Minimizing UG: Constraints upon Constraints

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1 Introduction

This paper questions the validity of various assumptions central to treatments of featural processes such as vowel and consonant harmony, namely that features are universal, that constraints are universal, that feature scales are universal, and so on. The paper begins with a discussion of various phonetic, phonological, and typological properties of distinctive features. It goes on to discuss various properties of constraints, examining in particular the question of constraint plausibility. The class of anti-faithfulness constraints is examined in this regard, including a case study of Luo voicing polarity.

It is customary in generative phonology to attribute a complex structure to Universal Grammar (UG), with numerous properties of natural language explained by the intrinsic structure of that grammatical component. For example, the sets of segments that exhibit class behavior are considered to be defined universally, with a single feature set appropriate for all languages (Chomsky & Halle 1968, etc.). Within Optimality Theory, such universality has been extended to the constraint set, with the postulation that phonological grammars draw on a fixed constraint set (Prince & Smolensky 1993, etc.). A major task for the linguist under such a conception is to uncover the properties of UG, for example, to discover the nature of the feature set and the composition of the constraint set. Given a 'built-in' set of constraints, for example, the problem for language acquisition consists of ranking the set of constraints but does not require the acquisition of constraints per se (Tesar 1995, etc.).

Following work such as Hume & Tserdanelis (2002), Pulleyblank (2003), Mielke (2004, 2005), etc., I argue here that such a structure for UG is unlikely. I begin by considering certain properties of distinctive features, concluding that distinctive features are learned, not supplied by UG. It follows that if features are acquired, not given, then any constraints referring to features must also be learned, not precompiled. Certain implications for feature reference, constraint types and locality will be examined.

2 Distinctive features

Though it is frequently assumed that there is a universal set of distinctive features for all languages, it is unclear what exactly this means. For example, the phonetic correlates of features are not consistent across languages, nor are the phonological correlates. The features that are phonologically active in a given language vary, as do the feature values appropropriate for a given segment type. I will elaborate on these points below. The conclusion seems problematic for the UG view of features. If phonetic correlates vary then the problem of mapping features onto articulation and perception requires learning. If the phonological patterns associated with particular features vary, then determining language-specific phonological patterns also requires learning. Since 'active' features vary from language to language, that too requires learning. Since the featural values for at least some segment classes vary, then that too requires learning. In short, it appears that both features and the patterns involving features must be learnable. We must seriously address the question of whether a universal set of 'features' is any more than a convenient set of labels.

2.1 Phonetic correlates of features

An example of cross-linguistic phonetic variation observable in feature realization can be seen with vowel quality where the formant values appropriate for particular vowels vary widely cross-

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linguistically. For example, Lindau & Ladefoged (1986) show that the vowel ‘[i]’ has significantly different F1 values in different languages. In Bavarian, they show that F1 for [i] is centered around 250 Hz; in Italian and Yoruba, F1 for [i] is centered around 300 Hz; in Tausug, F1 for [i] is centered around 400 Hz. Another example can be found in Ladefoged & Maddieson’s (1996) discussion of the interaction between vowel height and the feature for advanced tongue root. Ladefoged & Maddieson give examples of six languages (Akan, Ateso, DhoLuo, Ebira, Igbo & Ịjọ) where a tongue root feature cross-cuts a basic set of tongue height features. What is clear from the values they give is that the actual realization of the vowel sets differs in each of the six languages. To illustrate this point for a subset of the vowels found in these languages, consider the advanced ([i̘, e̘]) and retracted ([i, e]) values for the high and mid front vowels – pairs found in five of the six languages.

(1) *Comparison of F1 values for the four vowels [i̘, i, e̘, e]*

	Akan	Ateso	DhoLuo	Ebira	Ịjọ
F1 below 400 Hz	i̘ > e̘ > i		i̘ > i	i̘ > i > e̘	i̘
F1 centered at 400 Hz			e̘		
F1 above 400 Hz	e	i̘ > i > e̘ > e	e	e	e̘ > i > e

No two of these languages are comparable even for these four vowels. A high advanced vowel can have F1 values ranging from under 300 Hz (Ebira) to above 400 Hz (Ateso); an advanced mid vowel can have an F1 value below that of a high retracted vowel (Akan, Ịjọ) or above such a vowel (Ateso, DhoLuo, Ebira). What is clear is that if we were to identify a vowel as having an F1 value at, say, 400 Hz, without knowing which language the vowel comes from we would be completely unable to identify such a vowel as high, mid, advanced or retracted. In other words, one of the properties that a learner must acquire about a particular vowel system is how to map formant values onto specific vocalic categories. The point just made about F1 could just as easily be made about F2 or some other featural property.

Just as acoustic properties for vowels vary across languages, so do articulatory properties. On the issue of ‘tongue root advancement’, for example, Lindau & Ladefoged (1986) give various examples of differing articulatory patterns for this single ‘feature’. Languages like Akan, Igbo and Ịjọ articulate advanced and retracted classes by varying the size of the pharynx, combining tongue root advancement/retraction with larynx lowering/raising. In contrast, Ateso involves the tongue root, but no more than could be accounted for by tongue height changes. Shilluk and Dinka utilize the tongue root marginally, with the primary articulatory dimension being phonation differences. Luo articulates its categories with tongue height or root movements, with or without involvement of larynx height. Neither acoustically nor articulatorily can features be defined in a cross-linguistically reliable manner.

2.2 Phonological correlates of features

In order for the notion of distinctive feature to be theoretically interesting, it is necessary that testable predictions be made. This turns out to be rather problematic. We have already seen that the acoustic and articulatory correlates of features vary considerably. A ‘phonological’ issue that arises is what exactly it means to label a category as a particular feature. For example, what do we know about a category if it is labelled as ‘high’, ‘low’, ‘advanced’, and so on?

Consider, for example, the behavior of a class of segments identified as [+high]. While such a segment class might be prone to particular syllabification properties, such as glide formation, it is certainly not the case that all [+high] vowels undergo glide formation nor is it the case that only [+high] vowels undergo glide formation. High vowels may trigger spirantization but they need not, and other vowel heights may also trigger spirantization. High vowels may trigger palatalization, but again, being high is neither a necessary or sufficient property to predict palatalization. High vowels may trigger height harmony, but they need not. High vowels may be prone to deletion but they certainly do not always delete and there are certainly other vowel heights that do delete. It is common for epenthetic vowels to be high, but some languages epenthesize vowels that are not high. In short, knowing that a vowel is high tells us very little about what sort of behavior to expect from the vowel.

To exemplify this, consider the vowels that Bhat (1978) shows to be triggers for spirantization. In Nupe, spirantization occurs before front vowels; in Fanti, spirantization occurs before [i, e]; in Awa, spirantization occurs before [i]; in Lower Grand Valley Dani, spirantization occurs before [i, u]. As can be seen in these cases, being [+high] is neither necessary nor sufficient for predicting spirantization. Hence if spirantization is observed in a particular language, the class of segments triggering the process must be learned.

At best, labelling a phonological class in a particular way tells us something about what the behavior of the class *might* be. The actual behavior of the class must be learned by exposure to data.

2.3 Features found cross-linguistically

Let us imagine a somewhat different use for UG. Imagine that both the phonetic and phonological correlates of a feature could vary to some extent, but that the actual set of features does not. We could imagine a strong and a weak version of this hypothesis. According to the strong hypothesis, all languages use precisely the same feature set. According to the weak hypothesis, there could be a universal inventory of features, with a core set used by all languages and additional features added, perhaps in a predictable order.

To assess these hypotheses, let us consider the range of features found in natural language for vowels. According to Ladefoged & Maddieson (1996), we may distinguish between major and minor features of vowel quality. The major features include features for height {high, mid-high, mid, mid-low, low}, for backness {front, central, back}, for rounding compression {compressed, separated}, and for rounding protrusion {protruded, retracted}. The minor features include features of nasalization, more specialized tongue configurations {advanced tongue root, pharyngealization, stridency, rhotacization, frication}, phonation {voiceless, breathy, slack, stiff}, and temporal properties {long, diphthongal}. Keeping in mind that this set would need to be considerably expanded to account for consonants, it is nevertheless clear that a very large number of vowels is possible given such an array of features. We must ask, therefore, exactly how many vowels are in fact found in typical vowel systems.

To get some idea of what may be typical, we can examine a survey such as that of Maddieson (1984). In a balanced sample of 317 languages, Maddieson observes that well over half the languages have 7 vowels or fewer (56%); by far the most common vowel system is one with five vowels (22%) (1984:126). These values include all vowels, no matter how they are distinguished. If we restrict ourselves to vowel quality, we get different values. That is, a language might have four vowel qualities cross-cut by nasality (e.g. Mazatec). As such, the language would figure among those with more than 7 vowels unless we consider vowel quality alone, in which case it would count as having four vowel qualities. Considering only vowel quality, we find that 79% of the languages in Maddieson's survey contain seven vowel qualities or less; again, by far the most common system is one with five vowel qualities (31%) (1984:127).

What is clear from an examination of cross-linguistic vowel inventories is that only a tiny subset of the features available for vowels are actually used in most languages. It is telling to consider the inventory that is the largest in Maddieson's sample, that of !Xũ. As seen in (2), this language has five basic qualities cross-cut by three additional features: length, nasality, and pharygnealization. I present only the monophthongs here; Maddieson also lists 22 diphthongs (9 plain diphthongs plus nasalization and pharyngealization). Note that Maddieson's source does not indicate whether the mid vowels are 'higher' or 'lower' mid.

(2) *!Xũ vowel inventory: monophthongs*

Short vowels	*Oral*	*Nasalized*	*Pharyngealized*	*Pharyngealized Nasalized*
high	i u	ĩ ũ		
mid	e o	õ	oˤ	õˤ
low	a	ã	aˤ	ãˤ

Long vowels	*Oral*	*Nasalized*	*Pharyngealized*	*Pharyngealized Nasalized*
high	iː uː	ũː		
mid	eː oː		oˤː	õˤː
low	aː	ãː	aˤː	ãˤː

What is clear from an examination of such an inventory is that even in a language with an unusally large number of vowels, most vowel features are not used.

This presents a paradox for UG. According to Chomsky & Halle (1968:295): "The total set of features is identical with the set of phonetic properties that can in principle be controlled in speech; they represent the phonetic capabilities of man and, we would assume, are therefore the same for all languages". If we accept the proposal within Optimality Theory that all constraints are universal and found in all languages (Prince & Smolensky 1993), then since constraints refer to features this means that if a feature is found in one language then it is found in all languages. But if there are so many universal features built into UG, why don't they get used more often and more extensively?

Consider a specific example. Ladefoged & Maddieson (1996: 310) describe a class of strident vowels found in Khoisan, referred to as 'sphincteric' vowels by Traill (1986). Ladefoged & Maddieson describe these vowels as follows: 'the whole body of the tongue is much lower for the strident vowels. In addition the back wall of the pharynx...is drawn forward, and "the epiglottis vibrates rapidly during these sounds" (Traill 1985).' Following the logic of the UG proposal, sphincteric vowels must be universal, with the relevant features found in all languages and constraints governing sphincteric vowels found in all languages.

Schematically, the issue is as follows. According to a fairly standard UG view, there is a universal set of features, a universal set of faithfulness constraints on all features, and a universal set of context-free and context-sensitive constraints on all features.

(3) UG

Universal feature set: {F, G, H, ...}
Universal faithfulness constraints: {Faith[F], Faith[G], Faith[H], ...}
Universal markedness constraints: {*F, *G, *H, ...; *F/P, *F/Q, ...; *FP, *FQ, ...}

By hypothesis, these constraints exist for all features in all languages whether they play a role or not.

An alternative might be postulate a set of core features and constraints found in all languages (Christdas 1988), with features and constraints beyond the core being learned.This possibility is problematic for two reasons. First, if learning is required for non-core features and constraints, then Occam's razor would lead one to wonder what the function of a pre-defined core set is. That is, if we need to learn some features, then why not *all* features? An additional problem concerns the potential composition of such a core set.

Consider the sorts of features that are typically added to a basic five-vowel system. An examination of Maddieson's (1984) survey gives the following:

(4) *Types of features that cross-cut a basic five-vowel system*

Variable	*Number of languages (x/317)*	*Percent*
Some sort of central vowel or vowels	90	28.4%
Nasal	70	22.1%
Cross-height ATR-like feature	69	21.8%
Length	63	19.9%
A feature like roundness	46	14.5%
Pharyngealization	5	1.6%
Laryngealization	2	0.6%
Voicelessness	2	0.6%
Breathy voicing	1	0.3%

As can be seen in this table, if we consider any particular feature beyond, say, {high, low, back}, then the basic generalization is that most languages do *not* use that feature. For example, the most common addition to a five-vowel system is some sort of central vowel – and yet over 70% of languages in the sample do not have such a vowel. Some use of nasality, some sort of additional height-related feature, or length are all reasonably common, but in all cases roughly 80% of the sample does *not* use such a feature. The paradox is again plain: features like laryngealization on vowels must be possible, but the vast majority of languages (99% of this sample for laryngealization) do not use such a feature.

This point is particularly odd from an evolutionary standpoint. Why would a feature that is so rarely found end up canonized in an innately specified UG? What would be the advantage to such encoding? Why should all languages have a sphincteric feature?

An additional problem arises with the notion of core features. Based on the segments that are the most common in the inventories of the languages of his sample, and based on the modal size of inventory, Maddieson (1984:12) came up with the following ‘modal’ inventory: (for qualifications, see Maddieson’s discussion; the ‘modal’ inventory actually has 21 consonants so a language should have the inventory below, plus one additional consonant.)

(5) *‘Modal’ inventory: 20 most frequent consonants*

Modal inventory

p	b	*t	*d	tʃ		k	g	ʔ
f		*s		ʃ				
	m		*n		ɲ		ŋ	
	w		*l, *r		j			h

Frequencies of individual segments

	x/317	%		x/317	%		x/317	%		x/317	%
p	263	83%	k	283	89%	ʃ	146	46%	w	238	75%
b	198	62%	g	175	55%	m	299	94%	*l	(241)	76%
*t	(309)	97%	ʔ	146	46%	*n	(315)	99%	*r	(111)	35%
*d	(195)	62%	f	135	43%	ɲ	107	34%	j	271	85%
tʃ	141	44%	*s	(276)	87%	ŋ	167	53%	h	202	64%

As noted by Maddieson, the ‘modal’ inventory is quite plausible. What is interesting, however, is that there are no languages in the sample that actually contain exactly this inventory. Of the 29 languages with 21 consonants, none contain all 20 of the most frequent. Maddieson (1984:13) notes: ‘at the modal inventory size for consonants there is no greater tendency for more frequent segments to occur than in the UPSID data file as a whole.’ A sample of the 29 languages with 21 consonants is given in (6). The languages included are at the extreme ends of the scale, with inventories including 18 or 19 of the 20 most frequent consonants down to only 7 of the most frequent consonants; the most common pattern was to have 14-16 of the most common consonants.

(6) *Sample inventories of languages with 21 consonants*

Language name	*No of modal Cs*	*Inventory*
Bambara	19/20	{p,b,t,d,tʃ,dʒ,k,g,f,s,z,ʃ,h,m,n,ɲ,ŋ,r,l,j,w}
Fur	18/20	{p,b,t,d,dʒ,k,g,f,s,z,ʃ,ɣ,h,m,n,ɲ,ŋ,r,l,j,w}
…		
Mongolian	11/20	{p^{h},b,t^{h},d,ts,dz,tʃ,dʒ,k^{h},g,ɸ,x,β,s,ʃ,m,n,r,l̥,l,j}
Arabana-Wanganura	11/20	{p,t̪,t,ṭ,c,k,m,n̪,n,ṇ,ɲ,ŋ,r,r̤,l̪,l,ḷ,ʎ,ɹ̣,j,w}
Kariera-Ngarluma	11/20	{p,t̪,t,ṭ,c,k,m,n̪,n,ṇ,ɲ,ŋ,r,ṛ,l̪,l,ḷ,ʎ,ɹ̣,j,w}
Wichita	7/20	{t,k,k^{w},ʔ,t^{h},k^{h},k^{wh},k’,ts,ts:,ts^{h},ts’,ɦ,s,s:,s’,n,n:,rr,w,w̰}

What is clear is that languages do not show some deterministic pattern of expansion from a basic core (cf. Calabrese 1988). While there is an overall tendency to employ segments of higher frequency (there obviously could not be an overall tendency to have segments of lower frequency!), it is clearly not the case that all languages use some particular subset of features, gradually adding features in some prespecified or deterministic manner.

This returns us to the paradox. Since languages use only a very small subset of the possible set of features, and since most features are indeed rarely if ever used, then how and why were such features built into UG? If learners must actively acquire a feature set, and if the feature set has no cross-linguistically consistent phonetic and phonological correlates, then does UG actually have any role to play in understanding the natural classes observed in language? An alternative reading of Chomsky & Halle's observations concerning the total set of features is that they are identical with the set of "phonetic properties that can in principle be controlled in speech" since we use our vocal tracts to speak. That is, the speech sounds of all languages reflect the classes that can be produced by the vocal track and perceived by our auditory systems. The phonetics of production and perception shape the categories that are learned, with no defining or deterministic role for UG.

2.4 Segment types with varying specifications

Mielke (2004, 2005) points out an additional problem for a theory of distinctive features based on UG. If features form a fixed set and are part of UG, then particular segment types should be specified in consistent ways cross-linguistically. On the other hand, if features are emergent, then we would expect some degree of variation cross-linguistically. Specifically, where the phonetic properties of a segment are ambivalent to some degree, the emergent view would predict cross-linguistic variability.

Consider the case of laterals, namely, whether laterals should be specified as [+continuant] or [−continuant]. Chomsky & Halle (1968:318) describe the problem as follows: 'The characterization of the liquid [l] in terms of the continuant-noncontinuant scale is even more complicated [than for rhotics]. If the defining characteristic of the stop is taken …as total blockage of air flow, then [l] must be viewed as a continuant and must be distinguished from [r] by the feature of "laterality." If, on the other hand, the defining characteristic of stops is taken to be blockage of air flow *past the primary stricture*, then [l] must be included among the stops.' If the specification of segment classes is part of UG, then there must be a correct characterization for laterals. That is, there must be an answer to the question of whether laterals are continuants or non-continuants and the behavior of laterals cross-linguistically should be uniform. On the other hand, given the phonetic ambivalence of such segments, an emergent view would predict cross-linguistic variability.

As Mielke (2005) demonstrates, cross-linguistic data support the emergent view. In a survey of 561 languages, Mielke examined classes that either undergo or trigger a phonological process, creating a database of 6077 classes. Of this total number of classes, 928 contained a lateral liquid. Of the 928 classes including a lateral, 644 were 'natural' in terms of at least one of the feature theories considered by Mielke (see Mielke 2004, 2005). That is, some set of distinctive features could correctly identify the relevant set, including all and only the members of that set. Of the 644 'natural' classes including laterals, many could be characterized in terms of features other than continuancy. Mielke (2005:178) gives the example of /t d l/ in Boko/Busa which function as a class to the exclusion of /s z j/. While the class could be characterized as [Coronal, −continuant], it could also be characterized as [Coronal, −strident, −vocoid]. Such classes were excluded from consideration since they do not unambiguously require any particular value for continuancy. Once all such exclusions were complete, 66 'natural' classes required specifications of continuancy. Of these, 36 required the specification [+continuant] and 30 required the specification [−continuant].

In the cases where laterals patterned with [+continuant] segments, the most common additional segments were fricatives (13 cases), glides and fricatives (9 cases), and rhotics and fricatives (6 cases). In the cases where laterals patterned with [−continuant] segments, the most common additional segments were nasals (12 cases), stops (8 cases), nasals and stops (6 cases).

Mielke (2005:198) concludes on the basis of the data summarized here on laterals as well as comparable data on nasals that: "Universal distinctive features are most reliable for predicting the behaviour of phonetically unambiguous segments, suggesting that the phonetic unambiguity is responsible for the phonological patterning. In the phonetic gray areas, where universal features would be expected to define clear boundaries between two values of a feature, the phonological patterning of sounds is as varied as the phonetic cues are ambiguous".

3 Constraints

In the preceding section, I have raised various problems with conceiving features as a hard-wired set supplied by UG. Features do not appear to have consistent cross-linguistic phonetic correlates; they do not appear to pattern predictably in terms of their phonology; featural inventories appear to vary from language to language; the values features assign to particular classes of segments also appear to vary. These properties are suggestive of sets of language-specific acquired features rather than of a universal set of predetermined features.

There are immediate consequences for constraints. One simple one is that if features are emergent, it follows that any constraint referring to a feature must also be emergent. This would mean, for example, that there can be no 'grounded conditions' as part of UG (cf. Archangeli & Pulleyblank 1994), though for conditions to be phonetically grounded would be expected (Blevins 2004). There would be numerous implications in terms of a theory of constraint properties. For example, there has been considerable discussion over the years of whether 'binary' features can define a 'ternary' contrast (§3.1). If features and constraints emerge as a result of experience, it is difficult to see why such ternarity might not result in specific cases. In essence, we would expect that whether a contrast is binary or ternary on the surface would depend on the language – precisely as predicted by richness of the base (Prince & Smolensky 1993).

An overall heuristic would be that if features and constraints are emergent, then the conditions governing them should be of a very general type. We might assume, for example, that language learners construct and label segment classes, but not that the learner has a predefined set of labels. This would plausibly extend beyond feature classes. For example, McCarthy & Prince (1995), Urbanczyk (2006), etc. have proposed a general meta-constraint whereby root-faithfulness universally outranks affix-faithfulness. Clearly such a universal meta-constraint is only possible if categories like 'root' and 'affix' are defined as part of UG. Compare this approach to that of *harmonic domain ranking* proposed by Archangeli & Pulleyblank (2002). Building on a proposal by Mohanan (1993), Archangeli & Pulleyblank propose that "sets of constraints differentiated solely by domain are harmonically ranked from smaller to larger domain, smaller domains ranked higher than larger domains." Unlike the root-affix meta-constraint, harmonic domain ranking does not require any set of universal domain categories. It requires only that constraints, whatever their formulation, be assigned to nested sets of domain categories.

The general point is that featural constaints must be learnable. Though surface patterns might be complex, we would expect that the actual constraints themselves should be transparently derivable from observable data patterns. Consider a constraint family such as faithfulness (McCarthy & Prince 1995). If a string contains an ordered sequence of phonological units, then it follows that a grammar should be able to compare strings with respect to their content and order. Basic faithfulness constraints do exactly that. Whatever the precise featural content of a string – and this could be determined in language-specific ways – faithfulness would assess the extent to which strings correspond. But consider a family of constraints such as 'anti-faithfulness' (Alderete 1999), a constraint family that requires that phonological strings *not* correspond faithfully. If allowable at all, anti-faithfulness clearly plays a marginal role in the grammar of any language. Whereas something like faithfulness must exist if there are multiple levels of representation, anti-faithfulness clearly does not need to exist. Indeed, anti-faithfulness in general could cause incoherence since virtually any string could differ from virtually any other string, hence satisfy the relation of anti-faithfulness. As shown by Alderete, anti-faithfulness as a constraint family can only exist if the faithfulness family also exists; the reverse is certainly not the case. I will return in some detail to a discussion of anti-faithfulness below, considering a case where it has been argued by Alderete to be necessary. The conceptual point that I am raising here is just that some constraint types could plausibly be acquired given very minimal schematic information about phonological representations. Other constraint types are much less plausibly learnable, hence would more likely need to be hard-wired. If constraints on features are emergent, we expect to find instances of the former in natural language phonologies but not of the latter. This means that if we find that constraint types like anti-faithfulness are required in the description of natural language, this is very interesting since an emergent theory with a less construction-specific UG would not predict such constraints to be needed.

The general point being raised here is to what extent there can be universal constraints on constraints, and what the nature of such meta-constraints can be. For example, it is clear that sequences of features interact. What is less clear is whether they must be 'adjacent' in order to interact and what exactly adjacency means. If meta-constraints can be linguistic constraints of a highly specific nature, encoded in UG, then there are essentially no constraints on meta-constraints. On the other hand, if constraints are emergent and meta-constraints tend *not* to be specifically linguistic, then the nature of constraints is highly restricted.

In the following sections, I investigate several of these points in more detail.

3.1 Ternary specifications: Margi

For more than 40 years there has been discussion of whether it should be possible for 'binary' features to function in a 'ternary' fashion; see, for example, Lightner (1963), Stanley (1967), Ringen (1975), Kiparsky (1982), Pulleyblank (1986), Archangeli & Pulleyblank (1994) and Inkelas, Orgun & Zoll (1997). One point seems to have been clearly established: unless some restriction is placed on the way seemingly binary features are used, it is possible for ternary power to result.

Consider the kind of case that might motivate ternary power. In Margi (Hoffmann 1963, Pulleyblank 1986), tonally specified roots exhibit three basic patterns. Roots may be low, as seen in (7) both with and without a H-tone suffix:

(7) *Low tone roots*

	Root	*Gloss*	… + *H suffix*	*Gloss*
a.	ptsà	*roast*	ptsàbá	*roast thoroughly*
b.	tsàvə̀	*pierce*	tsàvə̀bá	*pierce through*
	L tsavə		L H tsavə-ba	

Roots may be high, again illustrated with and without a H-tone suffix

(8) *High tone roots*

	Root	*Gloss*	… + *H suffix*	*Gloss*
a.	tá	*cook*	tábá	*cook all*
b.	ŋgúlí	*roar*	ŋgúlíbá	*surpass in roaring*
	H ŋguli		H H ŋguli-ba	

Roots may also be low-high, in which case they surface with a rising tone in isolation and with a low tone before a H-tone suffix; see Hoffmann (1963) and Pulleyblank (1986), for details, including discussion of longer forms.

(9) *Low-High roots*

	Root	*Gloss*	… + *H suffix*	*Gloss*
a.	fǐ	*swell*	fìbá	*make swell*
b.	və̌l	*fly; jump*	və̀lbá	*jump over, across*
	LH vəl		L H vəl-ba	

Of particular interest is a class of roots and suffixes whose tones change (Hoffmann 1963). Such suffixes appear on a low tone when adjacent to a low tone root and on a high tone when adjacent to a high tone root.

(10) *Toneless suffixes*

	Root	*Gloss*	… + *Ø suffix*	*Gloss*
a.	pcì	*wash*	pcìnà	*wash*
b.	tlà	*cut*	tlànà	*cut off*
	L tla		L tla-na	
c.	tá	*cook*	táná	*cook and put aside*
d.	pə́r	*bathe*	pə́rná	*take a bath*
	H pər		H pər-na	

With a low-high root, the tones are distributed over the root and changing-tone suffix resulting in a low-high pattern.

(11) *Low-High roots with toneless suffix*

	Root	*Gloss*	… + *Ø suffix*	*Gloss*
a.	njǐ	*pass (urine)*	njìná	*pass (urine)*
b.	və̌l	*fly; jump*	və̀lná	*fly*
	L H vəl		L H vəl-na	

When a root itself bears a changing tone, it surfaces as low both in isolation and when followed by a changing-tone suffix.

(12) *Toneless roots with toneless suffix*

	Root	*Gloss*	… + *Ø suffix*	*Gloss*
a.	fà	*take*	fànà	*take away*
b.	tə̀tə̀l	*spread*	tə̀tə̀lnà	*spread (something)*
	L tətəl		L tətəl-na	

When a changing tone root is followed by a high-tone suffix, then both root and suffix surface as high.

(13) *Toneless roots with H suffix*

	Root	*Gloss*	… + *Ø suffix*	*Gloss*
a.	shù	*stir*	shúbá	*stir well*
b.	ŋàl	*bite*	ŋálbá	*bite a hole*
	L ŋal		H ŋal-ba	

The analysis of such cases is straightforward. Morphemes may bear a low tone, a high tone, or a low-high sequence. In addition, morphemes may be toneless, that is, they bear no tone at all. The basic point is that morphemes may underlyingly bear any possible combination of tones, including no tone at all. See Pulleyblank (1997) for discussion, as well as an account of why no high-low pattern is found.

This kind of case is not surprising, and was prominent in the autosegmental literature. It is worth reviewing in the context of ternarity. A pattern like that observed in Margi involves two surface tone levels, high and low. Free assignment of tones predicts the possibility of underlying tonelessness, however, and the language has a set of morphemes whose behavior is precisely what we would expect of such a class. This means that if our theory of features allows ternarity, we predict patterns like that found in Margi. But could the theory rule out such power?

There are two ways that such power might be ruled out. First, we could postulate a specific set of features with specific properties – but if, as outlined above, distinctive features are emergent rather than prespecified in UG, then such specificity is unlikely and perhaps impossible. Second, we could postulate some meta-constraint specifically to govern ternary use of binary features. Data such as that presented in this section, however, would argue against such a move. Ternary use of a binary tone feature is precisely what we want in a language like Margi. See also Kim & Pulleyblank (2006) for recent discussion of a case in Nuu-chah-nulth requiring such an effect.

I conclude therefore that the desired result is precisely the unconstrained result. Ternarity may arise, and the possibility of such cases is precisely what we would expect if features are emergent.

3.2 Plausibility of constraint types: Dholuo

Under the assumption that features and constraints are part of UG, there are no a priori limitations on the types of constraints that can be posited. Indeed, as alluded to above, the less grounded a constraint type, the greater the necessity for including it as part of UG. The reason for this is straightforward: if a constraint is grounded in some extralinguistic properties, then it is conceivable that the constraint type is acquired through experience and it is therefore not necessary that the constraint be part of UG; in contrast, if a constraint type is *not* readily learnable, then its very unlearnability means that it must be part of UG.

In this section, I consider a constraint type that seems at best marginally learnable, namely the class of 'anti-faithulness' constraints (Alderete 1999). Compare notions of 'faithfulness' and 'anti-faithfulness'. If two representations correspond to each other, the default relationship must be one of identity – all else being equal, there would be no reason for one representation to differ from the other. This is precisely the notion formalized in McCarthy & Prince (1995). In contrast, Alderete proposes a class of *anti-faithfulness* constraints, where the constraint family require that candidates differ from each other with respect to whatever dimension is relevant for the constraint.

(14) *Anti-Faithfulness* (Alderete 1999:132)

Given the Faithfulness constraint F, ¬F is the related Anti-Faithfulness constraint which is satisfied in a string S iff S has at least one violation of F.

For example, anti-faithfulness could require differences in the presence or absence of a segment (Max, Dep), in the identify of corresponding segments (Ident), in the order of segments (Linearity), and so on. This section considers a language, Dholuo, a Nilotic language of Kenya, where Alderete has argued that such anti-faithfulness is required. It will be argued here that no such enrichment of constraint types is needed for Dholuo.

The pattern to be examined is one that has been referred to as 'voicing polarity' (Alderete 1999). To understand the relevant patterns, I first present some background information.

Two aspects of the consonant inventory of Dholuo are directly relevant for the patterns to be considered here. First, note that there are two series of oral (obstruent) stops: (i) a voiceless series, (ii) a corresponding voiced series. Second, note that there is a series of prenasalized stops that corresponds to the set of nasal (sonorant) stops; I do not address the distribution of [nð] in this paper.

(15) *Consonants*

	Labial	Dental	Alveolar	Palatal	Velar	Glottal
Oral stops	p		t	c	k	
	b		d	ɟ	g	
Nasal stops	mb		nd	ɲɟ	ŋg	
	m		n	ɲ	ŋ	
Fricatives		θ	s			h
		ð , nð				
Liquids			l			
			r			
Glides	w			j (y)		

3.2.1 The anti-faithfulness account

The two series of oral and nasal stops exhibit interesting alternations in various morphological contexts. For example, Alderete (1999:129) discusses a pattern of voicing polarity observed in certain singular-plural pairs.

(16) *Consonantal polarity*

	Singular	*Plural*	
a.	bat	bed-e	*arm*
b.	lue	luð-e	*walking stick*
c.	rec	reɟ-e	*fish*
d.	cogo	cok-e	*bone*
e.	owadu	owet-e	*brother*
f.	luedo	luet-e	*hand*

Alderete observes (i) when the final obstruent is voiceless in the singular then it is voiceless in the plural, and (ii) when the final obstruent is voiced in the singular then it is voiceless in the plural. He proposes to capture this generalization by invoking an anti-faithfulness constraint (Alderete 1999:135).

(17) ¬OO-IDENT(VOI)

If a pair of words stand in an OO-correspondence relation, at least one pair of correspondent segments must be non-identical for the feature [voice].

For reasons that are orthogonal to the issues under discussion here, Alderete formulates the relevant constraints as 'transderivational', that is, they compare sets of output candidates (Benua 1997).

Consider two representative cases, namely, *bat/bed-e* 'arm' and *cogo/cok-e* 'bone'. As seen in (18), a candidate where the final consonant has the *same* voicing value as the base (18ai, bi) violates anti-faithfulness (¬OO-IDENT(VOI)) but obeys faithfulness (OO-IDENT(VOI)); in contrast, when a candidate has a consonant with a different voicing value than found in the base (18aii, bii), such a candidate satisfies anti-faithfulness (¬OO-IDENT(VOI)) but violates faithfulness (OO-IDENT(VOI)).

(18) *Consonantal polarity as transderivational anti-faithfulness* (Alderete 1999:135)

a. bat ≠ bede

	Base	/bat+e/	¬OO-IDENT(VOI)	OO-IDENT(VOI)
i.	bat	bet-e	*!	
ii. ☺	bat	bed-e		*

b. cogo ≠ coke

	Base	/bat+e/	¬OO-IDENT(VOI)	OO-IDENT(VOI)
i.	cogo	cog-e	*!	
ii. ☺	cogo	cok-e		*

By ranking ¬OO-IDENT(VOI) above ¬OO-IDENT(VOI), Alderete's account derives outputs exhibiting voicing polarity.

In the following discussion, I first present data exhibiting the behavior of various sub-patterns, going on to present problems with the anti-faithfulness account as an alternative is developed. Problems with the anti-faithfulness account are also presented in Trommer (2005) and the analysis proposed here is similar in significant respects to Trommer's analysis.

3.2.2 Maintaining voicing contrasts

The first point to note in developing an analysis of voicing alternations in Luo is that voicing polarity is not a general property, even for plurals. For example, plurals formed by the suffixation of *-ni* do not exhibit voicing alternations.

(19) *Plurals formed with –ni*

	Singular	Plural	
a.	hɪga	hig-ni	*year*
b.	bugo	bug-ni	*hole*
c.	okebe	okeb-ni	*rich man*
d.	pɔkɔ	pok-ni	*gourd*
e.	ŋgạto	ŋget-ni	*clog(s); sets of clogs*
f.	naŋga	neŋg-ni	*cloth, suit, garment*

Even for the class of nouns that take a plural with the suffix *-e*, examples of which were seen in (16), not all bases exhibit voicing alternation. The nouns in (20), for example, exhibit consonants that have the same voicing value in both the singular and the plural.

(20) *Nonalternating cases*

	Singular	Plural	
a.	cupa	cup-e	*bottle*
b.	ɔɵɪɵɔ	ɔɵɪɵ-ɛ	*small thing*
c.	osiki	osik-e	*stump*
d.	ip	ip-e	*tail*
e.	ŋut	ŋut-e	*neck*
f.	lak	lek-e	*tooth*
g.	ŋudi	ŋud-e, ŋud-ni	*neck of meat*
h.	dɛrɔ	der-e	*granary*

Whatever the details of the analysis of voicing alternations, the simplest assumption for such nonalternating cases is that they are underlying assigned the appropriate voicing value.

(21) a. *underlyingly voiceless forms:* e.g. [p] = [−voiced], /cupa/ 'bottle'
b. *underlyingly voiced forms:* e.g. [d] = [+voiced], /ŋudi/ 'neck of meat'

Given such underlying values for voicing, the correct results for (20) can be achieved by ranking a faithfulness constraint such as MAX[±voiced] above any 'polarity' constraint.

(22) MAX[±voiced]: Every [αvcd] value in the Input has a corresponding [αvcd] value in the Output.

3.2.3 The first half of polarity: voiceless singulars ~ voiced plurals

If the 'normal' situation is to maintain voicing contrasts, then we need to carefully examine those contexts where consonants appear to undergo either voicing or devoicing. The first point to note in this regard is that there are contexts in which domain-final obstruents devoice; see Trommer (2005). Tucker (1994) notes that Luo words may appear in both bound and free forms, observing the following: "No Luo word in its Free Form may end in –y … or a voiced explosive consonant… Consequently monosyllabic words derived from disyllabic words containing such consonants in second position substitute the corresponding unvoiced consonant here" (Tucker 1994: 35). Examples of such devoicing can be seen in deverbal nominals.

(23) *Deverbal nominals*

	Verb		Bound form		Free form (nominal)	
a.	tɔbɔ	*hit target*	tɔb odumbo	*hit the target!*	tɔp	*the hitting*
b.	buðo	*scorch*	buð lum	*scorch the grass!*	bueɵ	*to become scorched*
c.	codo	*break off*	cod wac	*make a decision!*	cot	*break off (int.)*
d.	nagɔ	*extract*	nag lak	*extract the teeth!*	nak	*extraction*

While there is a clear need to study in detail the distribution of bound and free forms to determine the precise nature of these domains, it suffices for present purposes to define devoicing as applying phrase-finally. As such, the verbs do not undergo devoicing in the bound forms but do undergo devoicing in the free forms. I assume a constraint prohibiting phrase-final voiced obstruents, and rank this constraint above faithfuless to voicing.

(24) a. FINALVOICELESSNESS: A phrase-final obstruent must not be [+voiced].
b. FINALVLESS >> MAX[±voiced]

This analysis makes an immediate prediction, that forms exhibiting voiced values in both the singular and plural should *not* have final obstruents. That is, cases involving nonalternating voiced obstruents should all be of the type: *ŋudi/ŋud-e* 'neck of meat' (20g). While this prediction appears to be correct, it should be noted that nonalternating examples of this type are quite rare (Tucker 1994).

With phrase-final devoicing in mind, consider representative cases where consonants are voiceless in the singular and voiced in the plural.

(25) *Voiceless singular ~ voiced plural*

	Singular	*Plural*	
a.	alot	alod-e	*vegetable*
b.	bat	bed-e	*arm*
c.	lʊɵ	lʊð-ɛ	*stick*
d.	ruoɵ	ruoð-i	*chief*
e.	guok	guog-i	*dog*

As noted by Trommer (2005), this class of cases is consistent with the generalization that obstruents are voiceless in final position. That is, the 'voicing' in the plural can actually be seen as devoicing in the singular. By analyzing this class of roots as having final obstruents that are underlyingly voiced, we see that the voicing value is maintained when the final consonant is protected by a vowel (as in the plural) but devoices when the consonant occurs in final position; see the tableaux in (26) and (27).

In the singular, a root like /alod/ undergoes devoicing, surfacing as [alot].

(26) *Final devoicing*

	/alod/	FINALVLESS	MAX[±vcd]
a.	alod	*!	
b. ☺	alot		*

In the plural, the same root surfaces with a voiced obstruent, [alode], because of the protection provided by the plural suffix.

(27) *Final devoicing inapplicable*

	/alod+e/	FINALVLESS	MAX[±vcd]
a. ☺	alod-e		
b.	alot-e		*!

Given this analysis of half of the voicing polarity effect, I turn in the next section to an analysis of cases where a voiced singular alternates with a voiceless plural.

3.2.4 The second half of polarity: voiced singulars ~ voiceless plurals

The reverse counterparts of the cases already seen are those where the obstruent has an intervocalic obstruent in the singular that is voiced, but where the corresponding consonant is voiceless when preceding the suffix of the plural.

(28) *Voiced singular ~ voiceless plural*

	Singular	Plural	
a.	kidi	kit-e	*stone*
b.	cogo	cok-e	*bone*
c.	puoðo	puoθ-e	*garden*
d.	mɔgɔ	mok-e	*flour*
e.	bɔðɔ	bɔθ-ɛ	*prostitute*

The key to understanding these forms is recognizing that they represent a pattern of intervocalic voicing in the singular (restricted to the stem domain for reasons we will see shortly) and a pattern of default obstruent voicelessness in the plural.

(29) *Intervocalic voicing*: $*\mathrm{VtV}]_{\mathrm{STEM}}$: *Vowel [−sonorant, −voiced] Vowel; domain = Stem
Default voicelessness: *VDOBS: *[−sonorant, +voiced]

The problem, however, is that neither of these patterns is general: intervocalic voicing is not observed in (20), for example, and 'default' voicelessness would need to be over-ruled in numerous examples.

The solution to this problem emerges from careful consideration of *richness of the base* (Prince & Smolensky 1993). If no constraints are placed on underlying representations, then there are three possible input forms for obstruents: voiced, voiceless, unspecified for voicing. Following work such as Inkelas (1994), Pulleyblank (2003), Kim & Pulleyblank (2006), etc., I propose here that it is the interaction of such unconstrained input possibilities with constraints on voicing that gives rise to the overall Luo pattern. To demonstrate this, I will work through the effects of the four constraints proposed for Luo on the various input types.

(30) *Luo voicing grammar*: FINALVLESS >> MAX[±vcd] >> $*\mathrm{VtV}]_{\mathrm{STEM}}$ >> *VDOBS

Phrase-final devoicing (FINALVLESS) is the only constraint that outranks faithfulness. Hence lexical voicing values are retained except in phrase-final position. Because of the relatively high ranking of faithfulness, the effects of $*\mathrm{VtV}]_{\mathrm{STEM}}$ and *VDOBS are only seen when a consonant happens to be underlyingly unspecified for voicing. In the following examples, I first consider roots with specified values, then go on to consider roots with obstruents that are unspecified for voicing. For each obstruent type, it is crucial to consider the behavior of both 'full' stems – those ending in a vowel – and 'short' stems – those ending in a consonant. See Okoth-Okombo (1982) and Tucker (1994) for discussion of these stem types. In all candidates below, stem boundaries are indicated by square brackets.

Consider first the behavior of a full stem with an obstruent that is specified underlyingly as [−voiced]. I propose that this is the appropriate representation for a nonalternating stem like *cupa* (sg) vs. *cup-e* (pl) 'bottle' (20a). In the singular, the stem occurs without a number suffix.

(31) *Full stem singular: voiceless input – voiceless output (cupa)*

Sg	/cupa/	FINALVLESS	MAX[±vcd]	$*\mathrm{VtV}]_{\mathrm{STEM}}$	*VDOBS
a. ☺	[cupa]			*	
b.	[cuba]		*!		*

Since the [p] of /cupa/ is voiceless underlyingly, replacement of [−voiced] by [+voiced] would result in a faithfulness violation. The optimal output is therefore [cupa]. Note that [cupa] violates $*\mathrm{VtV}]_{\mathrm{STEM}}$ since the intervocalic [p] is voiceless, but since $*\mathrm{VtV}]_{\mathrm{STEM}}$ is ranked below faithfulness this has no impact on the choice of optimal candidate.

In the plural of the same stem, the final vowel of the stem is lost before the vowel of the suffix, the result of constraints that are orthogonal to the patterns under examination here.

(32) *Full stem plural: voiceless input – voiceless output (cupe)*

Sg	/cupa+e/	FINALVLESS	MAX[±vcd]	*VtV]$_{\text{STEM}}$	*VDOBS
a. ☺	[cup]e				
b.	[cub]e		*!		*

The deletion of the first vowel in the *VV* sequence has no impact on voicing, with the optimal output, [cupe], continuing to show a voiceless [p]. Note that in this case, although the [p] of [cupe] is intervocalic, there is no violation of *VtV]$_{\text{STEM}}$ since only the prevocalic consonant is part of the stem.

For a short stem with an obstruent that is underlyingly specified as [−voiced], the pattern is fully comparable to that of a full stem. I exemplify this with *ip* (sg) vs. *ip-e* (pl) 'tail' (20d).

(33) *Short stem singular: voiceless input – voiceless output (ip)*

Sg	/ip/	FINALVLESS	MAX[±vcd]	*VtV]$_{\text{STEM}}$	*VDOBS
a. ☺	[ip]				
b.	[ib]	*!	*		*

(34) *Short stem plural: voiceless input – voiceless output (ipe)*

Sg	/ip+e/	FINALVLESS	MAX[±vcd]	*VtV]$_{\text{STEM}}$	*VDOBS
a. ☺	[ip]e				
b.	[ib]e		*!		*

The pattern is more dynamic when the stem contains an obstruent that is underlyingly voiced. Although the obstruent in a full stem is consistently voiced, devoicing occurs with a short stem in the singular. Consider first a nonalternating full stem like *ŋudi* (sg) vs. *ŋud-e* (pl) 'neck of meat' (20g).

(35) *Full stem singular: voiced input – voiced output (ŋudi)*

Sg	/ŋudi/	FINALVLESS	MAX[±vcd]	*VtV]$_{\text{STEM}}$	*VDOBS
a. ☺	[ŋudi]				*
b.	[ŋuti]		*!	*	

FINALVLESS is irrelevant in both the singular and the plural since the obstruent concerned is never phrase-final. Faithfulness therefore ensures that the output is voiced since the input is voiced.

(36) *Full stem plural: voiced input – voiced output (ŋude)*

Sg	/ŋudi+e/	FINALVLESS	MAX[±vcd]	*VtV]$_{\text{STEM}}$	*VDOBS
a. ☺	[ŋud]e				*
b.	[ŋut]e		*!		

With a short stem, the situation changes; consider an example like *alot* (sg) vs. *alod-e* (pl) 'vegetable' (25a). Because it is phrase-final in the singular, the underlyingly voiced obstruent optimally surfaces as voiceless in such a form.

(37) *Short stem singular: voiced input – voiceless output (alot)*

Sg	/alod/	FINALVLESS	MAX[±vcd]	*VtV]$_{\text{STEM}}$	*VDOBS
a.	[alod]	*!			*
b. ☺	[alot]		*		

With the addition of the plural suffix, however, final devoicing is no longer enforced.

(38) *Short stem plural: voiced input – voiced output (alode)*

Sg	/alod+e/	FINALVLESS	MAX[±vcd]	*VtV]$_{STEM}$	*VDOBS
a. ☺	[alod]e				*
b.	[alot]e		*!		

As discussed above, this combination of final devoicing in the singular and faithfulness to a voiced value in the plural makes such short stems form one half of the voicing polairty picture.

We turn now to the last type, where an obstruent happens to be unspecified underlyingly for voicing. As mentioned before, richness of the base predicts such a possibility since if a language employs the values [+voiced] and [−voiced], then in principle a phoneme could underlyingly be specified for neither. Given the constraint set proposed here, if a final obstruent was unspecified for [voiced], then since there is no input voicing specification to be faithful to, Max[±vcd] would play no role. Surface values should therefore be determined solely by the appropriate markedness constraints.

Consider first a full stem, a type I will exemplify with *kidi* (sg) vs. *kite* (pl) 'stone' (28a). Obstruents unspecified underlying for voicing are indicated in upper case.

(39) *Full stem singular: unspecified input – voiced output (kidi)*

Sg	/kiDi/	FINALVLESS	MAX[±vcd]	*VtV]$_{STEM}$	*VDOBS
a.	[kiti]			*!	
b. ☺	[kidi]				*

Since the obstruents are not phrase-final, FINALVLESS is irrelevant. MAX[±vcd] is also irrelevant since the obstruent has no underlying voicing value. Since the obstruent is surrounded by stem vowels, intervocalic voicing (*VtV]$_{STEM}$) forces the appearance of a voiced obstruent in the surface form.

The full stem plural is different since the final stem vowel is deleted to resolve vowel hiatus. The consequence of this deletion is that stem-internal intervocalic voicing is no longer a factor, hence the obstruent surfaces with a default voiceless specification.

(40) *Full stem plural: unspecified input – voiceless output (kite)*

Sg	/kiDi+e/	FINALVLESS	MAX[±vcd]	*VtV]$_{STEM}$	*VDOBS
a. ☺	[kit]e				
b.	[kid]e				*!

This analysis correctly predicts that pairs with a voiced plosive in the singular and a corresponding voiceless consonant in the plural can only occur with full stems (Trommer 2005). In a short stem, markedness would ensure that voiceless obstruents surface in both singular and plural. We can see this with a form like *ip* (sg) vs. *ip-e* (pl) 'tail' (20d); above, we assumed that this stem was underlyingly specified as voiceless ((33)/(34)); the same surface result is achieved if the input is unspecified.

(41) *Short stem singular: unspecified input – voiceless output (ip)*

Sg	/iP/	FINALVLESS	MAX[±vcd]	*VtV]$_{STEM}$	*VDOBS
a. ☺	[ip]				
b.	[ib]	*!			*

(42) *Short stem plural: unspecified input – voiceless output (ipe)*

Sg	/iP+e/	FINALVLESS	MAX[±vcd]	*VtV]$_{STEM}$	*VDOBS
a. ☺	[ip]e				
b.	[ib]e				*!

3.2.5 The end and the beginning

To summarize, two basic proposals interact to produce the pattern of voicing effects seen in Luo. On the one hand, we have rather routine markedness constraints: a constraint requiring phrase-final voicelessness, a stem-delimited constraint requiring intervocalic voicing, and a general markedness constraint against voiced obstruents. These markedness constraints interact with inputs that are unconstrained – exactly as expected given richness of the base. The patterns that result from this interaction are summarized in (43).

(43) *Summary*

	Singular	*Plural*	*Stem*	*UR*	*Example*
a.	voiceless	voiceless	full	voiceless	cupa (sg) vs. cupe (pl) 'bottle'
			short	voiceless; unspecified	ip (sg) vs. ipe (pl) 'tail'
c.	voiced	voiced	full	voiced	ŋudi (sg) vs. ŋudi (pl) 'neck of meat'
d.	voiceless	voiced	short	voiced	alot (sg) vs. alode (pl) 'vegetable'
e.	voiced	voiceless	full	unspecified	kidi (sg) vs. kite (pl) 'stone'

The interim conclusion is that run-of-the-mill faithfulness is fully sufficient to capture the kind of 'voicing polarity' seen in Luo. Moreover, the analysis proposed here explains several points that are problematic for the anti-faithfulness account. First, it is not the case that all stems exhibit voicing polarity. This is a problem for anti-faithfulness but follows in the account here from the proposal that inputs are unconstrained. Second, under the anti-faithfulness account there is no reason why forms exhibiting a voiced obstruent in the singular and a voiceless obstruent in the plural all involve full stems. This property follow here because it is only in full stems that we see the effects of intervocalic voicing. Third, under the anti-faithfulness account there is no reason why forms exhibiting a voiceless obstruent in the singular and a voiced obstruent in the plural all involve short stems. In the account proposed here, this follows from the independently motivated process of phrase-final devoicing.

At least as interesting as any of these points is an important additional fact, namely that segments other than simple obstruents also alternate. We turn to these cases in the next section.

3.2.6 Nasals

Recall that in addition to two series of obstruents (voiced & voiceless), Luo also has two series of nasal stops: (i) prenasalized stops, (ii) nasal sonorant stops. I reproduce the relevant part of the consonant inventory in (44).

(44) *Luo oral and nasal stops*

	Labial	Alveolar	Palatal	Velar
Oral stops	p	t	c	k
	b	d	ɟ	g
Nasal stops	mb	nd	ɲɟ	ŋg
	m	n	ɲ	ŋ

While the symmetry of these two series could prove deceptive, it is certainly plausible that there is a shared feature between the class of voiceless plosives and prenasalized stops, and between the voiced plosives and the nasal sonorant stops. We will see below that there is phonological evidence for exactly such a feature classification.

In terms of their behavior under pluralization, just as with the oral stop series, some stems exhibit consistent values for nasal stops.

(45) *Nonalternating nasals*

	Singular	*Plural*	
a.	rɔmbɔ	romb-e	*sheep*
b.	kendo	kend-e	*hearth*
c.	ɔrɛŋgɔ	ɔrɛŋg-ɛ	*fly switch*
d.	ɔmɪn	ɔmɪn-ɛ	*brother*
e.	ɔmbɔŋ	ɔmbɔŋ-ɛ	*ankle*

There is no statement in Tucker (1994) about the consistently prenasalized cases all being full stems but his examples all are; Tucker does state that consistently nasal sonorant cases are rare, and that the cases observed all involve short stems. Though a full explanation of these asymmetries will not be given here, some discussion will be given below.

A large class of nasal cases exhibit alternations, showing a nasal sonorant in the singular and a prenasalized stop in the plural. For the full set of alternatives with nasals, the change is unidirectional; that is, there are no cases of prenasalized stops in the singular alternating with nasal sonorants in the plural.

(46) *Alternating cases: unidirectional change*

	Singular	*Plural*	
a.	kuon	kuonde	*bread*
b.	ɵʊm	ɵʊmbɛ	*musical instrument*
c.	olemo	olembe	*fruit*
d.	pɪɲ	pɪɲɟɛ	*country*
e.	cɔŋ	coŋge	*knee*

I argue here that an understanding of these alternations involving nasal consonants depends on correctly assessing the features used to distinguish between the various stops of Luo. Given the series in (44), it would be common to assume disjoint features to specify the two oral series and the two nasal series. While [±voiced] would be fairly uncontroversial for the oral series, the nasal series is somewhat less clear. It might be distinguished by [±sonorant] (with the prenasalized stops being [−sonorant] and the nasal sonorant stops being [+sonorant]), or a branching structure might be proposed for the prenasalized stops (the prenasalized stops having a nasal-oral sequence and the nasal sonorant stops being nasal only). I argue here, however, that the phonology of Luo provides evidence for assuming a fundamental parallel between the two series. In both cases, I would suggest that the relevant feature is a fortis-lenis distinction, as per (47).

(47) *Feature specifications for stop series*

	[−nasal]	[+nasal]
[+fortis]	p, t, c, k	mb, nd, ɲɟ, ŋg
[−fortis]	b, d, ɟ, g	m, n, ɲ, ŋ

Phonetically, a fortis oral stop is realized as voiceless, a fortis nasal stop as prenasalized, a lenis oral stop as voiced, and a lenis nasal stop as fully nasal.

With these feature values in mind, there needs to be a reassessment of the constraints proposed for Luo. Regarding faithfulness, if we distinguish voicing in obstruents by [±fortis] instead of by [±voiced], then the relevant MAX constraint needs reformulation:

(48) MAX[±fortis]: Every [αfortis] value in the Input has a correspondent [αfortis] value in the Output.

As for the markedness constraints on voicing, the three constraints seem to be of three different types. The first is a constraint governing intervocalic lenition (*VtV]$_{\text{STEM}}$), the second is a positional markedness constraint (FINALVOICELESSNESS), and the third is a simple segmental markedness constraint (*VDOBS. I will consider each in turn.

For intervocalic lenition, the constraint simply needs to be generalized to require lenited forms for both oral and nasal stops. That is, rather than just requiring that plosives be voiced intervocalically, the constraint should require that both oral and nasal stops be lenis between vowels.

(49) *Intervocalic lenition (revised)*: *Vt/ndV]$_{\text{STEM}}$: *Vowel [+fortis] Vowel; domain = Stem

Turning to the constraint governing phrase-final voicelessness (FINALVOICELESSNESS (24)), recall that this constraint requires that plosives in phrase-final position be voiceless. For plosives, voicelessness is the least marked realization, with voicing marked in general and particularly marked in phrase-final position where cues to voicing are the poorest (Ohala 1990, Steriade 1997, etc.). For prenasalized stops, it is clear that nasal sonorant stops are less marked than prenasalized stops (see, for example, Ferguson 1975). So if we were to invoke a counterpart of phrase-final voicelessness for nasal stops, we might expect the relevant constraint to penalize phrase-final prenasalized stops. As it turns out, evidence will be presented below for precisely such a constraint. Several points are important to note, however, concerning the phrase-final condition on plosives and the phrase-final condition on nasals. The first point is that the two constraints cannot be collapsed. Since the unmarked value for a plosive is fortis and the unmarked value for a nasal is lenis, the two requirements must be expressed as two independent constraints.

(50) *Phrase-final constraints*

a. FINALVOICELESSNESS:	A phrase-final obstruent, [−sonorant, −nasal], must not be [−fortis].
b. *nd]:	A phrase-final nasal, [+nasal], must not be [+fortis].

The second point to note is that there is support for this separation of the two phrase-final effects. While devoicing is a general phrase-final effect (23), the loss of prenasalized stops is not. Tucker (1994:32) notes that prenasalized stops (referred to by Tucker as ‘nasal compounds’) may appear both initially and finally:

(51) *Initial and final prenasalized stops*

a.	mbaka	*conversation*	d.	rɪɛmb	*expulsion*
b.	ndɪra	*dysentery*	e.	tɪnd	*eating sparingly*
c.	ŋgɪma	*health*	f.	lʊŋg	*sting, smart*

Cases such as these show that faithfulness to [±fortis] values must outrank the phrase-final constraint governing nasal stops, but as already seen the phrase-final constraint governing plosives outranks faithfulness:

(52) FINALVLESS >> MAX[±fortis] >> *nd]

The last point concerning the constraint against phrase-final prenasalized stops concerns the generalization that the consistently prenasalized cases tend to be full stems; see (45). In essence, this generalization is simply a lexical manifestation of *nd] markedness: in short forms, where there is a final consonant, that consonant tends not to be prenasalized.

The final markedness constraint to be considered is the context-free markedness constraint, *VDOBS (29). Though a consideration of cross-linguistic markedness might lead us to expect that prenasalized stops would be ruled out by the relevant context-free markedness constraint, the plural alternations suggest that prenasalized stops are for Luo the default value for a nasal. I propose, therefore, that *VDOBS is simply reformulated, generalized and renamed in terms of [±fortis]:

(53) *LENIS: *[C, −fortis]

Given these revised constraints, the grammar for both oral and nasal stops in Luo is the following:

(54) FINALVLESS >> MAX[±fortis] >> *Vt/ndV]$_{\text{STEM}}$ >> *nd] >> *LENIS

The proposed changes will have no substantive effect on plosive alternations. The only new constraint is *nd] which is irrelevant as far as oral plosives are concerned. I consider below the effect of the grammar on nasal stops.

The first significant difference between oral and nasal stops involves the absence of any constraint outranking faithfulness to lexical [±fortis] values. That is, where oral stops can be forced into patterns of alternation by FINALVLESS, the comparable constraint affecting nasal stops (*nd]) is ranked below faithfulness. As a result, if a nasal is lexically specified as either [+fortis] or [−fortis] then that value will be retained in the optimal candidate.

To illustrate for a stem with a lexical [+fortis] value, I give tableaux for *kendo* (sg) vs. *kend-e* (pl) 'hearth' (45b).

(55) *Full stem singular: prenasalized stop input – prenasalized stop output (kendo)*

Sg	/kendo/	FINALVLESS	MAX[±fortis]	*Vt/ndV]$_{STEM}$	*ⁿd]	*LENIS
a. ☺	[kendo]			*	*	
b.	[keno]		*!			*

(56) *Full stem plural: prenasalized stop input – prenasalized stop output (kende)*

Sg	/kendo+e/	FINALVLESS	MAX[±fortis]	*Vt/ndV]$_{STEM}$	*ⁿd]	*LENIS
a. ☺	[kend]e					
b.	[ken]e		*!			*

FINALVLESS is irrelevant both because the rightmost consonant is oral and because it is not phrase-final. MAX[±fortis] guarantees no change in the lexically determined nature of the nasal.

A similar nonalternating type but with a [–fortis] nasal is given in tableaux for *ɔmɪn* (sg) vs. *ɔmɪn-ɛ* (pl) 'brother' (45d).

(57) *Short stem singular: nasal stop input – nasal stop output (ɔmɪn)*

Sg	/ɔmɪn/	FINALVLESS	MAX[±fortis]	*Vt/ndV]$_{STEM}$	*ⁿd]	*LENIS
a. ☺	[ɔmɪn]					*
b.	[ɔmɪnd]		*!		*	

(58) *Short stem singular: nasal stop input – nasal stop output (ɔmɪn)*

Sg	/ɔmɪn+ɛ /	FINALVLESS	MAX[±fortis]	*Vt/ndV]$_{STEM}$	*ⁿd]	*LENIS
a. ☺	[ɔmɪn]ɛ					*
b.	[ɔmɪnd]ɛ		*!			

In contrast to the above examples that do not alternate, we see the nature of the consonant changing when the input happens to have a nasal consonant unspecified for [±fortis]. A full stem example of this type is *olemo* (sg) vs. *olembe* (pl) 'fruit' (46c).

(59) *Full stem singular: unspecified nasal input – nasal stop output (olemo)*

Sg	/oleMo/	FINALVLESS	MAX[±fortis]	*Vt/ndV]$_{STEM}$	*ⁿd]	*LENIS
a. ☺	[olemo]					*
b.	[olembo]			*!		

Because the nasal is intervocalic within the stem, it is subject to lenition and surfaces as a nasal sonorant. In the plural, however, the final stem vowel deletes making lenition inapplicable and the nasal is not phrase-final, so *nd] has no effect. The combined result is that context-free markedness comes into play and the surface result is a prenasalized stop.

(60) *Full stem plural: unspecified nasal input – prenasaizedl stop output (olembe)*

Sg	/oleMo+e/	FINALVLESS	MAX[±fortis]	*Vt/ndV]$_{STEM}$	*ⁿd]	*LENIS
a.	[olem]e					*!
b. ☺	[olemb]e					

With a short stem, the surface result is similar but for different reasons. Consider the example of *kuon* (sg) vs. *kuonde* (pl) 'bread' (46a).

(61) *Short stem singular: unspecified nasal input – nasal stop output (kuon)*

Sg	/kuoN/	FINALVLESS	MAX[±fortis]	*Vt/ndV]$_{STEM}$	*^{n}d]	*LENIS
a. ☺	[kuon]					*
b.	[kuond]				*!	

As with all nasal cases, FINALVLESS is irrelevant. For both the singular and the plural, MAX[±fortis] is irrelevant since this particular stem happens to have a nasal that is underlyingly unspecified for the feature [±fortis]. Again for both the singular and the plural, *Vt/ndV]$_{STEM}$ is irrelevant because the stem is short. The difference between the singular output and the plural output therefore comes down to *nd] and *LENIS. In the singular, *nd] rules out the appearance of a final prenasalized stop resulting in *kuon*; in the plural, *nd] is inapplicable because of the plural suffix, hence *LENIS results in a prenasalized stop being optimal, *kuonde*.

(62) *Full stem singular: unspecified nasal input – prenasalized stop output (kuonde)*

Sg	/kuoN+e/	FINALVLESS	MAX[±fortis]	*Vt/ndV]$_{STEM}$	*^{n}d]	*LENIS
a.	[kuon]e					*!
b. ☺	[kuond]e					

To summarize, the big difference with the nasal alternations as opposed to the voicing alternations is that there is no constraint affecting nasals that overrides faithfulness to underlying values. This means that while both oral and nasal stops are subject to intervocalic lenition within stems, only oral stops are subject to the reverse effect phrase-finally.

3.2.7 Conclusion

If UG is the repository for an inventory of constraints that does not need to be learned, then constraints like anti-faithfulness are expected. Such a constaint is not trivially recoverable from simple relations that are observable and learnable, hence is exactly the kind of constraint that would need to be hardwired. In fact, however, the anti-faithfulness account of Luo turns out to be inadequate. An account that successfully derives both oral and nasal alternations consists instead of constraints that are simple and phonetically transparent. The successful account requires a constraint prohibiting phrase-final voiced plosives, a constraint prohibiting phrase-final prenasalized stops, and a constraint requiring intervocalic lenition within stems. These constraint types are not in and of themselves complex, though their interaction produces surface patterns that are.

A fundamental aspect of the analysis of Luo is the shared property between voiceless plosives and prenasalized stops (both [+fortis]) and between voiced plosives and nasal stops (both [–fortis]). Two points are important regarding this feature. First, it may or may not be universal; under the approach taken here, it could be widely attested but need not be. Second, the feature may go beyond the oral and nasal stop series considered here. Though the primary singular-plural alternations have been identified, Okoth-Okombo (1982) and Tucker (1994) identify additional patterns of alternation.

(63) *Examples of other alternations*

	Singular	*Plural*	
a.	bul	bunde	*drum*
b.	okolo	okonde	*millipede*
c.	taya	tece	*lamp*
d.	koyo	koce	*cold*
e.	pap	pewe	*field*

Such forms raise the possibility of further extending the fortis-lenis pairings. For example, a prenasalized stop could be the fortis variant of a liquid, and a voiceless palatal stop could be the fortis variant of a palatal glide. I leave these issues for future consideration. Additional examples can be found in Okoth-Okombo (1982) and Tucker (1994).

3.3 Locality

To conclude this discussion, I will briefly discuss the issue of locality, a topic to which books could be devoted rather than a few short paragraphs. Again, the theme of the discussion here is whether by reducing the scope of what is in UG we change the nature of the discussion of locality issues. As suggested with respect to other phenomena discussed above, there does indeed appear to be an effect. There is no question that interactions between segments and features tends to be between elements that are local to each other. At issue is whether there should be a hard and fast requirement that interactions be local, something that a meta-condition within UG could certainly do, or whether this requirement should be somewhat softer, as might be the case if constraints are an emergent phenomenon.

Consider the following statement concerning locality in Ní Chiosáin & Padgett (2001): “We assume that locality holds strictly in two senses of “strict”. First, spreading respects *segmental* adjacency… An essential result of this view is that segments are either blockers or participants in spreading; there is no transparency or skipping. Second, segmentally strict locality is inviolable; in Optimality Theoretic terms, Gen does not produce structures in which segments are skipped in a spreading domain”. Clearly, such a restriction is possible with UG. If constraints are emergent, however, it is less clearly possible.

First, to require such strict locality depends on a highly structured UG of precisely the type that is being questioned here. While it might be possible to have a fairly general principle of locality even if features and constraints were emergent, such a rigid interpretation of locality does not seem too likely. Consider, for example, differences between dissimilation and assimilation. In cases of dissimilation (Itô & Mester 1986, Suzuki 1998), there are cases where the interaction is long-distance. *Representations* do not need to violate a strict locality condition (note also Archangeli & Pulleyblank 1994), but *interactions* between segments may not be strictly local. For example, rendaku in Japanese would lead us to expect voicing of the initial consonant of the second member of a compound like *onna-kotoba* ‘feminine speech’ (Itô & Mester 1986). Voicing of the initial consonant of *kotoba* is blocked, however, because of the presence of the voiced obstruent [b]. If, for the purposes of dissimilation, we have interactions between segments that are not adjacent to each other, the problem is how to rule out such interactions in a theory that does not build in phenomenon-specific restrictions into UG. If constraints are emergent, and if UG does not encode construction-specific meta-constraints, then we would expect some degree of nonlocal behavior to be possible with assimilation is it is possible for dissimilation. Neither, of course, would be common since even with dissimilation, purely local interactions are by far the most common (Suzuki 1998).

Certain aspects of assimilation are interesting in this regard. For example, there are cases where assimilation involves a sequence where all intervening segments may be participants, but where they are not always triggers. Consider nasal harmony in Mọ̀bà, a dialect of Yoruba (Ajiboye 2002, Ajiboye & Pulleyblank *in prep*). Vowels in Mọ̀bà contrast in nasality, and a sonorant within a syllable with a nasal vowel must also be nasalized.

(64) *Vowels contrasting in nasality & sonorant harmony*

a.	tà	*sell*	c.	tã̀	*deceive*
	dù	*scramble for*		dũ̀	*sweet*
b.	rì	*drown*	d.	r̃ĩ̀	*walk*
	rù	*carry*		r̃ũ̀	*smell*

This syllable-internal data is comparable to Standard Yoruba (Pulleyblank 1988). Mọ̀bà differs, however, in that harmony is also transmitted leftwards from a nasal vowel in an unbounded fashion.

(65) *Word-level nasal harmony*

a.	ĩỹã́	*pounded yam*
b.	ũ̀ỹĩ̀	*praise*
c.	r̃ĩ́r̃ã̀	*spreading*

The examples in (65) shows nasal harmony affecting sonorant consonants and vowels.

The first issue of interest here is how harmony applies in cases with nasal consonants. As seen in (66a), harmony applies from a nasal vowel through a nasal consonant.

(66) *Nasal consonants: transmitters/transparent, not triggers*

a.	ĩ mṹ	*nose*
	ĩ̀ mã̀	*palm leaf*
	ĩ̀ mã́lɛ̀	*light*
	ũ̀mũmĩ	*drinking cup*
b.	ùmoɟì	*name of a village*
	ì mɛ̀lɛ́	*laziness*
	ùmórù	*personal name*

The cases in (66b), however, show that nasal consonants are not triggers. That is, nasal consonants allow nasality to be transmitted through them, but they do not themselves trigger nasal harmony.

Such cases are interesting in the way they bear on locality. Although the nasal harmony span can be considered 'local' in that it affects a contiguous string of segments, the trigger of harmony cannot be considered to be local to the target.

A further problem involves cases where intervening segments are *not* participants in harmony. Further examples from Mọ̀bà illustrate this too. When obstruents occur between an eligible trigger and an eligible target, harmony applies over the obstruent even though the obstruent itself is not nasalized.

(67) *Obstruents: transparent, neither undergoers nor triggers*

ĩ̀ tã̀	*story*
ĩ̀ dũ	*bed bug*
ĩ̀ sũ̀gbĩ̀	*traditional singers*

These cases, though less common than strictly local harmony, seem to constitute cases where the triggers and targets of harmony are not string-adjacent.

One last case that I will mention here is a case of height harmony in C'Lela (Dettweiler 2000, Pulleyblank 2002) where a root vowel causes a word-final vowel to agree in height. The word-final vowel may be in an adjacent syllable (the rightmost column of (68)) or it may be separated from the trigger by a syllable (the leftmost column of (68)). Not only does the harmony in this case not involve vowels that are adjacent, the intervening segment is a high vowel which could itself have undergone lowering but does not.

(68) *C'Lela height harmony* clela1

a.	u-rim-u-ni [rim-u-ni]	*CM-black-CM-ADJM*	u-rim-u [rim-u]	*CM-black-CM*
b.	u-rek-u-ne [rek-u-ne]	*CM-small-CM-ADJM*	u-rek-o [rek-o]	*CM-small-CM*

These and other cases suggest that strict locality may be too restrictive. It seems that though segments that intervene in harmony may be participants, they may not always be a trigger – in the sense of an iterative harmonic process. Indeed, intervening segments may even be non-participants, even in cases where the non-participating segment may be fully compatible with the harmonic feature. Such 'softness' of a locality condition suggests that locality should be viewed more as a tendency that as a hard constraint. To the extent that a locality constraint under a UG approach should be inviolable while a locality constraint under an emergent framework would be expected to show some degree of flexibility, such cases argue in favor of an emergent framework.

4 Conclusion

Generative phonology has routinely assumed that much of what is universally found in natural language phonologies results from properties of an innately specified Universal Grammar. As such, it is commonly assumed that there is a single, universal set of distinctive features, that segment types are always specified in the same way cross-linguistically, that the same constraints on features are found in all languages, always formulated in the same way. This research enterprise leads one to look for 'hard' universals: feature definitions, deterministic means of choosing which features are used in grammars, strict interpretations of restrictions on ternarity, locality, and so on. It has been suggested here that the evidence for such universality of features and constraints is less compelling than one might think. If UG governs phonologies in a prescriptive way, we expect a finite (and perhaps quite small) set of recurrent featural categories; we expect consistency cross-linguistically among consonant and vowel inventories; we expect segment types to behave according to their UG attributes (for example, laterals should behave like stops, or like continuants, but not both); binary features should behave like binary features; constraints should involve strictly adjacent sets of segments; wild and interesting constraints should be found – and found in language after language. In short, if UG governs phonology, then phonological features should be less transparent (whether synchronically or diachronically) but more regular. Phonologies should be quirky in specific, recurrent ways, but should be well-behaved in the way they respect constraints.

What we actually observe, however, is something rather different. Natural language phonologies seem to exploit in fairly unpredictable ways a rather full array of opportunities made transparently available by properties of the vocal tract and auditory system. While there is little doubt that some properties of human language require language-specific cognitive mechanisms, it is only by rigorously ruling out other sources for patterns that we can discover the linguistic core. The cases considered here suggest that a great deal of the substance of phonological representations and constraints needs to be learned on the basis of highly general mechanisms rather than linguistically specific ones.

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