A minimalist take on Setswana harmony*

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1 Introduction

Central to linguistic theory is the role of an innate human language faculty in shaping the types of grammars available to languages. Among the constructs generally attributed to such a faculty is the "underlying representation" or "input", a unique mental phonological representation from which the various surface realizations are derived (Chomsky & Halle 1968, Prince & Smolensky 1993, Krämer 2012). In this article, we question the "unique UR" imperative. We propose a model in which lexical entries are composed of morphs related by morphosyntactic features, where selection of the right set of morphs results from the interplay of phonological criteria, morphological criteria, and morphosyntactic criteria. Our focus is on the phonological criteria.

Our model (developed in Archangeli & Pulleyblank 2015, 2016, in press) takes as a working hypothesis that the innate human language faculty has quite a small role in structuring the phonological grammar, minimalist phonology.

Setswana is a Bantu language spoken by around 1.9m people in Botswana (Simons & Fennig 2017). Our data come from Dichabe 1997. Setswana is unusual in having three types of high vowels: high-retracted, high-advanced, and superhigh. The three degrees for high present a challenge to standard models of universal distinctive features (see Clements 1991), but are consistent with Emergent features (Mielke 2008): the learner acquires the distinctive categories in the language.

(1) *Vowels of Setswana (see Khabanyane 1991 on the closely related Sesotho)*

superhigh advanced	i	u	*advanced superhigh*	$*\begin{bmatrix}\text{rtr}\\ \text{superhigh}\end{bmatrix}$
high advanced	ɪ	ʊ		
high retracted	ɩ	ɷ		
mid advanced	e	o		
mid retracted	ɛ	ɔ		
low retracted	a		*retracted low*	$*\begin{bmatrix}\text{atr}\\ \text{low}\end{bmatrix}$

* This work was supported by an Insight Grant to Pulleyblank from the Social Sciences and Humanities Research Council of Canada.

In accordance with grounding (Archangeli & Pulleyblank 1994), low vowels are systematically retracted; superhigh vowels are systematically advanced.

As shown in (2), stems with nonlow retracted vowels in a neutral context have corresponding forms with advanced vowels when followed by a suffix with a superhigh advanced vowel, such as {is} 'causative' or {ile} 'past'.

(2) *Super-high trigger*

		neutral context		*pre-[i] context*	
a.	*[high] target*	lʊm-a	'plough'	lɪm-is-a	'plough-CAUS'
				lɪm-ile	'plough-PAST'
		rɷm-a	'send'	rʊm-is-a	'send-CAUS'
				rʊm-ile	'send-PAST'
b.	*[mid] target*	rɛk-a	'buy'	rek-is-a	'buy-CAUS'
				rek-ile	'buy-PAST'
		fɔl-a	'heal'	fod-is-a	'heal-CAUS'
				fod-ile	'heal-PAST'

We develop an analysis of Setswana without unique abstract representations for each morpheme. (We set aside consonant alternations such as [l/d], seen in (2b).)

2 Morph sets

Acquiring forms like those in (2) depends on the observation that in some cases, multiple phonological forms map to a single set of morphosyntactic features; e.g., 'plough' maps to both [lʊm] and [lɪm]. While early learning might class such pairs together idiosyncratically, creating the *morph set* {lʊm, lɪm} 'plough', observation of a sufficient number of such morph sets leads to generalization (Gerken & Bollt 2008), here pairing retracted vowels and advanced vowels, whether high ({lʊm, lɪm} 'plough', {rɷm, rʊm} 'send') or mid ({rɛk, rek} 'buy', {fɔl, fod} 'heal]). Generalization over such observations gives the *morph set relation* in (3). Note that morph set relations enable the learner to hypothesize related morphs on hearing a morph in only one context.[1]

1 There is an additional point that could be built into the actual formal expression of the MSR: MSR-tr affects all vowels in a morph simultaneously. See section 3.4.

(3) *Morph Set Relation-tongue root* (MSR-tr)

$\exists$ M$_i$, M$_i$ $\ni$ $\begin{bmatrix} \text{V}_p \\ \text{rtr} \end{bmatrix}$ $\leftrightarrow$ $\exists$ M$_j$, M$_j$ $\ni$ $\begin{bmatrix} \text{V}_p \\ \text{atr} \end{bmatrix}$

Subject to $*\begin{bmatrix} \text{rtr} \\ \text{superhigh} \end{bmatrix}$, $*\begin{bmatrix} \text{atr} \\ \text{low} \end{bmatrix}$

A morph set has a morph with a retracted vowel iff the morph set has a morph with a corresponding advanced vowel.

{rɛk} 'buy' → {rɛk, rek} 'buy' {rɔm} 'send' → {rɔm, rʊm} 'send'

{rek} 'buy' → {rɛk, rek} 'buy' {rʊm}'send' → {rɔm, rʊm} 'send'

MSR-tr appears to be unexceptional with high vowels, but there are a handful of advanced mid-voweled morphs with no retracted counterpart (Khabanyane 1991, Dichabe 1997): *besa* 'make fire', *betla* 'mould', *boro* 'boar', *telele* 'long/tall', -*ile* 'past'.[2] We assume both that "surprise" (Gerken et al. 2015) helps the learner identify these forms as exceptions to MSR-tr, and that exceptional roots will be susceptible to change over time (Blevins 2004) while exceptional affixes will tend to remain stable (Archangeli et al. 2012).

Multiple morphs in morph sets lead to the problem of when to use which one. While morph set relations express some of the properties captured by "structural change" in the rules of generative phonology (Chomsky & Halle 1968), how to make the selection among morphs taps into those properties expressed by "environment".

3 Selecting among morphs

When relevant morph sets are accessed (by specific morphosyntactic features), the members of those sets are combined to give potential realizations of the morphosyntactic features. When morph sets contain multiple members, there is a choice to be made: which combination should be used? Selection may rely on factors external to a morph set, e.g., *phonotactics*, or on factors internal to a morph set, namely *default*.

3.1 Phonotactics

In (2), the advanced morph appears when preceding a superhigh verbal suffix. We establish three points about the pattern. First, the pattern is general. In (4), the pattern holds between noun and noun class prefix.

2 Dichabe (1997) suggests a partial explanation in terms of the coronal consonants observed in such forms, but we do not pursue this question here.

(4) *Nouns*

a.	*[high] target*	lɪ-fifi	‘darkness-C5’	cf. lʉ-rakɔ ‘wall-C5’
		lɪ-itlhɔ	‘eye-C5’	
		mʊ-ru	‘bush-C3’	cf. mɷ-jakɔ ‘door-C3’
		mʊ-dupɔ	‘bad smell-C3’	
b.	*[low] target*	ma-ru	‘clouds-C6’	
		tshadi	‘women’	

Further evidence is found with the nominalizing suffix on verbs, shown in (5). These forms also illustrate our second point: only one morpheme is affected, e.g., [lʉl-a], [mɷ-lɪd-i] ‘cry’, *[mʊ-lɪd-i].

(5) *Examples with nominalizing suffixes on verbs*

	verb stem	*nominalization*		
a.	[ʉ, ɪ]	lʉl-a	mɷ-lɪd-i	‘cry’
b.		lɪm-a	mɷ-lɪm-i	‘plough’
c.	[ɷ, ʊ]	lɷg-a	mɷ-lʊg-i	‘knit’
d.		kɷlɷp-a	mɷ-kʊlʊp-i	‘throw’
e.	[ɛ, e]	rɛk-a	mɷ-rek-i	‘buy’
r.		bɛlɛg-a	m-meleg-i	‘carry on back’
g.	[ɔ, o]	bɔn-a	m-mon-i	‘see’
h.		kɔb-a	mɷ-kob-i	‘bend’

Third, the pattern is asymmetric. Some stems contain an initial superhigh vowel; retracted vowels freely occur following such vowels.

(6) *Vowels* following *a superhigh vowel*

a.	tirɔ	‘work’	e.	dikɛl-a	‘sunset’
b.	puɔ	‘language’	f.	dumɛl-a	‘agree’
c.	dimɷ	‘ogre’	g.	ditɪmʉ	‘dialects’
d.	pula	‘rain’	h.	pina	‘song’

These cooccurrence properties are expressed in a phonotactic penalizing retracted vowels that precede superhigh vowels. The phonotactic need not be formally restricted to nonlow vowels, because the low vowel has no advanced counterpart.

(7) *Phonotactic*: *[rtr][superhigh]

*[rtr] C_0 [superhigh]: assess a violation to a retracted vowel followed by a superhigh vowel.

3.2 Internal factors: default

The phonotactic *[rtr][superhigh] identifies the appropriate morph when there is a following superhigh vowel. But which morph is selected when there is no following vowel, or the following vowel is not superhigh? In some cases there is no choice to be made: There is only one morph in the set. This happens with morphs containing low vowels, superhigh vowels, and the sporadic cases with only advanced mid vowels.

(8) *Low vowels are always retracted*

a. ma-ru ‘clouds’ b. tshadi ‘women’

(9) *Superhigh vowels are always advanced*

a. phiri ‘hyena’
b. kubu ‘hippopotamus’
c. mmui ‘speaker’
d. mmidi ‘corn’
e. phuphu ‘grave’

Within morph sets with multiple members, there is a morph that is preferred when no other factors make a determination, the *default* morph. In some languages, the default morph may be determined idiosyncratically. In Nuu-chah-nulth (Archangeli & Pulleyblank in prep.), for example, many morphemes have both short and long variants, with the choice of forms in a neutral environment being made on a case-by-case basis. In other languages, such as Setswana, the default choice is made systematically. In the Setswana case, when there are multiple morphs in a set, the neutral form is retracted.

(10) *Default vowels: retracted (unless superhigh)*

a. kɛrɛkɛ ‘church’
b. ɯmaɔ ‘needle’
c. sɪ-fakɔ ‘hail-C7’
d. lɪ-bɔgɔ ‘hand-C5’
e. lɯ ‘egg’
f. pɪlɛ ‘heart’
g. gɔg-a ‘pull’
h. bɷbɔkɔ ‘hippopotamus’
i. thɛrɔ ‘sermon’
j. kgɛtlanɯ ‘collar bone’
k. kɷbɔ ‘blanket’
l. sɪ-lɷg-ɷlɷl-ɪ ‘NEG-knit-REV-FV’

These forms support *[atr]: retracted vowels appear where there is no external reason to prefer an advanced vowel.

(11) Default *[atr]: assess a violation to an advanced vowel.

MSR-tr (3) and the two conditions, *[rtr][superhigh] and *[atr], formally constitute the Setswana grammar for the facts discussed here. In (12) and (13) we show how to assess the various possible combinations.

3.3 Assessment

Assessments owe an obvious debt to Optimality Theory (Prince & Smolensky 1993), but there are crucial differences. The upper left cell shows the relevant morph sets and the leftmost column shows possible combinations of those morph sets; the pool of possibilities is no more and no less than the Cartesian product of the morph sets. The conditions in the top row are only those motivated by evidence in the language, not a ranking of a set of constraints provided by an innate language endowment.

In (12), the retracted vowel of [lʊm-a] satisfies all conditions while the advanced vowel of [lɪm-a] violates *[atr].

(12) *Assessment for* [lʊm-a] 'plough'

{lʊm, lɪm}$_{\text{PLOUGH}}$ - {a}$_{\text{F.V.}}$	*[rtr][superhigh]	*[atr]
→ a. lʊm-a		
b. lɪm-a		*!

With the superhigh-initial suffix [ile], the retracted vowel of *[lʊm-ile] in (13) violates the phonotactic *[rtr][superhigh]; the advanced vowel of [lɪm-ile] is preferred even though it violates the lower ranked condition *[atr].

(13) *Assessment for* [lɪm-ile] 'plough-PAST'

{lʊm, lɪm}$_{\text{PLOUGH}}$ - {ile}$_{\text{PAST}}$	*[rtr][superhigh]	*[atr]
a. lʊm-ile	*!	**
→ b. lɪm-ile		***

Morph sets with no retracted member, such as {-ile} 'past' in (13), will necessarily incur a *[atr] violation, but since there is only one morph, there is no alternative.

3.4 Consequences

First, given the bidirectional MSR-tr (3) and default *[atr] (11), advanced nonsuperhigh vowels appear only to avoid a violation that the [rtr] form incurs. A consequence of this constellation of properties is that for mid and high vowels the distinction between advanced and retracted forms is largely noncontrastive. Second, as noted, there is no need to refer to [low] vowels in *[rtr][superhigh] (7), even though [low] vowels do not have [atr] counterparts before superhigh vowels — the absence of [atr, low] vowels is a general property of Setswana, not specific to this envi-

ronment, (1). Third, within a morpheme, all vowels are affected by MSR-tr (3).[3] Consequently, in a morph with multiple relevant vowels, all vowels are either [atr] or [rtr]; e.g., [bɛlɛg-a], [m-meleg-i] 'carry on back' (5i). This gives the appearance of iterativity. But, as the next point shows, such iterativity is limited.

Finally, as defined by *[rtr][superhigh], the sequential condition refers to vowels immediately preceding a [superhigh] vowel (across C_0). Consequently, in tri-morph combinations, only the morph adjacent to the [superhigh] vowel is affected. This is illustrated in (14) with the nominalizing suffix [i]. (As comparison with (4) shows, the prefix {mɷ, mʊ} has two morphs.)[4]

(14) *Assessment for* [mɷ-kʊlʊp-i] 'throw-NOMINALIZER'

{mɷ, mʊ}-{kɷlɷp, kʊlʊp}-{i}	*[rtr][superhigh]	*[atr]
a. mɷ-kɷlɷp-i	*!	*
→ b. mɷ-kʊlʊp-i		***
c. mʊ-kɷlɷp-i	*!	**
d. mʊ-kʊlʊp-i		****!

This aspect of the Setswana pattern raises a challenge for conventional treatments of harmony. Harmony applies to prefixes (e.g., [mʊ-dupɔ]) and harmony applies iteratively (e.g., [...-kʊlʊp-i]; cf. [kɷlɷp-a]). However, harmony does not apply iteratively to a prefix if it has already applied to a root; e.g., [mɷ-kʊlʊp-i], *[mʊ-kʊlʊp-i]. The account offered here, which does not require a single underlying form, is not forced to characterize this type of harmony as an iterative process. The Setswana distribution is a consequence of the MSR-tr (which results in morphs with retracted vowels and morphs with advanced vowels) together with the prohibition against retracted vowels immediately preceding superhigh vowels. This gives the appearance of iteration within the stem, but not crossing the prefix-stem boundary.

4 The distribution of advanced mid vowels

Mid vowels are advanced in another context, before high vowels. Since MSR-tr (3) results in morph sets containing both an advanced and a retracted morph, the

3 We have found one exception to this statement, the item [kɷbong] 'blanket-LOCATIVE' (compare [kɷbɔ] 'blanket'). If this form represents a general pattern, the analysis would require an additional MSR or a modification to MSR-tr, perhaps limiting it to vowels of the same height within a morph.

4 Dichabe (1997) provides a few examples with multiple suffixes, but the data are insufficient to determine whether the analysis of Setswana involves morphotactic conditioning (if polymorphemic harmony occur with a subset of suffixes) or a domain-sensitive phonotactic (if harmony among multiple suffixes is a general pattern).

only addition needed to account for the additional data is a phonotactic specific to mid vowels. We propose (15), a prohibition on retracted mid vowels preceding high vowels (of any type).

(15) *Phonotactic*: *[rtr-mid] [high]

$*\begin{bmatrix}\text{rtr}\\ \text{mid}\end{bmatrix}\ C_0$ [high]: assess a violation to a retracted mid vowel followed by a high vowel.

The requirements on features and sequencing are supported by the forms in (16), (17), and (18). As (16) illustrates, advanced mid vowels must occur before high vowels within morphemes even though the high vowel is retracted.

(16) *Distribution of advanced mid vowels within morphemes*

a.	lebɷg-a	'thank'	d.	senɷl-a	'disclose'
b.	sebɷg-a	'imagine'	e.	kgomɷ	'cow'
c.	menɷl-a	'overturn'	f.	mɷ-lomɷ	'mouth-C3'

The same pattern is found when the two vowels are in different morphemes, (17): Here root vowels are advanced because of a following high suffix. Note again that these suffixes have *retracted* high vowels yet are preceded by *advanced* mid vowels.

(17) *Distribution of advanced mid vowels across morphemes*

	neutral	*pre-high advanced*		
a.	sɛl-a	'pick up'	sets-ɪ	'pick up-PAST'
b.	rɛk-a	'buy'	sɪ-rek-ɪ	'NEG-buy-FV'
c.	bɔn-a	'see'	bon-ɪ	'see-PAST'
d.	fɔl-a	'heal'	fots-ɪ	'heal-PAST'
e.	gɔg-a	'pull'	sɪ-gog-ɪ	'NEG-pull-FV'

Finally, this is an asymmetric pattern: high vowels are not [atr] before even [atr, mid] vowels.

(18) *No advancement of high vowels before advanced mid vowels*

a.	mɷ-rek-i	'buyer'	d.	sɪ-rori	'truck'
b.	mɷ-feny-i	'winner'	e.	sɪ-bokolodi	'type of warm'
c.	lɪ-podisi	'police'	f.	gɷ-rek-is-a	'to sell'

This aspect of the Setswana pattern is a challenge to conventional treatments of harmony as spreading, aligning, or extending the domain of a feature. Harmony between mid vowels and [high, rtr] vowels cannot be due to feature sharing because the triggering high vowel is not [atr], while the mid vowel is [atr] in the harmony context. There is nevertheless a relation between highness of trigger and advance-

ment of target. The facts demonstrate the need for phonotactics relating features in a way that is neither assimilatory nor dissimilatory in terms of distinctive features — though there is a clear phonetic motivation in terms of both articulation and perception.

5 Conclusion

We have analyzed Setswana vowel harmony with no appeal to abstract, unique underlying representations of the conventional sort. The analysis makes at most limited appeal to an innate human language faculty, a mental faculty specific to language. What the model does appeal to are the components laid out above and summarized in (19).

(19) *Properties of phonology without unique URs*
- a. Morph sets are collections of phonological forms identified by morphosyntactic features.
- b. Morphs may be systematically related by morph set relations.
- c. Satisfying morphosyntactic features results in the Cartesian product of member morph sets.
- d. Assessment selects among these forms.
- e. Assessments involve the interaction of phonotactics and default.
- f. Morphs, phonotactics, and default are deducible from surface forms.

We advocate for careful scrutiny of proposed universals, to determine whether the property is *necessarily* due to an innate human language faculty. Under this approach, phonology is (largely) driven by general properties of human cognition.

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