Voicing Polarity in Luo

1 Introduction

Alderete (2001) cites voicing alternations in Luo plural and possession marking as compelling evidence for transderivational antifaithfulness (TAF) constraints. In this paper, I show that a TAF analysis of Luo plural formation meets empirical problems, and argue for an alternative approach based on the interaction of faithfulness and markedness constraints in a containment-based version of Optimality Theory (van Oostendorp, 2006b; Revithiadou, 2007). The Luo data which have been taken as decisive evidence for a genuinely non-additive type of morphology turn out to be fully compatible with a conception of morphology which is broadly concatenative.

The paper is organized as follows: Section 2 discusses the data from Luo plural formation as they have been generally received in the literature, and introduces the details of Alderete's analysis. In section 3, I develop a fuller picture of the plural data, and argue that the antifaithfulness approach makes predictions which are not borne out, but also fails to capture significant restrictions on voicing alternations. The formal framework assumed in this paper is introduced in section 4. An alternative analysis of the plural data is developed in section 5, and extended to voicing alternations in possessive constructions in section 6. In section 7, I compare the analysis with other reductionist approaches to Luo voicing polarity. Section 8 discusses the repercussions of the obtained results for phonological theory.

2 Voicing polarity in Luo

Luo (also called Dholuo in the literature) is a Western-Nilotic language spoken in Kenya and parts of Uganda with the sound inventory shown in (1) and (2):

(1) **The vowel inventory of Luo**

[+ATR]		**[–ATR]**	
i	u	ɪ	ʊ
e	o	ɛ	ɔ
ɐ		a	

(2) **The consonant inventory of Luo**

Voiceless stops	p	t̪	t	c	k	(ʔ)
Voiced stops	b	d̪	d	ɟ	g	
Prenasalized Stops	mb	n̪d̪	nd	ɲɟ	ŋg	
Nasals	m		n	ɲ	ŋ	
Fricatives	f		s			h
Non-nasal Sonorants	w		l/r	j		

Luo shows pervasive tonal sandhi processes and [ATR] harmony which I will largely ignore in this paper. Note however that – apparently under lexical control – [+ATR] *a* sometimes gets *ɐ* and sometimes *e* under vowel harmony:

(3) **Harmonic behavior of *a***

	sg	**pl**		
a.	bat	bed-e	'arm'	(Okoth-Okombo, 1982:30)
b.	lá:c	lɐ:c-e	'urine'	(p. 130)
c.	bă:t̪	bé:t̪-ê/bé:t̪-ê	'side'	(p. 130)

Stress which is phonetically mainly expressed by vowel lengthening appears without exceptions on the last syllable of consonant-final roots (e.g. *ɐri:p*, 'Milky Way', p. 128) and on the penultimate syllable of vowel-final roots (e.g. *ɔt̪î:t̪ɔ*, 'small thing', p. 130), where it remains independently of affixation. In the following, I will notate tone and vowel length only in the first citation of a word form since the first is irrelevant for the analysis, and the latter completely predictable.[1]

Theoretical treatments of voicing polarity are largely based on data from **?** and Okoth-Okombo (1982), but the most comprehensive grammar of Kenya Luo is Tucker (1994) which will be the primary source of my analysis.[2] In the text, page numbers without explicit source refer generally to Tucker's grammar.

The type of data usually discussed in the literature on Luo voicing polarity is illustrated in (4) and (5). The voicing alternation is found with the productive nominal plural affix *-e* and its (lexically restricted) allomorph *-i*, where plural formation does not only involve affixation, but also changing the voicing of the last root consonant. If this is a voiced stop in the singular it turns voiced in the plural (4), and if it is voiced in the singular it gets voiceless in the corresponding plural form (5):

[1] Data from other sources usually omit tonal and length information, and also in some of Tucker's data predictable length is omitted. Apart from transliteration to IPA symbols, I give the data as they are in the primary source.

[2] This book has been edited by Chet Creider after Tucker's death.

(4) **Voicing exchange [–voice] → [+voice]**

	sg	**pl**		
a.	bat	bed-e	'arm'	(Okoth-Okombo, 1982:30)
b.	lut̪	lud̪-e	'walking stick'	(Okoth-Okombo, 1982:30)
c.	ɐri:p	ɐri:b-e	'milky way'	(p. 128)
d.	guok	guog-i	'dog'	(Okoth-Okombo, 1982:30)

(5) **Voicing exchange [+voice] → [–voice]**

	sg	**pl**		
a.	ki:dí	kí:t-ê	'stone'	(p. 128)
b.	ɔkɛ̂:bɛ	okɛ́:p-ɛ̂	'tin can'	(p. 127)
c.	cogo	cok-e	'bone'	(Okoth-Okombo, 1982:30)

A straightforward brute-force attack to this phenomenon has been proposed in **?** (**?**:106) who invokes the alpha-rule in (6) (slightly simplified here) triggered by the plural affix *-e* (cf. also Okoth-Okombo, 1982:61 for a similar rule):

(6) $\begin{bmatrix} \text{–voc} \\ \text{+con} \\ \alpha\text{voiced} \end{bmatrix} \rightarrow [-\alpha\text{voice}] / \_\_ \text{ [Pl -e]}$

In a constraint-based framework such as Optimality Theory, rules of this type cannot be formulated. In fact, the Luo data seem to be highly problematic for OT which is basically restricted to faithfulness and markedness constraints (Moreton, 2004): The change from *d* to *t* in (5a) violates a faithfulness constraint (IDENT [voice]) and while devoicing of a stop reduces markedness, this does not explain why devoicing only happens in the plural, and not in the phonologically crucially identical singular form. Even if markedness constraints forcing devoicing could be restricted to the plural forms, this seems to be at odds with the fact that forms which have unvoiced stops in the singular voice them in the plural forms.

Alderete (2001) (the same analysis can also be found in Alderete, 1999) takes these problems as evidence that OT must be complemented by a new constraint type, so-called *transderivational antifaithfulness* (TAF) constraints which require that the output of a derived form and the output of its morphological base differ for a specific property. More specifically, Alderete assumes that for every faithfulness constraint such as IDENT [voice] there is a corresponding antifaithfulness constraint (here: ¬IDENT [voice]):

(7) **Faithfulness and anti-faithfulness for [voice]**

a. IDENT [voice]
Corresponding segments agree in the feature [voice].

b. ¬IDENT [voice]
It is not the case that corresponding segments agree in the feature [voice].

The tableau in (8) shows how (7b) ranked above (7a) allows to derive voicing exchange in Luo. ¬IDENT [voice] requires to change the voicing of at least one segment, which rules out the c.-candidates. However, additional voicing changes as in the b.–candidates are blocked by IDENT[voice]:

(8) **Voicing exchange in Luo as antifaithfulness**

Base		Derivative	¬IDENT [voice]	IDENT [voice]
i. /bat/	☞	a. bed-e		*
		b. ped-e		**!
		c. bet-e	*!	
ii. /cogo/	☞	a. cok-e		*
		b. ɟok-e		*!*
		c. cog-e	*!	

Other constraints not discussed in detail by Alderete are necessary to ensure that the voicing change occurs consistently in the last root consonant to block e.g. *pet-e*, which fares equally well as (8-i-a) since it differs from *bat* by a voicing change in the initial stop.

Alderete claims further that, in contrast to faithfulness constraints, TAF constraints are always morphologically triggered, i.e. every TAF constraint is restricted to specific morphological constructions which means in most cases particular affixes. Thus ¬IDENT [voice] is associated to the plural affixes *-i* and *-e*, but not to the third plural allomorph *-ni* which does not exhibit voicing exchange:

(9) **No voicing exchange with plural -ni**

	sg	**pl**		
a.	kó:mbé	ko:mb-ni	'hole in a tree'	(p. 126)
b.	pɔ́:kɔ̂	po:k-ni	'gourd'	(p. 127)

3 A fuller picture of the data

While Alderete's analysis captures two important patterns in Luo plural formation, it predicts other types of alternations which are not or only marginally attested in the language, and excludes other patterns which are well-documented. First, there are no nouns following the hypothetical alternation in (10), where a noun ends in a voiced stop in the singular which

becomes unvoiced in the plural:

(10) *bad (sg.) bet-e (pl.)

In fact Tucker (p. 97) explicitly states that "the voiced consonants b, dh, d, j, g, and y [b,d̪, d, ɟ, and g] cannot occur finally in the free forms of short stems". A second pattern which is predicted to occur regularly according to Alderete's analysis are vowel-final roots which have a voiceless stop in the singular and a voiced one in the plural. This pattern is exemplified by the nouns in (11):[3]

(11) **Vowel-final [–vc] → [+vc] alternations**

	sg	**pl**		
a.	agɔ:kɔ	agɔ́g-ɛ̂	'chest'	(p. 491)
b.	koti	kod-e	'coat'	(English; Okoth-Okombo, 198254)
c.	ongeti	onged-e	'blanket'	(English; Okoth-Okombo, 198254)

However, the example in (11a) is the only example of this type in Tucker's grammar and the noun has a second plural variant without voicing (*agɔ́k-ɛ̂*, p.491). (11b) and (11c) are loanwords cited in Okoth-Okombo (1982).[4] Thus the status of this pattern is at most marginal in Luo.

On the other hand, many noun roots which take *-e* as their plural suffix have final stops which do not alternate for voicing. (12) contains cases with vowel-final, and (13) with consonant-final singular forms:

(12) **Vowel-final non-alternating roots with [–vc] stop**

	sg	**pl**		
a.	cu:pɐ	cú:p-ê	'bottle'	(Swahili; p. 130)
b.	ɔt̪̂:t̪ɔ	ɔt̪̂:t̪-ɛ̂:	'small thing'	(p. 130)
c.	osi:kí	osí:k-ê	'stump'	(p. 130)
d.	ɔkɔ̂:cɔ	ɔkɔ̂:c-ɛ̂	'neck rest of sisal trunk'	(p. 130)

(13) **Consonant-final non-alternating roots with [–vc] stop**

	sg	**pl**		
a.	í:p	i:p-e	'tail'	(p. 130)
b.	ŋu:t	ŋú:t-ê	'neck'	(p. 130)
c.	la:k	lé:k-e	'tooth'	(p. 130)
d.	bă:t̪	bɛ́:t̪-ê/bé:t̪-ê	'side'	(p. 130)

In addition, there is one word with a voiced stop in the singular which gets not unvoiced in the plural:

[3] In the following, the source language for loan words is indicated after examples.

[4] See section 5.6 for a discussion on the relevance of loanwords for voicing polarity.

(14) ŋu:di (sg.) ŋu:d-e (pl.) ‘neck of meat’ (p. 131)

(15) summarizes the voicing alternation patterns found in Luo and the extent to which they are documented in the data:

(15) **Voicing patterns in Luo**

		singular	**plural**	
V-final Root	a.	[–voice]	[+voice]	**well-attested**
	b.	[–voice]	[–voice]	
	c.	[+voice]	[–voice]	**marginal**
	d.	[+voice]	[+voice]	
C-final Root	e.	[–voice]	[+voice]	**well-attested**
	f.	[–voice]	[–voice]	
	g.	[+voice]	[+voice]	**not attested**
	h.	[+voice]	[–voice]	

The analysis I propose reflects the different status of these patterns by providing an analysis based on general phonological constraints for the well-attested patterns (15-a,b,e,f), while the marginal patterns (15-c,d) are derived by morphological particularities of the involved roots. In particular, I propose that nouns which are underlyingly voiceless do never alternate. This accounts for the vowel- and consonant-final roots which have a voiceless final stop in singular and plural (15-b,f). All alternating roots have underlyingly a voiced final consonant. What happens with consonant-final roots (15-e) which are underlyingly voiced is straightforward final devoicing. Accordingly the noun *bat* has the underlying form *bad* which surfaces in the plural, while *d* is devoiced in word-final position to *t*. What causes final devoicing is a general constraint of Luo which allows voiced obstruents only if they are licensed by an immediately following (voiced) sonorant. Hence in vowel-final roots such as *kidi* (15-a), the underlyingly voiced *d* surfaces as such since its voicing is licensed by the following *i*. In the plural, the root vowel, while deleted on the surface (*kidi-e* → *kide*), blocks licensing of *d* by suffixal *e* since licensing is not possible across segments which are underlyingly non-adjacent. This analysis will be developed in technical detail in the following two sections.

4 Preliminaries

4.1 Theoretical framework

The version of OT I use here is a variant of the Colored Containment version of Optimality Theory developed in van Oostendorp (2006b) and Revithiadou (2007). The central assumption of all versions of Containment Theory is that segments, features are never literally deleted, and are hence “contained” in the output, which has important consequences for the analysis of incomplete neutralization (van Oostendorp, 2006a) and opacity (see the discussion of Luganda

and of Dutch dialects below).

Colored Containment crucially departs from the classical implementation of containment in Prince and Smolensky (1993) in the representation of epenthesis. Whereas Prince and Smolensky equate epenthesis with unfilled prosodic positions, which causes serious problems for the interaction of empty segments with their phonological context (van Oostendorp, 2006b:6), Colored Containment exploits the widely held assumption that underlying phonological material is morphologically affiliated and – following Consistency of Exponence (McCarthy and Prince, 1993) – maintains this affiliation throughout the phonology. This assumption is made concrete by morphological coloring: Each morpheme has a unique color different from the colors of all other morphemes, and each non-epenthetic element in phonological structure wears the specific color of its morpheme throughout the grammar. This makes underlying (morphemic) material representationally distinct from epenthetic elements which are colorless.

A second major difference between different versions of Containment Theory is the treatment of deletion. Whereas Revithiadou and van Oostendorp capture the distinction between deleted and phonetically realized material by an adaptation of Goldrick's (2000) turbidity model, I will implement this difference in a more traditional autosegmental system which highlights the fact that phonology is the interface between morphology (or morphosyntax) and phonetics. Under this view, phonology has the option of producing representations which are (partly) invisible to either phonetics or morphology. "Epenthesis" corresponds to phonological material which is phonetically visible, but not morphologically visible, where morphological visibility implies morphological color and vice versa. Phonological material which is morphologically visible, but phonetically invisible (not pronounced) corresponds to "deletion". This results in a 2×2 typology of phonological visibility:

(16) **Typology of phonological visibility**

		morphologically visible	
		+	**–**
phonetically visible	**+**	realized underlying material	epenthetic material
	–	unrealized underlying material	

Output representations conform to the three unviolable wellformedness conditions in (17):[5]

(17) **Unviolable wellformedness conditions on phonetic visibility**

a. Phonological objects are either morphologically or phonetically visible (or both)

b. Phonetically visible links connect only phonetically visible structure

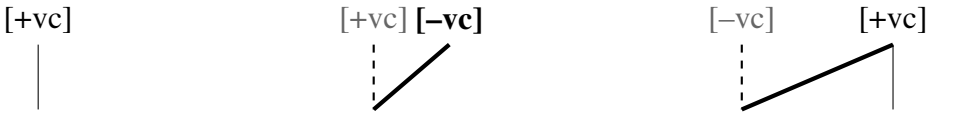
[5]A main reason for assuming the conditions in (17) is that they substantially restrict the sense of possible candidates, which allows more stringent ranking arguments. It is likely that (17-a) and (17-b) follow as theorems from an adequately constrained theory of possible constraint types, and (17-c) might be dropped in a theory which involves phonetically realized extrametrical elements.

c. Phonetic structure must be phonetically linked to higher phonetic structure (if there is any)

(17a) captures the intuition that structure which is neither motivated by morphological nor by phonetic evidence is uninterpretable and universally excluded. It follows that the fourth cell in (16) is empty, and the inventory of visible elements reduces to three possibilities: morphologically visible material which is phonetically visible or invisible, and epenthetic material (phonetically visible material which is morphologically invisible). (18) illustrates the notation I adopt to indicate visibility. Material which is morphologically and phonetically visible is written in normal print, morphological material which is phonetically invisible appears shaded, and phonetic material which is morphologically invisible is written in boldface. Hence, all three strings in (18) are phonetically interpreted as [bete]. In (18a) this corresponds to underlying /bete/, while the input for (18b) is /bet/ (with epenthetic [e]), and (18c) shows underlying /betep/ with deleted /p/:[6]

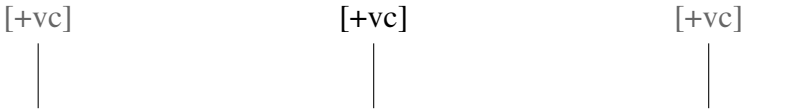
(18) a. b e t e b. b e t **e** c. b e t e p

Since for association lines, shading is difficult to read, I will replace it by dashed lines. (19a) shows an underlyingly voiced stop which is realized faithfully, (19b) is an underlyingly voiced stop under overt devoicing ([–vc] and its link are epenthetic), and (19c) shows a case where a stop assimilates in voicing to a following nasal:[7]



(19) a. [–son–cont] b. [–son–cont] c. [–son–cont][+son–cont]

The condition in (17-b) bans configurations as in (20), where elements which are phonetically invisible are connected by a phonetically visible association line:

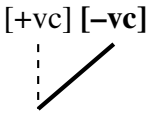


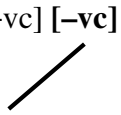
(20) a. [–son–cont] b. [–son–cont] c. [–son–cont]

The condition in (17-c) corresponds to stray erasure (Steriade, 1982; Itô, 1988). It excludes floating features in surface representations since this would require either the representation in (21a) or (21b) which both violate (17-c).

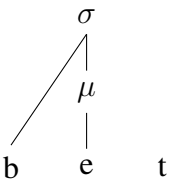
[6]The advantage of this notation is that it does not require any diacritics and can be combined with coloring wherever representation of morphological coloring is relevant and possible.

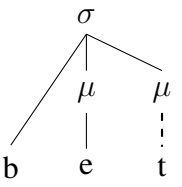
[7]I assume that [+/–sonorant] and [+/–continuant] are not part of the root-node (cf. appendix B.1), but use the more standard root node representation her for the exposition of the formalism.

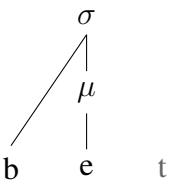
(21) a. 

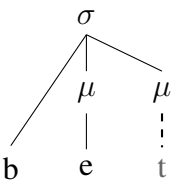
b. 

The same condition also has the effect that "extrametrical" segments must be phonetically invisible since the structures in (22) are excluded, only the corresponding structures in (23) are possible:

(22) a. 

b. 

(23) a. 

b. 

Let us finally see how the framework proposed here can capture cases of opacity which are the central motivation for the turbid version of Colored Containment. An often cited case in point is the deletion of vowels under hiatus before another vowel in Luganda which leads to compensatory lengthening of the surviving vowel (Goldrick, 2000:2):

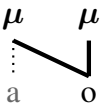
(24) **Compensatory lengthening in Luganda**

a. /ka + tiko/	→	katiko	'mushroom'
b. /ka + oto/	→	ko:to	'fireplace (dim.)'
c. /ka + ezi/	→	ke:zi	'moon (dim.)'

These data lead to an opacity problem for Correspondence Theory because the mora associated to the first vowel (*a* in (24b)) seems to reassociate to the second vowel (*o* in (24b)), but under Richness of the Base (Prince and Smolensky, 1993) nothing forces *a* to project a mora in the first place since constraints requiring vowels to associate to moras apply – like any other OT-constraint – to outputs, not to inputs. However if van Oostendorp (2006a:8) is right in assuming that "an association line is not a phonological object on a par with features and segments, but . . . rather describes a relation between two phonological objects", association lines are exempt from the condition in (17-a) and there are association lines which are both morphologically and phonetically invisible. Assuming a constraint which requires that every vowel (whether phonetically visible or not) is associated to a phonetically visible mora[8], an output structure

[8]Strictly speaking, the constraint must require that each vowel is linked to a mora which is not linked to an other vowel by an association line of the same phonetic visibility status. This is necessary to avoid that *a* and *o* in (25) link to one and the same mora, but extends also to cases of two overt vowels which do generally not share moras.

such as (25) results for (24b) (where a dotted line indicates a link which is phonetically *and* morphologically invisible):

(25) 

The visibility of the association line which links the leftmost mora in (25) to *a* follows from the representation: Since the mora is epenthetic, the association line must be morphologically invisible. Since *a* is phonetically invisible, the association line must also be phonetically invisible by (17-b). Compensatory lengthening results from a requirement that phonetically visible moras must be linked to phonetically visible root nodes.

4.2 Constraints

The constraints I assume are fairly standard or motivated straightforwardly by empirical evidence, but the technical details of implementation are crucial for the analysis of voicing polarity in section 5. Following Wetzels and Mascaró (2001), I assume that feature identity is captured by different IDENT constraints for [+voice] and [–voice] in the following format:

(26) **ID [+vc]:** Every segment which is morphologically associated with [+vc] is phonetically associated with [+vc]

(27) **ID [–vc]:** Every segment which is morphologically associated with [–vc] is phonetically associated with [–vc]

Note that these constraints do not penalize segments which are linked to different voicing features in input and output as long as the value of the feature is the same. In other words, they require linking to identical types, not to identical tokens.

Further, I follow Lombardi (1994, 1995) in assuming that final devoicing and a number of other processes involving voicing are triggered by a licensing condition on the feature [+voice] which I formulate in (28). Incorporating a basic insight from Steriade (1997)[9], (28) is not restricted to licensors and licensees which are in the same syllable, but requires only that both elements are phonetically adjacent and are linked to the same voicing feature:[10]

(28) **LICENSING CONSTRAINT** (Lombardi, 1994, 1995; Steriade, 1997):
A [+vc] obstruent should be phonetically visible through a phonetically right-adjacent sonorant in the same voicing span.

I take the voicing of stops and right-adjacent nasals to be governed by the constraint in (29):

[9]Steriade shows that in Lithuanian voiced obstruents are only possible if they are followed by a sonorant, even though both are separated by a syllable boundary. This follows from the licensing constraint as it is formulated here, but not from Lombardi's original version.

[10]Two segments are phonetically adjacent if no phonetically visible segment intervenes between them.

(29) **(TN):** Stops and phonetically right-adjacent nasals
should be linked to the same voicing feature.

This accounts for example for cases where pre-nasal stops get voiced as in Tangale where underlying stops get voiced before the nasal-initial suffix *-no* (Kidda, 1993; Kenstowicz, 1994), as shown in (30c-d) (the underlying voicing contrast is neutralized in bare nouns by final devoicing, but visible before the definite suffix *-i*):

(30) **Voicing of stops before nasals in Tangale**

	'N'	**'the N'**	**'my N'**	
a.	bugat	bugat-i	bugad-no	'window'
b.	aduk	aduk-i	adug-no	'load'
c.	tugat	tugad-i	tugad-no	'berry'
d.	kuluk	kulug-i	kulug-no	'harp'

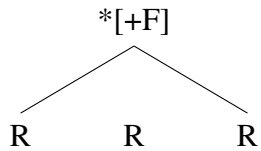
While Luo does not exhibit voicing assimilation of this type, I will show in section 5 that (29) leads to the licensing of voiced stops before nasals which would otherwise be devoiced.

The last type of constraints we need for an analysis of Luo voicing polarity are constraints penalizing autosegmental spans which skip intervening elements. Besides the more familiar constraint in (31) which only counts skipping of phonetically realized elements,[11] it is natural in a containment model of phonological representations that intervention effects of this type generalize to phonetically invisible elements. This intuition is captured by the constraint in (32):

(31) **NoSkipping-Vis:** Phonetically visible association spans
should not skip phonetically visible root nodes

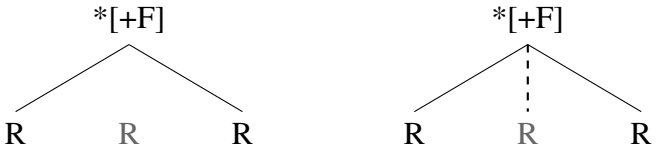
(32) **NoSkipping:** Phonetically visible association spans should not skip root nodes

Thus the configuration in (33) violates both, (31) and (32), but the structures in (34) violate only (32):

(33)


[11] This constraint is often claimed to be inviolable (see e.g. Gafos, 1999; Walker, 1999), a point which is not crucial for the argumentation here.

(34)



Evidence for the generalized Noskipping constraint in (32) comes from assimilation data in different varieties of Dutch. Thus van Oostendorp (2004) observes that in Hellendoorn Dutch, nasal suffixes assimilate in place to preceding stops (35a,c). However, in past tense forms, where an intervening underlying stop (the past tense suffix) is deleted, no assimilation takes place (35b,d):

(35) **Blocking of place assimilation in Hellendoorn Dutch** (van Oostendorp, 2004:2-3)

		Underlying	**Surface**
a.	'to work'	wɛrk-n	wɛrk̩ŋ
b.	'we worked'	wɛrk-t-n	wɛrk̩n
c.	'to hope'	hop-n	hop̩m
d.	'we hoped'	hop-t-n	hop̩n

Similarly, in Aalst Dutch nasals regularly assimilate to following obstruents in place across word boundaries (36a), but fail to assimilate if the underlying representation contains an intervening schwa (the gender marker) (36b):

(36) **Blocking of place assimilation in Aalst Dutch** (van Oostendorp, 2004:17)

		Underlying	**Surface**
a.	'handsome guy'	schoo/n/ ventje	schoo/ŋ/ ventje
b	'beautiful woman'	schoo/nə/ vrouw	schoo/n/ vrouw

Assuming that nasal assimilation is triggered by a constraint which requires that nasals are associated to the same place features as preceding stops, written here simply as PA ('Place Assimilation'), the contrasts in (35) follow from higher ranked NOSKIPPING (abbreviated in the following as NOSKIP) as shown in (37) and (38).[12] The brackets in (37b) and (38b) indicate that the included segments are linked to the same place feature.

(37) **Input:** wɛrk-n, 'to work'

	NOSKIP	PA
a. wɛrk-n		*!
☞ b. wɛr(k-ŋ)		

[12]Note that t cannot be linked to the same place feature as *k* and the nasal since this would violate condition (17-b).

(38) **Input:** wɛrk-t-n, ‘we worked’

	NoSkip	PA
☞ a.wɛrkt-n		*
b. wɛr(kt-ŋ)	*!	

The Aalst Dutch data can be obviously captured by the same type of analysis.

5 Voicing alternations in plural forms

The constraints introduced in section 4.2 allow now a straightforward account for apparent voicing polarity in Luo. Subsection 5.1 lays out the basic analysis for nouns with a final stop (or final stop-vowel syllable) and the plural suffixes *-e* and *-i*. Subsections 5.2, 5.3 and 5.5 extend the analysis to noun classes with different phonological or morphological properties. Subsection 5.4 sketches an account of root-final vowel deletion, which triggers devoicing in the plural of vowel-final roots, and subsection 5.6 treats exceptional nouns.

5.1 Basic analysis

I take consonant-final roots which exhibit a voiced stop in the singular, and a voiced one in the plural as a straightforward case of final devoicing. In the singular, a voiced stop in word-final position violates the Licensing Constraint. Since extending the voicing span of the stop to the left (indicated by the brackets in (39c)) would not remediate this situation, and other repair operations (especially deletion of the stop or insertion of a vowel after the stop) seem to be generally excluded in Luo, the only option is to devoice the final stop (recall that devoicing amounts technically to the structure in (19-b):

(39) **Input:** ʋrib, ‘milky way’

	Id [–vc]	(TN)	NoSkip	Lic	Id [+vc]
☞ a. ʋrip					*
b. ʋrib				*!	
c. ʋr(ib)				*!	

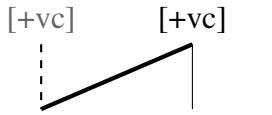
In plural forms, the root-final stop is followed by a vowel which opens the possibility to satisfy both, Licensing Condition and Id [+vc], by forming a voicing span which comprises the stop and the vowel (40a):

(40) **Input:** ʋrib-e, ‘milky way (pl.)’

	Id [–vc]	(TN)	NoSkip	Lic	Id [+vc]
☞ a. ʋri(b-e)					
b. ʋrip-e					*!
c. ʋrib-e				*!	

The voicing span in (40a) abbreviates the structure in (41), which involves relinking, but satisfies ID [–vc] since both sounds which link to an instance of [+vc] morphologically also link to an instance of [+vc] phonetically.

(41)



The same strategy of licensing a voiced stop by relinking it to the [+vc] feature of a following vowel applies in the singular forms of vowel-final roots with an underlyingly voiced stop. Since nothing intervenes, voicing of the stop is licensed without complications by forming a [+vc] span with the following vowel:

(42) **Input:** kidi, 'stone'

	ID [–vc]	(TN)	NOSKIP	LIC	ID [+vc]
☞ ki(di)					
kidi				*!	
kiti					*!

NOSKIPPING gets only relevant in the corresponding plural form where the stem-final vowel is deleted, hence becomes phonetically invisible. Voicing of *d* cannot be licensed by *i* since the LICENSING CONDITION requires licensing by a phonetically visible segment. However, to be licensed by *e*, *d* would have to be linked to the same voicing feature skipping *i*, (43a) which incurs a fatal NOSKIP violation:

(43) **Input:** kidi-e, 'stone (pl.)'

	ID [–vc]	(TN)	NOSKIP	LIC	ID [+vc]
a. ki(di-e)			*!		
b. ki(di)-e				*!	
☞ c. kiti-e					*

Roots with final stops which are underlyingly voiceless remain voiceless in the output due to high-ranked ID [–vc]:

(44) **Input:** ip, 'tail'

	ID [–vc]	(TN)	NOSKIP	LIC	ID [+vc]
☞ ip					
ib	*!			*	

(45) **Input:** ip-e, ‘tail (pl.)’

	ID [–vc]	(TN)	NOSKIP	LIC	ID [+vc]
☞ ip-e					
i(b-e)	*!				
ib-e	*!			*	

The same holds if the voiceless stop is followed by a root-final vowel:

(46) **Input:** osiki, ‘stump’

	ID [–vc]	(TN)	NOSKIP	LIC	ID [+vc]
☞ osiki					
osigi	*!			*	
osi(gi)	*!				

(47) **Input:** osiki-e, ‘stump (pl.)’

	ID [–vc]	(TN)	NOSKIP	LIC	ID [+vc]
☞ osiki-e					
osigie	*!			*	
osi(gie)	*!		*		

Summarizing, apparent polarity follows from a unique phonological source: Underlyingly voiced stops can only retain voicing if they are followed by a sonorant without intervention. For stop-final roots this means devoicing in the singular since the obstruent ends up in word-final position. On the other hand, vowel-final roots devoice in the plural because the deleted root-final vowel blocks licensing. In contrast to the Dutch and Luganda data, discussed in section 4.2, the intervention effect triggered by the phonetically invisible vowel could not be emulated through rule ordering: If licensing would apply before vowel deletion, the voiced stop would be licensed by the root vowel. If licensing would apply after vowel deletion, the stop would be licensed by the affix vowel. Thus devoicing in vowel-final roots is a case of genuinely non-derivational opacity.

5.2 The status of j

In one case, the voicing alternation discussed so far for stops seems to extend to a sonorant and to involve also a manner alternation. The segment transcribed as *j* by Tucker[13] is devoiced and hardened to *c* in the singular of consonant-final roots (48a-b), and in the plural of vowel-final roots (48c-d), hence exactly the same contexts where voiced stops devoice:[14]

[13]Tucker who uses Kenya Luo orthography actually writes *y* which he describes as a semi-vowel (p. 33).

[14]Other sonorants show morphologically triggered manner alternations, but no devoicing in plural forms. See appendix B.1 for an analysis.

(48) **Stopping**

	sg	**pl**		
a.	ti:c	tí:j-ê	'work'	(p. 128)
b.	ɪ:c	í:j-ê	'belly'	(p. 128)
c.	bi:je	bí:c-ê	'white ant(s)'	(p. 128)
d.	ŋgá:jî	ŋge:c-e	'paddle'	(p. 128)

Moreover, as Tucker notes, *j* never occurs in word-final position (p.35) just as if it were an obstruent, and no similar pattern is found with vowel-final roots, i.e., there are no hypothetical alternations like *bice ~ bije*. All these facts follow naturally if the sound transcribed as *j* is analyzed as a voiced fricative, hence *ʝ*,[15] under the assumption Luo systematically lacks the voiceless counterpart *ç* which I will exclude here simply by the ad-hoc constraint *ç. (49) shows how this captures devoicing and stopping for the noun *ɪc*, 'belly'. The analysis for *bije* is analogous:

(49) **Input:** ɪʝ, 'belly'

	*ç	ID [–vc]	(TN)	NOSKIP	LIC	ID [+vc]
☞ ɪc						*
ɪʝ					*!	
ɪç	*!					*

5.3 Plurals in -ni

An apparent problem for a purely phonological account of voicing polarity is the fact that it does not occur with nouns forming their plural by the affix *-ni*[16] instead of *-e* or *-i* (cf. Alderete, 2001:210):[17]

[15] A comparable case of an apparent approximant which behaves phonologically as a fricative is the *j* sound in German (cf. Eisenberg, 1998).

[16] According to Tucker (p.127) nouns which take *-ni* are much rarer than those with select *-e* or *-i*.

[17] Tucker (p.127) cites only 3 consonant-final roots which take *-ni*. All three end in sonorants and do not exhibit any voicing alternation.

(50) **Nouns forming the plural with *-ni***

	sg	**pl**		
a.	gɔ:gɔ́	gɔ:g-nɪ	“lump of clay”	(p. 126)
b.	pɛ́:dɔ̂	pɛ:d-ni	“thorny rambler”	(p. 127)
c.	aba:já	ʋbe:ɟ-ni	“large spear”	(p. 127)
d.	oké:bé	oke:b-nî	“rich man”	(p. 127)
e.	pɔ́:kɔ̂	po:k-ni	“gourd”	(p. 127)
f.	ŋgʉ́:tó	ŋge:t-ni	“clog”	(p. 127)
g.	fú:kó	fu:k-ni	“mole”	(p. 126)
g.	kúé:sí	kue:s-ni	“pipe”	(p. 126)

LICENSING CONSTRAINT and NOSKIP let expect that in a form such as *gɔg-nɪ* (represented as gɔgɔ-nɪ) the medial *g* is devoiced since it cannot be licensed across *o* (“☛” indicates the empirically correct candidate which is suboptimal under the given ranking):

(51) **Input:** gɔgɔ-ni, ‘lump of clay (pl.)’

	NOSKIP	LC	ID [+vc]
☛ a. gɔ(gɔ-n)ɪ	*!		
☞ b. gɔkɔ-nɪ			*
c. gɔgɔ-nɪ		*!	

However both constraints are dominated by (TN) which demands that *g* and *n* are linked to the same voice feature even though this leads to a NOSKIP violation. Since the configuration (gɔ-n) satisfies the LICENSING CONSTRAINT (*g* and *n* are phonetically adjacent and in the same voicing span) voicing of *g* is retained:

(52) **Input:** gɔgɔ-ni, ‘lump of clay (pl.)’

	ID [–vc]	(TN)	NOSKIP	LC	ID [+vc]
☞ a. gɔ(gɔ-n)ɪ			*		
b. gɔgɔ-nɪ		*!		*	
c. gɔkɔ-nɪ		*!		*	*

In the corresponding singular form, voicing is maintained as with other nouns with a final voiced stop:

(53) **Input:** gɔgɔ, ‘lump of clay’

	ID [–vc]	(TN)	NOSKIP	LC	ID [+vc]
☞ g(ɔgɔ)					
gɔgɔ				*!	
gɔkɔ					*!

Nouns with an underlying voiceless stop keep voicelessness throughout singular and plural by the protection of undominated ID [–vc]:

(54) **Input:** pɔkɔ, ‘gourd’

	ID [–vc]	(TN)	NOSKIP	LC	ID [+vc]
☞ pɔkɔ					*
p(ɔgɔ)	*!				
pɔgɔ	*!			*	

(55) **Input:** pɔkɔ-ni, ‘gourd’

	ID [–vc]	(TN)	NOSKIP	LC	ID [+vc]
☞ pɔkɔ-nɪ		*			
pɔgɔ-nɪ	*!	*		*	
pɔ(gɔ-n)ɪ	*!		*		

5.4 The deletion of root-final vowels

Let us now turn to the question why root-final vowels are consistently deleted in plural forms. While deletion of a root-final vowel before suffixal *-e* or *-i* could be argued to follow from hiatus avoidance or, more technically, the constraint ONSET, this reasoning would not extend to *goɔ.gɔ/gɔg-nɪ* (50-a), where **gɔgɔ-nɪ* would not involve any hiatus, and deletion of root-final *o* results in more, not less NOCODA violations.

On the other hand, the relevant deletion processes consistently result in stress on the penultimate syllable of the word.[18] Since stress in Luo nouns falls invariably on the single root vowel of a CVC root and the penultimate vowel of a polysyllabic, root, the only possibility to maintain penultimate stress position under affixation is to delete vocalic material.

Assuming that main stress in Luo involves binary trochaic feet, the deletion processes can then be derived from the three constraints in (56):

[18]Recall that stress is not explicitly marked in examples since it is usually indicated by vowel length.

(56) **Constraints governing stem-final vowel deletion in plural forms**

FAITH STRESS	Underlyingly stressed syllables are also stressed in the output
ALLFTRT	The right edge of metrical feet is aligned to the right edge of the prosodic word
$\text{MAX}_{\text{RIGHT}}$	Avoid phonetically invisible segments at the the right edge of the prosodic word

FAITH STRESS and ALLFTRT are fairly standard constraints on metrical structure (Kager, 1999). $\text{MAX}_{\text{RIGHT}}$ is a positional faithfulness constraint (Beckman, 1998) penalizing deletion at the right edge of the prosodic word. Note that $\text{MAX}_{\text{RIGHT}}$ predicts for cases of multiple affixation that it is always the rightmost affix or affix vowel which is retained. I will argue in appendix A.1 that this prediction is indeed borne out.

(57) shows that for the plural of *osiki*, 'stump' deletion of a vowel is inevitable to satisfy both FAITH STRESS and ALLFTRT leading to the elimination of (57c,d). That the stem vowel is deleted, and not the suffix vowel as in (57b) follows from $\text{MAX}_{\text{RIGHT}}$ (feet boundaries are indicated by brackets):

(57) **Input:** o.ˈsi.ki-e, 'stump (pl.)'

	FAITH STRESS	ALLFTRT	$\text{MAX}_{\text{RIGHT}}$	MAX
☞ a. o.[ˈsi.ki-e]				*
b. o.[ˈs.ki]-e			*!	*
c. o.[ˈsi.ki]-e		*!		
d. o.si.[ˈki-e]	*!			

MAX gets decisive in plural forms with *-ni* to block candidates with deletion of the stem-final vowel *and* suffix-initial *n* (58b):

(58) **Input:** ˈpɔkɔ-ni, 'gourd (pl.)'

	FAITH STRESS	ALLFTRT	$\text{MAX}_{\text{RIGHT}}$	MAX
☞ a. [ˈpɔ.kɔ-nɪ]				*
b. [ˈpɔ.kɔ-nɪ]				**!
c. [ˈpɔ.kɔ-nɪ]			*!	**
d. [ˈpɔ.kɔ]-nɪ		*!		
e. pɔ.[ˈkɔ-nɪ]	*!			

5.5 Nouns with lexical suffixes

Further complications arise with a class of nouns which contain what Tucker calls CV-suffixes: final CV-syllables which are dropped in plural forms:

(59) **Nouns with CV-suffixes**

	sg	**pl**		
a.	kɛ́n̪-nɔ́	kɛ́t̪-ɛ̂	“bile, gall bladder”	(p. 132)
b.	kog-no	kó:k-ê	“nail, claw”	(p. 132)
c.	kud-ni	kú:t-ê	“insect”	(p. 132)
d.	ŋɔk-lá	ŋok-ni	“thread worm”	(p. 132)
e.	líhṓmb-lṍ	lihumb-ni	“backbone”	(p. 132)
f.	ndṍk-lṍ	ndúk-ê	“otter”	(p. 132)

What is unexpected about these forms under the proposed analysis of final-vowel deletion is that not only the vowel of the CV-suffixes is deleted (resulting in forms such as **kok-ne* for (59b), which is phonotactically completely parallel to the existing plural form *pɔk-ni* in (58)) but also their onset consonants, suggesting that deletion in these cases is crucially triggered by morphological factors.

Therefore I assume that *-no, -ni* and *-la* which do not seem to have a clear meaning component and are not involved in productive affixation processes, are markers of rudimentary lexical classes comparable to the noun class markers of Romance languages, and alternate with a zero allomorph instantiating a standard case of phonologically conditioned suppletive allomorphy (Kager, 1996; Mascaró, 1996). Since true zero morphs, would not be visible to phonological computation I take the ‘zero allomorph’ to consist of a minimal amount of phonological structure, namely a single featurally unspecified root node (written in the following as ‘R’).

The alternation between the monosyllabic and the empty-root alternant is now governed by the ban to introduce a place feature for the defective root node DEP PLACE[19], low-ranked NOCODA and the already introduced constraints as is illustrated in (60) and (61) for the noun *ndṍk-lṍ*, ‘otter’. (60a) shows the case where the full-syllable allomorph is chosen, in (60b) the root node allomorph is selected and specified by epenthetic place features, while it is deleted in (60c) (an overt, but empty root node is excluded either by general interpretability conditions or an undominated constraint):

(60) **Input:** ˈnduk-$\left\{\begin{array}{c}\text{-lu}\\ \text{-R}\end{array}\right\}$, ‘otter (sg.)’

	FAITH STRESS	ALLFTRT	$\text{MAX}_{\text{RIGHT}}$	MAX	DEP PLC	NOCODA
☞ a. [ˈnduk-lu]						
b. [ˈnduk-$\mathbf{u}_{\text{R}}$]					*!	
c. [ˈnduk-R]				*!		*

[19] DEP PLACE is also crucial for the analysis of manner alternations in Luo. Cf. appendix B

NoCoda, which is otherwise invisible, gets effective to choose between forms where the vowel of the monosyllabic allomorph (61b) or the complete empty root allomorph (61a) is deleted:

(61) **Input:** ˈnduk-{ -lu / -R }-e, 'otter (pl.)'

	Faith Stress	AllFtRt	$\text{Max}_{\text{Right}}$	Max	Dep Plc	NoCoda
☞ a. [ˈndu.k-R-e]				*		
b. [ˈnduk.-lu-e]				*		*!
c. [ˈndu.k-lu-e]				**!		
d. [ˈnduk-lu]-e			*!	*		
e. [ˈnduk-lu]-e		*!				
f. nduk.-[ˈlu-e]	*!					
g. nduk-[ˈ$\mathbf{u}_{\text{R}}$-e]	*!				*	

While it is consistently deleted phonetically, the empty root node is visible to phonology. For nouns with an underlying voiced stop and plural *-e* this results in 'voicing polarity' for the plural form since voicing of *g* cannot be licensed across the deleted root node:

(62) **Input:** kog-{ -no / -R }, 'nail, claw'

	Id [–vc]	(TN)	NoSkip	LC	Id [+vc]
☞ ko(gn)o					
kog-no		*!		*	
kok-no	*!	*			*

(63) **Input:** kog-{ -no / -R }-e, 'nail,claw'

	Id [–vc]	(TN)	NoSkip	LC	Id [+vc]
☞ kokR-e					*
k(ogR-e)			*!		
kogR-e				*!	

In a form like *jok-ni* voicelessness of the root-final stop is again retained due to high-ranked Id [–vc].

5.6 Exceptions

While the analysis so far captures the overwhelming majority of noun plurals which display (and do not display) voicing changes, there is a handful of exceptions. In this section, I will

show that the phonological behavior of these exceptional nouns follows straightforwardly if they are analyzed as cases of morphological suppletion.

The first case of this type is the noun *ŋudi* for which Tucker reports that it retains voicing in the plural (cf. (14) repeated as (64)):

(64) ŋu:di (sg.) ŋu:d-e (pl.) 'neck of meat'

The analysis developed here predicts incorrectly devoicing of *d* instead (☛ indicates the technically suboptimal, but empirically correct candidate):

(65) **Input:** ŋudi-e, 'necks of meat (pl.)'

	ID [–vc]	(TN)	NOSKIP	LIC	ID [+vc]
☛ a. ŋu(di-e)			*!		
☞ b. ŋuti-e					*
c. ŋudi-e				*!	

However, this result depends on the assumption that *ŋudi* is a morphologically regularly decomposable noun. Now Luo as virtually any other inflecting language has suppletive stem allomorphs for a small number of roots. Thus in (66a-c), the plural is formed without further affixation by a suppletive root. In (66d), *-i* can be analyzed as a plural suffix, but *ɲir* remains as a suppletive allomorph of *ɲakɔ*. In (66e) and (66f) singular and plural stems are clearly related, but no other root in the language shows a change of *l* to *t* or from *r* to *nd*, so these seem to be also suppletive roots combining with the regular plural suffix *-e*:

(66) **Suppletive stem allomorphs**

sg	**pl**		
a. d̪á:kɔ	mó:n	'woman'	(p. 126)
b. dá:lâ	mie:r	'village'	(p. 126)
c. d̪ɪa:ŋ	d̪o:k	'cow'	(p. 126)
d. ɲá:kɔ	ɲi:r-i	'girl'	(p. 126)
e. lɪɛ:l	líét-ê	'anthill, grave'	(p. 129)
f. we:r	we:nd-e	'song'	(p. 129)

Crucially, while there are cases where suppletive allomorphs bear no resemblance to each other, there are also forms where suppletive morphs still show a certain similarity to each other. All we have to do to derive the *d* of *ŋudi* is to assume that it is suppletive in the same way as the roots in (66), visibly that it has a suppletive plural allomorph which lacks the final *i* (*ŋud*) in contrast to the vowel-final singular allomorph (*ŋudi*). As a consequence the suppletive allomorph retains voicing since licensing is not blocked by an intervening deleted vowel:

(67) **Input:** ŋud-e, ‘necks of meat (pl.)’

	ID [–vc]	(TN)	NOSKIP	LIC	ID [+vc]
☞ ŋu(d-e)					
ŋut-e					*!
ŋud-e				*!	

CVCV roots which exhibit a voicing change from voiceless (singular) to (voiced) in the plural pose a similar problem. Okoth-Okombo (1982) cites two cases of this type (68a-b), and there is a single example from Tucker’s grammar (68c) (which is a variant to regular *agɔ́k-ɛ̂*):

(68) **CVCV with [–vc] ➔ [+vc] change** (repeating (11))

	sg	**pl**		
a.	agɔ:kɔ	agɔ́g-ɛ̂	‘chest’	(p. 491)
b.	koti	kod-e	‘coat’	(English; Okoth-Okombo, 1982:54)
c.	ongeti	ongede	‘blanket’	(English; Okoth-Okombo, 1982:54)

Again an analysis invoking listing of suppletive allomorphs (*koti* for the singular, and *kod* for the plural) makes the correct predictions:[20]

(69) **Input:** koti, ‘coats (pl.)’

	ID [–vc]	(TN)	NOSKIP	LIC	ID [+vc]
ko(di)	*!				
kodi	*!			*	
☞ koti					

(70) **Input:** kod-e, ‘coats (pl.)’

	ID [–vc]	(TN)	NOSKIP	LIC	ID [+vc]
☞ ko(d-e)					
kote					*!
kod-e				*!	

The loanword examples in (68) together with the regularly patterning loanwords in (71) are taken by Okoth-Okombo (1982:54) as decisive evidence for a non-phonological analysis of voicing polarity.

[20]This type of alternation could also be derived under the assumption that the singular is a ‘singulative’ derived from the plural by affixation of *-e* and subsequent deletion of root-final *e*. This alternative is not completely implausible given the broad distribution of singulative morphology in other Western-Nilotic languages such as Shilluk (Gilley, 1992:62).

(71) **Regularly patterning loanwords**

	sg	**pl**		
a.	cak	cag-ɛ	'chalk'	(English; Okoth-Okombo, 1982:54)
b.	buk	bug-e	'book'	(English; Okoth-Okombo, 1982:54)

A loanword such as *book* has plausibly an underlying form ending in a voiceless stop since speakers of Luo never perceive an English input with a voiced stop such as *buge*. However, as recent experimental work shows, integration of non-words into a language often leads to underlying forms not directly evident in the source. Thus Ernestus and Baayen (2003) show that in Dutch, a language with final devoicing, speakers confronted experimentally with non-words ending in a voiceless obstruent often reanalyze these as ending underlyingly in the corresponding voiced obstruent based on the lexical frequency of similar words in the language. Similarly Nevins and Vaux (2006) report results from Turkish, another language showing final devoicing, that speakers frequently infer underlying forms with voiced final obstruents from inputs with final voiceless obstruents, both with non-words and in loanword adaptation, again based on lexical frequency and a number of other factors such as syllable number. As Dutch and Turkish, Luo has also loanwords which show no voicing alternation:

(72) **Luo loanwords without voicing alternation**

	sg	**pl**		
a.	cu:pɐ	cú:p-ê	'bottle'	(Swahili; p. 130)
b.	pa:ta	pɐ́:t-ê	'hinge'	(Swahili; p. 130)

Thus loanword adaptation does not seem to set Luo apart from other languages with regular final devoicing and is perfectly compatible with an approach where voicing polarity derives from the phonological licensing of voicing.[21] Given the empirical facts, it seems to be the case that under any analysis some nouns must be treated as exceptions. Crucially, the analysis proposed here minimizes the number of nouns which require exceptional treatment and implements this in a way which requires nothing else than the well established device of morpheme suppletion.

6 Voicing alternations in possessive forms

Apparent voicing polarity also appears in a second part of the Luo noun paradigm, namely in the forms which nouns assume if they are used as heads of a specific possessor construction. I will call these forms "nominal possessor forms". (73) shows two illustrative cases in appropriate contexts. (74) and (75) contain additional examples:

[21] Owina (2003) discusses phonological patterns of loanword adaptation in Luo, but does not treat any segmental alternations.

(73) **Possessive constructions with nominal possessor forms** (p. 190)

Bare root	ki·**dí**		'a stone'
	stone		
Nominal possessor form	k**ít**	gɔ̂:t	'a stone from the hill'
	stone	hill	
Bare root	ɔ:·**t**		'a nest'
	nest		
Nominal possessor form	ɔ**d**	wɪ:ɲɔ́	'a bird's nest'
	nest	bird	

(74) **Nominal possessor forms: consonant-final roots**

	root	**poss**		
a.	ja:t̪	ja**d̪**	'pole'	(p. 191)
b.	kuot	kúód	'shield'	(p. 191)
c.	ti:c	tíj	'work'	(p. 191)

(75) **Nominal possessor forms: vowel-final roots**

	root	**poss**		
a.	u:di	ut	'bird'	(p. 190)
b.	tí:gɔ̂	tík	'neck'	(p. 190)
c.	kɪtâbʊ	kɪtáp	'book'	(p. 190)

Nominal possessor forms seem to provide direct counterevidence to the assumption that polarity is (partially) triggered by word-final devoicing since in forms like *ɔd* no devoicing happens. In fact, Alderete (2001:207) cites them as additional evidence against a phonological account of Luo voicing alternations. I will show here that the nominal possessor forms are a straightforward case of morphological opacity: the voiced stop in *ɔd* is licensed in a morphologically related (possessor) form from which *ɔd* is derived, and exceptional maintaining of the voiced stop is due to faithfulness to the morphological input. Since the argument requires to take into account the full array of nominal possession morphology in the language, subsection 6.1 gives an overview of the morphosyntactic system of possession marking in Luo. Subsection 6.2 provides a phonological analysis of the apparent polarity data.

6.1 Possession marking in Luo

Besides the nominal possessor forms exemplified in (73) to (75) (named the "high-tension" construction by Tucker), Luo exhibits a second construction encoding nominal possession which Tucker calls the "low-tension" construction. (76) shows the noun *gagi* in both constructions. Crucially, stem-final vowels are lost in high-tension forms, but retained in low-tension

forms, where low-tension forms do not exhibit any voicing (or other alternations) of the stem-final consonant:

(76) **Low-tension and high-tension nominal possessor forms** (p. 202)

a. *gágí* *ɲat̪î*
cowry shell(s) child
'the child's cowry shell(s)' (high tension construction)

b. *gák* *ɲâːt̪î*
cowry shell(s) child
'the child's cowry shell(s) (low tension construction)'

While for many nouns such as *gagi* both constructions seem to be interchangeable with respect to use and meaning, for many others only one of both is available, and in a third substantial group of nouns low-tension and high-tension nominal possessor forms convey different meanings:

(77) **Low-tension and high-tension nominal possessor forms** (p. 198)

a. *cógo gúok (low tension)*
bone dog
'the dog's bone'

b. *cók ɖíaŋ (high tension)*
bone cow
'a cow bone'

Corresponding to the two nominal possessor constructions which are restricted to full-NP possessors, there are two paradigms of forms which are used for pronominal (overt or zero) possessors. In these forms which I will call "pronominal possessor forms", the noun bears agreement affixes which agree in person and number with the pronoun (78), where the suffixes partially differ in the high- and the low-tension variant. As with nominal possessor forms, the low tension forms retain the root-final vowel in contrast to the high-tension forms:

(78) **Pronominal possessor forms:** ga:gɪ, cowry shell(s) (p. 202)

a. **High tension**

	sg	**pl**
1	gá:k-á	gá:k-wá
2	gɛ́:k-í	gɛ́:k-ú
3	gá:k-ɛ́	gá:k-gí

b. **Low tension**

	sg	**pl**
1	gágí-ná	gágí-wá
2	gɛ́gí-ní	gágí-ú
3	gágí-nɛ́	gágí-gí

A second difference to low-tension forms is that the high-tension variants exhibit the voicing alternation pattern familiar from noun plurals:

(79) **Pronominal low-tension possessor forms with voicing alternation**

a. ki:dí, 'stone' (p. 166)

	sg	**pl**
1	kí:t-à	kí:t-wá
2	kí:t-í	kí:t-ú
3	ki:t-é	kí:t-gí

b. ɔt, 'house' (p. 165)

	sg	**pl**
1	ɔ:d-á	ɔ:d-wá
2	o:d-í	o:d-ú
3	ɔ:d-ɛ	ɔd-gí

(80) **Pronominal low-tension possessor forms with consistent final voiceless stop**[22]

a. mo:ko, 'affluence' (p. 169)

	sg	**pl**
1	mo:k-á	mo:k-wá
2	mo:k-í	mo:k-ú
3	mo:k-é	mo:k-gí

b. í:t, 'ear' (p. 169)

	sg	**pl**
1	í:t-a	í:t-wá
2	í:t-i	í:t-ú
3	í:t-e	í:t-gí

Crucially, also the (high-tension) pronominal possessor forms exhibit polarity, but in a way which is completely compatible with the analysis of noun plurals in section 5. Roots ending in a voiceless stop retain voicelessness throughout according to high-ranked IDENT [–vc] (80).[23] Vowel-final roots with an underlyingly voiced stop undergo devoicing in the possessive forms since voicing in the stop cannot be licensed across the phonetically invisible (deleted) final vowel (79a). Consonant-final roots with a final voiced stop maintain voicing because voicing is licensed by a following vowel or glide. Note that in *ɔd-gɪ* there is a voicing span covering both stops and the vowel (*ɔ(d-gɪ)*, hence the vowel licenses voicing in both stops.

Finally pronominal possessor forms follow the corresponding nominal possessor form in exhibiting gaps and in conveying (partially) different meanings as illustrated in (81), where for both high tension forms the possessor is animate while it is inanimate for the high-tension forms:

(81) **Low-tension and high-tension nominal possessor forms** (p. 198)

a. *mbalá rúo̱t* *(low tension)*
scar chief
'the chief's scar'

[22]The plural forms of *it*, 'ear' and *kidi*, 'stone' are constructed according to the description of Tucker, where only the singular forms are given.

[23]The only exception I am aware of is the noun *agɔkɔ*,'chest' which voices in the low-tension posessor forms. This noun shows also irregular voicing in plural forms (cf. (11)).

b. *mbánd lwɛ́:ɲ (high tension)*
scar battle
'a battle scar'

c. *mbalá-nɛ́ (low tension)*
scar-3sg
'his scar'

d. *mbá:nd-ɛ́ (high tension)*
scar-3sg
'its scar'

6.2 Polarity in possession marking as opacity

Returning to (high-tension) nominal possessor forms, we note that they truncate so that the final syllable is consistently closed (*moko* ⇒ *mok*, *kidi* ⇒ *kit*). It is a non-trivial question from which morphological base these truncations are derived, but there are two obvious possibilities. First, they might be derived directly from the root, and second, they might be truncated from the corresponding pronominal possessor forms. I will adopt the latter option. Thus *ɔd* in *ɔd wɪɲɔ* (cf. (73)) is derived as follows:

(82) **Derivation of od, 'house' (nominal possessor form)**

Root:	ɔd
Affixation:	ɔd-a
Truncation:	ɔd

That nominal possessors trigger agreement in the possessed noun just as nominal possessors is typologically rather unspectacular. Such a pattern is found for example in Hungarian:

(83) **Possessive agreement in Hungarian**

a. *a ház*
the house
'the house'

b. *a(z) ő ház-a*
the (s)he house-3sg
'his/her house'

c. *a tanár ház-a*
the teacher house-3sg
'the teacher's house'

Hence what would be special about Luo under a derivation as in (82) would only be the fact that nominal possession is additionally marked by truncation of the possessed noun. Evidence for this analysis comes from the handful of irregular nouns where alternations in the noun plural and nominal possessor forms differ. Crucially, pronominal possessor forms show always the same changes as nominal possessor forms, suggesting that both types of possession marking derive from the same morphological base:[24]

(84) **Consonant changes in irregular nouns** (p. 170,193)

Root	**Plural**	**Pron. Poss**	**Nom.Poss.**	
í:p	i:p-e	í·**w**-ê	í**w**	'tail'
mɔ	mó:d̪-î	mɔ́**r**-ɛ	mɔ́**r**	'oil,fat'
rawɛ:ra	rawé:r-ê	rɐwɛ:**c**ɛ́	rawɛ**c**	'boy'

Now, just as irregular consonant changes of pronominal possessor forms transfer to nominal possessor forms, so does the phonologically derived (non-)voicing of root-final consonants. Nominal possessor forms are hence comparable to standard cases of phonological opacity under truncation. To take just one similar case, consider the well-known alternation between *æ* and *ɑ* in many dialects of English, where *æ* cannot appear as the nucleus of a syllable closed by *r* (Kahn, 1980; Benua, 1995):

(85) **English *æ* ≈ ɑ alternation (Benua, 1995:78)**

a.	map	[mæp]	e.	mar	[mɑr]
b.	carry	[kæ.ri]	f.	car	[kɑr]
c.	Harry	[hæ.ri]	g.	hard	[hɑrd]
d.	Larry	[læ.ri]	h.	lark	[lɑrk]

Hypocoristics which involve truncation to a single syllable show a systematic exception to this restriction. If the *æ*-alternant is phonologically motivated in the base (e.g. *hæ.ri*) this is transferred to the truncated form even if the latter ends up in a syllable closed by *r* (e.g. *hær*) thus violating the otherwise exceptional restriction against *ær*-syllables:

(86) **English hypocoristics (Benua, 1995:79)**

a. Harry	[hæ.ri]	Har [hær]
b. Larry	[læ.ri]	Lar [lær]
c. Sarah	[sæ.rə]	Sar [sær]

In the OT-literature, there are currently two types of approaches to opacity of this type: Benua (1995) proposes specific output-output constraints which require identity between the output

[24] According to Tucker's description and the analysis of manner alternations developed in appendix B for *rawe:ra*, 'boy' it is the plural which shows irregular non-alternation while the possessor forms exhibit the expected type of mutation.

of the morphological base and the output of the truncated form and thus enforce for English a vowel quality of the base onto the truncated form which is excluded in non-truncated forms by a high-ranked markedness constraint. On the other hand, Inkelas and Zoll (2005) argue that such effects are due to different cophonologies: the cophonology associated with roots and untruncated words suppresses marked phonological structure by the high ranking of the corresponding markedness constraint while the cophonology linked to truncation ranks the relevant faithfulness higher which leads to emergence of marked structure in truncation.

While both approaches are consistent with the Luo truncation data, only a cophonology account is consistent with the containment-based analysis proposed for the basic polarity facts.

I will assume here along the lines of Stratal OT (Kiparsky, 2000; Bermúdez-Otero, 2008) that Luo has three cophonologies, a stem-level phonology (which is also relevant for voicing alternations in verbs, cf. appendix A), a word-level phonology linked to noun plurals and pronominal possessor forms, and a phrase-level phonology which applies in nominal possessor truncation. Crucially, voicing alternations are triggered transparently at the word level where the LICENSING CONSTRAINT is ranked above IDENT [+vc]. Truncation applies at the phrase level, probably in connection with the fact that (high-tension) nominal possessor forms are obligatorily followed by a head noun syntactically to which they seem to be prosodically adjoined. This becomes evident by the fact that they are never stressed. (Tucker, 1994; Bye, 2006). At the same time the phrase level shows ranking of IDENT [+vc] above LICENSING CONSTRAINT so that voiced stops which are licensed at the word level remain voiced at the phrase level even when truncation removes the licensing sonorant resulting in straightforward intralevel opacity. This is illustrated here by the nominal possessor form *ɔd*. At the word level, the underlying voicing of the root *ɔd* is retained since it is immediately followed by *ɛ*:

(87) **Input:** ɔd-e, 'his house' (Word Phonology)

	ID [–vc]	NOSKIP	LIC	ID [+vc]
☞ a. ɔ(d-ɛ)				
b. ɔd-ɛ				*!
c. ɔd-ɛ			*!	

The output of the word level - *ɔdɛ* - gets the input of the phrase level, where specific constraints – here abbreviated as TRUNC – achieve deletion of the final *ɛ*. Nonetheless the voicing of word-final *d* is retained to satisfy high-ranked IDENT [+vc]:

(88) **Input:** ɔ(d-ɛ), 'his house' (Phrase Phonology)

	TRUNC	ID [–vc]	ID [+vc]	NOSKIP	LIC
☞ a. ɔdɛ					*
b. ɔtɛ			*!		
c. ɔ(d-ɛ)	*!				

Apparent polarity emerges because in the bare singular root *ɔd*, *d* devoices regularly to *t* resulting in the citation form *ɔt*. For a bisyllabic root with a voiced stop such as *kidi*, devoicing of the nominal possessor form happens at the word level (89), and is then propagated to the phrase level by high-ranked IDENT [–vc], again inducing a voicing exchange with respect to the citation form:

(89) **Input:** kidi-e, 'his stone (Word Cophonology)

	ID [–vc]	(TN)	NOSKIP	LIC	ID [+vc]
a. ki(di-e)			*!		
b. ki(di)-e				*!	
☞ c. kiti-e					*

(90) **Input:** kit-e, 'his stone' (Phrase Cophonology)

	TRUNC	ID [–vc]	ID [+vc]	NOSKIP	LIC
☞ a. kit					
b. kid		*!			*

7 Previous analyses

In this section I discuss previous approaches to Luo voicing polarity which seek to eliminate an explicit stipulation of polarity or feature exchange. Analyses embracing the assumption that Luo has genuine feature polarity are summarized in section 2.

7.1 Stonham (1994)

Stonham (1994) provides the earliest attempt to reduce the Luo data to more standard means of morphological exponence. He claims that Luo number inflection has only one morphophonological rule which consistently triggers voicing of root-final stops. Under the assumption that nouns can be either inherently singular or plural in their basic form, and that voicing of stop serves to indicate the marked (non-inherent) value of number for each noun, this rule is formulated as in (91):

(91) C → [+voice] /__ (V)# [+marked number]

Unfortunately this analysis is at odds with the affixal morphology of number marking in the language. First, Luo has a substantial number of nouns which are consonant-final in the singular, and form the plural by adding the affix *-e* with or without additional change in voicing (e.g. *ip*/*ip-e* and *arip*/*arip-e*). Under Stonham's approach we would expect nouns which exhibit mirror-image affixation, i.e. consonant-final plural nouns with corresponding singular forms showing an additional *-e*. However Luo seems to systematically lack such a pattern.

Second, plural affixes in Luo are restricted to three allomorphs, *-e*, *-i*, and *-ni*, while singular forms may end in any vowel:

(92) **Final vowels of singular nouns**

a. kidí	'stone'	(p. 128)
b. kó:mbé	hole in tree	(p. 126)
c. u:do	'ostrich'	(p. 128)
d. cu:lɛ́	'island'	(p. 126)
e. bú:jú	'mole'	(p. 127)

This asymmetry in the distribution of noun-final vowels follows naturally if singulars are always basic, and plurals always derived, but remains a mystery under Stonham's approach. However probably the most serious problem for his analysis is the fact that there is no apparent semantic motivation which distinguishes basic singular and basic plural nouns. Thus the proposal in effect requires to mark a huge percentage of the noun vocabulary as underlyingly plural with the sole motivation to trigger the rule in (91). Finally, as noted in Baerman (2007:38) it is hard to see how an approach in terms of number markedness would extend to voicing polarity in possession marking.

7.2 Wolf (2005, 2007)

Wolf (2005, 2007) argues in a general discussion of mutation phenomena that Luo voicing polarity derives from the allomorphy of floating features:[25] the nominal possessive morpheme comprises two lexically listed allomorphs consisting of floating features, [+voice] and [–voice]. The constraint MAXFLT requires that one of the floating features is realized in the output. The central constraint however is NOVACDOCK which requires that association of a floating feature to a segment S is marked if S was already associated to a (different token of) the same value of the same feature underlyingly. Given the allomorphs for nominal possession marking, NOVACDOCK will always favor docking of the allomorph specifying the opposite voicing value. This is illustrated for the noun *bat* in (93):

(93) **Input:** $\text{bat}_{[+\text{vc}]_1}$ + { $[+\text{vc}]_2$, $[-\text{vc}]_3$ }

	MAXFLT	NOVACDOCK	IDENT [VC]
☞ a. $\text{bad}_{[-\text{vc}]_3}$			*
b. $\text{bat}_{[+\text{vc}]_{1,2}}$		*!	
c. $\text{bat}_{[+\text{vc}]_2}$		*!	
d. $\text{bat}_{[+\text{vc}]_1}$	*!		

[25] Wolf's proposal recapitulates an earlier unpublished analysis by de Lacy (2002) with differences in detail which are irrelevant to the Luo data. de Lacy (2008) develops an alternative version of the same basic idea, where the relevant feature changes are not implemented by attachment of floating features, but by coalescence of segments.

The central problem with Wolfs's analysis is that it implies roughly the same empirical predictions as an antifaithfulness analysis, especially it also predicts (counter to fact) that there should not be noun roots without voicing alternations. Moreover the analysis would also work in a putative language Luo' where voicing polarity appears regardless of syllable structure, i.e. a language without final devoicing where all roots are consonant-final would still be able to exhibit the same type of polarity as Luo. It seems that such languages do not exist, and if the approach in this paper is on the right track it cannot exist for principled reasons.

7.3 Trommer (2006) and Pulleyblank (2006)

Trommer (2006) assumes that final stops in Luo noun roots are underlyingly either voiced, unvoiced or unspecified for voicing. Voicing polarity in consonant-final roots then amounts basically to final devoicing, while vowel-final roots show the three way-contrast of voicing distribution exemplified in (94):

(94) **Voicing distributions in stops of vowel-final roots**

	sg	**pl**	
a. **Singular unvoiced - Plural unvoiced:**	osi:kí	osí:k-ê	'small thing' (p. 130)
b. **Singular voiced - Plural unvoiced:**	kidí	kít-ê	'stone' (p. 128)
c. **Singular voiced - Plural voiced:**	ŋu:di	ŋu:d-e	'neck of meat' (p. 131)

While the stops in (94a) and (94c) are analyzed as underlyingly unvoiced and voiced respectively which is retained on the surface by high-ranked faithfulness constraints, the alternating stop in (94b) is taken to be underlyingly unspecified for [+/–voice]. In the singular, the value [+voice] for *d* is provided by intervocalic voicing through a voicing span comprising *(idi)*. However, in the plural this process is blocked by a constraint against spans crossing morpheme boundaries, leading to insertion of the unmarked voicing value for the stop, hence [–voice]. Pulleyblank (2006) provides a similar analysis of voicing polarity with a different approach to the sensitivity of voicing to morpheme boundaries, and an extension to the alternation between nasals and prenasalized stops (e.g. *kuon* (sg.), *kuond-e*, 'bread'; Pulleyblank, 2006:32) which also relies on a three-way contrast using underspecification. Apart from the controversial status of underspecification, these analyses have only one substantial problem which however seems to be lethal: the pattern in (94b) is absolutely marginal in Luo, it occurs only as a variant of a single noun (alternatively the plural form is *ŋud-ni*).

7.4 Bye (2006)

The squib by Bye (2006) is the most elaborate recent reanalysis of the Luo data. Bye extends his analysis to the second type of alternations found in plural and possessor formation: sonorant-stop alternations (e.g. *lă:w* (sg.) – *lé:p-ê* (pl.), 'cloth' (p. 128); *i:m* (sg.) – *i:mb-e* (pl.), 'ram' (p. 129), see appendix B for details). Theoretically, Bye departs from a unary

feature system where voiceless stops are [stop]$_{\text{C-manner}}$, voiced stops and glides unspecified for C-manner, nasals [nasal]$_{\text{C-manner}}$, and prenasalized stops [stop,nasal]$_{\text{C-manner}}$ (Morén, 2003) with details of voicing supplied in the phonetic component. In this system, stopping of glides and devoicing can be unified to the insertion of [stop]$_{\text{C-manner}}$, while voicing implies deletion of [stop]$_{\text{C-manner}}$. Word-final devoicing and stopping is now derived from the constraint in (95), which requires that consonants at the right edge of a phonological phrase are specified as C-Manner [stop]:

(95) STOP: If C]$_{\text{PhP}}$, then C-Manner [stop]

Similarly nasal alternations as in *tɪm* (sg.) *tɪmb-ɛ* (pl.), 'act, deed' (p. 129) follow from a constraint against prenasalized stops in phrase-final position leading to neutralization of nasals and prenasalized stops in most word-final positions. Devoicing of stops in vowel-final noun roots is analyzed purely morphologically: the plural affixes *-e* and *-i* have each two allomorphs, one selecting vowel-final roots and inducing devoicing and stopping, and a default affix (effectively restricted to consonant-final roots) which fails to do so.[26]

While the unification of devoicing and fortition in Bye's analysis is elegant and theoretically attractive, it faces both conceptual and empirical problems: Capturing devoicing in plural forms by multiple semi-identical allomorphs seems to amount to the hidden formulation of an arbitrary morpholexical rule which changes the voicing of root-final consonants. This type of stipulation misses the generalization that devoicing happens regularly throughout the language whenever an stop is not followed by an appropriate licensor.[27] Practically double allomorphs have to be assumed not only for the two plural suffixes, but also for all high-tension possessive suffixes, and the qualitative suffix.

Empirically Byes analysis predicts that *w* cannot occur phrase-finally, and that prenasalized stops are impossible at the end of a phrase. The first prediction is wrong (cf. appendix B.2), while the second one holds only for non-derived stems (cf. appendix B.3). Moreover the claim that only vowel-final noun roots undergo fortition is contradicted by consonant-final roots ending in *r*, *w* and *l* which regularly undergo fortition in the plural (e.g. *ŋɛw* (sg.) *ŋe p-e* (pl.), 'peg'; *bʊr* (sg.) *bʊc-e*, 'ulcer' *bul* (sg.) *bund-e*, 'drum', cf. appendix B.1). Similarly it remains unexplained why roots which are nasal-final in the singular and do not undergo stopping in the plural are only marginally attested (cf. appendix B.5). All these observations follow straightforwardly if fortition and devoicing are separated along the lines proposed in

[26] A tentative sketch of a similar analysis, where one part of the voicing alternations is derived by final devoicing while the other part follows from a morpholexical rule, is found in Baerman (2007).

[27] Bye claims that devoicing in final position is crucially different from devoicing in forms which exhibit morphological hardening because *ɟ* becomes voiceless in the latter, but not in the first case. Indeed Tucker states at one point of his grammar (p.35) that *ɟ* is exempt from final devoicing citing the verbal noun *gáɟ*, 'entanglement'. However on p.97 he explicitly states that *ɟ is* subject to final devoicing illustrating this point by the verbal noun *dá:c*, 'emaciation' from the verb *décò*, 'to wear out, emaciate'. For nouns, Tucker gives no examples where *ɟ* is retained in word-final position, but two examples with final devoicing: *raci:c* (sg.), *racíɟ-ê* (pl.), 'right hand' (p.136) and *ti:c* (sg.), *tíɟ-ê* (pl.), 'work' (p.128).

this paper (see appendix B for details).

8 Consequences for phonological theory

Under the interpretation of Alderete (2001), Luo voicing alternations instantiate *morphophonological polarity*, i.e. a process where a morphological contrast productively triggers the exchange of a segmental feature. Morphophonological polarity must be carefully distinguished from *morphological polarity*, where specific morphological contexts trigger a reversal of the distribution for morphological markers, and from *phonological polarity*, where a strictly phonological process exchanges values of a given input feature. While there is an ongoing discussion on the status of morphological polarity (cf. e.g. Lecarme, 2002; Baerman, 2007; Lahne, 2007), there is a broad consensus in the literature that phonological polarity is virtually non-existent (cf. Anderson and Browne, 1973 and Moreton, 2004, but see Fitzpatrick et al., 2004 for counterarguments).

Luo has long been regarded the paradigm case of morphophonological polarity of a segmental feature, but in fact it is the only productive and well-documented process for which a polarity analysis has some plausibility. Similar exchange processes have been claimed to exist in other Western Nilotic languages closely related to Luo, namely Shilluk, Alur, Adhola, Anywa, and Päri (Anderson and Browne, 1973:458), but for none of these languages there is a formal analysis which would substantiate the claim that they instantiate systematic exchange processes. Outside of Western Nilotic, there are only two other cases of alleged segmental exchange processes I am aware of. First, Nichols (1971) claims that Sahaptin diminutive formation triggers an exchange of *s* and *ʃ*, however the data are far from clear (Cole, 1987:43-45). Second, there is an exchange of vowel quality in the verbal root-and-pattern morphology of some Semitic languages (Wolf, 2005, 2007). Thus in the Tiberian Hebrew imperfect the stem-final vowels *e* and *o* used in the perfect turn into *a*, while *a* turns into *o* (Chomsky and Halle, 1968:356). This process might be interpreted as a polarity for the feature [+/–low] for [–high] vowels, but this interpretation is by no means necessary. Under the traditional view that verbal morphemes in Semitic consist of consonantal roots, the stem-final vowels could be analyzed as markers of lexical inflectional class exhibiting allomorphy sensitive to the perfect/imperfect distinction, hence strictly morphological polarity. Crucially, Semitic vowel alternations do not provide unambiguous evidence for morphophonological exchange processes.

I conclude that there seem to be no convincing cases of morphophonological polarity targeting segmental features. If this observation is correct, it undermines the justification for morphophonological constraints demanding phonological non-identity between paradigmatically related forms. This holds for antifaithfulness as proposed by Alderete (2001), but also for the version of the constraint REALIZEMORPHEME advocated in Kurisu (2001), which requires paradigmatic non-identity without specifying a specific faithfulness dimension.[28] It remains

[28]This problem does not hold for versions of REALIZEMORPHEME which demand that input morphemes must

an open question whether there are true of morphophonological polarity for suprasegmental features (e.g. vowel length, stress, tone). Interestingly enough, the evidence for antifaithfulness Alderete (1999) locates in stress and tone phenomena seems to be non-conclusive (Féry, 2002; van Oostendorp, 2005).

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Appendices

Appendix A extends the analysis presented in the article to verbs. Appendix B gives an autosegmental analysis of manner alternations which partially occur in the same contexts as voicing alternations.

A Voicing alternations in verbs

Transitive verbs in Luo show similar alternations as nouns, but with interesting differences and complications. While transitive verbs are generally vowel-final (ending in *o* or ɔ according to the [ATR]-specification of the root), they allow the formation of a verbal noun which truncates the final vowel and shows the familiar pattern of devoicing (canonical transitive forms are called here 'applicatives' according to the terminology used in most studies on Nilotic and in Tucker's grammar):

(96) **Voicing alternations in verbs**

Applicative		**Verbal Noun**		
a. ca:bɔ	'to disorganize'	cá:p	'disorder'	(p. 97)
b. ri:do	'to tear'	rí:t	'act of tearing'	(p. 97)
c. muogo	'to dig deep,burrow'	múók	'digging'	(p. 97)
d. gɔ:jɔ	'to 'hit, beat'	gɔ́ :c	'a blow/beat'	(p. 97)

Besides vowel-final transitive verbs, there are also intransitive verbs ending in *o/*ɔ (97) and a large majority of intransitive verbs which are consonant-final (98):

(97) **Intransitive vowel-final forms**

a. nɪndɔ	'to sleep'	(p. 69)
b. gi:ro	'to gallop'	(p. 69)
c. jʊ:kɔ	'to trot'	(p. 70)
d. co:po	'to arrive'	(p. 70)

(98) **Intransitive consonant-final forms**

a. cʊ:r	'to groan'	(p. 72)
b. ŋɔ:l	'to be lame'	(p. 73)
c. muo:l	'to be gloomy'	(p. 73)

Many of the consonant-final intransitive verbs have corresponding transitive verbs which differ only by the presence of final *o/*ɔ. As with verbal nouns, obstruents which are voiced in the applicative are unvoiced in the intransitive (99), voiceless obstruents remain voiceless throughout:

(99) **Corresponding intransitive and applicative verbs**

Intransitive		**Applicative**		
a. ɲo:c	'to be weak'	ɲo:ɟo	'to weaken'	(p. 74)
b. cɪɛk	'to get ripe'	cɪɛgɔ	'to ripen'	(p. 74)
c. bo:t̪	'to be insipid'	bo:d̪o	'to make insipid'	(p. 74)
d. kuot	'to swell'	kuodo	'to cause to swell'	(p. 74)

Intransitive forms and verbal nouns are often identical, but differ in their semantics: intransitive verbs mostly denote stative-like predicates, while verbal nouns retain the implicit transitivity of applicative forms. Phonologically, intransitive verbs allow final *w* and disallow final prenasalized stops while verbal nouns exhibit stopping of final *w* and allow freely for prenasalized stops. These facts are discussed in detail in section B. At this point it is only important that intransitive forms are bare roots while verbal nouns are distinct formations derived from applicative forms.

In addition there are so-called qualitative verb forms, i.e. antipassive forms which license a non-overt object, in which voiced stops turn voiced and *j* is affected by the familiar type of plosivization:

(100) **Voicing alternations in verbs**

Applicative		**Qualitative**		
a. pogo cá:m	'divide the grain'	pó:kó	'to make a division'	(p. 67)
b. lʊd̪ɔ ŋa:tɔ	to maltreat someone	lú:t̪ó	'to maltreat in general'	(p. 67)
c. kadɔ tɔ:l	'to plait a rope'	ke:to	'to plait in general'	(p. 67)
d. kabɔ ŋa:tɔ	'to hold someone tightly'	ké:pó	'to be rough in handling'	(p. 66)

Note again the subtle morphosemantic difference: an 'intransitive' verb denotes an activity which is inherently intransitive, whereas qualitative denotes the same kind of action as the corresponding applicative with the sole difference that the object must not be overtly expressed. This difference becomes clear if we look at the qualitative forms corresponding to the pairs in (99):

(101) **Verbs with three variants (voiced stop in the applicative)**

Intransitive		**Applicative**	**Qualitative**		
a. ɲo:c	'to be weak'	ɲo:ɟo	ɲó:có	'to weaken'	(p. 74)
b. cɪɛk	'to get ripe'	cɪɛgɔ	cíékó	'to ripen'	(p. 74)
c. bo:t̪	'to be insipid'	bo:d̪o	bó:t̪ó	'to make insipid'	(p. 74)
d. kuot	'to swell'	kuodo	kúótó	'to cause to swell'	(p. 74)

Qualitative formation is accompanied by a number of other changes in the verb root which do not seem to interfere with the voicing alternation, but serve to distinguish the forms morphologically: [–ATR] roots change their vowels into [+ATR], *a* turns into *e*, and the final stem vowel is lengthened:[29]

[29]Qualitative indicative forms also have a characteristic tone pattern which distinguishes them from applicative forms (Tucker, 1994:ch.20). However, since Luo verbal tone tone primarily distinguishes mood and aspect, it is not clear whether this pattern is part of the qualitative affix or a tonal allomorph of the aspect/mood morpheme which is context-sensitive to the qualitative.

(102) **Consistently voiceless stops in qualitative formation**

	Applicative		**Qualitative**		
a.	bupo ji	'to hit with a large soft object'	bú:pó	'to do this kind of hitting'	(p. 67)
b.	luṭo la:w	'to dip a cloth'	lú:ṭó	'to dip in general'	(p. 67)
c.	keto pí:ɲ	'to put down'	ké:tó	'to put in general'	(p. 67)
d.	roco ŋa:tɔ	'to frustrate a person'	ró:có	'to be frustrating'	(p. 67)
e.	pɔkɔ rabwɔ̂:n	'to peel a potato'	pó:kó	'to do the peeling'	(p. 67)

A.1 Basic analysis

Morphosyntactically and semantically it is obvious that in the standard case applicative verbs are derived from intransitive verbs, while verbal nouns and qualitative verbs are derived from applicative forms. I will assume that the formation of applicative forms from bare (intransitive) roots is stem-level affixation[30] while qualitative and verbal noun formation happens at the word level. More concretely I will assume that both qualitative and verbal noun formation are preceded by a more general morphological operation which achieves morphosyntactic intransitivization and is phonologically realized by the floating features [–cont][–appr] triggering stopping of the glide *w* (see section B for a detailed analysis). Moreover I take the final round vowel in qualitative forms as a distinct suffix from the word-final vowel in applicatives. The applicative suffix is *-O*, i.e. a back round mid vowel without ATR-specification which assimilates to the [ATR]-value of its base, while the qualitative suffix is *-o*, a back round mid [+ATR] vowel which triggers [ATR]-harmony in the base (the base gets consistently [+ATR]). Since qualitative forms are derived from applicative forms, they exhibit affixation of both suffixes leading to deletion of the applicative marker.

This is illustrated in (103) for different forms based on the root *cɪɛg*. The bare intransitive root *cieg* undergoes final devoicing at the word level just as noun roots. In the applicative form, affixation of *-O* is followed by vowel harmony. Since the voicing of *g* is licensed by the suffix vowel without intervention it is retained at the word level. The qualitative form undergoes a three-way affixation: *-O* at the stem level, intransitivizing -[–cont][–appr] and *-o* at the word level. Deletion of the applicative suffix vowel now happens exactly as the deletion of stem-final vowels in nouns: To preserve the stress pattern of the stem (*cɪɛg-ɔ*), one of the vowels must be deleted, and $\textsc{Max}_{\textsc{Right}}$ ensures that the rightmost vowel is retained. The deleted vowel intervenes between the stop (*g*) and its potential licensor, which leads to devoicing in the word-level phonology:

(103) **Derivation for different forms of cieko, 'to get ripe/ripen'**

		Intransitive	**Applicative**	**Qualitative**
Root		cɪɛg	cɪɛg	cɪɛg
Stem	**Appl. Affixation**	—	cɪɛg-O	cɪɛg-O
	Phonology	—	cɪɛg-ɔ	cɪɛg-ɔ
Word	**Intransitivization**	—	—	cɪɛgɔ-[–cont][–appr]
	Qual. Affixation	—	—	cɪɛgɔ-[–cont][–appr]-[–low]o
	Phonology	cɪɛk	—	ciekɔo

(104) shows the derivation for a verbal noun. At the stem stratum there is no difference to

[30]Independent phonological evidence for this assumption is discussed in section B.2

the corresponding qualitative form. Intransitivization is for both without overt phonological effect. However truncation leaves the stop in word-final position where it cannot be licensed and consequently devoices:

(104) **Derivation for different forms of kad, 'to plait'**

		Verbal Noun	**Qualitative**
Root		kad	kad
Stem	**Appl. Affixation**	kad-O	kad-O
	Phonology	kadɔ	kadɔ
Word	**Intransitivization**	kadɔ-[–cont][–appr]	kadɔ-[–cont]–appr]
	Qual. Affixation	—	kadɔ-[–cont][–appr]-[–low]o
	Truncation	kadɔ	—
	Phonology	katɔ	ketɔo

Crucially all voicing alternations in verbs follow from the same mechanisms as employed for the analysis of nouns: At the word level, obstruents devoice when they occur in word-final position or are separated from a following sonorant by a phonetically invisible intervenor.

A.2 Opacity in imperative forms

As possessor forms, imperatives exhibit retention of voicing for verb-final obstruents:

(105) **Imperative forms**

	Applicative Indicative		**Applicative Imperative**	
a.	tɔ:bɔ	'hit target'	tɔb ódu:mbo	'hit the target!' (p.35)
b.	bu:d̪o	'to scorch'	bu:d̪ lûm	'scorch the grass!' (p.35)
c.	co:do	'to break off'	cod wác	'make a decision' (p.35)

While the imperatives in (105) seem to be truncated from the indicative forms, they are actually derived from a specific imperative form with suffixal *-í* which only shows up in utterance-final position, and is deleted whenever followed by other phonological material.[31] However, the high tone of *-í* is transferred to the first syllable of the following word (the object nouns in (106) do not have a high tone on the first syllable in isolation):

(106) **Imperative forms** (p.358/360)

	Indicative		**Final Imperative**		**Non-Final Imperative**	
a.	nɛ:pɔ	'fatten'	nɛpɪ	'fatten!'	nɛp ɲárɔja	'fatten the calf!'
b.	ka:bɔ	'hold,gulp'	kabɪ	'hold!'	kab ɲûka	'gulp the gruel!'
c.	kɛ:t̪ɔ	'damage'	ka:t̪í	'damage!'	kɛt̪ púod̪ó	'spoil the garden!'

Since imperative forms have no overt applicative affix, intransitive and applicative imperatives of the same root are systematically identical:

[31] After sonorants, the affix is also deleted in non-final position.

(107) **Ambiguous intransitive/applicative imperative**

	Intransitive		**Applicative**		**Imperative**	
a.	bo:po	'wither'	bo:p	'cause to wither'	bo:pí	(p.402)
b.	nu:t	'to wilt'	nu:to	'cause to wilt'	nu:tí	(p.402)
c.	cɪɛk	'to ripen (intr)	cɪɛgɔ	'to ripen (trans.)	cɪɛgí	(p.402)

Non-alternation of voicing in imperatives follows from the analysis developed so far under the natural assumptions that the applicative morpheme is phonologically zero in imperative forms, and deletion of *-í* happens at the phrase level. As shown in (108), voicing of a final obstruent is maintained at the word level since it is licensed by a following vowel and if there is no intervening material:

(108) **Input:** tɔ:b-í, 'hit target!' (Word Cophonology)

	ID [–vc]	(TN)	NOSKIP	LIC	ID [+vc]
☞ a. tɔ:(b-í)					
b. tɔ:b-í				*!	
c. tɔ:p-í					*!

At the phrase level, constraints I will not discuss here and indicated by DEL in (109) ensure deletion of *-í* and appropriate attachment of the floating high tone. Since voicing contrasts are consistently maintained at the phrase level, no devoicing applies:

(109) **Input:** tɔ:b-í odu:mbo, 'his stone' (Phrase Cophonology)

	DEL	ID [–vc]	ID [+vc]	NOSKIP	LIC
☞ a. tɔ:b ódu:mbo					
b. tɔ:p ódu:mbo			*!		
c. tɔ:b-í odu:mbo	*!				

B Manner alternations

Apart from voicing alternations, Luo exhibits manner alternations which also result in cases of apparent polarity. The first such case involves the sound transcribed as *j* by Tucker which has been analyzed as the voiced fricative (*j*) in section 5.2. The second case of apparent manner polarity involves *w* and *p*. Thus in (110a,b) the *w* of the singular root is hardened to *p* in the plural, while in (110c) the plural form lenites the *p* of the singular to *w*:

(110) **Apparent manner polarity involving *w* and *p***

	sg	**pl**		
a.	bɐ:wo	bé:p-ê	'plank'	(Swahili, p. 127)
b.	lă:w	lé:p-ê	'cloth'	(p. 128)
c.	lɛ́:p	le:w-e	'tongue'	(p. 128)

As with voicing alternations, the impression of polarity here is highly delusive, While *w* regularly turns into *p* before the plural suffixes *-e* and *-i*, the change of *p* to *w* is only marginally attested. In fact, *lɛ:p*, the only example of a consonant-final noun root showing this alternation, has the alternative form *le:pe* without lenition, and Luo has no vowel-final roots with the same

consonant change. Anyway, assuming a polarity rule which changes *w* to *p* in plural forms would lead to immediate problems for the roots in final *p* which do not alternate (e.g. *i:p* (sg.), *i:pe* (pl.), 'tail') or show only a voicing change (e.g. *ɐri:p* (sg.) *ɐri:b-e* (pl.), 'milky way') as discussed in section 5.

Thus it is safe to conclude that the plural form in (110c) is another case of a (optional) suppletive allomorph restricted to the context of the plural suffix. In the remainder of this appendix, I will show that the hardening of *w* to *p* in (110a,b) is due to more general consonant mutation patterns which are triggered by the association of floating features to specific affixes providing further evidence that (110) is not a true case of polarity. The complete analysis of the mutation data which also partially involve changes in voicing complements the discussion in the paper and gives rise to a complete account of voicing alternations in Luo.

B.1 Stopping in nouns

Apart from stopping *w* to *p*, Luo shows a number of other manner changes in nouns. Thus in noun plurals with *-e* and *-i*, nasals and the lateral *l* turn into homorganic prenasalised stops. *r* is replaced by *c*. (111) shows these alternations for consonant-final, and (112) for vowel-final nouns:[32]

(111) **Class alternations in consonant-final nouns**

	sg	**pl**		
a.	iːm	iːmb-e	'ram'	(p. 129)
b.	tê:n	teːnd-e	'neck rest'	(p. 129)
c.	pí:ɲ	pɪːɲɟ-ɛ	'country'	(p. 129)
d.	waːŋ	wɐ́ːŋg-ê	'eye'	(p. 129)
e.	buːl	buːnd-e	'drum'	(p. 129)
f.	bʊːr	bʊːc-ɛ	'ulcer'	(p. 128)
g.	ɔːr	ɔ́ːc-ɛ̂	'brother-in-law'	(p. 128)

(112) **Class alternations in vowel-final nouns**

	sg	**pl**		
a.	jaːmɔ	jéːmb-ê	'wind'	(p. 129)
b.	pɪːnɔ	píːnd-ɛ̂	'wasp'	(p. 129)
c.	ɲɪːɲɔ	ɲíːɲɟ-ɛ̂	'iron'	(p. 129)
d.	lɔːŋɔ	lɔ́ːŋg-ɛ̂	'hernia'	(p. 129)
e.	hʊːla	hʊ́ːnd-ɛ̂	'wax'	(p. 129)
f.	gaːra	géːc-ê	'leg bell'	(p. 128)
g.	gɐːri	géːc-ê	'vehicle'	(p. 128)

The following tables summarize all changes found in nouns and verbs (see appendix B.2 below):

[32] Apart from a small class of irregular nouns (cf. (84)), the same mutation pattern as in plural forms is found in nominal and pronominal possessor forms.

(113) **Consonant-final nouns**

sg	pl	
p,t,c,k c	b,d,ɟ,g j	**Polarity**
m,n,ɲ,ŋ l r w	mb,nd,ɲj,ŋg nd c p	**Mutation**

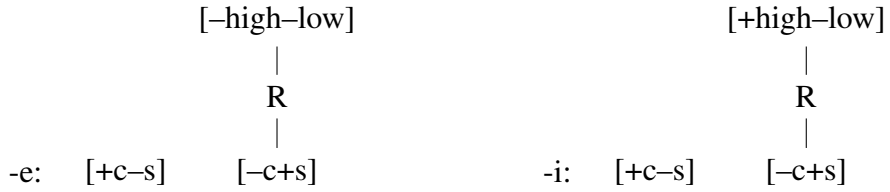
Vowel-final nouns

sg	pl	
b,d,g,ɟ j	p,t,c,k c	**Polarity**
m,n,ɲ,ŋ l r w	mb,nd,ɲj,ŋg nd c p	**Mutation**

Strikingly, and in contrast to the voicing alternations, there is no difference between consonant-final and vowel-final roots. In both, the alternations converge roughly in inserting a stop or stop quality in the pre-suffix position. I will argue that these cases follow from morphological mutation, i.e. incomplete phonological structure morphologically linked to the suffixes *-e* and *-i* which associates to place features of the noun root.[33]

More concretely, the suffixes *-e* and *-i* contain the floating features [+consonant –sonorant] (abbreviated in the following as [+c-s]). Following Padgett (1995), I assume that these features are not part of the root node, but located on a separate class node.[34] Hence the full representations for *-e* and *-i* are roughly as follows:

(114) **Full representations for -e and -i**



Mutation happens basically to preserve class nodes and if it is not possible to realize two consonantal class nodes between two vowels, mutation optimizes sonority sequencing of onsets and syllable nuclei. Under the assumption that Luo does not allow segments without place nodes (i.e. glottal sounds, cf. Clements and Hume, 1995) word-internally and that insertion of place nodes is blocked, [+c–s] can only be pronounced if it links to the place node of the preceding (root-final) consonant:[35] (115) shows the crucial constraints which implement this analysis:

[33]The same analysis extends to (pro)nominal possessor forms modulo the absence of segmental affixation.

[34]See Wolf (2005, 2007) on further evidence for this assumption from mutation processes. Kaisse (1992) argues independently on the basis of spreading processes that [consonantal] cannot be part of the root node. The same argument is made for [sonorant] in Olson and Schultz (2002).

[35]Obviously it is also impossible that the bare class node links to a place feature which is underlyingly associated to a vowel. I leave it open here by which (high-ranked) constraint this option is ruled out.

(115) **Constraints governing manner mutation**

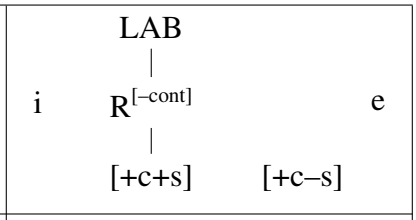
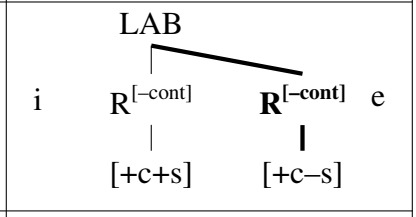
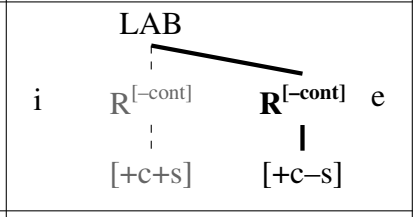
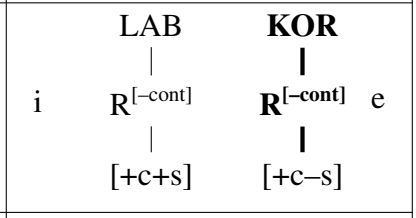
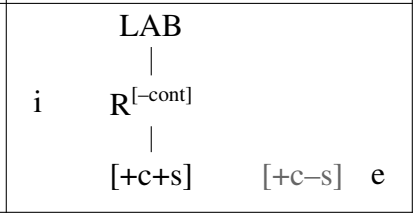
DEP PLACE	Don't insert place nodes
SHARE PLACE	Place can only be shared between root nodes of a nasal and a following homorganic stop
MAX C	Input class nodes of consonants should be retained in the output
SONORITYSEQUENCING	Avoid sonorants as onsets
IDENT MAN	Don't change the values of the features [continuant], [consonant], [sonorant] of an underlying class/root node

To avoid excessive blow-up of the tableaus, I will abbreviate the candidates as in (116). The autosegmental representations here are slightly simplified: Vowels and consonants not involved into the mutation process are replaced by the corresponding IPA-symbols. The linking of [+/–continuant] to a root node is indicated by writing the feature as a superscript. (116a) shows the input for *i:mbe*, the plural of *i:m*, 'ram', where the floating class node is indicated by *C*. (116b) is the correct output, both the nasal and the floating class node are associated to the place feature of the nasal (LAB) (in the case of the floating class node via an epenthetic root node).[36] In (116c) the floating class node also links to LAB, but the class and root node of the nasal itself are deleted. (116d) shows how association of the floating class node to place is achieved by insertion of an epenthetic place node (and again an epenthetic root node). I assume that the unmarked place feature in Luo is coronal resulting in *c*[37] In (116e) the floating class node is straightforwardly deleted.

[36] I analyze bimorphemic prenasalized stops in Luo as a sequence of two roots sharing a place node. See Downing (2005) for a recent double-root analysis of prenasalized stops in Bantu. Since in many languages there are no phonetic differences between nasal-stop sequences and prenasalized stops (Downing, 2005:183), it is also possible that bimorphemic NC sequences in Luo are bisegmental, and monomorphemic NC sequences are monosegmental.

[37] Appendix B.4 provides additional evidence that *c* represents the unmarked place specification for a stop in Luo.

(116) **Abbreviations For autosegmental representations In candidates**

a. im-Ce	
b. im-be	
c. i-pe	
d. im-ce	
e. im-e	

Although structures as in (116b-e) are suboptimal for roots with final nasals, similar configurations become optimal with other types of sounds. The tableau in (117) shows these candidates in the derivation of the plural form *i:m-be* where a nasal turns into a prenasalized stop. Insertion of a place node (117d) is banned by undominated DEP PLC, and deletion of either class node is excluded by MAX C. Both class nodes can be retained (117a) satisfying MAX C since the place sharing of the nasal and the floating class node does not violate SHARE PLC and no change of manner features (and consequent violation of ID MAN) is necessary to produce this configuration:

(117) **Input:** imCe, 'rams (pl.)'

	DEP PLC	SHARE PLC	ID MAN	MAX C	SON SEQ
☞ a. i[m-b]e					
b. i-pe				*!	
c. im-e				*!	*
d. im-ce	*!				

Crucially, the same holds for roots ending in *l*. Since *l* is [–continuant] and [+consonant+sonorant] just as the corresponding nasal, nasalizing *l* is tolerated to satisfy MAX C:[38]

(118) **Input:** bul-Ce, 'drums (pl.)'

	DEP PLC	SHARE PLC	ID MAN	MAX C	SON SEQ
☞ a. bu[n-d]e					
b. bu-te				*!	
c. bul-e				*!	*
d. bul-de		*!			
e. bul-ce	*!				

For roots ending in the trill *r* or the approximant *w*, turning the final consonant into a nasal is not an option, since they are specified [+cont] and nasalization would require to change this to [–cont] violating ID MAN. One of the class nodes has to be sacrificed, and SON SEQ favors realization of the floating [+cons–son] linked to the [CORONAL] place feature of *r* (or [LABIAL]/[DORSAL] of *w*):

(119) **Input:** bʊr-Ce, 'hole (pl.)'

	DEP PLC	SHARE PLC	ID MAN	MAX C	SON SEQ
☞ a. bʊ-cɛ				*	
b. bʊr-e				*	*!
c. bʊ[n-d]ɛ			*!		
e. bʊr-cɛ	*!				

For stop-final nouns such as *ip*, the constraint ranking introduced so far predicts a tie between deletion of the floating class node (120a) and deletion of the class node for the underlying *p* (with relinking of its place node) since both candidates fare equally well for MAX C and SON-SEQ, even though both candidates are phonetically identical. (120d,e) are eliminated for exactly the same reasons as (119d,e), but (120c) is excluded since changing [–sonorant] *p* into [+sonorant] *m* violates ID MAN:

(120) **Input:** ip-Ce, 'tails (pl.)'

	DEP PLC	SHARE PLC	ID MAN	MAX C	SON SEQ
☞ a. ip-e				*	
☞ b. i-pe				*	
c. i[m-b]e			*!		
d. ip-pe		*!			
e. ip-ce	*!				

The question whether the class node of the noun or the class node of the affix is retained gets empirically relevant in the (marginally attested) case of nouns ending in voiceless fricatives, where no stopping occurs:

[38]The faithfulness constraints violated by changing *l* into *n* must be located below MAX C to guarantee this effect.

(121) **Nouns ending in voiceless fricatives**

	sg	**pl**		
a.	nu:s	nú:s-ê	'half'	(Swahili, p. 130)
b.	sá:f	sɐ:f-e	'sub-chief'	(English, p. 130)
c.	dirî:sɐ	dirí:s-ê	'window'	(Swahili, p. 130)
d.	ɔfî:fɔ	ɔfî:f-ɛ̂	'spoilt cotton'	(p. 130)

Plausibly, the winning candidate has the structure in (122a). Hence we must exclude forms where the floating class node is retained and is linked to the [+cont] of the stem vowel (122b) or to an epenthetic [–cont] (122c) or [+cont] (122d):

(122) **Abbreviations For autosegmental representations In candidates**

a. nus-e	COR n u R[+cont] e [+c–s] [+c–s]
b. nu-s-e	COR n u R[+cont] **R** e [+c-s] [+c-s]
c. nu-se	COR n u R[+cont] **R[+cont]** e [+c-s] [+c–s]
d. nu-te	COR n u R[+cont] **R[–cont]** e [+c-s] [+c–s]

This can be achieved by the constraints in (123), applied to the plural form *nus-e* in (124):

(123) **Constraints**

***SPREAD [cont]**	Instances of the feature [cont] morphologically linked to root node R should not link phonetically to any R', $R \neq R'$
DEP [cont]	Instances of the feature [cont] should be morphologically visible
***[+cont–son]**	Obstruents should be [–cont] (Avoid fricatives)

(124) **Input:** nus-Ce, ‘halves (pl.)’

	SON SEQ	*SPREAD [cont]	DEP [cont]	*[+cont–son]
☞ a. nus-e				*
b. nu-s-e		*!		*
c. nu-se			*!	*
d. nu-te			*!	

This ranking is also responsible for the fact that for nouns ending in the glide *w* mutation does not lead to a fricative by linking the [–cont] of *w* to the floating class node:

(125) **Input:** ŋew-Ce, ‘pegs (pl.)’

	SON SEQ	*SPREAD [cont]	DEP [cont]	*[+cont–son]
a. ŋew-e	*!			
b. ŋe-f-e		*!		*
c. ŋe-fe			*	*!
☞ d. ŋe-pe			*	

Let us finally address the question why the stops created by mutation are consistently voiceless even when the corresponding root consonant is voiced as in the case of *ŋew ~ ŋep-e*. Basically instead of spreading the [+voice] feature of the affixal vowel to floating [+c–s], the latter is associated to an epenthetic [–voice] since this does neither violate Id [–vc] nor Id [+vc] and due to the preference for voiceless obstruents (*[–son +vc] = the Voiced Obstruent Prohibition in Kager, 1999):

(126) **Input:** ŋew-Ce, ‘pegs (pl.)’

	ID [–vc]	ID [+vc]	*[–son+vc]
☞ c. ŋe-(be)			
d. ŋe-pe			*!

B.2 Stopping in verbs

Although verbs show exactly the same voicing alternations as nouns, they lack most of the manner alternations found in the nominal paradigm, which provides evidence that manner alternations in Luo are mutation, i.e. morphologically, not phonologically conditioned. The only manner alternation pattern in verbs not related to the licensing of voicing is the hardening of *w* to *p* in qualitative formation (127), and the formation of verbal nouns (128):

(127) **Manner alternations in verbs: qualitative formation**

a. kawɔ pɛ:sa	'to accept money'	ké:pó	'to accept in general'	(p. 67)
b. buwo ɲat̪î	'to bully a child'	bú:pó	'to act in a bullying'	(p. 67)
c. tɔ:wɔ	'to discolor'	tó:pó	'to discolor something'	(p. 74)

(128) **Manner alternations in verbs: verbal nouns**

a. hɛ:wɔ	'to beat/excel'	hɛ́:p	'ability to excel'	(p. 97)
b. cwɔ́wɔ	'to inject'	cwɔ:p	'injection'	(p. 98)
c. ŋa:wɔ	'to hang up'	ŋá:p	'hanging up'	(p. 100)

Other sonorants do not show any alternations:

(129) **Non-alternation with other sonorants: qualitative formation**

a. kʊɲɔ bu:r	'to dig a hole'	kú:ɲò	'to dig'	(p. 67)
b. nɪŋɔ wa:ŋ	'to close one eye'	ní:ŋò	'to wink'	(p. 68)
c. cɪɛlɔ rí:ŋò	'to roast meat'	cíé:lò	'to do the roasting'	(p. 68)
d. gʊrɔ	'to trim, whittle'	gú:rò	'to do the trimming'	(p. 68)

(130) **Non-alternation with other sonorants: verbal nouns**

a. di:no	'to plug a hole'	di:n	'act of plugging'	(p. 97)
b. pi:mo	'to measure'	pi:m	'act of measuring'	(p. 97)
c. pu:ro	'to cultivate'	pu:r	'cultivation'	(p. 97)
d. ga:lɔ	'to delay'	ga:l	'delay'	(p. 97)

Crucially, thie alternation of *w* and *p* cannot be related to a general phonological process since word-final *w* in bare nouns and in the infinitive of intransitive roots is well-documented:

(131) **Free forms with final *w***

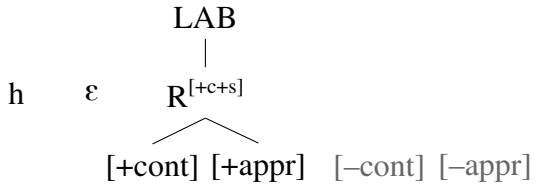
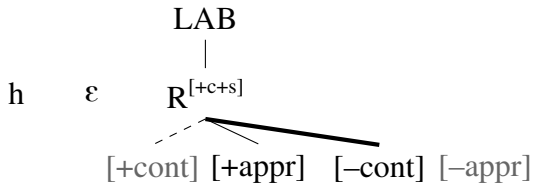
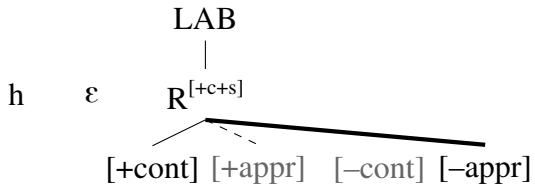
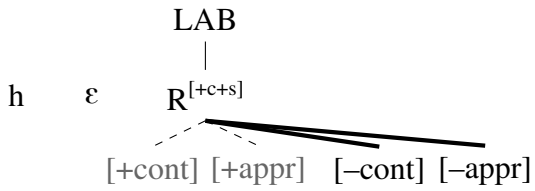
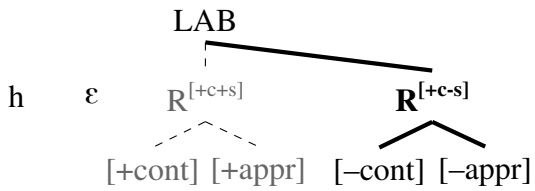
a. ŋêw	'peg'	(p. 128)
b. lă:w	'cloth'	(p. 128)
c. tɔ:w	'to be discolored'	(p. 74)
d. ciew	'to wake up'	(p. 74)

I conclude that the change of *w* to *p* is another instance of a mutation process triggered by floating features, in this case the features [–cont][–appr] associated with morphological intransitivization (cf. appendix A.1). What happens then in a stopping root such as *hɛ:wɔ*, 'to beat, excel' (with the verbal noun *hɛ:p*) is that a new root node is inserted to realize either feature according to the constraint REALIZEMORPHEME (van Oostendorp, 2005) and without violation of IDENT MAN.

(132) **REALIZEMORPHEME:** Each non-empty morpheme is phonetically visible by at least one phonological element

As soon as it gets necessary to have an epenthetic root node, this will include [–cont][–appr] and assume unmarked structure hence result in a voiceless stop. (133) shows the relevant candidates as autosegmental representations which are evaluated in (134) (ɪ stands for a probably independently excluded bilabial lateral):

(133) **Candidates**

a. hɛw	
b. hɛɪ	
c. hɛʙ	
d. hɛm	
e. hɛp	

(133a) violates REALIZEMORPHEME since no part of the intransitivizing affix is phonetically visible in the output. In (133b,c,d) the final root node of the noun is partially relinked to one or two of the floating features, but this is excluded by ID MAN. The only option is to insert an epenthetic root node and to link it to the floating features (133e) (Inserting a root node *and* a place node is ruled out by DEP PLC which is ranked higher than ID MAN, cf. section B.1.):

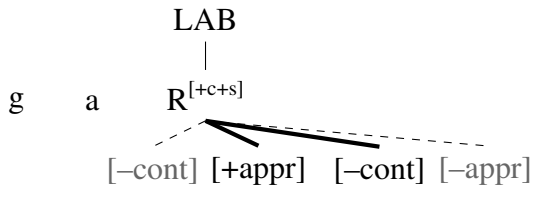
(134) **Input:** hɛwɔ+ [–cont][–appr] , 'excel'

	ID MAN	REALMORPH	DEP RT
a. hɛw		*!	
b. hɛɪ	*!		
c. hɛʙ	*!		
d. hɛm	*!*		
☞ e. hɛp			*

Now *w* is the only true approximant in Luo. All other consonants in the language are either [–cont] or [–appr] to begin with. This means that they can vacuously link to one of the floating features without overt mutation. For example in *gá:l*, 'delay' (p. 97) the final *l* is specified

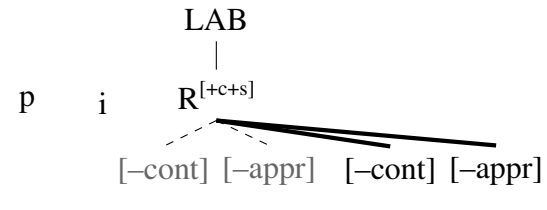
as [+c–s][–cont][+appr]. The optimal output is depicted in (135), where the root node of the noun-final consonant links to the floating [–cont] feature:

(135) gal:



This candidate satisfies REALIZEMORPHEME since the floating [–cont] gets phonetically visible, but is also perfect for ID MAN because the root node is linked to exactly the same types of features phonetically as morphologically. Finally, (135) outranks any candidate involving an epenthetic root node since it does obviate a violation of DEP RT. Similarly for *pi:m*, 'measure' (p. 97):

(136) pim:



B.3 Restrictions on prenasalized stops

Prenasalized stops exhibit a general restriction which seems to be tightly connected to the nature of manner alternations. Visibly no non-derived noun and no intransitive verb end in a prenasalized stop, while verbal nouns are freely allowed to do so:

(137) **Verbal nouns ending in prenasalized stops**

Applicative		**Verbal Noun**		
a. wɪ:mbɔ	'to take animals to temporal grazing'	wí:mb	'act of grazing animals'	(p. 97)
b. lɔ:nd̪ɔ	'to persuade'	lɔ́:nd̪	'persuasion'	(p. 97)
c. puonɟo	'to teach'	púónɟ	'teaching'	(p. 97)
d. kɪ:ŋgɔ	'to kill with a spell'	kí:ŋg	'spell killing'	(p. 97)

This difference follows straightforwardly if the following constraint is ranked above all relevant manner faithfulness constraints at the stem level:

(138) *NC]$_{\text{PWord}}$: No prenasalized stops at the right edge of a phonological word.

As a consequence a putative intransitive root such as *pamb* would be transformed at the stem cycle into *pam* before any further affixes could be attached. On the other hand, *wɪ:mbɔ* (137a) is licit at the root level. Truncation for the verbal noun only applies at the word level where (138) is ranked low, and has no effect.

B.4 Consonant insertion in nouns and verbs

A final alternation pattern not discussed so far appears with monosyllabic nouns which are vowel-final in the singular, but show *c* (139a-c) or *ɟ* (139d-f) root-finally in plural forms:

(139) **Monosyllabic vowel-final noun roots**

	sg	**pl**		
a.	sí	si:c-e	'pullet'	(p. 129)
b.	gé	ge:c-e	'second hole in board game'	(p. 129)
c.	cwǎ	cwɐ:c-e	'tamarind'	(p. 129)
d.	bwɛ̌	bwɛ:c-e/bwɛ́:j-ɛ̂	'jackal'	(p. 129)
e.	kɔ	kɔ́:j-ɛ̂	'churn'	(p. 129)
f.	pû	pú:j-ê	'buttock'	(p. 130)

Similarly there are intransitive verb roots which are monosyllabic and vowel-final which correspond to disyllabic applicative forms with root-final *j*:

(140) **Monosyllabic vowel-final verb roots**

	Intransitive	**Applicative**		
a.	kɛ	kɛj-ɔ	'to disperse'	(p. 75/76)
b.	ɲa	ɲa:j-ɔ	'to multiply, be prolific/to proliferate'	(p. 75/76)
c.	po	poj-o	'to be surprised/to startle'	(p. 75/76)
d.	jie	jiej-o	'to agree/to agree with'	(p. 75/76)

What seems to happen here is (partial) insertion to avoid a hiatus (i.e., an ONSET violation). For nouns I assume that *c* corresponds to the empty class node morphologically affiliated to the plural suffix which associates to an epenthetic place feature, unmarked [CORONAL]. In contrast to manner alternations in consonant-final nouns, the empty class node cannot link to any other morphologically licensed place feature since it is non-adjacent to the only other consonant in the word (NO-SKIPPING-VIS is basically undominated in Luo). The resulting sound is a stop because both a fricative (141b) and a stop (141a) require insertion of a value for [continuant], but stops are the unmarked obstruents, which follows from *[+cont–son] independently motivated for mutation:[39]

(141) **Input:** si-Ce, 'pullets (pl.)'

	ONS	FAITH STRESS	DEP PLC	ID MAN	MAX C	DEP [cont]	*[+cont–son]
☞ a. si-ce			*			*	
b. si-je			*			*	*!
c. s-e		*!			*		
d. si-e	*!				*		

While *c* seems to be the most frequent realization of the emerging intervocalic consonant, also *j* is attested. I assume that this is triggered by a floating [+continuant] associated lexically to specific roots such as *kɔ*. Basically, linking the floating class node of the plural suffix (via an epenthetic root node) to the floating [+continuant] of the root is preferred because it avoids a DEP CONT violation, and DEP CONT is ranked higher than *[+cont–son]. Note that linking of the floating [+cont] to the bare root node is not a violation of *SPREAD [cont] since [+cont] is not morphologically linked to any other root node:

[39]Luo tolerates ONSET violations in vowel-initial nouns such as *ʊma*, 'fork' similar to Tashlhiyt Berber, where ONSET violations are exceptionally licit in phrase-initial position (Prince and Smolensky, 1993). I assume that this pattern of facts follows from positional faithfulness: $\text{DEP}_{\text{First}}$ is ranked above ONSET in Luo blocking epenthesis word-initially.

(142) **Input:** kɔ[+cont]-Ce, ‘churns (pl.)’

	ONS	FAITH STRESS	DEP PLC	ID MAN	MAX C	*SPREAD [cont]	DEP [cont]	*[+cont–son]
a. kɔ-cɛ			*				*!	
☞ b. kɔ-ɟɛ			*					*
c. k-ɛ		*!			*			
d. kɔ-ɛ	*!				*			

The analysis for verbs is similar. Since the applicative suffix does not provide an empty class node, this is epenthesized here to avoid violation of ONSET and FAITH STRESS. Crucially DEP C must be ranked below these constraints.

(143) **Input:** po-[+cont]o, ‘to be surprised’

	ONS	FAITH STRESS	DEP C	DEP PLC
☞ a. po-ɟe				*
b. p-e		*!		
c. po-e	*!			

That the epenthetic consonant is almost always *ɟ* follows under the assumption that the applicative suffix is associated with a floating [–cont]. That the consonant is an obstruent is due to SON-SEQ. To avoid a DEP C violation the epenthetic segment links to the available instance of the feature [cont] resulting in a fricative.

B.5 Exceptional patterns

As with voicing alternations there are some exceptional cases of manner alternation, namely nouns and verbs where stopping exceptionally applies, fails to apply, or where destopping seems to take place. Thus the noun *lɛp*, ‘tongue’ (p. 128) with the regular plural *lep-e* has an alternative plural with a glide *lew-e*. The intransitive form of the verb *tɔwɔ*, ‘discolor’ has the irregularly stopped form *tɔp* in addition to the regular *tɔw* (p. 74). Moreover in a handful of cases, root-final nasals do not turn into prenasalized stops:

(144) **Root-final nasals failing to undergo stopping**

sg	**pl**		
a. ɔmî:n	ɔmín-ɛ̂	‘brother’	(p. 131)
b. pa:ɲ	pɛ́:ɲ-ɛ̂/pɛ́:ɲ-ɛ̂/pɛ́:ɲɟ-ɛ̂/pɛ́:ɲɟ-ɛ̂	‘mortar’	(p. 131)
c. ɔmbɔ́:ŋ	ɔmbɔ:ŋ-ɛ/ɔmbɔ:ŋg-ɛ	‘ankle’	(p. 131)

Again there are very few cases and even these are almost exclusively variants of forms which behave completely regularly according to the analysis proposed here. As the cases discussed in section 5.6 they can be captured as cases of morphemic suppletion. Thus assuming that the root *tɔw* has *tɔp* as a special allomorph for its intransitive form predicts that this will surface just as *tɔp* since intransitive verbs do not undergo any alternations besides regular final devoicing. For the non-stopping forms in (144), it is not the root showing suppletion, but the suffix. Instead of the regular ending *-[+cons–son]e*, these items bear the suffix *-e* which is homonymous apart from lacking the floating class node. Mutation in the corresponding plural forms is suppressed trivially because there is no floating structure triggering mutation. Note

that this case is completely analogous to exceptional allomorphy involving *-[+cons–son] i*. Both affixes are phonologically very similar to *-[+cons–son] e*, and for both affixes the nouns which take it must be lexically listed in some form. Logically, we also expect cases where affix *and* root involve suppletion of this type, and in fact this possibility seems to be instantiated by the plural *lew-e*. *lew* has to be listed as a suppletive allomorph of *lep* in the context of a plural suffix, but at the same time the suffix must be *-e*, not *-[+cons–son] e* since we would otherwise get stopping triggered by the floating root node. Finally suppletion analyses are also straightforward for marginal cases where monosyllabic vowel-final roots alternate with consonants other than *c* and *j*, for example *pi* (sg.), *pig-e* (pl.), 'water' (p. 130) or *u* (sg.) *up-e* (pl.), 'puff ader' (p. 130).