

# CHAPTER 6

## Interacting processes

### PREVIEW

In this chapter, you will broaden your understanding of how phonological systems work by

- looking at more complex patterns of phonological alternation
- seeing how complex surface patterns of alternations result from the interaction of different but related phonological rules
- understanding the effect of different rule orderings on how an underlying form is changed into a surface form

#### KEY CONCEPTS

*interaction*

*ordering*

Phonological systems are not made up of isolated and unrelated phonological rules: there are usually significant interactions between phonological processes. This chapter concentrates on two related topics. First, a seemingly complex set of alternations can be given a simple explanation if you separate the effect of different rules which may happen to apply in the same form. Second, applying rules in different orders can have a significant effect on the way that a given underlying form is mapped onto a surface form.

### 6.1 Separating the effects of different rules

Very often, when you analyze phonological alternations, insights into the nature of these alternations are revealed once you realize that a word may be subject to more than one rule, each of which can affect the same segment. You should not think of a phonology as being just a collection of direct statements of the relation between underlying segments and their surface realization. Such a description is likely to be confusing and complex, and will miss a number of important generalizations. Look for ways to decompose a problem into separate, smaller and independent parts, stated in terms of simple and general rules. The different effects which these rules can have on a segment may accumulate, to give a seemingly complex pattern of phonetic change.

#### 6.1.1 Votic: palatalization and raising/fronting

The following example from Votic (Russia) illustrates one way in which the account of phonological alternations can be made tractable by analyzing the alternations in terms of the interaction between independent phonological processes. In these examples, [ɫ] represents a velarized *l*.

(1)	a.	<i>Nominative</i>	<i>Partitive</i>	
		vərkkko	vərkkoa	‘net’
		tʰako	tʰakoa	‘cuckoo’
		lintu	lintua	‘bird’
		saatu	saatua	‘garden’
		jaŋka	jaŋkaa	‘foot’
		botʰka	botʰkaa	‘barrel’
		einæ	einææ	‘hay’
		vævy	vævyæ	‘son-in-law’
	b.	siili	siiliæ	‘hedgehog’
		lusti	lustia	‘pretty’
	c.	jarvi	jarvæa	‘lake’
		mætʰi	mætʰeæ	‘hill’
		tʰivi	tʰiveæ	‘stone’
	d.	kurtʰi	kurkæa	‘stork’
		əltʰi	əlkæa	‘straw’
		kahtʰi	kahkæa	‘birch’

The first group of examples (1a) shows that the nominative has no suffix, and the partitive has the suffix [-a] or [-æ] (the choice depends on the preceding vowels, determined by a vowel harmony rule according to which a suffix vowel is front if the preceding vowel is front – the rule skips over the vowel [i], but if there are no vowels other than [i] preceding, the harmony rule turns the suffix vowel into a front vowel). The second group of examples (1b) illustrates roots which have /i/ as the underlying final vowel of the root. The nouns in the third group (1c) illustrate a phenomenon of final vowel raising and fronting (which we have previously seen in closely related Finnish), whereby *e* and *ə* become [i] word-finally.

(2) *Final Fronting/Raising*

$$\begin{bmatrix} +\text{syl} \\ -\text{rd} \\ -\text{lo} \end{bmatrix} \rightarrow \begin{bmatrix} +\text{hi} \\ -\text{back} \end{bmatrix} / \text{—}\#$$

The essential difference between the examples of (1b) and (1c) is that the forms in (1b) underlyingly end in the vowel /i/, and those in (1c) end in /e/ or /ə/. In the last set of examples (1d), the noun root underlyingly ends in the sequence /kə/, which can be seen directly in *kurkə-a*. However, the final CV of the root appears as [tʰi] in the nominative *kurtʰi*.

It would be unrevealing to posit a rule changing word-final /kə#/ into [tʰi#] in one step. A problem with such a rule is that the change of a velar to a palatal conditioned by following word-final schwa is not a process found in other languages, and depends on a

very specific conjunction of facts, that is, not just schwa, but word-final schwa. You may not know at this point that such a rule is not found in other languages – part of learning about phonology is learning what processes do exist in languages, something you will have a better basis for judging by the end of this book. What you can see right now is that such a rule treats it as a coincidence that the underlying final schwa actually becomes [i] on the surface by an independently necessary rule, so that much of the supposed rule applying to /kə#/ is not actually specific to /kə#/.

This alternation makes more sense once it is decomposed into the two constituent rules which govern it, namely final raising (independently motivated by the data in (c)). Applying this rule alone to final /kə/ would result in the sequence [ki]. However, [ki] is not an allowed CV sequence in this language, and a process of palatalization takes place, in accordance with the following rule:

(3) *Palatalization*

$$\begin{bmatrix} + \text{ cons} \\ + \text{ back} \end{bmatrix} \rightarrow [+ \text{ cor}] / \text{---} \begin{bmatrix} + \text{ syl} \\ - \text{ back} \end{bmatrix}$$

We can thus account for the change of underlying /kurkə/ and /əlkə/ to [kurtʰi] and [əltʰi] by applying these two rules in a specific order, where the rule of vowel raising applies before palatalization, so that vowel raising is allowed to create occurrences of the vowel [i], and those derived cases of [i] condition the application of palatalization.

- (4)
- |         |                       |
|---------|-----------------------|
| /kurkə/ | <i>underlying</i>     |
| kurki   | <i>vowel raising</i>  |
| kurtʰi  | <i>palatalization</i> |

You should take note of two points regarding how the palatalization rule is formalized. First, by strictly making a velar consonant become [+cor], the result would be a velarized retroflex stop [tʰʷ]: such sounds simply do not exist in the language, in fact the [-ant] coronal sounds of the language are all alveopalatal, and the alveopalatal stops in Votic are all affricates. Observed [tʰ] is the closest segment of the language to [tʰʷ].

Second, we do not have direct evidence that all front vowels trigger the change of velars, in fact we only have direct evidence that word-final [i] triggers the change. At the same time, we do not have any direct evidence that it matter whether the triggering vowel is word-final or not, not do we have any evidence that the other front vowels [y ø e æ] fail to trigger the change. Because there is no evidence for adding restrictions to the rule, we follow the general scientific principle of stating the rule as simply as possible, consistent with the data.

### 6.1.2 Kamba: palatalization and glide formation

There is a phonological process in Kamba (Kenya) whereby the combination of a velar consonant plus the glide *j* fuses into an alveopalatal affricate. This can be seen in (5), which involves the plain and causative forms of verbs. In the examples on the left, the

verb is composed of the infinitive prefix /ko-/ (which undergoes a process of glide formation before another vowel, becoming [w]) followed by the verb root (e.g. *-kam-* ‘milk’), plus an inflectional suffix *-a*. In the righthand column we can see the causative of the same verb, which is formed by suffixing *-j-* after the verb root before the inflectional marker *-a*.

(5)	<i>to V</i>	<i>to Cause to V</i>	
a.	kokámǎ	kokámjǎ	‘milk’
	kokonà	kokonjà	‘hit’
	koláàmbà	koláàmbjà	‘lap’
	kotálǎ	kotáljǎ	‘count’
	kwaambatà	kwaambatjà	‘go up’
	kwaàǎ	kwaàǎjǎ	‘govern’
	kwéétǎ	kwéétjǎ	‘answer’
	kwíimbǎ	kwíimbjǎ	‘swell’
b.	koβikà	koβitǎ	‘arrive’
	koβálokà	koβálotǎ	‘fall’
	kolikà	kolitǎ	‘enter’
	kolééngà	kolééndǎ	‘aim’
	kwééngǎ	kwééndǎ	‘clear a field’
	kwaanekà	kwaanetǎ	‘dry’
	kwóókǎ	kwóótǎ	‘gather coals’

The examples in (a) illustrate the causative affix following various nonvelar consonants of the language. In (b), we see the causative of various roots which end in *k* or *g*, where by analogy to the data in (a) we predict the causatives /koβikjà/, /koβálokjà/, /kolééngjà/, and so on. Instead of the expected consonant sequences *kj*, *gj*, we find that the velar consonant has been replaced by an alveopalatal affricate, due to the following rule:

(6) *Palatalization*

$$\begin{bmatrix} + \text{cons} \\ + \text{back} \end{bmatrix} \begin{bmatrix} - \text{syl} \\ - \text{cons} \\ - \text{back} \end{bmatrix} \rightarrow [+ \text{cor}] \emptyset$$

Sometimes rules affect two segments simultaneously: this is an example of how such rules are formalized, stating that the first segment becomes [+cor] and the second is deleted.

Examples of glide formation are also seen in (5), where the vowel /o/ in the infinitive prefix becomes [w] before another vowel. This process of glide formation is further illustrated in (7) and (8). In (7), you can see across all of the columns that the prefix for the infinitive is /ko/, and appears phonetically as such when it stands before another consonant. The last three data columns show that the prefixes marking different classes of objects are /mó/ for class 3, /mé/ for class 4, and /ké/ for class 7 (Kamba nouns have a dozen grammatical agreement classes, analogous to gender in some European languages).

(7) to V	to V it(cl 3)	to V them (cl 4)	to V it(cl 7)	
koðukà	komóðukà	koméðukà	kokéðukà	‘churn’
kokaàðà	komókaàðà	komékaàðà	kokékaàðà	‘praise’
koliindà	komóliindà	koméliindà	kokéliindà	‘cover’
koméñá	komóméñá	koméméñá	kokéméñá	‘hate’
konuβà	komónuβà	koménuβà	kokénuβà	‘choose’

When the verb root begins with a vowel, we would predict a sequence of vowels such as \**koasja* for ‘to lose,’ in lieu of a rule modifying vowel sequences. Vowel sequences are avoided in Kamba by the application of the rule of glide formation, according to which any nonlow vowel becomes a glide before another vowel.

*The stem-initial vowel in these examples becomes long, as a side effect of the preceding vowel becoming a glide: this is known as **compensatory lengthening***

(8) to V	to V it (cl 3)	to V them (cl 4)	to V it(cl 7)	
kwáásjǎ	komwáásjǎ	komjǎásjǎ	koťáásjǎ	‘lose’
kwáákǎ	komwáákǎ	komjǎákǎ	koťáákǎ	‘build’
kwaàsà	komwáàsà	komjǎàsà	koťáàsà	‘carve’
kóómbǎ	komóómbǎ	komjǎóómbǎ	koťóómbǎ	‘mold’
kookeljǎ	komóookeljǎ	komjǎookeljǎ	koťóookeljǎ	‘lift’
kúúnǎ	komúúnǎ	komjǎúúnǎ	koťúúnǎ	‘fetch’
kuumbekà	komúumbekà	komjǎúumbekà	koťúumbekà	‘bury’
kwéénzǎ	komwéénzǎ	komjǎéénzǎ	koťéénzǎ	‘shave’
kwéëndà	komwéëndà	komjǎéëndà	koťééëndà	‘like’
kwóónǎ	komwóónǎ	komjǎóónǎ	koťóóónǎ	‘see’
kwóósǎ	komwóósǎ	komjǎóósǎ	koťóósǎ	‘take’
kwóóβǎ	komwóóβǎ	komjǎóóβǎ	koťóóβǎ	‘tie’

The Glide Formation rule can be formalized as (9).

- (9) *Glide Formation*  
 [+syl] → [-syl] / \_ V

While this rule does not explicitly state that the resulting glide is [+hi], that value is predictable via structure preservation, given the fact that the language does not have glides that are [-hi].

This rule would be expected to apply to underlying forms such as /kouna/ ‘to fetch’ and /ko-omba/ ‘to mold,’ since those forms have an underlying sequence of a vowel /o/ followed by another vowel. Applying that rule would result in \*[kwũũná] and \*[kwõõmbǎ], but these are not the correct forms. We can resolve this problem once we observe that the glide [w] never appears before the tense round vowels [u,o] (but it can appear before the vowel [ɔ], as seen in [kwõõná] ‘to see’ from /ko-ɔna/).

It does not help to restrict rule (9) so that it does not apply before /o,u/, since the vowel /e/ does actually undergo glide formation before these vowels (/ko-me-okelya/ becomes [komjókelyǎ] ‘to lift them’ and /ko-méũná/ becomes [komjúũná] ‘to fetch them’). What seems to be a restriction on glide formation is highly specific: the tense round vowel fails to surface as a glide only if the following vowel is *o* or *u*. Furthermore, the round vowel does not merely fail to become a glide, it actually deletes, therefore we can’t just rewrite (9) so that it doesn’t apply before [u,o], since that would give \*[koũná] and \*[koõmbǎ]. Two rules are required to account for these vowel-plus-vowel combinations. A very simple solution to this problem is to allow the most general form of the glide formation rule to apply, imposing no restrictions on which vowel trigger the rule, and derive the intermediate forms *kwũũná* and *kwõõmbǎ*. Since we have observed that the surface sequences [wo] and [wu] are lacking in the language, we may posit the following rule of glide deletion, which explains both why such sequences are lacking and what happened to the expected glide in the intermediate forms.

(10) *Glide Deletion*

$$\left[ \begin{array}{c} -\text{syl} \\ +\text{round} \end{array} \right] \rightarrow \emptyset / \text{---} \left[ \begin{array}{c} +\text{round} \\ +\text{tense} \end{array} \right]$$

Glide Formation first creates a glide, and then some of the glides so created are then deleted by (10).

Another crucial rule interaction which we observe in (8) is between Glide Formation and Palatalization. As we have seen, Palatalization specifically applies to *kj* and *gj*, and Glide Formation creates glides from vowels, which can trigger application of Palatalization. This is shown in the derivation of [kotʰǎǎsjǎ] from /ko-ké-ǎǎsjǎ/

- |      |               |                        |
|------|---------------|------------------------|
| (11) | /ko-ké-ǎǎsjǎ/ | <i>underlying</i>      |
|      | kokǎǎsjǎ      | <i>Glide Formation</i> |
|      | kotʰǎǎsjǎ     | <i>Palatalization</i>  |

Thus Glide Formation creates phonological structures which are crucially referenced by other phonological rules.

### 6.1.3 Bukusu: nasal+consonant combinations

The theme which we have been developing in this chapter is that phonological grammars are composed of simple rule elements that interact in ways that make the data patterns appear complicated, and factoring out of the fundamental processes is an essential part of phonological analysis. In the examples which we have considered above, such as vowel raising/fronting and velar palatalization in Votic, or glide formation and palatalization in Kamba, the phonological processes have been sufficiently different that no one would have problems seeing that these are different rules. A language may have phonological changes which seem similar in nature, or which apply in similar environments, and the question arises whether the alternations in question reflect a single phonological rule. Or, do the alternations reflect the operation of more than one independent rule, with only accidental partial similarity? Such a situation arises in Bukusu (Kenya), where a number of changes affect sequences of nasal plus consonant.

**Nasal Place Assimilation and Post-Nasal Voicing.** In the first set of examples in (12), a voicing rule makes all underlyingly voiceless consonants voiced when preceded by a nasal, in this case after the prefix for the first-singular present-tense subject which is /n/. The underlying consonant at the beginning of the root is revealed directly when the root is preceded by the third-plural prefix *βa-*, or when there is no prefix as in the imperative.

(12) <i>Imperative</i>	<i>3pl pres.</i>	<i>1sg pres</i>	
t <sup>f</sup> a	βat <sup>f</sup> a	ɲd <sup>3</sup> a	‘go’
t <sup>f</sup> exa	βat <sup>f</sup> exa	ɲd <sup>3</sup> exa	‘laugh’
t <sup>f</sup> ut <sup>f</sup> uunga	βat <sup>f</sup> ut <sup>f</sup> uunga	ɲd <sup>3</sup> ut <sup>f</sup> uunga	‘sieve’
talaanda	βatalanda	ndalaanda	‘go around’
teexa	βateexa	ndeexa	‘cook’
tiira	βatiira	ndiira	‘get ahold of’
piima	βapiima	mbiima	‘weigh’
pakala	βapakala	mbakala	‘writhe in pain’
ketulula	βaketulula	ɲgetulula	‘pour out’
kona	βakona	ɲgonā	‘pass the night’
kula	βakula	ɲgula	‘buy’
kwa	βakwa	ɲgwa	‘fall’

We can state this voicing rule as follows.

- (13) *Post-Nasal Voicing*  
 [-voice] → [+voice] / [+nasal] \_

You will also note that a nasal consonant always agrees in place of articulation with the following consonant, due to the following rule.

- (14) *Nasal Place Assimilation*

$$[+nas] \rightarrow \begin{bmatrix} \alpha_{ant} \\ \beta_{cor} \end{bmatrix} / \text{---} \begin{bmatrix} -syl \\ \alpha_{ant} \\ \beta_{cor} \end{bmatrix}$$

The data considered so far have not given clear evidence as to what the underlying place of articulation of the first-singular subject prefix is, since that nasal always assimilates to the following consonant. To determine that the prefix is indeed /n/, we turn to the form of stems which underlyingly begin with a vowel, where there is no assimilation. In the imperative, where no prefix precedes the stem, the glide [j] is inserted before the initial vowel. (The data in (17) include examples of underlying initial /j/, which is generally retained, showing that there cannot be a rule of *j*-deletion.) When the third-plural prefix /βa/ precedes the stem, the resulting vowel sequence is simplified to a single nonhigh vowel. No rules apply to the first-singular prefix, which we can see surfaces as [n] before all vowels.

(15)	<i>Imperative</i>	<i>3pl pres.</i>	<i>1sg pres</i>	
	jiixala	βeexala	niixala	‘sit’
	jaasama	βaasama	naasama	‘gape’
	joola	βoola	noola	‘arrive’
	jeekesja	βeekesja	neekesja	‘show’

One question that we ought to consider is the ordering of the rules of voicing and place assimilation. In this case, the ordering of the rules does not matter: whether you apply voicing first and assimilation second, or assimilation first and voicing second, the result is the same.

(16)		/n-kwa/		/n-kwa/
	voicing	ngwa	assimilation	ŋkwa
	assimilation	ŋgwa	voicing	ŋgwa

The reason why ordering does not matter is that the voicing rule does not refer to the place of articulation of the nasal, and the assimilation rule does not refer to the voicing of the following consonant. Thus information provided by one rule cannot change whether the other rule applies.

**Post-Nasal Hardening.** Another process of consonant hardening turns voiced continuants into stops after a nasal: *l* and *r* become *d*, *β* becomes *b*, and *j* becomes *dʲ*.

(17)	<i>Imperative</i>	<i>3pl pres.</i>	<i>1sg pres</i>	
	lola	βalola	ndola	‘look’
	lasa	βalasa	ndasa	‘shoot at’
	leβa	βaleβa	ndeβa	‘push’
	lwaala	βalwaala	ndwaala	‘be sick’
	ra	βara	nda	‘put’



rara	βarara	ndara	‘be stung’
roβa	βaroβa	ndoβa	‘ripen’
rusja	βarusja	ndusja	‘vomit’
rja	βarja	ndja	‘fear’
βakala	βaβakala	mbakala	‘spread’
βala	βaβala	mbala	‘count’
βasa	βaβasa	mbasa	‘forge’
βoola	βaβoola	mboola	‘tell’
jama	βajama	nd <sup>3</sup> ama	‘scout’
jaaja	βajaaja	nd <sup>3</sup> aaja	‘scramble with’
joola	βajoola	nd <sup>3</sup> oola	‘scoop’
juula	βajuula	nd <sup>3</sup> uula	‘snatch’

These data can be accounted for by the following rule:

(18) *Post-Nasal Hardening*

[+voice] → [-cont] / [+nasal] \_

This formalization exploits the concept of structure preservation to account for the changes to /r,l,j/. By becoming [-cont], a change to [-son] is necessitated since there are no oral sonorant stops in Bukusu. Likewise the lack of lateral stops in the language means that /l/ becomes [-lat] when it becomes [-cont]. Since there is no segment [ɟ] in Bukusu, making /j/ become a stop entails a change in place of articulation from palatal to alveopalatal, and from plain stop to affricate.

The generalizations expressed in rules (13) and (18) can be unified into one even-simpler rule, which states that consonants after nasals become voiced stops.

(19) *Post-Nasal Voicing-Hardening*

$$C \rightarrow \begin{bmatrix} + \text{voice} \\ - \text{cont} \end{bmatrix} / [+nas] \_$$

**I-Deletion.** A third process affecting sequences of nasal plus consonant can be seen in the following data.

(20)	<i>Imperative</i>	<i>3pl pres.</i>	<i>1sg pres</i>	
a.	tima	βatima	ndima	‘run’
	taaja	βataaja	ndaaja	‘hack’
	tiija	βatiija	ndiija	‘filter’
	rema	βarema	ndema	‘chop’
	riina	βariina	ndiina	‘run away’
	ruma	βaruma	nduma	‘send’

b.	laanda	βalaanda	naanda	‘go around’
	laangwa	βalaangwa	naangwa	‘be named’
	liinda	βaliinda	niinda	‘wait’
	loma	βaloma	noma	‘say’
	loondelela	βaloondelela	noondelela	‘follow’
	luma	βaluma	numa	‘bite’

The examples in (a) show the effect of rules of voicing and consonant hardening, applying as expected to /t/ and /r/. However, the examples in (b) show the deletion of underlying /l/ after a nasal. These examples contrast with the first set of examples in (17), where the root also begins with underlying /l/: the difference between the two sets of verbs is that in the second set, where /l/ deletes, the following consonant is a nasal, whereas in the first set where /l/ does not delete, the next consonant is not a nasal.

The significance of the examples in (20a) is that although underlying /t/, /l/ and /r/ all become [d] after a nasal, the deletion of an underlying consonant in the environment N\_VN only affects underlying /l/. Since the voicing-hardening rule (19) neutralizes the distinction between the three consonants after a nasal but in fact /l/ acts differently from /t/ and /r/ in the context N\_VN, we can conclude that there is a prior rule deleting /l/ – but not /t/ or /r/ – in this context.

(21) *l-deletion*

[+lat] → Ø / [+nasal] \_ V<sub>0</sub> [+nasal]

This rule clearly must apply before the hardening rule changes /l/ into [d] after a nasal, since otherwise there would be no way to restrict this rule to applying only to underlying /l/. When (19) applies, underlying /n-liinda/ would become *n-diinda*, but /n-riina/ would also become *n-diina*. Once that has happened, there would be no way to predict the actual pronunciations [niinda] versus [ndiina].

On the other hand, if you were to apply the *l-deletion* rule first, the rule could apply in the case of /n-liinda/ to give [niinda], but would not apply to /n-riina/ because that form does not have an *l*: thus by ordering the rules so that *l-deletion* comes first, the distinction between /l/, which deletes, and /r/, which does not delete, is preserved.

**Nasal Cluster Simplification.** Another phonological process applies to consonants after nasal consonants. When the root begins with a nasal consonant, the expected sequence of nasal consonants simplifies to a single consonant.

(22) <i>Imperative</i>	<i>3pl pres.</i>	<i>1sg pres</i>	
mala	βamala	mala	‘finish’
maja	βamaja	maja	‘know’
meela	βameela	meela	‘get drunk’
ŋoola	βaŋoola	ŋoola	‘see into the spirit world’
ja	βaja	ja	‘defecate’

naaŋa	βaŋaŋa	naaŋa	‘chew’
ŋwa	βaŋwa	ŋwa	‘drink’

In the case of *mala* ‘I finish,’ the underlying form would be /n-mala/ which would undergo the place assimilation rule (14), resulting in \**mmala*. According to the data available to us, there are no sequences of nasals in the language, so it is reasonable to posit the following rule.

- (23) *Nasal Cluster Simplification*  
 $[+nas] \rightarrow \emptyset / \_\_ [+nas]$

**Nasal Deletion.** The final process which applies to sequences of nasal plus consonant is one deleting a nasal before a voiceless fricative.

(24)	<i>Imperative</i>	<i>3pl pres.</i>	<i>1sg pres</i>	
	fuma	βafuma	fuma	‘spread’
	fuundixa	βafuundixa	fuundixa	‘knot’
	fwa	βafwa	fwa	‘die’
	xala	βaxala	xala	‘cut’
	xalaŋga	βaxalaŋga	xalaŋga	‘fry’
	xweesa	βaxweesa	xweesa	‘pull’
	seesa	βaseesa	seesa	‘winnow’
	siimbwa	βasiimbwa	siimbwa	‘have indigestion’
	somja	βasomja	somja	‘teach’
	sukuwa	βasukuwa	sukuwa	‘rub legs’
	sja	βasja	sja	‘grind’

The underlying form of *fuma* ‘I spread’ is /n-fuma/ since the prefix for 1sg is /n-/ and the root is /fuma/, and this contains a sequence nasal plus voiceless fricative. Our data indicate that this sequence does not appear anywhere in the language, so we may presume that such sequences are eliminated by a rule of nasal deletion. The formulation in (25) accounts for the deletion facts of (24).

- (25) *Nasal Deletion*

$$[+nasal] \rightarrow \emptyset / \_\_ \left[ \begin{array}{l} + \text{cont} \\ - \text{voice} \end{array} \right]$$

There can be an important connection between how rules are formulated and how they are ordered. In the analysis presented here, we posited the rules Nasal Deletion (25) and Post-Nasal Voicing-Hardening (19), repeated here, where Nasal Deletion applies first.

(19) *Post-Nasal Voicing-Hardening*

$$C \rightarrow \begin{bmatrix} + \text{voice} \\ - \text{cont} \end{bmatrix} / [+nas] \_$$

Since, according to (25), only *voiceless* continuants trigger deletion of a preceding nasal, we do not expect /n-βala/ ‘I count’ to lose its nasal. However, there is the possibility that (19) could apply to /n-fwa/ ‘I die’, since (19) does not put any conditions on the kind of consonant that becomes a voiced stop – but clearly, /f/ does not become a voiced stop in the surface form [fwa]. This is because Nasal Deletion first eliminates the nasal in /n-fwa/, before (19) has a chance to apply, and once the nasal is deleted, (19) can no longer apply.

You might consider eliminating the specification [-voice] from the formalization of (25) on the grounds that voiced continuants become stops by (19), so perhaps by applying (19) first, we could simplify (25). Such a reordering would fail, though, since (19) would not only correctly change /n-βala/ to [mbala], but would *incorrectly* change /n-fwa/ to \*[mbwa]. The only way to eliminate the specification [-voice] in (25) would be to split (19) into two rules specifically applying to voiced continuants and voiceless stops – a considerable complication that negates the advantage of simplifying (25) by one feature specification.

**Summary.** We have found in Bukusu that there are a number of phonological processes which affect N+C clusters, by voicing, hardening, or deleting the second consonant, or deleting the nasal before a nasal or a voiceless fricative.

(25) *Nasal Deletion*

$$[+nasal] \rightarrow \emptyset / \_ \begin{bmatrix} + \text{cont} \\ - \text{voice} \end{bmatrix}$$

(14) *Nasal Place Assimilation*

$$[+nas] \rightarrow \begin{bmatrix} \alpha_{\text{ant}} \\ \beta_{\text{cor}} \end{bmatrix} / \_ \begin{bmatrix} + \text{syl} \\ \alpha_{\text{ant}} \\ \beta_{\text{cor}} \end{bmatrix}$$

(21) *l-deletion*

$$[+lat] \rightarrow \emptyset / [+nasal] \_ V_0 [+nasal]$$

(19) *Post-Nasal Voicing-Hardening*

$$C \rightarrow \begin{bmatrix} + \text{voice} \\ - \text{cont} \end{bmatrix} / [+nas] \_$$

(23) *Nasal Cluster Simplification*

$$[+nas] \rightarrow \emptyset / \_ [+nas]$$

Despite some similarity in these processes, which involve a common environment of nasal-plus-consonant, there is no reasonable way to state these processes as one rule.

In addition to showing how a complex system of phonological alternations decomposes into simpler, independent, and partially intersecting rules, the preceding analyses reveal an important component of phonological analysis, which is observing regularities in data, such as the fact that Bukusu lacks any consonant sequences composed of a nasal plus a fricative on the surface.

### 6.1.4 Matuumbi

The following data from Matuumbi illustrate the different surface realizations of the noun-class prefixes (nouns are assigned lexically or syntactically to different classes, conventionally numbered between 1 and 21). You should be able to discern and formalize the rule that applies in these data, and order those rules correctly. What rule applies in the following data?

(26)	Class	C-initial noun		V-initial noun	
	4	mi-kaáte	‘loaves’	mj-oótó	‘fires’
	5	li-kunjuúnda	‘filtered beer’	lj-oowá	‘beehive’
	7	ki-kálaango	‘frying pan’	kj-uúlá	‘frog’
	8	i-kálaango	‘frying pans’	j-uúlá	‘frogs’
	14	u-tópe	‘mud’	w-ímbi	‘beer’
	11	lu-toóndwa	‘star’	lw-aaté	‘banana hand’
	13	tu-tóopé	‘little handles’	tw-aána	‘little children’
	15	ku-suúle	‘to school’	kw-iisiwá	‘to the islands’
	16	mu-kikú	‘in the navel’	mw-iikú	‘in the navels’

The examples in (27) illustrate three rules. First, there is an optional rule applying in both subsets of (27) which deletes *u* after *m*, hence in these words, the prefix /mu/ can be pronounced in two ways, one with *u* and one without *u*. You should formalize the optional vowel deletion rule illustrated by these data.

When a rule is optional, that fact is indicated by writing “(optional)” to the right of the rule – see chapter 2.

An independent rule assimilates a nasal to the place of articulation of the following consonant (we saw this rule in previous Matuumbi data in chapters 2 and 4). This rule applies in both subsets of examples, and is the only other rule besides deletion of *u* involved in the first subset. The third rule applies in the second subset of examples, and explains the change in the initial consonant of the stem. This rule only applies to a glide preceded by a nasal which is separated by a morpheme boundary, notated in rules as “+”.

(27)	Unreduced form	Reduced form	
a.	mu-tola . . .	n-tola . . .	‘you (pl) take’
	mu-kálaangite	ŋ-kálaangite	‘you (pl) fried’

	mu-pimé	m-pimé	‘you (pl) should measure’
b.	mu-wesa . . .	η-η <sup>w</sup> esa . . .	‘you (pl) can’
	mu-jíkítiile	η-jíkítiile	‘you (pl) agreed’
	mu-wuúngo	η-η <sup>w</sup> uúngo	‘in the civet’
	mu-jiíga	η-jiíga	‘in the body’

(An alternative transcription of this second set of forms would be *ηηwesa* and so on: the point of writing this as [ηη<sup>w</sup>esa] is to make clear that there is a change in the nature of the initial segment, and not the addition of another segment.)

The examples in (28) illustrate the point that nouns in class 7 in the singular (marked with the prefix *ki-*) have their plural in class 8 (with the prefix *i-*). The plural locative form gives further illustration of a phonological rule of the language which we already know.

(28)	<i>Singular</i> (cl 7)	<i>Plural</i> (cl 8)	<i>Plural locative</i>
	ki-báo	i-báo	mwii-báo ‘stool’
	ki-bígá	i-bígá	mwii-bígá ‘pot’
	ki-bíliítu	i-bíliítu	mwii-bíliítu ‘box of matches’
	ki-bógojó	i-bógojó	mwii-bógojó ‘toothless person’

How do you explain the following examples of nouns, which also have singulars in class 7 and plurals in class 8, given that the class prefixes in these examples are underlyingly /ki-/ and /i-/?

(29)	<i>Singular</i> (cl 7)	<i>Plural</i> (cl 8)	<i>Plural locative</i>
	kjáaí	jáaí	mujáaí ~ ηjáaí ‘soup pot’
	kjaáka	jaáka	mujaáka ~ ηjaáka ‘bush’
	kjukí	jukí	mujukí ~ ηjukí ‘stump’
	kjuúbá	juúbá	mujuúbá ~ ηjuúbá ‘chest’

The data in (29) demonstrate a specific conclusion about the ordering of two of the rules motivated here: what is that conclusion?

## 6.2 Different effects of rule ordering

Besides showing how greater generality can often be achieved by splitting a process into smaller pieces, the preceding examples have illustrated that the application of one rule can bring into existence new environments where the second rule can apply, an environment which did not exist in the underlying form. What we observed happening in these cases was that both of the rules applied. Not all interactions between phonological processes have this characteristic – sometimes applying one rule prevents a second rule from applying – and in this section we consider some of the effects of different rule orderings.

### 6.2.1 Lamba: harmony and palatalization

The following data illustrate the interaction between a rule of vowel harmony and a palatalization rule in the language Lamba (Zambia):

(30)	<i>Plain</i>	<i>Passive</i>	<i>Neuter</i>	<i>Applied</i>	<i>Reciprocal</i>	
	tʰita	tʰitwa	tʰitika	tʰitila	tʰitana	‘do’
	tula	tulwa	tulika	tulila	tulana	‘dig’
	tʰeta	tʰetwa	tʰeteka	tʰetela	tʰetana	‘spy’
	soŋka	soŋkwa	soŋkeka	soŋkela	soŋkana	‘pay tax’
	pata	patwa	patika	patila	patana	‘scold’
	fisa	fiswa	fɪʃika	fɪʃila	fisana	‘hide’
	tʰesa	tʰeswa	tʰeseka	tʰesela	tʰesana	‘cut’
	kosa	koswa	koseka	kosela	kosana	‘be strong’
	lasa	laswa	laʃika	laʃila	lasana	‘wound’
	masa	maswa	maʃika	maʃila	masana	‘plaster’
	ʃika	ʃikwa	ʃitʰika	ʃitʰila	ʃikana	‘bury’
	seka	sekwa	sekeka	sekela	sekana	‘laugh at’
	poka	pokwa	pokeka	pokela	pokana	‘receive’
	kaka	kakwa	katʰika	katʰila	kakana	‘tie’
	fuka	fukwa	futʰika	futʰila	fukana	‘creep’

In order to see what these data show, we must first understand the morphological structure of these words, a step which leads us to realize that the pronunciation of certain morphemes changes, depending on their phonetic context. Verbs in Lamba are composed of a root of the form CV(C)C, an optional derivational affix marking passive, neuter, applied or reciprocal, and a word-final suffix *-a* which marks the form as being a verb. The underlying forms of the passive and reciprocal suffixes are clearly *-w-* and *-an-*, since they exhibit no phonetic variations. The neuter and applied suffixes appear phonetically as *-ik-* and *-ek-*, *-il-* and *-el-*. The choice of vowel in the suffix is determined by the vowel which precedes the suffix: if the verb root contains the vowel *i*, *u* or *a* the suffix has the vowel *i*, and if the root contains the vowel *e* or *o* the suffix has the vowel *e*. The group of vowels *i*, *u*, *a* is not a natural phonetic class, so it is implausible that the suffixes are underlyingly *-el-* and *-ek-* with *-il-* and *-ik-* being derived by a rule. The class of vowels *e*, *o* is the phonetic class of mid vowels; it is thus evident that this language has a vowel harmony rule which assimilates underlying high vowels (in the suffixes /il/ and /ik/) to mid vowels when they are preceded by mid vowels.

(31) *Height harmony*

$$[+syl] \rightarrow [-hi] / \left[ \begin{array}{l} +syl \\ -hi \\ -low \end{array} \right] C_0 \_$$

There is an alternation in the realization of certain root-final consonants. As shown in examples such as *kaka* ~ *kat<sup>h</sup>ika* and *lasa* ~ *la<sup>f</sup>ika*, the velar consonants and the alveolar continuant *s* become alveopalatals when they are followed by the vowel *i*, by processes of palatalization. It is difficult to express a change of /k/ and /s/ to alveopalatal by one rule without including /t/ – which does not change, see [patika] – so two separate rules are needed.

(32) a. *Stop Palatalization*

$$\begin{bmatrix} + \text{hi} \\ - \text{syl} \end{bmatrix} \rightarrow [+ \text{cor}] / \text{---} \begin{bmatrix} + \text{syl} \\ + \text{hi} \\ - \text{back} \end{bmatrix}$$

b. *Fricative Palatalization*

$$\begin{bmatrix} + \text{cont} \\ + \text{cor} \end{bmatrix} \rightarrow [- \text{ant}] / \text{---} \begin{bmatrix} + \text{syl} \\ + \text{hi} \\ - \text{back} \end{bmatrix}$$

The interaction between these processes is seen in words which could in principle undergo both of these processes: roots with the vowel *e* or *o*, and the final consonant *k* or *s*. The example *sekeka* ‘laugh at’ from /sek-ik-a/ shows how these processes interact. Suppose, first, that palatalization were to apply before vowel harmony. Since the underlying representation has the sequence /ki/ which is required by palatalization, that rule would apply. Subsequently, vowel harmony would assimilate /i/ to [e] after /e/, giving the wrong surface result. This is illustrated below in a derivation which spells out the results of applying first palatalization, then height harmony.

(33)	/sek-ik-a/	<i>underlying</i>
	set <sup>h</sup> ika	<i>palatalization</i>
	*set <sup>h</sup> eka	<i>height harmony</i>

Thus, applying the rules in this order gives the wrong results: this order cannot be correct.

On the other hand, if we apply the processes in the other order, with height harmony applying before palatalization, then the correct form is generated.

(34)	/sek-ik-a/	<i>underlying</i>
	sekeka	<i>height harmony</i>
	(not applicable)	<i>palatalization</i>

## 6.2.2 Voicing and epenthesis

**Lithuanian.** Another example which illustrates how an earlier rule can change a form in such a way that a later rule can no longer apply is found in Lithuanian. There is a process of voicing assimilation in Lithuanian whereby obstruents agree in voicing with an



immediately following obstruent. This rule applies in the following examples to the verbal prefixes /at/ and /ap/.

- (35) a.     /at/       at-eiti               ‘to arrive’  
                           at-imti              ‘to take away’  
                           at-neſti             ‘to bring’  
                           at-leisti            ‘to forgive’  
                           at-likti             ‘to complete’  
                           at-ko:pti          ‘to rise’  
                           at-praſi:ti         ‘to ask’  
                           at-kurti            ‘to reestablish’  
               /ap/       ap-eiti              ‘to circumvent’  
                           ap-ieſko:ti       ‘to search everywhere’  
                           ap-akti             ‘to become blind’  
                           ap-mo:ki:ti        ‘to train’  
                           ap-temdi:ti       ‘to obscure’  
                           ap-ſaukti          ‘to proclaim’  
       b.     /at/       ad-bekti            ‘to run up’  
                           ad-gauti           ‘to get back’  
                           ad-bukti           ‘to become blunt’  
                           ad-gimti           ‘to be born again’  
               /ap/       ab-gauti           ‘to deceive’  
                           ab-ʒ<sup>i</sup>ureti        ‘to have a look at’  
                           ab-ʒelti            ‘to become overgrown’  
                           ab-dauʒi:ti        ‘to damage’  
                           ab-draski:ti       ‘to tear’

We would assume that the underlying forms of the prefixes are /at/ and /ap/, and that there is a rule which voices obstruents before voiced obstruents.

(36)     *Voicing assimilation*

$$[-\text{son}] \rightarrow [+ \text{voice}] / \text{ — } \begin{bmatrix} - \text{son} \\ + \text{voice} \end{bmatrix}$$

The alternative hypothesis would be that the prefixes are underlyingly /ad/ and /ab/. However, there is no natural context for describing the process of devoicing. Although devoicing of voiced obstruents before voiceless obstruents is quite natural, assuming that the prefixes have underlying voiced obstruents would also require the consonant to be devoiced before vowels and sonorant consonants, in order to account for the supposed

derivations /ad-eiti/ → [ateiti], /ab-eiti/ → [apeiti], /ad-neſti/ → [atneſti] and /ab-mo:ki:ti/ → [apmo:ki:ti]. But there is clearly no rule prohibiting voiced obstruents before vowels and sonorants in this language (in fact, no language has ever been attested with a rule of consonant devoicing where the conditioning environment is a following vowel). On the basis of this reasoning, we conclude that the prefixes have underlying voiceless consonants.

When the initial consonant of the root is an alveolar stop, the vowel [i] appears after the prefix /at/, and similarly when the initial consonant is a bilabial stop, [i] is inserted after the consonant of /ap/.

(37)	ati-duoti	‘to give back’
	ati-dari:ti	‘to open’
	ati-deti	‘to delay’
	ati-teisti	‘to adjudicate’
	api-berti	‘to strew all over’
	api-begti	‘to run around’
	api-puti	‘to grow rotten’

Given just the voicing assimilation rule, you would expect forms such as \*[adduoti], \*[abberti] by analogy to [adbekti] and [abdauzi:ti]. Lithuanian does not allow sequences of identical consonants, so to prevent such a result, an epenthetic vowel is inserted between **homorganic** obstruent stops (ones having the same values for the place of articulation features).

(38) Epenthesis

$$\emptyset \rightarrow \begin{bmatrix} +\text{syl} \\ +\text{hi} \\ -\text{back} \end{bmatrix} / \begin{bmatrix} -\text{cont} \\ -\text{son} \\ \alpha\text{ant} \\ \beta\text{cor} \end{bmatrix} - \begin{bmatrix} -\text{cont} \\ -\text{son} \\ \alpha\text{ant} \\ \beta\text{cor} \end{bmatrix}$$

The ordering of these rules is important: epenthesis (38) must apply before voicing assimilation, since otherwise the prefix consonant would assimilate the voicing of the root-initial consonant and would then be separated from that consonant by the epenthetic vowel. The result of applying the voicing assimilation rule first would be to create [adduoti], [abberti], and then this would undergo vowel epenthesis to give incorrect \*[adiduoti], \*[abiberti]. If, on the other hand, epenthesis is the first rule applied, then underlying /at-duoti/ becomes [atiduoti] and /ap-berti/ becomes [apiberti]. Epenthesis eliminates the underlying cluster of obstruents, preventing the voicing rule from applying.

**Armenian.** Interestingly, a similar pair of rules exists in the New Julfa (Iran) dialect of Armenian, but they apply in the opposite order. If rules apply in a particular order, you would expect to find languages with essentially the same rules A and B where A precedes B in one language and B precedes A in another: this is what we find in comparing Armenian and Lithuanian.

The first-singular future prefix is underlyingly *k-*, as shown in (39a), where the prefix is added to a vowel-initial stem. That /k/ assimilates voicing and aspiration from an obstruent which immediately follows it underlyingly (but not across a vowel). In addition, initial consonant clusters are broken up by an epenthetic schwa. As the data in (39b) show, the prefix consonant first assimilates to the initial consonant of the root, and then is separated from that consonant by schwa.

- (39) a.    *k-ert<sup>h</sup>am*                    ‘I will go’  
              *k-asiem*                      ‘I will say’  
              *k-aniem*                      ‘I will do’  
              *k-akaniem*                   ‘I will watch’  
              *k-oxniem*                   ‘I will bless’  
              *k-uriem*                      ‘I will swell’
- b.    *kə-tam*                      ‘I will give’  
              *kə-kienam*                  ‘I will exist’  
              *gə-bəzzam*                  ‘I will buzz’  
              *gə-lam*                      ‘I will cry’  
              *gə-zəram*                   ‘I will bray’  
              *k<sup>h</sup>ə-t<sup>h</sup>uojniem*              ‘I will allow’  
              *k<sup>h</sup>ə-t<sup>h</sup>ap<sup>h</sup>iem*               ‘I will measure’  
              *g<sup>h</sup>ə-b<sup>h</sup>ie.riem*               ‘I will carry’  
              *g<sup>h</sup>ə-g<sup>h</sup>uom*                  ‘I will come’  
              *g<sup>h</sup>ə-d<sup>zh</sup>ieviem*              ‘I will form’

The difference between this dialect of Armenian and Lithuanian is that vowel epenthesis applies before consonant assimilation in Lithuanian but after that rule in Armenian, so that in Armenian both epenthesis and assimilation can apply to a given word, whereas in Lithuanian applying epenthesis to a word means that assimilation can no longer apply.

### 6.2.3 Mongo: B-deletion and resolution of vowel hiatus

Sometimes, what needs to be remarked about the interaction between processes is the failure of one rule to apply to the output of another rule. This is illustrated in (40), (41) and (46) with examples from Mongo (Congo). The first four examples demonstrate the shape of the various subject prefixes when they stand before a consonant

(40)

<i>Imp</i>	<i>1sg</i>	<i>2sg</i>	<i>3sg</i>	<i>1pl</i>	<i>2pl</i>	<i>3pl</i>	
<i>saŋga</i>	<i>nsaŋga</i>	<i>osaŋga</i>	<i>asaŋga</i>	<i>toŋga</i>	<i>loŋga</i>	<i>baŋga</i>	‘say’
<i>kamba</i>	<i>ŋkamba</i>	<i>okamba</i>	<i>akamba</i>	<i>tokamba</i>	<i>lokamba</i>	<i>bakamba</i>	‘work’
<i>kɔta</i>	<i>ŋkɔta</i>	<i>ɔkɔta</i>	<i>akɔta</i>	<i>tɔkɔta</i>	<i>lɔkɔta</i>	<i>bakɔta</i>	‘cut’

tɛŋga	ntɛŋga	ɔtɛŋga	atɛŋga	tɔtɛŋga	lɔtɛŋga	batɛŋga	‘straighten’
mɛla	mmɛla	ɔmɛla	amɛla	tɔmɛla	lɔmɛla	bamɛla	‘drink’
d <sup>3</sup> ila	nd <sup>3</sup> ila	od <sup>3</sup> ila	ad <sup>3</sup> ila	tod <sup>3</sup> ila	lod <sup>3</sup> ila	bad <sup>3</sup> ila	‘wait’

The underlying forms of the subject prefixes are /N/ (which stands for a nasal consonant, whose exact place of articulation cannot be determined), /o/, /a/, /to/, /lo/ and /ba/. There is a vowel harmony process assimilating the closed vowel /o/ to the open vowel [ɔ] when the following syllable contains either of the open vowels [ɛ] or [ɔ], and the prefix for first-singular subject assimilates in place of articulation to the following consonant.

The examples in (41) show how the subject prefixes are realized if the verb root begins with a vowel.

(41)

<i>Imp.</i>	<i>1sg</i>	<i>2sg</i>	<i>3sg</i>	<i>1pl</i>	<i>2pl</i>	<i>3pl</i>	
ɛna	nd <sup>3</sup> ɛna	wɛna	ɛna	t <sup>s</sup> wɛna	d <sup>3</sup> wɛna	bɛna	‘see’
isa	nd <sup>3</sup> isa	wisa	isa	t <sup>s</sup> wisa	d <sup>3</sup> wisa	bisa	‘hide’
imed <sup>3</sup> a	nd <sup>3</sup> imed <sup>3</sup> a	wimed <sup>3</sup> a	imed <sup>3</sup> a	t <sup>s</sup> wimed <sup>3</sup> a	d <sup>3</sup> wimed <sup>3</sup> a	bimed <sup>3</sup> a	‘consent’
usa	nd <sup>3</sup> usa	wusa	usa	t <sup>s</sup> wusa	d <sup>3</sup> wusa	busa	‘throw’
ina	nd <sup>3</sup> ina	wina	ina	t <sup>s</sup> wina	d <sup>3</sup> wina	bina	‘hate’

When the first-singular subject prefix stands before the root, it has the shape [nd<sup>3</sup>], which we will treat as being the result of insertion of [d<sup>3</sup>] between the prefix and a vowel-initial root. (We might also assume the prefix /nd<sup>3</sup>/, which simplifies before a consonant, since such three-consonant sequences, viz. /nd<sup>3</sup>-sanga/, do not exist in the language.)

(42) *Consonant epenthesis*

$$\emptyset \rightarrow \left[ \begin{array}{c} -\text{syl} \\ -\text{cons} \\ +\text{voice} \\ -\text{back} \end{array} \right] / [+nas] + \_ V$$

The vowel /a/ deletes before another vowel, as shown by the third-singular and third-plural forms /a-ɛna/ → [ɛna] and /ba-ɛna/ → [bɛna].

(43) *Vowel truncation*

$$[+low] \rightarrow \emptyset / \_ V$$

The prefixes /o/, /to/, and /lo/ undergo a process of glide formation where /o/ becomes [w] before a vowel.

(44) *Glide formation*

$$[+round] \rightarrow [-syl] / \_ V$$

In the case of /to/ and /lo/ a further process affricates these consonants before a glide.

(45) *Affrication*

$$[+cor] \rightarrow [+del.rel] / \text{---} \begin{bmatrix} -syl \\ +hi \end{bmatrix}$$

*Turning /l/ into an affricate seems strange from a functional perspective, but is explained by the fact that l was originally /d/, so this rule comes historically from the more natural change /t, d/ → [tʰ, dʰ]/ \_ i.*

This affrication process must apply after glide formation, since it applies to a sequence of consonant plus glide that is created by the application of glide formation from an underlying consonant-plus-vowel sequence.

The final set of examples illustrates verb roots which underlyingly begin with the consonant /b/. As these data show, when underlying /b/ is preceded by a vowel, it is deleted.

(46)	<i>Imp</i>	<i>1sg</i>	<i>2sg</i>	<i>3sg</i>	<i>1pl</i>	<i>2pl</i>	<i>3pl</i>	
	bina	mbina	oina	aina	toina	loina	baina	‘dance’
	bota	mbota	oota	aota	toota	loota	baota	‘beget’

Thus, surface [oina] derives from /obina/ and [baina] derives from /babina/, via the following rule.

(47) *Labial elision*

$$\begin{bmatrix} + \text{voice} \\ + \text{ant} \\ - \text{cor} \end{bmatrix} \rightarrow \emptyset / V \text{---} V$$

In this case, even though deletion of /b/ creates new sequences of *o*+V and *a*+V which could in principle undergo the rules of *a*-deletion and glide formation, those rules do not in fact apply. In other words, in this case the grammar must contain some kind of explicit statement regarding the interaction of these processes, such as an explicit ordering of the rules, which guarantees that the output of *b*-deletion does not undergo glide formation or *a*-deletion. By ordering the *b*-deletion rule so that it applies after the glide formation and vowel truncation rules, we explain why those two rules fail to apply, just in case the consonant *b* is deleted intervocally. The ordering where *b*-deletion precedes vowel truncation and glide formation, illustrated in (48b), results in ungrammatical forms, which shows that that ordering of the rules is incorrect. (“NA” means that the rule cannot apply, because the conditions called for in the rule are not satisfied in the string.)

(48)	a.	/o-bina/	/a-bina/	<i>underlying</i>
		NA	NA	<i>Glide formation</i>
		NA	NA	<i>vowel truncation</i>
		oina	aina	<i>b-deletion</i>
	b.	/o-bina/	/a-bina/	<i>underlying</i>

oina	aina	<i>b-deletion</i>
wina	NA	<i>glide formation</i>
NA	ina	<i>vowel truncation</i>
*[wina]	*[ina]	

Mongo thus provides an example of the failure of rules – especially vowel truncation and glide formation – to apply to the output of a specific rule – *b*-deletion – which we explain by ordering *b*-deletion after the vowel rules.

#### 6.2.4 Examples for discussion

**Karok.** These data from Karok (California) illustrate three interacting phonological processes. Comment on the underlying forms of the following words, state what phonological rules are motivated, and discuss the order in which these processes apply.

(49)	<i>Imperative</i>	<i>1sg</i>	<i>3sg</i>	
	pasip	nipasip	ʔupasip	‘shoot’
	si:tva	niʃi:tva	ʔusi:tva	‘steal’
	kifnuk	nikifnuk	ʔukifnuk	‘stoop’
	suprih	niʃuprih	ʔusuprih	‘measure’
	ʔifik	niʔifik	ʔuʔifik	‘pick up’
	ʔi:ftih	niʔi:ftih	ʔuʔi:ftih	‘growing’
	ʔaktuv	niʔaktuv	ʔuʔaktuv	‘pluck at’
	ʔakrap	niʔakrap	ʔuʔakrap	‘slap’
	ʔarip	niʔarip	ʔuʔarip	‘cut a strip’
	ʔaxjar	nixjar	ʔuxjar	‘fill’
	ʔiʃkak	niʃkak	ʔuskak	‘jump’
	ʔimniʃ	nimniʃ	ʔumniʃ	‘cook’
	ʔikʃah	nikʃah	ʔuksah	‘laugh’
	ʔiʃriv	niʃriv	ʔusriv	‘shoot at a target’

**Shona.** Often, a seemingly complex problem can be significantly simplified by breaking the problem up into a few interacting processes. If you look at the phonetic realizations of the passive suffix in Shona (Zimbabwe), you see that there are seven different manifestations of this suffix. However, this considerable range of variation can be explained in terms of a much smaller set of very general phonological rules, whose interaction results in many surface realizations of the suffix.

(50)

<i>Active</i>	<i>Passive</i>		<i>Active</i>	<i>Passive</i>	
bika	bikwa	‘cook’	diba	dibya	‘dip’
p <sup>f</sup> ugama	p <sup>f</sup> ugamɲa	‘kneel’	pepa	pepxa	‘nurse’
buda	budɣwa	‘go out’	ruma	rumɲa	‘bite’
rova	rovɣa	‘stay away’	ɲana	ɲanɲwa	‘run’
sunɣa	sunɣwa	‘tie’	kwafa	kwafɣwa	‘hunt’
tenɣa	tenɣwa	‘buy’	funɣa	funɣwa	‘think’
tamba	tambɣa	‘play’	b <sup>v</sup> unza	b <sup>v</sup> unzɣwa	‘ask’
imba	imɣa	‘sing’	gara	garɣwa	‘stay’
set <sup>s</sup> a	set <sup>s</sup> xwa	‘amuse’	red <sup>z</sup> a	red <sup>z</sup> ɣwa	‘lengthen’
tapa	tapxa	‘capture’	βeza	βezɣwa	‘carve’
rega	regwa	‘leave’	ib <sup>v</sup> a	ib <sup>v</sup> ɣa	‘ripen’
ɟuza	ɟuzɣwa	‘store grain’	taɣa	taɣɣwa	‘ride’
peta	petɣwa	‘fold’	dana	danɲwa	‘call’
ona	onɲwa	‘see’	ita	itɣwa	‘do’
doka	dokwa	‘set’	seka	sekwa	‘laugh’
fesa	fesɣwa	‘prick’	rasa	rasɣwa	‘throw away’
raɲa	raɲɲwa	‘kick’	pema	pemɲa	‘beg food’
got <sup>f</sup> a	got <sup>f</sup> ɣwa	‘roast’	ɕika	ɕikwa	‘arrive’
d <sup>z</sup> id <sup>z</sup> a	d <sup>z</sup> id <sup>z</sup> ɣwa	‘learn’	fuka	fukwa	‘cover’
famba	fambɣa	‘walk’	nand <sup>z</sup> a	nand <sup>z</sup> ɣwa	‘lick’
gada	gadɣwa	‘mount’	ɓata	ɓatɣwa	‘hold’
tuma	tumɲa	‘send’	tora	torywa	‘take’
oɲa	oɲwa	‘growl’	rima	rimɲa	‘plow’
sefa	sefxa	‘sieve’	kweza	kwezɣwa	‘attract’
d <sup>3</sup> ud <sup>3</sup> a	d <sup>3</sup> ud <sup>3</sup> ɣwa	‘leak’	guruva	guruvɣa	‘deceive’
manɣa	manɣwa	‘arrest’	mɪna	mɪnɲwa	‘swallow’

The precise rules which you postulate will depend on what you assume to be the underlying form of the passive suffix, since there are two plausible underlying forms for the suffix, based on the data above. The phonological alternations seen in the following examples are relevant to deciding what the underlying form of the passive suffix is (and therefore exactly how these phonological alternations are to be analyzed). These inflected forms involve a prefix marking the subject, followed by one of various tense markers such as -t<sup>f</sup>a-, -no-, and -a-, or no marker, finally followed by the verb stem.

(51)	<i>Subjunctive</i>		<i>Future</i>	
	urime	‘that you (sg) plow’	ut <sup>f</sup> arima	‘you (sg) will plow’
	murime	‘that you (pl) plow’	mut <sup>f</sup> arima	‘you (pl) will plow’
	turime	‘that they (tiny) plow’	tut <sup>f</sup> arima	‘they (tiny) will plow’
	kunat <sup>s</sup> e	‘that there be nice’	kut <sup>f</sup> anat <sup>s</sup> a	‘there will be nice’
	<i>Habitual</i>		<i>Recent past</i>	
	unorima	‘you (sg) plow’	warima	‘you (sg) plowed’
	munorima	‘you (pl) plow’	mɲarima	‘you (pl) plowed’
	tunorima	‘they (tiny) plow’	txwarima	‘they (tiny) plowed’
	kunonat <sup>s</sup> a	‘there is nice’	kwanat <sup>s</sup> a	‘there was nice’

A further fact which is relevant to deciding on the correct analysis is that [ɣ], [x] do not appear after vowels or at the beginning of a word.

**Klamath.** The data in (52)–(56) from Klamath (Oregon) illustrate two processes. The first deaspirates and deglottalizes consonants before obstruents, before glottalized and voiceless resonants, as well as in word-final positions. The examples in (52) illustrate plain voiceless obstruents, which do not undergo any phonetic alternations. The data below involve a range of inflectionally and derivationally related word forms: the common root is underlined (the last form in this set also illustrates an alternation between *i* and *y*, which is not crucial).

(52)	<u>la:p</u> -a	‘two (obj.)’	<u>la:p</u>	‘two’
	sk <sup>h</sup> ot-a	‘puts on a blanket’	sk <sup>h</sup> ot-p <sup>h</sup> i	‘puts on a blanket again’
	q’la:t <sup>f</sup> -aksi	‘Blueberry Place’	q’la:t <sup>f</sup>	‘blueberry (sp)’
	poq-a	‘bakes camas’	poq-s	‘camas root’
	laqi	‘is rich’	laqj’-a:ka	‘little chief’

The data in (53) provide examples of underlyingly glottalized obstruents, which become plain voiceless consonants unless they are followed by a vowel or plain sonorant

(53)	<u>p’ak’</u> -a	‘smashes’	<u>p’ak</u> -ska	‘chips off (intr)’
	ʔe:t’-a	‘distributes’	se-ʔe:t-s	‘Saturday’
	poq-poq’-a	‘becomes dusty’	po:q-tki	‘becomes dusty’
	t <sup>h</sup> a:k’-a	‘melts (intr)’	t <sup>h</sup> a:k-tki	‘melts (as butter)’
	ʔi-t <sup>h</sup> i:t <sup>f</sup> -a	‘makes shavings’	k-t <sup>h</sup> it <sup>f</sup> -ta	‘scrapes ones foot on’
	t <sup>h</sup> lo:q’-a	‘is smooth’	t <sup>h</sup> lo:q-tki	‘becomes slick’
	qit’-lqa	‘pours down’	qit-q <sup>h</sup> a	‘pours out’
	-lo:p’-a	‘eats soup’	-lo:p-s	‘soup’

Data in (53) show that aspirated consonants deaspirate in this same context.



(54)	<u>li:t<sup>h</sup></u> -li:t <sup>f</sup> -l'i	'strong'	<u>li:t<sup>f</sup></u> -tki	'becomes strong'
	ponw- <u>o:t<sup>h</sup></u> -a	'while drinking'	ponw- <u>o:t</u> -s	'something to drink with'
	so:t <sup>h</sup> -a	'kindles a fire'	<u>so:t<sup>f</sup></u> -ti:la	'lights a fire under'
	<u>si:jo:t<sup>h</sup></u> -a	'trades (pl) obj with each other'	<u>si:jo:t</u> -pli	'trade back (pl obj)'
	<u>n'iq<sup>h</sup></u> -o:wa	'keeps putting a hand in water'	<u>n'iq</u> -tpa	'reaches and touches'

The second process, syncope, deletes a short vowel from the first syllable of a stem when preceded by a CV prefix and followed by CV.

(55)	<u>laqi:ta</u>	'suspects s.o.'	sa-lqita	'suspects e.o.'
	<u>mat<sup>h</sup></u> a:t-ka	'listens'	sna- <u>mt<sup>h</sup></u> a:t-i:la	'causes to hear'
	met <sup>f</sup> a	'moves camp'	me- <u>mt<sup>f</sup></u> a	'moves (distributive)'
	<u>saqo:tka</u>	'ask for s.t.'	sa- <u>sqo:tqa</u>	'ask for s.t. (distributive)'
	<u>sit<sup>f</sup>aq<sup>h</sup></u> wa	'wash hands'	hi- <u>st<sup>f</sup>aq-t<sup>h</sup></u> a	'are angry with e.o.'
	<u>som</u>	'mouth'	so- <u>sm</u> '-a:k	'little mouths (distributive)'

What do these examples show about the interaction of these two processes?

(56)	<u>q'ot<sup>f</sup></u> 'a	'bends'	jo- <u>qt<sup>f</sup></u> 'a	'bends with the feet'
	<u>q<sup>h</sup>ew</u> 'a	'breaks'	t <sup>h</sup> he- <u>qw</u> 'a	'sit on and break'
	<u>t<sup>h</sup>ew</u> 'a	'surface cracks'	je- <u>tw</u> 'a	'steps on and cracks surface'
	s- <u>t<sup>f</sup>iq</u> 'a	'squash with a pointed instrument'	ji- <u>t<sup>f</sup>q</u> 'a	'squash by pressure with the feet'
	w- <u>k'al</u> 'a	'cuts with a long instrument'	kin- <u>kl</u> 'a	'makes a mark with pointer'
	w- <u>p'eq</u> 'a	'hits in the face with a long instrument'	hom- <u>pq</u> 'a	'flies in the face'

## Summary

Systems of phonological alternations in most languages involve a number of rules. This interaction means that you must discern the effects of individual rules, rather than subsume all alternations under one complex do-everything rule. A rule changes a given set of segments in a uniform manner, in a specified environment. So even when a language like Bukusu has a number of rules pertaining to sequences of nasal plus consonant – rules which have in common a single context NC – there may be quite a number of specific rules that apply in that context. Besides identifying what rules exist in a language, you must also determine what the proper ordering of those rules is. The

correct order of a pair of rules can be determined by applying the rules very literally-mindedly in both of the logically possible orders.

## Exercises

### 1 Kerewe

What two tone rules are motivated by the following data? Explain what order the rules apply in.

<i>to V</i>	<i>to V e.o</i>	<i>to V for</i>	<i>to V for e.o.</i>	
kubala	kubalana	kubalila	kubalilana	‘count’
kugaja	kugajana	kugajila	kugajilana	‘despise’
kugula	kugulana	kugulila	kugulilana	‘buy’
kubála	kubálána	kubálíla	kubálílana	‘kick’
kulúma	kulúmána	kulúmíla	kulúmílana	‘bite’
kusúna	kusúnána	kusúníla	kusúnílana	‘pinch’
kulába	kulábána	kulábíla	kulábílana	‘pass’

  

<i>to V us</i>	<i>to V it</i>	<i>to V for us</i>	<i>to V it for us</i>	
kutúbála	kukíbála	kutúbálila	kukítúbalila	‘count’
kutúgája	kukígája	kutúgájila	kukítúgajila	‘despise’
kutúgúla	kukígúla	kutúgúlila	kukítúgulila	‘buy’
kutúbála	kukíbála	kutúbálila	kukítúbalila	‘kick’
kutúlúma	kukílúma	kutúlúmila	kukítúlumila	‘bite’
kutúsúna	kukísúna	kutúsúnila	kukítúsunila	‘pinch’
kutúlába	kukílába	kutúlábila	kukítúlabila	‘pass’

### 2. Mbunga

Account for the phonological alternations in the following data. Note that there are two roots ‘beat’, ‘cut’, ‘rub’, also there are derivational relations indicated with suffixes (-*el*-, -*il*-, -*is*-, -*es*- etc) which you need not account for: except for the difference between final -*a* and final -*i* which mark different tenses, you do not need to be concerned with possible suffixes and alternations caused by suffixes.

‘he V-ed me’	‘he V-ed us’	gloss
kamvutila	katufutila	rub for
kamvuwila	katufuwila	wash for
kanzeka	katuseka	laugh at
kanzukumula	katusukumula	push
kad <sup>3</sup> imisila	katud <sup>3</sup> imisila	extinguish for
kabota	katubota	beat
kababanisa	katubabanisa	squeeze

kadaŋgila	katudaŋgila	throw for
kadetela	katudetela	say to
kaguvila	katuguvila	fall on
kandova	katutova	beat
kaɲd <sup>3</sup> ubula	katut <sup>f</sup> ubula	scratch
kaŋgamula	katukamula	grab
kambutukila	katuputukila	rub for
kanduvila	katutuvila	run for
kaŋgetulila	katuketulila	cut for
kandelekela	katutelekela	cook for
‘I will V’	‘they will V’	gloss
dadumuli	davadumuli	cut
dad <sup>3</sup> imisi	davad <sup>3</sup> imisi	extinguish
daguvi	davaguvi	fall
dadeti	davadeti	say
dababanisi	davababanisi	squeeze
dadaŋgi	davadan̄gi	throw
danzeke	davaseke	laugh
damvuti	davafuti	rub
dandovi	davatovi	beat
dandeleke	davateleke	cook
daŋgetuli	davaketuli	cut
daŋgamuli	davakamuli	grab
danduvi	davatuvi	run
dambutuki	davaputuki	rub
daɲd <sup>3</sup> ubuli	davat <sup>f</sup> ubuli	scratch

### 3 Polish

What phonological rules are motivated by the following examples, and what order do those rules apply in?

<i>Singular</i>	<i>Plural</i>		<i>Singular</i>	<i>Plural</i>	
klup	klubi	‘club’	trup	trupi	‘corpse’
dom	domi	‘house’	snop	snopi	‘sheaf’
zwup	zwobi	‘crib’	trut	trudi	‘labor’
dzvon	dzvoni	‘bell’	kot	koti	‘cat’
lut	lodi	‘ice’	grus	gruzi	‘rubble’
nos	nosi	‘nose’	vus	vozi	‘cart’
wuk	wugi	‘lye’	wuk	wuki	‘bow’
sok	soki	‘juice’	ruk	rogi	‘horn’
bur	bori	‘forest’	vuw	vowi	‘ox’
sul	solu	‘salt’	buj	boji	‘fight’

jum	jumi	‘noise’	zur	zuri	‘soup’
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**4. Logoori.** Account for the vowel alternations in the following data. Tone may be ignored.

‘they just V’d’	‘they just V’d for’	‘they will V (rem. fut)’	‘they will V for (rem. fut)’	gloss
váakátáanga	váakátáángira	varakátáange	varakátáángiri	start
váakávónjaanja	váakávónjaanjira	varakávónjaanje	varakávónjaanjiri	break
váakázáázama	váakázáázamira	varakázáázame	varakázáázamiri	taste
váakavoroanja	váakavoroanjira	varakavoroanje	varakavoroanjiri	stir
váakagananja	váakagananjira	varakagananje	varakagananjiri	think
váakarunga	váakarungira	varakarungi	varakarungiri	season
váakariinda	váakariindira	varakariindi	varakariindiri	guard
váakátóma	váakátómira	varakátómi	varakátómiri	send
váakásúunga	váakásúungira	varakásúungi	varakásúungiri	hang up
váakatuuma	váakatuumira	varakatuumi	varakatuumiri	jump
váakávína	váakávínira	varakávini	varakávíniri	dance
váakavisa	váakavisira	varakavisi	varakavisiri	hide
váakávita	váakávítira	varakávíti	varakávítiri	pass
váakágámora	váakágámorira	varakágámori	varakágámoriri	catch
váakahiriita	váakahiriitira	varakahiriiti	varakahiriitiri	snore
váakadiginja	váakadiginjira	varakadiginji	varakadiginjiri	tickle
váakáhákiza	váakáhákizira	varakáhákizi	varakáhákiziri	scorch
váakavariza	váakavarizira	varakavarizi	varakavariziri	count
váakáfönjiiriza	váakáfönjiirizira	varakáfönjiirizi	varakáfönjiiriziri	smell
váakaminiika	váakaminiikira	varakaminiiki	varakaminiikiri	be ill
váakagarokiza	váakagarokizira	varakagarokizi	varakagarokiziri	reverse
váakarungikiza	váakarungikizira	varakarungikizi	varakarungikiziri	straighten
váakátónjamina	váakátónjaminjira	varakátónjaminji	varakátónjaminjiri	invert
váakasjeena	váakasjeenera	varakasjeene	varakasjeenerere	step
váakáréemba	váakáréémbera	varakáréembe	varakáréémberere	scold
váakáróota	váakáróótera	varakáróote	varakáróóterere	dream
váakaseka	váakasekera	varakaseke	varakasekere	laugh
váakateeva	váakateevera	varakateeve	varakateeverere	ask
váakáhéenza	váakáhéénzera	varakáhéenze	varakáhéénzere	seek
váakarwonda	váakarwondera	varakarwonde	varakarwonderere	follow
váakáréeta	váakárééterera	varakáréete	varakárééterere	bring
váakádéeka	váakádééekera	varakádééeke	varakádééekere	cook
váakáména	váakáménpera	varakáméne	varakáménperere	live
váakaswoma	váakaswomera	varakaswome	varakaswomere	read
váakávéga	váakávégera	varakávége	varakávégere	shave
váakamwoma	váakamwomera	varakamwome	varakamwomere	speak
váakareka	váakarekera	varakareke	varakarekere	stop

The following nouns illustrate a productive pattern for making nouns ‘tool for Ving with’

ividujirɔ	‘pound’	ivivégerɔ	‘shave’	ivikáragirɔ	‘cut’
ivisɔɔmerɔ	‘read’	ivivínirɔ	‘dance’	ivinágillo	‘catch’
ivisɛembello	‘cultivate’	ivirɔongirɔ	‘season’		

## 5 Shona

Acute accent indicates H tone and unaccented vowels have L tone. Given the two sets of data immediately below, what tone rule do the following data motivate? There are alternations in the form of adjectives, e.g. *kurefú*, *karefú*, *marefú* all meaning ‘long.’ Adjectives have an agreement prefix, hence *ku-refú* marks the form of the adjective in one grammatical class, and so on. In some cases, the agreement is realized purely as a change in the initial consonant of the adjective, i.e. *gúrú* ~ *kúrú* ~ *húrú*, which need not be explained.

bveni	‘baboon’	bveni pfúpi	‘short baboon’
táfura	‘table’	táfura húrú	‘big table’
ʃoko	‘word’	ʃoko bvúpi	‘short word’
ɓadzá	‘hoe’	ɓadzá gúrú	‘big hoe’
zigómaná (augmentative) ‘	‘boy (augmentative) ‘	zigómaná gúrú	‘big boy
imbá	‘house’	imbá tʰéna	‘clean house’
ṃará	‘gazelle’	ṃará tʰéna	‘clean gazelle’
marí	‘money’	marí tʰéna	‘clean money’
ɓáŋgá	‘knife’	ɓáŋga gúrú	‘big knife’
děmó	‘axe’	děmo bvúpi	‘short axe’
ṇúmé	‘messenger’	ṇúme pfúpi	‘short messenger’
dʒírá	‘cloth’	dʒíra dʒéna	‘clean cloth’
hári	‘pot’	hári húrú	‘big pot’
mbúndúdzi	‘worms’	mbúndúdzi húrú	‘big worms’
fúma	‘wealth’	fúma tʰéna	‘clean wealth’
ɲíka	‘country’	ɲíka húrú	‘big country’
hákáta	‘bones’	hákáta pfúpi	‘short bones’
dʒékéra	‘pumpkin’	dʒékéra gúrú	‘big pumpkin’

These data provide further illustration of the operation of this tone rule, which will help you to state the conditions on the rule correctly.

guɗo	‘baboon’	guɗo rákafá	‘the baboon died’
ɓadzá	‘hoe’	ɓadzá rákawá	‘the hoe fell’
nuŋgú	‘porcupine’	nuŋgú jákafá	‘the porcupine died’

báŋgá	‘knife’	báŋga rákawá	‘the knife fell’
ńúmé	‘messenger’	ńúme jákafá	‘the messenger died’
búku	‘book’	búku rákawá	‘the book fell’
mapfeni	‘baboons’	mapfeni makúru	‘big baboons’
mapadzá	‘hoes’	mapadzá makúru	‘big hoes’
mapángá	‘knives’	mapángá makúru	‘big knives’
ńúmé	‘messenger’	ńúmé ndefú	‘tall messenger’
matémó	‘axes’	matémó mapfúpi	‘short axes’
mabúku	‘books’	mabúku mazínd <sup>3</sup> í	‘many books’
t <sup>h</sup> ítóro	‘store’	t <sup>h</sup> ítóro t <sup>h</sup> íkúru	‘big store’

In the examples below, a second tone rule applies.

guḍo	‘baboon’	guḍo refú	‘tall baboon’
búku	‘book’	búku refú	‘long book’
ḡadzá	‘hoe’	ḡadzá refú	‘long hoe’
nuṅgú	‘porcupine’	nuṅgú ndefú	‘long porcupine’
maʃoko	‘words’	maʃoko marefú	‘long words’
kupíka	‘to the land’	kupíka kurefú	‘to the long land’
mapadzá	‘hoes’	mapadzá marefú	‘long hoes’
kaṃará	‘gazelle (dim)’	kaṃará karefú	‘long gazelle (dim)’
tunuṅgú	‘porcupines (dim)’	tunuṅgú túrefú	‘long porcupines (dim)’
guḍo	‘baboon’	guḍo gobvú	‘thick baboon’
búku	‘book’	búku gobvú	‘thick book’
ḡadzá	‘hoe’	ḡadzá gobvú	‘thick hoe’
makudó	‘baboons’	makudó makobvú	‘thick baboons’
mapadzá	‘hoes’	mapadzá makobvú	‘thick hoes’
tsamba	‘letter’	tsamba ṇete	‘thin letter’
búku	‘book’	búku ḡete	‘thin book’
ḡadzá	‘hoe’	ḡadzá ḡete	‘thin hoe’
imbá	‘house’	imbá ṇete	‘thin house’

What do the following examples show about these tone rules?

báŋgá	‘knife’	báŋgá ḡete	‘thin knife’
ḡémó	‘axe’	ḡémó ḡete	‘thin axe’
murúme	‘person’	murúme mútete	‘thin person’
kahúní	‘firewood (dim)’	kahúní karefú	‘long firewood’
mat <sup>h</sup> írá	‘clothes’	mat <sup>h</sup> írá marefú	‘long clothes’

hári

‘pot’

hári nété

‘thin pot’

## 6. Guerze

Account for the phonological alternations in the following data from Guerze. Be sure that you state the order of the rules which you propose, and justify your conclusion about ordering.

bamaŋ	‘harp-drum’	bama bo	‘10 harp-drums’
bama dɔno	‘1 harp-drum’	bama nɔɔlu	‘5 harp-drums’
bama ɲudono	‘100 harp-drums’	bama ɲujaa	‘heavy harp-drum’
balɔ	‘yam’	balɔ kujaa	‘long yam’
balɔ lɔɔlu	‘5 yams’	balɔ ɲɔŋɔ	‘bad yam’
balɔ tɛɣɔja	‘black yam’	balɔ joŋo	‘wet yam’
gbɔŋ	‘wood’	gbɔ naa	‘4 wood pieces’
gbɔ joŋo	‘wet wood’	gbɔ nɔnɔ	‘new wood’
hiɪŋ	‘design’	hiɪ dɔno	‘1 design’
hiɪ gujaa	‘long design’	hiɪ ɣɔnɔ	‘big design’
hiɪ naa	‘4 designs’	hiɪ ɲɔŋɔ	‘bad design’
hiɪ nokolo	‘small design’	hɔŋ	‘thing’
hɔ dɛɣɔja	‘black thing’	hɔ ɣɔnɔ	‘big thing’
hɔ joŋo	‘wet thing’	hɔ ɲudono	‘100 things’
hɔ ɲujaa	‘heavy thing’	kihi	‘suitcase’
kihi kujaa	‘long suitcase’	kihi lokolo	‘small suitcase’
kihi naa	‘4 suitcases’	kihi tɔno	‘1 suitcase’
kihi wujaa	‘heavy suitcase’	lii	‘heart’
lii kɔnɔ	‘big heart’	lii ɲɔŋɔ	‘bad heart’
lii ɲudono	‘100 hearts’	ɲiŋ	‘tooth’
ɲi bo	‘10 teeth’	ɲi dɛɣɔja	‘black tooth’
ɲi gujaa	‘long tooth’	ɲi nɔɔlu	‘5 teeth’
ɲi ɲɔŋɔ	‘bad tooth’	ɲi nɔnɔ	‘new tooth’
ɲi ɲujaa	‘heavy tooth’	tɛɛ	‘chicken’
tɛɛ kujaa	‘long chicken’	tɛɛ lɔɔlu	‘5 chickens’
tɛɛ lokolo	‘small chicken’	tɛɛ nɔnɔ	‘new chicken’
tɛɛ ɲudono	‘100 chickens’	tɛɛ po	‘10 chickens’
tɛɛ tɛɣɔja	‘black chicken’	tɛɛ joŋo	‘wet chicken’
jaba	‘onion’	jaba kɔnɔ	‘big onion’
jaba naa	‘4 onions’	jaba nɔnɔ	‘new onion’
jaba po	‘10 onions’	jaba tɔno	‘1 onion’
jaba wujaa	‘heavy onion’		

## 7 Catalan

Give phonological rules which account for the following data, and indicate what ordering is necessary between these rules. For each adjective stem, state what the underlying form of the root is. Pay attention to the difference between surface [b, d, g] and [β, ð, γ], in terms of predictability.

<i>Masc sg</i>	<i>Fem sg</i>		<i>Masc sg</i>	<i>Fem sg</i>	
əkɛɭ	əkɛɭə	‘that’	mal	malə	‘bad’
sɪβɪl	sɪβɪlə	‘civil’	əskɛrp	əskɛrpə	‘shy’
ʃɒp	ʃɒpə	‘drenched’	sɛk	sɛkə	‘dry’
əspɛs	əspɛsə	‘thick’	ɡros	ɡrosə	‘large’
baf	bafə	‘short’	koʃ	koʃə	‘lame’
tot	totə	‘all’	brut	brutə	‘dirty’
pək	pəkə	‘little’	prəsis	prəsizə	‘precise’
frənsɛs	frənsezə	‘French’	ɡris	ɡrizə	‘grey’
kəzət	kəzəðə	‘married’	bwit	bwidə	‘empty’
rɒɭ	rɒzə	‘red’	boɭ	bozə	‘crazy’
orp	orβə	‘blind’	ɭark	ɭaryə	‘long’
sɛk	sɛγə	‘blind’	fəʃuk	fəʃuyə	‘heavy’
ɡrok	ɡroyə	‘yellow’	puruk	puruyə	‘fearful’
kandit	kandiðə	‘candid’	fɾɛt	fɾɛðə	‘cold’
səɣu	səɣurə	‘sure’	du	durə	‘hard’
səɣəðo	səɣəðorə	‘reaper’	kla	klarə	‘clear’
nu	nuə	‘nude’	kru	kruə	‘raw’
flɒndʒu	flɒndʒə	‘soft’	dropu	dropə	‘lazy’
əgzaktə	əgzaktə	‘exact’	əlβi	əlβinə	‘albino’
sa	sanə	‘healthy’	pla	planə	‘level’
bo	bonə	‘good’	sərə	sərənə	‘calm’
suβlim	suβlimə	‘sublime’	al	altə	‘tall’
fɔr	fɔrtə	‘strong’	kur	kurtə	‘short’
sor	sorðə	‘deaf’	bɛr	bɛrðə	‘green’
san	santə	‘saint’	kəlɛn	kələntə	‘hot’
prufun	prufundə	‘deep’	fəkun	fəkundə	‘fertile’
dəsɛn	dəsɛntə	‘decent’	dulɛn	dulɛntə	‘bad’
əstuðian	əstuðiantə	‘student’	blaŋ	blaŋkə	‘white’



## 8 Finnish

Propose rules which will account for the following alternations. It would be best not to write a lot of rules which go directly from underlying forms to surface forms in one step; instead, propose a sequence of rules whose combined effect brings about the observed change in the underlying form. Pay attention to what consonants actually exist in the language.

<i>Genitive sg</i>			<i>Nom sg    Nom pl</i>			<i>Ablative sg    Essive sg</i>		
kanadan	kanada	kanadat				kanadalta	kanadana	‘Canada’
kirjan	kirja	kirjat				kirjalta	kirjana	‘book’
aamun	aamu	aamut				aamulta	aamuna	‘morning’
talon	talo	talot				talolta	talona	‘house’
koiran	koira	koirat				koiralta	koirana	‘dog’
hyvän	hyvæ	hyvæt				hyvæltæ	hyvænæ	‘good’
kuvan	kuva	kuvat				kuvalta	kuvana	‘picture’
lain	laki	lait				lailta	lakina	‘roof’
nælæn	nælkæ	næltæt				næltætæ	nælkænæ	‘hunger’
jalan	jalka	jalat				jalalta	jalkana	‘leg’
leuan	leuka	leuat				leualta	leukana	‘chin’
paran	parka	parat				paralta	parkana	‘poor’
reiæn	reikæ	reiltæt				reiltætæ	reikænæ	‘hole’
nahan	nahka	nahat				nahalta	nahkana	‘hide’
vihon	vihko	vihot				viholta	vihkona	‘notebook’
laihan	laiha	laihat				laihalta	laihana	‘lean’
avun	apu	avut				avulta	apuna	‘help’
halvan	halpa	halvat				halvalta	halpana	‘cheap’
orvon	orpo	orvot				orvolta	orpona	‘orphan’
leivæn	leipæ	leivæt				leivæltæ	leipænæ	‘bread’
pæivæn	pæivæ	pæivæt				pæivæltæ	pæivænæ	‘day’
kilvan	kilpa	kilvat				kilvalta	kilpana	‘competition’
kylvyn	kylpy	kylvyt				kylvyltæ	kylpynæ	‘bath’
tavan	tapa	tavat				tavalta	tapana	‘manner’
korvan	korva	korvat				korvalta	korvana	‘ear’
æidin	æiti	æidit				æidiltæ	æitinæ	‘mother’
kodin	koti	kodit				kodilta	kotina	‘home’
muodon	muoto	muodot				muodolta	muotona	‘form’
tædin	tæti	tædit				tædiltæ	tætinæ	‘aunt’

kadun	katu	kadut	kadulta	katuna	‘street’
maidon	maito	maidot	maidolta	maitona	‘milk’
pøydæn	pøytæ	pøydæt	pøydæltæ	pøytænæ	‘table’
tehdyn	tehty	tehdyt	tehdyltæ	tehtynæ	‘made’
læmmøn	læmpø	læmmøt	læmmøltæ	læmpønæ	‘warmth’
lanġan	lanġka	lanġat	lanġalta	lanġkana	‘thread’
sæŋġyn	sæŋġky	sæŋġyt	sæŋġyltæ	sæŋġkynæ	‘bed’
hinnan	hintä	hinnat	hinnalta	hintana	‘price’
linnun	lintu	linnut	linnulta	lintuna	‘bird’
opinnon	opinto	opinnot	opinnolta	opintona	‘study’
rannan	ranta	rannat	rannalta	rantana	‘shore’
luonnon	luonto	luonnot	luonnolta	luontona	‘nature’
punnan	punta	punnat	punnalta	puntana	‘pound’
tunnin	tunti	tunnit	tunnilta	tuntina	‘hour’
kunnon	kunto	kunnot	kunnolta	kuntana	‘condition’
kannun	kannu	kannut	kannulta	kannuna	‘can’
linnan	linna	linnat	linnalta	linnana	‘castle’
tumman	tumma	tummat	tummalta	tummana	‘dark’
auriġġon	auriġko	auriġġot	auriġġolta	auriġkona	‘sun’
reŋġin	reŋki	reŋġit	reŋġiltæ	reŋkinæ	‘farm hand’
vaŋġin	vaŋki	vaŋġit	vaŋġilta	vaŋkina	‘prisoner’
kellon	kello	kellot	kellolta	kellona	‘watch’
kellan	kelta	kellat	kellalta	keltana	‘yellow’
sillan	silta	sillat	sillalta	siltana	‘bridge’
kullan	kulta	kullat	kullalta	kultana	‘gold’
virran	virta	virrat	virralta	virtana	‘stream’
parran	parta	parrat	parralta	partana	‘beard’

### Further reading

Anderson 1974; Chomsky 1967; Goldsmith 1993; Kiparsky 1968; Koutsoudas, Sanders and Noll 1974.