben* 'to soap'

sabon - B4	VP4{ie}	VP1{aa}
a. saban	* (V-pattern mismatch)	* (binyan mismatch)
b. ☞ siben		* (V-pattern mismatch)
c. sebin	* (V-pattern mismatch)	* (V-pattern mismatch)

The vowels in cand-c do not constitute a licit V-pattern in Hebrew, and therefore this candidate gets a violation mark under all VP constraints (V-pattern mismatch). There will always be a candidate (actually five, corresponding to the five binyanim) that fares better than a candidate with an illicit V-pattern, and therefore a verb with an illicit V-pattern would never be surface true (unless a higher-ranked phonological constraint requires so). Cand-a gets a violation mark under VP4{ie}, because its V-pattern is {aa} (V-pattern mismatch), and another violation mark under VP1{aa}, since, as specified in the input, the output has to be in B4 (i.e. {ie}), rather than B1 (binyan mismatch). Given the five binyanim in Hebrew, and thus the five VP constraints, all the five candidates with a licit V-pattern would get four violation marks for V-pattern mismatch, and four of them would get one violation mark for a

[11] Note that I use "binyan" as a convenient term, referring to the entire configuration of V-pattern, prosodic structure, and prefixes (see fn. 4). VPn{v_iv_j} thus says that the verb has to consists of that specific vocalic pattern. The prosodic structure and the prefix would be assigned by other constraints. The constraint schema assigning the V-patterns can be viewed as an alignment constraint requiring the vowels to be at the edges of the stems. Higher ranked constraints on syllable structure, in particular those requiring a final stem consonant and an onset, would force the vowels to be inside the stem and not adjacent.

binyan mismatch. Thus, when the output has to be in Bn, the candidate that satisfies VPn would be the optimal candidate.

There are, however, cases where the same binyan has two V-patterns. These cases, I claim, support the constraint-based approach to V-patterns (and since V-patterns are viewed as affixes, then to affixation in general).

B4 and B5 have the regular V-patterns {ie} and {ae} respectively (where B5 also has a prefix *hit*-; see §2.3). For historical reasons, which will not concern us here, some reduplicated forms in B4 and B5 have an irregular V-pattern {oe}.[12] Thus, *x**i**ber* 'to connect' and *x**i**ded* 'to sharpen' contrast with *x**o**kek* 'to make a law' in B4, and *hitr**a**xec* 'to shower' and *hitb**a**ses* 'to get established' contrast with *hitk**o**nen* 'to get ready' in B5.

The {oe} pattern is marginal. It appears only in some reduplicated forms with a CVCVC stem (i.e. it never appears in forms like *gilgel* 'to roll' and *hitbalbel* 'to get confused'). In addition, a few {oe} verbs adopted the regular V-pattern in non-standard usage (e.g. *pocec* ~ *picec* 'to bomb B4', *hitʔolel* ~ *hitʔalel* 'to be cruel B5'), but no reduplicated {ie} verb adopted the {oe} pattern.

Despite its marginality, the {oe} pattern is selected for some newly derived denominative verbs. This selection is, however, not sporadic. As noted in Bat-El (1994a), {oe} is selected only for verbs derived from nouns with *o* (e.g. *xok* 'law' ---> *xokek* 'to make a law', *ʔot* 'sign' ---> *ʔotet* 'to signify', *boks* 'box (fist)' ---> *hitbokses* 'to fight (with fists)'). In addition, a few denominative verbs exhibit free variation, where both {oe} and {ie} are found (e.g. *kod* 'code' ---> *koded* ~ *kided* 'to codify'), parallel to the register variation noted above with respect to old verbs with {oe}.[13]

---

[12] Reduplicated forms have one or two identical consonants at the right periphery of the stem. As argued in Bat-El (2002a), both CVC$_i$VC$_i$ and C$_i$VC$_j$C$_i$VC$_j$ stems involve similar derivational devices.

[13] In such cases, the regular {ie} pattern is associated with non-standard usage. It should be noted that many B4 verbs which in the standard usage have the {oe} pattern appear in non-standard usage in either the {ie} pattern of B4 or the {aa} pattern of B1. The reason for the shift to B1 is that B4 {oe} past forms are homophonous with B1 participle forms; in both the V-pattern is {oe} and the prosodic structure is CVCVC (though B1 participles host reduplicated as well as non-reduplicated forms; e.g. *ʃoded* 'robber', *ʃomer* 'guard').

I claim that the variability in the V-patterns cannot be explained within an Optimality Theoretic model of Item-and-Arrangement since only one V-pattern can appear in the input. That is, the V-pattern itself cannot be introduced in the input. However, if the V-patterns are introduced as constraints, and the input is just specified for the binyan required in the output, the variability can be accounted for with constraint interaction.[14]

There are two VP4 (as well as VP5) constraints, VP4{ie} and VP4{oe}, which must be ranked with respect to each other to account for the preference of {ie}. The ranking VP4{ie} >> VP4{oe} would allow only VP4{ie} to be surface true. However, if we assume a higher ranked constraint IDENT[o], which requires preserving an input *o* in the output, we would get the {oe} pattern in denominative verbs derived from bases with *o* (6a) and the {ie} pattern in verbs derived from bases with a vowel other than *o* (6b).

(6) a. {oe}: *xok* 'law' ---> *xokek* 'to make a law'

xok - B4	IDENT[o]	VP4{ie}	VP4{oe}
a. xikek	*!		*
b. ☞ xokek		*	

b. {ie}: *cad* 'side' ---> *cided* 'to side with'

cad - B4	IDENT[o]	VP4{ie}	VP4{oe}
a. ☞ cided			*
b. coded		*!	

Formally, the distinction between *xokek* (6a) and *cided* (6b) could be achieved within the Item-and-Arrangement model, where the V-pattern would be specified in the input, {oe} for *xok* and {ie} for *cad*. However, such an approach does not express the generalization that only bases with *o* give rise to the {oe} pattern in denominative verbs, nor that {oe} is a marginal V-pattern. Under this approach the selection of {oe} by *xok* is arbitrary, and *cad* could as well select {oe}.[15]

[14] See, however, McCarthy (2002b), where the two nominalizing allomorphs in Nakanai (new Britain), *-il-* and *-la*, are introduced in the input. In addition, there are two different alignment constraints, one for each affix. When the undominated constraint attaching *-il-* cannot be respected, the default suffix *-la* is attached.

[15] The approach advocated here fails to account for the fact that the {oe} pattern appears only in reduplicated forms (e.g. *ʃóreʃ* 'root' ---> *ʃireʃ* 'to root' **ʃoreʃ*).

Furthermore, such a model cannot account for the free variation found in *kided* ~ *koded* ‘to codify’, both derived from *kod* ‘code’. Within the framework of Optimality Theory, free variation is accounted for by “crucial non-ranking” (or “free ranking”; see Anttila 2002 and references therein). When constraints A and B are crucially unranked, there are two grammars, A >> B and B >> A, where each grammar produces a different output. Quite often, the different rankings are not available for a single lexical item, but rather for two different items of the same relevant morpho-phonological make up (cf. *hitxanen* (**hitxonen*) ‘to beg for mercy’ vs. *hitʔonen* (**hitʔanen*) ‘to complain’). In other cases, both ranking are available for the same input, which then has two surface forms, as in *koded* ~ *kided* ‘to codify’. To account for the free variation in the present case, IDENT[o] and VP4{ie} have to be crucially unranked.

(7) Crucial non-ranking: IDENT[o] <> VP4{ie}

a. *kod* ---> *k**o**ded*: IDENT[o] >> VP4{ie} (>> VP4{oe})

b. *kod* ---> *k**i**ded*: VP4{ie} >> IDENT[o] (>> VP4{oe})

From the analysis above it seems that IDENT[o], by preserving the base *o*, renders VP4{oe} redundant, which would entail that there is no such V-pattern as {oe}. However, recall that many verbs with this pattern are not denominative (e.g. *hitʔonen* ‘to complain’), where the *o* cannot be attributed to a base (in the current stage of the language). Also, as noted above, in order for a form to be a permissible Hebrew verb it must have one of the language’s V-patterns, and therefore we must assume that {oe} is a V-pattern. Moreover, in other binyanim, with no V-pattern with *o*, a base *o* is not preserved (e.g. *ʃaxor* ‘black’ - *hiʃxir* **hiʃxor* ‘to become black B3’). That is, a base vowel can be preserved only when a V-pattern with this vowel (in the appropriate position) exists independently.[16]

[16] Similarly, the verbs *hiflik* ‘to give a blow B3’ and *hiʃvic* ‘to brag B3’ preserve the vowel *i* and the initial cluster of their bases, *flik* ‘blow’ and *ʃvic* ‘bragging’ respectively. As Bolozky (1978) notes, denominative verbs tend to select a binyan in which they can preserve the phonological property of their base (though semantic considerations may intervene).

To conclude this section, the V-patterns are structural units assigned by constraints (I have no say regarding their morpho-syntactic status). The constraints specify the V-pattern and the binyan (e.g. VP4{ie}), which has to match the binyan specification indicated in the base (e.g. *xad* - B4). This approach is supported here by cases where the same binyan has two vocalic patterns.

2.3. The Prefixes

Some verbal and nominal configurations (i.e. binyanim and mishkalim) in Hebrew include internal prefixes, i.e. consonantal prefixes that occupy a position within the disyllabic structure (see Bolozky and Schwarzwald 1992).

(8) Configuration internal prefixes

a. Nouns

m-	m-igdal 'tower' (cf. gadal 'to grow')	m-inhal 'administration' (cf. nóhal 'procedure')
	m-adrix 'guide' (cf. dérex 'way')	m-azkir 'secratery' (cf. zaxar 'to remember')
	m-axzor 'cycle' (cf. xazar 'to return')	m-axsor 'deficiency' (cf. xóser 'absence')
t-	t-aʃlum 'payment' (cf. ʃilem 'to pay')	t-agmul 'compensation' (cf. gamal 'to reward')
	t-asrit 'screen play' (cf. séret 'movie')	t-axbir 'syntax' (cf. xiber 'to connect')

b. Verbs

h- 'B3'	h-igdil 'to enlarge' (cf. gadal 'to grow')	h-idrix 'to guide' (cf. dérex 'way')
n- 'B2'	n-igmar 'to be finished' (cf. gamar 'to finish')	n-ignav 'to be stollen' (cf. ganav 'to steal')
y- '3pr. Future'	y-axlov 'he'll milk (B1)' (cf. xalav 'he milked')	y-akʃiv 'he'll listen (B3)' (cf. hikʃiv 'he listned')

The prefixes are, in most cases, independent as they can appear in various configurations. For example, the nominal prefix *t-* appears in the configuration CaCCiC (e.g. *t-asrit* 'screen play') as well as in CaCCuC (e.g. *t-aʃlum* 'payment'), and both *t-* and *m-* appear in CaCCiC (e.g. *t-axbir* 'syntax', *m-azkir* 'secratery'). The 3rd person future prefix *y-* (as well as all other future prefixes), appears with all the binyanim, either as an internal prefix (e.g. *y-igmor* 'he will finish B1') or as an external (e.g. *ye-gadel* 'he will raise B4'), where an external affix appears outside the disyllabic foot. The same is true for the participle prefix *m*-, which can be either internal (e.g. *m-atxil* 'he is starting B3') or external (e.g. *me-gadel* 'he is raising B4').

Since the prefixes are independent of the configuration, they have to be specified independently. As with the V-pattern (§2.2), the prefixes are attached via constraints, whose schema is ALIGNL(Pref, PrWd), i.e. the prefix has to be aligned with the left (L) edge of the prosodic word (McCarthy and Prince 1993b). However, most prefixes can appear only in specific configurations. While the (inflectional) future prefixes appear in all the binyanim, regardless of their configuration, the derivational prefix *n*- is limited to B2, whose V-pattern is {ia} (e.g. *n-igmar* 'to be finished'). The prefix *h*- appears in B3 (e.g. *h-itxil* 'to start'), in B5 (*hit-raxec* 'to shower'), and in B2 verbal noun (e.g. *h-ikalt-ut* 'absorbtion'), infinitive (*le-hi-kalet* 'to be absorbed') and the standard form of the imperative (*hi-kalet* 'absorb!'; cf. *n-iklat* 'to be absorbed'). The *t*- prefix in B5 (assuming that *hit*- is composed of *h*- plus *t*- and an epenthetic vowel) is limited to this binyan.

In order to get the correct, language specific, combinations we have to appeal to constraint conjunction, which is another method of constraint ranking (Prince and Smolensky 1993, Smolensky 1993, Lubowicz 1998, among others). A candidate violates a constraint conjunction, in our case ALIGN&VP, iff it violates both ALIGN and VP. For example, if we take candidates {*tixil*, *hatxil*, *hitxil*} for B3, only *hitxil* survives the constraint conjunction ALIGNL(*h*, PrWd)&VP3{ii}, since it is the only candidate that respects both constraints; *tixil* violates ALIGNL(*h*, PrWd) and *hatxil* violates VP3{ii}. This language specific constraint conjunction actually reflects the traditional approach to the binyan/mishkal as composed of a V-pattern and a prefix. We would thus have ALIGNL(*t*, PrWd)&VP{ai} for *taxbir* 'syntax', *tamsir* 'handout', ALIGNL(*m*, PrWd)&VP{ia} for *migdal* 'tower', *mixtav* 'letter', etc. That is, while the constraint schemata are universal, the specified segmental material (i.e. the prefixes and the V-patterns) and the conjunctions are language specific. It is the constraints and the constraint conjunctions that define the licit configurations in the language.

2.4. Prosodic Structure: Syllables

Verbal and nominal configurations may have the prosodic structure CVCVC or CVCCVC. It is tempting to assume a moraic structure (one mora for CV and two for CVC) to distinguish between the two structures (see Gafos 1998). However, this distinction would be relevant only for morphology; the phonology of Modern Hebrew (unlike that of Tiberian Hebrew) does not provide evidence for moraic structure. As shown below, the distinction between these two structures can be, in most cases, independently motivated, without reference to the mora.

In forms without a prefix the structure is contingent upon the number of consonants (suffixed forms, as well as irregular forms are not considered here). Since the output has to be disyllabic, in accordance with WORDMIN (2), a prefixless form with three consonants would have the structure CVCVC (e.g. *gidel* 'to raise', *gadol* 'big', *gódel* 'size'), and with four consonants CVCCVC (e.g. *tirgem* 'to translate', *targum* 'translation'). That is, complex syllable margins are avoided (when possible), and codas are preferred in stem final position. Due to the priority of *COMPLEX over *CODA, CVCCVC is better than CCVCVC (given four consonants), and due to FINALC, which requires a consonant in final position (McCarthy 1993), CVCVC is better than CVCCV (given three consonants). The ranking that defines the syllabic structure is thus *COMPLEX >> *CODA, FINALC (where a coma between two constraints indicates that there is no evidence for crucial ranking).

(9) Syllabic structure

a.

CVCVC	*COMPLEX	*CODA	FINALC
a. ☞ CV.CVC		*	
c. CVC.CV		*	*!
b. CCV.CV	*!		*

b.

CVCCVC	*COMPLEX	*CODA	FINALC
a. ☞ CVC.CVC		**	
c. CCV.CCV	*!*		*
b. CCV.CVC	*!	*	

Forms with three consonants and a prefix are in most cases CVCCVC, where the prefix occupies the first consonantal position (e.g. *h-itxil* 'to start', *m-igdal* 'tower', *y-*

igmor 'he will finish'). That is, the internal position of prefixes is determined by WORDMIN. External prefixes (as in the B4 paradgim *gidel* - *me-gadel* - *ye-gadel* 'to raise Past - Participle - Future'), are attributed to a constraint FAITHSYLLSTEM, which requires the preservation of the syllabic structure of the input stem (recall that the input is a surface representation, and thus includes a syllabic structure).

FAITHSYLLSTEM and WORDMIN often compete with each other, and the data suggest the existence of co-phonologies (Inkelas 1998, Anttila 2002), i.e. that in some configurations FAITHSYLLSTEM outranks WORDMIN, and in others WORDMIN outranks FAITHSYLLSTEM. In the B4 paradigm, *gidel* - *me-gadel* - *ye-gadel*, FAITHSYLLSTEM outranks WORDMIN, and therefore we do not get *gidel* - **m-agdel* - **y-agdel*. This ranking also holds for the paradigms of B3 (*h-ixnis* - *m-axnis* - *y-axnis* 'to put in Past - Participle - Future') and B5 (*hit-labeʃ* - *mit-labeʃ* - *yit-labeʃ* 'to get dressed Past - Participle - Future').

For B1, whose paradigm is *gamar* - *gomer* - *y-igmor* 'to finish Past - Participle - Future' we must assume the reverse ranking, WORDMIN >> FAITHSYLLSTEM, in order to account for the internal status of the future prefix; otherwise, the future form would have been **ye-gamor*.

Notice that in B3, B4, and B5 the stems are identical throughout the paradigm and therefore it is impossible to determine which of the forms serves as a base (though one may select as the base the morphologically simple form, i.e. the past form).[17] This is, however, not the case in B1 and B2. The future form of B1 has two possible V-patterns in the regular verbs ({io} - *y-iʃmor* 'he will guard' and {ia} - *y-iftax* 'he will open'), and two in the irregular verbs ({au} - *y-aruc* 'he will run' and {ai} - *y-aʃir* 'he will sing').[18] The V-pattern in the past forms is in all cases {aa}, or {a} in the

[17] In the absence of evidence for a base, all forms in the paradigm can be simultaneously evaluated against each other (in pairs), as proposed in McCarthy (2001).

	FAITHSYLLSTEM	WORDMIN
a. ☞ {$gidel_1$, $me\text{-}gadel_2$, $ye\text{-}gadel_3$}		** (2,3)
b. {$gidel_1$, $m\text{-}agdel_2$, $y\text{-}agdel_3$}	*!* (1-2, 1-3)	
c. {$gidel_1$, $me\text{-}gadel_2$, $y\text{-}agdel_3$}	*!* (1-3, 2-3)	* (2)

[18] Irregular verbs are defined as verbs which have at least one monosyllabic form in their paradigm (see Bat-El 2002b).

irregular verbs (e.g. *gadal* 'he grew', *rac* 'he ran'). Since the V-pattern of the future form is arbitrarily selected, it must be lexically specified, and the future form must then serve as a base (Horvath 1981). B2, whose paradigm is *n-igmar* - *n-igmar* - *yi-gamer* 'to be finished Past - participle - Future', is the most problematic one (and not surprisingly, the least productive). While all the forms in the paradigm, as in B3 and B5, have a prefix, only two of them (which are identical) conform to WORDMIN. We could assume that the future form is the lexically specified base, and the other forms are derived from it under the ranking WORDMIN >> FAITHSYLLSTEM.[19]

To sum up, the co-phonologies of the binyanim can be represented as in (10):

(10) Co-phonologies

a. B1 and B2: WORDMIN >> FAITHSYLLSTEM (base: future form)

b. B4 B3 and B5: FAITHSYLLSTEM >> WORDMIN (base: either form)

3. The Consonantal Root

The debate over morpheme-based vs. word-based morphology is not specific to Semitic languages (see review in Anderson 1992), but it becomes more acute when the basic morphological unit purported is a string of consonants, i.e. the C-root.[20] The traditional C-root has been carried over to studies within generative frameworks (e.g. McCarthy 1979, 1981), and has continued to be the standard approach. Heath (1987) was among the first generative linguists who did not follow the consensus in his stem-based analysis of Moroccan Arabic. Direct arguments against the C-root in pre-Optimality Theoretic frameworks appear also in Horvath (1981), Bat-El (1994a), Ratcliffe (1997), and Benmamoun (2000). In these studies, as well as in McCarthy and Prince (1990), it is shown that in some non-concatenative morphological

[19] Notice also that while external prefix consonants are followed by an epenthetic *e* in an open syllable (e.g. *me-gadel* - *ye-gadel* 'to grow Participle - Future') the prefix consonant in *yi-gamer* is followed by *i*.

[20] It should be noted that this debate is not new. As noted in Gesenius' Hebrew Grammar, "[t]he Jewish grammarians call the stem (i.e. the 3rd pers. sing. Perf. Qal) *root*… Others regard the three stem-consonants as a *root*, in the sense that, considered as *vowelless* and unpronounceable, it presents the common foundation of the verbal and nominal stems developed from it... For historical investigation of the language, however, this hypothesis of unpronounceable roots, with indeterminate meaning, is fruitless" (Gesenius 1910:99-100).

phenomena (e.g. Hebrew denominative verbs, Arabic broken plural, Arabic passive verbs) the base of the derived form cannot be a C-root.

The word-based view does not, by itself, dispense with the C-root. Bat-El (1986) and Zawaydeh and Davis (1999) advocate what is called in traditional Hebrew grammar a "secondary root" (*ʃoreʃ tanyani*), i.e. an extracted C-root (in Bat-El 1986) or an output root (in Davis and Zawaydeh 1999). That is, they assume a word-based view but also an intermediate C-root. McCarthy (1979, 1981) assumes fully specified lexical entries, thus the word-based view, but presents the C-root as a structural entity in every lexical entry. Arad (this volume) proposes, based on semantic considerations, that some words are derived from C-roots and others from words/stems, i.e. she accepts both the word- and the root-based view.

While arguments in favor of the word-based view do not constitute an argument against the C-root (as Prunet et al. 2000 claim), direct arguments against the C-root necessarily support the word-based view. In this section I provide such arguments based on empirical evidence from historical change (§3.1) and principles of learnability (§3.2).

3.1. Historical Change

From a historical point of view, if C-roots were independent entities they could be affected by historical changes. However, as noted in Bat-El (2001b), words, rather than C-roots, undergo semantic change or disappear from the language. For example, *daxal* 'to fear', the base of *daxlil* 'scarecrow', no longer exists in Modern Hebrew; *nimlat* 'to escape' and *himlit* 'to help someone to escape' were related in Tiberian Hebrew, but in Modern Hebrew *himlit* means 'to give birth (animals)' and the two forms are thus synchronically unrelated. Had historical changes affected the C-root, all words including the affected C-root would have undergone the same change, i.e. they would all have disappeared or acquired different semantic properties. This is, however, never the case. Note that the C-root is traditionally considered the carrier of the core semantic properties, and it is thus surprising, under the root-based approach, that it is not affected by semantic changes in the way just sketched out.

Similar evidence is drawn from Adam's (2002) study of variation in Modern Hebrew spirantization. Due to various historical changes, the post-vocalic spirantization found in Tiberian Hebrew is opaque in Modern Hebrew. For example, a stop can appear after a vowel (e.g. *tipes* 'to climb'), and a fricative can appear in initial position (e.g. *viter* 'to give up') or after a consonant (*tilfen* 'to phone').[21] Adam shows that at the current stage of the language there is a strong tendency to level an alternating inflectional paradigm, as in *__v__itel* - *ye__v__atel* instead of *__b__itel* - *ye__v__atel* 'to cancel Past - Future', i.e. *vitel* and *bitel* are in free variation. Adam argues that speakers who level the paradigm (*__v__itel* - *ye__v__atel*) have a fricative in the input, while speakers that do not level the paradigm (*__b__itel* - *ye__v__atel*) have a stop in the input (and spirantization). Not surprisingly, paradigm leveling does not affect the C-root but rather the word, as derivationally related forms, which reside outside the inflectional paradigm, are rarely affected (Bat-El 2001b). That is, speakers who say *__v__itel* - *ye__v__atel* 'to cancel Past - Future B3' may still preserve the stop in the derivationally related non-alternating paradigm *hit__b__atel* - *yit__b__atel* 'to be cancelled Past - Future B5'. Similarly, speaker who say *__x__ibes* instead of *__k__ibes* 'to launder' (cf. the future form *yexabes*), never say **__x__visa* instead of *__k__visa* 'laundry' (though the verbal noun *__k__ibus* 'laundering' may appear also as *__x__ibus*). Moreover, paradigm leveling does not affect the semantic relations between the derivationally related words; the relation between *vitel* and *hitbatel* for speakers who level the paradigm is identical to that between *bitel* and *hitbatel* for speakers who do not. Had the C-root {btl} been the input for both *bitel* and *hitbatel*, we would expect paradigm leveling to result in restructuring a new C-root {vtl}. The new C-root could replace the old one, which should then result in

[21] The verb *tipes* is historically *tippes*; Tiberian Hebrew geminates resist spirantization (see Hayes 1986 for a theoretical account), but Modern Hebrew has lost the geminates. The verb *viter* is historically *witter*; Tiberian Hebrew *w* appears in Modern Hebrew as *v* in word initial position. The verb *tilfen* is derived from the loan word *telefon* 'phone'.

changing *hitbatel* to *hitvatel*. Alternatively, it could exist alongside the old one, with slightly different semantic properties. However, none of these results are attested.

Word-to-word derivation in verbs is found in early stages of acquisition. Berman (1988) argues, on the basis of a long-term study of the acquisition of Hebrew morphology, that new verbs "are learnt as versions of, and based upon, the verbs known from before" (p. 62). I claim that this learning strategy is maintained at a later stage as word-to-word relation. I see no independent motivation to abandon this strategy in favor of C-root-to-word derivation. Moreover, as argued in the following section, the learnability principles of Optimality Theory do not, and cannot give rise to the C-root; when the learner searches for an input to a paradigm he/she can only arrive at a fully- specified base/stem.

3.2. Learnability

One of the central principles of Optimality Theory is "richness of the base" (Prince and Smolensky 1993), which states that all natural languages have the same universal set of possible inputs. Of course, languages have different sets of actual inputs, which constitute different subsets of the universal set of the possible ones. These subsets of inputs are selected on the basis of the language's constraint hierarchy, where the constraint hierarchy, as noted in §1, is language specific.

Given "richness of the base", the input of *gidel*, for example, can be the C-root {gdl} or the fully specified form *gadal* 'to grow' (as well as other forms, which are not relevant here). In both cases the speaker would arrive at *gidel*, given the constraints assigning the V-pattern {ie} (§2.2) and the prosodic structure (§2.1, 2.4). However, I argue that the learning process cannot lead to a C-root as an input; its only option is a fully specified word/stem.

The learning process involves constant modification of the constraint hierarchy, until the hierarchy produces the outputs of the target language (Tesar and Smolensky 2000). More crucially for the present discussion, the learner also has to select the actual inputs of her/his target language from the possible inputs defined by "the richness of the base". The leading principle in the selection of the actual inputs is "lexicon optimization" (Prince and Smolensky 1993), which directs the learner to select, for a given output, an input that minimally violates the constraint ranking.

At earlier stages of acquisition, when words are still learned by rote, the input of the child's grammar (which differs from the adult's output) is identical, and thus faithful to the output (of the child), because any other input would incur violation of at least one faithfulness constraint.[22] That is, in the absence of morpho-phonological alternation, lexicon optimization leads to the selection of an input that is identical to the output. This has been a general assumption in phonological analysis, as stated in Kenstowicz and Kisseberth (1979:141): "Unless there is evidence to the contrary, the UR of a morpheme is assumed to be identical to the phonetic representation".

At a later stage, when the child realizes that words are morphologically related, all members of the paradigm are considered for the selection of the input.[23] That is, at the stage where the child identifies the relation between *gidel* and *gadal*, as well as other related pairs of this sort, she/has arrived at the grammar that expresses this relation. This grammar, i.e. the constraint ranking, allows him/her to select the optimal input concomitantly.

On the basis of indisputable cases of word-to-word relation, i.e. denominative verbs, we can identify the active constraints in the grammar. Due to the dominating constraints imposing the licit configurations (§2), a vowel (and thus a syllable) can be added (e.g. *flik* 'blow' ---> *hiflik* 'to give a blow'), or deleted (e.g. *télefon* 'phone' ---> *tilfen* 'to phone'), and the quality of the vowel can change (e.g. *kaftor* 'button' ---> *kifter* 'to button'). These unfaithful relations between a base and its output incur violations of the following faithfulness constraints:

---

[22] Tesar and Smolensky (2000) argue that the child begins with a grammar where markedness constraints outrank all faithfulness constraints, where the former ones are gradually demoted in the course of acquisition. However, at the onset of production (which is not the onset of acquisition), some markedness constraints have already been demoted (see evidence in Ben-David 2001).

[23] Assuming, for the sake of argument, that all members of the paradigm are derived from the same input rather than word1 is derived from a stem and word2 from word1.

(11) a. DEPV: Do not add a vowel

b. MAXV: Do not delete a vowel

c. IDENTV: Do not change the quality of the vowel

There is no evidence for the ranking of these faithfulness constraints because they never compete; they are all minimally violated to satisfy the constraints defining the licit configurations.

The relevant distinction between word-to-word and C-root-to-word relations lies in the type of the violated constraint. In C-root-to-word relations (e.g. {gdl} ---> *gidel*) DEPV is violated, since vowels are added to the input due to the dominant WORDMIN and/or the VP constraints (recall from §2.2 that the assigned V-pattern is introduced by a constraint and does not appear in the input). In word-to-word relations (e.g. *gadal* ---> *gidel*) IDENTV is violated, as the quality of the input vowels is not preserved.

Regardless of the ranking of DEPV and IDENTV, word-to-word relation is more harmonic than C-root-to-word. Given all five possible forms of a verb in Hebrew (corresponding to the five binyanim) there is one form that does not violate IDENTV, the one identical to the base. In C-root-to-word relations all outputs violate DEPV, as an output cannot consist of consonants only. This reasoning expresses the traditional method of constructing an underlying form of a paradigm, as stated in Kenstowitz and Kisseberth (1979:197): "The UR of a morpheme is identical to the phonetic alternant that appears in isolation (or as close to isolation as the grammar of the language permits)".

The tableau below illustrates the selection of the optimal input out of the two possible (relevant) inputs,{gdl} and *gadal*. In such a tableau, the candidates under evaluation are the input forms, and the output forms of the paradigm serve for faithfulness considerations. As shown, since *gadal* has fewer faithfulness violations with respect to all the members in the paradigm, it is selected as the optimal input (multiple violations are ignored).

(12) Selection of the optimal input

Input candidates	Output Paradigm	Faithfulness DEPV	IDENTV
a. gdl	gadal	*	
	n-igdal[24]	*	
	h-igdil	*	
	gidel	*	
	hit-gadel	*	
b. ☞gadal	gadal		
	n-igdal		*
	h-igdil		*
	gidel		*
	hit-gadel		*

Notice that in the relation between *gadal* 'to grow' and *gidel* 'to raise', *gidel* could be the base of *gadal* as much as *gadal* of *gidel* (see §2.4 for similar cases in the inflectional paradigm). In most cases semantic considerations may lead the learner to choose one form rather than the other, though it is not necessarily the case that all speakers arrive at the same input.

There are, however, cases, especially in the inflectional paradigms, where no cues are available as to which form in the paradigm serves as its base (see §2.4). Hoberman (1992) encounters such a case in the Modern Aramaic inflectional paradigm, and posits a C-root as an input just because there is no way to decide which of the forms in the paradigm is the base. Such a motivation for positing a C-root is, in my opinion, not sufficient. Moreover, in the absence of structural or semantic cues, the base can be selected on the basis of typological markedness of the category, an idea Hoberman contemplates but does not adopt. However, following the argument given in (12) for the priority of the word as an input, consideration of the violations of IDENTV in the entire paradigm of Modern Aramaic would lead to the conclusion that the Jussive/Imperative, whose V-pattern is {ai}, is the base (this is true only for the 2nd binyan, whose prosodic structure remains constant throughout the inflectional paradigm). As Hoberman shows, there are two additional categories in the Modern Aramaic paradigm: Continuous, whose V-pattern is {ao}, and Preterite, whose V-pattern is {oi}. As shown below, while every surface form is a potential input, the

[24] The verb *nigdal* (B2) does not exist, but it is a possible verb form.

form with the {ai} pattern is the optimal one (here every alternating vowel gets a violation mark).[25]

(13) {*matxir*, *motxir*, *matxor*} 'to remind'

Input	Output	IDENTV
a. ☞ matxir	matxir	
	motxir	* (a-o)
	matxor	* (i-o)
b. motxir	matxir	* (o-a)
	motxir	
	matxor	**! (o-a, i-o)
c. matxor	matxir	* (o-i)
	motxir	**! (a-o, o-i)
	matxor	

As argued above for Hebrew, the selection of a C-root as an input in Modern Aramaic would cause even more violations of the faithfulness constraint, in this case DEPV, since each of the three surface forms would get two violations, one for every inserted vowel.

Thus, in accordance with the principle of Paradigm Optimization, the learner selects a fully specified actual form as the input, rather than a C-root, as there are always more violation marks in a derivation from a C-root to a paradigm than from a word to a paradigm.[26] Notice that at any stage in the acquisition process, regardless of the number of words from a single paradigm the learner has already acquired, one of these acquired words would serve as a base. It does not mean that once a base always a base, since the addition of lexical items to the paradigm during the acquisition process may lead the learner (for semantic and/or phonological reasons) to choose another base.

[25] It should be noted that the same conclusion could be reached within a rule-based approach, assuming Ockham's razor, which gives priority to the simpler analysis (other things being equal), in our case, to the one that uses fewer rules.

[26] Ussishkin (2000) assumes that the input of every verb paradigm is a B1 verb (CaCaC), whether or not it is an actual form in the language. Following the line of arguments above, in a derivational paradigm that lacks a B1 form (and there are quite a few of this sort) C-root-to-word and word-to-word relations would tie. That is, such paradigms are unlearnable because speakers would not be able to arrive at an input.

4. Menu de Dégustation

Before concluding this paper, I present a sample of tableaux, which formally express the relations between words.

When two related words are disyllabic and do not contain affixes, the relation involves only apophony, as in the case of *gadal* 'to grow B1' - *gidel* 'to raise B4'.[27] As noted earlier, semantic factors allow us to select B1 as the base (see Berman 1978), but structurally, *gidel* can be the base of *gadal* as much as *gadal* of *gidel* (to reduce cluttering, only the relevant V-pattern constraint is presented in the tableaux).

(14) *gadal* 'to grow B1' - *gidel* 'to raise B4'

a. Base: *gadal*

gadal-B4	WORDMIN	VP4{ie}	IDENTV
a. gadal		*!	
b. igadale	*!		
c. ☞ gidel			**

b. Base: *gidel*

gidel-B1	WORDMIN	VP1{aa}	IDENTV
a. gidel		*!	
b. agidela	*!		
c. ☞ gadal			**

As proposed in §2.4, the syllabic structure of both *gadal* and *gidel* is enforced by the ranking of the markedness constraints *COMPLEX >> *CODA, FINALC. The same ranking holds for forms with four consonants, with or without a prefix, which have a CVCCVC structure (to reduce cluttering, some low-ranked constraints are suppressed).

[27] When one of the words in a related pair is monosyllabic, there is often reduplication (e.g. *ken* 'nest' - *kinen* 'to nets') or a medial *y* or *v* (e.g. *ʔot* 'letter' - *ʔiyet* 'to spell', *xut* 'string' - *xivet* 'to wire'). As argued in Bat-El (1994a) and Ussishkin (1999, 2000), this is the effect of WORDMIN, though Bat-El (2002a) shows that reduplication cannot always be attributed to this constraint (e.g. *dover* 'spokesman' - *divrer* 'to speak as a spokesman'). I do not consider these cases here.

(15) *gadal* 'to grow' - *higdil* 'to enlarge'

gadal - B3	ALIGNL(*h*) &VP3{ii}	WORDMIN	*COMPLEX	*CODA	FINALC
a. hegidil		*!		*	
b. hagdal	*!			**	
c. higdli			*! (*dl*)	*	*
d. ☞ higdil				**	

*COMPLEX is also active in the relation between denominative verbs and their (native or borrowed) nouns and adjectives bases. As shown in (16) below, when the base is trisyllabic, WORDMIN eliminates the trisyllabic candidates (cand's-a and -b), and *COMPLEX rules out the candidate with the complex onset (cand-d). The optimal candidate is then the one that survives the dominating constraints (cand-e), and its massive violation of the dominated faithfulness constraints is immaterial.

(16) *telefon* 'phone' ---> *tilfen* 'to phone'

telefon - B4	WORDMIN	VP4{ie}	*COMPLEX	*CODA	MAXV
a. telefon	*!	*		*	
b. tilefon	*!			*	
c. talfan		*!		**	*
d. tlifen			*!	*	*
e. ☞ tilfen				**	*

While complex onsets are avoided in verbs (complex codas are in general rare in Hebrew), a verb derived from a base with a complex onset usually preserves it as it is (Bolozky 1978, Bat-El 1994a). It is thus necessary to appeal to the constraint CONTIGUITY (McCarthy and Prince1995), which requires the preservation of adjacency between segments in the base by stating that contiguous segments in the base are contiguous in the output. In order to have an effect, CONTIG has to outrank *COMPLEX. In the example below, the base *flirt* 'flirt' has two clusters, *fl* in the onset and *rt* in the coda. Both clusters are preserved in the denominative verb *flirtet* 'to flirt', one as a complex onset, which justifies the ranking CONTIG >> *COMPLEX, and the other by the additional syllable (due to WORDMIN). This additional syllable resolves the complex coda by hosting the final base consonant in the onset, as well as its copy in the coda (the constraint violated due to reduplication, not specified below, is ranked below CONTIG).

(17) *flirt* 'flirt' ---> *flirtet* 'to flirt'

flirt - B4	WORDMIN	VP4{ie}	CONTIG	*COMPLEX	DEPV
a. flirt	*!	*		**	
b. fliret			*! (rt)	*	*
c. filret			*!* (fl, rt)		*
d. ☞ flirtet				*	*

As can be seen in the optimal candidate, *COMPLEX violation in the onset is inevitable, given the higher ranking of CONTIG. In the coda, however, the additional syllable and reduplication allow to respect both *COMPLEX and CONTIG.[28]

Cases like *xantariʃ* 'nonsense' ---> *xintreʃ* 'to speak nonsense' show that unlike MAXV, the constraint MAXC, which requires the preservation of all base consonants, is undominated (see Bat-El 1995). In particular, it has to outrank *COMPLEX. That is, a segment cannot be deleted in order to rescue a complex syllable margin.

(18) *xantariʃ* 'nonsense' ---> *xintreʃ* 'to speak nonsense'

xantariʃ - B4	WORDMIN	VP4{ie}	CONTIG	MAXC	*COMPLEX
a. xantariʃ	*!	*			
b. xnitreʃ			*! (nt)		* (xn)
c. xinteʃ				* (r)	
d. ☞ xintreʃ					* (tr)

Notice that cand-c, where one of the base consonants is deleted, respects all the relevant constraints, except MAXC. The high ranking of MAXC, in particular above *COMPLEX, does not allow this candidate to be optimal.

The constraint ONSET, which requires syllables to have an onset, plays a role in the relation between a base with an internal prefix and its prefixless output. Such a relation is found in the inflectional paradigm of B1, *gadal* - *yigdal* 'to grow Past - Future', where the prefixed future form is the base (see §2.4) and the output is the prefixless past form. As the tableau in (19) suggests, ONSET has to outrank CONTIG.

[28] Notice that CONTIG has to be viewed as an existential constraint, as proposed in Struijke (2000) for all faithfulness constraints. That is, the adjacency of two segments in the input has to be preserved by at least one, but not necessarily all occurrences of these segments. Thus, *flirtet* does not violate CONTIG, although the final *t* is not adjacent to the *r*, because the form has one instance of adjacent *r* and *t*.

(19) *yigdal* 'to grow Future' ---> *gadal* 'Past'

yigdal-B1[Past]	WORDMIN	VP1{aa}	ONSET	CONTIG	*COMPLEX
a. gdal	*!	*			*
b. gidel		*!		*	
c. igdal			*!		
d. ☞ gadal				*	

In cases where the prosodic structure of the output stem is identical to that of the input, due to the ranking FAITHSYLLSTEM >> WORDMIN (§2.4), there is no motivation to violate CONTIG. Therefore, complex syllable margins are possible only when they appear throughout the inflectional paradigm.

(20) *xintreʃ* - *yexantreʃ* 'to speak nonsense Past - Future'

xintreʃ - B4[Fut]	FAITHSYLL STEM	ALIGNL(*y*) &VP4{ae}	WORDMIN	CONTIG	*COMPLEX
a. xantreʃ		*!			*(*tr*)
b. yexnatreʃ	*!		*	* (*nt*)	
c. ☞ yexantreʃ			*		* (*tr*)

Notice that here WORDMIN is violated in order to satisfy ALIGN&VP, which required the prefix and the two vowels of the V-pattern to be surface true.

In sum, below are the crucial rankings presented in this section (with reference to the relevant tableaux and the competing candidates):

(21) Crucial rankings

WORDMIN >> MAXV, DEPV
Vowels are deleted (16 b vs. e) or added (17 a vs. d), to arrive at a disyllabic form.

WORDMIN >> *CODA
A syllable has a coda, to ensure a maximum disyllabicity (15 a vs. d).

VP >> IDENTV, DEPV
Vowels are altered (14 a vs. c) or added (17 a vs. d), to arrive at a licit V-pattern.[29]

*COMPLEX >> *CODA
A syllable has a coda, to avoid a complex onset (16 d vs. e).

CONTIG >> *COMPLEX
Complex onset surfaces, to preserve adjacency in the base (17 c vs. d).

MAXC>> *COMPLEX
A complex onset surfaces, to avoid deletion of a consonant (18 c vs. d).

ONSET >> CONTIG
Adjacency is not preserved, to ensure onset (19 c vs. d).

ALIGN&VP >> WORDMIN
A word has more than two syllables, to allow the prefix and the V-pattern to be surface true (21 vs. c).

5. Conclusion

In this paper I demonstrated how to do non-concatenative morphology within the framework of Optimality Theory, presenting the relevant constraints and arguing for the crucial rankings. I adopted the universal constraints presented in the literature, specifying the language specific morphological information required for the VP and ALIGN constraints.

Beyond displaying an Optimality Theoretic grammar, I provided arguments concerning the status of the traditional structural units of non-concatenative morphology. I argued that the V-patterns and the affixes have to be introduced by

[29] Notice that both VP >> DEPV and WORDMIN >> DEPV trigger disyllabicity. However, as argued in §2.1, Hebrew provides independent evidence for WORDMIN.

constraints, thus supporting the constraint-based approach to morphology. I also provided a theory internal argument against the C-root, showing that the learning principles of Optimality Theory lead the learner to select one of the surface forms as an input, rather than the C-root.

REFERENCES

Adam, Galit. 2002. >*From Variable to Optimal Grammar: Evidence from Langage Acquisition and Language Change*. Ph.D. dissertation, Tel-Aviv University.

Adam, Galit and Outi Bat-El. 2000. Morphological knowledge without morphological structure: The emergence of inflectional suffixes in the acquisition of Hebrew verbs. A paper presented in a workshop on Phonology and Prosodic Morphology of Semitic Languages. Tel-Aviv. <http://www.tau.ac.il/humanities/lingui/people/batel. html>.

Anderson, Stephen R. 1992. *A-Morphous Morphology*. Cambridge: Cambridge University Press.

Anttila, Arto. 2002.Morphologically conditioned phonological alternations. *Natural Language and Linguistic Theory* 20:1-42.

Archangeli, Diana and Terence Langendoen (eds) 1997. *Optimality Theory: An Overview*. Oxford: Blackwell.

Arad, Maya. 200@@

Aronoff, Mark. 1976. *Word Formation in Generative Grammar*. Cambridge, MA: The MIT Press.

Bat-El, Outi. 1986. *Extraction in Modern Hebrew Morphology*. UCLA MA thesis.

Bat-El, Outi. 1994a. Stem modification and cluster transfer in Modern Hebrew. *NLLT* 12:571-596.

Bat-El, Outi. 1994b. The optimal acronym word in Hebrew. Proceedings of the 1994 Annual Conference of the Canadian Linguistic Association, ed. by Päivi Koskinen. 23-37. University of Toronto.

Bat-El, Outi. 1995. Resolving prosodic mismatch in Modern Hebrew verb formation. Leiden in Last: HIL Phonology Papers I, ed. by Harry van der Hulst and Jeroen van de Weijer. 25-40. The Hague: Holland Academic Graphics.

Bat-El, Outi. 2001a. On the site of vowel deletion in Modern Hebrew verbs and nouns: A constraint-based approach. A paper presented at the Israeli Seminar on

Computational Linguistics. Haifa: University of Haifa. <http://www.tau.ac.il/ humanities/lingui/people/batel. html>.

Bat-El, Outi. 2001b. In search for the roots of the C-root: The essence of Semitic morphology. A paper presented at the Workshop on Roots and Template Morphology. Los Angelses: USC. <http://www.tau.ac.il/humanities/lingui/people/ batel. html>.

Bat-El, Outi. 2002a. Hebrew reduplication: The Interpretation of forms with identical consonants. A paper presented at UC Santa Cruz colloquium. <http://www.tau.ac.il/ humanities/lingui/people/batel. html>.

Bat-El, Outi. 2002b. True truncation in Hebrew imperatives. *Language* 78:1-33.

Bat-El, Outi. 2003a. Semitic verb structure within a universal perspective. In J. Shimron (ed.) *Language, Processing, and Language acquisition in a Root-based Morphology*. Amsterdam: John Benjamins. pp. 29-59.

Bat-El, Outi. 2003b. Anti-faithfulness: An inherent morphological property. In J. Lecarme (ed.) *Research in Afroasiatic Grammar II*. Amsterdam: John Benjamins. pp. 21-34.

Ben-David, Avivit. 2001. *Language Acquisition and Phonological Theory: Universal and Variable Processes Across Children and Across Languages*. Tel-Aviv University Ph.D. dissertation (in Hebrew).

Benmamoun, Abbas. 2000. Lexical relations and the role of the imperfective template in Arabic. A paper presented at the 5th International Afroasiatic Linguistics Conference. Paris.

Benua, Laura. 1997. *Transderivational Identity: Phonological Relations Between Words*. Ph.D. dissertation, University of Massachusetts, Amherst. *ROA-259-0498*.

Berman, Ruth A. 1978. *Modern Hebrew Structure*. Tel-Aviv: University Publishing Projects.

Berman, Ruth A. 1988. Word class distinction in developing grammars. *Categories and Processes in Language Acquisition*, ed. By Y. Levy, I.M. Schlesinger, and M.D.S. Braine, 45-72. Hillsdale, NJ: Erlbaum.

Bolozky, Shmuel. 1978. Word formation strategies in the Hebrew verb system: Denominative verbs. *Afroasiatic Linguistics* 5:111-136.

Bolozky, Shmuel and Ora Schwarzwald. 1992. On the derivation of Hebrew forms with the +*ut* suffix. *Hebrew Studies* 33:51-69.

Boersma, Paul. 2000. Learning a grammar in functional phonology. *Optimality Theory: Phonology Syntax, and Acquisition*, ed. by J. Dekkers, F. van der Leeuw, and J. van de Weijer, 465-523. Oxford: Oxford University Press.

Carr, Philip. 2000. Scientific realism, sociophonetic variation, and innate endowments in phonology. *Phonological Knowledge: Conceptual and Empirical Issues*, ed. by N. Burton-Roberts, P. Carr, and G. Docherty, 67-104. Oxford: Oxford University Press.

Demuth, Katherin. 1996. The prosodic structure of early words. *Signal to Syntax: Bootstrapping from Speech to Grammar in Early Acquisition*, ed. by J. Morgan and K. Demuth, 171-184. Mahwah, NJ: Erlbaum.

Gafos, Diamandis. 1998. Eliminating long-distance consonantal spreading. *NLLT* 16:223-278.

Gesenius, W. 1910. *Gesenius' Hebrew Grammar*. Oxford: Clarendon (2nd English edition by K. Kautzsch, revised in accordance with the 26th German edition by A.E. Cowley. 1st German edition 1813).

Goldston, Chris. 1991. *Both Lexicons*. UCLA Ph.D. dissertation.

Guerssel, M. and Jean Lowenstamm. 1990. The derivational morphology of the verbal system of Classical Arabic. Ms. Université du Québec à Montréal and Université Paris 7.

Guerssel, M. and Jean Lowenstamm. 1996. Ablaut in Classical Arabic Measure I active verbal forms. *Studies in Afroasiatic Grammar*, ed. by J. Lecarme, J.

Lowenstamm, and U. Shlonsky, 123-134. The Hague: Holland Academic Graphics.

Hayes, Bruce. 1986. Inalterability in CV phonology. *Language* 86:321-351.

Heath, Jeffrey. 1987. *Ablaut and ambiguity:Phonology of a Moroccan Arabic Dialect*. Albany: State University of New York Press.

Hoberman, Robert D. 1992. Formal properties of the conjugations in Modern Aramaic. *Yearbook of Morphology 1991*, ed. by Gert Booij and Jaap van Marle. 49-64. Dordrecht: Kluwer.

Hockett, Charles. 1954. "Two models of grammatical description". *Word* 10:210-231.

Horvath, Julia. 1981. On the status of the vowel patterns in Modern Hebrew: Morphological rules and lexical representation. *Extended Word-and-Paradigm Theory: Occasional Papers in Linguistics 4*, 228-261. UCLA.

Inkelas, Sharon. 1998. The theoretical status of morphologically conditioned phonology: A case study of dominance effects. *Yearbook of Morphology 1997*, ed. by Gert Booij and Jaap van Marle. 121-155. Dordrecht: Kluwer.

Itô, Junko. 1990. Prosodic minimality in Japanese. *CLS 26: parasession on the Syllable in Phonetics and Phonology*, ed. by K. Deaton, M. Noske, and M. Ziolkowski, 213-239. ChicagoL CLS.

Kager, René. 1999. *Optimality Theory*. Cambridge: Cambridge University Press.

Kenstowicz, Michael and Charles Kisseberth. 1979. *Generative Phonology: Description and Theory*. New York: Academic Press.

Kiparsky, Paul. 1982. "From cyclic to lexical phonology". *The Structure of Phonological Representations (Part I)*. ed. by In van der Hulst and N. Smith, 131-75. Dordrecht: Foris.

Lieber, Rochelle. 1992. *Deconstructing Morphology*. Chicago: The University of Chicago Press.

Lubowicz, Anja. 1999. Derived environment effects in OT. In K. Shahin, S. Blake and E-S. Kim (eds) *Proceedings of W CCFL 17*,CSL I Publications. pp. 451-465.

McCarthy, John. 1979. *Formal Problems in Semitic Phonology and Morphology*. Ph.D. dissertation, MIT. [1982: IULC]

McCarthy, John. 1981. A prosodic theory of nonconcatenative morphology. *Linguistic Inquiry* 12:373-418.

McCarthy, John. 1993. A case of surface constraint violation. In C. Paradis and D. LaCharité (eds) *Constraint-Based Theories in Multilinear Phonology: Canadian Journal of Linguistics* 38:169-195.

McCarthy, John. 2001. Optimal paradigms. ROA 485-1201. <http://ruccs.rutgers.edu/roa.html>.

McCarthy, John. 2002a. *A Thematic Guide to Optimality Theory*. Cambridge: Cambridge University Press.

McCarthy, John. 2002b. Against gradience. ROA 510-0302. <http://ruccs.rutgers.edu/roa.html>

McCarthy, John and Alan Prince. 1986. Prosodic Morphology. Ms. University of Massachusetts and Brandeis.

McCarthy, John and Alan Prince. 1990. Foot and word in prosodic morphology: The Arabic broken plural. *Natural Language and Linguistic Theory* 8:209-283.

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. *Yearbook of Morphology 1993*, ed. by Geert Booij and Jaap van Marle. 79-153. Dordrecht: Kluwer.

McCarthy, John and Alan Prince. 1995a. Prosodic Morphology. *The Handbook of Phonological Theory*, ed. by John A. Goldsmith, 318-366. Cambridge, MA: Blackwell.

McCarthy, John and Alan Prince. 1995b. Faithfulness and reduplicative identity. *University of Massachusetts Occasional Papers in Linguistics 18: papers in*

Optimality Theory, ed. by J. Beckman, L. Walsh Dickey and S. Urbanczyk. 249-384. Amherst: GLSA.

Poser, William. 1990. Evidence for foot structure in Japanese. *Language* 66:78-105.

Prince, Alan and Paul Smolensky. 1993. Optimality Theory: Constraint interaction in generative grammar. Technical report RuCCSTR-2. Rutgers Center for Cognitive Science.

Prunet, Jean-François, Renée Béland, and Ali Idrissi. 2000. The mental representation of Semitic words. Linguistic Inquiry 31:609-648.

Ratcliffe, Robert R. 1997. Prosodic templates in a word-based morphological analysis of Arabic. In Mushira Eid and Robert R. Ratcliffe (eds) *Perspectives on Arabic Linguistics X*. Amsterdam: John Benjamins Publishing Company. pp. 149-171.

Russell, Kevin. 1995. Morphemes and candidates in Optimality Theory. ROA 44-0195. <http://ruccs.rutgers. edu/roa.html>.

Russell, Kevin. 1999. MOT: Sketch of an OT approach to morphology. ROA 352-1099. <http://ruccs.rutgers. edu/roa.html>.

Selkirk, Elisabeth. 1980. P*honology and Syntax: The Relation Between Sounds and Structure*. Cambridge, MA: The MIT Press.

Smolensky, Paul. 1993. Harmony, markedness, and phonological activity. Paper presented at Rutgers Optimality Workshop-1 at Rutgers University.

Struijke, Caro. 2000. *Existential Faithfulness: A Study of Reduplicative, TETU, Feature Movement, and Dissimilation*. University of Maryland Ph.D. dissertation.

Tesar, Bruce and Paul Smolensky. 2000. *Learnability in Optimality Theory*. Cambridge, MA: The MIT Press.

Ussishkin, Adam. 1999. The inadequacy of the consonantal root: Modern Hebrew denominal verbs and output-output correspondence. *Phonology* 16:401-442.

Ussishkin, Adam. 2000. *The Emergence of Fixed Prosody*. UCSC Ph.D. dissertation.

Yip, Moira. 1998. “Identity avoidance in phonology and morphology”. *Morphology and Its Relation to Phonology and Syntax.* ed. by S.G. Lapointe, D.K. Brentari and P.M. Farrell, 216-246. Stanford: CSLI Publications.

Zadok, Gila. 2002. *Abbreviations: A Unified Analysis of Acronym Words, Clippings, Clipped Compounds, and Hypocoristics*. Tel-Aviv University M.A. thesis.

Zawaydeh, Bushra Adnan and Stuart Davis. 1999. Hypocoristic formation in Ammani-Jordanian Arabic. *Perspectives on Arabic Lingistics XII*, ed. by A. Benmamoun, 113-139. Philadelphia: John Benjamins.