GREENBERG'S ASYMMETRY IN ARABIC: A CONSEQUENCE OF STEMS IN PARADIGMS

ADAMANTIOS I. GAFOS

New York University

How different is the phonology and morphology of nontemplatic (concatenative) word formation from that of templatic (nonconcatenative) word formation? In this article, I focus on the Arabic verbal system, the prototypical example of templatic morphology, with the aim of deriving some of its distinctly special traits from basic principles. The key novel aspect of the approach is its focus on paradigms. The main result is that the paradigm coupled with general phonotactic constraints sets limits on the theoretically possible diversity of stems within that paradigm. As a consequence of its generality, the proposed approach obviates a range of highly specific tools and postulates. Broader implications are developed for the phonological and morphological prerequisites of templatic (nonconcatenative) word formation.*

INTRODUCTION. A primary goal in the study of language is the search for a theory that is parsimonious in the number of explanatory principles yet of sufficient predictive power to account for the range of observed linguistic specificity within and across languages.

An example of the challenge posed by this goal comes from Arabic.[1] Arabic enjoys special status in the study of language. It is described as employing a special mode of word formation and a correspondingly special architecture of phonological forms. The consonantal root, the notion of template and its related parameters of association, the segmental OBLIGATORY CONTOUR PRINCIPLE, and morpheme structure conditions are among those fundamental notions that have been originally proposed on the basis of Arabic or have been sharpened by research on Arabic (see Al-Ani 1978 for a volume of classic papers and Hoberman 1995 for a recent review). Given this legacy, a conceptually clear statement of Arabic's special status is a prerequisite for drawing wide typological distinctions, for assessing the goal of a parsimonious theory, and for judiciously choosing among the tools used to carry on with that goal.

Consider a celebrated characteristic of Arabic. Verbal forms in Arabic exhibit an asymmetry in the distribution of geminate and identical consonants. Forms with an initial geminate or sequence of two identical consonants such as **ssam*, **sasam* are absent, but forms with final gemination or identity such as *samm*, *samam* abound (Greenberg 1950). Past analyses of this asymmetry invest a crucial piece of its account in the lexicon: the lack of **ssam*, **sasam* is due to a ban on morphemes with the relevant properties of gemination or repetition, a so-called (underlying) morpheme structure condition. Despite recurring concerns with the adequacy of such accounts (Clayton 1976, Kenstowicz & Kisseberth 1979, McCarthy 1998), it remains unclear how Greenberg's asymmetry can be accounted for without conditions on the lexicon.

* I would like to thank the audiences at the University College London, the Heinrich-Heine-University Dɯsseldorf, and the 14th Arabic Linguistics Symposium at UC Berkeley, where parts of this work were presented. Special thanks to Moira Yip and Richard Wiese for raising some excellent questions, and to Brian Joseph, Eugene Buckley, and two anonymous referees for careful reading of the manuscript and thoughtful comments. Support by a New York University Research Challenge Fund Grant (N5006, 'Nonconcatenative morphology revisited') and a New York University Goddard fellowship are kindly acknowledged. All errors are mine.

[1] Unless Arabic is otherwise qualified, it refers to Classical Arabic. But, since this paper focuses on doubled verbs and Greenberg's asymmetry, aspects of the Classical language that have been preserved in modern standard Arabic (the official language of over one hundred million people today), the forthcoming results apply to the modern language as well.

How can we derive the specific ban on **ssam*, **sasam* in Arabic using basic principles? More broadly, what shall we take as the proper characterization—the proper grammar model—of this and other apparently highly specific attributes ascribed to the phonology and morphology of Arabic stems?

1. THE MAIN PROPOSAL. A primary observation at the core of the approach developed in this article is that, in languages with rich inflection (like Arabic), stems are realized in the context of paradigms. It seems reasonable to explore the extent to which stem properties, patterns in the lexicon and alternations, derive from this fact rather than being idiosyncratic. Indeed, in the sense to be detailed here, the proposed model DERIVES lexical patterns by integrating two independently motivated factors: (a) constraints on what constitutes a phonologically well-formed word, so-called phonotactic constraints; and (b) identity constraints between related forms in the paradigm. Why these two factors?

Phonotactic constraints are among the basic notions of phonology and go far in specifying what is a phonologically well-formed stem in any given language (Goldsmith 1995). But in a morphology with rich inflection, stems are realized in a variety of paradigmatic contexts. This adds another source of conditions on what constitutes a phonologically viable stem.

Returning to the running example, consider the asymmetry in the distribution of geminates: Arabic verbal forms with an initial geminate such as **ssam* are unattested, but forms with final geminates such as *samm* abound. Arabic verbal stems must be realized in two related inflectional paradigms, the perfect and the imperfect. The crucial observation is that the imperfect supplies prefixes ending in vowels, but the perfect lacks prefixes altogether. Consider, then, the fate of a hypothetical stem *ssam*. In the context of the perfect, this stem would give rise to a surface form with a syllable-initial geminate. This structure is independently banned by the phonotactics of the language. Alternation to a form without the geminate would ensue in the local context.

The resulting form, in turn, would be transmitted to the rest of the verbal forms, that is, also to the imperfect forms, due to paradigmatic identity constraints. Effectively, the coupling of phonotactics and paradigmatic identity renders the relevant phonological trait of *ssam*-like stems (initial gemination) unrecoverable. By a language-independent learnability argument, stems with initial gemination are easily shown to be unlearnable and hence impossible in Arabic.

For geminate-final stems like *samm*, the situation is different. Both perfect and imperfect contexts supply vowel-initial suffixes. The trait of final gemination IS recoverable in these contexts. Consequently, stems with final gemination are viable in the Arabic lexicon.

The reasoning sketched above generalizes easily to account for other patterns in the lexicon, and arguably some important implications about the morphology and phonology of Arabic follow from it. The *samm*/*samam* alternation of doubled verbs, presented in §2, for instance, reveals a crucial part of the phonology that makes reference to geminates. This phonology, as worked out in §2 and tested in §3 with data other than doubled verbs, is indeed crucial because, as argued in §4, Greenberg's asymmetry follows as a prediction from it. Similarly, insights are gained into the invariant form of the 'strong' or triliteral verbs, as discussed in §5, and into other areas as well.

2. THE DOUBLED VERB ALTERNATION. The so-called doubled verbs in Arabic show a well-known alternation between a 'canonical' form [samam] and a 'derived' form [samm] with a final geminate. Understanding this alternation turns out to be the key to unlocking connections among other previously unrelated domains, including the intimate link between the phonology of this alternation and Greenberg's asymmetry.

Sections 2.1 and 2.2 focus on the two instances of this alternation in the perfect and imperfect paradigm, respectively.

2.1. ALLOMORPHY IN THE PERFECT. In the perfect, doubled verbs show two allomorphs, [madd] and [madad], as shown in 1 for the lexeme 'to stretch'. Henceforth, [madd] will be called the GEMINATE allomorph and [madad] the STRONG allomorph—strong due to its resembling the nonalternating, so-called strong verbs like [katab] 'to write' (1, 2, 3 stand for first, second, and third person; m, f for masculine, feminine).

(1)

Perfect	SINGULAR	PLURAL	DUAL	ALLOMORPH DISTRIBUTION
3 M	madd-a	madd-uu	madd-aa	
F	madd-at	madad-na	madd-ataa	Geminate [madd] /__V
2 M	madad-ta	madad-tum	madad-tumaa	Strong [madad] /__C
F	madad-ti	madad-tunna	madad-tumaa	
1	madad-tu	madad-naa		

The distribution of the allomorphs is also shown on the right in 1. The geminate allomorph occurs before vowels, and the strong allomorph before consonants. Which one of these two allomorphs underlies the alternation? One answer to this question is suggested by the following observation. The shape of [madad] is the shape of the nonalternating triliteral verbs like [katab-a] 'he wrote', [katab-tu] 'I wrote'. Conventionally, triliterals are assumed to be the canonical verbs in Arabic, and by extrapolation (not logical necessity) their shape is assumed to be the canonical shape for verbs. This assumption has been inherited in all discussions of doubled verbs known to me (Wright 1896:68–71, Cantineau 1946:133, Brame 1970:119, McCarthy 1979:265–67, Farley 1987, Moore 1990).[2] Specifically, this assumption implies an analysis where the canonical /madad/ is converted to [madd] before a vowel-initial suffix, via a process of syncope as in /madad + V/ → [maddV], and in some cases via a process of metathesis as in (the imperfect) /ya + mdud + V/ → [yamuddV]. But as McCarthy (1986:247–48) observes, this analysis treats the alternation as 'morpholexical' in character. There does not seem to be any reason why /madad/ should change to [madd] or why /ya-mdud-/ should change to [ya-mudd-]. If this alternation was phonological, it would falsely predict that /katab-/ should change to [katb-] and /ya-ktub/ should change to [ya-kutb-] before a vowel. Thus we see that the alternation, as formulated in the syncope/metathesis rule, is arbitrary in the sense that there is no phonological motivation for the particular form that this alternation takes.

However, there is an alternative: the underlying stem is /madd/, and [madad] is a surface variant of /madd/. Surprisingly, this alternative has not been pursued.[3] It is standard methodology in generative grammar that, given an alternation like [madd] ~ [madad], we consider at least the two hypotheses outlined above, and contemplate their consequences for the rest of the grammar (Kenstowicz & Kisseberth 1979). In what follows, I develop this alternative proposal: /madd/ is the underlying stem. In so doing, I argue that the alternation is not arbitrary. Rather, phonology determines the distribution of the allomorphs and the nature of their relation. Eventually, I also consider and reject the hypothesis of listing two stems for each verb, both /madd/ and /madad/.

To begin, observe that the vowel of doubled verbs changes between the perfect and the imperfect. Thus, in 2, the imperfect of 'to stretch' shows an /u/ whereas its perfect

[2] Brame, for instance, motivates the choice of /madad/ as basic because 'it permits us to generalize the doubled stem to the typical *CVCVC* pattern found in the case of strong stems such as *katab*' (1970:119).

[3] Aronoff (1994:195, n. 39) points to this alternative in passing. I am grateful to a referee for noting that this alternative is mentioned also in the classic *Gesenius' Hebrew grammar* (1910:175–76).

shows an /a/ in the second vowel position of [mad**a**d]. As discussed below, the first /a/ in [mad**a**d-] as well as the /a/ in [madd-] are inflectional markers.

(2) Vowel alternations between imperfect and perfect (Wright 1896:68–69)

Imperfect + V	Imperfect + C	Perfect + C	Perfect + V	
ya-m**u**dd-u	ya-md**u**d-na	mad**a**d-tu	madd-a	'to stretch'
ya-m**a**ll-u	ya-ml**a**l-na	mal**i**l-tu	mall-a	'to be weary'
ya-ħ**i**bb-u	ya-ħb**i**b-na	ħab**a**b-tu	ħabb-a	'to love'

It is well known that these alternations are found for all Form I verbs, not just for doubled verbs. Two strong-verb examples are [-kt**u**b-], [kat**a**b-] 'to write' and [-xr**i**b-], [xar**a**b-] 'to devastate'. The proper treatment of these alternations was and continues to be an important problem in Semitic studies (Wright 1896, Schramm 1962, 1991, Brame 1970, Kuryłowicz 1972, McCarthy 1979:290–93, 1994, McOmber 1995, Guerssel & Lowenstamm 1996). For current purposes, it suffices to make the minimal assumption that changes like /u/ in [-kt**u**b-] vs. /a/ in [kat**a**b-] are a matter of a part of the grammar regulating these vowels in the distinct morphosyntactic contexts, imperfect vs. perfect. See the references above for specific proposals.

Focusing on the perfect forms in 2, the point of interest is that the vowel contrasts in [mad**a**d-tu, mal**i**l-tu, lab**u**b-tu] are neutralized to /a/ in the prevocalic forms, which always surface as [CaC^{x}C^{x}-] (C^{x}C^{x} denotes a geminate). The situation is shown more explicitly below. Under the input column, the perfect stem is /mill/. As a convention, stems are shown with the characteristic vocalism of their intended morphosyntactic context: perfect stem /ktab/, imperfect /ktub/; perfect /mill/, imperfect /mall/, and so on.[4] Affixed to the stem /mill/ are the perfect active voice marker /a/, henceforth /a^{PAV}/, and a person, number, gender suffix. The /i/ of /mill/ surfaces only before a consonant-initial suffix, as in [malil-naa].[5]

(3)

INPUT		OUTPUT		MORPHOLOGICAL PARSE
/a^{PAV}, mill, + a/	→	mall-a	3MS	m-a^{PAV}-ll-a
/a^{PAV}, mill, + naa/	→	mal**i**l-naa	1PL	m-a^{PAV}-l**i**l-naa

Let us express formally the fact that the vowel of the perfect stem /mill/ is left unrealized before a vowel-initial suffix. The /a/ in [mall-] is the marker of perfect active voice, /a^{PAV}/. The requirement for expressing this marker, then, suppresses the requirement for realizing the stem vowel. This is shown in tableau 4. IO-MAX is a basic constraint of correspondence theory dictating that 'Input segments have output correspondents' (McCarthy & Prince 1995b). Individual morphemes come with different IO-MAX requirements. Here, IO-MAX^{PAV} dictates that /a^{PAV}/ must have a correspondent in the output, and IO-MAX^{V} dictates that the stem vowel must have a correspondent in the output. Since the constraints are in conflict and 4b is the actual output, we infer that IO-MAX^{PAV} ≫ IO-MAX^{V}.

(4) Stem vowel is replaced: priority to expression of aspect, voice

/a^{PAV}, mill, + a/	IO-MAX^{PAV}	IO-MAX^{V}
a. mill-a	*!	
b. ☞ ma^{PAV} ll-a		*

[4] Note that this does not NECESSARILY imply positing two stems for each verb. The stem can be /ktVb/ or /mVll/, with an unspecified vowel slot whose content is filled in by whatever constraints regulate the quality of this vowel in the distinct morphosyntactic contexts. However, the alternative of two stems for each verb is also compatible with my approach (see Aronoff 1994:41–42).

[5] I thank Robert Hoberman for pointing out this crucial fact to me.

The ranking inferred above is in apparent contradiction with the schema Root-Faith ≫ Affix-Faith, proposed by McCarthy and Prince (1995b:364) to hold between roots or stems and affixes, generally. Vocalic melodies in Semitic, however, offer good reasons to believe that this schema can be refined by making reference to different kinds of morphological realization. The /a/ of PAV is a marker of inflectional class. All Form I verbs show this vowel in the perfect's active voice. We know independently that the definitional characteristic of inflection is that it is obligatory (Aronoff 1994). Because of this, /a^{PAV}/ must be expressed even when there is only one vowel position in the surface realization of the stem.[6]

One way to avoid replacement of the lexical vowel is to employ the strong allomorph also in the prevocalic context, [malil-a]. In this form, both /a^{PAV}/ and the stem vowel /i/ surface. This also satisfies the templatic requirement, TEMPLATE = CVCVC, on the shape of the perfect (McCarthy 1979:248 et seq.).[7] However, [malil-a] violates another basic constraint of correspondence theory called INTEGRITY, defined in 5. INTEGRITY penalizes relations between a form S_1 (here, the stem) and another related form S_2 (here, the perfect realization), where a segment in S_1 has more than one correspondent in S_2. The superscripts portray pairs of correspondent segments, so that the segment /ll/ in /mill/ enters into two (hence the INTEGRITY violation) correspondent pairs, (ll^j, l^j), (ll^k, l^k).

(5) INTEGRITY: No segment of S_1 has multiple correspondents in S_2
IO-INTEGRITY violation: m i $ll^{j,\,k}$ S_1 (Stem), /mill/
m a l^j i l^k S_2 (Perfect), [malil]

Thus, since /a^{PAV}, mill, + a/ does not surface as [malil-a], it follows that IO-INTEGRITY ≫ TEMPLATE. Tableau 6 compares the two relevant candidates. It is also evident that IO-INTEGRITY ≫ IO-MAX^V. In other words, maintaining the geminate takes priority over satisfying the template and parsing the stem vowel.

(6) No consonant doubling before V-initial suffixes: /a^{PAV}, mill, + a/ → [mall-a]

/a^{PAV}, mill, + a/	IO-INT	TEMPLATE	IO-MAX^V
a. malil-a	*!		
b. ☞ mall-a		*	*

[6] This is true of several modern Arabic dialects as well, for example, Egyptian, Iraqi, and Syrian. For instance, in Egyptian all doubled verbs have [a] in the perfect as in [ħabb] 'to love', [dall] 'to indicate'. But in the imperfect, a stem vowel contrast emerges as in [biyħibb] vs. [biydull] (Abdel-Massih 1975:135–37). For Iraqi see Erwin 1969:240, and for Syrian see Cowell 1962:64.

A similar situation may be found in Hebrew. A number of researchers have converged on the conclusion that the paʕal binyan in Hebrew is in some sense basic. On the morphological side, Aronoff (1994) argues for the default status of paʕal in view of the fact that it is the most frequently attested binyan and also the most populated one. Ussishkin (2000) proposes an analysis where verbal forms in other binyanim derive from bases in paʕal. In different ways, then, paʕal forms are thought to be basic. But this faces the problem that forms in paʕal invariantly surface with the vowel /a/ as in /k**a**tav/ 'he wrote', /k**a**ved/ 'he was heavy', /q**a**ton/ 'he was small', and also in the minority class of monosyllabic forms like /s**a**m/ 'he put', /b**a**/ 'he came', /k**a**m/ 'he got up'. The problem (basic, yet predictable in certain ways) is resolved when the status of /a/ as a marker of the inflectional class of paʕal is recognized. Since this vowel expresses membership in that inflectional class, it must be invariantly present even when there is only one vowel in the surface realization of the stem.

[7] Following McCarthy 1979, the templatic constraint is stated as a sequence of C's and V's. Subsequent work on prosodic morphology converges on the hypothesis that templates must be stated in terms of purely prosodic predicates, the 'prosodic morphology hypothesis'. For a review, see McCarthy & Prince 1995a. The precise formulation of the templatic constraint is not crucial for present purposes.

As seen above, the template for the perfect is suppressed in favor of faithfulness to the stem, /mill/ → [mall-a], *[malil-a]. However, when the stem cannot surface as such due to phonotactics, the template does come into play. In particular, when the stem is combined with C-initial suffixes, as in /a^{PAV}, mill, + tu/, a phonotactic problem arises. Arabic does not permit sequences of a geminate followed by another consonant as in *[mill-tu]. Such sequences, we assume, are banned by a constraint disallowing geminates as syllable codas.[8]

(7) *$C_xC_x]^\sigma$: Syllable codas do not consist of geminates

The actual output from /a^{PAV}, mill, + tu/ is [malil-tu]. The phonotactic problem in *[mill-tu] is resolved by changing the stem in a way that violates IO-INTEGRITY. Therefore, the markedness constraint banning coda geminates *$C_xC_x]^\sigma$ dominates the faithfulness constraint IO-INTEGRITY. This is shown in 8.

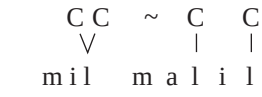
(8) Consonant doubling before C-initial suffixes: /a^{PAV}, mill, + tu/ → [malil-tu]; *$C_xC_x]^\sigma$ ≫ IO-INT

/a^{PAV}, mill, + tu/	*$C_xC_x]^\sigma$	IO-INT	TEMPLATE
a. mall-tu	*!		*
b. ☞ malil-tu		*	

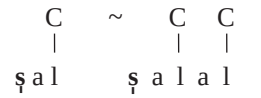
An alternative repair to the problem met by concatenating stem and suffix in /a^{PAV}, mill, + tu/ is to shorten the geminate as in [mal-tu]. This candidate, compared to the actual output [malil-tu], violates TEMPLATE and IO-MAX^V. But since these are ranked below IO-INTEGRITY as shown in 6, their violation cannot be the reason for the suboptimality of [mal-tu]. Rather, the constraint ruling out [mal-tu] is IDENT^Q in 9, which requires that the skeletal quantity of segments in the stem must be preserved or transferred to the surface (Dell & Elmedlaoui 1992).[9] Specifically, in the hypothetical /mill/ → [mal-tu], the /ll/ in /mill/ is linked to two skeletal C slots, but the correspondent of /ll/ in [mal-tu] is linked to a single C slot. IDENT^Q penalizes this mismatch.[10]

(9) IDENT^Q: A segment in S_1 and its correspondent set in S_2 have identical quantities (no. of C slots)

a. S_1 = /mill/ 'be weary', S_2 = [**malil**]



b. S_1 = /ṣal/ 'to arrive', S_2 = [**ṣalal**]



[8] See Angoujard 1990, Broselow 1992, Itô 1986, and Farwaneh 1995 for syllabification in Arabic. The constraint in 7 may ultimately be formulated as an instance of a general upper bound on syllabic weight. See Broselow et al. 1997:65 for a proposal on a bound of two moras. For present purposes, it suffices to formulate the constraint as given.

[9] For related notions in nontemplatic contexts see McCarthy 1995, Broselow et al. 1997, and Buckley 1997.

[10] The statement of IDENT^Q employs the notion of 'correspondent set' of a segment, which is defined precisely as follows. Given two forms S_1, S_2, and a correspondence relation ℜ between the two, the correspondent set of a segment x in S_1 is the set of all segments y in S_2 that are correspondents of x. This set may be empty, as in the case where x does not have a correspondent in S_2 (deletion), or it may consist of one or more elements. In general, given a correspondent set of segments $S = \{y_1, y_2, \ldots, y_n\}$, let the

As shown in 9a, no mismatch exists in the relation between /ll/ in /mill/ and its two correspondent /l/'s in [malil-tu]: the /ll/ in /mill/ is linked to two C slots, the same number of slots as those linked to the two correspondents of /ll/ in [malil]. Another example of a relation illustrating IDENT^{Q} is shown in 9b. The stem is /ṣal/ 'to arrive' and its hypothetical realization is [ṣalal] (the actual one is [waṣal], discussed in §3). Here, the /l/ of the stem is linked to one C slot, whereas its two correspondents in [ṣalal] are linked to two C slots, a violation of IDENT^{Q}.

Tableau 10 summarizes the discussion by comparing [mal-tu] to the actual output [malil-tu]. From this, we can infer the new ranking relation IO-IDENT^{Q} ≫ IO-INTEGRITY.

(10) Consonant doubling before C-initial suffixes: /a^{PAV}, mill, + tu/ → [malil-tu]

/a^{PAV}, mill, + a/	IO-IDENT^{Q}	IO-INT	TEMPLATE
a. mal-tu	*!		*
b. ☞ malil-tu		*	

This completes the core analysis of allomorphy in the perfect. To review, if we assume that the verbal stem is /mill/, then the alternation [mall] ~ [malil] is PHONOLOGICALLY DETERMINED. This is to say that the alternation can be formulated explicitly as a grammar, a set of generally accepted constraints and their language particular prioritization. Thus, the alternation is the result of the ranking *C$_x$C$_x$]$^{\sigma}$, IO-IDENT^{Q} ≫ IO-INTEGRITY ≫ TEMPLATE, along with the ranking about vowels MAX^{PAV} ≫ MAX^{V}. This grammar formally states the phonotactic motivation for the alternation and the particular form that this alternation takes. The phonotactic motivation is expressed by *C$_x$C$_x$]$^{\sigma}$: alternation of /mill/ before a C-initial suffix takes place to avoid the marked sequence of a geminate followed by another consonant. The particular form this alternation takes is expressed by *C$_x$C$_x$]$^{\sigma}$ ≫ IO-INTEGRITY, inducing multiple correspondence of the geminate rather than shortening.

The rest of this section addresses some secondary issues. First, I consider alternative repairs to the problem created between a geminate-final stem and a consonant-initial suffix, /a^{PAV}, mill, + tu/, such as deletion of the whole (geminate) segment as in *[matu], vowel epenthesis as in *[mall-V-tu], or metathesis as in *[mall**i**-tu]. These violate independently motivated constraints, which I thus assume to be undominated. For example, deletion violates the bimoraic minimality requirement for Arabic stems argued for by McCarthy and Prince (1990a,b). Epenthesis as in [mall-V-tu] violates IO-DEP^{V} and the requirement of proper stem-suffix alignment, since /V/ is inserted between stem and suffix (formally expressed by an alignment constraint, as in McCarthy & Prince 1993). Metathesis as in *[mall**i**-tu] violates proper stem-suffix alignment and also what McCarthy and Prince (1990b) argue to be a general canon for Arabic stems, namely, the constraint that stems end in a consonant, Final Consonantality (see also McCarthy 1993, Rose 1997).

quantity of the set be the union of the quantities of its elements. IDENT^{Q} requires preservation of quantity between a segment in some form S_1 and its correspondent set in a related form S_2. Thus, a geminate in an input stem must have a correspondent set in the output whose quantity is exactly two C slots. This extension of correspondence constraints to evaluate identity between segments and SETS OF SEGMENTS is unavoidable in applying correspondence theory to templatic morphology, where one input segment may have multiple output correspondents.

Another, ultimately more important, issue is that the presence of alternation for any given doubled verb implies nonuniformity in the paradigm of that verb; each verb has two stem allomorphs, as in [mall-] and [malil-]. There is a significant body of research that converges on the hypothesis that such (non)uniformity in paradigms is controlled by the synchronic grammar. The core idea promoted in this work is that identity constraints between related forms hold not only between input and output but also between pairs of related outputs, so called Output-Output (OO) Faith constraints (Benua 1995, Burzio 1993, 1994, 1998, Buckley 1999, Kenstowicz 1997, McCarthy 2000, Steriade 2003). An important precedent here is the notion of 'analogy' in historical linguistics (see Anttila 1977 for an extensive bibliography of the vast literature on this subject) and its early explorations in generative grammar (Kiparsky 1971, 1972, Harris 1973).

To return to the doubled verb facts, the presence of two distinct stem realizations, [mall-a] and [malil-tu], implies the violation of some Output-Output faithfulness constraint requiring uniformity within the perfect paradigm. The relevant constraint is OO-INTEGRITY: segment /ll/ in [mall-a] has two correspondents in [malil-tu]. The situation is shown in 11, with a PARADIGM TABLEAU (term due to Tesar & Smolensky 1998). A paradigm tableau computes the realizations of a hypothetical stem ς, here /mill/, in all contexts of some paradigm π, here the perfect. The candidate realizations are not individual forms but rather sets of forms. Henceforth, I refer to any such set as the REALIZATION SET of stem ς within paradigm π or in short π(ς). The candidate realization sets for /mill/ are discussed immediately below.[11]

(11) Nonuniform perfect paradigm: /mill/ → [mall-a, malil-tu]; $*C_xC_x]^\sigma \gg$ IO-INT ≫ OO-INT

π(/mill/) = ?	$*C_xC_x]^\sigma$	IO-INT	OO-INT
a. mall-a, mall-tu	*!		
b. malil-a, malil-tu		**!	
c. ☞ mall-a, malil-tu		*	*

The candidate in 11a is faithful to the stem with respect to maintaining its geminate, but violates the dominant $*C_xC_x]^\sigma$. The informative comparison is between 11b and 11c. In 11b, the stem surfaces invariantly as [malil-], thus avoiding the OO-INTEGRITY violation at the cost of violating IO-INTEGRITY twice. In 11c, [malil-tu] incurs one violation of IO-INTEGRITY and OO-INTEGRITY. Since the attested paradigm is 11c, it follows that IO-INTEGRITY ≫ OO-INTEGRITY. If, instead, OO-INTEGRITY ≫ IO-INTEGRITY, then uniformity of stem realization would be required, as in 11b.[12]

Finally, consider the apparent violation of geminate integrity in $/a^{PAV}$, mill, + tu/ → [malil-tu]. This seems unusual given the often-made assumption that geminates do not split in word formation (Kenstowicz & Pyle 1973, Guerssel 1977, 1978, Steriade 1982, Hayes 1986, Schein & Steriade 1986). However, the evidence supporting this

[11] Each candidate realization set (of a stem within the perfect paradigm) shows only two representative forms, one with a vowel-initial suffix, the 3MS /-a/, and the other with a consonant-initial suffix, the 1S /-tu/, out of a total of fourteen forms. The two forms shown are representative in an accurate sense; that is, within each candidate set, the forms not shown do not violate any constraints other than those violated by the forms shown.

[12] See §4 for an instance of this ranking.

generalization derives from cases of concatenative or affixal word formation. Crucially, the Arabic case in /a^{PAV}, mill, + tu/ → [malil-tu] involves a template. In templatic morphology, stem geminates CAN stand in correspondence to two consonants in derived words (see Steriade 1982:37–38 for relevant discussion). For present purposes, two representative cases will suffice. The one in 12a comes from the morphology of the professional noun in a dialect of Moroccan Arabic (Heath 1987:140). The template for the derived words is /CCaCC-i/. The other case, in 12b, comes from Imdlawn Tashlhiyt Berber and the template is /a-CCayC-iy/ (Dell & Elmedlaoui 1992:108–9). In 12a,b stems with geminate consonants have derived words with two nonadjacent consonants; /ṣbbən/ → [ṣbabn-i], /l-brrad/ → [a-brard-iy]. This is the same relation as that between /mill/, [malil] in doubled verbs.

(12) Geminates in correspondence to two consonants (templatic morphology)

a. Moroccan Arabic	b. Imdlawn Tashlhiyt Berber
ṣbbən → ṣbabn-i 'wash clothes'	l-brrad → a-brard-iy 'teapot'
s^{w}kkaṛ → skakṛ-i 'sugar'	a-skkif → a-skakf-iy 'soup'
drr-a → drayr-i 'handkerchief'	a-qššb → a-qšašb-iy 'smock'
nšəṭ → nšayṭ-i 'be lively'	a-zrg → a-zrayg-iy 'stone mender'

The examples in 12 also include two representative stems without a geminate consonant, /nšəṭ/ in 12a and /a-zrg/ in 12b. This is to illustrate the crucial role of gemination in forming the derived words. Consider the contrast between /ṣbbən/ and /nšəṭ/ in 12a or, equivalently, the contrast between /l-brrad/ and /a-zrg/ in 12b. Stem /l-brrad/ extends on the template by doubling, [a-brard-iy], whereas stem /a-zrg/ extends by /y/ epenthesis, [a-zrayg-iy]. It is only geminates that establish two correspondents in the derived word, showing that consonantal length must be specified in the stems. Using bare roots like |brd| or |zrg| as the bases on which word formation builds is not a viable alternative, because these roots discard the crucial length information. For the argument that consonant doubling in this data set is via correspondence, that is, via copying rather than spreading, see Gafos 2003.[13]

2.2. ALLOMORPHY IN THE IMPERFECT. The doubled verb allomorphy is also found in the imperfect. As 13 shows, the conditioning of the two allomorphs is the same as that in the perfect. The geminate allomorph occurs before vowels, the strong elsewhere: [ya-mudd-u], [ya-mdud-na]. The forms in 13 illustrate the indicative mood of the imperfect aspect of the lexeme 'to stretch'.[14] The other verbal moods built on the imperfect stem (subjunctive, jussive, imperative, and the rare energicus) are in all relevant respects similar to the indicative. That is, prefixes are vowel-final and suffixes are vowel-initial, consonant-initial, or null. Moreover, the doubled verb alternation in these moods is identical to that found in the indicative (e.g. jussive 3MS [ya-mdud], 3FPL [ta-mudd-a]).

[13] Note that the claim that geminates can establish relations of multiple correspondence does not imply that stems with geminates expand on a template ONLY via multiple correspondence or that stems with single consonants expand ONLY via epenthesis. For instance, in Sierra Miwok (Broadbent 1964, Smith 1985, Goldsmith 1990) epenthesis is employed systematically for both stem types, as illustrated here with the /CVCVC-kuH/ template: /loot/ 'to catch' → [lotuʔ-kuH] 'captive', /wemm/ 'to dig a hole' → [wemiʔ-kuH], with /ʔ/-epenthesis also for /wemm/ (Broadbent 1964:107–9).

[14] The mere listing of these undifferentiated prefix-suffix material should not be taken as reflecting some theoretical stand on their morphology. There are morphological issues about these exponents, such as their precise morphosyntactic content and the absence of a gender contrast in the first person, among others. This listing suffices for the current purpose, that is, exploring to what extent the inflectional context supplied by these exponents determines properties of verbal stems.

(13) Indicative

		SINGULAR	PLURAL	DUAL
3	M	ya-mudd-u	ya-mudd-uuna	ya-mudd-aani
	F	ta-mudd-u	ya-mdud-na	ta-mudd-aani
2	M	ta-mudd-u	ta-mudd-uuna	ta-mudd-aani
	F	ta-mudd-iina	ta-mdud-na	ta-mudd-aani
1		ʔa-mudd-u	na-mudd-u	

If we assume that /mudd/ is the stem, the alternation follows the pattern in the perfect: with a V-initial suffix the stem surfaces as in [ya-mudd-u], but with a C-initial or null suffix, a geminate coda would result, *[ya-mudd(-na)]. The ban on coda geminates enforces alternation to [ya-mdud(-na)]. The formal analysis appears in 14—no new rankings are needed. In 14a, [ya-mudd-na] violates the top-ranked *$C_xC_x]^{\sigma}$. Moreover, the stem cannot surface as in 14b [ya-mud-na] due to IO-IDENT^{Q} requiring preservation of the skeletal structure of segments. The actual alternant is [ya-mdud-na], with the stem geminate in multiple correspondence as in 14c. This alternation to [mdud] violates IO-INTEGRITY but saves the violation of the top-ranked *$C_xC_x]^{\sigma}$, IO-IDENT^{Q}.

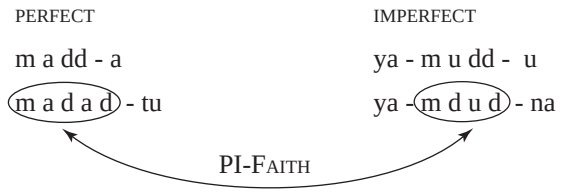
(14) Alternation before C-initial suffixes: /ya, mudd, na/ → [ya-mdud-na]

/ya, mudd, na/	*$C_xC_x]^{\sigma}$	IO-IDENT^{Q}	IO-INT
a. ya-mudd-na	*!		
b. ya-mud-na		*!	
c. ☞ ya-mdud-na			*

Now, imperfect morphology is affixal, adding a prefix-suffix pair to the stem /mudd/. As discussed earlier, germinates can establish multiple correspondents but only in templatic morphology. If the analysis above is correct, it seems to illustrate a case where a stem geminate is realized, via multiple correspondence, as two consonants in the derived form in affixal morphology, /ya, mudd, na/ → [ya-mdud-na]. We seem to have reached a contradiction. This is only apparent, however. Crucially, in Arabic, there is a mix of templatic (perfect) and affixal (imperfect) morphology. As I show next, under the presence of OO-Faithfulness in the grammar, this combination enables a stem geminate to establish multiple correspondence in the imperfect.

In the imperfect, before a consonant-initial suffix, the final geminate in /mudd/ must be avoided, but it cannot be avoided by shortening that geminate. Therefore, some other form that resolves the phonotactic problem must be employed. Assuming the presence of faithfulness constraints applying across the perfect-imperfect contexts, abbreviated PI-FAITH in 15, the needed allomorph must resemble some surface variant of the perfect paradigm.

(15) Transfer of the strong perfect allomorph to the imperfect via PI-FAITH



As shown in 15, in the templatic perfect, there exist stem variants, 1S [madad-tu] or 3FPL [madad-na], with the strong (triliteral) allomorph. This alternant is phonotactically

suitable before a consonant. It is this strong allomorph that is chosen in the imperfect context.

As noted earlier, the distinct vowels of the perfect [mad**a**d-tu] and imperfect [ya-md**u**d-u] are a matter of that part of the grammar regulating these vowels in the distinct morphosyntantic contexts, and overriding complete identity between perfect and imperfect stem realizations. For example, consider the $a^{Perf} \sim u^{Impf}$ alternation in [mad**a**d-], [-md**u**d-] or [kat**a**b-], [-kt**u**b-]. To state this alternation I add an interface constraint mediating between morphosyntactic features and their phonological expression. The specific constraint needed here is '[+perf] → [a], [+impf] → [u]'. This constraint overrides PI-IDENT^{V}, which requires identity in vowels across the perfect-imperfect contexts. This difference in vocalism aside, imperfect [-md**u**d-] consists of the same (nongeminate) consonants as perfect [mad**a**d-].

In sum, the stem geminate establishes multiple correspondence in the templatic perfect, that is, /madd/ → [madad-]. This strong allomorph of the perfect is transferred to the nontemplatic imperfect through faithfulness applying across the perfect-imperfect contexts. Hence the apparent violation of geminate integrity in the concatenative morphology of the imperfect /ya, mudd, na/ → [ya-mdud-na]. Further, important consequences of PI-FAITH are derived in §4.

With the basic idea in place, the rest of this section deals with its formal implementation. Despite the significant body of work on faithfulness constraints between related words, surprisingly little discussion has been devoted to the important issue of which surface forms are to be treated as 'related'. The present proposal on faithfulness across the perfect-imperfect is aimed at elaborating this notion in an inflectionally rich morphology. In this respect, PI-FAITH is different from the usual OO-Faithfulness constraints employed in the literature. PI-FAITH is interparadigmatic because it applies across the perfect-imperfect paradigms of a lexeme. Typically, OO-F constraints are intraparadigmatic. For an example, recall OO-INTEGRITY in 11, applying within the perfect or the imperfect paradigm. Thus, first, I justify the presence of a faithfulness relation between perfect and imperfect forms. By definition, correspondence relations hold between pairs of 'related forms' (McCarthy & Prince 1995b). The perfect and imperfect forms of a verb are forms of the same lexeme. It is by virtue of this fact that a relation exists between perfect and imperfect. Intuitively, the perfect-imperfect correspondence relation maintains coherence across the two distinct morphosyntactic contexts.

We must also specify the perfect-imperfect forms that stand in correspondence. One reasonable hypothesis is that the perfect-imperfect pairs are determined by the morphosyntactic features of person, number, and gender (henceforth, PNG). For example, an identity requirement would require that the 3MS perfect form must be identical to the 3MS imperfect. There are, however, imperfect forms with the strong allomorph, such as the jussive 3MS [ya-mdud], whose perfect counterparts (same PNG features) employ the geminate allomorph, e.g. perfect 3MS [madd-a]. The existence of such pairs shows that imperfect forms may resemble perfect allomorphs with which they do not necessarily share the same PNG features.

I now state in formal terms the notion of faithfulness across the perfect-imperfect paradigms. Let FAITH be any faithfulness constraint, let π^1, π^2 be two paradigms of a lexeme ℓ, and let S be any surface realization of ℓ within these paradigms. In our case, π^1 = imperfect and π^2 = perfect. Then, 16 states that π^1, π^2 satisfy FAITH, iff for each S_i in π^1 there exists some S_j in π^2 such that $S_i \Re S_j$ satisfies FAITH, and vice versa. ($S_i \Re S_j$ is a shorthand for the correspondence relation between S_i, S_j.)

(16) Definition of FAITH (π^1, π^2)
$\forall$ $S_i \in \pi^1$, $\exists$ $S_j \in \pi^2$ s.t. S_i $\Re$ S_j satisfies constraint FAITH, and vice versa (i.e. $\forall$ $S_i \in \pi^2$, $\exists$ $S_j \in \pi^1$ s.t. S_i $\Re$ S_j satisfies constraint FAITH)

As an example illustrating this definition, consider the constraint INTEGRITY applying across π^1 = imperfect and π^2 = perfect, and take the hypothetical pair perfect [mamad], imperfect [mmud] or [mud] (affixes dropped). Here, all perfect realizations surface as [mamad] and all imperfect as [mmud]/[mud]. Individually, these sets illustrate an ideal, uniform state WITHIN the perfect or imperfect sets—there is no allomorphy set internally. The intraparadigmatic OO-INTEGRITY, applying within the perfect or the imperfect set of forms, is satisfied. Across the perfect-imperfect, however, PI-INTEGRITY is violated. The first segment of imperfect [mmud]/[mud] corresponds to two segments in perfect [mamad].

Finally, consider the actual realization sets, imperfect [mudd, mdud] and perfect [madd, madad]. Here, the intraparadigmatic OO-INTEGRITY is violated, as discussed in §2. However, PI-INTEGRITY is satisfied. For each S_i in the imperfect, there exists S_j in the perfect such that no segment of S_i has multiple correspondents in S_j. For imperfect [mdud], that perfect form is [madad]; for imperfect [mudd] it is [madd]. And for each S_i in the perfect, there exists S_j in the imperfect such that no segment of S_i has multiple correspondents in S_j. For perfect [madad], that imperfect form is [mdud]; for perfect [madd] it is [mudd].[15]

To sum up, the stem /mudd/ underlies the set [ya-mudd-u, ya-mdud-na] in the imperfect. As with the perfect, the [mudd] ~ [mdud] alternation is phonologically determined. Specifically, the alternation is triggered by phonotactics in the sense that syllabification canons disallow a geminate-final stem in the contexts of *[mudd-na], *[mudd]. The specific form [mdud] is determined by the identity requirement in stem realization across the perfect-imperfect contexts, that is, the constraint PI-FAITH.

3. TESTING OF PREDICTIONS. We now have a sufficiently developed hypothesis about doubled verbs which states that their allomorphy is determined by phonological principles, that is, principles characteristic of the phonology of the language as a whole. Consequently, that hypothesis must make predictions that go beyond doubled verbs, and these predictions provide crucial tests for that hypothesis. In this section I pursue these predictions.

Up to now, discussion of verbal allomorphy has been confined to Form I of the Arabic verb. A first test of the proposed phonology involves other verbal Forms where allomorphy is found. If, as argued, the allomorphy is due to phonological principles rather than morphologically conditioned idiosyncracies of certain Forms, then we expect the alternation to be found whenever its phonological conditions are met. This prediction is confirmed. The alternation is also found in verbs of Form IX *ktabab* and Form QIV

[15] As indicated by the conjunction in 16, the faithfulness constraint holding across the two paradigms requires bidirectional identity: each imperfect form must be identical to some perfect form and vice versa. This is because the definition of faithfulness across paradigms is stated in most general terms, without assuming that there is a derivational relation between the two paradigms π^1 = imperfect and π^2 = perfect. In Arabic, the derivational relation between perfect and imperfect is an issue of some debate. Thus, Benmamoun (1999), McOmber (1995), and McCarthy (1979:164) argue for the imperfect as the basic form, while Guerssel and Lowenstamm (1996) argue for the perfect as basic. For the similar facts of Hebrew, Aronoff (1994) argues that we need only recognize a relation between perfect and imperfect, without directionality. It is this most minimal assumption that I adopted in stating 16. However, if it turns out that a derivational relation must be posited for Arabic, then 16 can be modified accordingly by dropping the conjunction.

Fɛʕlal (following Cowell's (1962) notation), under conditions identical to Form I (Schramm 1962). I focus here on Form IX, which is representative.

Traditionally, Form IX is identified with the pattern *ktabab* (Wright 1896:43). All subsequent work in the generative tradition known to me has assumed that *ktabab* is the canonical form of IX verbs. However, stems in IX surface as *ktabab* only before consonant-initial suffixes for reasons familiar by now. Representative examples of the alternation are given under the verbal part of 17.

(17)

Adjectives		Verbal alternation in Form IX (perfect)		
ʔa-ħmar-u	'red'	ʔi-ħmarr-a	ʔi-ħmarar-tu	'he/I blushed'
ʔa-ṣfar-u	'yellow'	ʔi-ṣfarr-a	ʔi-ṣfarar-tu	'he/I became yellow'
ʔa-qbal-u	'cross-eyed'	ʔi-qball-a	ʔi-qbalal-tu	'he/I became cross-eyed'
cf. Verbs		Form I (perfect)		
/radd/	'to return'	radd-a	radad-tu	'he/I returned'

Form IX verbs like [ʔi-ħmarr-a] 'he blushed' are related to adjectives of color and bodily defects, here [ʔaħmar-u] 'red' and its corresponding nominal form [ħumr-un] 'red.PL'.[16] In the verbal form [ʔi-ħmarr-a], putting aside the transparently epenthetic [ʔi-] and the suffix [-a], the final consonant is the long version of its corresponding segment in the noun or the adjective. There are a few different ways to state the morphological link between the verb and its derivationally related forms. One such way is to derive the verbal stem by adding a suffixal mora to the simpler stem /ħmVr/, underlying the noun or the adjective: /ħmVr-/$^{\text{Stem}}$ + μ → /ħmarr-/$^{\text{Verb-stem}}$. What is important for current purposes is that once the verbal stem is placed in its paradigm, it is clear that what is involved in the allomorphy [ʔi-ħmarr-a] ~ [ʔi-ħmarar-tu] is the by now familiar phonologically determined alternation.[17]

The second prediction concerns limitations on stem allomorphy implied by the presence of the two key faithfulness constraints IO-INTEGRITY and IO-IDENT^{Q} in the grammar. Consider a hypothetical biliteral stem /C^{1}VC^2/. It is predicted that such a stem cannot surface as [C^{1}VC^{2}VC^2] in analogy to the pattern of final identity in doubled verbs like [madad]. This is so because IO-INTEGRITY and IDENT^{Q} dominate TEMPLATE, and hence doubling cannot be employed in order to satisfy the perfect's /CVCVC/ template. This prediction is borne out by verbs that have only two consonants in the imperfect, in 18. The stems of these verbs are biliterals, attested as such in the imperfect context, e.g. [ya-ṣil-u] 'he arrives'. In the perfect, /CVC/ stems would fall short of the templatic requirement /CVCVC/. These stems apparently conform to the template by epenthesis of /w/, e.g. imperfect [ya-ṣil-u], perfect [waṣal-a].[18] In accordance with the

[16] For an illustration of exactly this morphology in a modern dialect, consider Form IX verbs from Syrian, e.g. [ʔaħmar] 'red' ~ [ħmarr] 'to blush', [ʔaṣfar] 'yellow' ~ [ṣfarr] 'to turn pale', and so on (Cowell 1962: 101, 250).

[17] Forms II and III are characterized as exceptional because doubled verbs in these Forms do not show the alternation (Wright 1896, Schramm 1962, Yushmanov 1961). The same applies to Forms V and VI, which are derived from II and III respectively by prefixation of /ta-/. Gafos 2001 argues that the 'exceptionality' of these Forms derives from the interaction of constraints on syllabic structure and morphological expression, as in the core analysis of this article.

[18] A plausible alternative view on /w/ is that it is the result of spreading from its adjacent /a/. Since this view is consistent with the main claim here, namely, that the /w/ is derived as opposed to being lexical, I will not pursue it further. Also, see Chekayri and Scheer 1996:74–75 and Ratcliffe 1997:157, 1998:45 for a proposal similar to that in the text about these verbs.

prediction of my analysis, such stems do not extend to the template as in *[ṣalal-a] or *[ṣaṣal-a].

(18) Verbs 'rejecting /w/' in the imperfect (Wright 1896:78–79)

IMPERFECT	PERFECT		IMPERFECT	PERFECT	
ya-rim-u	warim-a	'to swell'	ya-riθ-u	wariθ-a	'to inherit'
ya-ʕid-u	waʕad-a	'to promise'	ya-zar-u	wazar-a	'to let alone'
ya-zin-u	wazan-a	'to weigh'	ya-**ḍ**aʕ-u	wa**ḍ**aʕ-a	'to put'
ya-θiq-u	waθiq-a	'to trust, confide'	ya-ḷid-u	walad-a	'to bear children'

The proposed view of these verbs diverges from past description, which takes [waṣal-a] as basic and posits a morphologically conditioned process of /w/-deletion to derive [ya-ṣil-u] (Wright 1896:78). However, this description rests in part on the assumption that the basic verbal form is the one conventionally employed in dictionaries and descriptive grammars, the perfect. If we do not make this assumption, we can eliminate the arbitrary /w/-deletion. In fact, there is converging evidence for the claim that verbs like [ya-ṣil-u] do not contain an underlying /w/. This evidence derives from further facts related to these verbs and from facts of nominal and adjectival morphology to which I turn next.

A first piece of evidence comes from checking some basic predictions. If, as claimed here, the /w/ in [waṣal-a] is supplied to satisfy the perfect's template, rather than being a part of the lexical entry of the verb ('rejected' in [ya-ṣil-u]), we expect nonalternating /w/-initial stems, that is, stems beginning with /w/ in both the perfect and the imperfect. Examples are shown below. These stems DO have a lexical /w/. But whereas these are perfectly regular in the proposed analysis, they must be seen as exceptions to the already arbitrary process of /w/-deletion in the standard analysis (for 'be afraid', Wright also lists root |wɟr|; [ɟ] denotes a voiced palato-alveolar obstruent).

(19) Invariantly /w/-initial stems (Wright 1896:78–79, Haywood & Nahmad 1965: 219)

IMPERFECT	PERFECT		IMPERFECT	PERFECT	
ya-wɟal-u	waɟil-a	'be afraid'	ya-wɟaʕ-u	waɟiʕ-a	'be in pain'
ya-wħal-u	waħil-a	'stick in the mud'	ya-w**ḍ**uw-u	wa**ḍ**uw-a	'be clean & fair'
ya-wbul-u	wabul-a	'be unwholesome'	ya-wadd-u	wadd-a	'love'

A second argument for the derived status of /w/ in verbs like [ya-ṣil-u] ~ [waṣal-a] is that /w/-epenthesis is attested independently. In the nominal plural and diminutive, /w/ is the default onset filler in the iamb of the derived form: /xaatam/ 'signet-ring', plural [xa**w**aatim], diminutive [xu**w**aytim], /jaamuus/ 'buffalo', plural [ja**w**aamiis], diminutive [ju**w**aymiis]. See the CONSONANTAL DEFAULT RULE: 0 → /w/ in the influential analysis of these facts by McCarthy and Prince (1990a:247–79).

Epenthesis is also employed in adjectival morphology in stems that fall short of minimality requirements. Consider in this respect the denominal adjective or *nisba* of a biliteral noun like /ʔab/ 'father' which takes the form [ʔaba**w**-iiy] 'paternal'. McCarthy and Prince (1990a:256) have argued convincingly that this /w/ is inserted to satisfy the requirement that the base of /-iiy/ suffixation be minimally bimoraic. Derived nouns from the verbs in 18 show the same phenomenon. For example, the noun from [ya-ʕid-u], [waʕad-a] 'to promise' is built on the imperfect stem, hence [ʕid-at] 'promise'. Its denominal adjective is [ʕida**w**-iiy] 'promissory', with the epenthetic /w/ appearing again before the suffixal boundary. Thus, whether stem extension is due to mapping

to a template, as in the verbal perfect or the nominal plural and diminutive, or due to satisfying a minimality requirement, as in the denominal adjective, epenthesis is employed to fill in syllabic positions required by the (template's) prosody.

I now return to the verbal facts in 18 in order to obtain a formally explicit statement of what has so far been a description of that data. This turns out to be critical, because it enables further testing of the validity of the proposed phonology and derivation of some important results, a major theme in §4. Tableau 20 considers representative candidate realizations for a stem like /ṣal/ 'to arrive' in the perfect. Candidate 20a *[ṣalal-a] or *[ṣaṣal-a] is excluded due to IO-INTEGRITY and the quantity preservation constraint IO-IDENT^{Q}. Comparing 20b and c, we infer the new ranking TEMPLATE ≫ IO-DEP^{C}, expressing the fact that the templatic requirement is satisfied by epenthesis.

(20) Epenthesis to satisfy template: /a^{PAV}, ṣal, + a/ → [waṣal-a] 'to arrive'; TEMPLATE ≫ IO-DEP^{C}

/a^{PAV}, ṣal, + a/	IO-IDENT^{Q}	IO-INT	TEMPL	IO-DEP^{C}
a. ṣalal-a	*!	*!		
b. ṣal-a			*	
c. ☞ waṣal-a				*

We have just seen that multiple correspondence is not an option in forming the perfect of biliteral verbs, /ṣal/ → *[ṣalal-]. Conversely, epenthesis is not an option for doubled verbs, as 21 shows. The candidates with epenthesis in 21a,b violate the high ranked IO-IDENT^{Q}, *$C_xC_x]^{\sigma}$.[19] Candidate 21c, [malil-tu], avoids the violation of *$C_xC_x]^{\sigma}$ and IO-IDENT^{Q} by maintaining the quantity of the stem geminate. Alternatives such as [mall-tu], [mal-tu] are excluded because they violate *$C_xC_x]^{\sigma}$, IO-IDENT^{Q} respectively.

(21) Integrity violation rather than epenthesis before C-initial suffix: /a^{PAV}, mill, + tu/ → [malil-tu]

/a^{PAV}, mill, + tu/	IO-IDENT^{Q}	*$C_xC_x]^{\sigma}$	IO-INT	TEMPL
a. wamil-tu	*!			
b. wamill-tu		*!		*
c. ☞ malil-tu			*	

I summarize the overarching point from 20 and 21 in 22 to emphasize the role of lexically specified consonant length in verbal stems on the derived perfect. Specifically, the templatic constraint is satisfied via doubling in /madd/ (22a) but via epenthesis in /ṣal/ (22b). I refer to this observation about the potential of geminates, but not single consonants, in establishing multiple correspondence as QUANTITATIVE TRANSFER (term due to Clements 1985; see also McCarthy & Prince 1988, Dell & Elmedlaoui 1992).

[19] The constraint IO-DEP^{C} violated in 21a,b is not shown; it is irrelevant in this context because it is ranked below IO-INTEGRITY, the constraint violated in the actual output.

(22) Quantitative transfer in verbs (templatic morphology)
   a. Stems with geminate consonants extend via consonant doubling, as in /madd/ → [madad-]
   b. Stems with single consonants extend via epenthesis, as in /s̪al/ → [wasa̪l-], not *[s̪alal-] or *[s̪as̪al]

The crucial fact now is that this observation about verbs can also be made about the nominal morphology of the language. In an extensive study of plural formation, Ratcliffe observes that in Arabic 'there is a clear distinction between true biconsonantal stems . . . and geminate stems which are phonologically triconsonantal forms' (1998: 232). The former extend by epenthesis and the latter by consonant doubling. Compare below [ħam-un] vs. [li̪s̪s-un] and [dam-un] vs. [samm-un].[20]

(23)

SINGULAR	PLURAL		SINGULAR	PLURAL	
ħam-un	ʔa-ħmaaʔ-un	'father-in-law'	dam-un	dimaaʔ-un	'blood'
li̪s̪s-un	ʔa-l̪saas̪-un	'thief'	samm-un	sumuum-un, simaam-un	'poison'

The differential effect of length is not a peculiarity of this small set of biconsonantal nouns. The same effect has been observed with nouns of more than two consonants—see McCarthy & Prince 1990a:218, 248 and Hammond 1988. Consider the examples below. An epenthetic /w/ appears in the /CaCaa-/ part of the plural or the /CuCay-/ part of the diminutive output, as in 24a,b, except when the singular noun base contains a geminate. In the latter, the base extends by double correspondence between the geminate and two consonants in the derived form, as in 24c,d. The pattern is identical to that in 23 and 22.

(24)

	SINGULAR	PLURAL	DIMINUTIVE	
a.	faakih-at	fa**w**aakih	fu**w**aykih	'fruit'
b.	xaatam	xa**w**aatim	xu**w**aytim	'signet-ring'
c.	kuttaab	ka**t**aa**t**iib	ku**t**ay**t**iib	'Quranic school'
d.	nuwwaar	na**w**aa**w**iir	nu**w**ay**w**iir	'white flowers'

To review, the doubled verb alternation is phonologically determined if one assumes that gemination can be lexically specified in stems, /s̪al/ vs. /madd/. As we see now, the doubled verb stems pattern just like other stems in the templatic morphology of Arabic and, in fact, other languages (see 12): stems with single consonants expand by epenthesis, whereas stems with geminates expand by consonant doubling. Thus, the present proposal on doubled verbs reveals that the verbal and nominal morphology show certain striking similarities in the phonological patterns of word formation. I return to this consequence of the proposal in §6.

I conclude this section by raising a basic question about doubled verbs: given the alternation [mudd, mdud], how does the learner converge to the geminate allomorph /mudd/ as the stem underlying that alternation? I further sharpen this question by making explicit the assumptions that have informally guided the analysis in the article.

[20] Note that the epenthetic (final) consonant in the plurals [dimaaʔ-un], [ʔa-ħmaaʔ-un] is not /w/ but /ʔ/. In McCarthy and Prince's analysis, this /ʔ/ is assumed to be a phonologically conditioned variant of /w/ after /aa/ and before /u/ (1990a:247, 249, 255). From an extensive survey of the plural in various Semitic languages, Ratcliffe reports that this consonant can be any of /w, ʔ, y, h/ or a consonant that is usually part of an affix such as /t/ and rarely /m, n/ (1998:81, 91, 93). It seems safe to conclude that the factors determining the identity of this consonant have not been studied in detail. Nevertheless, the effect of lexically specified consonantal length stands out as a clear generalization.

Following standard practice in generative grammar, I have ASSUMED that the surface forms [mudd, mdud] of a doubled verb derive from a unique underlying stem. The surface realization of that hypothesized stem is a function of the grammatical context, usually what follows or precedes the stem in the intended utterance. The goal is to discover the degree to which the various realizations of the hypothesized stem are determined by generally accepted laws in a theory of language. In the case considered here, we have seen that, if we assume that the stem is /mudd/, then the realization set [mudd, mdud] can be accounted for by the grammar with the subranking $*C_xC_x]^{\sigma} \gg$ IO-INTEGRITY $\gg$ OO-INTEGRITY in its core, which highlights the phonotactic motivation for the alternation and the form that the alternation takes.

Given the surface data [mudd, mdud], however, another plausible underlying stem would be /mdud/, a form that is phonetically identical to the second surface variant. Yet another option is to interpret the final consonantism of [mudd] not as a geminate but as two abutting consonants. This leads to another hypothetical stem /mud^{1}d^2/. I show below that these alternative stems cannot underlie the surface set [mudd, mdud]. Further, I show that no stem exists that can derive the realization forms of the doubled verb better than the stem /mudd/ can.

Consider first the hypothesis that /md^{1}ud^2/ underlies the set [ya-mudd-u, ya-mdud-na]. This is to say that input /md^{1}ud^2/ is realized as [ya-mud^{1}d^2-u] before a vowel and as [ya-md^{1}ud^2-na] before a consonant. In [ya-mud^{1}d^2-u], the two separate /d/s of the hypothetical stem /md^{1}ud^2/ are adjacent. This is a violation of the OBLIGATORY CONTOUR PRINCIPLE (Leben 1973, Goldsmith 1976, McCarthy 1979, 1986, Odden 1988; hereafter OCP), defined in 25. Moreover, in /md^{1}ud^2/ → [ya-mud^{1}d^2-u, ya-md^{1}ud^2-na], the LINEARITY constraints are also violated. For OO-LINEARITY this is so because of the disparity in the order of the segments in the two surface forms, and IO-LINEARITY is violated in /md^{1}ud^2/ → [ya-mud^{1}d^2-u]. The violations are shown in 26a. In this tableau, OCP and OO-LINEARITY are shown to dominate IO-LINEARITY. This ranking is assumed because it is consistent with an independently supported assumption about the initial state of the grammar (see §5), but as I argue below this assumption is not crucial.

(25) OCP: Adjacent identical elements are prohibited ('elements': segments)

(26) Fate of stem /md^{1}ud^2/

/md^{1}ud^2/	OCP	OO-LIN	IO-LIN
a. ya-mud^{1}d^2-u, ya-md^{1}ud^2-na	*	*	*
b. ☞ ya-md^{1}ud^2-u, ya-md^{1}ud^2-na			

Another possible realization of stem /md^{1}ud^2/ that is phonetically identical to [ya-mudd-u] is via fusion of the two input /d/ consonants to a geminate [dd]. This realization would incur a violation of some constraint against fusion (McCarthy & Prince 1995b, Lamontagne & Rice 1995). Once again, the point is that /md^{1}ud^2/ → [ya-mudd-u, ya-mdud-na] violates SOME constraint. This suffices to show that /md^{1}ud^2/ cannot underlie the surface set [ya-mudd-u, ya-mdud-na], because the mapping in 26b /md^{1}ud^2/ → [ya-md^{1}ud^2-u, ya-md^{1}ud^2-na] does not violate ANY constraint.

The learner would be faced with a choice between the stems /mudd/, /mdud/, if both could underlie the observed surface facts. In the present case, however, the hypothetical stem /md^{1}ud^2/ gives rise to [ya-md^{1}ud^2-u, ya-md^{1}ud^2-na], a different set from [ya-mudd-u, ya-mdud-na]. Consequently, the set of possible stems that can derive the

surface set [ya-mudd-u, ya-mdud-na] does not include /md^{1}ud^2/. This conclusion confirms the earlier point that if /md^{1}ud^2/ is the form from which [mudd] is to be derived, then the facts cannot be accounted for in phonological terms. As noted in §2, a morpholexical rule must be set up to change /md^{1}ud^2/ to [mudd].

Observe now that the analysis above does not show that /md^{1}ud^2/ is an impossible stem. It shows only that if such a stem is 'fed' to the grammar, it would surface as [md^{1}ud^2] in all contexts. Just like a triliteral stem, the surface realization of /md^{1}ud^2/ would show no alternation. This is another testable prediction of my analysis that is borne out. Wright lists more than a dozen verbs showing precisely this invariable shape. For example, in their perfect forms, we find [šarur-a] 'he was bad', not *[šarr-a], [damum-a] 'he was ugly', not *[damm-a], [fakuk-a] 'he was silly', not *[fakk-a], [labub-a] 'he was wise or intelligent', not *[labb-a], [qaTaT-a] 'he was curly', not *[qaTT-a], and so on (Wright 1896:69). These verbs do not undergo the alternation seen in doubled verbs. Consequently, they had to be treated as exceptions in all previous accounts known to me (but see O'Leary 1969:264 who calls them 'regular' precisely because they behave like the strong verbs in not showing the alternation). The absence of alternation for these verbs is readily explained by proposing that their stems are /šrur/ for [šarur-a] 'to be bad', /dmum/ for [damum-a] 'to be ugly', and so on. Crucially, these stems are not geminate-final. Thus, the phonotactic pressure for the familiar alternation does not apply to them, just as it does not apply to strong stems like /ktab/.[21]

Consider another potential stem for the doubled verbs, namely, /mud^{1}d^2/ with two abutting, identical consonants. Can this stem give rise to the set [ya-mudd-u, ya-mdud-na]? By following the discussion above, one sees that /mud^{1}d^2/'s fate is the same as /md^{1}ud^2/'s. Its optimal realization is [ya-mdud-u, ya-mdud-na]. Hence, /mud^{1}d^2/ does not underlie the set [ya-mudd-u, ya-mdud-na].[22]

We have thus seen that hypothetical stems /md^{1}ud^2/ and /mud^{1}d^2/ cannot underlie the realization set of doubled verbs [mudd, mdud]. It is now possible to generalize this result by showing that stem /mudd/ supplies the optimal mapping to the set [mudd, mdud]. That is, the goal is to show that there exists no $\varsigma' \neq$ /mudd/ such that the mapping $\varsigma' \rightarrow$ [mudd, mdud] is more harmonic than /mudd/ $\rightarrow$ [mudd, mdud]. The demonstration begins by assuming the contrary to my hypothesis, namely, by assuming that there exists an $\varsigma' \neq$ /mudd/ such that $\varsigma' \rightarrow$ [mudd, mdud] is more harmonic than /mudd/ $\rightarrow$ [mudd, mdud]. Any such ς' must either incur a subset of the violations incurred by /mudd/ $\rightarrow$ [mudd, mdud], or incur violations of some other constraint(s) lower ranked than the highest ranked constraint violated in /mudd/ $\rightarrow$ [mudd, mdud],

[21] While it is clear that the phonological behavior of [š(a)rur-] type verbs is by no means exceptional—they pattern just like any triliteral verb—they are relatively infrequent. Why so? It is possible that their infrequency may be related to acquisition. At first, given the absence of alternation in these verbs, their learnability would seem to be a straightforward matter. But since instances of the doubled verb alternation are significantly more numerous in the primary data, it seems reasonable that the learner first acquires (the grammar for) the doubled verb alternation pattern. Given this, the learner exposed to [š(a)rur-] forms may overapply the alternation, and thus infer /šurr/ as the stem (see Hayes 1999 for a similar argument). The suggestion that learning the stem of [š(a)rur-] verbs may be related to their infrequency is consistent with the fact that such stems abound in modern dialects and other branches of Semitic where the doubled verb alternation has been eliminated (since there is no alternation to overapply). See Heath 1987 on Moroccan Arabic, Borg 1985 on Cypriot Arabic, and Bat-El 1989 on Hebrew. Moreover, at least for the cases cited, two identical consonants in underived verbal or nominal forms like [š(a)rur-] behave as two independent consonants for all purposes.

[22] A detailed demonstration can be found in Gafos 2001.

that is, IO-INTEGRITY. In /mudd/ → [mudd, mdud], there is a violation of IO-INTEGRITY, due to /mudd/ → [mdud], and OO-INTEGRITY, due to allomorphy. How can a hypothetical stem ς′ improve on these violations? The violation of IO-INTEGRITY could be avoided by a stem like /mdud/, with two separate, identical consonants. But then, as shown above, the realization set would consist of just [mdud]—no alternation. Similarly, avoiding the OO-INTEGRITY violation also implies no alternation, by definition of OO-INTEGRITY. We see then that, contrary to our assumption, the hypothetical ς′ cannot underlie the set [mudd, mdud]. It follows that there exists no ς′ ≠ /mudd/ with ς′ → [mudd, mdud] more harmonic than /mudd/ → [mudd, mdud].

Finally, yet another alternative analysis must be considered. Suppose that for each verb showing the [mudd, mdud] alternation, we list two stem allomorphs {/mudd/, /mdud/}. The choice of each stem allomorph would be conditioned phonologically, the geminate allomorph appearing before vowels and the strong allomorph elsewhere.[23] If unpredictability or arbitrariness is the defining property of listed allomorphs, then listing two allomorphs for every doubled verb cannot be right. The substance of the alternation is precisely the same across different lexemes: in all cases, [madd] ~ [madad], [samm] ~ [samam], [mall] ~ [malil], and so on, there is a relation between a form with a geminate and a form with two identical consonants. Moreover, this relation pervades the morphological system. As shown, it is found in other Forms of the verb and in the nominal morphology of plurals and diminutives. This recurrence of the same pattern under exactly the same conditions is the hallmark of a systematic relation between the two forms. It also falsifies the listing hypothesis, which admits no systematicity. Moreover, the systematic relation between the allomorphs can be captured only if the learner posits /mudd/ as the stem. The other form /mdud/ cannot underlie the surface facts.

4. DERIVING GREENBERG'S ASYMMETRY. I have formulated a hypothesis about the phonology of the verb in Arabic (§2) and presented evidence for its correctness (§3). In this section, I further test the hypothesis by pursuing its predictions about impossible stems in the Arabic lexicon.

The basic fact of interest is that in Arabic there are no Form I verbs with INITIAL gemination, *[mmVd], or with an INITIAL sequence of two identical consonants, *[mamVd]. But FINAL geminates and FINAL sequences of identical consonants are running patterns in doubled verbs and their alternation [mVdd] ~ [madVd]. Though these facts were well known to Arab grammarians—see Cantineau 1946 for relevant discussion—Greenberg's 1950 study is commonly taken as the modern landmark by all subsequent investigators. For continuity, I thus refer to these facts as Greenberg's asymmetry and argue that Greenberg's asymmetry is lawfully derived from the inflectional context of the paradigm and the phonology independently constructed in §2 and §3.

4.1. IMPOSSIBILITY OF INITIAL GEMINATION. Crucial to the absence of /mmVd/ stems is the fact that the perfect paradigm lacks prefixes. More accurately, the perfect paradigm does not have any vowel-final prefixes (see 1). Due to this, the initial geminate of a hypothetical stem /mmVd/ would be exposed to a syllable-initial position. In Arabic, as in other languages with long consonants like Classical Greek, Latin, or Japanese, length is neutralized at the edges of syllables (Ladefoged & Maddieson 1996:

[23] See Carstairs-McCarthy 1988, 1990 for such phonologically conditioned suppletion. For a recent analysis of some stem alternations in these terms, see Rubach & Booij 2001 on Polish, and for a recent proposal on the phonological conditioning of listed allomorphs, see Kager 2003.

92, Muller 2001). I assume that this is due to a markedness constraint which disallows geminates syllable-initially as defined in 27.[24]

(27) *$^{\sigma}$[C_xC_x: Syllable onsets do not consist of geminates

Thus, were /mmVd/ to surface as [mmad-] in the perfect, it would result in a violation of this constraint (V stands for any of /i, a, u/). Some alternation to a form without the geminate is required. Of interest, though, is that *$^{\sigma}$[C_xC_x and its effect of eliminating syllable-initial gemination in the perfect do not suffice to exclude stems with initial geminates. In a morphology with rich inflection, like that of Arabic, some other contexts may provide good hosts for stem-initial geminates. Indeed, the imperfect paradigm supplies a set of consistently vowel-final prefixes that would protect the geminate from exposure to initial position, [ya-mmVd-u] (see 13). However, identity constraints on stem realization across the perfect-imperfect contexts impose limits on how different these realizations can be. In fact, assuming the default ranking MARKEDNESS, PI-FAITH ≫ IO-FAITH (Smolensky 1996, Tesar & Smolensky 1998, McCarthy 1998, Hayes 1999; see §5), the top-ranked PI-FAITH demands that the effects of the pressure against the initial geminate in the perfect must be imparted also to the forms in the imperfect paradigm. In short, geminate-initial stems cannot surface as such because local pressures within the perfect ban initial geminates and PI-FAITH extends this ban to the rest of the verbal forms. See McCarthy 1998 on this general reasoning and its implications for morpheme structure conditions.

I now turn to a precise demonstration of this logic. Tableau 28 considers various realizations of a hypothetical stem /mmVd/ in the perfect-imperfect contexts. The constraint hierarchy is *$^{\sigma}$[C_xC_x, PI-F ≫ IO-F, where PI-F stands for faithfulness across the perfect-imperfect. The IO-F block can be ignored for now since its lower-ranked constraints are not yet relevant. The first candidate, 28a, illustrates the case of faithful stem realization. The stem surfaces with an initial geminate throughout, [mmad-a] in the perfect and [ya-mmVd-u] in the imperfect. In the prefixless perfect, however, the geminate incurs a fatal violation of *$^{\sigma}$[C_xC_x.

(28) Fate of geminate-initial stems (partial tableau—see 29 for the optimal candidate)

/mmVd/	*$^{\sigma}$[C_xC_x	PI-FAITH	IO-FAITH
a. mmad-a ya-mmVd-u	*		
b. mad-a ya-mmVd-u		*PI-IDENT^{Q}	...
c. mamad-a ya-mmVd-u		*PI-INT	...

The other candidates avoid the initial geminate in different ways but violate PI-FAITH. Thus, in 28b /mmVd/ is realized as [mad-] in the perfect, with loss of gemination. Recall that /mmVd/ could in principle surface as [ya-mmVd-u] in the imperfect. But the resulting set would be [mVd-u, ya-mmVd-na], a nonuniform set with respect to

[24] This is the mirror image of the constraint banning geminates in coda position in 7, which is crucially involved in the doubled verb alternation. The constraints 7 and 27 could be subsumed under a general constraint that bans geminates from syllable margins.

gemination. This is a violation of PI-IDENT^{Q}, which requires identical quantity of correspondent consonants across perfect-imperfect. PI-IDENT^{Q} in effect suppresses the length contrast also in the contexts where *$^{\sigma}$[C_xC_x is not in effect, that is, the imperfect.

A slightly different situation is met in 28c, where the phonotactic problem in the perfect is resolved by an IO-INT violation; the /mm/ in /mmVd/ establishes two correspondents in [mamad-]. In the imperfect, the stem surfaces with a geminate, but the set [mamad-a, ya-mmVd-u] violates PI-INTEGRITY since /mm/ in [ya-mmVd-u] is in correspondence with two consonants in [mamad-].

It can be easily verified that other realizations like [mamad-a, ya-mVd-u] or [wamad-a, ya-mmVd-u] also violate at least one PI-F constraint.[25] The important point in 28 is that any attempt to maintain stem-initial gemination or its various surface manifestations leads to violations of *$^{\sigma}$[C_xC_x or PI-FAITH. We must then turn to forms escaping such violations. Because these forms satisfy the top-ranked *$^{\sigma}$[C_xC_x, PI-FAITH, the tableau in 29 focuses on the lower part of the constraint hierarchy, which was suppressed in 28: IO-IDENT^{Q} ≫ TEMPLATE ≫ IO-DEP^{C}, established in §§2–3 (I omit IO-INTEGRITY, which is irrelevant here). In 29a, the stem surfaces with loss of gemination throughout. This violates IO-IDENT^{Q} but also TEMPLATE because [mad-a] falls short of the perfect's template /CVCVC/. This latter violation crucially renders 27a less harmonic than 29b, because TEMPLATE is ranked higher than the constraint against epenthesis IO-DEP^{C}. Thus, 29b, with loss of gemination and epenthesis in the templatic perfect, is the predicted output.

(29) Fate of geminate-initial stems (continued from 28)

/mmVd/	IO-IDENT^{Q}	TEMPL	IO-DEP^{C}
a. mad-a ya-mVd-u	**	*!	
b. ☞ wamad-a ya-mVd-u	**		*

The outcome in 29 establishes a connection between phonology and Greenberg's asymmetry. The phonology is such that a stem with initial gemination /mmVd/ surfaces as [wamad-a, ya-mVd-u]. It is the rankings inferred independently as part of the verbal phonology of Arabic that allow us to establish this connection. This result underscores the potential of the proposed model in establishing links between previously unrelated empirical domains, here, the allomorphy of doubled verbs and Greenberg's asymmetry.

The gist of the foregoing can be expressed in a different way that is more suited to the ultimate goal here of deriving the impossibility of stems like /mmVd/. The potential underlying contrast between /mVd/ and /mmVd/ is neutralized to [mVd] on the surface. The grammar is such that both /mVd/ and /mmVd/ map to the same surface forms [wamad-a, ya-mVd-u]. Which stem is the learner to choose as the one underlying the surface facts? A general answer to this question is obtained by the following logic,

[25] Note the candidate pair [mamad-a] (perfect) and [ya-mamVd-u] (imperfect), which avoids PI-F violations by leveling the two identical consonants throughout the perfect-imperfect contexts. However, the resulting trisyllabic imperfect [ya-CVCVC-] is unattested in Arabic—there is no imperfect *[ya-katab-] verb. Trisyllabic imperfects are excluded by a binarity constraint as in McCarthy and Prince's (1990b) 'Maximal Stem Constraint' or more recent prosodic binarity approaches (see McCarthy & Prince 1995a and Ussishkin 2000: 51ff. for a review and some proposals). Formally, that markedness constraint is top ranked, just like the markedness constraint against syllable-initial geminates.

originally due to Stampe (1972). Given that there are no surface [mmVd] forms in the data, the learner will not set up a stem /mmVd/. Even though both /mVd/ and /mmVd/ derive the surface forms, the learner will choose /mVd/ because this stem is 'closer' to the observed surface forms.

In OT, the logic of 'Stampean occultation' is expressed formally by LEXICON OPTIMIZATION (Prince & Smolensky 1993, Inkelas 1995, Tesar & Smolensky 1996, 1998, Itô et al. 1996, Yip 1997, McCarthy 1998). Lexicon optimization evaluates the relative harmony of the two mappings, /mVd/ → [wamad-a, ya-mVd-u], /mmVd/ → [wamad-a, ya-mVd-u] as shown in 30. Evaluation proceeds in the standard way: that is, the learner selects the stem that supplies the fewest violations of the most important constraints. In 30a, /mmVd/ → [wamad-a, ya-mVd-u] violates IO-DEP^{C}, IO-IDENT^{Q}, and TEMPLATE. But the rival stem /mVd/ in 30b maps on the same surface set more transparently, by incurring a subset of /mmVd/'s violations. Hence, /mVd/ provides the optimal mapping. (TEMPLATE appears in the IO-FAITH block due to the fact that it is ranked between two IO-FAITH constraints, as shown in §3.)

(30) Demonstration of /mVd/ ≻ /mmVd/ (α ≻ β stands for 'α is more harmonic than β')

Rival stems	Surface set	*$^{\sigma}$[C_xC_x	PI-FAITH	IO-FAITH
a. /mmVd/	wamad-a ya-mVd-u			*IO-DEP^{C} **IO-IDENT^{Q} *TEMP
b. ☞ /mVd/	wamad-a ya-mVd-u			*IO-DEP^{C}

There is no explicit, previous account for the part of Greenberg's asymmetry concerning geminates. This is due to the rather widespread assumption that root consonants are devoid of any prosodic properties such as length. It is apparently assumed that such surface properties are to be derived as a byproduct of mapping to template and associated processes (e.g. the morpholexical rule /madad-a/ → [madd-a]). In this view, then, |mmd| roots or /mmVd/ stems are precluded because gemination is ostracized from the lexicon. The proposed stem-in-paradigm perspective, however, derives the lack of /mmVd/ stems without stipulating a ban on their relevant property of gemination from the lexicon: the lack of V-final prefixes in the perfect, the independently necessary phonotactics, and intraparadigmatic identity 'conspire' in the spirit of Kisseberth 1970 for the absence of /mmVd/ stems.

4.2. IMPOSSIBILITY OF INITIAL REPETITION. Intuitively, the lack of stems with initial, identical consonants follows from the same logic as with /mmVd/ stems. Phonotactic pressures preclude such stems in specific contexts of their paradigm, and paradigmatic identity transmits the concomitant alternation (due to these pressures) to the rest of the verbal forms. The only notable difference from /mmVd/ stems is in the local context where the phonotactic pressures are met and in the specific phonotactics. For /mmVd/ stems, as we have seen, the phonotactic is that against syllable-initial geminates, and its pressure is present in the prefixless perfect. For stems with initial identity, the phonotactics are *COMPLEX and the OCP, and their pressures are met in the imperfect. The demonstration follows.

Consider a stem /m^1m^2Vd/, a triliteral with two identical consonants at the left edge of the stem. In the perfect, this would surface as [m^1am^2Vd-], a phonotactically unproblematic form. In the imperfect, however, /m^1m^2Vd/ is bound to phonotactic problems. If the stem is realized faithfully as [m^1m^2Vd], the /m/'s are adjacent. This is a violation of the OCP, as shown in the first candidate of tableau 32. To avoid this violation, the two identical consonants may shift apart by relocating the vowel as in [ya-m^1Vm^2d-a] of 32b. But such shifting is bound to meet other phonotactic strictures. Arabic does not permit CCC medial clusters. The CCC in *[ya-m^1Vm^2d-na] may be parsed as [. . . (mVm)$^{\sigma}$(dna)$^{\sigma}$] with a CC onset or as [. . . (mVmd)$^{\sigma}$(na)$^{\sigma}$] with a CC coda, but both are disallowed. I use *Complex for the constraint that disallows such clusters, defined in 31 (Prince & Smolensky 1993).

(31) *Complex: Syllable margins are not complex ('complex': more than one segment)

(32) Fate of /m^1m^2Vd/ in the imperfect: OCP, *Complex violations (cont. in 33)

/m^1m^2Vd/	OCP	*Complex
a. ya-m^1m^2Vd-a ya-m^1m^2Vd-na	**	
b. ya-m^1Vm^2d-a ya-m^1Vm^2d-na		*
c. ya-m^1Vm^2d-a ya-m^1m^2Vd-na	*	

An alternative is to change shape according to context, [m^1Vm^2d] before a vowel and [m^1m^2Vd] before a consonant, as in 32c. In any case, violations of the OCP or *Complex are unavoidable. Moreover, it is easy to see that the same problems arise with a variant of /m^1m^2Vd/, the stem /m^1Vm^2d/. That is, again, put in the context of the imperfect paradigm, that stem leads to violations of the OCP or *Complex.[26]

Thus, regardless of the linear order between the consonants and the vowel, /m^1m^2Vd/ or /m^1Vm^2d/ violate the OCP or *Complex. Given these strictures of the imperfect, consider now the fate of stem /m^1m^2Vd/ in the perfect. In 33a, /m^1m^2Vd/ surfaces as [m^1am^2Vd-a] in the perfect, without violating the OCP, but as just discussed the two identical consonants would violate the OCP in the imperfect. Shifting one of the identical consonants to avoid the OCP violation, as in 33b, would result in a violation of *Complex. Deleting an offending consonant in the imperfect would avoid the markedness violations, but as 33c shows, this would violate PI-Max, which requires that perfect-imperfect stem realizations consist of the same set of segments.

Candidate 33d is the best option. It avoids violating the markedness constraints and PI-Max at the expense of the low-ranked IO-Faith (recall that /w/-epenthesis in the perfect is due to Template $\gg$ IO-Dep^{C}).

[26] Any faithfulness violations incurred by the alternations shown in the tableau just discussed can be safely ignored. As noted, the point here is that there are unavoidable markedness violations.

(33) Fate of stems with initial identity: leveling of the absence of initial identity via PI-FAITH

/m^1m^2Vd/	OCP, *COMPLEX	PI-MAX	IO-MAX, IO-DEP^C
a. m^1am^2Vd-a ya-m^1m^2Vd-na	*!		
b. m^1am^2Vd-a ya-m^1Vm^2d-na	*!		
c. m^1am^2Vd-a ya-m^2Vd-na		*!	*IO-MAX
d. ☞ wam^2ad-a ya-m^2Vd-na			**IO-MAX, *IO-DEP^C

We thus see that stem /m^1m^2Vd/ is realized as [wamad-a, ya-mVd-a], the same set as that supplied by /mVd/. Consequently, via by-now-familiar logic, learners would not posit /m^1m^2Vd/ stems. Put in the context of the paradigm, such stems are subject to substantial alternation that effectively renders them unrecoverable. Formally, as tableau 34 shows, /mVd/ supplies the same realization set as /m^1m^2Vd/ in the most transparent way.

(34) Demonstration of /mVd/ ≻ /m^1m^2Vd/

Rival stems	Surface set	OCP	PI-FAITH	IO-FAITH
a. /m^1m^2Vd/	wam^2ad-a ya-m^2Vd-u			*!*IO-MAX *IO-DEP^C
b. ☞ /mVd/	wamad-a ya-mVd-u			*IO-DEP^C

The proposed account is in line with McCarthy's (1979) analysis in relating the absence of initial identity to the OCP. The crucial difference between the present account and McCarthy's concerns the level of application of this principle. In the latter, the OCP stated a restriction on what can be a possible input, effectively a morpheme structure condition: root |m^1m^2d| is banned by the OCP applying at the level of the input. In the present account, the OCP applies at the surface level like any other markedness constraint, e.g. the syllable structure constraint *COMPLEX. This makes it possible to integrate the OCP with other surface phonotactics and the identity constraints across perfect-imperfect surface forms. The *|m^1m^2d| gap is derived from these surface factors.

4.3. RECAPITULATION. I have pursued the predictions of two hypotheses: the first consists of the grammar underlying the phonology of doubled verbs and the second is the language-independent hypothesis about the default ranking MARKEDNESS, PI-FAITH ≫ IO-FAITH (Smolensky 1996, Tesar & Smolensky 1998, McCarthy 1998, Hayes 1999; see §5). The coupling of these two hypotheses makes precise predictions about the inventory of (im)possible stems in Arabic. It predicts that stems with initial gemination and repetition are impossible. These predictions are borne out. This result, in turn, provides further converging evidence for the correctness of the two hypotheses.[27]

[27] We are now in a position to compare the view of doubled verb allomorphy developed in §§2–3 with that in Rose 2000. For Arabic, Rose views syncope in /madad-a/ → [madd-a] as driven by a long-distance

Greenberg's asymmetry discussed above concerns IMPOSSIBLE stems. Another well-known fact about the Semitic lexicon concerns a class of POSSIBLE but underrepresented stems. Specifically, stems with nonidentical, homorganic consonants, such as /dtVf/, /kbVm/, /stVm/, are statistically underrepresented in the Semitic lexicon (Cantineau 1946, Greenberg 1950). This generalization stands in sharp contrast to the fact that [madad] forms, with two identical consonants, are well attested. Given that identical consonants are also homorganic, if homorganic consonants are avoided then identical consonants should be avoided too. As Greenberg characteristically writes, 'The geminate type is thus clearly an anomaly in terms of the overall patterning of Semitic verbal roots' (1950:162). In Greenberg's usage the term GEMINATE TYPE refers to the *madad* allomorph of doubled verbs.

The results presented here allow us to rationalize this apparent 'anomaly' by uncovering the factors underlying the doubled verb alternation. For work on the homorganic avoidance facts, see McCarthy 1986, 1988, 1994, Pierrehumbert 1993, Frisch et al. 1997, and references therein. For discussion of the relation between that work and the identity avoidance model proposed here, see Gafos 2001.

5. DERIVING KURYŁOWICZ'S FUNDAMENTAL FORM AND THE CONTRAST WITH NOUNS. The central intuition in this article is that paradigms in Arabic provide a powerful source of conditions on what constitutes a viable stem. I now extend this intuition and the approach taken here to an important trait of Arabic morphology: the invariant CCVC form of the 'strong' or triliteral verbs, Kuryłowicz's FUNDAMENTAL FORM. The goal is to show how the inflectional context of the paradigm coupled with simple phonotactics molds this shape of the triliteral stem.

The basic fact of interest is that all verbal moods for strong verbs are based on the imperfect form CCVC. The indicative is illustrated in 35 with the lexeme 'to write'. The other moods (subjunctive, jussive, energicus, and imperative) are in all relevant respects similar to the indicative.

(35)

INDICATIVE	SINGULAR	PLURAL	DUAL
3 M	ya-ktub-u	ya-ktub-uuna	ya-ktub-aani
F	ta-ktub-u	ya-ktub-na	ta-ktub-aani
2 M	ta-ktub-u	ta-ktub-uuna	ta-ktub-aani
F	ta-ktub-iina	ta-ktub-na	ta-ktub-aani
1	ʔa-ktub-u	na-ktub-u	

The stem vowel must be lexically specified: [yaktubu] 'he writes', [yalbasu] 'he dresses', [yaḍribu] 'he hits'. There are also a few minimal pairs distinguished by this vowel: [yasmaru] 'be brown', [yasmuru] 'spend the night conversing', and [yaħzunu] 'sadden', [yaħzanu] 'be sad'. Given these facts, Kuryłowicz writes: 'The fundamental form of the Sem. conjugation, the so-called ''imperfect(ive)'' yaqtul(u) shows a charac-

reformulation of the OCP, revised so as to disallow two identical consonants across a vowel as in *[madad-a] (contra McCarthy's 1986 interpretation of OCP's role in syncope). In this article, I maintain the standard OCP, banning only adjacent consonants. The crucial difference, however, between the present proposal and that in Rose 2000 is that the latter analysis shares with all past accounts the assumption that /madad-/ is the canonical form. This assumption forces one to treat Greenberg's asymmetry, derived in §4, and the connections between verbal and nominal morphology revealed in §3, as orthogonal to the facts of the verbal alternation. In fact, given that assumption, it is not possible to state these connections. But, as I argued, these facts are intimately related to the doubled verb alternation. To be precise, the same grammatical principles responsible for the alternation also derive Greenberg's asymmetry and the quantitative transfer effect in §3. As far as I know, no past analysis has established these connections.

teristic vowel after R2 [*AG*: the second root consonant]' (1972:34); or in Schramm's words, 'Verbs, then, are derived from roots having the shape |ABVC|, where the cover symbols A, B and C represent consonants and V represents the vowel inherent to the root' (1991:1403; see also Schramm 1962).

Put in modern terms, Kuryłowicz's and Schramm's views share the claim that the verbal morphology is stem based. This is a plausible claim—ultimately I argue that it is correct—but it raises an important question that has not been addressed so far by the proponents of stem-based morphology. Observe that there is no contrast between [ya-CCVC-u] and *[ya-CVCC-u]. Both [ya-CCVC-u], [ya-CVCC-u] are phonologically well-formed, but only the former is attested. Whence the [CCVC] invariance of Kuryłowicz's fundamental form?[28]

This question turns out to have a simple answer when one takes into account some independent properties of the language. First, Arabic does not allow complex syllable onsets or codas. Second, while all prefixes in 35 end in vowels, some suffixes begin with a consonant or are null in the other moods. Thus, a /CVCC/ stem would raise a phonotactic problem before a consonant-initial or null suffix, since *[CV-CVCC-CV] is banned. By contrast, a /CCVC/ stem presents no phonotactic problem because all prefixes end in vowels; [CV-CCVC-CV] is permissible because the first stem consonant can be parsed as a coda. Hence, at least intuitively, we begin to see how the inflectional context coupled with phonotactics require that the CC cluster be at the left edge of the stem.

A precise demonstration follows. Building on McCarthy's 1998 work on paradigm optimization, I begin by entertaining a hypothetical /CVCC/ stem. The goal is to identify the factors that prevent this stem from surfacing as [CVCC] in ANY context; recall that [CVCC] forms do not occur even before a vocalic suffix, *[ya-CVCC-u]. Once these factors are identified, the absence of /CVCC/ stems follows as a corollary. Since surface [CVCC] forms are absent, there is no evidence for positing /CVCC/ stems in the lexicon. Overall, then, the absence of /CVCC/ stems is not arbitrary, but rather it derives from the factors contributing to the lack of evidence for such stems in the surface data. What, precisely, are these factors, and how do they combine?

Three crucial factors combine to account for the absence of [CVCC] forms: the inflectional context supplied by the paradigm, basic phonotactics, and identity requirements between related forms within the paradigm. I consider each of these factors in turn. As shown in 35, the prefixes are always vowel final, but the suffixes sometimes begin with a consonant or are null. This asymmetry is related to the avoidance of [-kutb-]. Before a consonant-initial or null suffix, [-kutb-C] or [-kutb-#] presents a phonotactic problem, because the constraint *COMPLEX bans complex syllable margins (introduced in §4). Given this constraint, /ya, kutb, na/ cannot surface as *[ya-kutb-na]. The phonotactic problem created at the stem-suffix boundary could be resolved in a number of ways, one of which is metathesis as in /ya-kutb-na/ → [ya-ktub-na] (other repairs are addressed below). Metathesis breaches the identity between the stem /kutb/ and its realization [ktub]. The relevant constraint is LINEARITY, 36.

(36) LINEARITY: S_1 is consistent with the precedence structure of S_2, and vice versa.

[28] This is a good place to take note of a previous result. McCarthy and Prince (1990a:251–60, 1990b: 17–23) have argued that Arabic stems are subject to a minimality requirement of two moras. Both /CCVC/ and /CVCC/ would satisfy that. In [ya-CCVC-u], the first stem consonant (a coda) and the V are moraic. In [ya-CVCC-u], the V and the prefinal stem consonant are moraic. Thus, this requirement does not exclude either of the two stems.

By standard OT reasoning, hypothetical /kutb/ stems would surface as [ktub] as a result of the grammatical statement *COMPLEX ≫ IO-LINEARITY, illustrated in tableau 37. Intuitively, 37 expresses the fact that phonotactics takes priority over input-output identity, a typical case of constraint interaction in OT.

(37) Fate of hypothetical stem /kutb/:/ya, kutb, na/ → [ya-ktub-na]; *COMPLEX ≫ IO-LINEARITY

/ya, kutb, na/	*COMPLEX	IO-LIN
a. ya-kutb-na	*!	
b. ☞ ya-ktub-na		*

Metathesis, then, can repair the violation of *COMPLEX in the context before a consonant-initial suffix. However, metathesis creates allomorphy in the paradigm, since the stem /kutb/ surfaces variantly as [-ktub-] or [-kutb-], e.g. /ya, kutb, u/ → [ya-kutb-u] and /ya, kutb, na/ → [ya-ktub-na].

Nonuniformity in the paradigm is the final crucial factor involved in explaining the absence of [kutb] forms. Formally, this factor enters the grammar via intraparadigmatic identity constraints. The constraint penalizing the disparity between [ya-kutb-u] and [ya-ktub-na] is LINEARITY, or more precisely the Output-Output version of that constraint, OO-LINEARITY. Its crucial role in banning the nonuniform paradigm [ya-kutb-u, ya-ktub-na] is expressed formally in tableau 38. Candidate 38a, [ya-kutb-u, ya-kutb-na], fatally violates *COMPLEX. Candidate 38b, [ya-kutb-u, ya-ktub-na], is the one with metathesis, violating OO-LINEARITY and IO-LINEARITY. Candidate 38c avoids the OO-LINEARITY violation by leveling to [ktub] throughout. This violates the low-ranked IO-LINEARITY twice.

(38) Uniform realization: /kutb/ → [ya-ktub-u, ya-ktub-na]; *COMPLEX, OO-LIN ≫ IO-LIN

π(/kutb/) = ?	*COMPLEX	OO-LIN	IO-LIN
a. ya-kutb-u, ya-kutb-na	*!		
b. ya-kutb-u, ya-ktub-na		*!	*
c. ☞ ya-ktub-u, ya-ktub-na			**

Comparing 38b and c, we see that the crucial ranking is OO-LINEARITY ≫ IO-LINEARITY, imposing the same order [ktub] throughout the realization set. Overall, then, *COMPLEX, OO-LINEARITY ≫ IO-LINEARITY is the grammatical statement of the fact that allomorphy, as in [ya-kutb-u, ya-ktub-na], is not attested.[29]

Observe now that the grammar, that is, the ranking SYLL, OO-LINEARITY ≫ IO-LINEARITY, is responsible for the absence of [kutb] surface forms in any context. This grammar is such that both /kutb/ and /ktub/ map to the surface forms, [ya-ktub-u, ya-

[29] The discussion has focused on metathesis as a possible repair to the problem with *[ya-kutb-na], but we may now generalize by considering any repair such as epenthesis, deletion, or assimilation. The formal statement of the fact that no such repair is employed takes the same general form as with metathesis, that is, *COMPLEX, OO-F ≫ IO-F, where F is the faithfulness constraint violated in the repair, for example, MAX for deletion, DEP for epenthesis, and so on.

ktub-na]. Which stem is the learner to choose as the one underlying the surface facts? Lexicon optimization evaluates the relative harmony of the two mappings, /kutb/ → [ya-ktub-u, ya-ktub-na], /ktub/ → [ya-ktub-u, ya-ktub-na], as shown in 39. Here, /kutb/ → [ya-ktub-u, ya-ktub-na] violates IO-LINEARITY, but the rival stem /ktub/ maps on the same surface set transparently. Hence, /ktub/ provides the optimal mapping.

(39) Lexicon optimization: /ktub/ ≻ /kutb/

Rival stems	Surface set	*COMPLEX	OO-LIN	IO-LIN
a. /kutb/	ya-ktub-u ya-ktub-na			**
b. ☞ /ktub/	ya-ktub-u ya-ktub-na			

We see, then, that lexicon optimization projects the effects of the grammar from the surface forms back to their stems. In this way, the lack of /CVCC/ stems is derived without a direct ban on such stems from the lexicon, that is, without a morpheme structure constraint against */CVCC/. Independent properties of the language—the segmental makeup of the affixes in the paradigm coupled with intraparadigmatic identity—are responsible for the lack of /CVCC/ stems.

Consider now the fact that the result just obtained rests on a particular ranking of the constraints, namely, *COMPLEX, OO-LINEARITY ≫ IO-LINEARITY. This ranking is inferred here from negative evidence, the absence of paradigm [ya-kutb-u, ya-ktub-na] in the primary data. If acquisition proceeds on the basis of positive evidence only (Baker 1979, Angluin 1980), this ranking is unlearnable and hence it must be posited as such in my analysis. But then why is the proposed model for the lack of /CVCC/ stems an improvement over a model placing an explicit ban on the lexicon?

One point in support of the proposed model is that its crucial ranking is an instance of a general ranking schema that finds independent support from work on learnability and child language in OT. This work converges on the hypothesis that the initial constraint hierarchy of universal grammar, the INITIAL STATE, is not a disordered set of constraints but rather it is already structured in the way shown in 40. It is clear that *COMPLEX, OO-LINEARITY ≫ IO-LINEARITY is an instance of the general schema MARKEDNESS, OO-FAITH ≫ IO-FAITH. See the sources in 40 for arguments and applications.

(40) Language-independent hypothesis about the initial state
   a. MARKEDNESS ≫ IO-FAITH (Smolensky 1996, Tesar & Smolensky 1998)
   b. OO-FAITH ≫ IO-FAITH (McCarthy 1998, Hayes 1999)

More important support of the proposed model derives from its predictive power. Observe that morpheme structure constraints do not make any predictions beyond their highly specific assertions, e.g. no /CVCC/ verbal stem in the Arabic lexicon. The model promoted here, instead, employs general principles in a theory of grammar, and consequently makes predictions beyond specific data. Pursuing these predictions has been a recurring theme throughout this article. The last such prediction provides the closing argument of this section.

The stem-in-paradigm approach predicts that in a different paradigm with vowel-initial suffixes /CVCC/ stems would be possible. The example needed to test this prediction is provided by the morphology of the noun. As shown in 41, the inflectional

context for nouns consists of vowel-initial suffixes ([*stem*-un] in the indefinite, [ʔal-*stem*-u] in the definite). It is thus expected that the /CVCC/ stem banned in the verb should now be possible in the noun. This is indeed the case as shown by a few representative forms from the well-populated class of triliteral nouns, [nafs-un] 'soul', [baħr-un] 'sea', [qufl-un] 'lock', [burd-un] 'robe', and so on.

(41)

NOUN	M.S	M.PL	F.S	F.PL
NOMINATIVE	-un	-uuna	-atun	-aatun
GENITIVE	-in	-iina	-atin	-aatin
ACCUSATIVE	-an	-iina	-atan	-aatin

Beyond confirming a basic prediction of the proposed model, however, a precise demonstration of the nominal stem (im)possibilities cannot be pursued here. Detailed discussion can be found in McCarthy 2002, where the author independently develops a similar proposal in deriving Arabic noun-verb asymmetries.

To review briefly, I have shown how a paradigm coupled with phonotactics sets limits on the theoretically possible diversity of stem forms within that paradigm. Effectively, the paradigm molds stems to fit the inflectional context of their realizations.

6. IMPLICATIONS. The central concern of this article has been the construction of the argument that the phonological forms of stems are constrained by the contexts in which these stems must be realized. This argument has proven useful in understanding core aspects of the Arabic verb. Considerable simplifications in the grammar follow from this argument. I illustrate this in §6.1 by highlighting some specific consequences of the main proposal. Broader consequences about the phonology and morphology of Arabic are taken up in §§6.2–6.4.

6.1. THE CRUCIAL ROLE OF PARADIGMS. By considering the inflectional context where stems must be realized, the present analysis obtains a number of specific results.

Consider, first, Greenberg's asymmetry, which has attracted considerable attention, and which has been dealt with up to now by imposing restrictions on grammatical inputs. As argued in §4, by capitalizing on the role of paradigms, such restrictions are not necessary. Let us review briefly why stems with initial gemination or repetition are not possible stems in Arabic. The key observation is that phonotactic pressures from the paradigm's context result in substantial alternations for such stems. These alternations hide these stems behind other stems whose mapping to that realization is more transparent. Consequently, a learner would never posit these unrecoverable stems. Pursuing the logic of this language-independent argument obviates the three language-particular assumptions previously thought necessary in accounting for Greenberg's asymmetry: 'roots with initial geminates are not allowed', 'roots with two identical consonants are not allowed', and, as discussed next, 'the direction of mapping root consonants to template positions is left-to-right'.

Consider next the claim that the stem alternations discussed here are phonologically determined (term defined in §2.1). A consequence of this claim is that there is no need to set up grammatical machinery dedicated to individual Forms. I illustrate this by underscoring a difference between the present proposal and past ones, which posit left-to-right spreading in deriving the duplication pattern of [madad] in verbs of Forms I and IX (McCarthy 1981, 1993, Yip 1988, Hoberman 1988). The left-to-right setting of the directionality parameter was meant to capture the pattern of final, not initial, repetition in Forms I and IX, e.g. [madad-] not *[mamad-]. In the proposed alternative, there is no parameter dedicated to this aspect of verbal morphology. Final repetition

derives from the fact that the stems involved are geminate-final and the fact that some suffixes are consonant-initial. In short, the present analysis derives the effect of the directionality parameter.

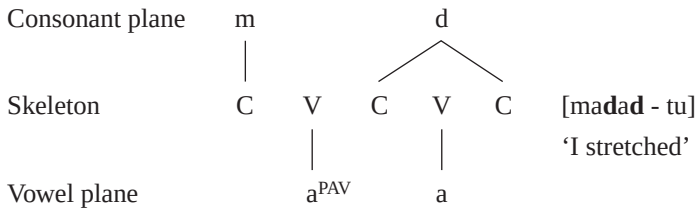
Compare the present analysis to that in Gafos 1998. For doubled verbs, the main claim therein is that doubling in [madad] is by segmental copying, not autosegmental spreading. What is relevant from that proposal for current purposes is that, to account for the pattern of final duplication, the reduplicant inducing copying is stipulated to be a suffix. No stipulation is necessary once we take into account the interaction between stems and their inflectional contexts.

The final point is relevant to a tradition of descriptive grammars that has had a significant impact in generative phonology. Traditionally, Semitic grammars enumerate verbal forms in terms of 'canonical' patterns so that, for instance, [madad], [ħmarar] are described as manifesting the orthodox realization of their Forms I and IX, with provisos for the nonorthodox realizations [madd], [ħmarr] (for a notable exception to this practice and cogent discussion, see Cowell 1962). But as emphasized throughout this article, shifting the focus from canonical patterns to actual stems and their contexts of occurrence within paradigms makes it possible to recognize genuine phonology across the different Forms of the Arabic verb. Specifically, the allegedly canonical realizations of doubled verbs in Forms I and IX 'with final duplication' are the phonologically determined surface variants of their geminate-final stems. No arbitrary terms or provisos are necessary.

6.2. PHONOLOGICAL PRIMITIVES. One goal of linguistic theory is to minimize apparent theoretical distinctions across descriptively distinct sets of data. In this respect, another implication of this article concerns the phonological prerequisites for nonconcatenative morphology.

Nonconcatenative morphology was originally formalized using special phonological representations, where consonants and vowels occupy distinct planes and full consonant spreading can apply across a vowel (42; see also McCarthy 1981, 1986, 1989, Yip 1988). The allomorphy of doubled verbs and Greenberg's asymmetry played prominent roles in supporting such representations (see Kenstowicz 1994).

(42) V/C planar segregation and spreading



As McCarthy and Prince write, subsequent work within the program of prosodic morphology attempts to 'reduce or eliminate the apparatus that is peculiar to reduplication and other forms of non-concatenative morphology' (1995b:25). With respect to phonological primitives in particular, Gafos 1996, 1998 argues that core distinctions between concatenative and nonconcatenative morphology, like V/C planar segregation and consonant spreading across vowels, are unnecessary. The main claim, as far as phonology is concerned, is that concatenative and nonconcatenative mor-

phology rely on the SAME PHONOLOGICAL REPRESENTATIONS. The patterns of consonant-vowel interleaving, characteristic of nonconcatenative morphology, derive from independently necessary means such as segmental copy, as opposed to spreading, and by the requirements of prosody, best expressed by the notion of template in prosodic morphology (McCarthy & Prince 1995a). Other authors have reached partly similar conclusions. See McCarthy 1995 and 2000 for a recent critique of V/C planar segregation, and Angoujard 1988, Bat-El 1989, 1994, Rose 1997, 2000, Kenstowicz & Banksira 1999, Ussishkin 1999, 2000, and Berent et al. 2001 for reanalyses of spreading as copying.

As shown here, no special phonology is involved in doubled verb allomorphy or Greenberg's asymmetry in Arabic. Consequently, this result provides converging evidence for the main claim cited above, namely, that the phonological prerequisites for nonconcatenative morphology are not distinct from those of concatenative morphology.

6.3. THE BASIC UNITS OF MORPHOLOGY. In the argument running throughout this article, core aspects of the verbal morphology of Arabic require stems specified for properties like vocalism and consonantal length, for example, /ṣubb/ 'to pour (liquid)', /ṣabb/ 'to love passionately', /ṣal/ 'to arrive'. I outline the morphological consequences of this argument after placing it in its broader context.

Some important studies on Arabic noun morphology have established that a stem, a unit that includes consonants and vowels rather than just the bare consonantal root, is the base on which morphology operates (e.g. noun broken plurals; see Hammond 1988, McCarthy & Prince 1990a). These studies have shown that surface properties of the noun stem such as vocalic and consonantal length condition in crucial ways the form of the corresponding plural stem.

For verbs, traditionally, derivation is assumed to operate on the consonantal root (Cantineau 1950, Fleisch 1956, McCarthy 1979, Yip 1988, Hoberman 1988, Moore 1990, Goldenberg 1994). More recently, however, various authors have suggested that a stem-based view of verbal morphology is worth exploring. See McCarthy and Prince's discussion of stem minimality (1990a:255) and especially McCarthy 1993, McOmber 1995, Ratcliffe 1998, and Benmamoun 1999. See also Bat-El's proposals (1989, 1994: 591–94) and Ussishkin 1999 on roots in Hebrew and alternatives.

A pressing problem for extending the stem-based view to verbs was the set of facts related to doubled verbs and Greenberg's asymmetry, whose explanation has continued to rely on root-based derivation. But a careful analysis of doubled verbs resolves the inconsistency in the current state of knowledge about root- vs. stem-based morphology. As argued, there is no need to get from a root |md| to /madad/ in a first step, treating that as an intermediate form, and then reducing it to /madd/ when necessary. Rather, the basic stem is /madd/, with [madad] surfacing before consonant-initial or null suffixes as a result of a phonologically determined alternation. In other words, an account of doubled verb allomorphy requires reference to underlying stems specified for vocalism and consonantal length. As soon as doubled verbs are properly understood, they cease to provide evidence for root-based derivation. In fact, they provide an argument for stem-based morphology.

Converging evidence for the validity of this conclusion derives from the links established between doubled verbs and other previously unrelated domains. The first such domain concerns noun morphology. Noun stems with single consonants extend via epenthesis whereas noun stems with geminates extend via consonant doubling (Ham-

mond 1988, McCarthy & Prince 1990a, Ratcliffe 1998). In 43, compare /dam/ with /li**s̬s̬**/, where inflectional markers are suppressed throughout. In McCarthy & Prince 1990a, this effect constitutes one of the arguments that nominal morphology is stem-based.

(43) Quantitative transfer in nouns and verbs
NOUNS /dam/ 'blood' → [dimaaʔ-] /li**s̬s̬**/ 'thief' → [-l**ṣ**aa**ṣ**-]
VERBS /**ṣ**al/ 'to arrive' → [wa**ṣ**al-] /ma**dd**/ 'to stretch' → [ma**d**a**d**-]

For verbs, this article uncovers the same quantitative transfer effect. The overarching generalization in 43, that the same pattern applies in both verbs and nouns, would be inexpressible if the parts of verbal morphology examined in this paper were root-based. Moreover, the stem-based grammar underlying the verbal facts in 43 is also crucially involved in deriving Greenberg's asymmetry. In short, it is at the stem level that generalizations can be observed and stated in the forms of a testable theory, and that connections to previously unrelated facts can be established. Coherence emerges in data and theory, if one accepts that the part of verbal morphology studied in this article builds on stems, just as has been argued to be the case for nominal morphology (McCarthy & Prince 1990a).

One may ask, can a root-based substrate still underlie the verbal stems of this article? Answering this question would require an explicit, testable statement of the principles used to construct stems from roots. For instance, why is root |md| 'to stretch' related to stem /madd/, but root |**ṣ**l| 'to arrive' to stem /**ṣ**al/, the crucial difference being the length of the final consonant? It is not at all clear what these principles may be and why they would be independently necessary, given the results reported on here. Note that augmenting roots with distinctive length is a step in the right direction, but it would also make the revised root-based analysis indistinguishable from the present proposal. Ultimately, however, the goal is not to argue that roots are irrelevant, as discussed next.

6.4. PROCESSING: EXTERNAL EVIDENCE FOR ROOTS. The view of Semitic morphology that has gained some impetus in recent years and that finds support in this article from a new domain is that the grammar, as a system of lawful relations between words, must have access to more richly specified underlying representations than allowed by consonantal roots. Typically, the arguments given in this line of research aim to establish claims about morphology and phonology. In the terms of Kenstowicz and Kisseberth (1979), these arguments constitute INTERNAL evidence for more articulated representations.

EXTERNAL evidence, however, suggests that consonantal roots are conspicuous units in processing. For example, roots seem to facilitate lexical decision and naming tasks (Frost et al. 1997). Roots also seem to play an important role in how Semitic words are processed in aphasia and speech games (see Barkai 1980, Safi-Stagni 1995, Prunet et al. 2000).

These two apparently opposing sources of evidence derive from different domains, grammar and processing. Phonology and morphology are components of the grammar. Lexical processing is the grammar in use. The relation between grammar and processing is complex or at least indirect (Chomsky 1965). The information structures implicated in processing must be related to the units of morphology, but that does not mean that they must be exactly identical to them. The arguments made in this article do not exclude consonantal roots as processing units. Conversely, as Prunet and colleagues

(2000:642–43) carefully point out, EXTERNAL evidence does not preclude that morphology may operate on units distinct from consonantal roots.[30]

The issue, then, that future work ought to address is how to put together the external evidence for roots with the internal evidence for more articulated representations in the grammar. Though this issue cannot be resolved here, I maintain that the two apparently opposing sources of evidence are not incompatible.

Assuming there is something essentially correct about both views, the key to their compatibility ought to be found in the RELATION between grammar and processing. Consider in this respect the role of vowels in Semitic morphology. A crucial fact is that vowels are employed as the inflectional markers in the voice-aspect system. As a prototypical example, compare the perfect actives below, where stem vowels are in bold, with their passives. In the passives, the stem vowels are replaced by /u, i/, the marker of passive voice in the perfect aspect. The same applies to the imperfect active-passive pairs.

(44) Vowel replacement

	PERF. ACTIVE	PERF. PASSIVE	IMPF. ACTIVE	IMPF. PASSIVE
'to drink'	šar**i**b-a	šurib-a	ya-šr**a**b-u	yu-šrab-u
'to write'	kat**a**b-a	kutib-a	ya-kt**u**b-u	yu-ktab-u

Given the obligatoriness of inflection, stem vowels must be suppressed. For another example, recall the perfect of doubled verbs. In non-prevocalic contexts we find [mad**a**d-] 'stretch', [mal**i**l-] 'be weary', [ħab**u**b-] 'become dear', but prevocalically the vowel contrasts are suppressed, [madd-], [mall-], [ħabb-], because the /a/ marker of the perfect, active voice must be expressed.

Ordinarily, then, stem vowels are masked by the inflectional markers attached to stems. In terms of the grammar, this means that stem vowels have LOW FAITHFULNESS requirements (see §2). This grammatical trait leads to an alternative, nonrepresentational view of the salience of consonants in Semitic morphology. It seems reasonable to propose that the low faithfulness of stem vowels renders these vowels transparent, or at least less salient than stem consonants, in processing. Consequently, stem consonants, or roots, float up or are emergent from the grammatical system as salient units in lexical processing. In short, then, it is not that the grammar is built on roots but rather that roots emerge from the grammar in use, and are thus crucially employed in lexical access.

To review, my intent here is not to argue against but to situate the evidence for roots in the context of grammar and processing. The two views of Semitic morphology, stem-based from the side of the grammar and root-based from the side of processing, may not be as incompatible as they first appear. Broad sources of evidence suggest that it is both reasonable and promising to maintain a distinction between grammar and processing and to seek the key to apparent incompatibilities in the relation between the two domains.

7. CONCLUSION. This article examined some well-known issues in the morphology and phonology of the Arabic verb by considering verbal forms not in isolation, as has been typical of previous work, but from a more systemic, stem-in-paradigm perspective. This enables us to derive lexical patterns and allomorphy as lawful consequences of independent properties of the language rather than as consequences of capricious mor-

[30] For related discussion see Davis & Zawaydeh 2001 on Arabic, Bat-El 1994 and Ussishkin 1999 on Hebrew, and Buckley 2003 on Tigrinya.

pheme structure constraints. I hope that the productivity of the approach promoted here will inspire similar approaches to other areas of Arabic morphology and phonology (e.g. hollow verbs, nouns, relations between verbs and nouns) and to other languages with rich inflectional morphology.

REFERENCES

ABDEL-MASSIH, ERNEST T. 1975. An introduction to Egyptian Arabic. Ann Arbor, MI: University of Michigan.

AL-ANI, SALMAN H. (ed.) 1978. Readings in Arabic linguistics. Bloomington, IN: Indiana University Linguistics Club.

ANGLUIN, DANA. 1980. Inductive reference of formal languages from positive data. Information and Control 45.117–35.

ANGOUJARD, JEAN-PIERRE. 1988. Gémination et redoublement. Langues Orientales Anciennes Philologie et Linguistique 1.1–15.

ANGOUJARD, JEAN-PIERRE. 1990. Metrical structure of Arabic. Dordrecht: Foris.

ANTTILA, RAIMO. 1977. Analogy. The Hague: Mouton.

ARONOFF, MARK. 1994. Morphology by itself: Stems and inflectional classes. (Linguistic Inquiry monograph 22.) Cambridge, MA: MIT Press.

BAKER, C. L. 1979. Syntactic theory and the projection problem. Linguistic Inquiry 10.4.533–81.

BARKAI, MALACHI. 1980. Aphasic evidence for lexical and phonological representations. Afroasiatic Linguistics 7/6.163–87.

BAT-EL, OUTI. 1989. Phonology and word structure in modern Hebrew. Los Angeles, CA: UCLA dissertation.

BAT-EL, OUTI. 1994. Stem modification and cluster transfer in modern Hebrew. Natural Language and Linguistic Theory 12.571–96.

BECKMAN, JILL N.; LAURA W. DICKEY; and SUZANNE URBANCZYK (eds.) 1995. Papers in optimality theory. University of Massachusetts Occasional Papers in Linguistics 18. Amherst, MA: Graduate Linguistic Student Association.

BENUA, LAURA. 1995. Identity effects in morphological truncation. In Beckman et al., 77–136.

BENMAMOUN, ELABBAS. 1999. Arabic morphology: The central role of the imperfective. Lingua 108.175–201.

BERENT, IRIS; DANIEL EVERETT; and JOSEPH SHIMRON. 2001. Do phonological representations specify variables? Evidence from the obligatory contour principle. Cognitive Psychology 42.1–60.

BORG, ALEXANDER. 1985. Cypriot Arabic. Stuttgart: Steiner.

BRAME, MICHAEL. 1970. Arabic phonology: Implications for phonological theory and historical Semitic. Cambridge, MA: MIT dissertation.

BROADBENT, SYLVIA M. 1964. The Southern Sierra Miwok language. Berkeley and Los Angeles: University of California Press.

BROSELOW, ELLEN. 1992. Parametric variation in Arabic dialect phonology. Perspectives on Arabic Linguistics 4, ed. by Ellen Broselow, Mushira Eid, and John McCarthy, 7–45. Amsterdam and Philadelphia: John Benjamins.

BROSELOW, ELLEN; SU-I CHEN; and MARIE HUFFMAN. 1997. Syllable weight: Convergence of phonology and phonetics. Phonology 14.47–82.

BUCKLEY, EUGENE. 1995. Cyclicity as correspondence. Paper presented at the Tilburg University Conference on the derivational residue in phonology.

BUCKLEY, EUGENE. 1997. Optimal iambs in Kashaya. Rivista di Linguistica 9.1–44.

BUCKLEY, EUGENE. 1999. Uniformity in extended paradigms. The derivational residue in phonological theory (LA 28), ed. by Ben Hermans and Marc van Oostendorp, 81–104. Amsterdam: John Benjamins.

BUCKLEY, EUGENE. 2003. Emergent vowels in Tigrinya templates. Research in Afroasiatic Grammar 2 (Proceedings of the 5th Conference on Afro-Asiatic Linguistics), ed. by Jacqueline Lecarme, 104–25. Amsterdam: John Benjamins.

BURZIO, LUIGI. 1993. English stress, vowel length and modularity. Journal of Linguistics 29.359–418.

BURZIO, LUIGI. 1994. Principles of English stress. Cambridge: Cambridge University Press.
BURZIO, LUIGI. 1998. Multiple correspondence. Lingua 194.79–109.
CANTINEAU, JEAN. 1946. Esquisse d'une phonologie de l'Arabe classique. Bulletin de la Société Linguistique de Paris 43.1–2.93–140.
CANTINEAU, JEAN. 1950. La Notion 'schème' et son alteration dans diverses langues Semitiques. Semitica 73–83.
CARSTAIRS-MCCARTHY, ANDREW. 1988. Some implications of phonologically conditioned suppletion. Yearbook of Morphology 1988.67–94.
CARSTAIRS-MCCARTHY, ANDREW. 1990. Phonologically conditioned suppletion. Contemporary morphology, ed. by Wolfgang U. Dressler, Hans Christian Luschützky, Oskar E. Pfeiffer, and John R. Rennison, 17–23. Berlin: Mouton de Gruyter.
CHEKAYRI, ABDELLAH, and TOBIAS SCHEER. 1996. The apophonic origin of glides in the verbal system of classical Arabic. Studies in Afroasiatic grammar, ed. by Jacqueline Lecarme, Jean Lowenstamm, and Ur Shlonsky, 62–76. The Hague: Holland Academic Graphics.
CHOMSKY, NOAM. 1965. Aspects of the theory of syntax. Cambridge, MA: MIT Press.
CLAYTON, MARY L. 1976. The redundance of underlying morpheme-structure conditions. Language 52.295–313.
CLEMENTS, G. NICK. 1985. The problem of transfer in nonlinear phonology. Cornell Working Papers in Linguistics 7.
COWELL, W. MARK. 1962. A reference grammar of Syrian Arabic [based on the dialect of Damascus]. Washington, DC: Georgetown University Press.
DAVIS, STUART, and BUSHRA ADNAN ZAWAYDEH. 2001. Arabic hypocoristics and the status of the consonantal root. Linguistic Inquiry 32.512–20.
DELL, FRANÇOIS, and MOHAMED ELMEDLAOUI. 1992. Quantitative transfer in the nonconcatenative morphology of Imdlawn Tashlhiyt Berber. Journal of Afroasiatic Languages 3.89–125.
EID, MUSHIRA (ed.) 1995. Perspectives on Arabic linguistics 7. Papers from the seventh annual symposium on Arabic linguistics. Amsterdam and Philadelphia: John Benjamins.
EID, MUSHIRA, and JOHN MCCARTHY (eds.) 1990. Perspectives on Arabic linguistics 2. Papers from the second annual symposium on Arabic linguistics. Amsterdam and Philadelphia: John Benjamins.
EID, MUSHIRA, and ROBERT R. RATCLIFFE (eds.) 1997. Perspectives on Arabic linguistics 10. Papers from the tenth annual symposium on Arabic linguistics. Amsterdam: John Benjamins.
ERWIN, WALLACE M. 1969. A basic course in Iraqi Arabic. Washington D.C.: Georgetown University Press.
FARLEY, ANNE M. 1987. The 'doubled verb' of standard Arabic. Chicago Linguistic Society 23.2.106–15.
FARWANEH, SAMIRA. 1990. Well-formed associations in Arabic: Rule or condition. In Eid & McCarthy, 120–42.
FARWANEH, SAMIRA. 1995. Directionality effects in Arabic dialect syllable structure. Salt Lake City: University of Utah dissertation.
FLEISCH, HENRI S. J. 1956. L'Arabe classique: Esquisse d'un structure linguistique. Beyrouth: Imprimerie Catholique.
FRISCH, STEFAN A.; MICHAEL B. BROE; and JANET B. PIERREHUMBERT. 1997. Similarity and phonotactics in Arabic. Bloomington IN: Indiana University, MS. [Rutgers Optimality Archive, ROA-223.]
FROST, RAM; AVITAL DEUTSCH; and KENNETH I. FROSTER. 1997. What can we learn from the morphology of Hebrew? A masked-priming investigation of morphological representation. Journal of Experimental Psychology 23.829–56.
GAFOS, ADAMANTIOS. 1996. The articulatory basis of locality in phonology. Baltimore, MD: Johns Hopkins University dissertation. [Published, New York: Garland, 1999.]
GAFOS, ADAMANTIOS. 1998. Eliminating long distance consonantal spreading. Natural Language and Linguistic Theory 16.223–78.

GAFOS, ADAMANTIOS. 2001. Deriving Greenberg's asymmetry in Arabic. CUNY/NYU Working Papers in Linguistics, ed. by Marcel den Dikken, 1–52. Online: http://web.gc.cuny.edu/Linguistics/liba/index.html.

GAFOS, ADAMANTIOS. 2003. Inherent parallelism in templatic morphology. New York: New York University, MS.

GESENIUS, W. 1910. Gesenius' Hebrew grammar, ed. and enlarged by E. Kautzsch, trans. and rev. by A. E. Cowley, 2nd English edn. Oxford: Clarendon Press. Revised printing, 1970. Oxford: University Press.

GOLDENBERG, GIDEON. 1994. Principles of Semitic word-structure. Semitic and Cushitic studies, ed. by Gideon Goldenberg and Shlomo Raz, 29–64. Wiesbaden: Otto Harrassowitz.

GOLDSMITH, JOHN. 1976. An overview of autosegmental phonology. Linguistic Analysis 2.23–68.

GOLDSMITH, JOHN. 1990. Autosegmental and metrical phonology. Oxford: Blackwell.

GOLDSMITH, JOHN. 1995. Handbook of phonological theory. Oxford: Blackwell.

GREENBERG, JOSEPH. 1950. The patterning of root morphemes in Semitic. Word 6.162–81.

GUERSSEL, MOHAMED. 1977. Constraints on phonological rules. Linguistic Analysis 3.267–305.

GUERSSEL, MOHAMED. 1978. A condition on assimilation rules. Linguistic Analysis 4.225–54.

GUERSSEL, MOHAMED, and JEAN LOWENSTAMM. 1996. Ablaut in Classical Arabic measure I active verbal forms. Studies in Afroasiatic grammar, Papers from the second conference on Afroasiatic languages, Sophia, Antipolis 1994, ed. by Jacqueline Lecarme, Jean Lowenstamm, and Ur Shlonsky, 123–34. The Hague: Holland Academic Graphics.

HAMMOND, MICHAEL. 1988. Templatic transfer in Arabic broken plurals. Natural Language and Linguistic Theory 6.247–70.

HARRIS, JAMES W. 1973. On the order of certain phonological rules in Spanish. A festschrift for Morris Halle, ed. by Stephen R. Anderson and Paul Kiparsky, 59–75. New York: Holt, Rinehart and Winston.

HAYES, BRUCE P. 1986. Inalterability in CV phonology. Language 62.321–51.

HAYES, BRUCE. 1999. Phonological acquisition in optimality theory: The early stages. Los Angeles: UCLA, MS. [Rutgers Optimality Archive, ROA-327.] To appear in Fixing priorities: Constraints in phonological acquisition, ed. by Rene Kager, Joe Pater, and Wim Zonneveld. Cambridge: Cambridge University Press.

HAYWOOD, J. A., and H. M. NAHMAD. 1965. A new Arabic grammar of the written language. Cambridge, MA: Harvard University Press.

HEATH, JEFFREY. 1987. Ablaut and ambiguity: Phonology of a Moroccan Arabic dialect. Albany: SUNY Press.

HOBERMAN, ROBERT. 1988. Local and long-distance spreading in Semitic morphology. Natural Language and Linguistic Theory 6.541–49.

HOBERMAN, ROBERT. 1995. Current issues in Semitic morphology. In Goldsmith 1995, 839–47.

INKELAS, SHARON. 1995. The consequences of optimization for underspecification. North Eastern Linguistic Society 25.287–302.

ITÔ, JUNKO. 1986. Syllable theory in prosodic phonology. Amherst, MA: University of Massachusetts, Amherst, dissertation. [Published, New York: Garland, 1989.]

ITÔ, JUNKO; ARMIN MESTER; and JAYE PADGETT. 1996. Licensing and underspecification in optimality theory. Linguistic Inquiry 26.571–613.

KAGER, RENÉ. 2003. Lexical irregularity and the typology of contrast. The nature of the word: Essays in honor of Paul Kiparsky, ed. by Kristin Hanson and Sharon Inkelas. Cambridge, MA: MIT Press, to appear.

KAYE, ALAN S. (ed.) 1991. Semitic studies in honor of Wolf Leslau on the occasion of his eighty-fifth birthday. Wiesbaden: Otto Harrasowitz.

KENSTOWICZ, MICHAEL. 1994. Phonology in generative grammar. Oxford: Blackwell.

KENSTOWICZ, MICHAEL. 1997. Base identity and uniform exponence: Alternatives to cyclicity. Current trends in phonology: Models and methods, ed. by Jacques Durand and Bernard Laks, 363–93. Salford, UK: European Studies Research Institute.

KENSTOWICZ, MICHAEL, and CHARLES KISSEBERTH. 1979. Generative phonology. San Diego: Academic Press.

KENSTOWICZ, MICHAEL, and CHARLES PYLE. 1973. On the phonological integrity of geminate clusters. Issues in phonological theory, ed. by Michael Kenstowicz and Charles Kisseberth, 27–43. The Hague: Mouton.
KENSTOWICZ, MICHAEL, and DEGIF PETROS BANKSIRA. 1999. Reduplicative identity in Chaha. Linguistic Inquiry 30.573–86.
KIPARSKY, PAUL. 1971. Historical linguistics. A survey of linguistic science, ed. by William O. Dingwall, 577–649. College Park, MD: University of Maryland Press.
KIPARSKY, PAUL. 1972. Explanation in phonology. Goals of linguistic theory, ed. by Stanley Peters, 189–227. Englewood Cliffs, NJ: Prentice Hall.
KISSEBERTH, CHARLES. 1970. On the functional unity of phonological rules. Linguistic Inquiry 1.291–306.
KURYŁOWICZ, JERZY. 1972. Studies in Semitic grammar and metrics. London: Curzon Press.
LADEFOGED, PETER, and IAN MADDIESON. 1996. The sounds of the world's languages. Oxford: Blackwell.
LAMONTAGNE, GREG, and KEREN RICE. 1995. A correspondence account of coalescence. In Beckman et al., 211–24.
LEBEN, WILLIAM R. 1973. Suprasegmental phonology. Cambridge, MA: MIT dissertation. [Published, New York: Garland, 1980.]
MCCARTHY, JOHN J. 1979. Formal problems in Semitic phonology and morphology. Cambridge, MA: MIT dissertation. [Published, New York: Garland, 1985.]
MCCARTHY, JOHN. 1981. A prosodic theory of nonconcatenative morphology. Linguistic Inquiry 12.373–418.
MCCARTHY, JOHN. 1986. OCP effects: Gemination and antigemination. Linguistic Inquiry 17.207–63.
MCCARTHY, JOHN. 1988. Feature geometry and dependency: A review. Phonetica 43.84–108.
MCCARTHY, JOHN. 1989. Linear order in phonological representations. Linguistic Inquiry 20.71–99.
MCCARTHY, JOHN. 1993. Template form in prosodic morphology. Papers from the third annual Formal Linguistics Society of Mid-America conference, ed. by Laurel Smith Stran, 187–218. Bloomington, IN: Indiana University Linguistics Club.
MCCARTHY, JOHN. 1994. The phonetics and phonology of Semitic pharyngeals. Phonological structure and phonetic form: Papers in laboratory phonology 3, ed. by Patricia Keating, 191–233. Cambridge: Cambridge University Press.
MCCARTHY, JOHN. 1995. Extensions of faithfulness: Rotuman revisited. Amherst, MA: University of Massachusetts, MS. (earlier version of McCarthy 2000.)
MCCARTHY, JOHN. 1998. Morpheme structure constraints and paradigm occultation. Chicago Linguistics Society 23.2.123–50.
MCCARTHY, JOHN. 2000. The prosody of phase in Rotuman. Natural Language and Linguistic Theory 18.147–97.
MCCARTHY, JOHN. 2002. Optimal paradigms. Amherst, MA: University of Massachusetts, Amherst, MS.
MCCARTHY, JOHN, and ALAN PRINCE. 1988. Quantitative transfer in reduplicative and templatic morphology. Linguistics in the morning calm 2, ed. by the Linguistic Society of Korea, 3–35. Seoul: Hanshin Publishing Co.
MCCARTHY, JOHN, and ALAN PRINCE. 1990a. Foot and word in prosodic morphology: The Arabic broken plurals. Natural Language and Linguistic Theory 8.209–82.
MCCARTHY, JOHN, and ALAN PRINCE. 1990b. Prosodic morphology and templatic morphology. In Eid & McCarthy, 1–54.
MCCARTHY, JOHN, and ALAN PRINCE. 1993. Generalized alignment. Yearbook of morphology 1993.79–153.
MCCARTHY, JOHN, and ALAN PRINCE. 1995a. Prosodic morphology. In Goldsmith 1995, 318–66.
MCCARTHY, JOHN, and ALAN PRINCE. 1995b. Faithfulness and reduplicative identity. In Beckman et al., 249–384.
MCOMBER, MICHAEL L. 1995. Morpheme edges and Arabic infixation. In Eid 1995, 173–89.
MOORE, JOHN. 1990. Doubled verbs in modern standard Arabic. In Eid & McCarthy, 55–93.

MULLER, JENNIFER S. 2001. The phonology and phonetics of word-initial geminates. Columbus, OH: Ohio State University dissertation.
ODDEN, DAVID. 1988. Anti antigemination and the OCP. Linguistic Inquiry 19.451–75.
O'LEARY, DE LACY. 1969. Comparative grammar of the Semitic languages. Amsterdam: Philo Press.
PIERREHUMBERT, JANET. 1993. Dissimilarity in the Arabic verbal roots. North Eastern Linguistics Society 23.367–81.
PRINCE, ALAN, and PAUL SMOLENSKY. 1993. Optimality theory: Constraint interaction in generative grammar. New Brunswick, NJ, and Boulder, CO: Rutgers University and University of Colorado, MS.
PRUNET, JEAN-FRANÇOIS; RENÉE BÉLAND; and ALI IDRISSI. 2000. The mental representation of Semitic words. Linguistic Inquiry 31.4.609–48.
RATCLIFFE, ROBERT R. 1997. Prosodic templates in a word-based morphological analysis of Arabic. In Eid & Ratcliffe, 147–72.
RATCLIFFE, ROBERT R. 1998. The 'broken' plural problem in Arabic and comparative Semitic: Allomorphy and analogy in Arabic and comparative Semitic. (Current issues in linguistic theory 168.) Amsterdam: John Benjamins.
ROSE, SHARON. 1997. Theoretical issues in comparative Ethio-Semitic phonology and morphology. Montreal: McGill University dissertation.
ROSE, SHARON. 2000. Rethinking geminates, long-distance geminates, and the OCP. Linguistic Inquiry 31.85–122.
RUBACH, JERZY, and GEERT E. BOOIJ. 2001. Allomorphy in optimality theory: Polish iotation. Language 77.26–60.
SAFI-STAGNI, SABAH. 1995. Morphological structure and lexical processing: Evidence from Arabic. In Eid 1995, 93–106.
SCHEIN, BARRY, and DONCA STERIADE. 1986. On geminates. Linguistic Inquiry 17.691–744.
SCHRAMM, M. GENE. 1962. An outline of classical Arabic verb structure. Language 38.360–75.
SCHRAMM, M. GENE. 1991. Semitic morpheme structure typology. In Kaye, 1402–8.
SMITH, NORVAL. 1985. Spreading, reduplication, and the default option in Miwok nonconcatenative morphology. Advances in non-linear phonology, ed. by Harry van der Hulst and Norval Smith, 363–80. Dordrecht: Foris.
SMOLENSKY, PAUL. 1996. The initial state and 'richness of the base' in optimality theory. Technical Report JHU-CogSci-96-4, Cognitive Science Department, Johns Hopkins University. [Rutgers Optimality Archive, ROA–154.]
STAMPE, DAVID. 1972. How I spent my summer vacation [a dissertation in natural phonology]. Chicago, IL: University of Chicago dissertation. [Published, New York: Garland, 1980.]
STERIADE, DONCA. 1982. Greek prosodies and the nature of syllabification. Cambridge, MA: MIT dissertation.
STERIADE, DONCA. 2003. Paradigm uniformity and the phonetics-phonology boundary. Papers in laboratory phonology 6, ed. by Janet Pierrehumbert and Michael Broe. Cambridge: Cambridge University Press.
TESAR, BRUCE, and PAUL SMOLENSKY. 1996. Learnability in optimality theory (long version). Technical report JHU-CogSci-96-3, Cognitive Science Department, Johns Hopkins University. [Rutgers Optimality Archive, ROA-156.]
TESAR, BRUCE, and PAUL SMOLENSKY. 1998. Learnability in optimality theory. Linguistic Inquiry 29.229–68.
USSISHKIN, ADAM. 1999. The inadequacy of the consonantal root: Modern Hebrew denominal verbs and output-output correspondence. Phonology 16.401–42.
USSISHKIN, ADAM. 2000. The emergence of fixed prosody. Santa Cruz, CA: University of California at Santa Cruz dissertation.
WRIGHT, W. 1896. A grammar of the Arabic language. 3rd edn. Cambridge: Cambridge University Press.
YIP, MOIRA. 1988. Template morphology and the direction of association. Natural Language and Linguistic Theory 6.551–77.
YIP, MOIRA. 1997. Lexicon optimization in a language without alternations. Current trends in phonology: Models and methods, ed. by Jacques Durand and Bernard Laks, 757–88. Salford, UK: European Studies Research Institute.

YUSHMANOV, NIKOLAI VLADIMIROVICH. 1961. The structure of the Arabic language. Trans. by Moshe Perlman. Washington, DC: Center for Applied Linguistics.

Department of Linguistics
New York University
719 Broadway
New York, NY 10003
[adamantios.gafos@nyu.edu]

[Received 27 March 2000;
revisions received 19 January 2002,
17 September 2002;
accepted 21 October 2002]