CHAPTER 7
Doing an analysis

PREVIEW

This chapter explores a subset of the phonologies of a number of languages. The purpose of this chapter is to make explicit the reasoning typically applied to the task of solving a phonology problem. By studying models of problem solving, you not only better understand the logic of problem solving, you will also gain experience with rules and issues regarding underlying representations encountered in the languages of the world.

KEY TERMS

hypothesis formation and testing

competing hypotheses

Analyzing a system of phonological alternations is not trivial: it requires practice, where you gain experience by solving phonological problems of increasing complexity, experience which facilitates subsequent problem solving. The wider your experience is with actual phonological processes and problem solving, the better able you will be to appreciate what processes are common in the languages of the world, and to understand the dynamics of hypothesis formation, testing and revision. The first analyses given here will be more explicit about the reasoning that goes into solving data sets of this nature, in some cases deliberately going down the wrong analytical path, so that you have the opportunity to recognize the wrong path, and see how to get back on the right path. In practice, many of the calculations that are involved here are done without explicitly thinking about it – once you have suitable experience with problem solving.

7.1 Yawelmani

Our first problem involves alternations in the verb paradigm in the Yawelmani dialect of Yokuts (California).

7.1.1 The data

Three phonological rules will be motivated by the following examples: vowel epenthesis, vowel shortening, and vowel harmony. It is not obvious what the underlying representation of verb roots is, so besides finding the rules we must make decisions about underlying forms.

(1) *Nonfuture*	*Imperative*	*Dubitative*	*Passive aorist*	
xathin	xatk’a	xatal	xatit	‘eat’
dubhun	dubk’a	dubal	dubut	‘lead by hand’
xilhin	xilk’a	xilal	xilit	‘tangle’
k’oʔhin	k’oʔk’o	k’oʔol	k’oʔit	‘throw’

doshin	dosk’o	do:sol	do:sit	‘report’
ʂaphin	ʂapk’a	ʂa:pal	ʂa:pit	‘burn’
lanhin	lank’a	la:nal	la:nit	‘hear’
mek’hin	mek’k’a	me:k’al	me:k’it	‘swallow’
wonhin	wonk’o	wo:nol	wo:nit	‘hide’
p’axathin	p’axatk’a	p’axa:tal	p’axa:tit	‘mourn’
hiwethin	hiwetk’a	hiwe:tal	hiwe:tit	‘walk’
ʔopothin	ʔopotk’o	ʔopo:tol	ʔopo:tit	‘arise from bed’
jawalhin	jawalk’a	jawa:lal	jawa:lit	‘follow’
paʔiʈhin	paʔiʈk’a	paʔʈal	paʔʈit	‘fight’
ʔilikhin	ʔilikk’a	ʔilkal	ʔilkit	‘sing’
logiwhin	logiwk’a	logwol	logwit	‘pulverize’
ʔugunhun	ʔugunk’a	ʔugnal	ʔugnut	‘drink’
lihimhin	lihimk’a	lihmal	lihmit	‘run’
ʔajijhin	ʔajijk’a	ʔajjal	ʔajjit	‘pole a boat’
t’ojixhin	t’ojixk’a	t’ojxol	t’ojxit	‘give medicine’
luk’ulhun	luk’ulk’a	luk’lal	luk’lut	‘bury’
so:nilhin	so:nilk’a	sonlol	sonlit	‘put on back’
ʔa:milhin	ʔa:milk’a	ʔamlal	ʔamlit	‘help’
mo:jinhin	mo:jink’a	mojnol	mojnit	‘become tired’
ʂa:lik’hin	ʂa:lik’k’a	ʂalk’al	ʂalk’it	‘wake up’

7.1.2 The first step: morphology

First we need a morphological analysis of the data. In a simple case, this involves looking at columns and rows of data, and figuring out which sub-parts of words are consistently present with one meaning, and which other subparts are consistently present with other meanings. This task is more complicated when the surface shape of roots and affixes changes due to phonological rules. We cannot provide a definitive morphological analysis of these data without knowing what the phonological system is, and certainty as to the phonological rules is impossible without knowing the morphological analysis. We break out of this seeming circle by adopting – and constantly revising in the face of new evidence – a preliminary and less precise analysis of the phonology and morphology. Improvement in the underlying representations should result in better rules, and as we refine the system of rules, the nature of the underlying distinctions becomes clearer.

In this case, four suffixes are added to roots, *-hin ~ -hun* ‘nonfuture,’ *-k’a ~ -k’o* ‘imperative,’ *-al ~ -ol* ‘dubitative’ and *-it ~ -ut* ‘passive aorist.’ The notation *-hin ~ -hun* indicates that the suffix is pronounced either as *-hin* or as *-hun.* We need to discover

when one form versus the other is used, and express that relation in terms of an underlying form and a rule changing the underlying form.

Stem variants. Some stems have only one surface shape: *xat-* 'eat,' *dub-* 'lead by hand,' *xil-* 'tangle,' and *k'o*ʔ- 'throw,' so the most natural assumption would be that these *are* the underlying forms for these particular stems (this assumption may turn out to be wrong, but it is a good starting assumption). Most stems in the data set have two surface manifestations. An important first step in understanding the rules of the language is to identify the alternations in the data, and one way to make the alternations explicit is to list the phonetic variants of each stem.

(2)	dos ~ do:s	'report'	ʂap ~ ʂa:p	'burn'
	lan ~ la:n	'hear'	mek' ~ me:k'	'swallow'
	won ~ wo:n	'hide'	p'axat ~ p'axa:t	'mourn'
	hiwet ~ hiwe:t	'walk'	ʔopot ~ ʔopo:t	'arise from bed'
	jawal ~ jawa:l	'follow'	paʔiʈ ~ paʔʈ	'fight'
	ʔilik ~ ʔilk	'sing'	logiw ~ logw	'pulverize'
	ʔugun ~ ʔugn	'drink'	lihim ~ lihm	'run'
	ʔajij ~ ʔajj	'pole a boat'	t'ojix ~ t'ojx	'give medicine'
	luk'ul ~ luk'l	'bury'	so:nil ~ sonl	'put on back'
	ʔa:mil ~ ʔaml	'help'	mo:jin ~ mojn	'become tired'
	ʂa:lik' ~ ʂalk'	'wake up'		

In these cases, decisions must be made regarding the underlying forms.

Suffix variants. We must decide what the underlying form of each suffix is, and they all have two surface variants in terms of their vowel: either a nonrounded vowel, or a rounded vowel. For each suffix, we group the verbs in terms of which variant of the suffix is used with them.

(3)	*-hin*	xat, xil, k'oʔ, dos, ʂap, lan, mek', won, p'axat, hiwet, ʔopot, jawal, paʔiʈ, ʔilik, logiw, lihim, ʔajij, t'ojix, so:nil, ʔa:mil, mo:jin, ʂa:lik'
	-hun	dub, ʔugun, luk'ul
	-k'a	xat, dub, xil, ʂap, lan, mek', p'axat, hiwet, jawal, paʔiʈ, ʔilik, logiw, ʔugun, lihim, ʔajij, t'ojix, luk'ul, so:nil, ʔa:mil, mo:jin, ʂa:lik'
	-k'o	k'oʔ, dos, won, ʔopot
	-al	xat, dub, xil, ʂa:p, la:n, me:k', p'axa:t, hiwe:t, jawa:l, paʔʈ, ʔilk, ʔugn, lihm, ʔajj, luk'l, ʔaml, ʂalk'
	-ol	k'oʔ, do:s, wo:n, ʔopo:t, logw, t'ojx, sonl, mojn
	-it	xat, xil, k'oʔ, do:s, ʂa:p, la:n, me:k', wo:n, p'axa:t, hiwe:t, ʔopo:t, jawa:l, paʔʈ, ʔilk, logw, lihm, ʔajj, t'ojx, sonl, ʔaml, mojn, ʂalk'
	-ut	dub, ʔugn, luk'l

7.1.3 Indentifying phonological regularities

Vowel harmony. Having grouped the examples in this fashion, a phonological regularity can be detected. For the suffix *hin ~ hun*, the vowel *u* appears when the preceding vowel is *u*, and *i* appears in the suffix after any other vowel. The suffix *it ~ ut* obeys this same rule. The suffixes *k'a ~ k'o* and *al ~ ol* have the vowel *o* after *o*. This can be explained by positing a rule of vowel harmony between the suffix vowel and whatever vowel precedes it, where /a/ assimilates to /o/ and /i/ assimilates to /u/.

$$(4)\quad \begin{bmatrix} V \\ \alpha hi \end{bmatrix} \rightarrow [+\,round] / \begin{bmatrix} V \\ \alpha hi \\ +round \end{bmatrix} C_{o}\_$$

The variable notation – αhi…. αhi…. – expresses the condition that the vowels must have the same value of [hi], i.e. the harmonizing vowel must be [+hi] after a [+hi] round vowel, and [-hi] after a [-hi] round vowel, in order for the harmony rule to apply.

Vowel shortening. The next problem to tackle is the variation in the shape of the stem. A useful next step in trying to analyze that variation is to see whether the variants can be arranged into a small number of groups, organized according to the nature of the difference between the two stem shapes. In looking for such an organization, notice that some stems alternate in terms of having long versus short vowels, and in terms of having versus lacking a second vowel. Accordingly, we organize the data into the following classes of stem alternations (including the class of stems which have no alternation).

(5) *CVC* -	xat, dub, xil, k'oʔ
CVC ~ CV:C –	dos ~ do:s, ʂap ~ ʂa:p, lan ~ la:n, mek' ~ me:k', won ~ wo:n
CVCVC ~ CVCV:C –	p'axat ~ p'axa:t, hiwet ~ hiwe:t, ʔopot ~ ʔopo:t, jawal ~ jawa:l
CVCVC ~ CVCC –	paʔiɬ ~ paʔɬ, ʔilik ~ ʔilk, logiw ~ logw, ʔugun ~ ʔugn, lihim ~ lihm, ʔajij ~ ʔajj, t'ojix ~ t'ojx, luk'ul ~ luk'l
CV:CVC ~ CVCC –	so:nil ~ sonl, ʔa:mil ~ ʔaml, mo:jin ~ mojn, ʂa:lik' ~ ʂalk'

The initial hypothesis is that the invariant CVC stems have the underlying shape CVC. If there is no reason to make the underlying form be different from the surface form, the two forms should be assumed to be identical. Building on that decision, we will now set forth a hypothesis for stems which vary in shape between CVC and CV:C. It is highly unlikely that these stems also have the underlying shape CVC, since that would make it hard to account for stems such as /xat/ which are invariant CVC. We could not predict whether a stem vowel is supposed to have a length alternation or not, and the reasoning that leads to hypothesizing an underlying distinction /xat/ vs. /do:s/ which is contextually neutralized is exactly the same as that which leads to hypothesizing that in Russian (discussed in chapter 4) the word for 'time' is underlyingly /raz/ and 'forest' is /les/.

Given the conclusion that stems like *do:s ~ dos* have an underlying CV:C form, under what circumstance is the underlyingly long vowel of the stem shortened? Taking /do:s/ as a representative, and mechanically combining the assumed underlying stem with what we take to be the underlying form of the suffix, we arrive at the following underlying and surface relations.

(6) *underlying*	do:s-hin	do:s-k'a	do:s-al	do:s-it
surface	doshin	dosk'o	do:sol	do:sit

The change of /a/ to [o] is due to vowel harmony. There is also a change in vowel length before *k'a* and *hin,* and not before *-al* and *-it.* These suffixes are distinguished by whether they begin with a consonant or a vowel, thus whether combining the stem and suffix would result in the sequence V:CC. Scanning the entire data set reveals an important generalization, that a long vowel is always followed by CV, that is, a long vowel only occurs in an open syllable. The discovery of this generalization allows us to posit the following vowel shortening rule.

(7) V → [-long]/ __ CC

This rule is all that is needed to explain both the invariant CVC stems and the alternating CV:C ~ CVC stems. Underingly /do:s-hin/ undergoes (7) and gives the surface form [doshin] – all other forms preserve the underlying length of the vowel. The existence of this rule also explains why we do not find the surface sequence V:CC – a long vowel before a cluster of two consonants – anywhere in the data, as such sequences undergo vowel shortening.

We turn next to the stems with the shape CVCVC ~ CVCV:C such as *p'axat ~ p'axa:t.* Since we have already encountered a rule which accounts for alternations in vowel length, we should immediately suspect that this length alternation is the same as the one just accounted for in CV:C ~ CVC stems. When we inspect the contexts where the long-vowel variant occurs, we see that there are long vowels when a vowel-initial suffix is added, and short vowels when a consonant-initial suffix is added. In other words, these stems are virtually the same as /CV:C/ stems, except that they have the underlying shape /CVCV:C/. We initially hypothesized that there was a rule of vowel shortening based on /CV:C/ stems, and that rule nicely handled those data. The way we formulated that rule was quite general, since it only said "shorten a long vowel before two consonants." Such a statement predicts that, if there are other stem shapes such as /CVCV:C/, they too will undergo that rule. We have now discovered that such stems do undergo the shortening rule, providing independent support for that rule.

Epenthesis. This reduces the unsolved part of the problem to two remaining classes of stems. In one of those, there is an alternation between presence versus absence of a vowel, and in the second group there is an alternation in vowel length as well as an alternation in the presence versus lack of a vowel in the second syllable; this should make us suspect that the vowel shortening rule applies to the second of these sets. Concentrating on the contexts where the stem has the shape CV(:)CVC as opposed to the shape CVCC, we notice that CV(:)CVC appears before consonant-initial suffixes and CVCC appears before vowel-initial suffixes. We do not know at this point whether the

second vowel is underlyingly part of the stem and is deleted in one context, or whether the vowel is inserted in a different context. Therefore, we will consider both possibilities: consideration of alternative hypotheses is an essential part of problem solving.

First suppose that the vowel is not part of the underlying representation of the stem. In that case, we assume the following representations

(8) *underlying*	ʔilk-hin	ʔilk-k'a	ʔilk-al	ʔilk-it
surface	ʔilik-hin	ʔilik-k'a	ʔilk-al	ʔilk-it
underlying	ʂa:lk'-hin	ʂa:lk'-k'a	ʂa:lk'-al	ʂa:lk'-it
Surface	ʂa:lik'-hin	ʂa:lik'-k'a	ʂalk'-al	ʂalk'-it

Focusing on the hypothesized underlying representations where a vowel might be inserted, we notice that a vowel appears only where the underlying representation has a sequence of three consonants. Looking at all of the data, we notice that there are no surface sequences of three or more consonants, making such an epenthesis approach plausible.

In order for an epenthesis solution to work, the actual quality of the inserted vowel must be completely predictable. If we were to discover that the quality of the second vowel is unpredictable, then it would necessarily be part of the underlying representation since unpredictable information must be in the underlying form. The vowel in the second syllable is always high, and is round when the preceding vowel is high and round. In other words, the vowel in question is a high vowel whose backness and roundness is predictable, given the rule of vowel harmony, and thus the vowel is fully predictable. Given the harmony rule, we can assume that the second vowel is t. It is then possible to account for these examples by applying the following rule of epenthesis.

(9) $\varnothing \rightarrow \underset{[+hi]}{V} / C \_\_ CC$

Given (9), the underlying form of the CVCiC ~ CVCC stems would be /CVCC/ and the underlying form of the CV:CiC ~ CVCC stems would be /CV:CC/. For stems like /ʔilk/, epenthesis applies to underlying /CVCC+CV(C)/ to give surface [CVCiC+CV(C)]: /ʔilk-hin/ → [ʔilikhin]. The alternant CVCC before VC suffixes ~ [ʔilkal] ~ directly reflects the underlying form.

For /CV:CC/ stems like /ʂa:lk'/, epenthesis will also apply to underlying /CV:CC+CV(C)/, giving the surface form [CV:CiC+CV(C)]: /ʂa:lk-hin/ → [ʂa:likhin]. When a VC suffix is added to such stems, there is no epenthesis, but we do find shortening of the underlyingly long vowel which stands before a consonant cluster: (/ʂa:lkal/ → [ʂalkal]). The rules of vowel harmony, epenthesis and vowel shortening, combined with our analyses of underlying representations, account for all aspects of the data in (1). We conclude that epenthesis is a *possible* account of these alternations.

The preceding analysis has assumed a rule of epenthesis based on underlying representations of the form /CVCC/ and /CV:CC/, but we should explore the competing hypothesis that the vowel found in these stems is not inserted, and is part of the underlying representation. Under that hypothesis, underlying representations of the relevant stems would be the following.

(10) paʔit, ʔilik, logiw, ʔugun, lihim, ʔajij, t'ojix, luk'ul so:nil, ʔa:mil, mo:jin, ʂa:lik'

Presuming that these are the underlying stems, a rule of vowel deletion is required to explain the discrepancy between surface and underlying forms, which can be seen in (11).

(11) *underlying*	luk'ul-hun	luk'ul-k'a	luk'ul-al	luk'ul-ut
surface	luk'ul-hun	luk'ul-k'a	luk'l-al	luk'l-ut
underlying	so:nil-hin	so:nil-k'a	so:nil-ol	so:nil-it
surface	so:nil-hin	so:nil-k'a	sonl-ol	sonl-it

In forms which involve an alternation between a vowel and Ø, the context for vowel deletion would initially appear to be in an open syllable. This statement would produce too general a rule, since there are many vowels in open syllables, viz. *xatal, k'oʔit*, *do:sit, p'axathin* and *p'axa:tal* among others. In some of these, deletion of a vowel would lead to a word-initial consonant cluster, i.e. we would predict **xtal, *k'ʔit, *dsit, *p'xathin,* and **p'xa:*tal, and we see no word-initial clusters of consonants. If we are to have vowel deletion, the rule must be restricted from creating such clusters, so one way to enforce that requirement is to require the target of deletion to be preceded by the sequence VC. Thus, we might hypothesize the following syncope rule, one found in many languages.

(12) V → Ø / VC _ CV

This rule still makes incorrect predictions, since in fact there are vowels in the context VC_CV, as shown by forms such as *p'axa:tal, ʔopo:tit*, which according to (12) should be deleted. Since all such examples involve long vowels, it is a simple matter to restrict the assumed deletion rule to short vowels.

(13) $V \rightarrow \varnothing / VC\_\_CV$
$[-long]$

With this rule of vowel syncope, the problem of vowel ~ Ø alternations can also be accounted for. The remaining details of the analysis are exactly the same as they are under the assumption that there is a rule of vowel insertion.

7.1.4 Evaluating alternatives

In terms of simply generating the data, both the syncope and epenthesis analyses work. The question then becomes, is there a reason to chose one of these hypotheses over the other? It is entirely possible that we will not be able to come up with any compelling reasons for selecting one analysis over the other, in which case we must simply accept the

fact that there are two equally plausible ways to account for the facts. As far as the simplicity, naturalness and generality of the two analyses is concerned, neither theory is superior to the other. Processes inserting vowels to break up CCC clusters are very common, as are rules of syncope which delete short vowels in the context VC_CV.

We should also consider the factual predictions of the two analyses. The epenthesis analysis predicts that there should be no CCC sequences in the language, and this appears to be correct. On the other hand, the syncope analysis predicts that there should be no short vowels in the context VC_CV, which also appears to be correct. Interestingly, neither account actually makes the prediction of the competing analysis – so, the epenthesis analysis does not preclude the existence of short vowels in the VC_CV context, and the syncope analysis does not preclude the existence of CCC sequences. If it turns out that there *are* CCC sequences in the language, the epenthesis solution will probably have to be rejected; whereas if there *are* VCVCV sequences in the language, the syncope analysis will probably have to be rejected. This would motivate further research into the language, to determine if one of these analyses makes a bad prediction.

A related issue to consider is the question of "coincidence," in terms of assumed underlying representations. In lieu of a specific rule which restricts the occurrence of phonemes in some environment, we expect phonemes to combine without any constraints. Clearly there must be some constraints on underlying representations in Yawelmani, since, for example, we do not find underlying representations such as /ioate/ with sequences of vowels. In this case, there is no motivation from phonological alternations to suspect that there might be underlying forms such as /ioate/. As far as logical possibilities in underlying forms are concerned for the issue at hand – epenthesis versus deletion – both analyses result in systematic gaps in the logically possible underlying forms. Under the epenthesis analysis, there are apparently no stems of the underlying form /CVCVC/, although there are stems of the form /CVCV:C/. Under the syncope analysis, we notice that all short second-syllable vowels in disyllabic stems are in fact /i/ (surface [u] in some cases, in accordance with vowel harmony).

At this point, it is impossible to give strong arguments in favor of one analysis over another, so we accept this indeterminacy for now. The fundamental point is that each analysis implies a set of predictions about possible and impossible forms in the language, and these predictions need to be tested against the available data. In this case, we have not been able to determine that one theory is clearly superior to the other. The main research problem which we face is that the corpus of data from Yawelmani available to us at this point is restricted, so we cannot know whether generalizations which we extract about the language based on this particular corpus are representative of the language as a whole. Even if we had access to a reference grammar for the language, there is some chance that our empirical generalizations based on the data from that grammar would not hold for the whole language, if the author of the grammar were not aware of all relevant types of examples.

7.2 Hehe

The following data illustrate phonological processes of Hehe (Tanzania). Each noun is in one of fifteen numbered noun classes, like genders in French or German. The class of a

noun is marked by a prefix. The goal is to determine the underlying form of stems and prefixes, and explain the processes at work in these data.

7.2.1 The data

Here are the relevant data from nouns.

(14) *Class 1*

mutesi	‘trapper’	mulagusi	‘sorcerer’
mutelesi	‘cook’	muŋwi	‘drinker’
mwiimbi	‘singer’	mweendi	‘one who likes people’
mwaasi	‘builder’	moogofi	‘one who is afraid’
moofusi	‘one who washes’	muut^{s}i	‘one who comes’
Class 2			
vatesi	‘trappers’	valagusi	‘sorcerers’
vatelesi	‘cooks’	vaŋwi	‘drinkers’
viimbi	‘singers’	veendi	‘ones who like people’
vaasi	‘builders’	woogofi	‘ones who are afraid’
woofusi	‘ones who wash’	wuut^{s}i	‘ones who come’
Class 3			
muhoomi	‘cow hump’	muhogo	‘cassava’
mufuniko	‘cover’	muvili	‘body’
mwiina	‘hole’	mwiigiigi	‘shadow’
mweenda	‘cloth’	mooto	‘fire’
muuŋi	‘salt’		
Class 4			
mihoomi	‘cow humps’	mihogo	‘cassavas’
mifuniko	‘covers’	mivili	‘bodies’
miina	‘holes’	miigiigi	‘shadows’
mjeenda	‘cloths’	mjooto	‘fires’
mjuuŋi	‘salts’		
Class 6			
mavafi	‘hairy caterpillars’	masaasi	‘bullets’
maboga	‘pumpkins’	majaji	‘legs’
miino	‘teeth’	miiho	‘eyes’
Class 7			
kigidi	‘waist’	kingaamba	‘sweet potato’

kisogo	‘back of head’	tʃuula	‘frog’
tʃuunga	‘wet lowland’	tʃaanga	‘grave’
kifuniko	‘tiny cover’	kivili	‘tiny body’
kihoomi	‘tiny cow hump’	kivafi	‘tiny hairy caterpillar’
tʃooto	‘tiny fire’	tʃeenda	‘tiny cloth’
tʃuuɲu	‘tiny salt’	kiiho	‘tiny eye’
kiina	‘tiny hole’	kiigiigi	‘tiny shadow’
Class 8			
figidi	‘waists’	fingaamba	‘sweet potatoes’
fisogo	‘backs of head’	fjuula	‘frogs’
fjuunga	‘wet lowlands’	fjaanga	‘graves’
fifuniko	‘tiny covers’	fivili	‘tiny bodies’
fihoomi	‘tiny cow humps’	fivafi	‘tiny hairy caterpillars’
fjooto	‘tiny fires’	fjeenda	‘tiny cloths’
fjuuɲu	‘tiny salts’	fiiho	‘tiny eyes’
fiina	‘tiny holes’	fiigiigi	‘tiny shadows’
Class 11			
luteefu	‘reed mat’	lupava	‘stirring stick’
lutego	‘trap’	ludali	‘power
luhaanga	‘sand’	lwiimbo	‘song’
lweendo	‘loving’	lwaaniko	‘dry stuff
lwiifwi	‘chameleon’		
Class 12			
kateefu	‘small mat’	kakoongo	‘small wound’
kafuniko	‘small cover’	kangaamba	‘small sweet potato’
kaasi	‘small builder’	kiimbi	‘small singer’
kaanga	‘small grave’	kooto	‘small file’
kuula	‘small frog’	kuunga	‘small wet lowland’
Class 13			
tuteefu	‘small mats’	tukoongo	‘small wounds’
tufuniko	‘small covers’	tungaamba	‘small sweet potatoes’
twaasi	‘small builders’	twiimbi	‘small singers’
twaanga	‘small graves’	tooto	‘small files’
tuula	‘small frogs’	tuunga	‘small wet lowlands’

Class 14

wuvaso	'sleeping place'	wulime	'cultivating'
wugali	'porridge'	wutiitu	'blackness'
weelu	'whiteness'	wuumi	'life'
woogofu	'fear'	wiijooga	'mushroom'
waangufu	'speed'		

7.2.2 Morphological analysis

As always, a preliminary morphological analysis is the first step in solving this phonology problem. Each noun has some prefix that marks noun class, followed by a stem. We also see, comparing nouns in various classes, that the same stems can appear in different classes, so for example class 3 *mu-hoomi* 'cow hump' is clearly related to class 4 *mi-hoomi* 'cow humps' – singulars and plurals are marked by changes in class; class 11 *lu-teefu* 'reed mat' is clearly related to *ka-teefu* 'small mat' and *tu-teefu* 'small mats.' The class prefixes have a number of phonetic manifestations, so we find *mu-, mw-* and *m-* for classes 1 and 3, *va, v-* and *w-* for class 2, *mi-, mj-* and *m-* for class 4, *ma-* and *m-*for class 6, *ki-* and *tʃ-* for class *7, fi-* and *fj-* for class 8, *lu-* and *lw-* for class 11, *ka-* and *k-* for class 12, *tu-, t-* and *tw-* for class 13, and *wu-*, *w-* for class 14.

7.2.3 Phonological alternations

Noun stems fall in two groups in terms of phonological processes: those which begin with a consonant, and those beginning with a vowel. Examples of stems which begin with a consonant are *-tesi* (cf. *mu-tesi, va-tesi*) and *-lagusi* (cf. *mu-lagusi, va-lagusi*); examples of stems which begin with vowels are *-iimbi* (cf. *mw-iimbi, v-iimbi*) and *-eendi* (*mw-eendi, v-eendi*). The best phonological information about the nature of the prefix is available from its form before a consonant, so our working hypothesis is that the underlying form of the noun prefix is that found before a consonant it preserves more information.

As we try to understand the phonological changes found with vowel-initial stems, it is helpful to look for a general unity behind these changes. One important generalization about the language, judging from the data, is that there are no vowel sequences in the language (what may seem to be sequences such as *ii, ee* are not sequences, but are the orthographic representation of single long-vowel segments). Given the assumption that the prefixes for classes 1 and 2 are respectively /mu/ and /va/, the expected underlying forms of the words for 'singer' and 'singers' would be /muiimbi/ and /va-iimbi/. These differ from the surface forms [mw-iimbi] and [v-iimbi]: in the case of /mu-iimbi/, underlying /u/ has become [w], and in the case of underlying /va-iimbi/, underlying [a] has been deleted. In both cases, the end result is that an underlying cluster of vowels has been eliminated.

Glide formation versus vowel deletion. Now we should ask, why is a vowel deleted in one case but turned into a glide in another case? The answer lies in the nature of the prefix vowel. The vowel /u/ becomes the glide [w], and the only difference between *u*

and *w* is that the former is syllabic (a vowel) where the latter is nonsyllabic. The low vowel /a/, on the other hand, does not have a corresponding glide in this language (or in any language). In other words, a rule of glide formation simply could not apply to /a/ and result in a segment of the language.

To make progress in solving the problem, we need to advance hypotheses and test them against the data. We therefore assume the following rules of glide formation and vowel deletion.

(15) $V \rightarrow \begin{bmatrix} -\text{syl} \\ +\text{hi} \end{bmatrix} / \_\_ V$ *glide formation*

(16) $V \rightarrow \varnothing / \_\_ V$ *a – deletion*

By ordering (16) after (15), we can make (16) very general, since (15) will have already eliminated other vowel sequences. At this point, we can simply go through the data from top to bottom, seeing whether we are able to account for the examples with no further rules – or, we may find that other rules become necessary.

For nouns in class 1, the examples *mw-iimbi, mw-eendi* and *mw-aasi* are straightforward, deriving from /mu-iimbi/, /mu-eendi/ and /mu-aasi/. The forms *m-oogofi, m-oofusi* and *m-uuci* presumably derive from /mu-oogofi/ and /mu-oofusi/ and /mu-uuci/. The vowel /u/ has been deleted, which seems to run counter to our hypothesis that high vowels become glides before vowels. It is possible that there is another rule that deletes /u/ before a round vowel.

(17) $u \rightarrow \varnothing / \_ \begin{matrix} V \\ [+\text{ round}] \end{matrix}$ *u-deletion*

We could also consider letting the glide formation rule apply and then explain the difference /mu-aasi/ → *mw-aasi* vs. /mu-oofusi/ → *m-oofusi* by subjecting derived *mw-oofusi* to a rule deleting *w* before a round vowel.

(18) $w \rightarrow \varnothing / \_ \begin{bmatrix} +\text{round} \end{bmatrix}$ *w-deletion*

Thus we must keep in mind two hypotheses regarding /u+o/ and /u+u/ sequences.

***v*-rounding.** Now consider class 2. In stems beginning with a vowel, we easily explain *v-iimbi, v-eendi* and *v-aasi* from *va-iimbi, va-eendi* and *va-aasi,* where *a*-deletion applies. Something else seems to be happening in *w-oogofi, w-oofusi,* and *w-uuci* from *va-oogofi, va-oofusi,* and *va-uut^{s}i.* Application of *a*-deletion would yield *v-oogofi, v-oofusi* and *v-uut^{s}i*, which differ from the surface forms only in the replacement of *v* by *w*. Since this process takes place before a round vowel, we conjecture that there may be an assimilation rule such as the following.

(19) $\begin{bmatrix} +\text{labial} \\ +\text{cont} \\ +\text{voice} \end{bmatrix} \rightarrow$ [–cons] / __ [+round] *v-rounding*

If there is such a rule in the language, it would eliminate any sequences *vu, vo*: and the data contain no such sequences. There is still a problem to address, that *w*-deletion (18) should apply to *woogofi* but it does not – the surface form is not *[oogofi]. Two explanations are available. One is that *v*-rounding is ordered after *w*-deletion, so at the stage where w-deletion would apply, this word has the shape *voogofi* and not *woogofi* (so *w*-deletion cannot apply). The other is that (18) needs to be revised, so that it only deletes a postconsonantal *w* before a round vowel.

(20) [+round,–syl] → Ø / C _ [+round]

Our decision-making criteria are not stringent enough that we can definitively choose between these solutions, so we will leave this question open for the time being.

Moving to other classes, the nouns in class 3 present no problems. Glide formation applies to this prefix, so /mu-iina/ → [mw-iina], and before a round vowel derived *w* deletes, so /mu-ooto/ → *mw-ooto* which then becomes [m-ooto].

Front vowels and glides. The nouns in class 4 generally conform to the predictions of our analysis. Note in particular that underlying /mi-uuɲu/ and /mi-ooto/ undergo glide formation before a round vowel. Such examples show that it was correct to state the glide formation rule in a more general way, so that all high vowels (and not just /u/) become glides before any vowel (not just nonround vowels).

We cannot yet fully explain what happens with noun stems beginning with the vowel *i*, as in *m-iina, m-iigiigi*. Given /mi-iina/, /mi-iigiigi/, we predict surface **mj-iina, *mj-iigiigi.* This is reminiscent of the problem of /mu-oogofi/ and /mu-uuci/ and we might want to generalize the rule deleting a glide, to include deleting a front glide before a front vowel (analogous to deleting a round glide before a round vowel). What prevents us from doing this is that while *w* deletes before both *u* and *o, y* only deletes before *i* and not *e,* as we can see from *mj-eenda.* It might be more elegant or symmetrical for round glides to delete before round vowels of any height *and* front glides to delete before front vowels of any height, but the facts say otherwise: a front glide only deletes before a front *high* vowel.

(21) $\begin{bmatrix} +\text{hi} \\ -\text{back} \\ -\text{syl} \end{bmatrix} \rightarrow \varnothing / \_\_\_ \begin{bmatrix} +\text{hi} \\ -\text{back} \end{bmatrix}$ *j-Deletion*

Checking other classes: discovering a palatalization rule. The class 6 prefix *ma-* presents no surprises at all: it appears as *ma-* before a consonant, and its vowel deletes before another vowel, as in *m-iino* from *ma-iino.* The class 7 prefix, on the other hand, is more complex. Before a consonant it appears as *ki-*, and it also appears as *k(i)-* before *i*. Before other vowels, it appears as *tʃ*, as in *tʃ-uula, tʃ-aanga, tʃ-ooto,* and *tʃ-eenda.* Again, we continue the procedure of comparing the underlying and predicted surface forms (predicted by mechanically applying the rules which we have already postulated to the underlying forms we have committed ourselves to), to see exactly what governs this

discrepancy. From underlying *ki-uula, ki-aanga, ki-ooto* and *ki-eenda* we would expect *kj-uula, kj-aanga, kj-ooto* and *kj-eenda,* given glide formation. The discrepancy lies in the fact that the predicted sequence *kj* has been fused into *tʃ*, a process of palatalization found in many languages. Since *kj* is nowhere found in the data, we can confidently posit the following rule.

(22) $\begin{bmatrix} +\text{cons} \\ +\text{back} \\ -\text{voice} \end{bmatrix}\begin{bmatrix} -\text{syl} \\ -\text{cons} \\ -\text{back} \end{bmatrix} \rightarrow [+\text{cor}]\,\emptyset$

Since /ki/ surfaces as [tʃi] when attached to a vowel-initial noun stem, the question arises as to what has happened in *k-iiho, k-iina* and *k-iigiigi.* The glide formation rule should apply to /ki-iiho/, /ki-iina/ and /ki-iigiigi/ giving *kj-iiho, kj-iina* and *kj-iigiigi,* which we would expect to undergo (22). But there is a rule deleting *j* before *i*. If *j* is deleted by that rule, it could not condition the change of *k* to *tʃ*, so all that is required is the ordering statement that *j*-deletion precedes palatalization (22). Thus /ki-iina/ becomes *kj-iina* by glide formation, and before the palatalization rule can apply, the j-deletion rule (21) deletes the glide that is crucial for (22).

Deciding on the form of w-deletion; degemination. At this point, we can quickly check the examples in classes 8, 11, 12 and 13 and verify that our analysis explains all of these forms as well. The final set of examples are those in class 14, which has the prefix /wu/. This prefix raises a question in terms of our analysis: why do we have the sequence [wu], which is eliminated by a rule elsewhere? One explanation is the statement of the rule itself: if (20) is the correct rule, then this *w* could not delete because it is not preceded by a consonant. The other possibility is that [wu] actually comes from /vu/ by applying *v*-rounding (19), which we assumed applies after *w*-deletion. While both explanations generate the correct outputs, the analysis where [wu] is underlying /vu/ has the disadvantage of being rather abstract, in positing an underlying segment in the prefix which never appears as such. This issue is discussed in more detail in Chapter 9: for the moment we will simply say that given a choice between a concrete analysis where the underlying form of a morpheme is composed only of segments which actually appear as such in some surface manifestation of the morpheme, and an abstract form with a segment that never appears on the surface, the concrete analysis is preferable to the abstract one, all other things being comparable. On that basis, we decide that the underlying form of the class 14 prefix is /wu/, which means that the proper explanation for failure of w-deletion lies in the statement of w-deletion itself, as (20).

Still analyzing this class of nouns, we now focus on examples where the prefix precedes a vowel-initial stem, e.g. *w-eelu, w-uumi, w-oogofu, w-iijooga* and *w-aangufu* from underlying /wu-eelu/, /wu-uumi/, /wu-oogofu/, /wu-iijooga/ and /wu-aangufu/. Applying glide formation would give the surface forms **ww-eelu, *ww-uumi, *ww-oogofu, *ww-iijooga* and **ww-aangufu,* which differ from the surface form in a simple way, that they have two *w*'s where the actual form has only a single *w*, which allows us to posit the following degemination rule.

(23) $\begin{bmatrix} -\text{syl} \\ +\text{rd} \end{bmatrix} \rightarrow \emptyset \,/\, \_\_ \begin{bmatrix} -\text{syl} \\ -\text{rd} \end{bmatrix}$ *Glide Degemination*

7.2.4 Extending the data

Verbs are subject to these same rules, as some additional data will show, and an analysis of verbs will provide additional support for aspects of this analysis. Hehe is a tone language, and while we have not been concerned with accounting for tone (and have not marked tones), in the following data, tones are marked, and can be predicted by rule. In analyzing these data, we want to account for the placement of the high tone (H), which is marked with an acute accent.

(24)

V	*V for*	*V for each*	*make V*
kúkama	kúkamíla	kúkamilána	kúkamjá
kúsana	kúsaníla	kúsanilána	kúsanjá
kútova	kútovéla	kútovelána	kútovjá
kúlava	kúlavíla	kúlavilána	kúlavjá
kúfwiíma	kúfwiimíla	kúfwiimilána	kúfwiimjá
kúkalaánga	kúkalaangíla	kúkalaangilána	kúkalaangjá
kúkaláva	kúkalavíla	kúkalavilána	kúkalavjá
kwéenda	kwéendéla	kwéendelána	kwéendjá
kwíimba	kwíimbíla	kwíimbilána	kwíimbjá
kóogópa	kóogopéla	kóogopelána	kóogopjá

be V'd	*V us*	*V them*	
kúkamwá	kútukáma	kúvakáma	'milk'
kúsanwá	kútusána	kúvasána	'comb'
kútowá	kútutóva	kúvatóva	'beat'
kúlawá	kútuláva	kúvaláva	'look at'
kúfwiimwá	kútufwiíma	kúvafwiíma	'hunt'
kúkalaangwá	kútukalaánga	kúvakalaánga	'fry'
kúkalawá	—	—	'take bath'
kwéendwá	kútweénda	kúveénda	'love'
kwíimbwá	kútwiímba	kúviímba	'sing'
kóogopwá	kútoogópa	kúwoogópa	'fear'

The morphology. These data indicate that all verbs begin with *kú* or something derivable from /kú/ by the rules already motivated, thus we assume that *kú-* is an inflectional prefix. In addition, all verbs end with the vowel *a*, which is probably a morpheme since it is unlikely that every root would end in exactly the same vowel. The stem of the word for 'milk' is probably *-kam-*. Various grammatical relations are expressed by suffixes

standing between the stem and the suffix *-a*, such as *-il-* 'for,' *-an-* 'each other,' *-j-* 'make,' *-w-* passive: the objects 'us' and 'them' are marked by the prefixes *-tu-* and *-va-* between the prefix *kú* and the verb stem.

Phonological rules. Looking at the last three roots, which are vowel-initial, the prefixes *kú-, tu-* and *va-* are subject to the rules motivated on the basis of nouns, where /u/ becomes [w] before a vowel, but deletes after a consonant and before a round vowel (so, /ku-oogopa/ → *kwoogopa* → [kóogópa]); the sequence *vo* becomes *wo* (/ku-va-oogopa/ → *kuvoogopa* → [kúwoogópa]). The change of /v/ to *w* is also seen in examples such as *kútowá* and *kúlawá*, coming (apparently) from /ku-tov-w-a/ and /ku-lav-w-a/. The rule of *v*-rounding would derive *kútowwá* and *kúlawwá*, and the actual phonetic forms can be accounted for based on that intermediate form by Glide Degemination.

One additional segmental process of vowel harmony is motivated by the above examples. The benefactive suffix retains its underlying high vowel in forms such as *kúkam-íl-a, kúsan-íl-a* and *kúfwiim-íl-a*, but that vowel assimilates in height to a preceding mid vowel in examples such as *kútov-él-a, kwéend-él-a* and *kóogop-él-a*. This motivates the following vowel harmony rule:

(25) $V \rightarrow [\text{-hi}] / \begin{bmatrix} V \\ \text{-hi} \\ \text{-low} \end{bmatrix} C_0 \_\_\_$ *Vowel Harmony*

Regarding tone, most examples have an H tone on the second-to-last vowel of the word (this may be the second part of a long vowel in the penultimate syllable, or the only vowel of a short penultimate syllable), which can be accounted for by the following rule.

(26) $V \rightarrow [+H] / \_\ C_0\ V\#$ *tone assignment*

In some verbs, this H is missing – see *kúkama, kúsana, kútova*. Applying this tone assignment rule to these forms would result in outputs such as **kúkáma, *kúsána, *kútóva*, with H tones on adjacent vowels. Since our examples contain no cases of consecutive H-toned vowels, we may assume a rule along the following lines.

(27) $V \rightarrow [-H] / \underset{[+H]}{V}\ C_0 \_$

What about the columns with the suffixes *-j-* 'make' and *-w-* 'passive,' which have word-final H, not penult H ? We expect **kúkalaángwa*. But if these two suffixes are underlyingly *i* and *u,* then the underlying form of *kúkalaangwá* would be /kúkalaang-u-a/. H tone would be assigned to the penultimate vowel under that assumption, giving *kúkalaangúa.* However, we already know that there is a rule of glide formation which would turn *u* and *i* into *w* and *y* before vowels, a rule which has obviously applied in these forms. Since only syllabic elements can bear tones, the tone on the penultimate vowel apparently shifts to the final syllable, where it can be pronounced.

Such tone shift, where the tone of a vowel shifts to another vowel when the original vowel deletes or desyllabifies, is common in tone

languages and is discussed in the last chapter.

7.3 Fore

The next problem comes from Fore, spoken in Papua New Guinea.

7.3.1 The data

The following data motivate a set of phonological rules that apply in combinations of noun plus personal possessive affix. Your final goal is to identify the underlying forms of all roots and affixes, to discover the operative phonological rules, and order those rules.

(28)

1s	*2s*	*3s*	*1p*	
tunte	tuka	tunkwa	tute	'axe'
kajne	kajga	kajwa	kajre	'clothes'
ka:ʔne	ka:ka	ka:ʔwa	ka:te	'one (thing)'
awnte	awka	awnkwa	awte	'liver'
awne	awga	awwa	awre	'eye'
pine	piga	piwa	pire	'shell'
ma:ʔne	ma:ka	ma:ʔwa	ma:te	'snake'
kone	koga	kowa	kore	'trap'
awʔne	awka	awʔwa	awte	'skin'
inte	ika	inkwa	ite	'bee'
na:nte	na:ka	na:nkwa	na:te	'house'
agene	agega	agewa	agere	'name'
koʔne	koka	koʔwa	kote	'bag'
mune	muga	muwa	mure	'vomit'
arawnte	arawka	arawnkwa	arawte	'kneecap'
kajnte	kajka	kajnkwa	kajte	'ginger'
abeʔne	abeka	abeʔwa	abete	'navel'

7.3.2 Morphological analysis

Separating roots from suffixes in this language is difficult, since it is not obvious whether certain segments are part of the root and delete in one context, or are part of the suffix and delete in another context – or, are they epenthetic? Thus the root for 'axe' might be /tun/ or it might be /tu/ – if the former, some rule must delete /n/ in [tuka] 'your sg. ax', if the latter, we would conclude that the 1s and 3s suffixes are /-nte, -nkwa/. If we assume the suffixes /-nte, -nkwa/, then we would need to explain why they appear as [-ne, -wa] after 'clothes' and 'one'. It almost seems that in order to get the answer to one question, you have to know the answer to all other questions.

The first step to solving this problem is to determine how many significant behavioral categories there are. By comparing the forms of 'clothes' and 'eye', we can conclude that these two roots are identical in terms of behavior: the suffixes have the same shape after these two roots, and the following inflectional material is the same across the roots. We

can also see that there are major differences in the form of the suffixes between ‘eye’ and ‘liver’, although the roots look very similar and in half of the forms are exactly the same.

(29)	*1s*	*2s*	*3s*	*1p*	
	kajne	kajga	kajwa	kajre	‘clothes’
	awne	awga	awwa	awre	‘eye’
	awnte	awka	awnkwa	awte	‘liver’

The data of (28) can be reordered by roots, according to the surface patterns of the apparent personal suffixes, and this reveals that there are three behavioral classes of roots.

(30)		*1s*	*2s*	*3s*	*1p*	
	a.	kajne	kajga	kajwa	kajre	‘clothes’
		awne	awga	awwa	awre	‘eye’
		pine	piga	piwa	pire	‘shell’
		kone	koga	kowa	kore	‘trap’
		agene	agega	agewa	agere	‘name’
		mune	muga	muwa	mure	‘vomit’
	b.	ka:ʔne	ka:ka	ka:ʔwa	ka:te	‘one (thing)’
		ma:ʔne	ma:ka	ma:ʔwa	ma:te	‘snake’
		awʔne	awka	awʔwa	awte	‘skin’
		koʔne	koka	koʔwa	kote	‘bag’
		abeʔne	abeka	abeʔwa	abete	‘navel’
	c.	tunte	tuka	tunkwa	tute	‘axe’
		awnte	awka	awnkwa	awte	‘liver’
		inte	ika	inkwa	ite	‘bee’
		na:nte	na:ka	na:nkwa	na:te	‘house’
		arawnte	arawka	arawnkwa	arawte	‘kneecap’
		kajnte	kajka	kajnkwa	kajte	‘ginger’

In (a), the invariance of the portion that precedes *ne* in the 1s, *ga* in the 2s, *wa* in the 3s and *re* in the 1p suggests that these roots are /kaj, aw, pi, ko, age, mu/, further leading to the conclusion that the suffixes are /-ne/ ‘1s’, /-ga/ ‘2s’, /-wa/ ‘3s’, /-re/ ‘1p’, or some phonologically similar form. Having identified the root-suffix boundary, we can now proceed with the phonological analysis of underlying forms and rules.

7.3.3 Phonological alternations

We concluded that the (a) subset of roots are underlyingly /kaj, aw, pi, ko, age, mu/ because those are the parts of words that invariantly correlate with the choice of a particular root. A further consequence of that conclusion is that the roots in (b) and (c), which behave differently, should have a significantly different-looking underlying form. The roots in (30b) have the surface realizations [ka:ʔ, ma:ʔ, awʔ, koʔ, abeʔ] and [ka:,

ma:, aw, ko, abe]. The roots of (30a) underlyingly end in a glide or vowel, and since the roots in (30b) behave differently, those roots must *not* end in a vowel or glide, which leads to the conclusion that the roots of (30b) are /ka:ʔ, ma:ʔ, awʔ, koʔ, abeʔ/, i.e. these roots end in a glottal stop.

Similar reasoning applied to the roots of (30c) leads to the conclusion that these roots are /tun, awn, in, na:n, arawn, kajn/. Again, the roots have two types of surface realization, and the alternative theory for (30c) that the roots are /tu, aw, i, na:, araw, kaj/ can be ruled out on the grounds that this would incorrectly render the (a) and (c) roots indistinguishable. The distinguishing feature of the (c) roots is that they all end with a nasal.

Having sorted out the underlying forms of the roots, we can turn to the suffixes, drawing one representative from each phonological class of roots.

(31)

	1s	*2s*	*3s*	*1p*	
a.	aw-ne	aw-ga	aw-wa	aw-re	'eye'
b.	awʔ-ne	aw-ka	awʔ-wa	aw-te	'skin'
c.	awn-te	aw-ka	awn-kwa	aw-te	'liver'

One fact stands out from this organization of data, that while both the 1s and 1p suffixes have the variant [te] somewhere, these suffixes cannot be the same because they act quite differently. A second fact which can be seen from these examples is that the 1p and 2s suffixes are similar in the nature and context of their variation. Both alternate between a voiceless stop and a voiced consonant – we can suspect that [r] is the surface voiced counterpart of [t]. And, the voiced alternant appears after roots which underlyingly end in a glide or a vowel, whereas the voiceless variant appears after an underlying nasal or a glottal stop.

Nasals and glottal stops have in common the fact of being [-continuant], and glides and vowels have in common the fact of being [+voice,-cons]. This gives rise to two theories regarding the underlying forms of the 2s and 1p and the rules that apply to those suffixes. First, we could assume /ga, re/ and the following rule to derive the voiceless variant.

(32) [+cons] → [-voice] / [-cont] __ *Devoicing*

Alternatively, we could assume /ka, te/ and the following voicing rule.

(33) $[+\text{cons}] \rightarrow [+\text{voice}] / \begin{bmatrix} +\text{voice} \\ -\text{nas} \end{bmatrix} \_\_\_$ *Voicing*

Either analysis is, at this point, entirely reasonable, so we must leave the choice between these analyses unresolved for the moment. We might reject (33) on the grounds that it requires specification of an additional feature, but such a rejection would be valid only in the context of two competing *complete* analyses which are empirically correct and otherwise the same in simplicity.

The 3s suffix surfaces as [kwa] and [wa], the former after a nasal and the latter after an oral segment. That leads to two pairs of rule and underlying representation. If the underlying form of the suffix is /wa/ then there is a rule inserting [k] between a nasal and *w*.

(34) $\emptyset \rightarrow \begin{bmatrix} +\text{hi} \\ +\text{cons} \\ -\text{voice} \end{bmatrix} / [+\text{nas}] \_\_ \begin{bmatrix} +\text{rd} \\ -\text{syl} \end{bmatrix}$ *k-insertion*

If the suffix is underlyingly /kwa/, a rule deletes *k* after an oral segment before *w*.

(35) $\begin{bmatrix} +\text{hi} \\ +\text{cons} \\ -\text{voice} \end{bmatrix} \rightarrow \emptyset / [-\text{nas}] \_\_ \begin{bmatrix} +\text{rd} \\ -\text{syl} \end{bmatrix}$ *k-deletion*

Finally, the 1s suffix might be /ne/ or it might be /te/. As noted above, we could rule out the possibility /te/ *if* we knew that the 1p suffix is /te/. This means that a choice of /te/ for the 1s entails that the 1p suffix is not /te/, therefore is /re/. If the 1s suffix is /ne/, on the other hand, the 1p could be either /te/ or /re/. If the 1s suffix is /te/, then the following rule is required to derive the variant [ne].

(36) $\begin{bmatrix} +\text{cor} \\ -\text{voice} \end{bmatrix} \rightarrow [+\text{nas}] / [-\text{nas}] \_\_$ *Nasalization*

If the suffix is /ne/ then the following rule derives the variant [te].

(37) [+nas] → [–nas] / [+nas] __ *Denasalization*

Besides three rules which affect the initial consonant of the personal suffixes, a rule deletes root-final glottal stop and nasals. In comparing roots with deleted consonants, we see that both glottal stop and nasals delete in the same context: before the 2s and 1p suffixes (which we have determined are /ka, te/ or /ga, re/).

(38)

1s	*2s*	*3s*	*1p*	
awʔ-ne	aw-ka	awʔ-wa	aw-te	‘skin’
awn-te	aw-ka	awn-kwa	aw-te	‘liver’

What phonological property unifies these two suffixes and distinguishes them from /ne ~ te/ and /kwa ~ wa/? A simple answer would be that these suffixes begin with voiceless stops – if we assume that the suffixes are /ne/ ‘1s’, /ka/ ‘2s’, /wa/ ‘3s’ and /te/ ‘1p’. We will pursue the consequences of that concrete decision about suffixes.

The choice of underlying forms for suffixes entail certain choices for rules: in this analysis, we are committed to Voicing (33), *k*-insertion (34) and Denasalization (37). The rule deleting root-final stops is as follows.

(39) [-cont] → Ø / __ [-voice] *Stop Deletion*

We must determine how these four rules are ordered. Although Voicing affects underlying voiceless stops after voiced oral segments, we see from [awka] 'your skin' from /awʔka/ and [awka] 'your liver' from /awn-ka/ that Voicing precedes Stop Deletion. The structural description of the latter rule is not satisfied in /awnka, awʔka/, hence Voicing does not apply. Subsequently, Stop Deletion applies to eliminate *n* and *ʔ* before a voiceless stop.

(40)	/awʔ-ka/	*underlying*
	NA	*Voicing*
	[awka]	*Stop Deletion*

Stop Deletion obscures the Voicing rule, because it creates surface counterexamples to the prediction of Voicing that [k,t] should not follow a vowel or glide.

The ordering of *k*-insertion is also a matter of concern, since that rule inserts a voiceless stop but Stop Deletion is not triggered by inserted *k*. Underlying /awn-wa/ undergoes *k*-insertion to become [awnkwa], a form which satisfies the structural description of Stop Deletion (which would delete the nasal), yet the nasal is not deleted. This indicates that *k*-insertion follows Stop Deletion – *k* created by the former rule is not present when Stop Deletion applies.

We can also determine that Denasalization follows Stop Deletion, since the former rule creates a sequence of nasal plus stop – /awn-ne/ → [awn-te] 'my liver' – and Stop Deletion applies to a sequence of nasal plus stop – /awn-te/ → [awte] 'our liver' – yet Stop Deletion does not apply to the output of Denasalization. In summary, the rules of Fore which we have proposed, with their ordering, are as follows.

(33) $[+\text{cons}] \rightarrow [+\text{voice}] / \begin{bmatrix} +\text{voice} \\ -\text{nas} \end{bmatrix} \_\_\_$ *Voicing*

(39) [-cont] → Ø / __ [-voice] *Stop Deletion*

(34) $\text{Ø} \rightarrow \begin{bmatrix} +\text{hi} \\ +\text{cons} \\ -\text{voice} \end{bmatrix} / [+\text{nas}] \_\_ \begin{bmatrix} +\text{rd} \\ -\text{syl} \end{bmatrix}$ *k-insertion*

(37) [+nas] → [-nas] / [+nas] __ *Denasalization*

To be sure that our analysis works, derivations of relevant examples are given in (41).

(41) a.	/aw-ne/	/aw-ka/	/aw-wa/	/aw-te/	*underlying*
		awga		awre	*Voicing*
	[awne]	[awga]	[awwa]	[awre]	

b.	/awʔ-ne/	/awʔ-ka/	/awʔ-wa/	/awʔ-te/	*underlying*
	NA	NA	NA	NA	*Voicing*
		awka		awte	*Stop Deletion*
	[awʔne]	[awka]	[awʔwa]	[awte]	
c.	/awn-ne/	/awn-ka/	/awn-wa/	/awn-te/	*underlying*
	NA	NA	NA	NA	*Voicing*
		awka		awte	*Stop Deletion*
			awnkwa		*k-insertion*
	awnte				*Denasalization*
	[awnte]	[awka]	[awnkwa]	[awte]	

7.3.3 Alternative analysis

Now that we have one analysis of the data, we need to consider alternatives, to determine if our analysis is the best one. Our basis for evaluating alternatives will be how they mesh into an integrated system – the individual rules themselves are not significantly different in terms of their simplicity. In constructing an alternative to be compared with our hypothesized account, we must construct the best analysis that we can.

One alternative to consider is that the 3s suffix is underlyingly /kwa/, not /wa/, an assumption which would mean a rule of *k*-deletion rather than insertion. There is a fundamental incompatibility between this proposed underlying form and the theory that there is a stop-voicing rule applying to the affixes /te, ka/, since deletion of root-final stops applies in the latter case (/awn-ka/ → [aw-ka] 'your liver') but not the former (/awn-kwa/ → [awn-kwa] 'his/her liver'). Under the theory that there is a *k*-deletion rule, we must assume the underlying suffixes /ga, re/, meaning that there is a devoicing rule, and Stop Deletion must be suitably reformulated so that only /ga, re/ trigger the rule, and /ne (te), kwa/ do not.

> Yet another possibility which preserves the underlying suffixes /ka, te/ is that *k*-deletion specifically requires a following *w*, therefore /kwa/ becomes [wa] but /ka/ remains unchanged. Such a complication in the *k*-deletion rule is sufficient to cause us to reject that analysis.

The hypothesized consonants that trigger stop-deletion would be /g,r/, which can be distinguished from the consonants that do not trigger the rule in being [+voice,-nasal]. The added complication of specifying that the triggering consonant is [-nasal] is necessary only under the assumption that the 1s suffix /ne/; we can avoid that complication by assuming that the suffix is /te/, in which case the following alternative statement of stop deletion is necessitated by the alternative assumptions about underlying forms (/te, ga, kwa, re/).

(42) [-cont] → Ø / __ [+voice] *Stop Deletion* (alternative version)

Given these alternative underlying forms, the variant [ne] of the 1s suffix found in [aw-ne] ‘my eye’ and [awʔ-ne] ‘my skin’ (but not [awn-te] ‘my liver’) can be accounted for by the following rule nasalization rule.

(43) [-voice] → [+nasal] / [-nasal] __ V *Nasalization*

The reason for specifying that a following vowel is required is so that the suffix /kwa/ does not undergo the rule.

To summarize the alternative analysis, we might instead assume the suffixes /te, ga, kwa, re/, and the following rules.

(40) [-voice] → [+nasal] / [-nasal] __ V *Nasalization*
(32) [+cons] → [-voice] / [-cont] __ *Post-stop devoicing*
(39) [-cont] → Ø / __ [+voice] *Stop deletion*
(35) $\begin{bmatrix} +\text{hi} \\ +\text{cons} \\ -\text{voice} \end{bmatrix} \rightarrow \emptyset \,/\, [-\text{nas}] \_\_ \begin{bmatrix} +\text{rd} \\ -\text{syl} \end{bmatrix}$ *k-deletion*

There is a fatal flaw in the alternative analysis, centering around the interaction of Devoicing and Stop Deletion. The suffixes which condition Stop Deletion are underlyingly [+voice], but that consonant is also subject to Devoicing – by the stop which is deleted. If Stop Devoicing applies first, then /awn-ga/ becomes *awnka*, and Stop Deletion cannot apply since only voiced consonants trigger the rule – *[awnka] rather than [awka] would result. On the other hand if Stop Deletion applies first, then /awn-ga/ does undergo Stop Deletion to become *awga*, but then the consonant needed to trigger Devoicing no longer exists, and *[awga] results. Thus the hypothesized rules cannot be ordered in a manner that gives the correct output, meaning that the rules are wrong. On those grounds, the alternative analysis must be rejected.

7.4 Modern Hebrew

The next case study comes from a set of alternations in the conjugation of verbs in a certain derivational class in Modern Hebrew.

> These data are from a nonstandard dialect that has pharyngeals which were deleted (in the case of ʕ) or changed to x (in the case of *ħ*) in the standard dialect.

7.4.1 The data

The goal of this problem is to determine the underlying representations of the verbal prefix and the stems, as well as whatever rules are needed to account for these phonological alternations. In some cases, a related word is provided in order to clarify aspects of the underlying stem. The data to be accounted for are in (44).

(44)

1sg	*3sg masc*	*3pl*		*Related word*	
itparnasti	itparnes	itparnesu	‘earn’		
itparsamti	itparsem	itparsemu	‘become famous’		
idbalbalti	idbalbel	idbalbelu	‘be confused’		
idgalgalti	idgalgel	idgalgelu	‘revolve’		
itħamakti	itħamek	itħamku	‘turn away’		
itlabaʃti	itlabeʃ	itlapʃu	‘get dressed’		
idbadarti	idbader	idbadru	‘make fun’		
idgaraʃti	idgareʃ	idgarʃu	‘divorce’		
itpalalti	itpalel	itpalelu	‘pray’		
itxamamti	itxamem	itxamemu	‘warm’		
itmotati	itmotet	itmotetu	‘quake’		
itʔoʃaʃti	itʔoʃeʃ	itʔoʃeʃu	‘recover’		
idbodati	idboded	idbodedu	‘seclude oneself’		
istaparti	istaper	istapru	‘get a haircut’	sapar	‘barber’
istarakti	istarek	istarku	‘comb hair’	ma-srek	‘comb’
iʃtaparti	iʃtaper	iʃtapru	‘improve’	ʃipur	‘improvement’
it^{s}talamti	it^{s}talem	it^{s}talmu	‘have photo taken’	t^{s}alem	‘photographer’
izdakanti	izdaken	izdaknu	‘age’	zaken	‘old’
izdarasti	izdarez	izdarzu	‘hurry’	zariz	‘alert’
itamamti	itamem	itamemu	‘feign innocence’	tamim	‘innocent’
idardarti	idarder	idarderu	‘decline’	dirdur	‘rolling’
itpataħti	itpateaħ	itpatħu	‘develop’		
idgalaħti	idgaleaħ	idgalħu	‘shave’		
itnat^{s}aħti	itnat^{s}eaħ	itnat^{s}ħu	‘argue’		
iʃtagati	iʃtagea	iʃtagʕu	‘become mad’		
itparati	itparea	itparʕu	‘cause disorder’		
itmaleti	itmale	itmalʔu	‘become full’		
itpaleti	itpale	itpalʔu	‘become surprised’		

itnaseti itnase itnasʔu ‘feel superior’

7.4.2 Morphological analysis

Each of these verbs verb has a prefix which is either /it/ or /id/, and the prefix transparently surfaces as one of these two variants in most examples. The first-person-singular form is marked with a suffix *-ti*, the third-plural has the suffix *-u,* and the third-plural has no suffix. The vowel in the second stem syllable is underlyingly the same for all verbs: this fact is not entirely obvious from these data but is made obvious by a more extensive analysis of the morphological structure of words in the language. An analysis of the phonological factors surrounding the second vowel in these examples will show that the surface variants can be derived from a single particular underlying vowel. Derivationally related words, such as the root underlying *iʃtaparti* ‘improve’ and *ʃipur* ‘improvement’ have in common a set of consonants, but their vowels differ (vowel changes are a means of indicating derivational relations in Semitic languages, which we will not be concerned with).

7.4.3 Phonological alternations

Voicing assimilation. As for the choice between an underlying voiced or voiceless consonant in the prefix, scanning the data reveals that a voiced consonant appears before voiced obstruents and a voiceless consonant appears before voiceless obstruents and sonorants. Since sonorants are phonetically voiced, it is clear that there is no natural context for deriving the voiceless consonant [t], so we assume that the prefix is underlyingly /it/ and not /id/. Before a voiced obstruent, a voiceless obstruent becomes voiced.

$$(45)\quad [-\text{sonorant}] \rightarrow [+\text{voice}] / - \begin{matrix} \text{C} \\ \begin{bmatrix} -\text{son} \\ +\text{voi} \end{bmatrix} \end{matrix}$$

Alternations in V_2. The second vowel of the stem has three phonetic variants: [a] as in *itparnasti*, [e] as in *itparnes,* and Ø as in *idbadru* (cf. *idbader*). Deletion of the second stem vowel only takes place before the suffix *-u,* so we will first attempt to decide when the vowel is deleted. A partial specification of the context for vowel deletion is before C+V, which explains why the first- and third-singular masculine forms (with the suffixes *-ti* and -Ø do not undergo vowel deletion. The next step in determining when a vowel is deleted is to sort the examples into two groups: those with vowel deletion before *-u*, and those with no vowel deletion. In the following examples, the site of vowel deletion (or its lack) is marked with an underscore.

(46) *Vowel deletion*

itħam_ku	itlap_ʃu	idbad_ru
idgar_ʃu	istap_ru	istar_ku
iʃtap_ru	it^{s}tal_mu	izdak_nu
izdar_zu	itmal_ʔu	itpal_ʔu

itnas_ʔu	itpat_ħu	idgal_ħu
itnat^{s}_ħu	iʃtag_ʕu	itpar_ʕu
No vowel deletion		
itparn̲esu	itpars̲emu	idbalb̲elu
idgalg̲elu	idard̲eru	itpal̲elu
itxam̲emu	itmot̲etu	itʔoʃ̲eʃu
idbod̲edu	itam̲emu	

Based on this grouping, we discover that a vowel is deleted when it is preceded by just a single consonant; if two consonants precede the vowel, there is no deletion.

However, it is not always the case that a vowel deletes after a single consonant, so our rule cannot simply look for one versus two consonants. There are cases such as *itʔoʃeʃu* where there is no vowel deletion, despite the fact that there is only a single consonant before the vowel. Inspecting all of those examples, we discover that the consonants preceding and following the vowel are the same, and in every case where a vowel is deleted, the preceding and following consonants are different. Thus, a vowel deletes only if it is preceded by a single consonant, and that consonant must be different from the consonant which follows the vowel (indicated informally as "C_i . . . C_j," in the rule).

(47) e → Ø / V C_i _ C_j V

How would one state the generalization "the preceding and following consonants are not the same" in the formalism given in Chapter 4?

At this point, we now clearly recognize this process as a kind of syncope, a phonological rule which we have encountered many times before.

Closed syllable lowering. Now we turn to the alternation between [a] and [e]. Concentrating on the first set of examples in the dataset, we find [a] before CC (*itparnasti*), and [e] before C# or CV (*itparnes, itparnesu*). Assuming that this distribution is generally valid, we would therefore posit the following rule to derive [a] from /e/.

(48) e → a / _ CC

An attempt to derive [e] from underlying /a/ runs into the difficulty that the context "when followed by C# or CV" is not a coherent context, but is just a set of two partially related contexts. This motivates the decision to select underlying /e/.

In four examples, the second stem vowel /e/ appears as [a] before a single consonant, namely the first-person-singular forms *itmotati, idbodati, iʃtagati* and *itparati.* These examples fall into two distinct subgroups, as shown by looking at their underlying stems, which is revealed in the third-plural forms (*itmotet-u, idboded-u* and *iʃtagʕ-u, itparʕ-u*). In the first two examples the stems underlyingly end in a coronal stop *t* or *d*, and in the

second two examples the stems underlyingly end in the voiced pharyngeal ʕ. At the underlying level, the second stem vowel is followed by two consonants (/itmotetti/, /itbodedti/, /iʃtageʕti/ and /itpareʕti/). Surface [a] is explained on the basis of the underlying consonant cluster – it must simply be assured that the rules simplifying these clusters apply after (48).

In the first two examples (*itmotati* and *idbodati* from /itmotat-ti/ and /idbodad-ti/) combination of the suffix *-ti* with the root would (after assimilation of voicing) be expected to result in **itmotatti* and **idbodatti.* In fact, the data provide no examples of geminate consonants, and where geminates might have been created by vowel syncope in *idbodedu,* syncope is blocked. Thus, the language seems to be pursuing a strategy of avoiding the creation of geminate consonants. We can account for this simplification of consonant clusters by the following rule.

(49) $C_iC_i \rightarrow C_i$

This rule also explains *itamem* and *idarder,* where the stem begins with /t/ or /d/. The underlying forms would be /it-tamem/ and /it-darder/: the surface form with a single consonant reflects the application of this consonant-degemination process.

Stems with final pharyngeals and laryngeals. The vowel quality of /ʃageʕ/ and /pareʕ/ will be left aside temporarily. We thus turn to the stems represented in *itpataħti, idgalaħti* and *itnatˢaħti*. What is problematic about these stems is the appearance of [ea] when no suffix is added, viz. *itpateaħ, idgaleaħ* and *itnatˢaħ*. Assuming the underlying forms to be *itpataħ, idgalaħ* and *itnatˢeħ* (selecting /e/ as the second vowel, analogous to *itparnes, itlabeʃ* and *idboded*) we would need a rule inserting the vowel [a]. These stems have in common that their final consonant is the pharyngeal [ħ], suggesting a rule along the following lines.

(50) Ø → a / e _ ħ

Why does this rule only apply in the suffixless third-singular masculine form? When the stem is followed by *-u* (/itpateħu/ → [itpatħu]) the vowel /e/ is deleted by the syncope rule, so there is no vowel before *ħ*. Syncope does not apply before the suffix *-ti* in /itpateħti/ → [itpataħti] but there is still no epenthetic vowel. The reason is that underlying /e/ changes to [a] by rule (48), before a cluster of consonants. Since that rule changes /e/ to a but (50) applies after *e,* prior application of (50) deprives vowel insertion of a chance to apply.

Now returning to the stems *ʃageʕ* and *pareʕ,* we can see that this same process of vowel insertion applies in these stems in the second-singular masculine. Starting from /iʃageʕ/ and /itpareʕ/, vowel epenthesis obviously applies to give intermediate *iʃtageaʕ* and *itpareaʕ*. This argues that the epenthesis rule should be generalized so that both of the pharyngeal consonants trigger the process.

(51) $\varnothing \rightarrow \underset{[+low]}{V} / e \_ \underset{[+low]}{C}$

The forms derived by (51) are close to the actual forms, which lack the consonant ʕ, and with an appropriate consonant deletion rule we can finish the derivation of these forms. To formalize this rule, we need to determine where the consonant ʕ appears in the language: our data indicate that it appears only before a vowel, never before a consonant or at the end of a word (which is to say it never appears at the end of a syllable). Knowing this generalization, we posit the following rule.

(52) ʕ→ Ø/_ {C,#} (=) ʕ→ Ø/_.

No further rules are needed to account for this set of examples. In *iʃtagati* and *itparati,* from *iʃtageʕti* and *itpareʕti,* there is no epenthetic vowel. This is predicted by our analysis, since these verbs must undergo the rule lowering /e/ to [a] before CC, and, as we have just argued, vowel lowering precedes vowel epenthesis (thus preventing epenthesis from applying). In this respect, *iʃtagati* and *itparati* are parallel to *itpateah, idgaleaħ,* and *itnatˢeaħ.* The nonparallelism derives from the fact that syllable-final ʕ is deleted, so predicted **iʃtagaʕti* and **itparaʕti* are realized as *iʃtagati* and *itparati* thanks to this deletion.

The final set of verb stems typified by the verb *itmaleti ~ itmale ~ itmalʔu* exhibit a glottal stop in some contexts and Ø in other contexts. The two most obvious hypotheses regarding underlying form are that the stem is /male/, or else /maleʔ/. It is difficult to decide between these possibilities, so we will explore both. Suppose, first, that these stems end in glottal stop. In that case, we need a rule deleting glottal stop syllable-finally – a similar rule was required to delete the consonant ʔ. A crucial difference between stems ending in ʕ and stems presumably ending in ʔ is that the stem vowel /e/ does not lower to [a] before *-ti* in the latter set. Thus, deletion of ʔ would have to be governed by a different rule than deletion of ʕ, since ʔ-deletion precedes lowering and ʕ-deletion follows lowering.

An alternative possibility that we want to consider is that these stems really end in a vowel, not a glottal stop. Assuming this, surface [itpaleti] would simply reflect concatenation of the stem /pale/ with the suffix, and no phonological rule would apply. The problem is that we would also need to explain why the rule of syncope does not apply to [itpaleti], since the phonetic context for that rule is found here. The glottal-final hypothesis can explain failure of syncope rather easily, by ordering glottal stop deletion after syncope – when syncope applies, the form is /itpaleʔti/, where the consonant cluster blocks syncope.

Metathesis. The last point regarding the Hebrew data is the position of *t* in the prefix. The consonant of the prefix actually appears after the first consonant of the stem in the following examples.

(53) istaparti	‘get a haircut’	istarakti	‘comb hair’
iʃtaparti	‘improve’	itˢtalamti	‘have photo taken’
izdakanti	‘age’	izdarasti	‘hurry’

We would have expected forms such as [itsaparti], [itʃaparti], [ittˢalamti] by just prefixing *it-* to the stem. A metathesis rule is therefore needed which moves *t* after the stem-initial

consonant. What makes this group of consonants – [s, ʃ, t^{s}, z] – a natural class is that they are all and the only strident coronals. We can thus formalize this rule as follows: a coronal stop followed by a coronal strident switch order.

(54) $\begin{bmatrix}+\text{cor}\\-\text{cont}\end{bmatrix}\begin{bmatrix}+\text{cor}\\+\text{strid}\end{bmatrix}\rightarrow\begin{bmatrix}+\text{cor}\\+\text{strid}\end{bmatrix}\begin{bmatrix}+\text{cor}\\-\text{cont}\end{bmatrix}$

The ordering of this metathesis rule with respect to the voicing assimilation rule is crucial. Given underlying /it-zakanti/, you might attempt to apply metathesis first, which would yield *iztakanti,* where voiceless *t* is placed after stem-initial *z.* The voicing assimilation rule (in a general form, applying between all obstruents) might apply to yield **istakanti.* So if metathesis applies before voicing assimilation, we will derive an incorrect result, either **iztakanti* if there is no voicing assimilation (assuming that the rule only turns voiceless consonants into voiced ones) or **istakanti* if there is voicing assimilation. However, we will derive the correct output if we apply voicing assimilation first: /itzakanti/ becomes *idzakanti,* which surfaces as [izdakanti] by metathesis. With this ordering, we have completed our analysis of Modern Hebrew phonology.

7.5 Japanese

The analysis of phonological alternations found in connection with the conjugation of verbs in Japanese provides our final illustration of the kinds of issues that must be considered in coming up with appropriate rules and underlying representations. In solving this problem, it is particularly important to make the correct assumptions about underlying representations, since the selection of underlying forms goes hand in hand with stating the rules correctly.

7.5.1 The data

The relevant data are given in (55).

(55) *Present*	*Negative*	*Volitional*	*Past*	*Inchoative*	
neru	nenai	netai	neta	nejo:	‘sleep’
miru	minai	mitai	mita	mijo:	‘see’
ʃinu	ʃinanai	ʃinitai	ʃinda	ʃino:	‘die’
jomu	jomanai	jomitai	jonda	jomo:	‘read’
jobu	jobanai	jobitai	jonda	jobo:	‘call’
kat^{s}u	katanai	kat^{ʃ}itai	katta	kato:	‘win’
kasu	kasanai	kaʃitai	kaʃita	kaso:	‘lend’
waku	wakanai	wakitai	waita	wako:	‘boil’
t^{s}ugu	t^{s}uganai	t^{s}ugitai	t^{s}uida	t^{s}ugo:	‘pour’
karu	karanai	karitai	katta	karo:	‘shear’
kau	kawanai	kaitai	katta	kao:	buy’

7.5.2 Morphological analysis

We could make an initial guess regarding suffixes, which leads to the following hypotheses: *-u* "present," *-nai* "negative," *-tai* "volitional," *-ta* "past" and *-jo:* "inchoative": that analysis seems reasonable given the first two verbs in the data. We might also surmise that the root is whatever the present-tense form is without the present ending, i.e. underlying *ner, mir, ʃin, jom, job, kat^s, kas, wak, t^{s}ug, kar* and *ka.* In lieu of the application of a phonological rule, the surface form of a word should simply be whatever we hypothesize the underlying form of the root to be, plus the underlying form of added affixes. Therefore, given our preliminary theory of roots and suffixes in Japanese, we predict the following surface forms, with hyphens inserted between morphemes to make the division of words into roots and suffixes clear: it is important to understand the literal predictions of your analysis, and to compare them with the observed facts.

(56) *Predicted surface forms*

Present	*Negative*	*Volitional*	*Past*	*Inchoative*
ner-u	ner-nai	ner-tai	ner-ta	ner-jo:
mir-u	mir-nai	mir-tai	mir-ta	mir-jo:
ʃin-u	ʃin-nai	ʃin-tai	ʃin-ta	ʃin-jo:
jom-u	jom-nai	jom-tai	jom-ta	jom-jo:
job-u	job-nai	job-tai	job-ta	job-jo:
kat^s-u	kat^s-nai	kat^s-tai	kat^s-ta	kat^s-jo:
kas-u	kas-nai	kas-tai	kas-ta	kas-jo:
wak-u	wak-nai	wak-tai	wak-ta	wak-jo:
t^{s}ug-u	t^{s}ug-nai	t^{s}ug-tai	t^{s}ug-ta	t^{s}ug-jo:
kar-u	kar-nai	kar-tai	kar-ta	kar-jo:
ka-u	ka-nai	ka-tai	ka-ta	ka-jo:

The forms which are correct as is are underlined: as we can see, all of the present-tense forms are correct, and none of the others is. It is no surprise that the present-tense forms would be correct, since we decided that the underlying form of the root is whatever we find in the present tense minus the vowel *-u.* It is possible, but unlikely, that every other word undergoes some phonological rule.

Changing our hypothesis. Since our first guess about underlying forms is highly suspect, we should consider alternative hypotheses. Quite often, the cause of analytic problems is incorrect underlying forms. One place to consider revising the assumptions about underlying representations would be those of the affixes. It was assumed – largely on the basis of the first two forms *nenai* and *minai* – that the negative suffix is underlyingly *-nai.* However, in most of the examples, this apparent suffix is preceded by the vowel *a (ʃinanai, jomanai, jobanai* and so on), which suggests the alternative possibility that the negative suffix is really *-anai.* Similarly, the decision that the volitional suffix is underlyingly *-tai* was justified based on the fact that it appears as *-tai*

in the first two examples; however, the suffix is otherwise always preceded by the vowel *i* (*ʃinitai, jomitai, jobitai,* and so on), so this vowel might analogously be part of the suffix.

One fact strongly suggests that the initial hypothesis about the underlying forms of suffixes was incorrect. The past-tense suffix, which we also assumed to be *-ta*, behaves very differently from the volitional suffix, and thus we have *ʃinitai* versus *ʃinda, jomitai* versus *jonda, katʃitai* versus *katta*, *karitai* versus *katta* (there *are* similarities such as *kaʃitai* and *kaʃita* which must also be accounted for). It is quite unlikely that we can account for these very different phonological patterns by reasonable phonological rules if we assume that the volitional and past-tense suffixes differ solely by the presence of final *i*.

It is this realization, that there is a thorough divergence between the past-tense and volitional suffixes in terms of how they act phonologically, that provides the key to identifying the right underlying forms. Given how similar these two suffixes are in surface forms, *-(i)tai* vs. *-(i)ta*, but how differently they behave phonologically, they must have quite different underlying forms. Since the past-tense suffix rarely has a vowel and the volitional suffix usually does, we modify our hypothesis so that the volitional is /-itai/ and the past tense is /ta/. Because the negative acts very muct like the volitional in terms of where it has a vowel, we also adopt the alternative that the negative is /anai/.

These changed assumptions about underlying representations of suffixes yield a significant improvement in the accuracy of our predicted surface forms, as indicated in (57), with correct surface forms underlined.

(57) *Modified predicted surface forms*

Present	*Negative*	*Volitional*	*Past*	*Inchoative*
ner-u	ner-anai	ner-itai	ner-ta	ner-jo:
mir-u	mir-anai	mir-itai	mir-ta	mir-jo:
ʃin-u	ʃin-anai	ʃin-itai	ʃin-ta	ʃin-jo:
jom-u	jom-anai	jom-itai	jom-ta	jom-jo:
job-u	job-anai	job-itai	job-ta	job-jo:
kat^{s}-u	kat^{s}-anai	kat^{s}-itai	kat^{s}-ta	kat^{s}-jo:
kas-u	kas-anai	kas-itai	kas-ta	kas-jo:
wak-u	wak-anai	wak-itai	wak-ta	wak-jo:
t^{s}ug-u	t^{s}ug-anai	t^{s}ug-itai	t^{s}ug-ta	t^{s}ug-jo:
kar-u	kar-anai	kar-itai	kar-ta	kar-jo:
ka-u	ka-anai	ka-itai	ka-ta	ka-jo:

Implicitly, we know that forms such as predicted *[kat^{s}anai] (for [katanai]) and *[kas-itai] (for [kaʃitai]) must be explained, either with other changes in underlying forms, or by hypothesizing rules.

We will consider one further significant modification of the underlying representations, inspired by the success that resulted from changing our assumptions about *-itai* and *-anai,* in reducing the degree to which underlying and surface forms differ. The original and dubious decision to treat these suffixes as *tai* and *nai* was influenced by the fact that that is how they appear with the first two verbs. It is also possible that our initial hypothesis about the underlying form of these two verb roots was incorrect. There is good reason to believe that those assumptions were indeed also incorrect. Compare the surface form of the three verbs in our dataset which, by hypothesis, have roots ending in *r*.

(58)

Present	*Negative*	*Volitional*	*Past*	*Inchoative*	
ner-u	ne-nai	ne-tai	ne-ta	ne-jo:	'sleep'
mir-u	mi-nai	mi-tai	mi-ta	mi-jo:	'see'
kar-u	kar-anai	kar-itai	katt-a	kar-o:	'shear'

Clearly, the supposed roots /ner/ and /mir/ act quite differently from /kar/. The consonant *r* surfaces in most of the surface forms of the verb meaning 'shear,' whereas *r* only appears in verbs 'sleep' and 'see' in the present tense. In other words, there is little reason to believe that the first two roots are really /ner/ and /mir/, rather than /ne/ and /mi/: in contrast, there seems to be a much stronger basis for saying that the word for 'shear' is underlyingly /kar/. Now suppose we change our assumption about these two verbs, and assume that /ne/ and /mi/ end in vowels.

(59) *Modified predicted surface forms*

Present	*Negative*	*Volitional*	*Past*	*Inchoative*
ne-u	ne-anai	ne-itai	ne-ta	ne-jo:
mi-u	mi-anai	mi-itai	mi-ta	mi-jo:
ʃin-u	ʃin-anai	ʃin-itai	ʃin-ta	ʃin-jo:
jom-u	jom-anai	jom-itai	jom-ta	jom-jo:
job-u	job-anai	job-itai	job-ta	job-jo:
kat^{s}-u	kat^{s}-anai	kat^{s}-itai	kat^{s}-ta	kat^{s}-jo:
kas-u	kas-anai	kas-itai	kas-ta	kas-jo:
wak-u	wak-anai	wak-itai	wak-ta	wak-jo:
t^{s}ug-u	t^{s}ug-anai	t^{s}ug-itai	t^{s}ug-ta	t^{s}ug-jo:
kar-u	kar-anai	kar-itai	kar-ta	kar-jo:
ka-u	ka-anai	ka-itai	ka-ta	ka-jo:

In terms of being able to predict the surface forms of verbs without phonological rules, this has resulted in a slight improvement of predictive power (sometimes involving a shuffling of correct and incorrect columns, where under the current hypothesis we no longer directly predict the form of the present tense, but we now can generate the past and inchoative forms without requiring any further rules). More important is the fact that we now have a principled basis, in terms of different types of underlying forms, for predicting the different behavior of the verbs which have the present tense *neru, miru*

versus *karu,* which are in the first two cases actually vowel-final roots, in contrast to a consonant-final root.

7.5.3 Phonological rules

Since we have made reasonable progress in solving the problem of underlying forms, we will attempt to discover phonological rules which explain remaining differences between underlying and surface forms – though it always remains possible that we will need to change our assumed underlying forms, as our analysis progresses. The approach to take is to look at forms which are still not completely explained, and construct hypotheses to account for these forms: what new rules are needed to get from the underlying to surface forms. One useful way to approach this is to look for columns or rows of data where similar things seem to be happening. The incorrectly predicted forms are re-listed below, this time excluding the forms which are already explained, with information about the nature of the problem added. If a segment is predicted but does not actually surface, that segment is placed in parentheses; if there is a segment which appears in the surface form but which does not appear to be present in the underlying form, the segment is placed in square brackets; segments whose phonetic quality differs from the predicted quality are italicized.

(60) *Present*	*Negative*	*Volitional*	*Past*	*Inchoative*	
ne[r]u	ne(a)nai	ne(i)tai			‘sleep’
mi[r]u	mi(a)nai	mi(i)tai			‘see’
			ʃin*t*a	ʃin(j)o:	‘die’
			jo*mt*a	jom(j)o:	‘read’
			jo*bt*a	job(j)o:	‘call’
	ka*t*^{s}anai		ka*t*^{s}ta	ka*t*^{s}(j)o:	‘win’
		kasitai	kas[i]ta	kas(j)o:	‘lend’
			wa*k*ta	wak(j)o:	‘boil’
			t^{s}ug*t*a	t^{s}ug(j)o:	‘pour’
			karta	kar(j)o:	‘shear’
	ka(w)anai		ka[t]ta	ka(j)o:	‘buy’

The glide in the inchoative. In order to explain most of the problems which arise with the inchoative form, we will consider the possibility that there is a rule deleting consonants after consonants, since that is the nature of the problem with the inchoative column. Such a consonant deletion cannot be totally general, i.e. deleting any consonant after any other consonant, since, as is evident in the past tense column, the consonant clusters [tt] and [nd] are possible in the language. Nevertheless, these two clusters are a rather restricted subset of the imaginable two-consonant combinations which can be formed from the consonants of the language, and this is a good indication that there may be some process deleting a consonant after another consonant. Thus we might assume a rule deleting the glide *j* after a consonant.

$$(61)\quad \begin{bmatrix} -\text{cons} \\ -\text{back} \end{bmatrix} \rightarrow \varnothing \,/\, \text{C\_}$$

The postulation of any such rule immediately makes a prediction about possible surface forms: there should be no sequences of consonant plus glide in the data. Since there are none in the data at hand, our hypothesis has passed an important test. Armed with this rule, we have accounted for a very large chunk of otherwise problematic examples in (60) – all of the inchoative forms except for *kao:* 'buy,' where the glide deletes but there seems to be no consonant which would condition deletion of the glide.

> If you know Japanese, you may know of words with j after a consonant, e.g. [To:kjo:], which contradict the proposed rule. We restrict ourselves to the specific dataset given here, but a restriction on the rule that the deleted consonant must be suffix-initial solves this problem.

Vowel deletion. Another area where some success is possible in reconciling underlying and surface forms by focusing on possible segment sequences is with the verbs 'sleep' and 'see.' The difference between the predicted (**neanai, *mianai; *neitai, *miitai*) and actual forms (*nenai, minai; netai, mitai*) of the negative and volitional forms is that the actual forms lack the suffix vowel. In the predicted forms, we find a sequence of vowels, whereas in the actual form, only the first of those vowels is found. This raises the question whether we might postulate a rule deleting a vowel after another vowel. In positing such a rule, we want to consider what V-V sequences are found in the data. The sequence [ai] exists in the volitional and negative suffixes, and in past tense watta; also [ui] in the past of the word for 'pour'; also the sequences [ao:] and [au] in the verb 'buy.' We do not find sequences of vowels with the front vowels [e] or [i] plus a vowel ([ia], [ii], [ea] and [ei]). Therefore, we posit the following rule of vowel deletion.

$$(62)\quad \text{V} \rightarrow \varnothing \,/ \begin{bmatrix} +\text{syl} \\ -\text{back} \end{bmatrix} —$$

This resolves many problematic forms of the word for 'sleep' and 'die', such as the change /ne-itai/ → [netai], but there are still examples that we cannot explain. In the present tense, we find [neru] and [miru], which we presume derive from /ne-u/ and /mi-u/. The vowel deletion rule (62) should apply to these underlying forms, resulting in incorrect *[ne] and *[mi]. We might try to resolve this by assuming that the vowel [u] cannot be deleted by (62) – we would then need to restrict the rule to exclude round vowels from deletion. Alternatively, /u/ fails to be deleted in /ne-u/, perhaps a consonant is inserted thereby eliminating the cluster of vowels.

> We will consider another possibility later, that the present suffix is /ru/, so rather than inserting it in neru, we delete it in [jomu].

$$(63)\quad \varnothing \rightarrow \text{r} \,/ \begin{bmatrix} +\text{syl} \\ -\text{back} \end{bmatrix} \_\_\, \text{V}$$

Armed with these new rules, we will have actually accounted for all forms of the verbs 'sleep' and 'see.'

Nasal + consonant. The remaining problems have been reduced to a very small set. A comparison of presumed underlying and surface past forms is given below.

(64) /ʃinta/	[ʃinda]	/jomta/	[jonda]
/jobta/	[jonda]	/kat^{s}ta/	[katta]
/kasta/	[kaʃita]	/wakta/	[waita]
/t^{s}ugta/	[t^{s}uida]	/karta/	[katta]
/kata/	[katta]		

The problem posed by the past-tense form is that by combining the root with the suffix -*ta,* underlying clusters of consonants would be created, but there are very severe restrictions on what consonant clusters exist in Japanese. The simplest problem is that presented by [ʃinda] from /sinta/, where /t/ becomes voiced after a nasal. A process of postnasal voicing is rather common in the languages of the world, so we may hypothesize that there is such a process in Japanese.

(65) C → [+voice] / [+nasal] _

The data further suggest that the rule applies in other examples, since we see that in the past tense [jonda] of the roots /jom/ and /job/, the final consonant of the root is a nasal on the surface, and /t/ becomes voiced.

We account for the stems /job/ and /jom/ by noting that the final consonant in these roots becomes [n], which is part of the change from the nonexistent sequences /mt/ and /bt/ to the actually occurring [nd]. Thus, these consonants become [n] before /t/ (and subsequently, /t/ voices after the derived [n]).

$$(66)\quad [-\text{coronal}] \rightarrow \begin{bmatrix} +\text{coronal} \\ +\text{nasal} \end{bmatrix} / \_\_\, \text{C}$$

Although the data only illustrate nasalization before /t/, (66) is stated as generally as possible, predicting that /k/ or /d/ would nasalize as well.

Watching for contexts where a phenomenon seems to be relevant to more than one form, we also notice that the surface forms [waita] and [tsuida] differ from their underlying forms /wakta/ and /t^{s}ugta/ by replacing the preconsonantal velar with the vowel [i], suggesting a vocalization rule such as the following.

$$(67)\quad \begin{matrix} \text{C} & & \text{V} \\ [+\text{high}] & \rightarrow & [-\text{back}] / \_\, \text{C} \end{matrix}$$

This rule accounts for [waita], and almost accounts for [t^{s}uida]: but we still need to explain why the suffix consonant is voiced. The underlying representation itself provides a reason for this voicing, since, underlyingly, /t/ is preceded by a voiced consonant in /t^{s}ugta/. We know that /t/ voices in another context, after a nasal, so we could account for

voicing in [t^{s}uida] by restating the rule so that it applies not just after nasals (which are voiced), but after all voiced consonants. By applying the voicing rule which is sensitive to underlying consonant voicing before the velarvocalization rule, we can explain the opaque surface difference, [waita] versus [t^{s}uida], as deriving from the voicing of the consonant which precedes it underlyingly. We also want to be sure to apply rule (67) before rule (66), given the way we have formulated these rules. We did not explicitly restrict (66), which changes noncoronals to [n] before a consonant, to applying only to labials. Therefore, the more specific rule (67) must apply first, otherwise velars would also be incorrectly turned into [n] before a consonant.

7.5.4 Taking stock

We should review the analysis to be sure there are no loose ends. We have six rules – j-deletion, vowel deletion, *r*-insertion, consonant voicing, velar vocalization, and labial nasalization – which, given our assumptions regarding roots and suffixes, account for most of the forms in the dataset. It is important to recheck the full dataset against our rules, to be certain that our analysis does handle all of the data. A few forms remain which we cannot fully explain.

The forms which we have not yet explained are the following. First, we have not explained the variation in the root-final consonant seen in the verb meaning 'win' (*kat^{s}-u, kat-anai-anai, kat^{ʃ}-itai, kat-ta, kat-o:*). Second, we have not accounted for the variation between *s* and *ʃ* in the verb 'shear,' nor have we explained the presence of the vowel [i] in the past tense of this verb. Finally, in the verb 'buy' we have not explained the presence of [w] in the negative, the appearance of a second [t] in the past-tense form, and we have not explained why in the inchoative form [kao:] the suffix consonant *j* deletes.

Correcting the final consonant. The first problem to tackle is the variation in the final consonant of the verb 'win'. Looking at the correlation between the phonetic realization of the consonant and the following segment, we see that [t^{s}] appears before [u], [t^{ʃ}] appears before [i], and [t] appears elsewhere. It was a mistake to assume that the underlying form of this root contains the consonant /t^{s}/; instead, we will assume that the underlying consonant is /t/ (so nothing more needs to be said about the surface forms *kat-anai, kat-ta,* and *kat-o:*). Looking more generally at the distribution of [t^{ʃ}] and [t^{s}] in the data, [t^{ʃ}] only appears before [i], and [t^{s}] only appears before [u], allowing us to posit the following rules.

(68) t → [+del.rel]/ _ u

(69) t → [+del.rel,-ant] / __ i

Moving to the word for 'lend', we find a related problem that /s/ appears as [ʃ] before [i]. This is reminiscent of the process which we assumed turning *t* into *t^{ʃ}* before *i*. In fact, we can decompose the process *t* → *t^{ʃ}* into two more basic steps: /t/ becomes an affricate before [i], and *s* and *t^{s}* become alveopalatal [ʃ] and [t^{ʃ}] before the vowel [i].

***i*-epenthesis.** All that remains to be explained about the word for 'lend' is why [i] appears in the past tense, i.e. why does /kasta/ become *kasita* (whence [kaʃita])? This is simple:

we see that [st] does not exist in the language, and no assimilations turn it into an existing cluster, so [i] is inserted to separate these two consonants.

(70) $$\emptyset \rightarrow \begin{bmatrix} +\text{syl} \\ +\text{hi} \\ -\text{back} \end{bmatrix} / \begin{bmatrix} +\text{cont} \\ -\text{son} \end{bmatrix} \_\_ \begin{bmatrix} +\text{cor} \\ -\text{cont} \end{bmatrix}$$

***r*-assimilation and final *w*.** Turning now to the form [katta] 'shear (past)' from /kar-ta/, a simple assimilation is needed to explain this form:

(71) $r \rightarrow C_i / \_ C_i$

The last remaining problems are in the verb 'buy,' where we must explain the extra [t] in [katta], the presence of [w] in [kawanai], and the loss of /j/ in the inchoative form [kao:]. We might explain the form [kawanai] by a rule of *w*-insertion inserting *w* between two occurrences of the vowel [a]; more puzzling is the form [katta], which we presume derives from /ka-ta/. It would be very unusual for a consonant to spontaneously double between vowels. Since there are so many problems associated with this one root, perhaps the problem lies in our assumptions about the underlying form of this root. Perhaps the *w* in [kawanai] is part of the root itself. What would be the benefit of assuming that this root is really /kaw/? First, it explains the presence of *w* in [kawanai]. Second, it provides a basis for the extra [t] in [katta]: /w/ assimilates to following [t]. Such an assimilation is implicit in our analysis, namely rule (71) assimilating /r/ to /t/. We can generalize this rule to applying to both /r/ and /w/, which are oral sonorants. Finally, positing underlying /kaw/ helps to resolve the mystery of why /j/ deletes in the inchoative form [kao:], when otherwise /j/ only deletes when it is preceded by a consonant. If we start with /ka-jo:/ there is no reason for /j/ to delete, but if we start with /kaw-jo:/, /j/ is underlyingly preceded by a consonant /w/, which causes deletion of *j*, and then /w/ itself is deleted.

The cost of this analysis – a small cost – is that we must explain why [w] does not appear more widely in the root, specifically, why do we not find surface [w] in *ka-u, ka-itai* and *ka-o:*. The answer lies in the context where [w] appears: [w] only appears before a low vowel, suggesting the following rule.

(72) $$w \rightarrow \emptyset / \_\_ \begin{bmatrix} +\text{syl} \\ -\text{low} \end{bmatrix}$$

At this point, we have a complete analysis of the data. The rules (partially in shorthand versions) and underlying forms are recapitulated below.

(73) *Roots*: /ne/ 'sleep,' /mi/ 'see,' /ʃin/ 'die,' /jom/ 'read,' /job/ 'call,' /kat/ 'win,' /kas/ 'lend,' /wak/ 'boil,' /t^{s}ug/ 'pour,' /kar/ 'shear,' /kaw/ 'buy'

Suffixes: -u 'present,' *-anai* 'negative,' *-itai* 'volitional,' *-ta* 'past,' *-jo*: 'inchoative'

Rules:

$j \rightarrow \emptyset / C \_$

$\emptyset \rightarrow r / e, i \_ V$ $\qquad$ $V \rightarrow \emptyset / [+syl,–round] \_\_$

b, m → n / _t	k, g → i/ _t
t → t^s / _u, i	t^s, s → $t^ʃ$, ʃ / _i
Ø → i / s _t	r, w → t / _t
w → Ø / _[+syl,–lo]	t → d / [–syl,+voi] _

Progress by hypothesis forming and testing. Three important points have emerged as our analysis developed. First, analysis proceeds step-by-step, by forming specific hypotheses which we then check against the data, revising those hypotheses should they prove to be wrong. Second, it is vital to consider more than one hypothesis: if we had only pursued the first hypothesis that the roots /ne/, /mi/, /kar/ and /kaw/ were really underlying /ner/, /mir/, /kar/ and /ka/, we would never have been able to make sense of the data. The most important skill that you can bring to the task of problem-solving is the ability to create and evaluate competing hypotheses intended to explain some fact. Finally, it is particularly important to remember that assumptions about underlying representations go hand-in-hand with the phonological rules which you postulate for a language. When you check your solution, the problem may not be that your rules are wrong, but that your underlying forms are wrong. By continuously reviewing the analysis, and making sure that the rules work and your assumptions about underlying forms are consistent, you should arrive at the stage that no further improvements to the analysis are possible, given the data available to you.

It might occur to you that there are aspects of the underlying representation which could still be questioned. Consider the present-tense form, which we assumed was /u/. An alternative may be considered: the suffix might be /ru/. The presence of underlying /r/ in this suffix is made plausible by the fact that *r* actually appears in the forms *miru, neru.* We assumed that *r* is epenthetic, but perhaps it is part of the present suffix. That would allow us to eliminate the rule of *r*-epenthesis which is needed only to account for [neru] and [miru]. At the same time, we can also simplify the rule of vowel deletion, by removing the restriction that only nonround vowels delete after [e] and [i]: we made that assumption only because /ne-u/ and /mi-u/ apparently did not undergo the process of vowel deletion.

Any change in assumed underlying forms requires a reconsideration of those parts of the analysis relevant to that morpheme. We would then assume the underlying forms /ʃin-ru/, /jom-ru/, /kat-ru/, and so on, with the root-final consonant being followed by /r/. This /r/ must be deleted: but notice that we already have a rule which, stated in a more general form, would delete this /r/, namely the rule deleting /j/ after a consonant.

(74) [+sonor] → Ø / C _

If we generalize that rule to apply to any sonorant consonant after a consonant, we eliminate the rule of *r*-insertion, and generalize the rules *j*-deletion and vowel deletion, which results in a better analysis.

Summary

Analyzing a complex set of data into a consistent system of underlying representations and rules requires you to pay attention to details. A solution to a problem requires that

you formulate reasoned hypotheses and test them against the data. The most important skill needed to test a hypothesis is that you must apply your rules completely literally. Do what the rule says must be done, and if that does not give you the correct result, you must change your underlying representations, rules, or rule ordering. The ability to conceive of and evaluate multiple hypotheses is one of the most important skills in problem solving.

Exercises

1 Serbo-Croatian

These data from Serbo-Croatian have been simplified in two ways, to make the problem more manageable. Vowel length is omitted, and some accents or stresses are omitted. The language has both underlying stresses whose position cannot be predicted – these are not marked in the transcriptions – and a predictable "mobile" stress which is assigned by rule – these are the stresses indicated here. Your analysis should account for how stress is assigned in those words marked with a rule-governed stress: you should not try to write a rule that predicts *whether* a word has a stress assigned by rule versus an underlying stress. Ignore the stress of words with no stress mark (other parts of the phonology of such words must be accounted for). Past-tense verbs all have the same general past-tense suffix, and the difference between masculine, feminine and neuter past-tense involves the same suffixes as are used to mark gender in adjectives.

Adjectives

Masc	*Fem*	*Neut*	*Pl*	
mlád	mladá	mladó	mladí	'young'
túp	tupá	tupó	tupí	'blunt'
blág	blagá	blagó	blagí	'mild'
grúb	grubá	grubó	grubí	'coarse'
béo	belá	beló	belí	'white'
veseo	vesela	veselo	veseli	'gay'
debéo	debelá	debeló	debelí	'fat'
mío	milá	miló	milí	'dear'
zelén	zelená	zelenó	zelení	'green'
kradén	kradená	kradenó	kradení	'stolen'
dalék	daleká	dalekó	dalekí	'far'
visók	visoká	visokó	visokí	'high'
dubók	duboká	dubokó	dubokí	'deep'
kriʒan	kriʒana	kriʒano	kriʒani	'cross'
suntʃan	suntʃana	suntʃano	suntʃani	'sunny'
svetʃan	svetʃana	svetʃano	svetʃani	'formal'
bogat	bogata	bogato	bogati	'rich'
rapav	rapava	rapavo	rapavi	'rough'
jásan	jasná	jasnó	yasní	'clear'

vázan	vaʒná	vaʒnó	vaʒní	‘important’
sítan	sitná	sitnó	sitní	‘tiny’
ledan	ledna	ledno	ledni	‘frozen’
tának	tanká	tankó	tankí	‘slim’
krátak	kratká	kratkó	kratkí	‘short’
blízak	bliská	bliskó	bliskí	‘close’
úzak	uská	uskó	uskí	‘narrow’
dóbar	dobrá	dobró	dobrí	‘kind’
óʃtar	oʃtrá	oʃtró	oʃtrí	‘sharp’
bodar	bodra	bodro	bodri	‘alert’
ustao	ustala	ustalo	ustali	‘tired’
múkao	muklá	mukló	muklí	‘hoarse’
óbao	oblá	obló	oblí	‘plump’
pódao	podlá	podló	podlí	‘base’

Verbs

1sg pres	*Masc past*	*Fern past*	*Neut past*	
tepém	tépao	teplá	tepló	‘wander’
skubém	skúbao	skublá	skubló	‘tear’
tresém	trésao	treslá	tresló	‘shake’
vezém	vézao	vezlá	vezló	‘lead’

2 Standard Ukrainian

Standard Ukrainian has palatalized and nonpalatalized consonants, but only nonpalatalized consonants before e. Consonants are generally palatalized before *i,* with some apparent exceptions such as *bilʲ* ‘ache,’ which need not be seen as exceptions, given the right analysis. Give ordered rules to account for the alternations of the following nouns. The alternation between *o* and *e* is limited to suffixes. Also for masculine nouns referring to persons, *ov/ev* is inserted between the root and the case suffix in the locative singular (see words for ‘son-in-law,’ ‘grandfather’). The data are initially ambiguous as to whether or not the alternations between *o* and *i* and between *e* and *i* are to be implemented by the same rule. Consider both possibilities; give an argument for selecting one of these solutions.

Masculine nouns

Nom sg	*Dat pl*	*Dat sg*	*Loc sg*	
zub	zubam	zubovʲi	zubʲi	‘tooth’
svʲit	svʲitam	svʲitovʲi	svʲitʲi	‘light’
zʲatʲ	zʲatʲam	zʲatevʲi	zʲatevʲi	‘son-in-law’

koʃʲilʲ	koʃelʲam	koʃelevʲi	koʃelʲi	‘basket’
zlodʲij	zlodʲijam	zlodʲijevʲi	zlodʲijevʲi	‘thief’
mʲisʲatˢʲ	mʲisʲatˢʲam	mʲisʲatˢevʲi	mʲisʲatˢʲi	‘month’
korovaj	korovajam	korovajevʲi	korovaji	‘round loaf’
kamʲinʲ	kamenʲam	kamenevʲi	kamenʲi	‘stone’
mʲidʲ	mʲidʲam	mʲidevʲi	mʲidʲi	‘copper’
xlʲiw	xlʲivam	xlʲivovʲi	xlʲivʲi	‘stable’
holub	holubam	holubovʲi	holubʲi	‘dove’
sʲin	sʲinam	sʲinovʲi	sʲinovʲi	‘son’
lebʲidʲ	lebedʲam	lebedevʲi	lebedʲi	‘swan’
susʲid	susʲidam	susʲidovʲi	susʲidovʲi	‘neighbor’
tʃolovʲik	tʃolovʲikam	tʃolovʲikovʲi	tʃolovʲikovʲi	‘man’
lʲid	ledam	ledovʲi	ledʲi	‘ice’
bilʲ	bolʲam	bolevʲi	bolʲi	‘ache’
riw	rovam	rovovʲi	rovʲi	‘ditch’
stiw	stolam	stolovʲi	stolʲi	‘table’
dʲid	dʲidam	dʲidovʲi	dʲidovʲi	‘grandfather’
lʲit	lʲotam	lʲotovʲi	lʲotʲi	‘flight’
mist	mostam	mostovʲi	mostʲi	‘bridge’
vetʃir	vetʃoram	vetʃorovʲi	vetʃorʲi	‘evening’

Neuter nouns

Nom sg	*Gen sg*	*Dat sg*	*Loc sg*	*Gen pl*	
tʲilo	tʲila	tʲilu	tʲilʲi	tʲiw	‘body’
koleso	kolesa	kolesu	kolesʲi	kolʲis	‘wheel’
ozero	ozera	ozeru	ozerʲi	ozʲir	‘lake’
selo	sela	selu	selʲi	sʲiw	‘village’
pole	polʲa	polʲu	polʲi	pilʲ	‘field’
slovo	slova	slovu	slovʲi	sliw	‘word’
more	morʲa	morʲu	morʲi	mirʲ	‘sea’

3 Somali

Account for all phonological alternations in these data. In your discussion of these forms, be sure to make it clear what you assume the underlying representations of relevant morphemes are. Your discussion should also make it clear what motivates your

underlying representations and rules. For instance if you could analyze some alternation by assuming underlying X and rule Y, say why (or whether) that choice is preferable to the alternative of assuming underlying P and rule Q.

Singular	*Sing, definite*	*Plural*	
daar	daarta	daaro	‘house’
gees	geesta	geeso	‘side’
laf	lafta	lafo	‘bone’
lug	lugta	luɣo	‘leg’
naag	naagta	naaɣo	‘woman’
tib	tibta	tiβo	‘pestle’
sab	sabta	saβo	‘outcast’
bad	bada	baðo	‘sea’
dʒid	dʒida	dʒiðo	‘person’
feeɖ	feeɖa	feezo	‘rib’
ʕiir	ʕiirta	ʕiiro	‘buttermilk’
ʔul	ʔuʃa	ʔulo	‘stick’
bil	biʃa	bilo	‘month’
meel	meeʃa	meelo	‘place’
kaliil	kaliiʃa	kaliilo	‘summer’
najl	najʃa	najlo	‘female lamb’
sun	sunta	sumo	‘poison’
laan	laanta	laamo	‘branch’
sin	sinta	simo	‘hip’
dan	danta	dano	‘affair’
daan	daanta	daano	‘river bank’
saan	saanta	saano	‘hide’
nirig	nirigta	nirgo	‘baby female camel’
gaβaɖ	gaβaɖa	gabɖo	‘girl’
hoɣol	hoɣoʃa	hoglo	‘downpour’
baɣal	baɣaʃa	baglo	‘mule’
waħar	waħarta	waħaro	‘female kid’
irbad	irbada	irbaðo	‘needle’
kefed	kefeda	kefeðo	‘pan’
dʒilin	dʒilinta	dʒilino	‘female dwarf’
bohol	bohoʃa	boholo	‘hole’

dʒirid	dʒirida	dʒirdo	‘trunk’
ʔaajad	ʔaajada	ʔaajaðo	‘miracle’
gaʕan	gaʕanta	gaʕmo	‘hand’
ʔinan	ʔinanta	ʔinano	‘daughter’
3sg masc past	*3sg fern past*	*1pl past*	
suɣaj	sugtaj	sugnaj	‘wait’
kaβaj	kabtaj	kabnaj	‘fix’
siðaj	sidaj	sidnaj	‘carry’
dilaj	diʃaj	dillaj	‘kill’
ganaj	gantaj	gannaj	‘aim’
tumaj	tuntaj	tunnaj	‘hammer’
argaj	aragtaj	aragnaj	‘see’
gudbaj	guðubtaj	guðubnaj	‘cross a river’
qoslaj	qosoʃaj	qosollaj	‘laugh’
hadlaj	haðaʃaj	haðallaj	‘talk’

4 Latin

Provide a complete account of the following phonological alternations in Latin, including underlying forms for noun stems.

Nominative	*Genitive*	
arks	arkis	‘fortress’
duks	dukis	‘leader’
daps	dapis	‘feast’
re:ks	re:gis	‘king’
falanks	falangis	‘phalanx’
filiks	filikis	‘fern’
lapis	lapidis	‘stone’
li:s	li:tis	‘strife’
fraws	frawdis	‘deceit’
noks	noktis	‘night’
frons	frontis	‘brow’
frons	frondis	‘leaf
inku:s	inku:dis	‘anvil’
sors	sortis	‘lot’

fu:r	fu:ris	‘thief’
murmur	murmuris	‘murmur’
augur	auguris	‘augur’
arbor	arboris	‘tree’
pugil	pugilis	‘boxer’
sal	salis	‘salt’
adeps	adipis	‘fat’
apeks	apikis	‘top’
pri:nkeps	pri:nkipis	‘chief’
ekwes	ekwitis	‘horseman’
miles	militis	‘soldier’
no:men	no:minis	‘name’
karmen	karminis	‘song’
lu:men	lu:minis	‘light’
wenter	wentris	‘belly’
pater	patris	‘father’
kada:wer	kada:weris	‘corpse’
tu:ber	tu:beris	‘swelling’
piper	piperis	‘pepper’
karker	karkeris	‘prison’

The following 6 nouns and adjectives select a different genitive suffix, *-i:* as opposed to *-is*. You cannot predict on phonological grounds what nouns take this suffix, but otherwise these words follow the rules motivated in the language.

die:s	die:i:	‘day’
li:ber	li:beri:	‘free’
miser	miseri:	‘wretched’
ager	agri:	‘field’
sinister	sinistri:	‘left’
liber	libri:	‘book’

What other phonological rule or rules are needed to account for the following data?

as	assis	‘whole’
os	ossis	‘bone’
far	farris	‘spell’
mel	mellis	‘honey’
o:s	o:ris	‘mouth’

flo:s	flo:ris	‘flower’
mu:s	mu:ris	‘mouse’
kru:s	kru:ris	‘leg’
kinis	kineris	‘ash’
pulvis	pulveris	‘dust’

5 Turkish

Provide a phonological analysis of the following data from Turkish. Note that long vowels like [a:] are phonetically distinct from identical vowel clusters like [aa].

Nom	*Poss*	*Dat*	*Abl*	*Nom pl*	
oda	odasɨ	odaja	odadan	odalar	‘room’
dere	deresi	dereje	dereden	dereler	‘river’
yty	ytysy	ytyje	ytyden	ytyler	‘iron’
balo	balosu	baloja	balodan	balolar	‘ball’
arɨ	arɨsɨ	arɨja	arɨdan	arɨlar	‘bee’
la:	la:sɨ	la:ja	la:dan	la:lar	‘la (note)’
bina:	bina:sɨ	bina:ja	bina:dan	bina:lar	‘building’
imla:	imla:sɨ	imla:ja	imla:dan	imla:lar	‘spelling’
be:	be:si	be:je	be:den	be:ler	‘B (letter)’
kep	kepi	kepe	kepten	kepler	‘cap’
at	atɨ	ata	attan	atlar	‘horse’
ek	eki	eke	ekten	ekler	‘affix’
ok	oku	oka	oktan	oklar	‘arrow’
gyt^{ʃ}	gyd^{ʒ}y	gyd^{ʒ}e	gyt^{ʃ}ten	gyt^{ʃ}ler	‘power’
ahmet	ahmedi	ahmede	ahmetten	ahmetler	‘Ahmed’
kurt	kurdu	kurda	kurttan	kurtlar	‘worm’
tyrk	tyrky	tyrke	tyrkten	tyrkler	‘Turk’
gent^{ʃ}	gent^{ʃ}i	gent^{ʃ}e	gent^{ʃ}ten	gent^{ʃ}ler	‘young’
halk	halkɨ	halka	halktan	halklar	‘folk’
yst	ysty	yste	ystten	ystler	‘upper plane’
sarp	sarpɨ	sarpa	sarptan	sarplar	‘steep’
harp	harbɨ	harba	harptan	harplar	‘war’
alt	altɨ	alta	alttan	altlar	‘bottom’
renk	rengi	renge	renkten	renkler	‘color’
his	hissi	hisse	histen	hisler	‘feeling’

hyr	hyrry	hyrre	hyrden	hyrler	‘free’
mahal	mahalli	mahalla	mahaldan	mahallar	‘place’
hak	hakki	hakka	haktan	haklar	‘right’
zam	zammi	zamma	zamdan	zamlar	‘inflation’
af	affi	affa	aftan	aflar	‘excuse’
arap	arabi	araba	araptan	araplar	‘Arab’
kojun	kojunu	kojuna	kojundan	kojunlar	‘sheep’
pilot	pilotu	pilota	pilottan	pilotlar	‘pilot’
kitap	kitabi	kitaba	kitaptan	kitaplar	‘book’
domuz	domuzu	domuza	domuzdan	domuzlar	‘pig’
davul	davulu	davula	davuldan	davullar	‘drum’
bajɨr	bajɨrɨ	bajɨra	bajɨrdan	bajɨrlar	‘slope’
somun	somunu	somuna	somundan	somunlar	‘loaf’
fikir	fikri	fikre	fikirden	fikirler	‘idea’
isim	ismi	isme	isimden	isimler	‘name’
bojun	bojnu	bojna	bojundan	bojunlar	‘neck’
tʃevir	tʃevri	tʃevre	tʃevirden	tʃevirler	‘injustice’
devir	devri	devre	devirden	devirler	‘transfer’
kojun	kojnu	kojna	kojundan	kojunlar	‘bosom’
karɨn	karnɨ	karna	karɨndan	karɨnlar	‘thorax’
burun	burnu	burna	burundan	burunlar	‘nose’
akɨl	aklɨ	akla	akɨldan	akɨllar	‘intelligence’
ʃehir	ʃehri	ʃehre	ʃehirden	ʃehirler	‘city’
namaz	namazɨ	namaza	namazdan	namazlar	‘worship’
zaman	zama:nɨ	zama:na	zamandan	zamanlar	‘time’
harap	hara:bɨ	hara:ba	haraptan	haraplar	‘ruined’
i:kaz	i:ka:zɨ	i:ka:za	i:kazdan	i:kazlar	‘warning’
hajat	haja:tɨ	haja:ta	hajattan	hajatlar	‘life’
ispat	ispa:tɨ	ispa:ta	ispattan	ispatlar	‘proof’
inek	inei	inee	inekten	inekler	‘cow’
mantɨk	mantɨɨ	mantɨa	mantɨktan	mantɨklar	‘logic’
ajak	ajaɨ	ajaa	ajaktan	ajaklar	‘foot’
tʃabuk	tʃabuu	tʃabua	tʃabuktan	tʃabuklar	‘quick’
dakik	dakii	dakie	dakikten	dakikler	‘punctual’
merak	mera:kɨ	mera:ka	meraktan	meraklar	‘curiosity’

tebrik	tebri:ki	tebri:ke	tebrikten	tebrikler	‘greetings’
hukuk	huku:ku	huku:ka	hukuktan	hukuklar	‘law’

6 Kera

Propose rules to account for the following alternations. It will prove useful to think about Kera vowels in terms of high versus nonhigh vowels. Also, in this language it would be convenient to assume that [h] and [ʔ] are specified as [+low]. Pay attention to both verbs like *bilan* ‘want me,’ *balnan* ‘wanted me’ and *balla* ‘you must want!’, i.e. there are present, past, and imperative forms involved, certain tenses being marked by suffixes. Finally, pay attention to what might look like a coincidence in the distribution of vowels in the underlying forms of verb roots: there are no coincidences.

haman	‘eat me’	se:nen	‘my brother’
hamam	‘eat you (masc)’	se:nem	‘your (masc) brother’
hɨmi	‘eat you (fem)’	si:ni	‘your (fem) brother’
hɨmu	‘eat him’	si:nu	‘his brother’
hama	‘eat her’	se:na	‘her brother’
hamaŋ	‘eat you (pl)’	se:neŋ	‘your (pl) brother’
kolon	‘change me’	gi:din	‘my belly’
kolom	‘change you (masc)’	gi:dim	‘your (masc) belly’
kuli	‘change you (fem)’	gi:di	‘your (fem) belly’
kulu	‘change him’	gi:du	‘his belly’
kola	‘change her’	gi:dɨ	‘her belly’
koloŋ	‘change you (pl)’	gi:diŋ	‘your (pl) belly’
ci:rɨn	‘my head’	gunun	‘wake me’
ci:rɨm	‘your (masc) head’	gunum	‘wake you (masc)’
ci:ri	‘your (fem) head’	guni	‘wake you (fem)’
cu:ru	‘his head’	gunu	‘wake him’
ci:rɨ	‘her head’	gunɨ	‘wake her’
ci:riŋ	‘your (pl) head’	gunuŋ	‘wake you (pl)’
bɨlan	‘want me’	ŋɨfan	‘meet me’
bɨlam	‘want you (masc)’	ŋɨfam	‘meet you (masc)’
bɨli	‘want you (fem)’	ŋɨfi	‘meet you (fem)’

bɨlu	‘want him’	ŋɨfu	‘meet him’
bɨla	‘want her’	ŋɨfa	‘meet her’
bɨlaŋ	‘want you (pl)’	ŋɨfaŋ	‘meet you (pl)’

ʔasan	‘know me’	ʔapan	‘find me’
ʔasam	‘know you (masc)’	ʔapam	‘find you (masc)’
ʔɨsi	‘know you (fem)’	ʔɨpi	‘find you (fem)’
ʔɨsu	‘know him’	ʔɨpu	‘find him’
ʔasa	‘know her’	ʔapa	‘find her’
ʔasaŋ	‘know you (pl)’	ʔapaŋ	‘find you (pl)’

haran	‘give me back’
haram	‘give you (masc) back’
hɨri	‘give you (fem) back’
hɨru	‘give him back’
hara	‘give her back’
haraŋ	‘give you (pl) back’

balnan	‘wanted me’	ŋafnan	‘met me’
balnam	‘wanted you (masc)’	ŋafnam	‘met you (masc)’
bɨlni	‘wanted you (fem)’	ŋɨfni	‘met you (fem)’
bɨlnu	‘wanted him’	ŋɨfnu	‘met him’
balna	‘wanted her’	ŋafna	‘met her’
balnaŋ	‘wanted you (pl)’	ŋafnaŋ	‘met you (pl)’
balla	‘you must want!’	ŋafla	‘you must meet!’

ba ‘not’ pa ‘again’ bɨpa ‘no more’

7 Keley-i

Account for the alternations in the following verbs. The different forms relate to whether the action is in the past or future, and which element in the sentence is emphasized (subject, object, instrument). Roots underlyingly have the shape CVC(C)VC, and certain forms such as the subject focus future require changes in the stem that result in a CVCCVC shape. This may be accomplished by reduplicating the initial CV- for stems whose first vowel is [e] (*ʔum-bebhat* ← *behaf*) or doubling the middle consonant (*ʔum-buŋŋet – buŋet*). The contrastive identification imperfective form conditions lengthening of the consonant in the middle of the stem, when the first vowel is not [e] (*memajjuʔ* ← *bajuʔ*). These changes are part of the morphology, so do not attempt to write phonological rules to double consonants or reduplicate syllables. Be sure to explicitly

state the underlying form of each root and affix. Understanding the status of [s] and [h] in this language is important in solving this problem. It is also important to consider exactly what underlying nasal consonant is present in these various prefixes and infixes – there is evidence in the data which shows that the underlying nature of the nasal explains certain observed differences in phonological behavior.

Subject focus future	*Direct object focus past*	*Instrumental focus past*	
ʔumduntuk	dinuntuk	ʔinduntuk	‘punch’
ʔumbajjuʔ	binajuʔ	ʔimbajuʔ	‘pound rice’
ʔumdillag	dinilag	ʔindilag	‘light lamp’
ʔumgubbat	ginubat	ʔirjgubat	‘fight’
ʔumhullat	hinulat	ʔinhulat	‘cover’
ʔumbuŋŋet	binuŋet	ʔimbuŋet	‘scold’
ʔumgalgal	ginalgal	ʔiŋgalgal	‘chew’
ʔumʔagtuʔ	ʔinagtuʔ	ʔinʔagtuʔ	‘carry on head’
ʔumʔehneŋ	ʔinehneŋ	ʔinʔehneŋ	‘stand’
ʔumbebhat	binhat	ʔimbehat	‘cut rattan’
ʔumdedʔek	dinʔek	ʔindeʔek	‘accuse’
ʔumtuggun	sinugun	ʔintugun	‘advise’
ʔumtetpen	simpen	ʔintepen	‘measure’
ʔumpeptut	pintut	ʔimpetut	‘dam’
ʔumhehpuŋ	himpuŋ	ʔinhepuŋ	‘break a stick’
ʔumtetkuk	siŋkuk	ʔintekuk	‘shouf
ʔumkekbet	kimbet	ʔiŋkebet	‘scratch’
ʔumbebdad	bindad	ʔimbedad	‘untie’
ʔumdedgeh	diŋgeh	ʔindegeh	‘sick’
Instrumental past focus	*Contrastive id. imperfective*	*Contrastive id. perfective*	
ʔinduntuk	menuntuk	nenuntuk	‘punch’
ʔimbajuʔ	memajjuʔ	nemajuʔ	‘pound rice’
ʔindilag	menillag	nenilag	‘light lamp’
ʔiŋgubat	meŋubbat	neŋubat	‘fight’
ʔinhulat	menullat	nenulat	‘cover’
ʔintanem	menannem	nenanem	‘plant’
ʔimpedug	memdug	nemdug	‘chase’
ʔimbedad	memdad	nemdad	‘untie’
ʔiŋkebet	meŋbet	neŋbet	‘scratch’

ʔimbekaʔ	memkaʔ	nemkaʔ	‘dig’
ʔintepen	mempen	nempen	‘measure’
ʔinteba ʔ	memba ʔ	nemba ʔ	‘kill a pig’
ʔintekuk	meŋkuk	neŋkuk	‘shouf
ʔindegeh	meŋgeh	neŋgeh	‘sick’
ʔinhepaw	mempaw	nempaw	‘possess’
ʔinteled	menled	nenled	‘sting’
ʔindeʔek	menʔek	nenʔek	‘accuse’
ʔinʔeba ʔ	meŋba ʔ	neŋba ʔ	‘carry on back’
ʔinʔinum	meŋinnum	neŋinum	‘drink’
ʔinʔagtuʔ	meŋagtuʔ	neŋagtuʔ	‘carry on head’
ʔinʔala ʔ	meŋalla ʔ	neŋala ʔ	‘get’
ʔinʔawit	meŋawwit	neŋawit	‘get’

The following past subject clausal focus forms involve a different prefix, using some of the roots found above. A number of roots require reduplication of the first root syllable.

nandunduntuk	‘punch’	nampepedug	‘chase’
naŋkekebet	‘scratch’	nambebekaʔ	‘dig’
nantetekuk	‘shouf	nandedeʔek	‘accuse
nanʔeʔeba ʔ	‘carry on back’	nanʔiʔinum	‘drink’
nantanem	‘plant’		

8 Kuria

In some (but not all) of the examples below, morphemes boundaries have been been introduced to assist in the analysis. Pronouns are assigned to a grammatical class depending on the noun which they refer to, conventionally given a number (1–20). Tone may be disregarded (however, it is predictable in the infinitive). It is important to pay attention to interaction between processes in this problem.

ogo-táángá	‘to begin’	oko-gɛ́sa	‘to harvest’
oko-rɔ́ga	‘to witch’	oko-réma	‘to plow’
oko-hóórá	‘to thresh’	ugu-sííká	‘to close a door’
ugu-súraangá	‘to sing praise’	uku-gíingá	‘to shave’
ugútúúhá	‘to be blunt’		

ogo-kó-báră	‘to count you (sg)’	uku-gú-súraánga	‘to praise you (sg)’
oko-mó-báră	‘to count him’	uku-mú-súraánga	‘to praise him’
ogo-tó-báră	‘to count us’	ugu-tú-súraánga	‘to praise us’
oko-gé-báră	‘to count them (4)’	uku-gí-súraánga	‘to praise it (4)’

oko-ré-bárə̆	‘to count it (5)’	uku-rí-súraánga	‘to praise it (5)’
uku-bí-bárə̆	‘to count it (8)’	uku-bí-súraánga	‘to praise it (8)’
ugu-tʃí-bárə̆	‘to count it (10)’	ugu-tʃí-súraánga	‘to praise it (10)’

oko-mó-gó-gɛsɛ́ra	‘to harvest it (3) for him’
uku-mú-gú-siíkja	‘to make him close it (3)’
uku-mú-gú-siíndja	‘to make him win it (3)’
oko-bá-súraánga	‘to praise them’
oko-mó-bá-suráángéra	‘to praise them for him’
oko-bá-mú-suráángéra	‘to praise him for them’

To V	*To make to V*	*To V for*	*To make V for*	
okoréma	ukurímjá	okoréméră	ukurímírjá	‘weed’
okoróma	ukurúmjá	okoróméră	ukurúmírjá	‘bite’
okohóórá	ukuhúúrjá	okohóóréra	ukuhúúrírjá	‘thresh’
okohéétóká	ukuhíítúkjá ‘remember’	okohéétókerá	ukuhíítúkirjá	
okogéémbá	ukugíímbjá	okogéémbérá	ukugíímbírjá	‘make rain’
ogosóóká	ugusúúkjá	ogosóókérá	ugusúúkírjá	‘respect’
ogotégétă	ugutígítjă	ogotégéterá	ugutígítirjá	‘be late’
okorɔ́ga	okorógjá	okorɔ́géră	okorógérjá	‘bewitch’
okogɔ́ɔ́gá	okogóógjá	okogɔ́ɔ́gérá	okogóógérjá	‘slaughter’
okogɔ́ɔ́tá	okogóótjá	okogɔ́ɔ́tɛ́rá	okogóótérjá	‘hold’
ogosɔ́ka	ogosókjá	ogosɔ́kéră	ogosókérjá	‘poke’
ogotɛ́rɛ́kă	ogotérékjá	ogotɛ́rɛ́kɛrá	ogotérékerjá	‘brew’
okogɛ́sa	okogésjá	okogéséră	okogésérjá	‘harvest’
ogoséénsá	ogoséénsjá	ogoséénsérá	ogoséénsérjá	‘winnow’

To V	*To make to V*	*To V for*	*To make V for*	
ugusííká	ugusííkjá	ogoséékérá	ugusííkírjá	‘to close’
ukurúga	ukurúgjá	okorógéră	ukurúgírjá	‘to cook’
ugusúka	ugusúkjá	ogosókéră	ugusúkírjá	‘to plait’
ukurííngá	ukurííngjá	okorééngérá	ukurííngírjá	‘to fold’
ugusííndá	ugusííndjá	ogosééndérá	ugusííndírjá	‘to win’

Imperative	*Infinitive*	*They will V*	*Then will V for*	
remă	okoréma	mbareréma	mbareréméra	‘cultivate’
bară	okobára	mbarebára	mbarebáréra	‘count’
ată	ogɔ́ta	mbarɛ́ta	mbarɛ́tɛ́ra	‘be split’
ahă	okɔ́ha	mbarɛ́ha	mbarɛ́hɛ́ra	‘pick greens’
agă	okɔ́ga	mbarɛ́ga	mbarɛ́gɛ́ra	‘weed’
aangá	okɔ́nga	mbarɛ́nga	mbarɛ́ngɛ́ra	‘refuse’
andeká	okɔ́ndɛ́kă	mbarɛ́ndɛ́ka	mbarɛ́ndɛ́kɛra	‘write’

Imperative	*3g subjunctive*	*3sg subjunctive for*	
remă	aremɛ̆	aremerɛ́	‘cultivate’
tɛrɛka	atɛrɛkɛ́	atɛrɛkɛ́rɛ	‘brew’
ebă	ɛɛbɛ̆	ɛɛbɛrɛ́	‘forget’
egă	ɛɛgɛ̆	ɛɛgɛrɛ́	‘learn’
ogă	ɔɔgɛ̆	ɔɔgɛrɛ́	‘be sharp’
ɛjă	ɛɛjɛ̆	ɛɛjɛrɛ́	‘sweep’
ɔrɔka	ɔɔrɔkɛ́	ɔɔrɔkɛ́rɛ	‘come out’

9 Lardil

Account for the phonological alternations seen in the data below.

Bare N	*Accusative*	*Nonfuture*	*Future*	
kentapal	kentapalin	kentapalŋaɾ	kentapaluɭ	‘dugong’
keṯaɾ	keṯaɾin	keṯaɾŋaɾ	keṯaɾuɭ	‘river’
mijaɭ	mijaɭin	mijaɭŋaɾ	mijaɭuɭ	‘spear’
jupuɾ	jupuɾin	jupuɾŋaɾ	jupuɾuɭ	‘red rock cod’
taŋuɾ	taŋuɾin	taŋuɾŋaɾ	taŋuɾuɭ	‘crab (sp)’
jaɾaman	jaɾamanin	jaɾamanaɾ	jaɾamankuɭ	‘horse’
maan	maanin	maanaɾ	maankuɭ	‘spear’
piɾŋen	piɾŋenin	piɾŋenaɾ	piɾŋenkuɭ	‘woman’
mela	melan	melaŋaɾ	melaɭ	‘sea’
ṯawa	ṯawan	ṯawaŋaɾ	ṯawaɭ	‘rat’
wanka	wankan	wankaŋaɾ	wankaɭ	‘arm’
kuŋka	kuŋkan	kuŋkaŋaɾ	kuŋkaɭ	‘groin’

taɾŋka	taɾŋkan	taɾŋkaŋaɾ	taɾŋkaʈ	‘barracuda’
ŋuka	ŋukun	ŋukuŋaɾ	ŋukuʈ	‘water’
ŋuʈa	ŋuʈun	ŋuʈuŋaɾ	ŋuʈuʈ	‘forehead’
kaʈa	kaʈun	kaʈuŋaɾ	kaʈuʈ	‘child’
muna	munun	munuŋaɾ	munuʈ	‘elbow’
ŋawa	ŋawun	ŋawuŋaɾ	ŋawuʈ	‘dog’
kenʈe	kenʈin	kenʈiŋaɾ	kenʈiwuʈ	‘wife’
tʲimpe	tʲimpin	tʲimpiŋaɾ	tʲimpiwuʈ	‘tail’
ŋine	ŋinin	ŋiniŋaɾ	ŋiniwuʈ	‘skin’
pape	papin	papiŋaɾ	papiwuʈ	‘father’s mother’
tʲempe	tʲempen	tʲempeŋaɾ	tʲempeʈ	‘mother’s father’
wiʈe	wiʈen	wiʈeŋaɾ	wiʈeʈ	‘interior’
waŋal	waŋalkin	waŋalkaɾ	waŋalkuʈ	‘boomerang’
menʲel	menʲelkin	menʲelkaɾ	menʲelkuʈ	‘dogfish (sp)’
makaɾ	makaɾkin	makaɾkaɾ	makaɾkuʈ	‘anthill’
jalul	jalulun	jaluluŋaɾ	jaluluʈ	‘flame’
majaɾ	majaɾan	majaɾaŋaɾ	majaɾaʈ	‘rainbow’
ʈalkuɾ	ʈalkuɾan	ʈalkuɾaŋaɾ	ʈalkuɾaʈ	‘kookaburra’
wiwal	wiwalan	wiwalaŋaɾ	wiwalaʈ	‘bush mango’
kaɾikaɾ	kaɾikaɾin	kaɾikaɾiŋaɾ	kaɾikaɾiwuʈ	‘butter-fish’
jilijil	jilijilin	jilijiliŋaɾ	jilijiliwuʈ	‘oyster (sp)’
jukaɾ	jukaɾpan	jukaɾpaŋaɾ	jukaɾpaʈ	‘husband’
pulŋaɾ	pulŋaɾpan	pulŋaɾpaŋaɾ	pulŋaɾpaʈ	‘huge’
wulun	wulunkan	wulunkaŋaɾ	wulunkaʈ	‘fruit (sp)’
wuʈal	wuʈalʲtʲin	wuʈalʲtʲiŋaɾ	wuʈalʲtʲiwuʈ	‘meat’
kantukan	kantukantun	kantukantuŋaɾ	kantukantuʈ	‘red’
kaɾwakaɾ	kaɾwakaɾwan	kaɾwakaɾwaŋaɾ	kaɾwakaɾwaʈ	‘wattle (sp)’
ʈuɾaɾa	ʈuɾaɾaŋin	ʈuɾaɾaŋaɾ	ʈuɾaɾaŋkuʈ	‘shark’
ŋalu	ŋalukin	ŋalukaɾ	ŋalukuʈ	‘story’
kuɾka	kuɾkaŋin	kuɾkaŋaɾ	kuɾkaŋkuʈ	‘pandja’
taŋku	taŋkuŋin	taŋkuŋaɾ	taŋkuŋkuʈ	‘oyster (sp)’
kuɾpuʈu	kuɾpuʈuŋin	kuɾpuʈuŋaɾ	kuɾpuʈuŋkuʈ	‘lancewood’
putu	putukan	putukaŋaɾ	putukaʈ	‘short’
maali	maalijan	maalijaŋaɾ	maalijaʈ	‘swamp turtle’
tʲintiɾpu	tʲintiɾpuwan	tʲintiɾpuwaŋaɾ	tʲintiɾpuwaʈ	‘willie wagtail’

pukatʲi	pukatʲijan	pukatʲijaŋaɾ	pukatʲijaɽ	‘hawk (sp)’
muɾkuni	muɾkuniman	muɾkunimaŋaɾ	muɾkunimaɽ	‘nullah’
ŋawuŋa	ŋawuŋawun	ŋawuŋawuŋaɾ	ŋawuŋawuɽ	‘termite’
tipiti	tipitipin	tipitipiŋaɾ	tipitipiwuɽ	‘rock-cod (sp)’
t̪apu	t̪aputʲin	t̪aputʲiŋaɾ	t̪aputʲiwuɽ	‘older brother’
muŋkumu	muŋkumuŋkun	muŋkumuŋkuŋaɾ	muŋkumuŋkuɽ	‘wooden axe’
tʲumputʲu	tʲumputʲumpun	tʲumputʲumpuŋaɾ	tʲumputʲumpuɽ	‘dragonfly’

10 Sakha (Yakut)

Give a phonological analysis of the following case-marking paradigms of nouns in Sakha.

Noun	*Plural*	*Associative*	
aɣa	aɣalar	aɣaliɨn	‘father’
paarta	paartalar	paartaliɨn	‘school desk’
tɨa	tɨalar	tɨaliɨn	‘forest’
kinige	kinigeler	kinigeliin	‘book’
dʒie	dʒieler	dʒieliin	‘house’
ije	ijeler	ijeliin	‘mother’
kini	kiniler	kiniliin	‘3rd person’
bie	bieler	bieliin	‘mare’
oɣo	oɣolor	oɣoluun	‘child’
χopto	χoptolor	χoptoluun	‘gull’
børø	børølør	børølyyn	‘wolf’
tɨal	tɨallar	tɨalliɨn	‘wind’
ɨal	ɨallar	ɨalliɨn	‘neighbor’
kuul	kuullar	kuulluun	‘sack’
at	attar	attiɨn	‘horse’
balɨk	balɨktar	balɨktiɨn	‘fish’
ɨskaap	ɨskaaptar	ɨskaaptiɨn	‘cabinet’
oɣus	oɣustar	oɣustuun	‘bull’
kus	kustar	kustuun	‘duck’
tynnyk	tynnykter	tynnyktyyn	‘window’
sep	septer	septiin	‘tool’
et	etter	ettiin	‘meat’
ørys	øryster	ørystyyn	‘river’

tiis	tiister	tiistiin	‘tooth’
soroχ	soroχtor	soroχtuun	‘some person’
oχ	oχtor	oχtuun	‘arrow’
oloppos	oloppostor	oloppostuun	‘chair’
øtøχ	øtøχtør	øtøχtyyn	‘abandoned farm’
ubaj	ubajdar	ubajdiin	‘elder brother’
saraj	sarajdar	sarajdiin	‘barn’
tɨj	tɨjdar	tɨjdiin	‘foal’
atɨir	atɨirdar	atɨirdiin	‘stallion’
ojuur	ojuurdar	ojuurduun	‘forest’
yt$^{\int}$ygej	yt$^{\int}$ygejder	yt$^{\int}$ygejdiin	‘good person’
ed^{3}iij	ed^{3}iijder	ed^{3}iijdiin	‘elder sister’
tomtor	tomtordor	tomtorduun	‘knob’
moɣotoj	moɣotojdor	moɣotojduun	‘chipmunk’
køtør	køtørdør	køtørdyyn	‘bird’
bølkøj	bølkøjdør	bølkøjdyyn	‘islet’
χatɨŋ	χatɨŋnar	χatɨŋnɨin	‘birch’
aan	aannar	aannɨin	‘door’
tiiŋ	tiiŋner	tiiŋniin	‘squirrel’
sordoŋ	sordoŋnor	sordoŋnuun	‘pike’
olom	olomnor	olomnuun	‘ford’
oron	oronnor	oronnuun	‘bed’
bødøŋ	bødøŋnør	bødøŋnyyn	‘strong one’

Noun	*Partitive*	*Comparative*	*Ablative*	
aɣa	aɣata	aɣataaɣar	aɣattan	‘father’
paarta	paartata	paartataaɣar	paartattan	‘school desk’
tɨa	tɨata	tɨataaɣar	tɨattan	‘forest’
kinige	kinigete	kinigeteeɣer	kinigetten	‘book’
d^{3}ie	d^{3}iete	d^{3}ieteeɣer	d^{3}ietten	‘house’
ije	ijete	ijeteeɣer	ijetten	‘mother’
kini	kinite	kiniteeɣer	kinitten	‘3rd person’
bie	biete	bieteeɣer	bietten	‘mare’
oɣo	oɣoto	oɣotooɣor	oɣotton	‘child’
χopto	χoptoto	χoptotooɣor	χoptotton	‘gull’

børø	børøtø	børøtøøɣør	børøttøn	‘wolf’
tɨal	tɨalla	tɨallaaɣar	tɨaltan	‘wind’
ɨal	ɨalla	ɨallaaɣar	ɨaltan	‘neighbor’
kuul	kuulla	kuullaaɣar	kuultan	‘sack’
moχsoɣol	moχsoɣollo	moχsoɣollooɣor	moχsoɣolton	‘falcon’
at	atta	attaaɣar	attan	‘horse’
balɨk	balɨkta	balɨktaaɣar	balɨktan	‘fish’
ɨskaap	ɨskaapta	ɨskaaptaaɣar	ɨskaaptan	‘cabinet’
oɣus	oɣusta	oɣustaaɣar	oɣustan	‘bull’
kus	kusta	kustaaɣar	kustan	‘duck’
tynnyk	tynnykte	tynnykteeɣer	tynnykten	‘window’
sep	septe	septeeɣer	septen	‘tool’
et	ette	etteeɣer	etten	‘meat’
ørys	øryste	ørysteeɣer	ørysten	‘river’
tiis	tiiste	tiisteeɣer	tiisten	‘tooth’
soroχ	soroχto	soroχtooɣor	soroχton	‘some person’
øtøχ	øtøχtø	øtøχtøøɣør	øtøχtøn	‘abandoned farm’
ubaj	ubajda	ubajdaaɣar	ubajtan	‘elder brother’
saraj	sarajda	sarajdaaɣar	sarajtan	‘barn’
tɨj	tɨjda	tɨjdaaɣar	tɨjtan	‘foal’
atɨɨr	atɨɨrda	atɨɨrdaaɣar	atɨɨrtan	‘stallion’
χɨrur	χɨrurda	χɨrurdaaɣar	χɨrurtan	‘surgeon’
yt$^{\int}$ygej	yt$^{\int}$ygejde	yt$^{\int}$ygejdeeɣer	yt$^{\int}$ygejten	‘good person’
tomtor	tomtordo	tomtordooɣor	tomtorton	‘knob’
moɣotoj	moɣotojdo	moɣotojdooɣor	moɣotojton	‘chipmunk’
køtør	køtørdø	køtørdøøɣør	køtørtøn	‘bird’
suorɣan	suorɣanna	suorɣannaaɣar	suorɣantan	‘blanket’
χatɨŋ	χatɨŋna	χatɨŋnaaɣar	χatɨŋtan	‘birch’
aan	aanna	aannaaɣar	aantan	‘door’
tiiŋ	tiiŋne	tiiŋneeɣer	tiiŋten	‘squirrel’
sordoŋ	sordoŋno	sordoŋnooɣor	sordoŋton	‘pike’
olom	olomno	olomnooɣor	olomton	‘ford’
bødøŋ	bødøŋnø	bødøŋnøøɣør	bødøŋtøn	‘strong one’

Noun *Dative* *Accusative*

aɣa	aɣaɣa	aɣanɨ	‘father’
d^{3}ie	d^{3}ieɣe	d^{3}ieni	‘house’
ije	ijeɣe	ijeni	‘mother’
oɣo	oɣoɣo	oɣonu	‘child’
børø	børøɣø	børøny	‘wolf’
tɨal	tɨalga	tɨalɨ	‘wind’
kuul	kuulga	kuulu	‘sack’
at	akka	atɨ	‘horse’
balɨk	balɨkka	balɨgɨ	‘fish’
ɨskaap	ɨskaapka	ɨskaabɨ	‘cabinet’
oɣus	oɣuska	oɣuhu	‘bull’
kus	kuska	kuhu	‘duck’
sep	sepke	sebi	‘tool’
et	ekke	eti	‘meat’
tiis	tiiske	tiihi	‘tooth’
ot	okko	otu	‘grass’
soroχ	soroχχo	soroɣu	‘some person’
øtøχ	øtøχχø	øtøɣy	‘abandoned farm’
oχ	oχχo	oɣu	‘arrow’
saraj	sarajga	sarajɨ	‘barn’
tɨj	tɨjga	tɨjɨ	‘foal’
køtør	køtørgø	køtøry	‘bird’

ojuun	ojuuŋŋa	ojuunu	‘shaman’
χatɨŋ	χatɨŋŋa	χatɨŋɨ	‘birch’
aan	aaŋŋa	aanɨ	‘door’
olom	olomŋo	olomu	‘ford’

Noun	*OurN*		*Noun*	*Our N*	
aɣa	aɣabɨt	‘father’	ije	ijebit	‘mother’
uol	uolbut	‘son’	køtør	køtørbyt	‘bird’
kɨlaas	kɨlaaspɨt	‘classroom’	ɨskaap	ɨskaappɨt	‘cabinet’
kuorat	kuorappɨt	‘town’	tiis	tiispit	‘tooth’
ohoχ	ohoχput	‘stove’	tynnyk	tynnykpyt	‘window’
aan	aammɨt	‘door’	kapitan	kapitammɨt	‘captain’

tiiŋ	tiiŋmit	‘squirrel’	oron	orommut	‘bed’
kyn	kymmyt	‘day’			

11 Sadzhava Ukrainian

Give a phonological analysis of the following data. Assume that all surface occurrences of k^j and g^j in this language are derived by rule. Also assume that stress is located on the proper vowel in the underlying representation: the rules for shifting stress are too complex to be considered here. Nouns in declension II depalatalize a consonant before the locative suffix, and nouns in declension III depalatalize in the genitive. The variation in the genitive and locative singular suffix in declension I (*-i* or *-a* versus *-u*) is lexically governed: do not write rules which select between these suffixes. Concentrate on establishing the correct underlying representations for the noun stem.

Declension I

Nom sg	*Gen sg*	*Loc sg*	
ˈplast	plasˈta	plas^{j}ˈk^{j}i	‘layer’
skoˈrux	skoruˈxa	skoruˈs^{j}i	‘mountain ash’
ˈɣ^{j}r^{j}ix	ɣ^{j}r^{j}ixa	ɣ^{j}r^{j}iˈs^{j}i	‘sin’
pasˈtux	pastuˈxa	pastuˈs^{j}i	‘herdsman’
ˈm^{j}n^{j}ux	ˈm^{j}n^{j}uxa	ˈm^{j}n^{j}us^{j}i	‘fish (sp)’
ˈpluɣ	ˈpluɣa	ˈpluz^{j}i	‘plow’
ˈs^{j}t^{j}iɣ	ˈstoɣa	ˈstoz^{j}i	‘stack’
ˈsak	ˈsaka	ˈsat^{sj}i	‘fishnet’
ˈbek	bəˈka	bəˈt^{sj}i	‘bull’
ˈlest	ləsˈta	ləs^{j}ˈk^{j}i	‘letter’
ˈlest	ˈlesta	ˈles^{j}k^{j}i	‘leaf’
ˈp^{j}l^{j}it	ˈplota	ˈplok^{j}i	‘wicker fence’
ˈs^{j}m^{j}r^{j}id	ˈsmroda	ˈsmrog^{j}i	‘stench’
ˈf^{j}ist	fosˈta	fos^{j}ˈk^{j}i	‘tail’
ˈm^{j}ist	ˈmosta	ˈmos^{j}k^{j}i	‘bridge’
ˈl^{j}id	ˈlædu	ləˈdu	‘ice’
ˈd^{j}r^{j}it	ˈdrota	ˈdrok^{j}i	‘thick wire’
ˈm^{j}id	ˈmædu	məˈdu	‘honey’
ˈv^{j}il	voˈla	voˈl^{j}i	‘ox’
ˈv^{j}iz	ˈvoza	ˈvoz^{j}i	‘cart’
ˈser	ˈsera	ˈser^{j}i	‘cottage cheese’
ˈs^{j}n^{j}ip	snoˈpa	snoˈp^{j}i	‘sheaf’
ˈɣreb	ɣrəˈba	ɣrəˈb^{j}i	‘mushroom’

ˈlæbʲid	ˈlæbəda	ˈlæbəgʲi	‘swan’
ˈbærʲiɣ	ˈbærəɣa	ˈbærəzʲi	‘shore’
pəˈrʲiɣ	pəˈroɣa	pəˈrozʲi	‘dumpling’
ˈporʲiɣ	poˈroɣa	poˈrozʲi	‘threshhold’
boˈlʲek	boɫʲəˈka	boɫʲəˈtˢʲi	‘abcess’
ˈvorʲiɣ	ˈoroɣa	ˈorozʲi	‘enemy’
ˈkonək	ˈkonəka	ˈkonətˢʲi	‘grasshopper’
ˈpotʲik	poˈtoka	poˈtotˢʲi	‘stream’
ˈtʲik	ˈtoka	ˈtotˢʲi	‘current’
ˈkʲil	koˈla	koˈlʲi	‘stake’

Declension II

Nom sg	*Gen sg*	*Loc sg*	
koˈvaɫʲ	kovaˈlʲe	kovaˈle	‘blacksmith’
ˈdᶾmʲilʲ	dᶾmʲiˈlʲe	dᶾmʲiˈle	‘bumblebee’
ˈkʲrʲilʲ	kʲrʲiˈlʲe	kʲrʲiˈle	‘rabbit’
uˈtʃetəlʲ	uˈtʃetəlʲə	uˈtʃetələ	‘teacher’
ˈgræbʲinʲ	ˈgræbənʲə	ˈgræbənə	‘comb’
ˈolənʲ	ˈolənʲə	ˈolənə	‘deer’
yatʲʃʲˈmʲinʲ	yatʃˈmænʲə	yatʃˈmænə	‘barley’
ˈyasʲinʲ	ˈyasənʲə	ˈyasənə	‘ash tree’
ˈzʲekʲ	ˈzʲekʲə	ˈzʲetə	‘son-in-law’

Declension II

Nom sg	*Gen sg*	
ˈmasʲkʲ	ˈmastə	‘fat’
ˈsʲmʲirʲkʲ	ˈsmærtə	‘death’
ˈvʲisʲkʲ	ˈvʲistə	‘news’
ˈsʲilʲ	ˈsolə	‘salt’
ˈpoʃʲisʲkʲ	ˈpoʃəstə	‘epidemic’
ˈzamʲikʲ	ˈzamətə	‘snowstorm’
ˈskatərʲkʲ	ˈskatərtə	‘tablecloth’
ˈkʲisʲkʲ	ˈkostə	‘bone’

12 Koromfe

Koromfe has two kinds of vowels, [-ATR] ɪ ʊ ɛ ɔ a and [+ATR] i u e o ʌ. Provide an analysis of the alternations in the following data, which involve singular and plural forms of nouns and different tense-inflections for verbs:

Singular	*Plural*	
gɪbrɛ	gɪba	‘hatchet’
hubre	hubʌ	‘ditch’
nɛbrɛ	nɛba	‘pea’
dĩŋgre	dĩŋgʌ	‘bush type’
zoŋgre	zoŋgʌ	‘wing’
lõŋgrɛ	lõŋga	‘shoe’
hullre	hullʌ	‘gutter’
sɛkrɛ	sɛka	‘half’
tɛfrɛ	tɛfa	‘cotton fiber’
dabɛɛrɛ	dabɛɛja	‘camp’
dɔɔrɛ	dɔɔja	‘long’
gĩgaarɛ	gĩgaaja	‘vulture’
pʊpaarɛ	pʊpaaja	‘grass type’
koire	kojʌ	‘bracelet’
dʊmdɛ	dʊma	‘lion’
hulomde	hulomʌ	‘marrow’
tɛmdɛ	tɛma	‘beard’
logomde	logomʌ	‘camel’
bɪndɛ	bɪna	‘heart’
hɔ̃ndɛ	hɔ̃na	‘hoe’
honde	honʌ	‘bean’
geŋde	geŋʌ	‘pebble’
zɛŋdɛ	zɛŋa	‘upper arm’
bɛllɛ	bɛla	‘back’
jɪllɛ	jɪla	‘horn’
selle	selʌ	‘space’
pallɛ	pala	‘stretcher’
deŋgele	deŋgelʌ	‘open area’
sembele	sembelʌ	‘piece’
dãĩnɛ	dãj̃ã	‘wood’
hõĩnɛ	hõj̃ã	‘caterpillar’

kɔ̃ĩnɛ	kɔ̃jã	‘squirrel’
kɔ̃ɔ̃nɛ	kɔ̃ɔ̃jã	‘old’
sɔ̃ɔ̃nɛ	sɔ̃ɔ̃jã	‘period’
bɛtɛ	bɛra	‘male animal’
datɛ	dara	‘chest’
gete	gerʌ	‘forked stick’
gote	gorʌ	‘stream’
bɪtɛ	bɪra	‘frog’
dɔtɛ	dɔra	‘cloud’

Neutral	*Past*	*Progressive*	
ta	taɛ	taraa	‘shoot’
gɔ	gɔɛ	gɔraa	‘go back’
kʊ	kɔɛ	kʊraa	‘kill’
tu	toe	turʌʌ	‘coat’
li	lee	lirʌʌ	‘forget’
dɪ	dɛ	dɪraa	‘eat’
tã	tãɛ̃	tãnaa	‘contradict’
nɛ̃	nɛ̃	nɛ̃naa	‘defecate’
saɪ	sajɛ	saɪraa	‘separate’
jɛɪ	jɛjɛ	jɛɪraa	‘waste’
sɔɪ	sɔjɛ	sɔɪraa	‘split’
j̃ɛ̃ĩ	j̃ɛ̃j̃ɛ̃	j̃ɛ̃ĩnaa	‘catch’
dɔ̃ĩ	dɔ̃j̃ɛ̃	dɔ̃ĩnaa	‘dream’
kɛndɪ	kɛndɛ	kɛndraa	‘finish’
kɛ̃sɪ	kɛ̃̃sɛ	kɛ̃sraa	‘surpass’
kɛtɪ	kɛtɛ	kɛtraa	‘open’
tɛŋgɪ	tɛŋgɛ	tɛŋgraa	‘accompany’
jisi	jise	jisrʌʌ	‘suffice’
jɪsɪ	jɪsɛ	jɪsraa	‘draw water’
birgi	birge	birgrʌʌ	‘blacken’
pasgɪ	pasgɛ	pasgraa	‘split’
mɛntɪ	mɛntɛ	mɛntraa	‘assemble’
gondu	gonde	gondrʌʌ	‘depart’
hɔ̃ŋgʊ	hɔ̃ŋgɛ	hɔ̃ŋgraa	‘point’

sʊrgʊ	sʊrgɛ	sʊrgraa	‘drop’
hɔ̃kʊ	hɔ̃kɛ	hɔ̃kraa	‘scratch’
zullu	zulle	zullrʌʌ	‘bow’
sɪbʊ	sɪbɛ	sɪbraa	‘die’
zambʊ	zambɛ	zambraa	‘deceive’
wufu	wufe	wufrʌʌ	‘borrow’
zɪgamsʊ	zɪgamsɛ	zɪgamsraa	‘be dirty’
hɛ̃msʊ	hɛ̃msɛ	hɛ̃msraa	‘meet’
leli	lele	lellʌʌ	‘sing’
pɪlɪ	pɪlɛ	pɪllaa	‘trample flat’
tarɪ	tarɛ	tataa	‘plaster’
fɛrɪ	fɛrɛ	fɛtaa	‘cultivate’
tʊrʊ	tʊrɛ	tʊtaa	‘introduce’

Further reading

Kenstowicz and Kisseberth 1979; Zwicky 1973, 1974, 1975; Pullum 1976.

Online at https://languagedescriptions.github.io/IP3/Ch7.html are two longer descriptive analyses, which further exemplify the typical analytical reasoning used in phonological description. These were intended to be part of the original version of this textbook but had to be removed for space reasons. Thanks to the internet, it is now possible to make these sketches, of Matumbi and Damascene Arabic, generally available. Apart from providing more information on aspects of these two languages, these sketches present the structure of the languages in a less-curated fashion – you will observe the same kind of reasoning used throughout the textbook, but written with much less explicit meta-analysis of how to perform an analysis, thus more closely matching what articles look like.