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Prosodic Morphology and Templatic Morphology

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PROSODIC MORPHOLOGY AND TEMPLATIC MORPHOLOGY

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1. Introduction

Much of the time, morphology is just word-syntax. That is, the morphological grammar of a language reduces to statements like "ness is a Level 2 suffix". But this is not always true, and the cases where it is not true reveal a great deal about morphological structure and its relation to phonology.

In many languages, morphological categories are expressed not by conventional affixes but by morphemes whose only constant is a fixed canonical pattern -- what might be called shape-invariant morphology. The most common kind of shape-invariant morphology is reduplication, but it is also central to the somewhat rarer templatic morphology of Arabic. In Arabic, various morphological distinctions are expressed by specifying a fixed canonical form of the stem that does not vary despite independent morphological or lexical changes in the consonants or vowels that fill this canonical form. For example, (1) demonstrates the property of shape-invariance for the Arabic causative, known as the faʕʕala or Form 2. (Here and throughout this article, unless otherwise indicated, Arabic words are given in their stem form, which abstracts away from the effects of phonological rules and the addition of inflectional affixes from the agreement, mood, and case-marking systems):

(1) Shape Invariance in Arabic Form 2 (faʕʕala)

	/ktb/ 'write'	/drs/ 'study'	/ʕlm/ 'know'	/sm/ 'poison'
	kattab	darras	ʕallam	sammam
perfect active				
	kuttib	durris	ʕullim	summim
perfect passive				
Cu+	kattib	darris	ʕallim	sammim
imperfect active				
Cu+	kattab	darras	ʕallam	sammam
imperfect passive				

Taken in the context of the fuller analysis of the verbal system in McCarthy (1981), this small array of facts is sufficient to demonstrate the property of shape-invariance in Arabic templatic morphology. Moving across the columns of (1) changes the consonantal root, the fundamental lexical unit of the language. Despite this change in the consonants, the canonical pattern remains the same. Similarly, moving down the rows of (1) changes the vocalism: voice goes from active to passive or aspect from perfective to imperfective. Again the canonical pattern remains the same. Similar regularities are met with throughout the Arabic system of verbal conjugations.

Clearly, as more information about shape-invariant morphology in general and templatic morphology in particular becomes available, it becomes increasingly important that a satisfactory theory of these phenomena underlies the analysis. In recent research (McCarthy and Prince 1986, 1988, 1990, forthcoming), we have developed an approach to shape-invariant morphology that is fundamentally founded in the phonology of prosody. It is called "Prosodic Morphology". The properties attributed to reduplicative and templatic morphology in Prosodic Morphology are independently motivated by their role in the characterization of phonological processes, stress, and versification. Our first task in this article is to lay out briefly the fundamental tenets of this theory.

The article continues with an extended analysis of the templatic morphology of Standard Arabic. We begin by sketching in a very brief and superficial way the nature of the prosodic analysis of Arabic templatic morphology. This is followed by detailed treatment of the most significant issues, demonstrating that the prosodic theory is not only a viable alternative to its predecessors but is in fact superior to them, revealing and capturing regularities that have played no role in previous treatments.

The investigation is guided by one fundamental idea, called the Prosodic Morphology Hypothesis. It asserts that the templates of reduplicative or templatic morphology are defined in terms of the authentic units of prosody: the mora, the syllable, the foot, and the phonological word. In other words, the Prosodic Morphology Hypothesis demands that the vocabulary of templates is the same as the vocabulary of prosody in general, including stress, syllabification, epenthesis, compensatory lengthening, rhyme, "counting rules", and poetic metre.

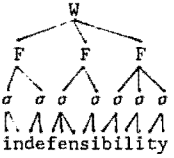
The prosodic constituents are arranged in a hierarchy of exhaustive domination (cf. Selkirk 1980):

(2) Prosodic Hierarchy

Phonological Word	W
Foot	F
Syllable	σ
Mora	μ

The hierarchy is read from top to bottom, so the units at a higher level only contain units from lower levels. The phonological word corresponds roughly but not exactly to the grammatical or syntactic word; it is typically the domain of main-stress assignment. The foot is a constituent composed of at least one stressed syllable and usually an unstressed syllable as well. For example, the single phonological word indefensibility contains three feet dominating seven syllables, as (3) shows:

(3)



indefensibility

The mora is the unit by which syllable weight is measured -- its role in a theory like (2) has been explored by Prince (1983), Hyman (1985), McCarthy and Prince (1986 et seq.), Hayes (1989), Archangeli (1988), and Itô (1989). Investigation of systems of stress assignment, versification, and other phenomena reveals a fundamental distinction between two types of syllables, heavy and light. Usually heavy syllables are those that contain a long vowel (Cvv) or are closed by a final consonant (CvC), while light syllables are open with a short vowel (Cv), but occasionally

languages adopt a different dichotomy). By definition, heavy syllables contain two moras, while light syllables contain only one.

This establishes the set of descriptive primitives and the hierarchy in which they are arranged. The theory also includes constraints on the combination of prosodic units, but we will not give a comprehensive treatment of that topic at this time (see McCarthy and Prince (1986, 1988, 1990, forthcoming) for additional development), introducing only those notions that become necessary as particular examples are treated.

3. Prosodic Morphology in Arabic

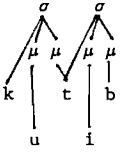
In McCarthy (1981), it is shown that a form like kuttib simultaneously expresses three different morphemes: the consonantal root /ktb/ 'write', the vowel melody /u_i/ 'perfective passive', and the templatic morpheme CVCCVC 'Form 2' or 'causative/factive'. It is the templatic morpheme CVCCVC -- called a CV skeleton -- that accounts for morphological shape invariance. The coordination of these three levels is by the principles of autosegmental phonology (Goldsmith 1976, Clements and Ford 1979), so the form kuttib is represented as follows:

(4)

Vowel Melody	u i	'perfective passive'
CV Skeleton	CVCCVC	'causative (Form 2)'
Root	k t b	'write'

The Form 2 template is, in CV skeleton theory, a string of segment-sized units C and V. The Prosodic Morphology Hypothesis requires that a very different vocabulary be used to characterize templates like this one: it is a sequence of two heavy syllables. In prosodic morphological terms, then, kuttib is represented as:

(5)



(This will later be refined somewhat.) Since moras are the prosodic unit of syllable weight, a syllable dominating two moras is heavy, like the syllables kat and tab of the Form 2 verb kattab.

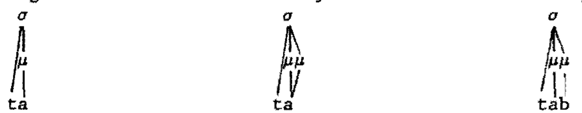
What are the differences between these two seemingly equivalent characterizations of the Form 2 template? First, the prosodic template only refers to units that are independently motivated in prosody. This is not a mere tautology, since independent motivation for the segment-sized units of CV skeleton theory is difficult to come by and often, if not always, subject to plausible reanalysis. Unambiguous evidence for segment-sized skeletal units is nonexistent. Second, as we will see below, prosodic templates reveal connections with other aspects of Arabic prosody, particularly foot structure and minimality, that could not be obtained from a CV template. Third, the Prosodic Morphology Hypothesis often forces the correct analysis in cases where CV skeletal theory is confronted with an array of incompatible and inadequate options, as we show in our study of the Arabic broken plural (McCarthy and Prince 1990). Finally, prosodic morphological theory is more restrictive than CV skeletal theory (since the units of prosody are needed independently in either theory), and is therefore to be preferred to it on general grounds of parsimony and learnability.

4. Moras and Extrametricality

Moraic theory provides us with certain basic tools for characterizing the syllable types of a language. A syllable normally may contain one mora or two; a monomoraic syllable is called light and a bimoraic one heavy. Peripheral elements -- those at the left or right edge of a stem, word, or other domain -- may be extrametrical, not participating in the overall prosody of a word.

In medial position, where extrametricality is not a factor, Standard Arabic has just three types of syllables: Cv (ta), Cvv (taa), and CvC (tab). On the basis of cross-linguistic comparison, our normal expectation is that Cv syllables are light or monomoraic while Cvv and CvC syllables are heavy or bimoraic. We therefore represent these syllable types as follows:

(6)
a. Light Cv   b. Heavy Cvv   c. Heavy CvC



The representations in (6) segregate syllables into two classes, lumping Cvv and CvC syllables together as bimoraic. Evidence for this classification is abundant.

The first set of arguments comes from an aspect of prosody, the classical system of versification. In Al-Xalil's analysis of this system, a fundamental distinction is made between two kinds

consists of any syllable, heavy or light. But a peg is composed specifically of a sequence of a light syllable followed by a heavy one. (The peg, then, is an iambic foot.) In other words, the characterization of a peg must count moras: it is a syllable with one mora followed by a syllable with two moras (with the usual moraic equivalence of the heavy CvC and Cvv syllables). An even better case for moras comes from the phenomenon of resolution, which appears in the meters called kaamil and waafir. In these meters, in certain positions in the verse the poet may use either two light syllables or a single heavy syllable (mutafaaʕilun and mufaaʕalatun are the mnemonic examples). This too is an instance of mora counting -- since a light syllable occupies one mora and a heavy syllable occupies two, the equivalence between two light syllables and one heavy syllable is precisely what is expected. Finally, the traditional theory of the rhyme in poetry and rhymed prose (sajʕ) relies crucially on the notion "heavy syllable":

(7) Traditional Typology of Rhymes

Rhyme Type	Rhyming Words
mutawaatir	Zulmi, siHru, šaybaanaa, Zunuunii
mutadaarik	ʔal-mubaasilu, yazuurahaa, haykali
mutaraakib	walaa faraqaa, qad Husiduu

Each of the four types of rhyme is distinguished from the others by the position of the rightmost nonfinal heavy syllable in the verse: in mutawaatir it is the penultimate syllable, in mutadaarik it is the antepenultimate, and in the rare mutaraakib it is the preantepenultimate.[1]

Another aspect of prosody, stress, leads to exactly the same conclusion as the rhyme facts do. There is considerable discrepancy in the stressing of standard Arabic words between different areas of the Arab world, and no direct testimony on this subject exists from the Classical period. Nevertheless, a plausible norm with wide geographic and ethnic distribution is represented by the data in (8):

(8) Stress Placement

Final	Penult	Antepenult
yaquul	yaquulu	kataba
qaanuun	yaqulna	katabat
sirHaan	qaalat	katabuu
tarjamt	ramaa	

[1] Another, rare rhyme type, mutaraadif, is distinguished by final CvvC or CvCC syllables.

McCarthy and Prince: Prosodic Morphology and Templatic Morphology

(9)

a. Stress the final syllable if it is CvvC or CvCC.
b. Otherwise stress the penultimate syllable if it is Cvv or CvC (or the word is disyllabic).
c. Otherwise stress the antepenultimate.

Leaving aside the cases of final stress in (9a) (which occur only pre-pausally in Classical Arabic, under loss of case and agreement desinences), the basic observation is that the penult is stressed if it is bimoraic, otherwise stress falls on the antepenult.

In the typology of metrical stress feet introduced by Hayes (1987) and McCarthy and Prince (1986), based on Hayes's (1985) survey, this type of stress pattern is derived by a foot called the moraic or quantitative trochee. This foot type contains exactly two moras and is stressed on the left:

(10) Quantitative Trochee

For purposes of stress assignment, final (light) syllables are not included in the application of this foot. They are therefore extrametrical with respect to foot assigment.[2]

The segmental phonology of Arabic also provides direct evidence of the light/heavy distinction. Consider first a process originally described in generative phonological terms by Brame (1970). The alternation in vowel length in hollow verbs[3] in (11a) is a typical example of a well-established phonological phenomenon: vowel shortening in closed syllables. The derivation proceeds as in (11b):

---

[2] An interesting case is presented by forms like tárjama 'he translated', with a heavy antepenult followed by a light syllable. With final extrametricality, the metrical portion of the word is tarja. A final bimoraic foot cannot be placed on this word to give ta[rja]$_F$ because this would violate the prosodic hierarchy. A final monomoraic foot (tar[ja]$_F$) is impossible, because the quantitative trochee is exactly two moras. Therefore the right-to-left operation of foot-assignment must move on to yield [tar]$_F$ja, correctly resulting in antepenultimate stress.

[3] Hollow verbs are those whose medial root consonant is a high glide -- /qwl/ in 11. The w appears overtly when geminate (qawwaal 'garrulous') or syllable-final (qawl 'word'); it is otherwise usually subject to complex morphophonemic processes which will not be discussed here.

(11)

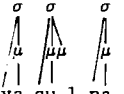
a.	qaala	qulu	he/I said
	yaquulu	yaqulna	'he/they (f) say'

b.

/yaquul+u/	/yaquul+na/	Underlying Form
[yaquulu]	[yaqul+na]	Shortening Rule

The rule of vowel shortening in closed syllables has a straightforward interpretation in moraic terms. The heaviest syllable in Arabic is one with two moras, and a long vowel occupies both of them. But a CvC syllable also has two moras. Taking these two facts together, it is apparent that a long vowel should normally be incompatible with a syllable-final consonant. In Arabic and usually elsewhere, the length of the vowel gives way under the pressure of the consonant that would otherwise be unsyllabifiable.[4] Example (12) shows in a somewhat informal way what happens:

(12)



Input Form ya qu l na (= /yaquul+na/)

Derived Form ya qul na (= [yaqul+na])

Moraic theory provides a straightforward account of this common phonological rule.[5]

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[4] Makkan Arabic (Abu-Mansour 1987:163) takes another option. Instead of shortening the long vowel before an unsyllabifiable consonant, it epenthesizes a vowel: /muftaaH+kum/ -> muftaaHakum 'your (pl.) key'. The third logical possibility, loss of the unsyllabifiable consonant after a long vowel, is attested in no language known to us.

[5] There is an interesting aspect to the treatment of CVVC in word-final position. The jussive of yaquulu is yaqul, with vowel shortening in a closed syllable. But the pausal form of yaquulu is yaquul, which retains the long vowel, as predicted by the conditions on extrasyllabicity developed below. There is evidence (from the jussives of III-w, y roots) that the jussive is formed by a morphological truncation of the final vowel, and this may be responsible for the lack of final extrasyllabicity in jussives.

Another sort of phonological process that provides similar evidence for the mora in Arabic is the phenomenon of compensatory lengthening, in which deletion of a syllable-final consonant is compensated for by lengthening of the preceding vowel. (Compensatory lengthening is treated briefly in McCarthy and Prince (1986); a recent comprehensive review of the topic in moraic terms is provided by Hayes (1989).) In Arabic, compensatory lengthening is quite common; it shows up most obviously in the derivation of Form 4 (ʔafʕala) from roots whose first consonant is ʔ. Example (13) contains the evidence and an informal statement of the rule:

(13)
a.
Underlying ʔaʔθar (Form 4 (ʔaCCaC) of root /ʔθr/)
Derived ʔaaθar

b. ʔ Deletion
ʔ -> ϕ / ʔV__

In moraic terms, compensatory lengthening is simply an exchange of one type of heavy syllable for another -- the moras remain the same but the segments associated with them change. This is shown in (14):

(14)

Underlying Form

Derived Form

Deletion of the ʔ leaves a mora stranded; this mora is then filled by spreading of the vowel a. The equivalence of the two types of heavy syllables is apparent in this example.

In summary, these arguments all point toward the central importance of the notion mora in Arabic. The evidence indicates a fundamental classification into light (monomoraic) Cv syllables and heavy (bimoraic) Cvv and CvC syllables. This typology, though, holds only of syllables in medial position. Initially or finally, extrametricality provides a richer array of options. Let us consider, then, what is special about initial or final position.

Although medial syllables begin with exactly one consonant, initial sequences of two consonants occur. These appear in verb forms and their derivatives that have what is traditionally called hamzatu l-waSli, the "elideable" glottal stop. Examples include Form 7 ʔinfaʕal, Form 8 ʔiftaʕal, and Form 10 ʔistafʕal. The distribution of this property forces any generative phonological analysis to say that the initial glottal stop and the vowel following it are not in fact elided, but rather inserted in the course of syllabification. For example, the underlying representation of the Form 8 stem is ftaʕal, although on the surface this word in isolation is pronounced as ʔiftaʕal.

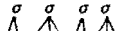
The following examples show what happens to this form in different phonological contexts within the utterance or major phonological phrase:

(15) The Phenomenon of hamzatu l-waSli

a. Postpausally (that is, utterance initially)

ʔiftaʕal

b. Postconsonantally



qad iftaʕal

c. Postvocalically

huwwa ftaʕal

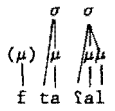
waftaʕal

The examples indicate the syllabic affiliation of every segment in the three possible phonological contexts. In postvocalic contexts, underlying ftaʕal emerges unchanged. In postconsonantal contexts, a triconsonantal cluster is broken up by an epenthetic vowel -- i before a or i, u before u. Postpausally, the initial biconsonantal cluster of ftaʕal requires an epenthetic vowel, and the epenthetic vowel itself requires a preceding consonant, ʔ, since all Arabic syllables must begin with a consonant. The appearance of ʔ and the epenthetic vowel are fully predictable from the underlying representation ftaʕal. For that reason we cannot speak of elision, but rather of insertion.

Having established the existence of underlying representations with initial consonant clusters, we must now integrate them into the moraic model. Since this phenomenon is limited to stem-initial position, extrametricality, inherently restricted to the periphery (Hayes 1982, Harris 1983), is the mechanism that presents itself.

As a first approximation, the initial consonant of ftaʕal can be analyzed as an extrametrical mora, one that is not linked to any syllable. Extrametricality is conventionally marked by parentheses in representations like the following:

(16)



When f becomes intrametrical, either by prefixation or in the postlexical phonology, it remains moraic but must be fully integrated into a complete syllabic structure. A preceding vowel supplies that in (15c), while epenthesis is necessary in (15a, b). In all cases in (15), the f is indeed in a moraic position, closing a heavy syllable.

But this by itself is not proof that f is linked to an extrametrical mora in underlying representation -- the phonology of Standard Arabic (specifically, the epenthesis rule) could simply stipulate the position of the epenthetic vowel, since there is little evidence for epenthesis elsewhere in the language. This is emphatically not the case in Egyptian Colloquial, however. As Broselow (1976) and Selkirk (1981) have shown in considerable detail, the treatment of otherwise unsyllabifiable consonants in Egyptian Arabic follows a very regular pattern in which a vowel is always inserted after the consonant, as (17a, b) show. Indeed, as Itô (1986) shows, a single parameter in the grammar of Egyptian Arabic, left-to-right syllabification, accounts for this consistent placement of the epenthetic vowel relative to the otherwise unsyllabifiable, or "stray", consonant.

(17) Egyptian Colloquial Treatment of Stray Consonants

a. Vowel Insertion in CC___C Context
/katabtlu/ -> katabtilu

b. Vowel Insertion in #C___C Context in Loans
plastic -> bilastik

c. Vowel Insertion in #___CC Context in Templatic Verbs
/gtamaʕ/ -> igtamaʕ (-> ʔigtamaʕ)

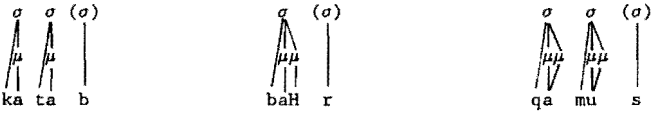
It is puzzling, then, that just the opposite treatment is accorded the initial extra consonant in templatic Form 8 verbs like (17c). Yet this is exactly what is expected if the g of ʔigtamaʕ is an underlying extrametrical mora -- it must remain a mora despite the normal vowel insertion process of the language.

This evidence shows, then, that the extrametrical initial mora has some independent motivation. Prosodic theory forces us to posit this analysis in both Standard Arabic and the Cairene colloquial. Other facts of Standard Arabic are consistent with this approach, but they do not prove its correctness. But in Cairene, the difference between epenthesis in templatic verbs and elsewhere in the language requires the extrametrical initial mora.

At the right edge of stems, we also find both a more limited and a richer structure than the Cv, CvC, and Cvv medial syllables would allow. All stems of Arabic must end in a consonant; thus, Cvv and Cv stem-final syllables are prohibited. Furthermore, noun stems can end in CvCC (baHr 'sea') or CvvC (qaamuus 'ocean'), with a heavy syllable followed by an extra consonant. Stem-finally, then, the only permitted sequences are CvC, CvCC, and CvvC. (In word-final position, because of affixes, Cv, Cvv, and prepausally CvvC are also permitted.)

The licit stem-final sequences can be analyzed as a sequence consisting of any possible medial syllable followed by an obligatory consonant: Cv+C, CvC+C, and Cvv+C. The obligatory stem-final consonant is plausibly analyzed as extrametrical but not as moraic, since it becomes an onset before vowel-initial suffixes or words: cf. (15b) and katab+a 'he wrote', qaamuus+un 'ocean (nom. indef.)'. We might, then, regard the position to which this consonant is linked as an extrametrical final syllable, as in the following representations:

(18)



(The examination of biliteral roots in the next section will show why final consonants must be linked to a skeletal position; they cannot simply float.) For stems, the final extrametrical syllable is required; thus, all stems must end in a consonant. The following rule records this:

(19) Final Incompleteness

$\phi \rightarrow (\sigma) \; / \; \_\_\_]_{Stem}$

Thus far, we have a significant asymmetry between initial and final position. Initially, we posit an extrametrical mora to bear the parenthesized extrasyllabic consonant of forms like (f)ta$al. Finally, there is an extrametrical syllable to bear the extrasyllabic consonant of kata(b), baH(r), and qaamuu(s). The unifying observation is that the inital extrasyllabic consonant

has a characteristic property of syllable-final position -- it is moraic -- while the final extrasyllabic consonant is not moraic, as if it were syllable-initial.

This paradoxical behavior of extrasyllabic consonants has been noted before, originally by Itô (1982: 13-14) for Russian and later by Borowsky (1986: 197-199) for English. In these languages which, unlike Arabic, allow complex onsets and codas, the permitted sequences of final extrasyllabic consonants are just exactly the permitted onsets and the permitted sequences of initial extrasyllabic consonants are the permitted codas. Itô's general schema for a Russian word, then, is (Coda)σ^*(Onset), where σ^* denotes a string of zero or more syllables. The same can be said of an Arabic stem, except that the initial Coda appears only in certain morphological classes of the verb and the final Onset is obligatory in all stems.

We can now incorporate these results into prosodic theory. The fundamental insight is that syllables at the periphery of a stem, word, or other domain may be incomplete, consisting solely of a moraic consonant (a Coda) or a nonmoraic consonant (an Onset). Clearly these incomplete peripheral syllables are what we have been calling up until now extrametrical ones, and we can continue to denote them by (σ). We stipulate that (σ) is vowel-less (in Arabic), but derive its positional characteristics (initial (σ) is a moraic coda, final (σ) is a nonmoraic onset) from the following principle:

(20) Contiguity Constraint

Syllabic well-formedness is enforced over contiguous strings of subsyllabic elements.

The Contiguity Constraint entails that vowel-less syllables (σ) can be found only at the periphery of words, since a representation like ...$[CvC]_\sigma[C]_\sigma[CvC]_\sigma$... violates well-formedness with respect to the string CCC. Similarly, an initial or final $[CC]_\sigma$ syllable violates the Contiguity Constraint. Furthermore, a representation like $[C]_\sigma[Cv]_\sigma$... respects the contiguity constraint if and only if the initial C is analyzed as a moraic position in the vowel-less syllable, because syllabic well-formedness demands that, in any heterosyllabic CC sequence, the first C be a mora. Likewise, ...$[CV]_\sigma[C]_\sigma$ is well-formed if and only if the final C is nonmoraic (an onset), since it is syllable-initial and follows another syllable.

The Contiguity Constraint we take to be universal, although there is some variation in how it is enforced. Morphological templates like those of Arabic enforce it absolutely, but subsequent morphological (Archangeli 1988) or phonological (Itô 1986, 1989) developments may respect it only by requiring the

provision of an epenthetic vowel or consonant to fill-out the gaps in the strings of subsyllabic elements.

We tentatively suggest that the limitation of the incompleteness property to vowel-less syllables is part of the particular grammar of Arabic, rather than universal. There is some evidence from other languages that initial onset-less (therefore incomplete but voweled) syllables may also show extrametrical behavior. In the Timugon Murut diminutive and instrumental morphology (Prentice 1971, McCarthy and Prince 1986), initial CV reduplication is the norm for consonant-initial words: bulud 'hill', bu-bulud; dondo? 'one', do-dondo?. But vowel-initial words disregard the entire first syllable, so the reduplicative morphology is infixed: ulampoy (not glossed), u-la-lampoy; indimo 'five times', in-di-dimo 'dim./inst.'; ompod, om-po-pod 'dim./inst.'. And in Western Aranda (Strehlow 1942, Davis 1988, Archangeli 1986, Halle and Vergnaud 1987), main stress falls on the first syllable if the word begins with a consonant (túkuṛa 'ulcer') and on the second if the word begins with a vowel (ergúma 'to seize').[6] Both of these phenomena have been treated as effects of syllable extrametricality; in our conception, this correlates with the incompleteness of these peripheral syllables.

To sum up this discussion, we have argued that the treatment of extrasyllabic consonants at the edge of Arabic stems is the reflection of a far more general property, the option for languages to have incomplete syllables at the periphery. We obtain the particular properties of these elements in Arabic -- moraicity initially, non-moraicity finally -- from the universal Contiguity Constraint in (20) and the stipulation that incomplete syllables are vowel-less. These extrametrical syllables therefore fit-in nicely with the general view of Arabic syllable prosody offered here.

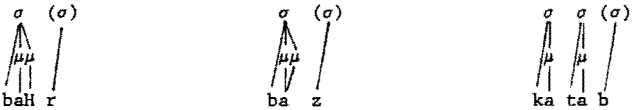
5. Minimality in Arabic

Since the word dominates the foot in the prosodic hierarchy, the smallest word will be a single foot. We call a word, stem, or other top-level category that exactly meets this criterion **minimal**. Since Arabic requires quantitative trochaic stress feet, the minimal stem (and therefore word) will be a single foot of this type, or two moras. These two moras can be contained in a single heavy syllable or distributed between two light syllables. Final incomplete syllables, although required in Arabic stems, do not contribute to the fulfillment of the minimal stem requirement, and so they are in addition to the two moras required by

[6] Western Aranda disyllabic words nevertheless always have initial stress.

minimality. Some typical examples of minimal stems -- that is, forms with exactly two moras -- appear in (21):

(21)



Modulo final extrametricality, each of these forms minimally satisifies the two-mora requirement. They (and of course many others like them) are all uncontroversially words of the language, abstracting away from the addition of case and agreement affixes.

There are, however, a few apparent counterexamples to the minimal stem requirement. Some candidate words that are too small appear in (22):

(22) Apparent Monomoraic Words

Non-words	Biliterals	Imperatives
wa 'and'	ʔab	li (imperative /wly/)
qad 'past'	bn	daʕ (imperative /wdʕ/)
bi 'in, with'		ktub (imperative /ktb/)

All of these forms have at most one mora by the criteria established; in fact, in the case of bn there are evidently no metrical moras at all in underlying representation (since this form contains no intrametrical syllables). These apparent counterexamples must obviously be dealt with.

Those in the category "non-words" in (22) are exactly that. All of these forms are in the so-called nonlexical vocabulary -- they are not members of the major lexical categories noun, verb, and adjective.[7] Cross-linguistic investigation reveals that nonlexical vocabulary rarely has the phonological or grammatical properties of ordinary nouns and verbs. (For example, the only "words" of English beginning with voiced th are non-lexical: the, this, that, thou, then, etc.) The minimal word constraint is a prosodic constraint on the lexicon: it therefore does not apply to nonlexical vocabulary. Furthermore, there is no reason to believe that these nonlexical words are independent prosodic words in any case.

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[7] The traditional conception of "word" implicit in the orthography evidently counts letters; wa and bi require a single letter and are written as prefixes, while laa and qad require two letters and are written as separate words.

requirement, yet all of them are nonlexical as well. Such words run afoul of another requirement on Arabic stems -- they must end in a consonant by (19), a constraint that is required independently of minimality.

The examples in the second column of (22) are lexical vocabulary items -- they are nouns -- but they too are not compelling evidence against the minimal word requirement. The reason is that they come from a very small, closed class of items that never reflected a productive pattern of the language. In the 1-mora class with ʔab are Ham, ʔax, dam, fam, and yad. And in the 0-mora class with bn is sm.[8] These lists are exhaustive, so the numbers are obviously quite small. Moreover, these words are quite irregular whenever they participate in any of the truly productive morphology of the language, and the irregularities they display always make the stem larger, so that it satisfies the minimality requirement. ʔab, for instance, receives an added aw in the dual and nisba (a productive denominal adjective obtained by suffixing iiy): ʔabaw+aan, ʔabaw+iiy. It also has this w in the plural /ʔaʔbaaw/ (which becomes ʔaabaaʔ by regular phonological rules). And, interestingly, it lengthens the case suffix (making the word bimoraic) in the definite singular: ʔal-ʔabuu, ʔal-ʔabii. These observations indicate that these monomoraic words are in fact exceptional in nearly all respects; it is no surprise, then, that they are exceptions (rather than counterexamples) to the minimality requirement.

The examples in the third column of (22) are all imperatives. Traditionally, imperatives are special in two respects, both of which involve morphological truncation or deletion processes. First, the imperative, like the jussive, deletes the final vowel of the indicative imperfective. Second, the imperative is derived from the jussive by deleting the agreement prefix. What has happened in these forms is that application of these morphological truncation processes creates the apparent violation of the minimal word constraint. The constraint, then, must be enforced at a relatively early stage of the derivation before these truncations.

Apart from these basic observations, there are at least four other arguments in support of the bimoraic minimal stem in Arabic. First, it is clear that CvC stems like ʔab are abnormal even when

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[8] Interestingly, all of these except for sm 'name' are words for near kin (ʔab 'father', Ham '(woman's) father-in-law', ʔax 'brother', bn 'son') or body parts (dam 'blood', fam 'mouth', yad 'hand'). In many languages, such words, including 'name', are inalienably possessed, requiring possessive pronouns. If this situation obtained in an earlier, unattested stage of Arabic, it would account for the violation of minimality here; with possessive suffixes, all these words would be at least two moras long.

the root is biconsonantal. Versus the tiny number of words like ʔab, our lexical material contains over 150 monosyllables like barr, buzz, or tall, in which biliteral roots like /br/ or /bz/ must satisfy the minimum of two metrical moras via gemination of the final radical. For this reason, too, the bimoraic minimality requirement is not reducible to counting root consonants, as traditional accounts would have it. If all Arabic roots had three consonants, as the tradition assumes, then a CvCC/CvCvC minimum would follow simply from the need to find positions for all of them. But biliteral roots are a prominent feature of the Arabic lexicon (McCarthy 1979, 1981, 1986), and so the prosodic requirement of bimoraicity is essential.

Second, many roots whose initial consonant is w lose this w in the masdar (a kind of nominalization) by a partly phonological rule, as (23) shows:

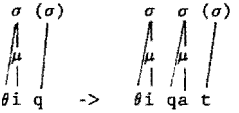
(23)

Perfective	Masdar	
waθiq	θiq+at	'rely'
wadaʔ	daʔ+at	'put'
wada(y)	diy+at	'pay wergild'
wariθ	riθ+at	'inherit'
wazan	zin+at	'weigh'
wasiʕ	saʔ+at	'be wide'

The problem is why just these masdar forms require the feminine suffix +at.

The obligatory feminine suffix in these masdars is explained by the bimoraic minimum. With the loss of the root-initial w, a form like θiq is simply too small, since it contains only a single mora. Addition of the feminine suffix augments it to make it bimoraic, as (24) shows:

(24)



The traditional idea (Wright 1971: 118) that the feminine suffix compensates for the loss of the first radical is expressed formally by the bimoraic minimal stem requirement. An additional bit of evidence in support of this analysis comes from the nisba derived from these masdar forms. Since the feminine suffix can never precede the nisba suffix, the feminine suffix must be lost. The result is that the base is then too small. This problem is resolved by introducing a final aw, just as in the case of ʔab: perfective waʔad 'make a promise', imperfective yaʕid, masdar ʕid+at 'a promise', nisba of masdar ʕidaw+iy. 'promissory'

A third line of evidence in support of the bimoraic minimal word comes from the treatment of borrowed words that would otherwise be too small. A few examples, gathered at random, appear in (25):

(25)

Source	Arabicized form
bar	baar
jazz	jaaz
gas	gaaz
Shem	saam
Gaul	gaal
shawl	šaal

Words that would be monomoraic when borrowed into Modern Standard Arabic are made bimoraic, satisfying minimality, by lengthening the vowel. Along the same lines, Broselow (p.c.; cf. Broselow 1982: 124) observes that the English word bus, which would be monomoraic in Arabic, is borrowed into the Palestinian colloquial variously as baas, bass, and basi, all bimoraic. In fact, Smeaton (1973: 87), in his comprehensive treatment of loan words in a Saudi Bedouin dialect, proposes a rule of Arabicization by which all CvC monosyllables are borrowed with gemination of the final consonant: baSS 'bus', natt 'nut', rigg 'rig'.

Similar regularities are even more profoundly integrated into the phonology of the modern Arabic dialects. Broselow 1982 notes that in Iraqi Arabic initial epenthesis is obligatory for sub-minimal CCvC imperatives but optional in longer ones. And Kenstowicz 1981 has argued that vowel-length alternations observed in Lebanese Arabic imperatives like ktoob 'write! (m. sg.)', ktibu 'write! (pl.)' also demonstrate a two-mora minimality requirement.

A final phenomenon demonstrating the role of the bimoraic minimal word is found in the remarkable behavior of the truncated vocative. Cross-linguistically, truncated hypocoristics or vocatives (nicknames) often are based on the minimal word or, equivalently, the foot (McCarthy and Prince 1986, forthcoming). Arabic has truncated vocatives occasionally in classical verse (though not in the contemporary literary language). These are discussed by Wright (1971:2.88) and Howell (1986:1.1.191-4). Representative data, all proper nouns, appear in (26):

(26)

a. CvvCvC nouns	
maazin	maazi
maalik	maali
ʕaamir	ʕaami
Haariθ	Haari
b. CvCvvC nouns	
suʕaad	suʕaa
majiid	majii
θamuud	θamuu
c. CvCCvC nouns	
jaʕfar	jaʕfa
d. CvCCvvC nouns	
ʕuθmaan	ʕuθma
marwaan	marwa
manSuur	manSu
miskiin	miski

Smaller nouns -- those with stems CvCC or CvCvC -- do not form distinctive truncated vocatives. This is to be expected, if the truncated vocatives are based on the minimal word; CvCC and CvCvC stems are already minimal.

The most interesting contrast in (26) is between CvCvvC and CvCCvvC stems; the former retain the length of the final vowel in the truncated vocative, as in majiid/majii, while the CvCCvvC forms do not, as in marwaan/marwa. The source of this difference is clearly the weight of the initial syllable -- light in CvCvvC and heavy in CvCCvvC.

If the minimal stem is bimoraic, then the truncated vocative is a minimal stem followed by a vowel: [maji]i, [marw]a. Since the vocative "stem" is always followed by a vowel, it is not subject to Final Completeness (19). The vocative vowel is not some arbitrary appurtenance to the bimoraic template. Rather, it is a kind of simulation of the normal case-marking final short vowel (usually the nominative +u) that untruncated vocatives have: yaa Haariθ+u, yaa jaʕfar+u (yaa is the vocative particle). In fact, the final vowel of the truncated vocative may assume the melody of the nominative case-marking: yaa Haar+u, yaa jaʕf+u. Thus, the truncated vocatives are minimal words to which the appearance, and sometimes the reality, of normal vocative nominative case-marking is added.

Let us now summarize the discussion up to this point. We have a characterization of moras and extrasyllabicity in Arabic, and we have seen how these notions play a role in the minimal word constraint. Now we will turn to the templatic morphology, first of the noun, then of the verb.

The problem now to be examined is the characterization of shape-invariance in Arabic morphology. The analysis begins with a look at the basic stem structures -- not including prefixes or suffixes -- in the noun. We will have little to say about the broken plural, which we have dealt with extensively elsewhere (McCarthy and Prince 1988, 1990).

(27) contains a list of representative underived nouns of all possible basic patterns. Since our concern is with overall shape or canonical pattern here, differences in vowel quality have been disregarded. The percentages in parentheses below each word give a rough idea of how common each of these canonical patterns is; they were obtained by counting all the nouns that form broken plurals in the first half of Wehr's (1971) dictionary (about 2400 words):

(27) Basic Nominal Patterns

	Mora Count				
	Two		Three		Four
Biliteral root	barr (6%)	sabab (<1%)	jadiid (3%)	baarir (<1%)	jaaruur (<1%)
Triliteral root	baHr (27%)	badal (7%)	ʔataan (18%)	kaatib (12%)	jaamuus (2%)
Quadriliteral root				xanjar (14%)	rasmaal (11%)

CvvC nouns like baab 'door' are all arguably derived from underlying /CvGvC/; compare the plural ʔabwaab.

The noun patterns have been sorted into columns according to their canonical pattern and into rows according to the number of root consonants. In the left two columns are words that are exactly minimal -- with the final consonant extrasyllabic they have only two moras subject to metrical scansion. In the middle columns are the patterns that contain three moras. These three moras can be divided among two syllables either as light-heavy (ʔataan) or heavy-light (kaatib). At the extreme right are the noun patterns with both syllables heavy. These observations about the moraic and syllabic composition of the forms in (27) are summarized in (28):

(28)

Two Moras		Three Moras		Four Moras
barr	sabab	jadiid	baarir	jaaruur
baHr	badal	ʔataan	kaatib	jaamuus
			xanjar	rasmaal

What the analysis must now explain is why these are the possible basic noun patterns and no others are. Part of the explanation comes from the minimal stem constraint -- it sets a lower limit on stem size of two metrical moras that all noun patterns must respect. The other half of the explanation comes from the rule stated in (24):

(29) Maximal Stem Constraint

Templates are maximally disyllabic.

In other words, since all canonical noun stems are formed on templates, no stem can exceed two intrametrical syllables. This seemingly arbitrary disyllabic upper bound on templates is in fact not arbitrary at all: as we show in McCarthy and Prince (1986, forthcoming), general considerations of locality in linguistic theory require that no rules count to greater than two. The rules specifying the Arabic templates are subject to locality, and so the Maximal Stem Constraint can be obtained from a principle of much wider application.

The minimality constraint, on the one hand, sets a lower bound in terms of moras; the maximal stem constraint, on the other hand, sets an upper bound in terms of syllables (incidentally showing that both levels of representation are required). Between these two extremes, everything that is possible is actually being quite heavily used by the language. With the additional requirement in (19) that all stems end in an incomplete syllable (equivalently, a consonant), (28) contains everything expected given these two constraints. In a sense, this is the ideal situation, where the analysis accounts for just exactly the phenomena that the language displays.

There is some independent evidence for the Maximal Stem Constraint, just as there is for the minimality constraint. First, there is the problem of distinguishing diptotic from

triptotic broken plurals.[9] A list of the diptotic broken plural patterns appears in (30):

(30) Diptotic Broken Plural Patterns

Pattern	Example
CuCaCaa?	xulafaa?
?aCCiCaa?	?aqribaa?
CaCaaCiC	ǰadaawil
CaCaaCiiC	Sanaadiiq
CawaaCiC	bawaaʕiθ
CawaaCiiC	ǰawaamiis
CaCaa?iC	ǰazaa?ir

What the diptotic broken plurals all have in common is that they are stems with three syllables -- one greater than the maximum. (How they get that way while still respecting the requirements of locality and the Prosodic Morphology Hypothesis is a topic treated in McCarthy and Prince (1988, 1990).) In other words, only those stems that do not exceed the maximality constraint are triptotic. There are other, nonphonological criteria by which a noun can be diptotic, but the maximal stem constraint provides an explanation for why just this set of broken plurals should be consistently diptotic.

Second, the maximal stem constraint predicts that singular noun stems of three syllables should be rare and extremely irregular in their behavior, like the sub-minimal nouns like ʔab or bn. A sample of some of these super-maximal noun stems appears in (31):

(31) Trisyllabic Noun Stems

namuuðaǰ
ʕankabuut
safarǰal
barnaamaǰ

Such words are quite rare. More important, however, is the fact that they are very irregular as well. The most important aspect of their irregularity is that they are not templatic: they display no regularities of formation other than respect for the

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[9] The regular or triptotic ('three'+'case') declension of Arabic distinguishes three cases in the singular, marked by suffixes +u nominative, +i genitive, and +a accusative. The diptotic declension has only +u nominative and +a genitive-accusative. The diptotic declension also lacks the suffix +n that marks indefinite nouns. Apart from the broken plurals discussed in the text, diptotic declension is restricted to certain adjectival patterns and some proper nouns. The monoptotic or indeclinable declension is phonologically explicable.

phonotactics of the language. Another sign of the irregularity appears with older words like those in (31). Although these nouns form broken plurals and diminutives, they do so only with very odd conditions on the treatment of vowel length and supernumerary consonants. These are discussed in detail in McCarthy and Prince (1988, 1990). The other sign of irregularity comes from more recent loans that have three syllables, like tilifuun. In the half of Wehr's (1971) dictionary that we have examined, no recent trisyllabic loan ever forms a broken plural; instead, they have the sound plural tilifuun-aat. This is a powerful indication of how irregular these super-maximal words are, since the broken plural system is otherwise so productive that it very quickly assimilates borrowed words, like bank/bunuuk, malyuun/malaayiin, and so on. The super-maximal noun stems -- those with three syllables -- are quite clearly outside the Arabic morphological system, as the Maximal Stem Constraint predicts.

The moraic and syllabic skeleta in (28) do not exhaust the insights obtainable from an examination of the basic nominal patterns. Other, more suprising results of prosodic analysis also emerge.

The Prosodic Morphology Hypothesis asserts that templates are composed of the units of prosody. The skeleta in (28), composed as they are of the prosodic units mora and syllable, satisfy this condition only weakly. But interpreted strongly, the Prosodic Morphology Hypothesis requires templates that are exactly specified by a single prosodic constituent. We have already seen how the nouns in the two-mora class satisfy this requirement. These nouns are minimal words, whose template is identical to a prosodic constituent, the quantitative trochaic foot. In other words, under the Hypothesis, the desirable equation is Template=P, where P is any prosodic constituent.

There is an important and unexplained asymmetry between the two types of trimoraic stems, CvvCvC baarir/kaatib and CvCvvC ǰadiid/ʔataan. Our statistical investigations reveal that CvCvvC nouns are considerably more common and diverse than CvvCvC nouns. The data are summarized in the following table:

(32)

CvvCvC		CvCvvC	
CaaCiC	263	CaCiiC	265
CaaCaC	7	CiCaaC	106
CaaCuC	1	CaCaaC	37
		CaCuuC	29
		CuCaaC	25
		CiCiiC	1
Total	271	Total	463

CvCvvC stems are much more common and occur in many more vocalic patterns in a more even distribution than CvvCvC stems. On deeper analysis, the skew turns out to be even worse than this -- all CaaCiC nouns, constituting 97% of the CvvCvC class, owe their existence to a single morphological process, the formation of the Form I active participle (kaatib) from the corresponding finite verb (katab). Apart from this single source, there are practically no CvvCvC stems, while the iambic stems are abundant and diverse.

The explanation for this dramatic skew comes from the Prosodic Morphology Hypothesis. Pursuing the implications of Hayes's (1985) typological study, McCarthy and Prince (1986) and Hayes (1987) propose that there is a fundamental structural distinction between iambic and trochaic feet: the iambic foot is asymmetrically light-heavy, but the trochaic one consists of two equal parts -- two moras in the case of Arabic. On this view, the mirror-image symmetry of CvCvvC and CvvCvC is linguistically meaningless; the two have incommensurable prosodic structures. The form [$_F$CvCvvC] is an entire iambic foot (with the final consonant extrasyllabic), but CvvCvC is a bimoraic (trochaic) foot plus something more: [$_F$Cvv]CvC. The anti-iambic form [$_F$Cvv]CvC cannot be analyzed as a single prosodic constituent. It is therefore excluded from the list of nonderived stem types by the Prosodic Morphology Hypothesis.

The morphology shows that CvvCvC is indeed a derived stem type. Since it occurs in the noun system almost exclusively as the active participle of the CvCvC Form 1 verb, participial CvvCvC can be derived from finite CvCvC by prefixation of a mora, lengthening the initial vowel:

(33) Form 1 Active Pariciple

The finite verbs that are also heavy-light, like Form 3 CvvCvC, are derived as well; as we show below in section 7, they are composed of a heavy syllable base and a light syllable suffix, the latter marking them as finite. In the language as a whole, there is no role for the prosodically incoherent CvvCvC sequence as a primitive, underived template.

Before pursuing these matters, it is worthwhile to develop further the role of iambicity in the system. The contrast between general CvCvvC and restricted CvvCvC nouns lies in the fact that the former can be analyzed by an iambic foot (a light syllable followed by a heavy syllable), but the latter are unanalyzeable with the independently motivated constituents of prosody. But the prosodic analysis has also claimed that the foot type required by the stress system, the minimal word, and the characterization of

the bimoraic noun stems is the quantitative trochee (two moras, either in one heavy syllable or two light syllables). There is no contradiction here. Universal grammar supplies a small vocabulary of possible foot types among which languages are free to choose. Although perhaps ideally a language would refer to a single foot type in all rules of morphology or prosody, nothing in the theory requires this. In Arabic, stress and the minimal word rely on the quantitative trochee, but the broken plural (McCarthy and Prince 1990) and the system of versification are iambic. The basic noun templates draw from both types: the quantitative trochees are CvCC and CvCvC, while the iamb is CvCvvC.

Along similar lines, our investigations have revealed a hitherto unnoticed fact about "medial geminate quadriliterals", triliteral nouns like ǰabbaar (from the root /ǰbr/) which have the quadriliteral pattern of rasmaal but with medial gemination. The basic observation is that CvC_iC_ivC with medial gemination is quite rare, while CvC_iC_ivvC with medial gemination is common by comparison. There are two sources of evidence for this. First, among nouns taking broken plurals in Levy's (1971) comprehensive study of the Wehr dictionary, there is the following distribution:

(34) Medial Geminate Quadriliterals

CvC_iC_ivC		CvC_iC_ivvC	
CuC_iC_iaC	6	CaC_iC_iaaC(+at)	60
CuC_iC_iaC+at	2	CaC_iC_iuuC	34
		CvC_iC_ivvC+at	15
Total	8	Total	109

Clearly the vast majority (93%) of medial geminate quadriliterals have a long vowel in the second syllable. Second, CvC_iC_ivC is not used by the derivational morphology of the noun, but CvC_iC_ivvC is heavily, productively used in the noun of profession or habitual action: kallaaf 'stablehand', kawwaay 'slanderer'. Since such nouns do not take broken plurals, they do not bias the statistics above. In contrast, CvC_iC_ivC plays no role in the derivational morphology of the noun. (This pattern is important in the verb, but only as a derived template. See section 7.)

Again there is a significant skew between two seemingly equivalent patterns. The explanation is similar to the earlier one. CvC_iC_ivC is a heavy syllable followed by a light one (as always, assuming final consonant extrasyllabicity), a prosodically meaningless configuration. CvC_iC_ivvC is composed of two heavy syllables, equivalent to a sequence of two minimal words or two quantitative trochaic feet. Here, then, Template=P^2, or perhaps P^*, up to the limit of two imposed by locality considerations (McCarthy and Prince 1986.

We can now summarize the results, imposing a truly prosodic analysis on the morphic templates in (28). A single trochaic foot is the proper description of CvCC, CvvC, and CvCvC nouns. CvCvvC nouns are formed by a single iambic foot. A sequence of two trochees yields the CvC_1C_1vvC pattern. Note that two trochees in sequence must each be a single heavy syllable; the usual trochaic option of two light syllables is unavailable because of the Maximal Stem Constraint. For the same reason, two disyllabic iambic feet cannot be concatenated together.[10] The licit basic stem patterns of Arabic nouns are exactly those that can be generated from a vocabulary of iamb and quantitative trochee, the option of a sequence of two of the same constituent, and the bounds set by the minimal word constraint and the Maximal Stem Constraint. The basic templates that the language actually employs are far more narrowly restricted by the Prosodic Morphology Hypothesis than was first suspected.

This analysis fits well with the facts, but leaves a major question unanswered: what about CvCCvC nouns from true quadriliteral roots, like xanǰar? Although true quadriliterals CvCCvvC like rasmaal are somewhat more common than true quadriliterals CvCCvC, there is no radical skew between the two types.

The explanation for this is that templates of true quadriliteral nouns are lexically underspecified compared to the templates of triliteral nouns like ǰabbaar or ǰaamuus. The templates of the triliterals ǰabbaar or ǰaamuus must specify the weight of both syllables -- to ensure gemination or vowel length in the first syllable and vowel length in the second. With a quadriliteral root, though, the template only needs to specify the weight of the second syllable. The first syllable is necessarily heavy or bimoraic, since four consonants must be linked. There is no option in the language for linking a quadriliteral root onto a skeleton with just three available positions for consonants; for that reason, in McCarthy and Prince (1986: 66, 105) we proposed a general principle of melodic conservation, requiring that all root segments be linked to the skeleton. Moreover, even the fact that the skeleton is disyllabic is predictable for quadriliteral nouns; no other configuration is possible that conserves the melody. In other words, given a quadriliteral root, it is sufficient to know only whether or not it contains a light syllable. The base of the quadriliteral nouns as simply light syllable vs. heavy syllable; the rest of the template can be supplied by rule.[11]

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[10] The minimal expansion of an iambic foot is a single heavy syllable. This is then identical to a quantitative trochee.

[11] See Archangeli 1988 for a very interesting approach to a similar problem of skeleton generation.

The complete prosodic analysis of the basic noun stems is quite different from the first attempt or, indeed, from the inventory required in CV skeletal theories. It is much more restricted, focusing as it does on the overall prosodic well-formedness of the different templates. In the following table, we use the notation F_{QT} to refer to the quantitative trochaic foot and F_I to refer to the iambic foot:

(35)

a. CvCC (baHr)

b. CvCvC (badal)

c. CvCvvC (ǰadiid)

d. CvvCvvC (ǰaamuus)
CvC$_i$C$_i$vvC (ǰabbaar)

e. CvC$_i$C$_j$vC (xanǰar)

f. CvC$_i$C$_j$vvC (rasmaal)

The two types of bimoraic nouns are distinguished as monosyllabic versus disyllabic quantitative trochees. Foot theory permits only one type of iamb, so it is unnecessary to indicate that the iambic type is disyllabic. The Maximal Stem Constraint limits stems to two syllables, so it is unnecessary to say that the two quantitative trochees concatenated together in a single stem are each monosyllabic. The quadriliteral nouns, constrained by melodic conservation, specify only the weight of a single syllable, from which the full skeleton can be unambiguously determined with general conditions of prosodic well-formedness.

Let us now sum up the results to this point. The same notions of mora, syllable, and extrasyllabicity that function in Arabic phonology also characterize the basic noun templates. In the course of demonstrating this, two constraints have been presented -- the bimoraic minimal word and the disyllabic maximal stem. Together with the Prosodic Morphology Hypothesis, these constraints have explained the central regularities in the formation of the basic stem types.

7. Templatic Morphology in the Arabic Verb

The classic example of templatic morphology is presented by the derivational system -- the conjugations -- of the Arabic verb. The abundant evidence for the templatic character of the Arabic conjugations essentially reduces to the observation that the shape

or canonical pattern of an Arabic verb stem is severely restricted by both its morphological class membership and overall patterns of the language. In comparison with a language like English, for example, this is a truly remarkable situation.

(36) presents the stem patterns of the Arabic verb along the same lines adopted earlier in (27), using the model roots /sm/ 'poison', /fʕl/ 'do', and /dHrj/ 'roll' to represent all biliterals, triliterals, and quadriliterals respectively. The numerals preceding the forms are the designations of the Western system of classification; the parenthesized numbers following the forms give an exact indication of the frequency of these types in Wehr's (1971) dictionary; those stem patterns with a count of zero are known only from the Classical literature.

(36) Basic Verb Stem Patterns

Biliteral /sm/

1 samam (270)	2 sammam (127)	7 nsamam (31)	10 stasmam (34)
	3 saamam (18)	8 stamam (68)	11 smaamam (0)
	4 ʔasmam (78)	9 smamam (0)	12-15 ?

Triliteral /fʕl/

1 faʕal (2299)	2 faʕʕal (1271)	7 nfaʕal (229)	10 stafʕal (355)
	3 faaʕal (445)	8 ftaʕal (553)	11 fʕaalal (2)
	4 ʔafʕal (873)	9 fʕalal (18)	12 fʕawʕal (7)
			13 fʕawwal (0)
			14 fʕanlal (2)
			15 fʕanlay (0)

Quadriliteral /dHrǰ/

Q1 daHraǰ (296)	Q3 dHanraǰ (1)	
	Q4 dHarǰaǰ (8)	

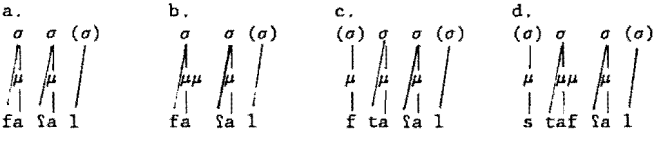
Excluded from analysis:
5 tasammam (85)
6 tasaamam (17)
5 tafaʕʕal (940)
6 tafaaʕal (377)
Q2 tadaHraǰ (111)

One remark is in order before we continue. The stems with prefixed ta are not regarded as basic patterns to be treated in this analysis. There are several reasons for this difference from earlier analyses (McCarthy 1981). First, they obviously have a prefix tV, whereas the other stem patterns cannot be straightforwardly decomposed into concatenations of a prefix plus independently occurring base morpheme. Second, statistical examination of the pairings of different conjugations for a given root shows, not surprisingly, that Form 5 tafaʕʕal tends to occur only together with roots having Form 2 faʕʕal, Form 6 with Form 3,

and Form Q2 with Q1. This dependency between different conjugations, which an analysis with a tV prefix predicts, is otherwise unknown in the Arabic verb system. Third, the conjugations with prefixed tV are special in the vocalism that they present in the imperfective active; it is yatafaaʕalu when yatafaaʕilu is expected, based on what happens in the other conjugations. Fourth, just these conjugations take a peculiar form of the masdar that involves no alteration in the canonical shape of the verb: 5 tafaʕʕul, 6 tafaaʕul, Q2 tadaHruj. They thus present other evidence for special treatment.

Unlike the nouns, the verbs in the third and fourth columns of (36) have an initial consonant linked to an incomplete syllable. As we earlier showed, this consonant must be moraic by the Contiguity Constraint. A first pass at the analysis appears in (37), with the columns of (37) corresponding to those of (36):

(37) Moraic Skeleta for Verb Templates



One issue which we must address is the conformity of these templates to the Prosodic Morphology Hypothesis in its strongest sense. Only the template in (37a) corresponds to a prosodic constituent (the quantitative or moraic trochee); the others do not. We will show that none of the verb templates is basic. Rather, all are derived by concatenating templatic morphemes, each of which is itself a prosodic constituent.

Some significant differences between the verb and the noun immediately emerge. First, the verb stem is always disyllabic, whereas nouns come in both monosyllabic (CvCC) and disyllabic (CvCvC, CvCvvC, etc.) flavors. Second, the finite verb stem permits no contrast in the weight of the second syllable -- it is always light, containing just one mora. But there are nouns with one (CvCvC) and nouns with two (CvCvvC) moras in the final syllable.

These observations obviously require some sort of explanation. In fact, a single explanation is possible for both: all finite verb stems have a light syllable templatic suffix. 38 represents this:

(38) Finite Verb Suffix

(a) The finite verb templatic suffix explains why all verbs have the same final syllable weight: the final syllable of the verb stem is actually a suffix which is constant across all conjugations of the verb. The differences among verb templates of different conjugations are therefore limited to the weight of the first (only) syllable and the presence or absence of an initial (σ). Moreover, this suffix also explains why finite verb stems are necessarily disyllabic. The finite verb suffix is attached to a monosyllabic base that is specified for each conjugation (the character of this base is investigated further below). If the base to which this suffix is attached were disyllabic, then with this suffix the result would exceed the Maximal Stem Constraint. And there must be a base to attach the suffix to, so no verb stem can be monosyllabic either.

There is solid independent motivation for this somewhat surprising result. There is only one pattern of masdar (nominalization) formation in the language that applies in a general way across the different conjugations of the verb. This masdar pattern is exemplified by the following forms. When unbracketed, they are the primary or only means of masdar formation for a particular conjugation (except in Form 1, where fiʕaal is one of about six common options); when bracketed, they are attested but described by Wright (1971) as rare:

(39)

Conjugation	Finite Verb	Masdar
1	faʕal	fiʕaal
2	faʕʕal	[fiʕʕaal]
3	faaʕal	[fiiʕaal]
4	ʔafʕal	ʔafʕaal
7	nfaʕal	nfiʕaal
8	ftaʕal	ftiʕaal
9	fʕalal	fʕilaal
10	stafʕal	stifʕaal
11	fʕaalal	fʕiilaal
12	fʕawʕal	fʕiwʕaal
13	fʕawwal	fʕiwwaal
14	fʕanlal	fʕinlaal
15	fʕanlay	fʕinlaay
Q1	daHraǰ	diHraaǰ
Q3	dHanraǰ	dHinraaǰ
Q4	dHarǰaǰ	dHirǰaaǰ

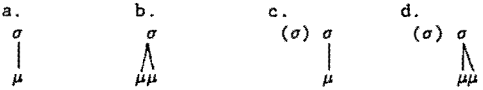
The cross-categorial generalization is that the masdar is identical to the finite verb except that the vowel melody is [i_a] and the final syllable contains a long vowel. This difference in final vowel length between the masdar and the finite verb is straightforwardly accounted for by setting up a different suffix for non-finite verbs:

(40) Non-finite Verb Suffix

Indeed, other processes for forming non-finite verbs or nouns from finite verbs very often seem to involve this suffix: passive participle 1 maf$uul; masdar 2 taf$iil; noun of instrument 1 mif$aal.

The canonical form of the stem of every conjugation includes the finite verb suffix. Therefore all differences in the canonical form of different conjugations reside in the monosyllabic base obtained by stripping off this suffix. The bases, corresponding to the columns of (36), are:

(41) Base Templates



The bases are necessarily monosyllabic, for reasons already outlined. All possibilities occur within the range delimited by two options: (a) whether the syllable is heavy or light; and (b) whether or not there is an initial (σ), the extrasyllabic mora.

The option for the initial syllable to be heavy or light is, of course, expected under prosodic morphological theory. The initial (σ), then, is clearly what requires our attention now.

Moore (to appear) has gone on to argue on phonological grounds that an initial extrasyllabic mora (what we analyze as (σ)) is a separate morpheme. Morphological considerations lead to the same conclusion. The role of the initial incomplete syllable (σ) within the morphological system as a whole is rather closely circumscribed. Most conspicuously, it is impossible in nouns (except for obviously deverbal ones like the masdars). This observation follows straightforwardly if (σ) is a prefix of the verbal system only, therefore unavailable in nouns. In that case, the base templates of the various verbal conjugations would reduce to just two possibilities, a light monosyllable and a heavy monosyllable. We can even make a stab at the meaning of this morpheme. Consider the set of conjugations that have this putative prefix: 7-15, Q3, Q4. What these all have in common is intransitivity or, more correctly, a reduction or minimization of the valence of the underlying verb. Form 7 is usually described as a passive or middle: kasar 'break (tr.)', nkasar 'break (intr.)'. Form 8 is also a kind of reflexive or middle: faraq 'divide (tr.)', ftaraq 'divide (intr.)'. Form 10 is yet another reflexive or middle, related in meaning to Form 4: ?aslam 'give

up', staslam 'give oneself up'. Forms 9 and 11 describe the state of being a color or bearing a bodily defect: Sfarar 'be yellow', Hwalal 'have a squint'. The rare forms 12-15 and Q3-Q4 all describe states as well.

The statistics of the distribution of conjugations among different root types also support the analysis of (σ) as a separate morpheme. Roots tend not to occur in both Form 7 and Forms 8 or 10: out of 3062 biliteral and triliteral roots, only 69 occur in both 7 and 8 and only 29 occur in both 7 and 10. (The scarcity of roots that take both 7 and 10 is significant at the .05 level.) This is plausibly analyzed as a blocking effect (Aronoff 1976): forms 7, 8, and 10 are functionally similar and share the formal property of the prefixed (σ).

No doubt a more precise characterization of the semantics of the different conjugations could better pin-down the meaning of (σ), but it is sufficient for our purposes to recognize that the different conjugations with initial (σ) have enough in common to warrant setting it up as a prefix:

(42) Detransitivizing Verbal Prefix

(σ)

This leaves only one unexplained source of differentiation in canonical pattern among the conjugations, whether the single syllable of the base is monomoraic (light) or bimoraic (heavy). The conjugations with a light-syllable base are 1, 7, 8, and 9. What these have in common is that all are plausibly related to Form 1. Form 7 is a kind of passive of 1, Form 8 is the reflexive of 1, and form 9 could be regarded as the stative of 1. At this point the analysis is somewhat subtle and conjectural, but nevertheless it is worth pursuing this point to its logical conclusion. The monomoraic syllable is the base of Form 1 and closely related conjugations, while the bimoraic syllable is a kind of default base, appearing with all other conjugations, a set of derivational patterns that appear to have nothing in common:

(43) Bases of Verbal Derivational System

a. Form 1 Base

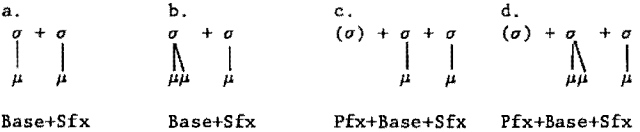
b. Default Base

Further evidence for the default status of the bimoraic base comes from the treatment of recently borrowed verbs -- they are always in Form 2, with the bimoraic base: barrak 'park a car', dayyaT 'go on a date' (cf. Smeaton 1973).

support for this idea. The posited relation between Forms 1, 7, and 8 (9 is too uncommon for meaningful statistical analysis) is confirmed by an authentic tendency for roots to take Form 7 or Form 8 only if they also take Form 1. Of 260 roots in Form 7, 249 take Form 1 as well. Of the remaining 11 roots, 7 occur only in Form 7. (These could plausibly be analyzed as instances of the "missing base" phenomenon, like English uncanny/*canny.) The connection is less striking between Forms 1 and 8. Of 621 roots occurring in Form 8, 581 occur in Form 1 as well. Of the remaining 40, 12 appear only in Form 8.

Let us now sum up. The canonical patterns of the various conjugations of the Arabic verb can be analyzed into a set of morphological constituents. Conjugations marked by intransitivity have a prefix (σ); those not so marked lack this prefix. Form 1 and its close relatives 7, 8, and 9 have a monomoraic monosyllabic base; other conjugations have a default, bimoraic monosyllabic base. All finite verb stems have a light-syllable suffix $[\mu]_\sigma$; the most general pattern of nonfinite verb (masdar) formation has a heavy-syllable suffix $[\mu\mu]_\sigma$. Thus, the moraic skeleta in 37 are decomposed as follows (to which final (σ) is obligatorily added):

(44)



The units which make up the verb stem templates -- prefix, base, and suffix -- each individually conforms to the Prosodic Morphology Hypothesis in its strongest sense. The concatenations of these morphemes do not, but this is what we expect; the Hypothesis governs only the shape of basic templates, not what the syntax or morphology do with them.

The Prosodic Morphology Hypothesis has led to a much deeper understanding of the internal structure of Arabic verb templates than previously. Looking at the templates as a sequence of prosodic units rather than a concatenation of CV segments reveals significant internal regularities: all verb templates are decomposable into a sequence of prosodic units with distinct morphological functions.

8. Template Satisfaction

It is now appropriate to turn to the question of template satisfaction: how are the root and skeleton associated with one another? This is of particular importance since moraic theory,

unlike its CV theory predecessor, is unable to distinguish between the two types of heavy syllables Cvv and CvC.[12] It will emerge that the ability to make this distinction is a liability rather than an advantage of the CV theory, since Arabic grammar does not actively exploit this putative skeletal distinction.

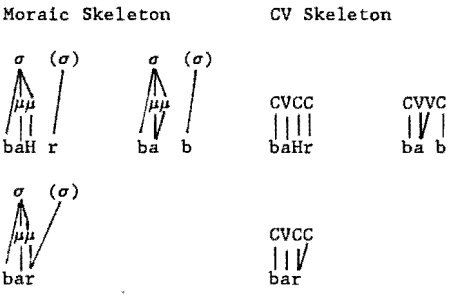
During the following discussion, it is important to keep in mind that terms like "CV theory" or "CV skeleton" are being used loosely, to refer to a whole family of phonology theories with the following properties. First, they must have segment-sized skeletal elements, unlike the moraic elements of prosodic theory. Second, they must be capable in principle of distinguishing Cvv from CvC syllables. This is obviously true of CV theory proper, but it is also true of those theories that can distinguish them by differences in syllabic structure. In particular, those theories with undifferentiated skeletal elements that nevertheless posit a branching syllabic nucleus for Cvv syllables but a branching rhyme (and a non-branching nucleus) for CvC syllables will meet this criterion (Levin 1983, 1985; Lowenstamm and Kaye 1986).

There are several basic observations about root/skeleton association in Arabic. First, syllable onsets are obligatorily filled. Second, all stems must be consonant-final. In our terms, all stems must end in an incomplete syllable (σ) by rule 19. Third, association of root with skeleton has a left-right asymmetry: there are biliteral verbs samam or nouns samm, but no biliterals *sasam or *sasm. Fourth, as is universally the case in prosodic morphology, maximization of melodic association takes absolute precedence over other considerations (McCarthy and Prince 1986: 66, 105). In particular, root consonants must be conserved; there are no cases (except for sporadic lexical exceptions) where a root consonant is lost by Stray Erasure (McCarthy 1979) because there is no templatic position available for it to occupy.

The basis has now been established for addressing the problem of the moraic nondistinctness of Cvv and CvC heavy syllables. Consider the monosyllabic stems like baHr or barr vs. baab. From (45), it looks as if the CV skeleton can distinguish these two types but the moraic skeleton cannot:

[12] See also Levin 1983, 1985 and Lowenstamm and Kaye 1986 for other approaches to eliminating the Cvv/CvC distinction.

(45) Monosyllabic Stems: Moraic and CV Skeleton Comparison



But the CV skeleton is making a distinction that the Arabic language really doesn't make. While words like triliteral baHr or biliteral barr are extremely common and fully integrated into the morphological system, with over one thousand examples in the lexical material we have examined, words like baab are quite special. It is arguably the case that all such words are derived by regular phonological rules from underlying disyllables /CawaC/ or /CayaC/, as evidenced by singular/plural alternations like baab/ʔabwaab 'door'. There may be a few nouns which present no independent evidence for the underlying disyllable (like baaz, plural biizaan 'bustard'), but they constitute a tiny minority of irregular lexical expections (less than 1% of our data).

So CvCC is the obligatory treatment of the monosyllabic noun stem. This is one part of a more pervasive regularity: observe that no disyllabic noun stem ever ends in CvCC, but many end in CvvC. (Again, there are a few lexical exceptions, like dimašq 'Damascus'.) There is, then, no lexical distinction between the two types of heavy final syllables; stem-finally, a bimoraic syllable is necessarily CvC in monosyllables and Cvv in disyllables. (Likewise, the masdars in (39), necessarily disyllabic, also have Cvv final syllables.) The CvC/Cvv split can be intepreted along minimal/super-minimal lines. Minimal words with a final heavy syllable are necessarily monosyllabic; super-minimal words with a final heavy syllable are necessarily disyllabic. Many cases with this sort of segregation of the lexicon are discussed in McCarthy and Prince (1990), where a theory of the phenomenon is elaborated. The general idea is that the behavior of minimal words constitutes a special case to which super-minimal behavior is the default. The following rule characterizes the generalization in these terms:

(46) Final Mora Association

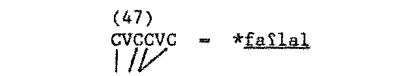
This rule does not need to be explicitly limited to the second mora of a heavy syllable; its inapplicabilty to light syllables is guaranteed by the requirement (in the Contiguity Condition) that all nonperipheral syllables have vowels.

Within the noun, there is only one other locus where an apparent CvC/Cvv distinction is made: CvCCvvC medial geminates like ǰabbaar versus CvvCvvC nouns like ǰaamuus. The number of root consonants and the prosodic skeleta are identical in both cases; how then to account for the apparent contrast between a closed and open heavy initial syllable?

As was already observed, medial gemination in the noun is not limited to underived nouns like ǰabbaar, but also applies productively in the noun of profession or habitual action and semi-productively in one type of broken plural. Nouns like ǰaamuus, on the other hand, are rather rare and this pattern is not used in any systematic way by the morphology. In fact, Levy 1971 refers to it as only "semi-canonical". It is therefore tempting to suggest that cases like ǰabbaar are the norm and that ǰaamuus is lexically marked. (A few roots occur in both forms: ballaaʕ+at 'sink, drain', baaluuʕ+at 'sewer, sink, drain'.) Unfortunately, this explanation, whatever its merits for the noun, is clearly not generalizeable to exactly the same problem in the verb. In particular, Forms 2 and 3 (faʕʕal and faaʕal) are both built on the heavy syllable templatic base, one with medial gemination and one with vowel length.

Medial gemination presents a problem for the otherwise fairly straightforward extension of autosegmental phonology as a theory of tone to prosodic morphology like that of Arabic. In autosegmental tonal phonology (see especially Clements and Ford 1979 for the most striking evidence of this regularity), the normal mode of association is one-to-one and left-to-right or right-to-left. When the root /fʕl/ is associated with the CV skeleton CVCCVC in this way, the result is incorrect, as (47) shows:

(47)



Associating in the other direction also fails, producing the impossible form *faʕʕal. In the original treatment (McCarthy 1979, 1981), cases like this were dealt with by adding an additional rule that produces the desired medial geminate by

reassociation. Alternative approaches to this problem have subsequently been proposed: Levin (1983), Broselow (1984), Angoujard (1984), Farley (1987), Farwaneh (to appear), Yip (1988), Hoberman (1988), and no doubt others as well.

It is obviously impossible to review all of these proposals here. Rather, we will focus on the most important observation about medial gemination: it is always grammatically controlled. That is, medial gemination appears under several different conditions in the verb and noun which all must be specified grammatically: nouns of occupation, plurals of lexicalized active participles (see (48) below), Form 2 of the verb. There is just one exception to this: the relatively unusual (about 2% of all nouns) underived nouns like ǰabbaar. In contrast, final doubling of a consonant is, in most cases, phonologically controlled, appearing systematically with biliteral roots: nouns barr, ǧabab, ǰadiid, baarir, ǰaaruur; verbs Halal, Haaǰaǰ, Hallal, ʔaHlal, nHalal, Htalal, staHlal.

The broken plurals with medial gemination provide a further clue about how this grammatical control is exercised. Arabic active participles, like other productively derived nouns, do not normally form broken plurals. Nevertheless, when they become lexicalized (Levy 1971), as evidenced by some degree of specialization of meaning, they may form broken plurals according to one of the following patterns (the numbers represent the frequency of each type in our sample):

(48)

a. fuʕʕal type			
baahil	buhhal	21	'free'
b. fuʕʕaal type			
ʔaabiq	ʔubbaaq	50	'fugitive'

The pattern of vocalization, [u_a], appears elsewhere in the language with the same function, marking the broken plurals of human nouns: waziir 'vizier', pl. wuzar-aaʔ.

Although most Arabic broken plurals are templatic (McCarthy 1983, McCarthy and Prince 1990) -- that is, they are formed on different skeleta from their corresponding singulars -- these plurals are not. For one thing, they obviously bear a close resemblance in canonical form to their singulars. For another, unlike the templatic broken plurals, these are formed from singulars of invariant shape. The whole point of templatic morphology is to satisfy a criterion not met here -- the independence of the canonical form of input and output.

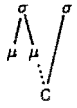
Assembling these observations into an analysis leads to the following (cf. McCarthy 1983: 312-313). Substitution of medial gemination for vowel length is the primary mechanism relating the

plural to the singular. In addition, lexically specified words of this type undergo an additional rule lengthening the final vowel. The two rules are formalized in (49a); sample derivations appear in (49b):

(49)

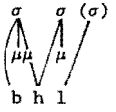
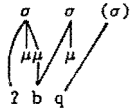
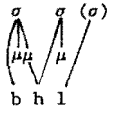
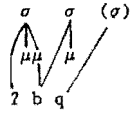
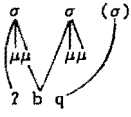
a.

Medial Gemination



Vowel Lengthening (in some words)

b.

Singular		
Medial Gemination		
Vowel Lengthening	DNA	
[u_a] Vocalism	buhhal	ʔubbaaq

The discussion of this type of broken plural formation yields two results that are of great importance to the treatment of medial gemination. First, it shows that the distinction between the two types of heavy syllables that a CV skeleton can make is, if anything, an impediment to the analysis of medial gemination. The rule of Medial Gemination in (49a) places crucial reliance on the moraic equivalence of Cvv and CvC heavy syllables. Second, at least in this case, medial geminates are derived by rule from representations without geminates. Arabic must contain a rule creating geminates by adding an association line from an onset consonant onto a preceding mora.

Generalizing from this one case where the source of medial gemination is demonstrably an association rule, it is plausible that all instances of medial gemination are derived by applying the association rule 49a. This essentially moves the problem of gemination outside the scope of skeletal theory; it is enough if

the skeleton provides the mora to which the geminated consonant will be associated by rule. There is, then, no need for the greater expressive power of the CV skeleton with its distinction between the two types of heavy syllables. This also explains the original observation that medial gemination is always grammatically controlled: it must be grammatically controlled because it is derived by a grammatically conditioned rule of association. The relatively uncommon words like jabbaar are derived by lexically governed applications of this rule.

With medial gemination done by rule, the association of consonantal root to template in the noun system can be entirely determined from the following constraints:

(i) Final Incompleteness (19), the requirement that all stems end in an incomplete syllable (that is, a consonant, by the Onset Rule).

(ii) Final Mora Association (46), the requirement that final consonant clusters appear in all and only monosyllables.

(iii) The Onset Rule, the requirement that all syllables begin with a consonant.

(iv) Melodic conservation, the requirement that all root consonants be linked.

(v) Left-to-right association.

These principles correctly generate all patterns of association observed in noun stems. Some of them are independently motivated, and may in fact be universal; (i) and (ii) are presumably language-particular, but they capture significant generalizations that have been mostly overlooked in previous accounts.

We will take only a cursory look at consonant association in the verb system, which still presents certain problems. In most cases, the properties of the verb system can be accounted for in exactly the same way as the noun:

1. Form 2 (sammam, faʕʕal) vs. Form 3 (saamam, faaʕal). Medial gemination in Form 2 is the result of a grammatically-conditioned rule of association. Form 3, then, is derived by simple filling of the obligatory consonantal positions (onsets) in (37b), to which Form 2 adds the application of the Medial Gemination Rule.

2. All cases like Form 1 (samam, faʕal), Form 7 (nsamam, nfaʕal), Form 8 (stamam, ftaʕal), Form 9 (smamam, fʕalal), Form 11 (smaamam, fʕaalal), and the rare Forms 12 (fʕawʕal, 13 (fʕawwal), 14 (fʕanlal), 15 (fʕanlay), and Q3 (dHanraj) involve root associations only to obligatorily consonantal positions (onsets and an initial incomplete syllable), sometimes in competition with

a consonantal affix whose position is specified by the morphology. (The affixes are prespecified to the template along the lines of McCarthy 1979, 1981.)

3. Association in Form Q1 daHraǐ follows from melodic conservation.

What remains after these cases have been put aside are Forms 4 and 10 with biliteral roots, ʔasmam and stasmam. Conservation of melodic elements cannot in general account for the fact that the first syllable in these stems is closed, because this condition is satisfied in the biliterals by *ʔaasam and *staasam. Perhaps these are ill-formed because no root consonants are linked with the heavy-syllable "base" of the template (see (43)).

In general, association of root to skeleton in the verb reduces to filling of obligatorily consonantal positions exclusively, subject only to melodic conservation. Positioning of non-root templatic consonants like the t infix of Form 8 must be stipulated in Prosodic theory, as in any other. Medial gemination is the result of a grammatically conditioned rule that also applies in other morphological constructions.

9. Conclusion

We have argued that templatic constraints on word structure should be characterized in prosodic terms -- that is, in terms of notions like minimal word, foot, syllable and mora. In particular, we have seen that basic, underived templates of Arabic must be analyzeable in prosodic terms, as required by the Prosodic Morphology Hypothesis. Taken together with the treatment of the broken plural in McCarthy and Prince (1990), this material provides a comprehensive analysis of Arabic templatic morphology within prosodic theory.

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