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

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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, [ł] represents a velarized *l*.

(1) a. *Nominative*   *Partitive*

      vərkko   vərkkoa   'net'

      tʃako   tʃakoa   'cuckoo'

      lintu   lintua   'bird'

      saatu   saatua   'garden'

      jałka   jałkaa   'foot'

      botʃka   botʃkaa   'barrel'

      einæ   einææ   'hay'

      vævy   vævyæ   'son-in-law'

   b. siili   siiliæ   'hedgehog'

      łusti   łustia   'pretty'

   c. jarvi   jarvəa   'lake'

      mætʃi   mætʃeæ   'hill'

      tʃivi   tʃiveæ   'stone'

   d. kurtʃi   kurkəa   'stork'

      əłtʃi   əłkəa   'straw'

      kahtʃi   kahkəa   '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*

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

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 [tʃi] in the nominative *kurtʃi*.

It would be unrevealing to posit a rule changing word-final /kə#/ into [tʃi#] 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*

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

We can thus account for the change of underlying /kurkə/ and /əɫkə/ to [kurtˤi] and [əɫtˤi] 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/   *underlying*

     kurki   *vowel raising*

     kurtˤi   *palatalization*

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 [tˤ]: 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 [tˤ] is the closest segment of the language to [tˤ].

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)   *to V*   *to Cause to V*

a.	kokǎmǎ	kokǎmjǎ	'milk'
	kokonà	kokonjà	'hit'
	kolaǎàmbà	kolǎàmbjà	'lap'
	kotǎlǎ	kotǎljǎ	'count'
	kwaambatà	kwaambatjà	'go up'
	kwaàðà	kwaàðjà	'govern'
	kwé̋ḗtǎ	kwé̋ḗtjǎ	'answer'
	kwí̋ı̋mbǎ	kwí̋ı̋mbjǎ	'swell'
b.	koβikà	koβitʃà	'arrive'
	koβálokà	koβálotʃà	'fall'
	kolikà	kolitʃà	'enter'
	kolɛ́̂ɛ̂ŋgà	kolɛ́̂ɛ̂ɲdʒà	'aim'
	kwɛ́̋ɛ́̋ŋgǎ	kwɛ́̋ɛ́̋ɲdʒǎ	'clear a field'
	kwaanekà	kwaanetʃà	'dry'
	kwɔ̋ɔ̋kǎ	kwɔ̋ɔ̋tʃǎ	'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/, /kolɛ́̂ɛ̂ŋgjà/, 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*

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

> 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' |
| koliìndà | komóliìndà | koméliìndà | kokéliìndà | 'cover' |
| komɛ́́nɛ́́ | komómɛ́́nɛ́́ | komémɛ́́nɛ́́ | kokémɛ́́nɛ́́ | 'hate' |
| koɲuβà | komóɲuβà | koméɲuβà | kokéɲuβà | '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) | |
|------|------|------|------|------|
| kwǎǎsjǎ | komwǎǎsjǎ | komjǎǎsjǎ | kotʃǎǎsjǎ | 'lose' |
| kwǎǎkǎ | komwǎǎkǎ | komjǎǎkǎ | kotʃǎǎkǎ | 'build' |
| kwaàsà | komwǎàsà | komjǎàsà | kotʃǎàsà | 'carve' |
| kőőmbǎ | komőőmbǎ | komjőőmbǎ | kotʃőőmbǎ | 'mold' |
| kookeljà | komóokeljà | komjóokeljà | kotʃóokeljà | 'lift' |
| kűűnǎ | koműűnǎ | komjűűnǎ | kotʃűűnǎ | 'fetch' |
| kuumbekà | komúumbekà | komjúumbekà | kotʃúumbekà | 'bury' |
| kwɛ́́ɛ́́nzǎ | komwɛ́́ɛ́́nzǎ | komjɛ́́ɛ́́nzǎ | kotʃɛ́́ɛ́́nzǎ | 'shave' |
| kwɛ̀ɛ̂ndà | komwɛ́́ɛ̂ndà | komjɛ́́ɛ̂ndà | kotʃɛ́́ɛ̂ndà | 'like' |
| kwɔ̌ɔ̌nǎ | komwɔ̌ɔ̌nǎ | komjɔ̌ɔ̌nǎ | kotʃɔ̌ɔ̌nǎ | 'see' |
| kwɔ̌ɔ̌sǎ | komwɔ̌ɔ̌sǎ | komjɔ̌ɔ̌sǎ | kotʃɔ̌ɔ̌sǎ | 'take' |
| kwɔ̌ɔ̌βǎ | komwɔ̌ɔ̌βǎ | komjɔ̌ɔ̌βǎ | kotʃɔ̌ɔ̌βǎ | '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 *[kwűűnǎ] and *[kwőőmbǎ], 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 [kwɔ́ɔ́nǎ] '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 [komjóokeljà] 'to lift them' and /ko-méűnǎ/ becomes [komjűűnǎ] '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 *[koŭnǎ] and *[koőmbǎ]). 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 *kwűűnǎ* and *kwőőmbǎ*. 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*

$$\begin{bmatrix} -\,\text{syl} \\ +\,\text{round} \end{bmatrix} \rightarrow \text{Ø/} \underline{\quad} \begin{bmatrix} +\,\text{round} \\ +\,\text{tense} \end{bmatrix}$$

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 [kotʃ ́ǎ́ǎsjǎ] from /ko-ké-ǎ́ǎsjǎ/

(11)   /ko-ké-ǎ́ǎsjǎ/   *underlying*

        kokjǎ́ǎsjǎ   *Glide Formation*

        kotʃ ́ǎ́ǎsjǎ   *Palatalization*

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 noone 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) | *Imperative* | *3pl pres.* | *1sg pres* | |
|---|---|---|---|
| tʃa | βatʃa | ɲdʒa | 'go' |
| tʃexa | βatʃexa | ɲdʒexa | 'laugh' |
| tʃutʃuuŋga | βatʃutʃuuŋga | ɲdʒutʃuuŋga | 'sieve' |
| talaanda | βatalaanda | 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 | ŋgetulula | 'pour out' |
| kona | βakona | ŋgona | 'pass the night' |
| kula | βakula | ŋgula | 'buy' |
| kwa | βakwa | ŋgwa | '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*

$$[+\text{nas}] \rightarrow \begin{bmatrix} \alpha\text{ant} \\ \beta\text{cor} \end{bmatrix} / \underline{\quad} \begin{bmatrix} -\text{syl} \\ \alpha\text{ant} \\ \beta\text{cor} \end{bmatrix}$$

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)

Imperative	*3pl pres.*	*1sg pres*	
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 *d^{β}*.

(17)

Imperative	*3pl pres.*	*1sg pres*	
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	ɲdʒama	'scout'
jaaja	βajaaja	ɲdʒaaja	'scramble with'
joola	βajoola	ɲdʒoola	'scoop'
juula	βajuula	ɲdʒuula	'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*

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

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

(20)		*Imperative*	*3pl pres.*	*1sg pres*	
	a.	tima	βatima	ndima	'run'
		taaɲa	βataaɲa	ndaaɲa	'hack'
		tiiŋa	βatiiŋa	ndiiŋa	'filter'
		rema	βarema	ndema	'chop'
		riina	βariina	ndiina	'run away'
		ruma	βaruma	nduma	'send'

b.	laanda	βalaanda	naanda	'go around'
	laaŋgwa	βalaaŋgwa	naaŋgwa	'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_0 [+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)	*Imperative*	*3pl pres.*	*1sg pres*	
	mala	βamala	mala	'finish'
	maɲa	βamaɲa	maɲa	'know'
	meela	βameela	meela	'get drunk'
	ŋoola	βaŋoola	ŋoola	'see into the spirit world'
	ɲa	βaɲa	ɲa	'defecate'

| ɲaaɲa | βaɲaaɲa | ɲaaɲa | 'chew' |
| ɲwa | βaɲwa | ɲwa | '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*

$$[+\text{nas}] \rightarrow \emptyset \; / \; \underline{\quad} \; [+\text{nas}]$$

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

(24)

Imperative	*3pl pres.*	*1sg pres*	
fuma	βafuma	fuma	'spread'
fuundixa	βafuundixa	fuundixa	'knot'
fwa	βafwa	fwa	'die'
xala	βaxala	xala	'cut'
xalaaŋga	βaxalaaŋga	xalaaŋga	'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*

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

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*

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

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*

$$[+\text{nasal}] \rightarrow \varnothing / \underline{\quad} \begin{bmatrix} + \text{cont} \\ - \text{voice} \end{bmatrix}$$

(14)   *Nasal Place Assimilation*

$$[+\text{nas}] \rightarrow \begin{bmatrix} \alpha\text{ant} \\ \beta\text{cor} \end{bmatrix} / \underline{\quad} \begin{bmatrix} + \text{syl} \\ \alpha\text{ant} \\ \beta\text{cor} \end{bmatrix}$$

(21)   *l-deletion*

$$[+\text{lat}] \rightarrow \varnothing / [+\text{nasal}] \underline{\quad} V_0 [+\text{nasal}]$$

(19)   *Post-Nasal Voicing-Hardening*

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

(23)   *Nasal Cluster Simplification*

$$[+\text{nas}] \rightarrow \varnothing / \underline{\quad} [+\text{nas}]$$

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*

Class	C-initial noun		V-initial noun	
4	mi-kaáte	'loaves'	mj-oótó	'fires'
5	li-kuŋuúnda	'filtered beer'	lj-oowá	'beehive'
7	ki-kálaaŋgo	'frying pan'	kj-uúlá	'frog'
8	i-kálaaŋgo	'frying pans'	j-uúlá	'frogs'
14	u-tópe	'mud'	w-ıímbı	'beer'
11	lu-toóndwa	'star'	lw-aaté	'banana hand'
13	tu-tóopé	'little handles'	tw-aána	'little children'
15	ku-suúle	'to school'	kw-iisíwá	'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-kálaaŋgite   ŋ-kálaaŋgite   'you (pl) fried'

	mu-pımé	m-pımé	'you (pl) should measure'
b.	mu-wesa . . .	ŋ-ŋʷesa . . .	'you (pl) can'
	mu-jíkıtiile	ɲ-ɲíkıtiile	'you (pl) agreed'
	mu-wuúngo	ŋ-ŋʷuúngo	'in the civet'
	mu-jıíga	ɲ-ɲıíga	'in the body'

(An alternative transcription of this second set of forms would be *ŋŋwesa* and so on: the point of writing this as [ŋŋʷesa] 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)

Singular (cl 7)	*Plural* (cl 8)	*Plural locative*	
ki-báo	i-báo	mwii-báo	'stool'
ki-bıgá	i-bıgá	mwii-bıgá	'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)

Singular (cl 7)	*Plural* (cl 8)	*Plural locative*	
kjáaí	jáaí	mujáaí ~ ɲɲáaí	'soup pot'
kjaáka	jaáka	mujaáka ~ ɲɲaáka	'bush'
kjııkí	jııkí	mujııkí ~ ɲɲııkí	'stump'
kjuúbá	juúbá	mujuúbá ~ ɲɲuúbá	'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)

Plain	Passive	Neuter	Applied	Reciprocal	
tˢita	tˢitwa	tˢitika	tˢitila	tˢitana	'do'
tula	tulwa	tulika	tulila	tulana	'dig'
tˢeta	tˢetwa	tˢeteka	tˢetela	tˢetana	'spy'
soŋka	soŋkwa	soŋkeka	soŋkela	soŋkana	'pay tax'
pata	patwa	patika	patila	patana	'scold'
fisa	fiswa	fiʃika	fiʃila	fisana	'hide'
tˢesa	tˢeswa	tˢeseka	tˢesela	tˢesana	'cut'
kosa	koswa	koseka	kosela	kosana	'be strong'
lasa	laswa	laʃika	laʃila	lasana	'wound'
masa	maswa	maʃika	maʃila	masana	'plaster'
ʃika	ʃikwa	ʃitˢika	ʃitˢila	ʃikana	'bury'
seka	sekwa	sekeka	sekela	sekana	'laugh at'
poka	pokwa	pokeka	pokela	pokana	'receive'
kaka	kakwa	katˢika	katˢila	kakana	'tie'
fuka	fukwa	futˢika	futˢila	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*

$$[+\text{syl}] \rightarrow [-\text{hi}] \, / \begin{bmatrix} +\text{syl} \\ -\text{hi} \\ -\text{low} \end{bmatrix} C_0 \underline{\quad}$$

There is an alternation in the realization of certain root-final consonants. As shown in examples such as *kaka ~ katʲika* and *lasa ~ laʃika*, 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*

$$\begin{bmatrix} +\text{hi} \\ -\text{syl} \end{bmatrix} \rightarrow [+\text{cor}] / \underline{\hspace{1cm}} \begin{bmatrix} +\text{syl} \\ +\text{hi} \\ -\text{back} \end{bmatrix}$$

        b.   *Fricative Palatalization*

$$\begin{bmatrix} +\text{cont} \\ +\text{cor} \end{bmatrix} \rightarrow [-\text{ant}] / \underline{\hspace{1cm}} \begin{bmatrix} +\text{syl} \\ +\text{hi} \\ -\text{back} \end{bmatrix}$$

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/   *underlying*

        setʃika   *palatalization*

        *setʃeka   *height harmony*

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/   *underlying*

        sekeka   *height harmony*

        (not applicable)   *palatalization*

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-neʃti   'to bring'
                    at-leisti   'to forgive'
                    at-likti   'to complete'
                    at-ko:pti   'to rise'
                    at-praʃi:ti   'to ask'
                    at-kurti   'to reestablish'
            /ap/   ap-eiti   'to circumvent'
                    ap-ieʃko:ti   'to search everywhere'
                    ap-akti   'to become blind'
                    ap-mo:ki:ti   'to train'
                    ap-temdi:ti   'to obscure'
                    ap-ʃaukti   '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-ʒʲureti   '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*

$$[-\text{son}] \rightarrow [+\text{voice}] \ / \ \underline{\hspace{1cm}} \begin{bmatrix} -\text{son} \\ +\text{voice} \end{bmatrix}$$

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-neʃti/ → [atneʃti] 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 [abdauʒi: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

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

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-ertʰam   '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'
          kʰə-tʰuojniem   'I will allow'
          kʰə-tʃʰapʰˑiem   'I will measure'
          gʰə-bʰieɹiem   'I will carry'
          gʰə-gʰuom   'I will come'
          gʰə-dᶻʰieviem   '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)

Imp	*1sg*	*2sg*	*3sg*	*1pl*	*2pl*	*3pl*	
saŋga	nsaŋga	osaŋga	asaŋga	tosaŋga	losaŋga	basaŋga	'say'
kamba	ŋkamba	okamba	akamba	tokamba	lokamba	bakamba	'work'
kɔta	ŋkɔta	ɔkɔta	akɔta	tɔkɔta	lɔkɔta	bakɔta	'cut'

tɛŋga	ntɛŋga	ɔtɛŋga	atɛŋga	tɔtɛŋga	lɔtɛŋga	batɛŋga	'straighten'
mɛla	mmɛla	ɔmɛla	amɛla	tɔmɛla	lɔmɛla	bamɛla	'drink'
dʒila	ndʒila	odʒila	adʒila	todʒila	lodʒila	badʒila	'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)

Imp.	1sg	2sg	3sg	1pl	2pl	3pl	
ɛna	ndʒɛna	wɛna	ɛna	tˢwɛna	dʒwɛna	bɛna	'see'
isa	ndʒisa	wisa	isa	tˢwisa	dʒwisa	bisa	'hide'
imedʒa	ndʒimedʒa	wimedʒa	imedʒa	tˢwimedʒa	dʒwimedʒa	bimedʒa	'consent'
usa	ndʒusa	wusa	usa	tˢwusa	dʒwusa	busa	'throw'
ina	ndʒina	wina	ina	tˢwina	dʒwina	bina	'hate'

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

(42)   *Consonant epenthesis*

$$\emptyset \rightarrow \begin{bmatrix} -\text{syl} \\ -\text{cons} \\ +\text{voice} \\ -\text{back} \end{bmatrix} / [+\text{nas}] + \_\_V$$

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*

$$[+\text{low}] \rightarrow \emptyset / \_ V$$

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

(44)   *Glide formation*

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

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

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(45)   *Affrication*

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

> *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/→[tˢ, ɟ]/ _ 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)

Imp	*1sg*	*2sg*	*3sg*	*1pl*	*2pl*	*3pl*	
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*

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

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 intervocalically. 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/   *underlying*

           NA   NA   *Glide formation*

           NA   NA   *vowel truncation*

           oina   aina   *b-deletion*

       b.   /o-bina/   /a-bina/   *underlying*

oina	aina	*b-deletion*
wina	NA	*glide formation*
NA	ina	*vowel truncation*
*[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)	*Imperative*	*1sg*	*3sg*	
	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)

Active	*Passive*		*Active*	*Passive*

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ɓika	ɓikwa	'cook'	diba	dibɣa	'dip'
pꜰugama	pꜰugamŋa	'kneel'	pepa	pepxa	'nurse'
ɓuɗa	ɓuɗɣwa	'go out'	ruma	rumŋa	'bite'
rova	rovɣa	'stay away'	m̥aɲa	m̥aɲŋwa	'run'
suŋga	suŋgwa	'tie'	kwaʃa	kwaʃxwa	'hunt'
teŋga	teŋgwa	'buy'	fuŋga	fuŋgwa	'think'
tamba	tambɣa	'play'	bᵛunza	bᵛunzɣwa	'ask'
imba	imbɣa	'sing'	gara	garɣwa	'stay'
setˢa	setˢxwa	'amuse'	reḍᶻa	reḍᶻɣwa	'lengthen'
tapa	tapxa	'capture'	βeza	βezɣwa	'carve'
rega	regwa	'leave'	ibᵛa	ibᵛɣa	'ripen'
ʃuʒa	ʃuʒɣwa	'store grain'	taʂa	taʂxwa	'ride'
peta	petxwa	'fold'	dana	danŋwa	'call'
ona	onŋwa	'see'	ita	itxwa	'do'
doka	dokwa	'set'	seka	sekwa	'laugh'
fesa	fesxwa	'prick'	rasa	rasxwa	'throw away'
raṇa	raṇŋwa	'kick'	peṃa	peṃŋa	'beg food'
gotʃa	gotʃxwa	'roast'	ʂika	ʂikwa	'arrive'
dᶻidᶻa	dᶻidᶻɣwa	'learn'	fuka	fukwa	'cover'
famba	fambɣa	'walk'	nandᶻa	nandᶻɣwa	'lick'
gada	gadɣwa	'mount'	ɓata	ɓatxwa	'hold'
tuma	tumŋa	'send'	tora	torɣwa	'take'
oŋa	oŋwa	'growl'	rima	rimŋa	'plow'
sefa	sefxa	'sieve'	kwezạ	kwezɣwa	'attract'
dᶾudᶾa	dᶾudᶾɣwa	'leak'	guruva	guruvɣa	'deceive'
maŋga	maŋgwa	'arrest'	miɲa	miɲŋwa	'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 -tʃa-, -no-, and -a-, or no marker, finally followed by the verb stem.

(51)   *Subjunctive*   *Future*

urime   'that you (sg) plow'   utʃarima   'you (sg) will plow'

murime   'that you (pl) plow'   mutʃarima   'you (pl) will plow'

turime	'that they (tiny) plow'	tutˢarima	'they (tiny) will plow'
kunatˢe	'that there be nice'	kutˢanatˢa	'there will be nice'
Habitual		*Recent past*	
unorima	'you (sg) plow'	warima	'you (sg) plowed'
munorima	'you (pl) plow'	mŋarima	'you (pl) plowed'
tunorima	'they (tiny) plow'	txwarima	'they (tiny) plowed'
kunonatˢa	'there is nice'	kwanatˢa	'there was nice'

A further fact which is relevant to deciding on the correct analysis is that [γ], [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)	la:**p**-a	'two (obj.)'	la:**p**	'two'
	skʰo**t**-a	'puts on a blanket'	skʰo**t**-pli	'puts on a blanket again'
	q'la:**tʃ**-aksi	'Blueberry Place'	q'la:**tʃ**	'blueberry (sp)'
	po**q**-a	'bakes camas'	po**q**-s	'camas root'
	la**q**i	'is rich'	la**qj**'-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)	p'a**k'**-a	'smashes'	p'a**k**-ska	'chips off (intr)'
	ʔe:**t'**-a	'distributes'	se-ʔe:**t**-s	'Saturday'
	poq-po**q'**-a	'becomes dusty'	po:**q**-tki	'becomes dusty'
	tʃʰa:**k'**-a	'melts (intr)'	tʃʰa:**k**-tki	'melts (as butter)'
	ʔi-tʃʰi:**tʃ'**-a	'makes shavings'	k-tʃʰi**tʃ'**-ta	'scrapes ones foot on'
	tʃʰlo:**q'**-a	'is smooth'	tʃʰlo:**q**-tki	'becomes slick'
	qi**t'**-lqa	'pours down'	qi**t**-qʰa	'pours out'
	-lo:**p'**-a	'eats soup'	-lo:**p**-s	'soup'

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

(54)	li**tʃʰ**-litʃ'-l'i	'strong'	**li:tʃ**-tki	'becomes strong'
	ponw-o:**tʰ**-a	'while drinking'	ponw-o:**t**-s	'something to drink with'
	so:**tʃʰ**-a	'kindles a fire'	so:**tʃ**-ti:la	'lights a fire under'

si:jo:**t**ʰ-a	'trades (pl) obj with each other'	si:jo:**t**-pli	'trade back (pl obj)'
n'i**q**ʰ-o:wa	'keeps putting a hand in water'	n'i**q**-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)
l<u>a</u>qi:ta	'suspects s.o.'	sa-<u>lq</u>ita	'suspects e.o.'
m<u>a</u>tʃʰa:t-ka	'listens'	sna-<u>mt</u>ʃʰa:t-i:la	'causes to hear'
m<u>e</u>tʃa	'moves camp'	me-<u>mt</u>ʃ'a	'moves (distributive)'
s<u>a</u>qo:tka	'ask for s.t.'	sa-<u>sq</u>o:tqa	'ask for s.t. (distributive)'
s<u>i</u>tʃaqʰwa	'wash hands'	hi-<u>st</u>ʃaq-tʰa	'are angry with e.o'
s<u>o</u>m	'mouth'	so-<u>sm</u>'-a:k	'little mouths (distributive)'

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

(56)
q'otʃ'a	'bends'	jo-**qt**ʃ'a	'bends with the feet'
qʰew'a	'breaks'	tʃhe-**qw**'a	'sit on and break'
tʰew'a	'surface cracks'	je-**tw**'a	'steps on and cracks surface'
s-**tʃ'i**q'a	'squash with a pointed instrument'	ji-**tʃq**'a	'squash by pressure with the feet'
w-**k'a**l'a	'cuts with a long instrument'	kin-**kl**'a	'makes a mark with pointer'
w-**p'e**q'a	'hits in the face with a long instrument'	hom-**pq**'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 literal-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.

to V	to V e.o	to V for	to V for e.o.	
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'

to V us	to V it	to V for us	to V it for us	
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 causes 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
kad³imisila	katud³imisila	extinguish for
kabota	katubota	beat
kababanisa	katubabanisa	squeeze
kadaŋgila	katudaŋgila	throw for
kadetela	katudetela	say to
kaguvila	katuguvila	fall on
kandova	katutova	beat
kaŋd³ubula	katutʃubula	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
dad³imisi	davad³imisi	extinguish
daguvi	davaguvi	fall
dadeti	davadeti	say
dababanisi	davababanisi	squeeze
dadaŋgi	davadaŋgi	throw
danzeki	davaseki	laugh
damvuti	davafuti	rub
dandovi	davatovi	beat
dandeleki	davateleki	cook
daŋgetuli	davaketuli	cut
daŋgamuli	davakamuli	grab
danduvi	davatuvi	run
dambutuki	davaputuki	rub
daŋd³ubuli	davatʃubuli	scratch

3 Polish

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

Singular	Plural		Singular	Plural	
klup	klubi	'club'	trup	trupi	'corpse'
dom	domi	'house'	snop	snopi	'sheaf'
ʒwup	ʒwobi	'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	soli	'salt'	buj	boji	'fight'
ʃum	ʃumi	'noise'	ʒur	ʒuri	'soup'

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	váakátáángɪra	varakátáángɛ	varakátáángɪrɪ	start
váakávʊ́njaanja	váakávʊ́njaanjɪra	varakávʊ́njaanjɛ	varakávʊ́njaanjɪrɪ	break
váakázáázama	váakázáázamɪra	varakázáázamɛ	varakázáázamɪrɪ	taste
váakavʊrʊganja	váakavʊrʊganjɪra	varakavʊrʊganjɛ	varakavʊrʊganjɪrɪ	stir
váakaganaganja	váakaganaganjɪra	varakaganaganjɛ	varakaganaganjɪrɪ	think
váakarʊʊnga	váakarʊʊngɪra	varakarʊʊngɪ	varakarʊʊngɪrɪ	season
váakarɪɪnda	váakarɪɪndɪra	varakarɪɪndɪ	varakarɪɪndɪrɪ	guard
váakátʊ́ma	váakátʊ́mɪra	varakátʊ́mɪ	varakátʊ́mɪrɪ	send
váakásúunga	váakásúúngɪra	varakásúungɪ	varakásúúngɪrɪ	hang up
váakatuuma	váakatuumɪra	varakatuumɪ	varakatuumɪrɪ	jump
váakávína	váakávínɪra	varakávínɪ	varakávínɪrɪ	dance
váakavisa	váakavisɪra	varakavisɪ	varakavisɪrɪ	hide
váakávíta	váakávítɪra	varakávítɪ	varakávítɪrɪ	pass
váakágámʊra	váakágámʊrɪra	varakágámʊrɪ	varakágámʊrɪrɪ	catch
váakahɪɪrɪɪta	váakahɪɪrɪɪtɪra	varakahɪɪrɪɪtɪ	varakahɪɪrɪɪtɪrɪ	snore
váakadiginja	váakadiginjɪra	varakadiginjɪ	varakadiginjɪrɪ	tickle
váakáhákiza	váakáhákizɪra	varakáhákizɪ	varakáhákizɪrɪ	scorch
váakavariza	váakavarizɪra	varakavarizɪ	varakavarizɪrɪ	count
váakáfʊ́njɪɪriza	váakáfʊ́njɪɪrizɪra	varakáfʊ́njɪɪrizɪ	varakáfʊ́njɪɪrizɪrɪ	smell
váakamɪnɪɪka	váakamɪnɪɪkɪra	varakamɪnɪɪkɪ	varakamɪnɪɪkɪrɪ	be ill
váakagarʊkiza	váakagarʊkizɪra	varakagarʊkizɪ	varakagarʊkizɪrɪ	reverse
váakarʊʊngikiza	váakarʊʊngikizɪra	varakarʊʊngikizɪ	varakarʊʊngikizɪrɪ	straighten
váakátʊ́ɲaminja	váakátʊ́ɲaminjɪra	varakátʊ́ɲaminjɪ	varakátʊ́ɲaminjɪrɪ	invert
váakasjɛɛna	váakasjɛɛnɛra	varakasjɛɛnɛ	varakasjɛɛnɛrɛ	step
váakárɛ́ɛmba	váakárɛ́ɛmbɛra	varakárɛ́ɛmbɛ	varakárɛ́ɛmbɛrɛ	scold
váakárɔ́ɔta	váakárɔ́ɔtɛra	varakárɔ́ɔtɛ	varakárɔ́ɔtɛrɛ	dream
váakasɛka	váakasɛkɛra	varakasɛkɛ	varakasɛkɛrɛ	laugh
váakatɛɛva	váakatɛɛvɛra	varakatɛɛvɛ	varakatɛɛvɛrɛ	ask
váakáhɛ́ɛnza	váakáhɛ́ɛnzɛra	varakáhɛ́ɛnzɛ	varakáhɛ́ɛnzɛrɛ	seek
váakarɔɔnda	váakarɔɔndɛra	varakarɔɔndɛ	varakarɔɔndɛrɛ	follow
váakárɛ́ɛta	váakárɛ́ɛtɛra	varakárɛ́ɛtɛ	varakárɛ́ɛtɛrɛ	bring
váakádɛ́ɛka	váakádɛ́ɛkɛra	varakádɛ́ɛkɛ	varakádɛ́ɛkɛrɛ	cook
váakámɛ́ɲa	váakámɛ́ɲɛra	varakámɛ́ɲɛ	varakámɛ́ɲɛrɛ	live
váakasɔɔma	váakasɔɔmɛra	varakasɔɔmɛ	varakasɔɔmɛrɛ	read
váakávɛ́ga	váakávɛ́gɛra	varakávɛ́gɛ	varakávɛ́gɛrɛ	shave
váakamɔrɔma	váakamɔrɔmɛra	varakamɔrɔmɛ	varakamɔrɔmɛrɛ	speak
váakarɛka	váakarɛkɛra	varakarɛkɛ	varakarɛkɛrɛ	stop

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

ividujɪrʊ	'pound'	ivivɛ́gɛrʊ	'shave'	ivikáragɪrʊ	'cut'

| ivisɔɔmɛrɔ | 'read' | ivivínɪrʊ | 'dance' | ivinágɪllʊ | 'catch' |
| ivisɛɛmbɛllɔ | 'cultivate' | ivirʊʊngɪrʊ | '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 tʃéna	'clean house'
m̩ará	'gazelle'	m̩ará tʃéna	'clean gazelle'
marí	'money'	marí tʃéna	'clean money'
ɓáŋgá	'knife'	ɓáŋga gúrú	'big knife'
ɗĕmó	'axe'	ɗĕmo bvúpi	'short axe'
n̩úmé	'messenger'	n̩úme pfúpi	'short messenger'
dʒírá	'cloth'	dʒíra dʒéna	'clean cloth'
hárí	'pot'	hári húrú	'big pot'
mbúndúdzí	'worms'	mbúndúdzi húrú	'big worms'
fúma	'wealth'	fúma tʃéna	'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'
ɓáŋgá	'knife'	ɓáŋga rákawá	'the knife fell'
n̩úmé	'messenger'	n̩úme jákafá	'the messenger died'

búku	'book'	búku rákawá	'the book fell'
mapfeni	'baboons'	mapfeni makúrú	'big baboons'
mapadzá	'hoes'	mapadzá makúrú	'big hoes'
mapáŋgá	'knives'	mapáŋgá makúrú	'big knives'
ņúmé	'messenger'	ņúmé ndefú	'tall messenger'
matémó	'axes'	matémó mapfúpi	'short axes'
mabúku	'books'	mabúku maʒíndʒí	'many books'
tʃitóro	'store'	tʃitóro tʃikúrú	'big store'

In the examples below, a second tone rule applies.

guɗo	'baboon'	guɗo refú	'tall baboon'
búku	'book'	búku refú	'long book'
ɓadzá	'hoe'	ɓadzá refú	'long hoe'
nuŋgú	'porcupine'	nuŋgú ndefú	'long porcupine'
maʃoko	'words'	maʃoko marefú	'long words'
kuņíka	'to the land'	kuņíka kurefú	'to the long land'
mapadzá	'hoes'	mapadzá márefú	'long hoes'
kaṃará	'gazelle (dim)'	kaṃará kárefú	'long gazelle (dim)'
tunuŋgú	'porcupines (dim)'	tunuŋgú túrefú	'long porcupines (dim)'
guɗo	'baboon'	guɗo gobvú	'thick baboon'
búku	'book'	búku gobvú	'thick book'
ɓadzá	'hoe'	ɓadzá gobvú	'thick hoe'
makuɗo	'baboons'	makuɗo makobvú	'thick baboons'
mapadzá	'hoes'	mapadzá mákobvú	'thick hoes'
tsamba	'letter'	tsamba ņete	'thin letter'
búku	'book'	búku ɗete	'thin book'
ɓadzá	'hoe'	ɓadzá ɗéte	'thin hoe'
imbá	'house'	imbá ņéte	'thin house'

What do the following examples show about these tone rules?

ɓáŋgá	'knife'	ɓáŋgá ɗéte	'thin knife'
ɗémó	'axe'	ɗémó ɗéte	'thin axe'
murúmé	'person'	murúmé mútete	'thin person'
kahúní	'firewood (dim)'	kahúní kárefú	'long firewood'
matʃírá	'clothes'	matʃírá márefú	'long clothes'
hárí	'pot'	hárí ņéte	'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 dɔnɔ	'1 harp-drum'	bama nɔɔlu	'5 harp-drums'
bama ŋudono	'100 harp-drums'	bama ŋujaa	'heavy harp-drum'
bʌlʌ	'yam'	bʌlʌ kujaa	'long yam'
bʌlʌ lɔɔlu	'5 yams'	bʌlʌ ɲɔŋɔ	'bad yam'
bʌlʌ tɛɣʌja	'black yam'	bʌlʌ joɣo	'wet yam'
gbɔŋ	'wood'	gbɔ naa	'4 wood pieces'
gbɔ ɲoɣo	'wet wood'	gbɔ nʌnʌ	'new wood'
hiiŋ	'design'	hii dɔnɔ	'1 design'
hii gujaa	'long design'	hii gʌnʌ	'big design'
hii naa	'4 designs'	hii ɲɔŋɔ	'bad design'
hii nokolo	'small design'	hʌŋ	'thing'
hʌ dɛɣʌja	'black thing'	hʌ gʌnʌ	'big thing'
hʌ ɲoɣo	'wet thing'	hʌ ŋudono	'100 things'
hʌ ŋujaa	'heavy thing'	kɨhɨ	'suitcase'
kɨhɨ kujaa	'long suitcase'	kɨhɨ lokolo	'small suitcase'
kɨhɨ naa	'4 suitcases'	kɨhɨ tɔnɔ	'1 suitcase
kɨhɨ wujaa	'heavy suitcase'	lii	'heart'
lii kʌnʌ	'big heart'	lii ɲɔŋɔ	'bad heart'
lii ŋudono	'100 hearts'	ɲɨŋ	'tooth'
ɲɨ bo	'10 teeth'	ɲɨ dɛɣʌja	'black tooth'
ɲɨ gujaa	'long tooth'	ɲɨ nɔɔlu	'5 teeth'
ɲɨ ɲɔŋɔ	'bad tooth'	ɲɨ nʌnʌ	'new tooth'
ɲɨ ŋujaa	'heavy tooth'	tɛɛ	'chicken'
tɛɛ kujaa	'long chicken'	tɛɛ lɔɔlu	'5 chickens'
tɛɛ lokolo	'small chicken'	tɛɛ nʌnʌ	'new chicken'
tɛɛ ŋudono	'100 chickens'	tɛɛ po	'10 chickens'
tɛɛ tɛɣʌja	'black chicken'	tɛɛ joɣo	'wet chicken'
jaba	'onion'	jaba kʌnʌ	'big onion'
jaba naa	'4 onions'	jaba nʌnʌ	'new onion'
jaba po	'10 onions'	jaba tɔnɔ	'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.

Masc sg	Fem sg		Masc sg	Fem sg	
əkelʲ	əkelʲə	'that'	mal	malə	'bad'
siβil	siβilə	'civil'	əskerp	əskerpə	'shy'
ʃop	ʃopə	'drenched'	sɛk	sɛkə	'dry'
əspɛs	əspɛsə	'thick'	gros	grosə	'large'
baʃ	baʃə	'short'	koʃ	koʃə	'lame'
tot	totə	'all'	brut	brutə	'dirty'
pɔk	pɔkə	'little'	prəsis	prəsizə	'precise'
frənses	frənsezə	'French'	gris	grizə	'grey'
kəzat	kəzaðə	'married'	bwit	bwiðə	'empty'
rɔtʃ	rɔʒə	'red'	botʃ	boʒə	'crazy'
orp	orβə	'blind'	lʲark	lʲarɣə	'long'
sek	seɣə	'blind'	fəʃuk	fəʃuɣə	'heavy'
grok	groɣə	'yellow'	puruk	puruɣə	'fearful'
kandit	kandiðə	'candid'	frɛt	frɛðə	'cold'
səɣu	səɣurə	'sure'	du	durə	'hard'
səɣəðo	səɣəðorə	'reaper'	kla	klarə	'clear'
nu	nuə	'nude'	kru	kruə	'raw'
flɔŋdʒu	flɔŋdʒə	'soft'	dropu	dropə	'lazy'
əgzaktə	əgzaktə	'exact'	əlβi	əlβinə	'albino'
sa	sanə	'healthy'	pla	planə	'level'
bo	bonə	'good'	sərɛ	sərɛnə	'calm'
suβlim	suβlimə	'sublime'	al	altə	'tall'
fɔr	fɔrtə	'strong'	kur	kurtə	'short'
sor	sorðə	'deaf'	bɛr	bɛrðə	'green'
san	santə	'saint'	kələn	kələntə	'hot'
prufun	prufundə	'deep'	fəkun	fəkundə	'fertile'
dəsen	dəsentə	'decent'	dulen	dulentə	'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.

Genitive sg	Nom sg	Nom pl		Ablative sg	Essive sg	
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'
hyvæn	hyvæ	hyvæt		hyvæltæ	hyvænæ	'good'
kuvan	kuva	kuvat		kuvalta	kuvana	'picture'
lain	laki	lait		lailta	lakina	'roof'
nælæn	nælkæ	nælæt		nælæltæ	nælkænæ	'hunger'
jalan	jalka	jalat		jalalta	jalkana	'leg'
leuan	leuka	leuat		leualta	leukana	'chin'
paran	parka	parat		paralta	parkana	'poor'
reiæn	reikæ	reiæt		reiæltæ	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'
laŋŋan	laŋka	laŋŋat	laŋŋalta	laŋkana	'thread'
sæŋŋyn	sæŋky	sæŋŋyt	sæŋŋyltæ	sæŋkynæ	'bed'
hinnan	hinta	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	kuntona	'condition'
kannun	kannu	kannut	kannulta	kannuna	'can'
linnan	linna	linnat	linnalta	linnana	'castle'
tumman	tumma	tummat	tummalta	tummana	'dark'
auriŋŋon	auriŋko	auriŋŋot	auriŋŋolta	auriŋkona	'sun'
reŋŋin	reŋki	reŋŋit	reŋŋiltæ	reŋkinæ	'farm hand'
vaŋŋin	vaŋki	vaŋŋit	vaŋŋilta	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.