

Morphological Templates and Phonological Opacity

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24.962 Advanced Phonology • 27 April 2000

1 Opacity

Kiparsky 1971, 621–2:

- (1) A rule $A \rightarrow B / C _ D$ is opaque to the extent that there are surface representations of the form
 - a. A in environment $C _ D$ **or**
 - b. B in environment other than $C _ D$.

McCarthy (1999a, 1), in prose (emphasis in original):

- (2)
 - a. Linguistically significant generalizations are often *not surface-true*. That is, some generalization G appears to play an active role in some language L, but nonetheless there are surface forms of L (apart from lexical exceptions) that violate G.
 - b. Linguistically significant generalizations are often *not surface-apparent*. That is, some generalization G appears to play an active role in shaping the surface form F, but the conditions that lead to G's applicability are not apparent from F.

Approaches to opacity:

- (3) Serial Derivation
 - a. Opacity is predicted and expected
 - b. To the extent that opacity is marked/infrequent, it is a result of extragrammatical factors (opaque rules are difficult to learn)
- (4) Within Optimality Theory
 - a. Derivational OT (Prince and Smolensky 1993, Booij 1997, Kiparsky 1997, Rubach 2000)
 - b. Output-Output Correspondence (Benua 1995)
 - c. Paradigm Uniformity (Kenstowicz 1995)
 - d. Reference to levels in constraints (McCarthy 1994)
 - e. Sympathy (McCarthy 1999b)
 - f. Denial of its existence (anyone?)

Significance of “linguistically significant”:

- Most approaches to opacity in the abstract assume that cases from the literature involve well-established phonological generalizations.
- In many cases, however, the putatively opaque processes are subject to reanalysis. The correct phonological generalizations may not involve opacity.

2 Opacities in Tiberian Hebrew

- Classic generative analysis of Tiberian Biblical Hebrew is that of Prince 1975, who outlines a series of ordered rules for deriving the surface forms of the language.
- Prince's analysis has been adopted almost without alteration in the subsequent literature, particularly in debates about stress (e.g., Halle and Vergnaud 1987) and opacity (e.g., 1998a, Idsardi 1998b; McCarthy 1999b).
- Here I will re-examine the data and show that the generalizations drawn by Prince are inadequate. The correct generalizations involve very little opacity.

2.1 Segholate Epenthesis

- (5) Segholate epenthesis (nouns /CVCC/)¹
- | | | | | |
|--------|--------|-------------|---------|------------|
| | ‘king’ | ‘young man’ | ‘grass’ | ‘wild ass’ |
| X | mélex | náʕar | dése | pére |
| ‘my X’ | malkí: | naʕárí: | dašʕí: | parʕí: |

- Problem for output-oriented constraints: the output has no cluster, hence no reason for epenthesis to have applied. Faithfulness (however low-ranking) should prevent epenthesis.
- Classic case of rule ordering: epenthesis precedes glottal stop deletion.

- (6) Ordered rule derivation (Idsardi 1998a, 4):

UR	/malk/ ‘king’	/dašʕ/ ‘grass’	/gader/ ‘wall’	/sabaʕ/ ‘army’
Stress Assignment	máلك	dášʕ	gadér	sabáʕ
Pretonic Lengthening	–	–	gə:dér	sə:báʕ
Tonic Lengthening	–	–	gə:dé:r	sə:bó:ʕ
Epenthesis	máleک	dášʕeʕ	–	–
Vowel Harmony	mélex	déseʕ	–	–
Spirantization	mélex	–	gə:ðé:r	sə:vó:ʕ
ʕ deletion	–	dése	–	sə:vó:
SR	mélex	dése	gə:ðé:r	sə:vó:

- (7) Sympathy (McCarthy 1999a, 22):

/dašʕ/	♡MAX- V _{Max-C}	*COMPLEX	ANCHOR _{IO}	CODA-COND (*ʕ in coda)	MAX-C _{IO}	DEP-V _{IO}
⇒ dese					*	*
deš	*!				*	
dešʕe			*!		✓	*
♡dešʕeʕ				*!	✓	*
dešʕ	*!	*!		*!	✓	

- (8) Criticism:

- a. Idsardi (1998a) shows that Sympathy does not work to capture all of the opacities present in a host of segholate examples. These include:
 - penultimate stress (usual stress is final)
 - lack of tonic lengthening (contrast də:vó:r ← /dabar/)
 - spirantization (malxè: ‘kings of (constr pl)’)
 - vowel harmony (/malk/ → mélex)
- b. Ordered rules lack explanatory power (many of them are quite arbitrary, like pretonic lengthening; cf. McCarthy 1981b). We would like to understand *why* segholates have penultimate stress, and why Tiberian Hebrew has tonic (and pretonic) lengthening, plus usually final stress.

2.2 Prosodic Factors

- (9) Prince’s generalizations re: stress, lengthening, reduction:

- a. Stress assignment: place stress on the final vowel.
- b. Pretonic lengthening: lengthen the vowel of the pretonic syllable if open.
- c. Tonic lengthening: lengthen a stressed vowel in an open syllable.
- d. Vowel reduction: Prince hypothesizes several *different* processes of vowel reduction.

Work since Prince’s has recognized the role of prosody in these processes (McCarthy 1979, Rappaport 1984, Halle and Vergnaud 1987).

¹Sources: Brown, Driver, and Briggs (1999), Gesenius (1910), Harper (1910), Kahn (1997), Martin (1993), Weingreen (1959).

- (10) Halle and Vergnaud 1987, 63–9 (following Rappaport 1984):
1. Construct left-headed binary feet from right to left for the purposes of stress; a final closed syllable forms a foot by itself:

(x)(x -)	(x) (x -)(x -)	(x)(x -)(x)
yiktobu:	wayyadabberu:	yaladehem
‘they (M) write’	‘and they (M) will speak’	‘their (M) children’
 2. Assign main stress to rightmost foot:

(x)(x́ -)	(x) (x -)(x́ -)	(x)(x -)(x́)
yiktobu:	wayyadabberu:	yaladehem
 3. Pretonic lengthening: lengthen pretonic vowel in open syllable

(x)(x́ -)	(x) (x -)(x́ -)	(x)(x -)(x́)
yiktobu:	wayyadabberu:	yalade:hem
 4. Construct *right*-headed binary feet from right to left for the purposes of vowel reduction:

(x)(x́ -)	(x) (x -)(x́ -)	(x)(x -)(x́)
yiktobu:	wayyadabberu:	yalade:hem
(x)(- x)	(x) (- x)(- x)	(x)(- x)(x)
 5. Reduce the troughs of these feet if short and in open syllable:

(x)(x́ -)	(x) (x -)(x́ -)	(x)(x -)(x́)
yiktəbu:	wayyədabbəru:	yaləde:hem
(x)(- x)	(x) (- x)(- x)	(x)(- x)(x)
 6. Reduced vowels cannot bear stress, so stress shifts:

(x)(. x́)	(x) (x -)(. x́)	(x)(x -)(x́)
yiktəbu:	wayyədabbəru:	yaləde:hem
(x)(- x)	(x) (- x)(- x)	(x)(- x)(x)
 7. Spirantization and final representation:

[yixtəvú:]	[wayyəðabbəru:]	[yaləðe:hém]
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- There is *no* connection between factors inducing pretonic lengthening and vowel reduction.
- There is *no* connection between conditioning factors for stress and vowel reduction.
- The conditioning factors for stress and PTL, on the one hand, and vowel reduction on the other, are prosodic, but require different prosodies.
- Opacity results from ordering:
 - (i) PTL precedes and bleeds vowel reduction
 - (ii) Vowel reduction causes a stress shift, obscuring “normal” penultimate stress and rendering PTL opaque.

2.3 Critique and New Proposal

Prince’s generalizations are wrong (as are Halle and Vergnaud’s): they miss the prosodic facts.

- (11) Real generalizations:
- a. Stress: varies between ultima and penult depending on morphological and phonological factors.
 - b. Pretonic lengthening: misses the fact that alternate syllables are always heavy, and that many pretonic vowels reduce rather than lengthen:

wayyəðabbəru:	yiqṭəlél:x
‘and they (M) will speak’	‘he killed you (fs)’
 - c. Vowel reduction and lengthening are related: alternating pattern typical of iambic stress systems.
- (12) **Claim:** If we examine the *surface* prosody of Tiberian Hebrew, we find an alternating, iambic pattern that fits with other iambic systems: lengthening of the head of each foot, and reduction of the trough of each foot. Once we understand the prosody, we understand why pretonic lengthening takes place where it does and why pretonic vowels reduce in other contexts.

However, the Segholate nouns do not quite fit into an iambic stress system.

- (13) **Proposal:**

- Previous treatments of Hebrew (and Semitic generally) have failed to recognize templatic morphology as a driving force behind phonological processes.
- Previous versions of templatic morphology (e.g., McCarthy 1979, 1981a, 1993) hold templates to be the input to phonological rules; I claim that templates specify *output conditions*.
- In the spirit of the Prosodic Morphology hypothesis (McCarthy and Prince 1986, 1988), these output templates are prosodic *feet*: either iambs or trochees.
- Templatic feet are the *same* feet that figure in stress. Changes in syllable structure due to lengthening, reduction, deletion, etc., all drive to best fit the morphologically specified templates.
- This allows an understanding of vowel lengthening (tonic and pretonic), reduction, deletion, etc. as being driven by the **Iambic-Trochaic Law** (Hayes 1985, 1995; Prince 1990; cf. Kager 1997): iambic feet want to be unbalanced in weight, while trochaic feet want to be balanced.
- The difference between the Segholates and other nouns is that the Segholates are trochees, while other nouns are iambs. Their phonological differences follow.
- Side effect: phonological processes turn out to be largely storable as surface-true generalizations.

3 Biblical Hebrew Templates: Noun Classes

(14) Vowel System (Malone 1993)

i	i:	u	u:
e	e:	o	o:
ɛ	ɛ:	ə	ɔ
		a	

3.1 The First vs. the Second Declension

(15)	1st Declension		2nd Declension	
	‘word’	‘army’	‘king’	‘wonder’
<i>Sing. abs.</i>	də:vó:r	ʂə:və:	mélɛx	pélɛ
<i>ctr.</i>	dəvər	ʂəvə:	mèlɛx	pèlɛ
<i>1s. suff.</i>	dəvə:rí:	ʂəvə:ʔi:	malki:	pilʔi:
<i>2ms. suff.</i>	dəvə:rəxó:	ʂəvə:ʔ ^a xə:	malkəxə:	pilʔ ^a xə:/ pilʔéxə:
<i>2mpl. suff.</i>	dəvarxém	ʂəvə:ʔ ^a xém	malkəxém	pilʔ ^a xém
<i>Plural abs.</i>	dəvə:rí:m	ʂəvə:ʔo:θ	mələ:xi:m	pələ:ʔi:m
<i>ctr.</i>	divrè:	ʂivʔò:θ	malxè:	pilʔè:
<i>1s. suff.</i>	dəvə:ráy	ʂivʔo:θay	mələ:xay	pələ:ʔay
<i>2ms. suff.</i>	dəvə:rəxə:	ʂivʔo:θéxə:	mələ:xéxə:	pələ:ʔéxə:
<i>2mpl. suff.</i>	divre:xém	ʂivʔo:θe:xém	malxe:xém	pilʔe:xém
	Final stress		Penultimate stress	
	Tonic lengthening		No tonic lengthening	
	No vowel harmony		Vowel harmony	
	Construct: no pre- or tonic lengthening, V harmony, reduction		Construct: no change	
			Plural: long vowel	
			Suffixed: no V harmony	

3.2 Iambicity

- Hebrew stress is usually final (e.g., Prince 1975, McCarthy 1979, Hayes 1980, Rappaport 1984, Halle and Vergnaud 1987, Churchyard 1999), and the final syllable is almost always heavy.
- Iambicity clear in verbs and in First Declension nouns (taking into account final closed syllables).

(16) Verbs:
 (qə: I)(təló: I) ‘she killed’ (qəʔal I)(tén I) ‘you (fp) killed’
 (yiq I)(təlu: I)(xém I) ‘they (m) will kill you (mp)’

- (17) First Declension nouns:
- (də.və: _I)(rɪ: _I) ‘my word’ LH iamb
 - (də.və: _I)(rə.xɔ: _I) ‘your (ms) word’ LH iamb
 - (də.var _I)(xém _I) ‘your (mp) word’ LH iamb
- (18) Descriptive algorithm for constructing iambs:
- A final closed syllable is its own foot.
qatəlb: ‘she killed’ qatəl(tən) ‘you (fp) killed’
 - Build binary right-headed feet from right to left.
(qa)(təlb:) ‘she killed’ (qatəl)(tən) ‘you (fp) killed’
 - Now reduction and lengthening = trough and head; main stress right.
(qə:)(tə́lɔ:) ‘she killed’ (qətə́l)(tén) ‘you (fp) killed’

The Iambic-Trochaic Law (1985, 1995; Prince 1990; cf. Kager 1997) explains alternating reduction and lengthening:

- (19) The Iambic-Trochaic Law
- Iambic Scale: LH ≫ H, LL, HH
 - Trochaic Scale: LL, H ≫ HH ≫ HL, LH

Iambs want to be maximally unbalanced: a reduced (lighter than light?) vowel followed by a heavy syllable.

3.3 Analysis: First Declension Nouns

- (20) There is a difference between nouns and verbs:
- Verbs parse from R to L, such that stem varies in patterns of reduction and lengthening under suffixation:
/qatə́l/ → (qə:)(tə́lú:) but (qətə:)(ləxɔ:)
‘kill’ ‘they killed’ ‘he killed you (ms)’
 - But 1st and 2nd declension nouns don’t:
/dabar/ → (də.və:)(rɪ:) *(də:)(vəri:)
 - Compare 3rd declension: (qə:)(tə́.lí:) ‘my killing’ ← /qə:təl/

Proposal: 1st declension nouns must conform to an iambic template:

- (21) First Declension Noun Template = F_I
- (22) LEFT ANCHOR: the left edge of the stem must align with the left edge of the prosodic template.

Now right-to-left construction of iambs must be subordinated to templatic requirements.

- (23) Optimality-Theoretic Analysis:
- TEMPLATE SATISFACTION: A morphological template must be realized in the output.
 - PARSE SYLLABLE: All syllables in the output must be parsed into feet.
 - ALIGN FOOT RIGHT: All feet must align with the right edge of the prosodic word. (Assign one violation for each syllable intervening between the right edge of a foot and the right edge of a word.)
 - WEIGHT-BY-POSITION: A final closed syllable must be parsed as a foot.
 - TEMPSAT, LEFT ANCHOR, WBP ≫ PARSE-σ ≫ ALIGN-Ft-R

(24)

/dabar/ ‘word’	Temp Sat	Left Anchor	WBP	Parse σ	Align Ft-R
⇒(də:)(və:r)	✓	✓	✓	✓	*
(dəvə:r)	✓	✓	*!	✓	✓

(25)

/dabar+i:/ ‘my word’	Temp Sat	Left Anchor	WBP	Parse σ	Align Ft-R
⇒(də.və:)(rɪ:)	✓	✓	–	✓	*
(də:)(vəri:)	✓	✓	–	✓	**!
(də:)(və:)(rɪ:)	✓	✓	–	✓	***!

(Note that final closed syllables are special metrically: force a single foot, but final consonants must be non-moraic (as in other semitic languages) in order to get vowel lengthening.)

3.3.1 Properties of First Declension Nouns

(26)	1st Declension IAMB	2nd Declension ?
	Final stress	Penultimate stress
	Tonic lengthening	No tonic lengthening
	Pretonic lengthening	No pretonic lengthening
	Vowel reduction	No vowel reduction (stem)
	No vowel harmony	Vowel harmony
	Construct: no pre- or tonic lengthening	Construct: no change Suffixed: no V harmony

(27) Explanations now available:

- Final stress: stress is iambic, with main stress on the final foot.
- Tonic lengthening: realization of iambicity: the head of each foot must be heavy.
- Pretonic lengthening: same explanation. Occurs pretonically only when the final syllable is closed and forms a monosyllabic foot; hence head of penultimate foot abuts head of final foot.
- Vowel reduction: troughs of iambic feet reduce as a realization of iambicity.

3.3.2 The Construct

Construct State: noun bears a close syntactic, semantic, and phonological relation to a following noun. Semantic relation: possession/genitive. Phonological: the construct noun is part of the stress domain of the following word:

(28) *dəvār ham-mélex*
word the-king
'the word of the king'

Part of the stress domain = part of the same phonological word.

(29) WEIGHT-BY-POSITION: A final closed syllable must be parsed as a foot.

(30) Final = Final within the phonological word.

(31)

CONSTRUCT /dabar/ 'word'	Temp Sat	Left Anchor	WBP	Parse σ	Align Ft-R
\Rightarrow (dəvar)	✓	✓	–	✓	✓
(dɔ:)(var)	✓	✓	–	✓	*!

(Note that now the final consonant counts for weight, since it is no longer final within the prosodic word.)

3.4 Analysis: Second Declension “Segholates”

(32)	1st Declension		2nd Declension	
	'word'	'army'	'king'	'wonder'
<i>Sing. abs.</i>	dɔ:vó:r	ʃɔ:vɔ:	mélex	péle
<i>cstr.</i>	dəvār	ʃəvɔ:	mèlex	pèle
<i>1s. suff.</i>	dəvɔ:rí:	ʃəvɔ:ʔi:	malki:	piʔi:
<i>2ms. suff.</i>	dəvɔ:rəxó:	ʃəvɔ:ʔ ^a xɔ:	malkəxɔ:	piʔ ^a xɔ:/ piʔéxɔ:
<i>2mpl. suff.</i>	dəvarxém	ʃəvɔ:ʔ ^a xém	malkəxém	piʔ ^a xém
	IAMB		TROCHEE	
	Final stress		Penultimate stress	
	Tonic lengthening		No tonic lengthening	
	Pretonic lengthening		No pretonic lengthening	
	Vowel reduction		No vowel reduction	
	No vowel harmony		Vowel harmony	

There is evidence that the second vowel in the second declension (the Segholates) is epenthetic (Prince 1975); for example, it's absent when CC cluster heterosyllabic: *mal.ki*: 'my king'. Underlying form for 'king' is then /malk/.

- (LL) and (H) are both optimal trochees, but (L) is not a valid trochee. Given glottal stop deletion, we must either lengthen the remaining vowel or insert another one. If epenthesis is cheaper in Hebrew than vowel lengthening, epenthesis occurs even in forms with a final glottal stop.
- The conditioning factors are apparent on the surface: prosody. No opacity here.

3.4.3 Epenthesis is Prosodic and Prosody is Morphological

If epenthesis were driven purely by breaking up clusters, we would not expect the existence of forms like the following:

(47) ħé:t ‘sin’ ħetʔí: ‘my sin’ $\text{ħ}^a\text{t}:\text{ʔí:m}$ ‘sins’ $/\text{ħetʔ}/$

Being underlyingly of the same form as $/\text{dašʔ}/$ and $/\text{pilʔ}/$, $/\text{ħetʔ}/$ should surface in exactly the same way.

- (48) ħé:t is simply a member of the first declension, and must conform to an iambic template rather than a trochaic one.
- The difference here (not phonological in any relevant respect) shows that surface forms are dictated by arbitrary properties of noun classes: $/\text{dašʔ}/$ is a member of the class specified to be a trochee, while $/\text{ħetʔ}/$ is a member of the first declension, which must be an iamb.
 - The ordered rule approach would have to divide nouns into declensions and mark the first as being exceptions to epenthesis.
 - We see both possible responses to FOOT-MIN: epenthesis and lengthening, conditioned by other factors:
 - Templatic: The segholates are trochees, while $/\text{ħetʔ}/$ is iambic. The best iamb it can form is a single H syllable (lengthening):

(49) DEP- \acute{V} : A stressed vowel must have a correspondent in the input.

(50)

$/\text{ħetʔ}/$ ‘sin’	Temp Sat	Left Anch	Dep \acute{v}	Foot Min	Coda Cond	Parse σ	Align Ft-R	Wt- Ident	Dep V
$\Rightarrow(\text{ħe:t})$	✓	✓	✓	✓	✓	✓	✓	*	✓
$(\text{ħət}:\text{c})$	✓	✓	*!	✓	✓	✓	✓	✓	*

3.4.4 Vowel Harmony

Hypothesizing the foot structures above, we might expect to find phonological processes that are sensitive to them. One possibility is vowel harmony.

- Malone (1993) lists processes like the following, all of which amount to regressive vowel harmony:

(51) a. General Raising $[-\text{high}] \rightarrow [+ \text{high}]$ (before $[-\text{low}]$)
 $\epsilon \rightarrow i$ piryí: ‘my fruit’ vs. peryaxó ‘thy fruit’
 $a \rightarrow i$ divrè: ‘words (constr)’ vs. $\text{d}:\text{v}:\text{r}$ ‘word’
 $\text{ɔ} \rightarrow u$ ħuqqí:m ‘statutes’ vs. $\text{ħ}:\text{ɔq}$ ‘statute’

b. Midding Assimilation (before ϵ)
 $a \rightarrow \epsilon$ $\text{m}^\epsilon\text{l}^\epsilon\text{x}$ ‘king’ vs. malkí: ‘my king’

c. Checked Midding
 $a \rightarrow \epsilon$ (seems to always be followed by $\epsilon \rightarrow i$)

(52) Idsardi (1998a): spread [front] and [round] ($a \rightarrow \epsilon$).

- These processes (which I will not attempt to formalize) all seem to be dependent on foot structure: vowel harmony is confined to spreading of features within a single foot (cf. McCarthy 1979, Idsardi 1998a, who postulate feet different from those used in stress).

(53) a. $(\text{m}^\text{ə}\text{ð}^\text{ab})(\text{b}^\text{é}\text{r}^\text{e}\theta)$ ‘speaking (fs)’ \leftarrow $/\text{midabbart}/$ (transcription from Malone 1993)
 b. $(\text{w}^\text{ay})(\text{y}^\text{é}\text{ɣ}^\text{el})$ ‘and he exiled’

(54) Since the segholates (second declension nouns) all consist of a single foot in the absolute singular, we see vowel harmony:

- a. /malk/ → (mé.lɛx) ‘king’
 b. /rɔgz/ → (ró.ɣɛz) ‘anger, excitement’
- (55) But not in the suffixed forms, where a foot boundary is hypothesized to intervene:
 a. (mal)(kí:) ‘my king’ b. (rɔɣ)(zí:) ‘my anger’
- (56) For the same reason, we never see vowel harmony in the first declension singulars and suffixed forms:

3.5 Further Evidence that Feet are Morphological

- (57) What we’ve explained so far:
- Stress: iambic in the 1st declension but trochaic in the 2nd.
 - Tonic lengthening in the first but not in the second declension. Tonic lengthening is nothing more than the desire to create a well-formed foot, which must be heavy if monosyllabic; or to optimize an iamb, which is optimally LH.
 - Patterns of reduction in the first declension: the desire to create an optimal unbalanced iamb.
 - Pretonic lengthening: also a desire for an unbalanced iamb.
 - Lack of vowel harmony in the first declension: foot boundary.
 - Vowel harmony in the second declension: a single trochaic foot.
 - Lack of vowel harmony in suffixed forms (first and second declensions): foot boundary.
- (58) Further evidence that footing is morphological (templatic) and specified for each noun class comes from the plurals:

Plurals:

(59)		1st Declension		2nd Declension	
		‘word’	‘army’	‘king’	‘wonder’
	<i>Plural abs.</i>	dəvɔ:rí:m	ʃəvɔ:ʔo:θ	mələ:xí:m	pələ:ʔi:m
	<i>ctr.</i>	divrè:	ʃivʔo:θ	malxe:	pilʔe:
	<i>1s. suff.</i>	dəvɔ:ráy	ʃivʔo:θay	mələ:xay	pələ:ʔay
	<i>2ms. suff.</i>	dəvɔ:rɛ́xɔ:	ʃivʔo:θɛ́xɔ:	mələ:xɛ́xɔ:	pələ:ʔɛ́xɔ:
	<i>2mpl. suff.</i>	divre:xém	ʃivʔo:θe:xém	malxe:xém	pilʔe:xém
		Long vowel		Long vowel	
		Vowel harmony (constr)		No vowel harmony	

- (60) Prince (1975) hypothesizes a rule inserting -a- into the segholates in the plural. This misses the generalization that the first and second declensions are conforming to the same template in the plural.
- (61) It is evident that the plural imposes an iambic template with a long vowel as second syllable (compare Arabic broken plural; McCarthy and Prince 1990).
- (62) The first and second declensions fall together in the plural to the exclusion of the third, indicating again that it is noun classes that are relevant:
- (63) The third declension
- ko:hé:n ‘priest’ ko:h^aní:m
 - qo:ʔé:l ‘killing’ qo:ʔəlí:m
 - məqaddé:š ‘sanctifying’ məqaddəsí:m

4 Conclusion

- (64) Advantages of the proposal:
- Realizing that phonological processes are driven by a desire to optimize foot structure provides an account of those processes as arising from the Iambic-Trochaic Law (Hayes 1985, 1995; Prince 1990):
 - Patterns of reduction and lengthening are all driven by well-formedness conditions on feet: that iambs be unbalanced and trochees balanced.

- c. Once we understand the foot structure, we see that reduction and lengthening mostly optimize iambs by making them unbalanced. Conversely, lengthening does not occur where trochees must be optimized.
 - d. Crucial differences between declensions follow from their being specified to be different types of feet in the output.
 - e. The correct foot structure explains other segmental processes that are sensitive to metrical feet, such as vowel harmony.
 - f. There is no need to postulate different planes of metrical structure, as in McCarthy (1979), Rappaport (1984), and Halle and Vergnaud (1987). The postulated feet figure in all processes: stress, reduction, lengthening, deletion, vowel harmony.
- (65) Opacity:
- a. Once we recognize the templatic nature of Hebrew, we see that epenthesis in the segholates is driven not just by breaking up illicit clusters, but by the desire to achieve an optimal foot (the template). Thus *the context for epenthesis is always surface true in Hebrew*.
 - b. Vowel harmony, reduction, lengthening, and stress assignment are all governed by surface footing. The context for these processes are also surface true in Hebrew.
 - c. Conclusion: A reanalysis of “linguistically significant” phonological generalizations can lead to a deeper understanding of the forces at work, and can even (as here) lead to opacity vanishing.

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