CHAPTER 10
Nonlinear representations

PREVIEW

This chapter introduces an alternative model of how sounds are represented, the nonlinear theory. The purpose of this chapter is to show how troublesome facts can lead to a reconceptualization of a domain which seemed to be well understood, leading to an even better understanding of the nature of language sounds. This will also help you to understand how and why theories change.

KEY TERMS
autosegmental phonology
tone stability
floating tone
across-the-board effects
feature geometry

The theoretical model that we have been assuming – known as the linear theory of representation – was quite successful in explaining a number of facts about sound systems. An essential characteristic of the theory is that segments are matrices of feature values, where every segment has a specification for each of the two dozen distinctive features. There was one phonological realm which the theory had largely ignored, tone, a disregard that had significant repercussions.

10.1 The autosegmental theory of tone: the beginnings of a change

There were a few proposals regarding tone features in the linear theory, but they did not reach anything like the degree of acceptance that other features had reached. One of the primary problems of tone analysis was how to represent contour tones such as rising and falling tones.

10.1.1 The problem of contours

Tones can be characterized in terms of pitch level, and change between levels. A language might have 3 tones defined just in terms of relative level, which we would term High (H), Mid (M) or Low (L) –Yoruba is like that. There could be 2 levels H and L (the usual case in Bantu languages), or up to 6 levels (Chori). Additionally, tone languages often have tones defined in terms of a pitch movement from one level to another level: these are contour tones. They can generally be rising or falling, and some languages have contour tones that change direction of pitch-change (rise-fall or fall-rise). Some attention was paid to developing conventional names for the levels, but for the most part tone levels were simply treated as [+H], [+L] and [+M]. Contour tones posed a much larger problem.

One possibility is that contour tones are simply H or L tones with a positive specification for a feature "contour." We could take the pitch at the beginning of a vowel as representing the "reference" tone value, and if the pitch changes from that point (either up or down), then the vowel is [+contour]. This is the simplest possible theory of contours, which gives us the following representations of H, L, R (rising) and F (falling) tones.

(1) H = [+H,–contour]   R = [–H,+contour]

L = [–H,–countour]   F = [+H,+contour]

Ultimately we would need to account for more than two levels of tone, but we can pursue this theory with just two levels to see what progress can be made. Perhaps if this theory works, it can be modified to account for other tone levels.

An essential test of a theory of features is how it accounts for phonological processes. This kind of theory of tone makes predictions: it predicts that R and F will be a natural class because they are [+contour], and it predicts that L and R are a natural class because they are [–H]. As it happens, some relevant typological work had been done on common tone rules, most notably Hyman and Schuh 1974. Such research has shown that the following are fairly common tonal processes.

(2) a. $H \rightarrow R / \{L,F\}$ _   b. $L \rightarrow F / \{H,R\}$ _

c. $H \rightarrow F /$ _ $\{L,R\}$ d. $L \rightarrow R /$ _ $\{H,F\}$

The problem is that the "[±contour]" theory does not provide any natural way to express all of these processes. The last two processes can be formulated:

(3) c. $[+H] \rightarrow [+\text{contour}] /$ _ $[-H]$

d. $[-H] \rightarrow [+\text{contour}] /$ _ $[+H]$

However, the first two processes cannot be formalized, since {L,F} or {H,R} are not a definable class using this theory. L tone is, *ex hypothesii*, [-H] whereas F is [+H], so the class of progressive tone assimilations, one of the most common tone rules, is unformalizable.

This theory also predicts the following rules, which are simply the rules in (3) with the conditioning environment on the left rather than the right:

(4) *[+H] → [+contour] / [-H] __   (H → F / {L,R} __)

*[+H] → [+contour] / [-H] __   (L → R / {H,F} __)

Unlike the common rules in (2), such rules are totally nonexistent in the languages of the world. The "[±contour]" theory thus makes a bad prediction, that certain processes should exist when they do not, and in addition the theory provides no way to express certain very natural processes, in particular processes where the conditioning environment is on the left. Finally, even for the two processes which the theory can formalize in (3), there is an unexplained element of arbitrariness - why should an H tone become a falling tone before [–H]? Those processes are formally just as simple to express as the rules in (5), and should therefore be found as commonly as the former set of rules, but this latter set of rules is completely unattested in language.

(5) c. $[+\text{H}] \rightarrow [+\text{contour}] / \_ [+\text{H}]$ $\quad$ $(\text{H} \rightarrow \text{F} / \_ \{\text{H,F}\})$

d. $[-\text{H}] \rightarrow [+\text{contour}] / \_ [-\text{H}]$ $\quad$ $(\text{L} \rightarrow \text{R} / \_ \{\text{L,R}\})$

It is obvious that this theory of tone is wrong because it doesn't express the right generalizations, so what is the alternative?

There was a longstanding intuition that contour tones were in some sense composite tones, where R is simply a combination of L followed by H, and F is a combination of H followed by L. Falling and rising pitch is simply the continuous transition between the higher and lower pitch levels which H and L define. An example of the kind of phonological patterns which were responsible for this intuition is the pattern of tone changes that result from merging vowels between words in Yekhee, illustrated below.

(6)	ídzé élà → ídzélà	'three axes'
	èké élà → èkélà	'three rams'
	údzé òkpá → údzôkpá	'one axe'
	òké òkpá → òkôkpá	'one ram'
	ówà ówà → ówǒwà	'every house'

The combination of H+L results in a falling tone, and L+H results in a rising tone. How can the intuition that fall is H+L and rise is L+H be expressed in the theory?

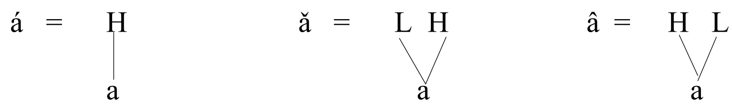
There is little problem in doing this for contour tones on long vowels, since long vowels can be represented as a sequence of identical vowels, so treating a long rising tone as being a sequence of tones is easy.

(7) $\quad$ ǎ: $\quad = \quad$ àá $\quad = \quad$ $\begin{bmatrix} +\text{syllabic} \\ +\text{back} \\ -\text{rd} \\ -\text{H-tone} \end{bmatrix} \begin{bmatrix} +\text{syllabic} \\ +\text{back} \\ -\text{rd} \\ +\text{H-tone} \end{bmatrix}$

The problem is short contour tones. A single vowel cannot be both [–H-tone] and [+H-tone], and feature values cannot be ordered within a segment, but that is what is needed to represent short rising and falling tones.

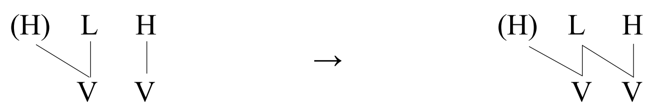
10.1.2 Autosegmental contours

A resolution of this problem was set forth in Goldsmith 1976, who proposed that tones be given an autonomous representation from the rest of the segment, so that regular segments would be represented at one level and tones would be on an another level, with the two levels of representation being synchronized via **association lines**. This theory, known as **autosegmental phonology**, posited representations such as those in (8).

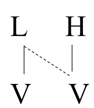
(8) 

This representation of [á] simply says that when the rest of the vocal tract is in the configuration for the vowel [a], the vocal folds should be vibrating at a high rate as befits an H tone. The representation for [ǎ] on the other hand says that while the rest of the vocal tract is producing the short vowel [a], the larynx should start vibrating slowly (produce an L tone), and then change to a higher rate of vibration, to match that specified for an H tone - this produces the smooth increase in pitch which we hear as a rising tone. The representation of [â] simply reverses the order of the tonal specifications.

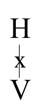
The view which autosegmental phonology takes of rules is different from that taken in the classical segmental theory. Rather than viewing the processes in (2) as being random changes in feature values, autosegmental theory views these operations as being adjustments in the temporal relations between the segmental tier and the tonal tier. Thus the change in (2a) where H becomes rising after L and fall can be expressed as (9). What L and fall have in common, when looking to the left, is that both end with L tone. The change of H to rise is a change from solitary H to a sequence LH – i.e. the L preceding the second vowel encroaches on the domain of the H.

(9) 

By simply adding an association between the L tone element on the left and the vowel which stands to the right, we are able to express this tonal change, without changing the intrinsic feature content of the string: we change only the timing relation between tones and vowels. This is notated as in (10), where the dashed association line means "insert an association line."

(10) 

Two other notational conventions are needed to understand the formulation of autosegmental rules. First, the deletion of an association line is indicated by crossing out the line:

(11) 

Second, an element (tone or vowel) which has no corresponding association on the other tier (vowel or tone) is indicated with the mark [΄], thus, V΄ indicates a toneless vowel and H΄ indicates an H not linked to a vowel.

It is important to be up-front about some "details" of rule formulation in our discussion. Observe that (10) looks for a tonal sequence L H, meaning "L immediately followed by H", each being associated to a vowel (V). But in actual rule-writing practice, this does not mean "a vowel immediately followed by another vowel", it means "the next vowel: ignoring consonants". In a properly-formulated linear theory rule of vowel harmony, the rule is stated as $V_\alpha \rightarrow V_\beta / V_\beta C_0$ __, not $V_\alpha \rightarrow V_\beta / V_\beta$ __ which means "when *immediately* precede by V_β, no consonants allowed". The factual generalization regarding tone rules is that they only operate from vowel to vowel (or perhaps syllable to syllable, but we do not have syllables yet), and they do not care about consonants, except in a special class of rule rule where voiced consonants may play a role in rule application. In the vast majority of cases, tone rules only care about vowels and don't see consonants. The theory of rules presented to this point simply cannot directly express that fact very conveniently. The solution to this problem lies in saying exactly what it is that tones associate to – something above the level of the segment, which we will discuss in chapter 11. For now, we will mostly operate under the formally-mysterious principle that "tones ignore vowels". However, it will be necessary to borrow the notion of syllable (not an alien notion in this book), even though it has yet to be properly motivated or integrated into the theory presented so far.

One striking advantage of the autosegmental model is that it allows us to express this common tonal process of contour formation in a very simple way. The theory also allows each of the remaining processes in (2) to be expressed equally simply - in fact, essentially identically, as involving an expansion of the temporal domain of a tone either to the left or to the right.

(12) H L (=2b)) H L (=2c)) L H (=2d))
V V V V V V

The problem of the natural classes formed by contour tones and level tones was particularly vexing for the linear theory. Most striking was the fact that what constitutes a natural class for contour tones depends on the linear order of the target and conditioning tones. If the conditioning tones stand on the left, then the natural classes observed are {L,F} and {H,R}, and if the conditioning tones stand on the right, then the natural groupings are {L,R} and {H,F}. In all other cases, the groupings of elements into natural classes are independent of whether the target is to the right or the left of the trigger. The autosegmental representation of contour tones thus provides a very natural explanation of what is otherwise a quite bizarre quirk in the concept "natural class."

The autosegmental model also provides a principled explanation for the nonexistence of rules such as (4), i.e. the rules H → F / {L,R} _ and L → R / {H,F} _. The change of H to F after L would involve not just an adjustment in the temporal organization of an L-H sequence, but would necessitate the insertion of a separate L to the right of the H tone, which would have no connection with the preceding L; the change of H to F after R is even worse in that the change involves insertion of L when H is remotely preceded by a L. Thus, the closest that one could come to formalizing such a rule in the autosegmental approach would be as in (13).

(13) L (H) H → L (H) H L
V V V V

As we will discuss in this chapter, autosegmental theory resulted in a considerable reconceptualization of phonological processes, and the idea that rules should be stated as insertions and deletions of association relationships made it formally impossible to express certain kinds of arbitrary actions, such as that of (13).

In addition to the fact that the theory provides a much-needed account of contour tones, quite a number of other arguments can be given for the autosegmental theory of tone. The essential claim of the theory is that the relation between the number of tones in an utterance and the number of vowels is not a one-to-one. A single tone can be associated with multiple vowels, or a single vowel can have multiple tones. Moreover, an operation on one tier, such as the deletion of a vowel, does not entail a corresponding deletion on the other tier. We will look at a number of arguments for the autonomy of tones and the vowels which phonetically bear them in the following sections.

10.1.3 Tone preservation

One very common property exhibited by tones is **stability**, where the deletion of a vowel does not result in the deletion of the tone born by the vowel. Very commonly the tone of a deleted vowel is transferred to the neighboring vowel, often resulting in a contour tone. We have seen an example of this phenomenon in Yekhee, where the combination of an L vowel plus H vowel results in a rising-toned vowel, and H+L gives a falling-toned vowel.
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(14)	òké òkpá → òkôkpá	'one ram'
	ówà ówà → ówǒwà	'every house'

In the autosegmental theory, deletion of a vowel does not directly affect the tone which was associated with it, and as a result, after deletion of the vowel the tone simply remains on the tonal tier with no association with the segmental tier - such an unassociated tone is referred to as a **floating** tone.

(15)
L H L H → LH L H   H L H L → H LH L
o k e o kp a → o k o kp a   o w a o w a → o w o w a

One of the principles proposed in this theory is that all vowels must (eventually) bear some tone, and all tones must be borne by some vowel. This condition is known as the **Well-formedness Condition**. Accordingly, the unassociated tones which resulted from the deletion of a vowel would then be associated with the following vowel, resulting in a falling or rising tone.

(16)
LH L H   H LH L
o k o kp a   o w o w a

The combination of two like-toned vowels, as in the case of *èké élà → èkélà* 'three rams,' brings out another principle of the theory. By the operation of vowel deletion and reassociation of the floating tone, one would expect the following representation.

(17)
L H H L
e k e l a

This would not be distinct from the simple tone melody LHL: (17) says that the vowel *e* should be produced at high pitch at the beginning and at the end, with no other pitches being produced. The **Twin Sister Convention** was proposed as a constraint on the theory, so that such a phonetically indistinguishable representation is formally disallowed.

(18) *Twin Sister Convention*

Adjacent identical tones on one vowel are automatically simplified to one

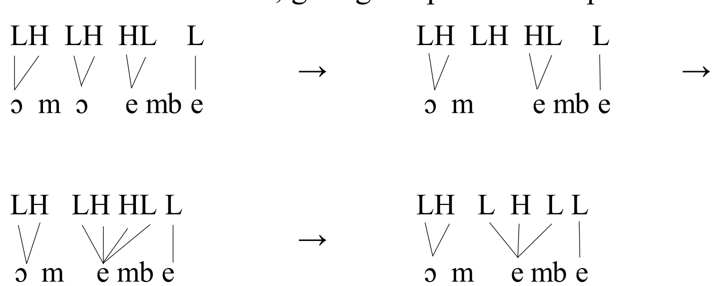
As mentioned before, Autosegmental Phonology not only changed the theory of representations, it brought along a change in perspective on the theory of grammar, by adding numerous universal constraints which facilitate rule-application and narrow the range of possible outputs. Whether this is a good thing to do is still a current matter of debate.

Another illustration of the autosegmental treatment of tone preservation comes from Mongo. When vowels are brought together, either directly in the underlying representation or as the result of deleting certain consonants, the vowel sequence is reduced to a single vowel which preserves all of the component tones of the two vowels. This can result not just in the simple contours R and F, but also in the complex three-tone contours fall-rise (FR) and rise-fall (RF).

(19)	H+H → H	bètámbá béfé	→	bètámbéfé	'two trees'
	L+L → L	là ìtókò	→	lìtókò	'with the fork'
	H+L → F	mpùlú ìnɛ́	→	mpùd^{3}wînɛ́	'these birds'
	L+H → R	là bɔ́nà	→	lɔ̌nà	'with the baby'
	H+F → F	sóngóló ɔ̂tswɛ̀	→	sóngólɔ̂tswɛ̀	'may S. enter'
	H+R → FR	bàlóngá bǎkáé	→	bàlóngã káé	'his blood'
	L+F → RF	fàkàlà ɔ̂tswà	→	fàkàlɔ᷈ tswà	'F. comes in'
	L+R → R	bǎnkò bǎmɔ̌	→	bǎnkǎmɔ̌	'those others'
	R+F → RF	ɔ̌mɔ̌ êmbè	→	ɔ̌mɛ᷈ mbè	'may someone else sing'

The derivation of the last example illustrates how the autosegmental theory explains the pattern elegantly. In this case, the first vowel deletes, causing its two tones to become floating. Those tones are associated with the following vowel by the Well-formedness Conditions. This results in two adjacent H tones on one vowel, which by the Twin Sister Convention reduce to one H, giving the phonetic output.

(20)



The fact that the theory effortlessly handles tri-tonal contours, when the linear theory struggled to handle even two-tone contours, is clear evidence that autosegmental theory is the better theory.

10.1.4 Across-the-board effects

Another phenomenon which argues for the autosegmental representation of tone is across-the-board tone change. An illustration of such a tonal effect can be found in Shona. The examples in (21) show that if a noun begins with some number of H tones, those H's become L when preceded by one of the prefixes *né-, sé-* and *ché.*

(21)	*N*	*with N*	*like N*	*of N*	
	mbwá	né-mbwà	sé-mbwà	ché-mbwà	'dog'
	hóvé	né-hòvè	sé-hòvè	ché-hòvè	'fish'
	mbúndúdzí	né-mbùndùdzì	sé-mbùndùdzì	ché-mbùndùdzì	'army worm'
	hákátà	né-hàkàtà	sé-hàkàtà	ché-hàkàtà	'bones'
	bénzíbvùnzá	né-bènzìbvùnzá	sé-bènzìbvùnzá	ché-bènzìbvùnzá	'fool'

As shown in (22) and by the last example of (21), an H tone which is not part of an initial string of H's will not undergo this lowering process.

(22)	*N*	*with N*	*like N*	*of N*	
	mùrúmé	né-mùrúmé	sé-mùrúmé	ché-mùrúmé	'man'
	bàdzá	né-bàdzá	sé-bàdzá	ché-bàdzá	'hoe'

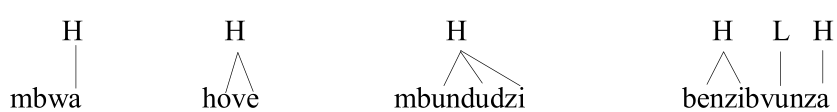
The problem is that if we look at a word such as *mbúndúdzí* as having three H tones, then there is no way to apply the lowering rule to the word and get the right results. Suppose we apply the following rule to a standard segmental representation of this word.

(23)	V	$\rightarrow$ [–H]/	se, ne, che _
	[+H]		[+H]

Beginning from /né-mbúndúdzí/, this rule would apply to the first H-toned vowel giving *né-mbùndúndzí.* However, the rule could not apply again since the vowel of the second syllable is not immediately preceded by the prefix which triggers the rule. And recall from examples such as *né-mùrúmé* that the rule does not apply to noninitial H tones.

This problem has a simple solution in autosegmental theory, where we are not required to represent a string of *n* H-toned vowels as having *n* H tones. Instead, these words can have a single H tone which is associated with a number of vowels.

(24)



Given these representations, the tone-lowering process will only operate on a single tone, the initial tone of the noun, but this may be translated into an effect on a number of adjacent vowels.

(25)
L L L L L H
mbwa hove mbundudzi benzibvunza

There is a complication in this rule which gives further support to the autosegmental account of this process. Although this process lowers a string of H tones at the beginning of a noun, when one of these prefixes precedes a prefixed structure, lowering does not affect every initial H tone. When one prefix precedes another prefix which precedes a noun with initial H's, the second prefix has an L tone and the noun keeps its H tones.

(26)	*N*	*of N*	*like of N*	
	mbúndúdzí	ché-mbùndùdzì	sé-chè-mbúndúdzí	'army worm'
	hákátà	ché-hàkàtà	sé-chè-hákátà	'bones'

However, if there are three of these prefixes, the second prefix has an L tone, and lowering also affects the first (apparent) string of tones in the noun.

(27)	sé-nè-ché-mbùndùdzì	'like with of army worm'
	sé-nè-ché-hàkàtà	'like with of bones'

A simple statement like "lower a sequence of adjacent H toned vowels" after an H prefix would be wrong, as these data show. What we see here is an alternating pattern that counts tones, not the vowels which realize them, a result which follows automatically from the rule that we have posited and the autosegmental theory of representations. Consider the derivation of a form with two prefixes.

(28)
H H H → H L H
se-che-mbundudzi → se-che-mbundudzi

The lowering of H on *che* gives that prefix an L tone, and therefore that prefix cannot then cause lowering of the H's of the noun. On the other hand, if there are three such prefixes, the first H-toned prefix causes the second prefix to become L, and that prevents prefix 2 from lowering prefix 3. Since prefix 3 keeps its H tone, it therefore can cause lowering of H in the noun.

(29)
H H H H → H L H L
se-ne-che-mbundudzi → se-ne-che-mbundudzi

Thus it is not simply a matter of lowering the tones of any number of vowels. Unlike the traditional segmental theory, the autosegmental model provides a very simple and principled characterization of these patterns of tone lowering.

10.1.5 Melodic patterns

Another phenomenon which supports the autonomy of tones and segments is the phenomenon of melodic tonal restriction. In some languages, there are restrictions on the possible tones of words, irrespective of the number of vowels in the word. Mende is an example of such a language. Although this language has H, L, rising, falling and rise-falling tones, the distribution of those tones in words is quite restricted. Words can be analyzed as falling into one of five tone melodies, illustrated in (30).

(30)	H	háwámá 'waist', pɛ́lɛ́ 'house,' kɔ́ 'war'
	L	kpàkàlì 'three-legged chair', bɛ̀lɛ̀ 'trousers,' kpà 'debt'
	HL	félàmà 'junction', kényà 'uncle', mbû 'owl'
	LH	ndàvúlá 'sling', fàndé 'cotton', mbǎ 'rice'
	LHL	nìkílì 'groundnut,' nyàhâ 'woman,' mbȁ 'companion'

If tones were completely unrestricted, then given five surface tones, one would predict twenty-five patterns for bisyllabic words and 125 patterns for trisyllabic words. Instead, one finds five patterns no matter how many vowels there are.

(31)	LHL	L H L	LH L
	nikili	nyaha	mba

This distribution can be explained if the restriction is simply stated at the level of the tonal representation: the tone pattern must be one of H, L, LH, HL or LHL. As seen in (31), given an autosegmental representation of tone, *nìkílì, nyàhâ,* and *mbȁ* all have the same tonal representation.

10.1.6 Floating tones

Another tonal phenomenon which confounds the segmental approach to tone, but which is handled quite easily with autosegmental representations, is the phenomenon of floating tones, which are tones not linked to a vowel.

Anlo tone. The Anlo dialect of Ewe provides one example. The data in (32) illustrate some general tone rules of Ewe. Underlyingly the noun 'buffalo' is /ētō/, with M tone on its two vowels. However, it surfaces as [ètò] with L tones, either phrase-finally or when the following word has an L tone.

(32)	ètò	'buffalo'	ètò mè	'in a buffalo'
	ētō φēφlē	'buffalo-buying'	ētō djí	'on a buffalo'
	ētō mēgbé	'behind a buffalo'		

These alternations are explained by two rules; one rule lowers M (mid) to L at the end of a phrase, and the second assimilates M to a following L.

(33) $M \rightarrow L$ / __ ## $\qquad$ $M \rightarrow L$ / __ L

Thus in the citation form, /ētō/ first becomes *ētò*, then [ètò].

Two other tone rules are exemplified by the data in (34).

(34)	ètó	‘mountain’	ètó djí	‘on a mountain’
	ètő me̋gbé	‘behind a mountain’		

Here, we see a process which raises M to Superhigh tone (SH) when it is surrounded by H tones; subsequently a nonfinal H tone assimilates to a preceding or following SH tone.

(35) M → SH / H _ H H → SH% SH _

We know from *ētō mēgbé* ‘behind a buffalo’ that *mēgbé* has the tones MH. Therefore, the underlying form of *ètő me̋gbé* ‘behind a mortar’ is *ètó mēgbé.* The underlying form is subject to the rule raising M to SH since the M is surrounded by H tones, giving *ètó me̋gbé.* This then undergoes the SH assimilation rule. Another set of examples illustrating these tone processes is (36), where the noun /àtjíkē/ ends in the underlying sequence HM. When followed by /mēgbé/, the sequence HMMH results, so this cannot undergo the M-raising rule. However, when followed by /dyí/, the M-raising rule applies to /kē/, giving a SH tone, and the preceding syllable then assimilates this SH.

(36)	àtjíkè	‘root’	àtjíkē φēφlē	‘root-buying’
	àtjíkē mēgbé	‘behind a root’	àtjíke̋ djí	‘on a root’

There are some apparently problematic nouns which seem to have a very different surface pattern. In the citation form, the final M tone does not lower; when followed by the MM-toned participle /φēφlē/, the initial tone of the participle mysteriously changes to H; the following L-toned postposition *mè* inexplicably has a falling tone; the postposition /mēgbé/ mysteriously has an initial SH tone.

(37)	ētō	‘mortar’	ētō φēφlē	‘mortar-buying’
	ētō mê	‘in a mortar’	ētō djí	‘on a mortar’
	ētō me̋gbé	‘behind a mortar’		

All of these mysteries are resolved, once we recognize that this noun actually does not end with an M tone, but rather it ends with a H tone which is not associated with a vowel, thus the underlying form of the noun ‘mortar’ is (38).

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(38)   e t o
       |   |
       M   M  H
```

Because this noun ends in a (floating) H tone and not an M tone, the rule lowering prepausal M to L does not apply, which explains why the final tone does not lower. The floating H at the end of the noun associates with the next vowel if possible, which explains the appearance of an H on the following postposition as a falling tone (when the postposition is monosyllabic) or level H (when the next word is polysyllabic). Finally, the floating H serves as one of the triggering tones for the rule turning M into SH, as seen in *ētō me̋gbé.* The hypothesis that this word (and others which behave like it) ends in a floating H tone thus provides a unified explanation for a range of facts that would otherwise be inexplicable. However, the postulation of such a thing as a “floating tone” is possible only assuming the autosegmental framework, where tones and featurs are not necessarily in a one-to-one relation.

Mixtec. Another example of floating tones can be seen in the language Mixtec. As (39) indicates, some words such as *kēē* ‘will eat’ have no effect on the tone of the following word, but other words such as the apparently homophonous verb meaning ‘will go away’ cause the initial tone to become H.

(39)	sùt^{ʃ}í	‘child’	kēē	‘will go away’
	kōò	‘snake’		
	kēē	‘will eat’		
	kēē sùt^{ʃ}í	‘the child will eat’	kēē sút^{ʃ}í	‘the child will go away’
	kēē kōò	‘the snake will eat’	kēē kóò	‘the snake will go away’

A similar effect is seen in (40), where *tàká* ‘all’ has no effect on the following word, but *máá* ‘that’ causes raising of the initial tone of the next word.

(40)	tàká sùt^{ʃ}í	‘all the children’	máá sút^{ʃ}í	‘that child’
	tàká bēʔē	‘all the houses’	máá béʔē	‘that house’
	tàká kōò	‘all the snakes’	máá kóò	‘that snake’
	tàká mìnī	‘all the puddles’	máá mínī	‘that puddle’

These data can be explained very easily if we assume the following underlying representations.

(41)	MM	MMH	L H	HH H
	k e e	k e e	t a k a	m a a
	‘will eat’	‘will go away’	‘all’	‘that’

When a word ending in a floating H tone, such as ‘will go away’ or ‘that’, is followed by another word, that H associates to the first vowel of the next word and replaces the initial lexical tone. When there is no following word, the floating tone simply deletes.

Gã. Other evidence for floating tones comes from Gã. Some of the evidence for floating L tone in this language involves the phenomenon of “downstep”, which is the contrastive partial lowering of the pitch level of tones at a specified position. Downstep is exemplified in Gã with the words [kɔ̀tɔ́kɔ̀] ‘porcupine’, [ònű̃fű̃] ‘snake’ and [átáꜝtú] ‘cloud’. In ‘porcupine’, the syllable [tɔ́] has H and the following syllable [kɔ̀] has L – the physical pitches are maximally separate. The second and third syllables of ‘snake’ are both H and are not physically distinct – they are produced at the same pitch, at the top of the voice range. In the third example, the syllable [tá] has the same high pitch that all of the second syllables of these words have, and the following syllable, which is phonologically H toned, has a pitch physically between that of the L toned syllable of [kɔ̀tɔ́kɔ̀] and the H toned syllable of [ònű̃fű̃]. What happens here is that the pitch range of all tones is lowered after the second syllable of [átáꜝtú], even those of a following word. This lowering of pitch range, notated with “ꜝ”, is known as “downstep”. A floating L between H tones is what in fact generally causes downstep.

In Gã, there is a rule changing the tone sequence HL before pause into HꜝH. The operation of this rule can be seen in the data of (42), where the presence of the future tense prefix -*bàá-* causes a change in the tone of final L-toned verbs with the shape CV (the unmodified tone of the root is seen in the 3sg past form).

(42)	*3sg past*	*3sg future*	
	è-t^{ʃ}à	è-bàá-ꜝt^{ʃ}á	'dig'
	è-d^{ʒ}ò	è-bàá-ꜝd^{ʒ}ó	'dance'
	è-gbè	è-bàá-ꜝgbé	'kill'
	è-kpɛ̀	è-bàá-ꜝkpɛ́	'sew'
	è-ʃɔ̃̀	è-bàá-ꜝʃɔ̃́	'pull'
	è-tũ̀	è-bàá-ꜝtṹ	'jump'
	è-wò	è-bàá-ꜝwó	'wear'

The necessity of restricting this rule to HL before pause is demonstrated by examples such as *èbàágbè Àkò* 'he will kill Ako,' *èbàákpɛ̀ àtààdé* 'he will sew a shirt,' *èbàáʃɔ̃̀ kpàŋ* 'he will pull a rope.' In such examples, the tone sequence is not prepausal, and the underlying L is retained in phrase-medial position, whereas the verb has ꜝH tone in prepausal position in (42).

The restriction to applying just to prepausal HL also explains why verbs with long vowels or two syllables do not undergo this alternation: the L-toned syllable that comes after the H is not also at the end of the phrase, since another L tone follows it.

(43)	*3sg past*	*3sg future*	
	è-gbɔ̀	è-bàá-gbɔ̀ɔ̀	'hunt'
	è-hàò	è-bàá-hàò	'worry'
	è-sɔ̀ɔ̀	è-bàá-sɔ̀ɔ̀	'catch'
	è-sɔ̀lè	è-bàá-sɔ̀lè	'pray'
	è-hàlà	è-bàá-hàlà	'chose'

A further restriction is that this rule does not apply to tense-inflections on verbs, for example the plural imperative -*à* (*ɲɛ̃́-hé-à* 'buy (pl)!') or the habitual -*ɔ̀* (*è-mã̀d^{ʒ}é-ɔ̀* 'he sends').

A second relevant rule of Gã is Plateauing, whereby HLH becomes HꜝHH. This can be seen in (44) involving verbs with final HL. If the following word begins with L tone, the final L of the verb is unchanged. When the following object begins with a H tone, the resulting HLH sequence becomes HꜝHH by the Plateauing rule.

(44)	ɲɛ̃́-hé-à	'buy (pl)!'
	ɲɛ̃́-hé-ꜝá tṹ	'buy (pl) a gun!'
	ɲɛ̃́-hé-à fɔ̀	'buy (pl) oil!'
	è-mã̀d^{ʒ}é-ɔ̀ àkò	'he sends Ako'
	è-mã̀d^{ʒ}éꜝɔ́ ákú	'he sends Aku'

ḿŋ̀gbè kwàkwɛ́	'I am killing a mouse'
ḿŋ̀ꜜgbé fótè	'I am killing a termite'

In these examples, the rule changing prepausal HL to HꜜH does not apply to the verb in citation form because the L tone is in a tense suffix.

This rule also applies within words, when the verb stem has the underlying tone pattern LH and is preceded by an H-toned prefix, such as the future prefix.

(45)	*3sg past*	*3sg future*	
	è-hùlú	è-bàáꜜ-húlú	'jump'
	è-kàsé	è-bàáꜜ-kásé	'learn'
	è-kòd³ó	è-bàáꜜ-kód³ó	'judge'
	è-mȁd³é	è-bàáꜜ-mã́d³é	'send'

Again, by the Plateauing rule, /è-bàá-hùlú/ becomes [è-bàáꜜ-húlú].

There are a number of areas in the language where floating tones can be motivated. The perfective tense provides one relevant example. Consider the data in (46), which contrasts the form of the subjunctive and the perfective. Segmentally these tenses are identical: their difference lies in their tone. In both tenses the subject prefix has an H tone. In the perfective, the rule affecting prepausal HL exceptionally fails to apply to an L toned CV stem, but in the subjunctive that rule applies as expected.

(46)	*3sg subjunctive*	*3sg perfective*	
	é-ꜜtʃá	é-tʃà	'dig'
	é-ꜜd³ó	é-d³ò	'dance'
	é-ꜜgbé	é-gbè	'kill'
	é-ꜜkpɛ́	é-kpɛ̀	'sew'
	é-ꜜʃɔ̃́	é-ʃɔ̃̀	'pull'
	é-ꜜwó	é-wò	'wear

You might think that the perfective is an exception to the general rule turning HL into HꜜH, but there is more to it.

Another anomaly of the perfective is that the Plateauing rule fails to apply between the verbs of (46) and the initial H tone of a following word, even though the requisite tone sequence is found.

(47)		
	é-gbè ákú	'he has killed Aku'
	é-ʃɔ́ gúꜜgɔ̃́	'he has pulled a nose'
	é-wò d³wɛ́ꜜɛ́	'he has worn grass'

The failure of both the HL → HꜜH rule and the Plateauing rule can be explained by positing that the perfective tense is marked by a floating L tone which comes between the subject prefix and the verb stem; thus the phonological representation of perfective *é-wo* would be (48), and we can identify a L tone which has no assciated vowel as being the morpheme marking the perfective.

(48)
```
H  L   L
|      |
e  -  wo
```

The floating L between the H and the L of the root means that the H is not next to the prepausal L, and therefore the rule changing HL into HꜜH cannot apply. In addition, the presence of this floating L explains why this verb form does not undergo Plateauing. Thus two anomalies are explained by the postulation of a floating L tone.

Other examples of the failure of the Plateauing rule in this tense can be seen below. The examples from the simple past show that these verb roots underlyingly have the tone pattern LH, which surfaces unchanged after the L-toned subject prefix used in the simple past. The subjunctive data show that these stems do otherwise undergo Plateauing after an H-toned prefix; the perfective data show that in the perfective tense, Plateauing fails to apply within the word, because of the floating L of the perfective

(49)	*3sg past*	*3sg subjunctive*	*3sg perfective*	
	è-hùlú	éꜜ-húlú	é-hùlú	'jump'
	è-kàsé	éꜜ-kásé	é-kàsé	'learn'
	è-kòdʒó	éꜜ-kódʒó	é-kòdʒó	'judge'
	è-mã̀dʒé	éꜜ-mã́dʒé	é-mã̀dʒé	'send'

Again, these facts can be explained by positing a floating L tone in the perfective tense: that L means that the actual tone sequence is HLLH, not HLH, so Plateauing would simply not be applicable to that tone sequence.

(50)
```
H L L H
|    | |
e -  hulu
```

Finally, the postulation of a floating L as the marker of the perfective explains why a downstep spontaneously emerges between the subject prefix and a stem-initial H tone in the perfective, but not in the subjunctive.

(51)	*3sg past*	*3sg subjunctive*	*3sg perfective*	
	è-bé	é-bé	éꜜ-bé	'quarrel'
	è-tʃṹ	é-tʃṹ	éꜜ-tʃṹ	'send'
	è-dṹ	é-dṹ	éꜜ-dṹ	'cultivate'
	è-fó	é-fó	éꜜ-fó	'weep'
	è-fɔ́té	é-fɔ́té	éꜜ-fɔ́té	'pour'
	è-dʒálé	é-dʒálé	éꜜ-dʒálé	'rinse'

Thus the postulation of a floating tone as the marker of the perfective explains a number of anomalies: insofar as floating tones have a coherent theoretical status in autosegmental phonology but not in the linear theory, they provide strong support for the correctness of the autosegmental model.

10.1.7 Tonal morphemes

Another example of the kind of dissynchrony between tones and vowels which is explained by the autosegmental model is the tonal morpheme, where a particular morpheme is expressed solely as a tone - this is a variant of the problem of floating tones. One such example is the expression of case marking and the marking of modified nouns in Angas. When a noun is case marked in Angas (when it is at the end of the subject or object NP, for example), case marking is indicated with a suffixed floating H which links to the final vowel, forming a rising tone if the final tone of the noun is M or L. When a noun is followed by an adjective in its phrase, that fact is marked by the suffixation of a floating L tone, which forms a falling contour tone when the last tone is M or H.

(52)	téŋ	'rope'	téŋ	'rope (case)'	têŋ	'rope (modified)'
	mús	'cat'	mús	'cat (case)'	mûs	'cat (mod.)'
	t^{ʃ}én	'hoe'	t^{ʃ}én	'hoe (case)'	t^{ʃ}ên	'hoe (mod.)'
	ɲí	'elephant'	ɲí	'elephant(case)'	ɲî	'elephant (mod.)'
	ʔās	'dog'	ʔā́s	'dog (case)'	ʔā̀s	'dog (mod.)'
	ʒwāl	'boy'	ʒwā́l	'boy (case)'	ʒwā̀l	'boy (mod.)'
	ɟēm	'child'	ɟḗm	'child (case)'	ɟḕm	'child (mod.)'
	màs	'locust bean'	mǎs	'bean (case)'	màs	'bean (mod.)'
	pùk	'soup'	pǔk	'soup (case)'	pùk	'soup (mod.)'
	ʔàs	'tooth	ʔǎs	'tooth (case)'	ʔàs	'tooth (mod.)'
	d^{ʒ}ólì	'ape'	d^{ʒ}ólǐ	'ape (case)'	d^{ʒ}ólì	'ape (mod.)'

Tiv is another language with morphemes being marked by tone, in this case verbal tense-aspect. Verb roots in Tiv lexically have either an H tone or an L tone on the first syllable of the root. The general past tense is marked with a floating L tone; the past habitual with a H; the recent past with the tone sequence HL.

(53)	H verbs		L verbs	
	General past (L)			
	vá	'come'	d^{z}à	'go'
	úngwà	'hear'	vèndè	'refuse'
	jévèsè	'flee'	ngòhòrò	'accept'
	Past habitual (H)			
	vá		d^{z}á	

úngwá	vèndé
jévésé	ngòhóró
Recent past (HL)	
vá	d^{z}á
úngwá	vèndé
jévésè	ngòhórò

In addition to showing the effects of various floating tone morphemes which mark tense-aspect, these data illustrate the application of a contour-simplification rule. We now consider how representative forms are derived. The concatenation of the L root *ngohoro* and the recent past morpheme gives the following underlying form:

(54)   L   H L

ngohor

These tones must be assigned to the vowels of the stem: we can see that the first tone links to the first free vowel and the second tone links to the second free vowel. This is an instance of **one-to-one left-to-right mapping.**

(55) Link free tones to free vowels, one-to-one, from left to right

This process is so common that it had been thought that it is actually a universal convention on free tones - we now know, since languages have been discovered which do not obey this condition - that it is a language-specific rule, though a very common one. Application of this rule to (54) gives the surface form.

Now consider the disyllabic L root *vèndé.* This root has two vowels but three tones. If all of the tones were to be associated with the vowels of the root, this would force the final syllable to bear the tone sequence HL, i.e. it would have a falling tone. We can see that there are no contour tones in the data. This leaves us with two possibilities in accounting for *vèndé*: either the rule associating floating tones with vowels simply does not link a floating tone with a vowel that already has a tone, or floating tones do associate with vowels that already bear a H and then some later rule eliminates tonal contour tones. If we assume that floating tones are all initially associated with a vowel and contours are later eliminated, we will require the following rule, which deletes the L-tone component of a falling tone.

(56)   H L → Ø

V

Finally, we come to /dzà/, which has H if one of the floating tone patterns H or HL is added to the root. This can be explained if floating tones are associated with root vowels even when this would result in a contour tone. Linking the melodic tones to this root would result in the following representation:

(57)   L H L

dza

Rule (56) applies in a mirror-image fashion: it deletes L in combination with an H on one vowel, standing before or after the H. This explains why the lexical L is replaced with an H. Under the alternative account, that floating tones only link to vowels which do not have any other tone, we would be unable to explain why the lexical L is replaced by H when a melodic pattern with an H tone is added.

10.1.8 Toneless vowels

Another phenomenon demonstrating the independence of tones and vowels is the existence of underlyingly toneless vowels. This can be illustrated with data from Margyi. There are two tones in Margyi, H and L, but there are three underlying types of vowels in terms of tonal behavior, namely H, L, and toneless. Examples of underlyingly toneless morphemes are /ɗəl/ 'buy' /skə/ 'wait' and /na/ 'away.' When two morphemes with underlying tones are combined, there are no surface tone changes. However, when one of the toneless morphemes is combined with a morpheme with tone, the toneless morpheme takes on the tone of the tone-bearing morpheme.

(58)	tá + bá → tábá	'to cook all'
	ndàl + bá → ndàlbá	'to throw out'
	ɗəl + bá → ɗə́lbá	'to buy'
	ná + ɗà → náɗà	'give me'
	hərì + ɗà → hərɗà	'bring me'
	skə + ɗà → skə̀ɗà	'wait for me'
	tá + na → táná	'to cook and put aside'
	ndàl + na → ndàlnà	'to throw away'
	ɗəl + na → ɗə̀lnà	'to sell'

As (59) indicates, this can be accounted for by spreading tone (i.e. adding associations between tone and vowels) to toneless vowels.

(59)
H
ɗəl + ba

H
ta + na

L
ndal + na

The form *ɗə̀l-nà* 'to sell,' which combines two toneless morphemes, illustrates another property of tone systems. Since all vowels must on the surface have some tonal specification, the following question arises: if there is no tone present in the string which could spread to toneless vowels, how do toneless vowels get their surface tone? The answer is that there are also rules of **default tone assignment,** which guarantee that if a vowel does not otherwise have a tone value, one is automatically assigned. Such a rule can be formalized as (60).

(60)
$$V' \rightarrow \begin{array}{c} L \\ | \\ V \end{array}$$

Generally, in languages with two levels of tone, the default value assigned to otherwise toneless vowels is L; in languages with three tone levels, the default tone specification is usually M tone. Yoruba is a language with three tone levels, where it can be argued that M-toned vowels are actually underlyingly toneless, and M tones are assigned by a default tone-assignment rule. The examples in (61) illustrate a very general tone-spreading rule whereby L tone becomes falling after H, and H tone becomes rising after L. However, M is unchanged after either L or H, and M also has no effect on a following L or H.

(61)	kò pɔ́	'it is not plentiful'	kò dũ̀	'it is not sweet'
	ó pɔ̂	'it is plentiful'	ó dũ̂	'it is sweet'
	ɛ̀kɔ̂	'lesson'	ɔ̀bɔ̄	'monkey'
	ɔ̀fɔ̀	'mourning'	gígā	'height'
	īʃé	'work	ēd^{3}ò	'snake'

The question is how to exclude M tone from being targetted by this rule, and how to prevent M tone from spreading. If we assume that tonally unspecified vowels are assigned an M tone by default, and that M tones in Yoruba derive only from application of this default specification rule, then we can explain these patterns rather simply. We can assume the following tone-spreading rule, where T represents any tone.

(62)
```
T    T
|  ⋱ |
V    V
```

The fact that contours are not formed with M tone follows from the fact that a contour is two tone specifications on one vowel, plus the hypothesis that M tone is only assigned if there is no tonal specification on a vowel.

From the fact that under an autosegmental analysis vowels need not have any tone associated to them, and the fact that in many languages like Yoruba one of the tones behaves like it is "not there", gave rise to (resurrected) a more general notion of featural "underspecification", which we discuss in §10.3.

10.1.9 Tonal mobility

The final demonstration of the autonomy of tone from segments is the tone mobility, which is the fact that tones can move about from vowel to vowel quite easily, in a fashion not shared with segmental properties. One example of tonal mobility comes from Nkore, seen in (63). This language has an underlying contrast between words whose last syllable is H toned, and those whose penultimate syllable is H toned. In prepausal position, underlyingly final H tones shift to the penultimate syllable, thus neutralizing with nouns having an underlyingly penult H. When some word follows the noun, the underlying position of the H tone is clearly revealed.

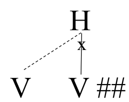
(63) *Nouns with penult H*

òkùgúrù	'leg'	òkùgúrù kùrùùnjì	'good leg'
òmùkózì	'worker'	òmùkózì mùrùùnjì	'good worker'
èmbúzì	'goat'	èmbúzì nùùnjì	'good goat'
èchìkópò	'cup'	èchìkópò chìrùùnjì	'good cup'

èmbíbò	‘seeds’	èmbíbò nùùnjì	‘good seeds’
Nouns with final H			
òmùgúzì	‘buyer’	òmùgùzí mùrùùnjì	‘good buyer’
òmùkámà	‘chief	òmùkàmá mùrùùnjì	‘good chief
èémbwà	‘dog’	èèmbwá nùùnjì	‘good dog’
òbúrò	‘millet’	òbùró bùrùùnjì	‘good millet’
kàsúkù	‘parrot’	kàsùkú nùùnjì	‘good parrot’

There are a number of reasons internal to the grammar of Nkore for treating L tone as the default tone, and for only specifying H tones in the phonology so that phonetically L-toned vowels are actually toneless. This alternation can be accounted for by the following rule of tone-throwback.

(64)



Another example of tone shift can be seen in Kikuyu. Like Nkore, there are good reasons to analyze this language phonologically solely in terms of the position of H tones, with vowels not otherwise specified as H being realized phonetically with a default L tone. We will follow the convention adopted in such cases as marking H-toned vowels with an acute accent, and not marking toneless (default L) vowels.

Consider the Kikuyu data in (65), illustrating the current habitual tense. The first two examples in (65a) would indicate that the morphemes *to*-, *-rɔr-, -aγ-,* and *-a* are all toneless. The third example, however, shows the root *rɔr* with an H tone: this happens only when the root is preceded by the object prefix *ma.* In (65b), we see that – in contrast to what we see in (65a) – the habitual suffix *-aγ-* has an H tone when it is preceded by the root *tom* (which is itself tone-less on the surface). As with (65a), the syllable that follows *ma* has an H tone.

(65) a. to -rɔr-aγ -a — ‘we look at’

we-look at-hab-tense

to -mo -rɔr -aγ -a — ‘we look at him’

we-him-look at-hab-tense

to -ma -rɔ́r -aγ -a — ‘we look at them’

we-them-look at-hab-tense

b. to-tom-áγ-a — ‘we send’

to-mo-tom-áγ-a — ‘we send him’

to-ma-tóm-áγ-a — ‘we send them’

It is clear, then, that certain syllables have the property of causing the following syllable to have a surface H tone. This is further demonstrated in (66), where the derivational suffixes *-er-* and *-an-* follow the roots *-rɔr-* and *-tom-*: we can see that the syllable after *-tom* always receives an H tone.

(66) to-rɔr-er-aɣ-a 'we look for'
to-tom-ér-aɣ-a 'we send for'
to-rɔr-an-aɣ-a 'we look at each other'
to-tom-án-aɣ-a 'we send each other'
to-rɔr-er-an-aɣ-a 'we look for each other'
to-tom-ér-an-aɣ-a 'we send for each other'

Further examples of this phenomenon are seen in the examples of the recent past in (67). In (67a), the root *rɔr* (which generally has no H tone) has an H tone when it stands immediately after the recent-past-tense prefix -*a*-; or, the object prefix that follows -*a*- will have a surface H tone. The examples in (67b) show the same thing with the root -*tom*- which we have seen has the property of assigning an H tone to the following vowel.

(67) a. to-a-rɔ́r-a 'we looked at'
to-a-mó-rɔr-a 'we looked at him'
to-a-má-rɔ́r-a 'we looked at them'
b. to-a-tóm-á 'we sent'
to-a-mó-tom-á 'we sent him'
to-a-má-tóm-á 'we sent them'

We would assume that the root -*tóm*- has an H, as do the object prefix -*má*- and the tense prefix -*a*-, and this H tone is subject to the following rule of tone shift, which moves every H tone one vowel to the right.

(68) H
x
V V

Thus, /to-tóm-er-aɣ-a/ becomes *totoméraɣa*, /to-má-rɔr-aɣ-a/ becomes *tomarɔ́raɣa,* and /to-á-má-tóm-a/ becomes *toamátómá.*

(69) H H H
x x x
t o a m a t o m a

An even more dramatic example of tone shifting comes from Digo. In this language, the last H tone of a word shifts to the end of the word. The root *vugura* is toneless, as is the object prefix *ni*, but the object prefix *a* 'them' has an underlying H tone, which is phonetically realized on the last vowel of the word. Similarly, the root *togora* is toneless, as is the subject prefix *ni*, but the third-singular subject prefix *a* has an H tone, which shifts to the end of the word. Lastly, the root *t͡ˢukura* is toneless, as is the tense-aspect prefix -*na*-, but the perfective prefix *ka* has an H tone which shifts to the last vowel of the word.

(70) a. ku-vugura 'to untie' ku-vugurira 'to untie for'
ku-ni-vugurira 'to untie for me' ku-a-vugurirá 'to untie for them'
b. ku-togora 'to praise' ni-na-togora 'I'm praising'

a-na-togorá	‘he’s praising’		
c. ku-t^{s}ukura	‘to carry’	ni-na-t^{s}ukura	‘I’m carrying’
a-na-t^{s}ukurá	‘he’s carrying’	ni-ka-t^{s}ukurá	‘I have carried’

These data can be accounted for by a rule of tone shift which is essentially the same as the Kikuyu rule, differing only in that the tone shifts all the way to the end of the word.

(71) H
V ... V#

10.2 Autosegmental tone analyses

To recapitulate the main ideas of Autosegmental Phonology applied to tone, the theory primarily differs from SPE-style linear phonology by subdividing representations into parallel tiers of segments and tones, with association relations between the elements of these tiers. In linear phonology, a representation with *N* segments has exactly *N* specifications for each of the features, but in Autosegmental Phonology the number of elements on the tonal and segmental tiers can differ – vowels may share a tone or have no tones, a vowel may have multiple ordered tones, and tones can exist without being on any specific vowel (“floating tones”). Autosegmental rules are reconceptualized as manipulating the association relations between vowels and segments, not just as changing features values of individual segments.

To firm up your understanding of phonological analysis using Autosegmental Phonology, we work through an analysis of tone alternations in Kerewe. (72) provides basic examples of prefixes and suffixes: *ku*- ‘infinitive’, *bal*- ‘count’, -*il*- ‘for’, -*an*- ‘each other’, -*a* ‘tense inflection’. The root *bal*- has no H tone, so all vowels in the verb are toneless (unmarked). One could also mark all vowels lacking acute accent with a grave accent, but this provides no advantage, and would obscure the fact that the language operates more on the basis of H versus nothing. We will, however, see specific evidence bearing on the question whether L tones play any role in the phonology of Kerewe.

(72)	kubala	‘to count’
	kubalila	‘to count for’
	kubalana	‘to count each other’
	kubalilana	‘to count for each other’

These morphemes are also found in (73), using the root *lás*- which has a lexical H tone. We observe that the following vowel is H toned under certain circumstances. For example -*il*- and -*an*- become H toned after *las*-, but final -*a* does not.

(73)	kulása	‘to throw at’
	kulásíla	‘to throw at for’
	kulásána	‘to throw at each other’
	kulásílana	‘to throw at for each other’

The examples in (74) clarify why -*a* seems to be an exception: it *does* receive H tone after *lás*-, provided that a word follows the verb.

(74)	kubala bulemo	‘to count Bulemo’
	kubalila bulemo	‘to count for Bulemo’
	kulásá bulemo	‘to throw at Bulemo’
	kulásíla bulemo	‘to throw at for Bulemo’

All of these facts fall under one simple generalization, that if an toneless vowel follows a H vowel (therefore is not at the end of the utterance), it becomes H toned.

(75) provides another class of morphemes which cause H to spread to the right. We see here a variety of lexically toneless verb roots, and when an object prefix such as *bá-, tú-, bú-* precedes the verb, H spreads to the right from the prefix.

(75)	kubala	‘to count’
	kubábála	‘to count them (cl. 2)’
	kusakaalila	‘to thatch for’
	kutúsákaalila	‘to thatch for us’
	kusja	‘to grind’
	kubúsja	‘to grind it (cl. 14)’

This rule is formalized in (76).

(76) H *Rightward Spread*

V V V

(77) provides examples of toneless and toned stems of a single syllable, at the end of the utterance versus when followed by another vowel. The lexically H verb has H on the one stem vowel as well as the preceding vowel, but only when it is at the end of the utterance. Otherwise, the H spreads from the verb into the following word (by Rightward Spreading).

(77)	kumwa	‘to shave’
	kútá	‘to release’
	kumwa bulemo	‘to shave Bulemo’
	kutá búlemo	‘to release Bulemo’

Starting from the underlying form /ku-tá/, the presence of H on the infinitive prefix can be accounted for by a rule spreading H at the end of an utterance to the preceding vowel. In this rule, ## means “end of the utterance”.

(78) H *Leftward Spread*

V V ##

More examples of the Leftward Spread rule are in (79) with nouns which end with H, alongside examples of Rightward Spread from the noun to a following word.

(79)	amátá	'milk'
	meengi	'much (cl. 6)'
	amatá méengi	'much milk'
	amází	'feces'
	ganu	'these (cl. 6)'
	amazí gánu	'these feces'
	ekíkó	'elbow'
	kileehi	'long (cl. 7)'
	ekikó kíleehi	'long elbow'

By Leftward Spread (78), /amatá/ becomes *amátá*, and by Rightward Spread (76) /amatá meengi/ becomes *amatá méengi*. Another example of Leftward Spread is in (80). The modifier *kí* is monosyllabic and ends with H, therefore when it is prepausal, its H spreads leftward to the preceding word.

(80)	omugela	'river'
	omugelá kí	'which river'
	kubala	'to count'
	kubalá kí	'to count what'

Above, we noted examples of object prefixes which have H, a tone which spreads to the root-initial syllable when a toneless verb stem follows. When the verb stem is lexically H toned, we also find a H on the object prefix and the following vowel. Note that we find a second H *only* on the vowel immediately following the object prefix.

(81)	kubóna	'to see'
	kubábóna	'to see them (cl. 2)'
	kuhálúla	'to scrape food'
	kubúhálula	'to scrape it (cl. 14)'
	kukómólola	'to disentangle'
	kubúkómolola	'to disentangle it (cl. 14)'
	kutátágulikanisja	'to make grope about'
	kutútátagulikanisja	'to make us grope about'

Since the root is underlyingly H toned, we would incorrectly predict that /ku-bú-hálul-a/ should become *[kubúhálúla], by simply adding /bú/ to kuhálúla. What makes /ku-bú-hálul-a/ unique for our analysis is that it has two underlyingly adjacent H tones. The predicament is solved by positing a rule deleting H after H.

(82) H H → Ø *H deletion*
| |
V V

Underlying /ku-bú-hálul-a/ first becomes ku-bú-halul-a by H deletion, then [kubúhálula] by Rightward Spread.

Kerewe allows multiple object prefixes. As we see in (83), when there is more than one object prefix, only the H of the first prefix surfaces.

(83)	kubónésja	‘to make see’
	kubábónesja	‘to make them (cl. 2) see’
	kutúbábonesja	‘to make them (cl. 2) see us’
	kuhálúlilisja	‘to make scrape for’
	kubúhálulilisja	‘to make scrape it for’
	kutúbúhalulilisja	‘to make us scrape it for’
	kutúbábuhalulilisja	‘to make us scrape it for them’

H deletion works its way through the string of Hs in /ku-tú-bá-bú-hálulilisja/ to yield intermediate *kutúbabuhalulilisja*, then surfaces as [kutúbábuhalulilisja] via Rightward Spread.

In case there is one toneless syllable between the first of two underlying H tones, the outcome is the tone sequence HHꜜH(H), with a downstep separating the two H spans. We observe this in the conditional, where the subject prefix has H tone and the toneless prefix /ka/ follows. The data in (84) show H on the subject prefix and the conditional prefix -*ka*- before a toneless verb.

(84)	túkásja	‘if we grind’
	túkábala	‘if we count’
	túkábalila	‘if we count for’
	túkásakaala	‘if we thatch’
	túkátʃelemja	‘if we measure’

H toned verbs are in (85), with a downstep between the H of the prefix -*ka*- and the root.

(85)	túkáꜜlása	‘if we throw at’
	túkáꜜlásíla	‘if we throw at for’
	túkáꜜhálúla	‘if we scrape food’

We will assume, following standard analysis, that a downstep between H tones is represented as a floating L tone between the Hs, thus (86).

(86) H L H
/\ |
tu ka la sa

If we begin with /túkalása/ and unmarked vowels have no underlying tone, we need some rule to provide a L tone which functions as a surface downstep marker for phonetics. This can be handled by ordering a L Default rule before Rightward Spreading, which explains why Rightward Spreading does not cause deletion of underlying H in /tú-ka-lás-a/.

(87) Ø → L *Default L*
¦
V′

In (88) we also see an interaction between rightward and leftward spreading in the HØH trisyllable /túkatá/. In prepausal *túꜜkátá*, Leftward Spreading applies first, which prevents Rightward Spreading from applying. But in *túkáꜜtá búlemo* from /túkatá bulemo/, Leftward Spreading cannot apply because the prepausal syllable is not H toned. Therefore Rightward Spreading is free to apply.

(88)	túꜜkátá	'if we release'
	túkáꜜtá búlemo	'if we release Bulemo'

A final set of examples demonstrates a tone-shift rule, which moves H from a word-initial vowel to the following syllable. The subject prefix in subordinate clause verbs, such as the conditional as well as in relative clauses, is H toned. As expected from the above examples, that H then spreads to the following inflectional prefix vowel. The pattern of H on most subject prefixes in the conditional is shown in (89).

(89)	túkálima	'if we plow'
	múkálima	'if 2pl. plow'
	vákálima	'if they (cl. 2) plow'
	zíkálimwa	'if they (cl. 4) are plowed'
	líkálima	'if it (cl. 5) is plowed'

When the subject prefix is vowel-initial, the H instead appears on the vowel following the subject prefix, from which position Rightward Spreading applies to the root-initial syllable.

(90)	okálíma	'if you plow'
	akálíma	'if (s)he plows'
	ekálímwa	'if it (cl. 9) is plowed'

The H at the left edge of the verb can be treated as a clause-type subordination morpheme composed of just a floating H, which links to the leftmost vowel.

(91) H′ *Prefix Tone Docking*
¦
\# V

Subsequently, in case the word-initial syllable has a H tone, that tone shifts to the right.

(92) H *Onsetless Tone Shift*

\# $[_\sigma$ V V

Although tone rules are generally insensitive to segmental properties such as nasality or vowel rounding, they are often sensitive to suprasegmental properties, especially vowel length and occasionally onsetlessness of syllables. The meaning of "$[_\sigma$ V" in the statement of Onsetless Tone Shift is an example of such a condition, meaning "when the vowel is at the beginning of the syllable".

When the subject prefix is just a vowel, the H instead appears on following /ka/ and spreads from there to the next non-final syllable

(93)	okásja	'if we grind'
	okábála	'if we count'
	okábalila	'if we count for'
	okásákaala	'if we thatch'
	okát͡ʃélemja	'if we measure'

When the vowel after /ka/ is H toned, we find two or three Hs (depending on number of stem syllables) and no downstep.

(94)	okálása	'if we throw at'
	okálásá bulemo	'if we throw at Bulemo'
	okálásíla	'if we throw at for'
	okáhálúla	'if we scrape food'

The reason why there is no downstep in [okálásíla] is that Onsetless Tone Shift applies before Default L. In /bákalása/, Onsetless Tone Shift does not apply, Default L does giving /bákàlásà/, then Rightward Spreading spread the first H to *kà*, dislodging L from the prefix. In /ókalásila/, Onsetless Tone Shift applies first giving *okálásila*. Since shifting of H from an onsetless syllable does not cause H to be deleted from the following vowel, we also conclude that H deletion applies first among the tone rules of Kerewe.

10.3 Extension to the segmental domain

The foregoing modification of phonological theory had the obvious good consequence that tonal phenomena could be accounted for very nicely, whereas previously, tone was largely beyond the grasp of the theory. The impact of autosegmental phonology was much more profound than that, however. The obvious thing to wonder is, if tones are separate from the rest of the segment, then perhaps segments themselves are not monolithic, unstructured entities. Investigators then sought evidence for a similar separation of segmental features.

10.3.1 The autonomy of all features

An example of segmental phenomena which are reminiscent of autosegmental tonal properties are floating segmental features as morphemes. One such case is seen in Vata, where the past-tense marker can be argued to be simply the specification [+hi], which is suffixed to the stem and is realized phonetically on the last vowel.

(95)	n le	‘I eat’	n li	‘I ate’
	n ple	‘I pass’	n plɪ	‘I passed’
	n mlɛ	‘I go’	n mlɪ	‘I went’
	n no	‘I hear’	n nu	‘I heard’
	n zɔ	‘I place’	n zʊ	‘I placed’
	n wɔlɔ	‘I wash’	n wɔlʊ	‘I washed’

A second example comes from Fula, where a particular agreement pattern (“pattern B” below) is marked by a prefix composed of the segmental specification [– continuant] which causes an initial continuant to become a stop.

(96)	*Pattern □*	*Pattern B*	
	wecco	becce	‘rib’
	wibd$^{\text{ʒ}}$o	bibd$^{\text{ʒ}}$e	‘wing’
	ruulde	duule	‘cloud’
	sekko	cekke	‘mat’
	hello	kelle	‘slap’
	jeɓre	d$^{\text{ʒ}}$eɓel	‘seed’
	jimre	d$^{\text{ʒ}}$imel	‘poem’
	jontere	d$^{\text{ʒ}}$onte	‘week

The general strategy of analysis in these cases is to posit that in Vata, the past tense suffix is simply a specification [+hi] which associated to the final vowel, and in Fula the agreement prefix is just a specification [–continuant] which links to the first consonant of a root.

Aramaic CP. Azerbaijani Aramaic provides evidence for treating the feature [constricted pharynx] ([CP]) autosegmentally. This dialect has a contrast between pharyngealized or emphatic vowels (A E I U O) specified as [+CP], and plain vowels (a e i u o). In most words, either all of the vowels are emphatic, or none of them is.

CP has been proposed as a feature used to describe pharyngealization.

(97)	AmrA	‘wool’	brata	‘daughter’
	zArʔA	‘seed’	bela	‘house’

qUlOx	‘stand up!’	nŭd^{ʒ}um	‘sorcery’

Some words may have nonemphatic vowels followed by emphatic vowels. In such a case, the first emphatic vowel is always a low vowel.

(98)	ʃarAw	‘corn growing wild’	riswAj	‘unmannerly speech’
	sejfullAh	‘a great deal’	fandbAz	‘trickster’
	niʃAn	‘sign’	peʃtAmAl	‘towel’
	milAqE	‘hung grapes’	elijAhU	‘name’
	galimbAd^{ʒ}I	‘brother’s wife’	silAhlAmIʃ	‘supplied with weapons’

These distributional properties will play an important role in arguing for an autosegmental treatment of [CP].

In line with the fact that all vowels in a word generally agree in the feature [CP], (99) shows that suffixes harmonize in [CP] with the preceding vowel.

(99)	lixma	‘bread’	lixm-e	pl
	pirt^{ʃ}axwar-a	‘old woman’	pirt^{ʃ}axwar-e	pl
	nOhr-A	‘mirror’	nOhr-E	pl
	dIqnAxwAr-A	‘old man’	dIqnAxwAr-E	pl
	klu	‘write! (sg)’	klu-mun	pl
	bilbul	‘seek!’	bilbul-un	pl
	qU	‘rise!’	qU-mUn	pl
	mIʃltUn	‘make a king!’	mIʃltUn-Un	pl

[CP] will spread through a whole sequence of suffixes.

(100)	mĭr-a	‘she said’	xIt-lAx	‘you (fem sg) sewed’
	mir-wa-la	‘she had said’	xIt-wA-lAx	‘you had sewn’
	mir-wa-la-la	‘she had said it’	xIt-wA-lAx-U	‘you had sewn them’

We will assume that the only value underlyingly marked for this feature is [+CP], and that [+CP] spreads to the right by the following rule:

(101) [+CP]

V V

This rule thus explains why [+CP] vowels are always followed by [+CP] vowels. However, we also need to explain why roots with a [+CP] specification (generally) have [+CP] beginning with the first vowel. We can assume that, in the general case, the specification [+CP] is not associated to any particular vowel, but is just floating, and an unassociated [+CP] specification is associated with the first vowel of the word by the following rule:

(102) [+CP]′

C_0 V

The derivation of *mI∫ItUn-Un* ‘make a king (pl)!’ shows these rules.

(103) [+CP] (rule 102)) → [+CP] (rule (101)) → [+CP]

mi∫itun-un → mi∫itun-un → mi∫itun-un

There are some suffixes whose vowels are invariably emphatic; that vowel is always the vowel [A]. No suffixes are invariably plain.

(104)	qalăma	‘pen’	qalam-dAn	‘case for scribe’s utensils’
	qand	‘sugar’	qand-dAn	‘sugarbowl’
	∫akăr	‘sugar’	∫akăr-dAn	‘sugarbowl’
	dukana	‘store’	dukan-dAr	‘shopkeeper’
	mewana	‘guest’	mewan-dAr	‘hospitable’
	d^3ut	‘plow’	d^3ut-kAr	‘plower’
	nŭd^3um	‘sorcery’	nŭd^3um-kAr	‘sorcerer’
	naq∫	‘engraving’	naq∫-kAr	‘engraver’

These suffixes will be assumed to have underlying [CP] specifications, in contrast to most other suffixes which are unspecified for [CP]. Since the suffix vowel is lexically associated with [+CP], it does not associate with the first vowel of the word, and since it does not associate with the first vowel of the word, [+CP] does not spread to any vowels before that of the suffix.

We also find spreading of [+CP] between members of a compound. In the examples of (105), [+CP] spreads from the first compound to the second.

(105)	tAhA	‘3’	imme	‘100’
	tAhA-mmE	‘300’		
	dIqnA	‘beard’	xwara	‘white’
	dIqnA-xwArA	‘old man’		

This is the expected pattern: [+CP] spreads rightward from the first member of the compound to the second.

If the second member of the compound has [+CP] vowels, [+CP] spreads through the second member of the compound.

(106)	xwara	‘white’	dIqnA	‘beard’
	xwArA-dIqnA	‘old man’		
	be	‘without’	hAd	‘limit’
	bEhAd	‘exceedingly’		

qahwa	‘coffee’	xAnA	‘shelter’
qAhwA-xAnA	‘coffee-room’		

This apparent exceptional leftward spreading of [+CP] is nothing of the sort. Rather, the second member of the compound has a floating [+CP] specification; in a compound, that feature links to the first vowel of the word by rule (79), and then spreads to the right.

(107) [+CP] → [+CP] → [+CP]

xwara diqna   xwara diqna   xwara diqna

Another case of [+CP] appearing to the left of the morpheme where it originates is seen in (108), where a prefix is added to a root with a floating [+CP] specification.

(108)	xoʃ	‘good’	na-xoʃ	‘ill’
	hAq	‘right’	nA-hAq	‘wrong’
	rAzI	‘satisfied’	nA-rAzI	‘unsatisfied’
	pjala	‘fall’	ma-pole	‘cause to fall’
	ʃatoe	‘drink’	ma-stoe	‘give drink’
	mjAsA	‘suck’	mA-mOsE	‘give the suck’
	rAdOxE	‘boil (intr.)’	mA-rdOxE	‘boil (tr.)’

Given the assumption that a root specification of [+CP] is not generally associated in the underlying form (except in roots such as (98) where [+CP] is unpredictably associated with a noninitial low vowel), our analysis predicts that the [+CP] specification will link to the first vowel of the word, which will be the prefix vowel in this case, and spreads to the right thereafter.

The locational suffix -*istan* has the interesting property that it causes all vowels in the word to which it is attached to become [+CP],

(109)	xaraba	‘ruined’	xArAb-IstAn	‘ruined place’
	$t^ʃ$ol	‘uninhabited land’	$t^ʃ$Ol-IstAn	‘wilderness’
	hind	‘India’	hInd-IstAn	‘India’

This makes sense if the suffix -*istan* also has a floating specification [+CP], which automatically associates with the first vowel of the stem and then spreads rightward.

(110) [+CP] → [+CP] → [+CP]

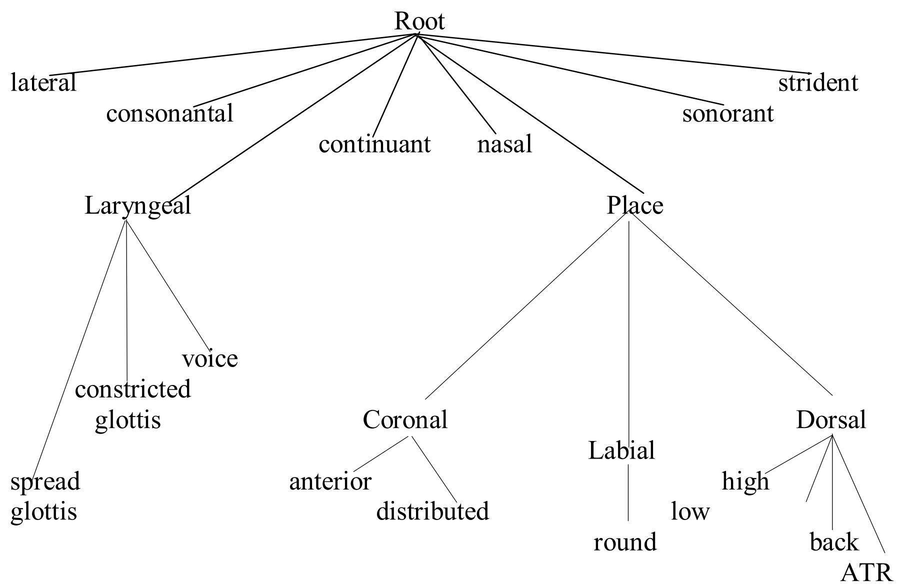
xarab - istan   xarab - istan   xarab - istan

10.3.2 Feature geometry

It was realized that all features are autonomous from all other features, and potentially exhibit the kind of behavior which motivated the autosegmental treatment of tone. The question then arises as to exactly how features are arranged, and what they associate with, if the “segment” has had all of its individual features removed. The generally accepted theory of how features relate to each other is expressed in terms of a feature-tree such as

(111). This tree – known as a **feature geometry** – expresses the idea that while all features express a degree of autonomy certain subsets of the features form coherent phonological groups, as expressed by their being grouped together into constituents such as “Laryngeal” and “Place.”

(111)



The organization of features into such a structure went hand-in-hand with the realization that the theory of rules could be constrained in very important ways. A long-standing problem in phonological theory was the question of how to express rules of multiple-feature assimilation. We have discussed rules of nasal place assimilation in previous chapters, and noted in chapter 4 that such rules necessitate a special notation, the feature variable notation using α, β, γ and so on. The notation makes some very bad predictions. First, notice that complete place assimilation requires specification of ten features in total.

(112) $$C \rightarrow \begin{bmatrix} \alpha\text{coronal} \\ \beta\text{anterior} \\ \gamma\text{back} \\ \delta\text{high} \\ \theta\text{distributed} \end{bmatrix} / \_\_ \begin{bmatrix} \alpha\text{coronal} \\ \beta\text{anterior} \\ \gamma\text{back} \\ \delta\text{high} \\ \theta\text{distributed} \end{bmatrix}$$

This is less simple and, by the simplicity metric used in that theory, should occur less frequently than (113).

(113) C → [αcoronal] / ___ [αcoronal]

This prediction is totally wrong: (113) is not just uncommon, it is completely unattested. Were there to be such a rule that assimilates only the specification of coronal, we would expect to find sets of assimilations such as the following:

(114)	$mt^{ʃ}$ → $nt^{ʃ}$ (not $ɲt^{ʃ}$)	$ŋt^{ʃ}$ → $ɲt^{ʃ}$
	ɲp → ŋp	np → mp

ɲk → ŋk nk → mk

ɲt → ɲt $nt^{ʃ}$ → $nt^{ʃ}$

The fact that the feature-variable theory allows us to formulate such an unnatural process at all, and assigns a much higher probability of occurrence to such a rule, is a sign that something is wrong with the theory.

The theory says that there is only a minor difference in naturalness between (113) and (112), since the rules are the same except that (113) does not include assimilation of the feature [anterior].

$$(113)\quad C \rightarrow \begin{bmatrix} \alpha\text{coronal} \\ \gamma\text{back} \\ \delta\text{high} \\ \theta\text{distributed} \end{bmatrix} / \_\_ \begin{bmatrix} \alpha\text{coronal} \\ \gamma\text{back} \\ \delta\text{high} \\ \theta\text{distributed} \end{bmatrix}$$

There is a huge empirical difference between these rules: (112) is very common, (112) is unattested. Rule (113) is almost complete place assimilation, but [anterior] is not assimilated, so /np/, /ɲk/, and /mt/ become [mp], [ŋk], and [nt] as expected, but /ɲt/ and /$nt^{ʃ}$/ do not assimilate (as they would under complete place assimilation); similarly /$ŋt^{ʃ}$/ becomes [$ɲt^{ʃ}$] as expected (and as well attested), but /ŋp/ and /ŋt/ become [np] and [nt], since the underlying value [– anterior] from /ŋ/ would not be changed. Thus the inclusion of feature variables in the theory incorrectly predicts the possibility of many types of rules which do not exist in human language.

The variable-feature theory gives no special status to a rule where both occurrences of α occur on the same feature, therefore in principle the change-values of one feature may be the value of a totally different feature in the trigger segment.

$$(114)\quad C \rightarrow \begin{bmatrix} \alpha\text{coronal} \\ \beta\text{anterior} \\ \gamma\text{back} \\ \delta\text{high} \\ \theta\text{distributed} \end{bmatrix} / \_\_ \begin{bmatrix} \theta\text{coronal} \\ \alpha\text{anterior} \\ \beta\text{back} \\ \gamma\text{high} \\ \delta\text{distributed} \end{bmatrix}$$

This rule describes an equally unnatural and unattested process whereby a consonant becomes [t] before [p^{j}], [p] before [q], and [p^{j}] before [k]. Rules such as (114) do not exist in human language, which indicates that the linear theory which uses this notation as a means of expressing assimilations makes poor predictions regarding the nature of phonological rules.

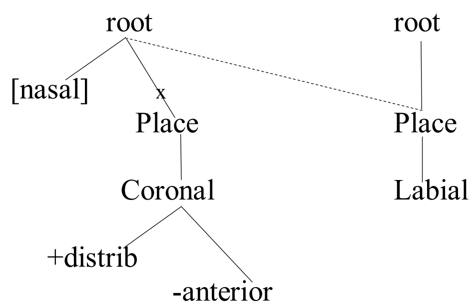
The variable notation allows us to refer to legions of unnatural classes by randomly linking any two unrelated features with a single variable.

(115) a. $\begin{bmatrix}\alpha\text{high}\\ \alpha\text{round}\end{bmatrix}$ b. $\begin{bmatrix}\alpha\text{distributed}\\ \alpha\text{nasal}\end{bmatrix}$ c. $\begin{bmatrix}\alpha\text{coronal}\\ \alpha\text{anterior}\end{bmatrix}$ d. $\begin{bmatrix}\alpha\text{voice}\\ \alpha\text{lateral}\end{bmatrix}$

Class (a) applied to vowels refers to [y, u, e, ə, a]; (b) refers to [n̪, ɲ, p, ʈ, k] but excludes [m, ɳ, t̪, tʃ, ŋ]; (c) groups together [t, k] and excludes [p, tʃ]; (d) refers to [l] plus voiceless consonants. Such groupings are not attested in any language.

With the advent of a theory of feature geometry such as in (111), this problem disappeared. In that theory, the process of place assimilation is formulated not as the change of one feature value into another, but is expressed as the spreading of one node – in this case the Place node – at the expense of another Place node. Thus the change /ɲ/ → [m] / _ [p] is seen as working as in (116):

(116)



Just as tone assimilation is the rightward or leftward expansion of the domain of a tone feature, this process of place assimilation is expansion of the domain of one set of place specifications, to the exclusion of another. When one Place node spreads and replaces the Place node of a neighboring segment, that means that all of the original place features are deleted, and the segment then comes to bear the entire set of place features that the neighboring segment has.

What the feature-variable notation was able to do was express multiple-feature assimilations, but given this alternative theory, multiple feature assimilations will be recast as spreading some node such as Place. The feature-variable notation can be entirely eliminated since its one useful function is expressed by different means. The theory of feature geometry enables a simple hypothesis regarding the form of phonological rules, which radically constrains the power of phonological theory. The hypothesis is that phonological rules can perform one simple operation (such as spreading, inserting or deletion) on a single element (a feature or organizing node in the feature tree).

The thrust of much work on the organization of phonological representations has been to show that this theory indeed predicts all and only the kinds of assimilations found in human languages (specific details of the structure of the feature tree have been refined so that we now know, for example, that the features which characterize vowel height form a node in the feature tree, as do the features for the front/back distinction in vowels). The geometric account of assimilations precludes the unnatural classes constructed by the expressions in (115), since the theory has no way to tie a specific value for a feature to the value of another feature. The geometric theory does not allow a rule like (113), which involves spreading of only a random collection of features under the place node. Rules in this theory do not apply to collections of individual features, they apply to single objects, either one specific feature, or one specific node, which means, all features underneath it are affected equally. Unattested "assimilations" typified by (114) cannot be described at all in the feature geometric theory, since in that theory the concept "assimilation" necessarily means "of the same unit," and this was not available in the variable-feature theory.

The theory of structure in (111) makes other claims, pertaining to how place of articulation is specified, which has some interesting consequences. In the linear model of features, every segment had a complete set of plus or minus values for all features at all levels. This is not the case with (111). In this theory, a well-formed consonant simply requires, at most, specification of one of the **articulator nodes**, Labial, Coronal or Dorsal. While a coronal consonant may have a specification under the Dorsal node for a secondary vocalic articulation such as palatalization or velarization, plain coronals will not have any specification for [back] or [high]; similarly, consonants have no specification for [round] or Labial unless they are labial consonants, or secondarily rounded. In other words, segments are specified in terms of positive, characteristic properties.

Laryngeal consonants like h and ʔ, however, may lack any place specifications: the feature structure of laryngeals remains a topic for investigation.

This has a significant implication in terms of natural classes. Whereas labials, coronals, and dorsals are natural classes in this theory (each has a common property) – and, in actual phonological processes, these segments do function as natural classes – the complements of these sets do not function as units in processes, and the theory in (111) provides no way to refer to the complement of those classes. Thus there is no natural class of [–coronal] segments ([p, k] excluding [t, t^ʃ]) in this theory. Coronal is not seen as a binary feature in the theory, but is a single-valued or **privative property**, and thus there is no way to refer to the noncoronals since natural classes are defined in terms of properties which they share, not properties which they don't share (just as one would not class rocks and insects together as a natural group, to the exclusion of flowers, by terming the group "the class of nonflowers"). Importantly, phonological rules do not ever seem to refer to the group [–coronal], even though the class identified by [+coronal] is well attested as a phonological class. The model in (111) explains why we do not find languages referring to the set [p, k]. It also explains something that was unexplained in the earlier model: the consonantal groupings [p, t] versus [t^ʃ, k] are unattested in phonological rules. The earlier model predicted these classes, which are based on assignment of the feature [±anterior]. In the model (111) the feature [anterior] is a dependent of the Coronal node, and thus labials and velars do not have a specification of [anterior], so there is no basis for grouping [p, t] or [t^ʃ, k] together.

10.3.4 Underspecification

Because autosegmental theory rejects the SPE stance that all segments must have specifications for all features, we have the beginnings of a theory of "underspecification" implicit in ASP. The concept of "underspecification" embodies two distinct claims. First is the question of whether features have two values (+,–) as posited in SPE, or are some features simply "present" vs. "absent", i.e. are features privative? The second, and historically earlier question in ASP, is whether binary values are distributionally symmetrical – both [+voice] and [–voice] are present in phonology – or might there be only one value (in a defined context) with the opposite value being later supplied by a convention. It has been proposed for example that *voice* can be reduced to just an underlying specification [+voiced] for obstruents in English or French, and [–voice] can be supplied by later convention, an automatic rule of UG supplying [–voice] to any segment lacking a voice specification, applying somewhere before the phonetic output. There may also be a rule that supplies the value [+voice] automatically to sonorants. Such pre-phonetic fill-in values are termed **default** values.

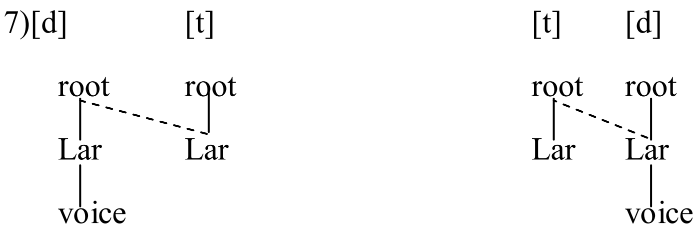
These two aspects of underspecification are clearly related, in that privativity and default theory both allow [t] to be not specified for voicing at an earlier stage of the derivation. They differ in whether they claim that [t] must or can be supplied with a specification, conventionally [–voice], at some point in the derivation, where default theory adheres to the SPE position for the output of phonology (but not the entirety of the phonological derivation preceding) saying that all segments leave the phonology with + or – specifications for all features, and privativity say that there is never any such specification for [t] in the phonology because features are just bare attributes, which means that vocal fold abduction during obstruents would be an automatical phonetic consequence of not having a specification for vocal fold adduction – and not a matter of phonological specification.

To illustrate the fill-in and privative theories, we consider a rule of Sanskrit phonology, voicing assimilation – two rules, or one rule with two domains of application. Within the word, there is a regressive voicing assimilation rule where obstruents regressively assimilate voicing from a following obstruent. In the verb inflection system, subject is marked by various suffixes exemplified in the verb ‘bear’ which has a “theme vowel” suffix between the root and final person marker, as in *b^{h}ar-a:-mi* (1s active indicative), *b^{h}ar-a-si* (2s active indicative), *b^{h}ar-a-ti* (3s active indicative), *b^{h}ar-a-d^{h}we* (2p middle indicative). Certain verbs directly add the subject suffix to the root, for example ‘eat’ with the corresponding forms *ad-mi, at-si, at-ti, ad-d^{h}we* where an underlyingly voiced consonant becomes voiceless before a voiced obstruent. In the verb ‘turn’, we find voicing of underlying /t/ before a voiced obstruent (there is also an accent-related vowel deletion) in *wawart-mi, wawart-si, wawart-ti, wawr̩d-d^{h}we*. There is also voicing assimilation between words, but the conditions for cross-word voicing assimilation are more general: obstruents assimilate voicing from *any* voiced segment, including vowels, liquids and nasals which do not trigger word-internal voicing.

Parallel to word-internal assimilation, a obstruent assimilates voicing from a following segment, illustrated with the ablative singular suffix /a:t/, where /t/ is voiceless in *lob^h-a:t krod^{h}ah* ‘anger from greed’, *muk^h-a:t srawati* ‘it flows from the mouth’, but voiced in *nagar-a:d gamiʂjati* ‘he will go from the city’ and *wja:gr-a:d bib^{h}eti* ‘he fears the tiger’. Unlike the word-internal situation, there is also voicing before voiced sonorants in *pattan-a:d a:gacc^{h}at* ‘he comes from the city’, *caur-a:d rakʂate* ‘he protects from the thief’, *a:lasj-a:d na paʈ^{h}ati* ‘he doesn’t read from laziness’ and *paʈ^h-a:t wiramati* ‘he escapes from reading’.

Word-internal voicing assimilation can be formalized under the binary-features interpretation by having sonorants be unspecified, thus lacking a voicing specification. If [–voice] is unspecified, we would expect that there could not be regressive devoicing, yet there is. However, a geometric structure like (111) provides a way to get devoicing via assimilation. Even though there is no voiceless feature under the Laryngeal node, we assume that obstruents at least have a Laryngeal node – empty in the case of /t/.

(117)



The prediction of this analysis is that aspiration should also regressively assimilate; however, all aspirates deaspirate when followed an obstruent, so we can say that the predictin is correct but not obvious because a later rule gets rig of aspiration in what should be *wawr̥*d^hd^h*we*. So even though there is no specification [–voice] to spread and eliminate preceding [+voice], the Laryngeal node can spread, and spreading an empty Laryngeal node allows a spreading account of regressive devoicing.

Since, by hypothesis (possibly an incorrect one) [–voice] is the ultimate default value, the [+voice] fill-in for sonorants must be supplied before [–voice] is filled in. But if sonorant [+voice] is filled in at the word level, we incorrectly predict that sonorants trigger regressive voicing within the word. Therefore we know that default fill-in cannot have supplied a [–voice] value when word-internal assimilation applies. The derivation of voicing assimilation within words therefore *must* operate under the assumptions seen in (117).

Underspecification plays a role in this analysis in that sonorants do not even have a Laryngeal node (there is no laryngeal contrast in sonorants, unlike obstruents), therefore for purposes of internal voicing assimilation, Laryngeal spreading cannot spread a nothing from a vowel. But at a later derivational stage, the phrasal level, sonorants will have been provided with a default voicing specification, therefore sonorants as well as obstruents can trigger regressive voicing assimilation. However: another way to derive the differential treatment of sonorants and obstruents at the word versus phrase level is simply to stipulate that word-internal assimilation is only triggered by an obstruent, but at the phrasal level it is triggered by any segment (not even a consonant). This point was not so obvious at the time since we were more concerned with “saying less” in rules, leaving more matters to UG.

An orthogonal but related question is how strongly these representational choices are enforced across languages. For instance, the most common state of affairs is that [+ATR] is specified, that feature can spread, but [–ATR] is not specified, is not preserved and cannot spread. This follows from the premise that [+ATR] is the universally specified value therefore [–ATR] is the default value supplied later, and apparently [–ATR] vowel have no initial specification, therefore are vulnerable to being spread to. The same asymmerty also follows from the premise that [ATR] is a privative feature, so only

[ATR] can be preserved, the "lack of ATR" cannot be preserved and cannot spread. However there are languages with the vowel pairs [e o; ɛ ɔ] where the ATR value of [ɛ ɔ] is what is phonologically active, suggesting either that there is also a feature RTR (retracted tongue root), or that the default value of ATR might be [–ATR] on a language specific basis. Other examples of the asymmetry argument are that there are very many rules of rounding harmony making vowels round after other round vowels, but only one example of non-rounding harmony where vowels unround after unrounded vowels (in Hungarian). Nasalization, where an oral segment becomes nasal is the context of a nasal, is rather common, but nasals rarely become oral in an oral context. We encounter aspiration dissimilation where an aspirated stop becomes plain in the context of an aspirate, but a plain consonant does not become aspirated in the context of a plain consonant. An argument of the asymmetry kind has been offered from Yoruba, where a phrase-level rule of vowel assimilation optionally assimilates V_1 to V_2, except if V_2 is [i], e.g. *owó adé* → (opt.) *owá adé* 'Ade's money', *owó ɔmɔ* → *owɔ́ ɔmɔ* 'child's money', *owó epo* → *owé epo* 'oil money', but *owó ilé* 'money of house' does not become **owí ilé*. If high vowels are underspecified, there is nothing to spread.

A rare but quite powerful argument for underspecification is the discovery of ternary specifications. In the realm of ATR, Turkana has an ATR harmony system, with the complication that some vowel are specified [+ATR], some are [–ATR] and some are unspecified – there are three behavioral patterns, where specified values spread and unspecified vowels are spread to. There are also languages with surface H and L tone, where L tones lexically split into "specified L" versus "unspecified" – like Yoruba, only the unspecified tone in Yoruba is phonetically distinct M tone. As you may predict, though, this is compatible with having both ATR and RTR rather than [+ATR] and [–ATR] as well as Ø, or H vs L rather that [+H] and [–H] as well as Ø.

The theoretically most-powerful argument for underspecification (either kind) is transparency under spreading. For example, there are consonant harmonies which spread a consonantal property over quite a distance, such as the famous case of Chumash where /kʃaqutinan'us/ → /kaqutinan'us/ 'I tell him a story'. Spreading of [+anterior] from the final fricative crosses over 5 segments that are specified [–anterior] (q and 4 vowels) and 3 segments that are [+anterior] ([t, t, n']) under SPE theory – a massive violation of the No-Crossing constraint. However, the feature [anterior] is only phonologically contrastive for the class of sibiliants, which are the segments that trigger and undergo sibilant harmony. The neutral vowels of Finnish vowel harmony, which are ignored by the rule, are [i e] which do not phonologically contrast with the (non-existent) vowels [ɨ ʌ]. These are cases where underspecification theory predicts that the segments will be lacking a particular feature specification, and where on theoretical grounds it is desirable to not have such a specification.

Many questions regarding feature specification remain unresolved to this day.

10.3.5 Autosegmental rule theory

Narrowly construed, Autosegmental Phonology is just a modified theory of representations. Nevertheless, a working assumption when the theory was introduced was that "if you get the representations right, the rules will follow", meaning that with an improved theory of representations, the burden of figuring out how to write rules would be lightened, perhaps trivialized. The theory followed a trend at the time of reducing the machinery of language-specific rules, instead attributing most aspects of what rules do to automatic conventions of Universal Grammar. The entire theory of “abbreviatory notations” with expressions like [αhi,βlow…] or $(C_0VC_0)_0$ was replaced with representational enrichments such as (111). While this seemed to lead to a simpler theory of rules, there was also a growth in appeal to presumed universal conventions of grammars, therefore while language-specific rule statements became simpler, the underlying mechanisms of what rules accomplish became more complex. As an example, the notion of tone-stability introduced in §10.1.3 relies on there being an automatic mechanism where deletion of segmental content in the mapping /à+í/ → [ǐ] requires that only the segment /a/ deletes, and not its tone. That tone then automatically re-associates with the following vowel, by an invariant mechanism of tone-rearrangment. This is not a bad idea, since tone preservation under vowel deletion (as we considered in Yekhee and Mongo), is very common in tone languages. In Yekhee and Mongo, the tonal result of vowel deletion is that the tones of the target and trigger vowel realign to the surviving vowel, resulting in a contour tone except when the two tones are identical (as expected: contour tones are sequences of *different* tones on a vowel).

We do not always find contour tones arising from vowel-deletion applied to different-tone sequences. In Yoruba, /wá ōwó/ becomes [wówó] ‘search for money’ and /sī̄ òkú/ becomes [sì̄kǔ] ‘bury the dead’ by vowel deletion, the output of vowel deletion being *sì̄kú* which then undergoes a general rule of tone spreading (discussed in 10.1.8) where HL becomes HF and LH becomes LR. Whenever M tone is one of the tones in a vowel sequence, the M disappears without a trace. There are various arguments showing that M tone in Yoruba is unspecified, so there is only one tone to preserve in these cases where vowels merge. From this fact, we can surmise that Yekhee and Lomongo are different in that their L tone *is* a specified tone, so we can localize this difference between languages (in terms of what rules do) to a difference in representations.

But in Yoruba, we would expect a falling tone to result from the combination of H plus L, yet in /wá ɔ̀nà/ → [wɔ́nâ] ‘search for a way’ and /wá ìmɔ̀/ → [wámɔ̂] ‘search for knowledge’, this does not happen: we do not get *[wɔ̂nà] or *[wâmɔ̀]. Again, the change of *wɔ́nà* and *wámɔ̀* to [wɔ́nâ] and [wámɔ̂] is due to the later rule HL→HF. These examples illustrate that in Yoruba, whether the first vowel or the second vowel deletes, it is always the H tone that is preserved at the expense of L tone. In light of the fact that /wá ɔ̀nà/ → [wɔ́nâ], preserving the tone of the first vowel which is the one deleted, this clearly is an example of tone preservation, but we have to explain why this causes loss of the low of the non-deleted vowel. For Yoruba (and every other known language), the explanation is that H is preserved at the expense of L, and never the other way around. But still, we have to explain why we do not derive a contour tone, not *[wɔ̂nà] or *[wâmɔ̀]. This cannot be fully explained by claiming that the language does not allow (short) contour tones which is a common explanation for tone loss, because the surface form does have a short contour, via a specific rule creating contours.

In /wá ɛ̀kɔ́/ → [wɛ́kɔ̌] ‘search for knowledge’ we see that the dislodged L tone of /ɛ̀/ is still phonologically preserved, and triggers the LH → LR rule: we require a stage /wá ɛ̀kɔ́/ → wá ` kɔ́ where the floating L then triggers the LH→ LR rule. In /dʒí ɔ̀bɛ̄/ → [dʒɔ́ꜜbɛ̄] 'steal a knife', the dislodged L tone remains in the representation, serving as a trigger of phonetic downstepping of H. Facts like this show that there cannot be a universal reassociation convention which automatically relinks any tone set adrift. Instead, grammars must include specific rules dealing with floating tones under vowel deletion, perhaps giving contour tones on the surviving vowel in Yekhee, but sometimes abstractly trigger other tone rules or serving as a downstep operator. Somewhat surprisingly, no language has been found with a vowel hiatus deletion rule that deletes both the segmental content and the tone of the affected vowel, e.g. /à+í/ → [í], /ì+á/ → [á], /á+ì/ → [ì], /í+à/ → [à]. Segmental vowel deletion always seems to retain – in some form – whatever specified tone was on the tone, then, but other rules of the language can delete or reassociate that tone, or leave the tone floating. The autonomy of tone and segmental quality remain a robust fact: no rule simultaneously deletes vowel quality and tone.

While tone preservation is ubiquitous, segmental feature-preservation is not. Segmental feature preservation is found when two segments combine into one which combines features of the input segments. We have seen examples of vowel merger (coalescence, fusion) in Matumbi (8.3) where /ai, au/ becomes [ee, oo] and a different vowel merger figures into Kuria problem 8 of ch. 7; merger of velars plus [j] into [tʃ, dʒ] happens in Kamba (6.1.2) and Hehe (7.2), another consonant fusion figures into Somali problem set 3 of ch. 7; there is nasalization of a preceding vowel in Sanskrit when /m/ stands before a fricative, and many Austronesian languages merge nasal + consonant sequences into a nasal version of the consonant (n+p → m). But there is no coalescence under vowel deletion in Yekhee or Yoruba, nasals before fricatives simply delete without causing nasalization in Bukusu (6.1.3), and stops delete without a trace before voiceless consonants in Fore (7.3), or when unassimilated in Diola Fogny.

What then seems to be a relatively simple idea, that subparts of a segment may go their separate ways, has complex consequences, in that we need some mechanism whereby a rule can specify "delete this segment except preserve those features", and we need a theory of what becomes of those preserved features. Following the dominant reasoning of that era, it was assumed that Universal Grammar provided a rich set of built-in options, and we simply needed some means of saying which option was chosed in a particular language. In the final chapter, we briefly touch on current views of this problem.

Summary

Answering a simple problem, namely how to represent contour tones, led to ideas which not only solved the problem of contours, but also solved a whole array of problems related to tone. Since there is no reason to think that there should be a special theory just for tone, a natural development of these changes applied to tone was a general application of the autosegmental idea to all of phonology. This resulted in sweeping changes to the theory of phonology, and has resolved many earlier problems in how to state rules in a constrained manner. This generalization of the results in one area to an entire subdiscipline is typical of the progression of scientific theories.

Exercises

1 Lulubo

Note on tone marks: [v᷅] = rising from L to M, [v᷆] = falling from M to L, [v᷄] = rising from M to H and [v᷇] = falling from H to M. Give the underlying form of the noun roots and whatever morphemes mark the four case forms in the following data; briefly discuss what theoretically interesting property these data illustrate.

Citation	*Unfocused object*	*Focused object*	*Proper name*	
èbì	ándɛ bì	ándɛ èbǐ	ándɛ̀ èbi᷆	‘lion’
àrī	ándɛ àri᷆	ándɛ àri᷄	ándɛ̀ àrī	‘bird’
t̪í	ándɛ̀ t̪î	ándɛ t̪í	ándɛ̀ t̪i᷇	‘cow’

2 Shambaa

Propose autosegmental rules to account for the following tone alternations. Note that all infinitives have the final suffix *-a*.

‘to V’	‘to V for’	‘to V e.o’	‘to V for e.o’	‘to V it’	‘to V it for’	
kudika	kudikia	kudikana	kudikiana	kut^ʃídíka	kut^ʃídíkía	‘cook’
kutoa	kutoea	kutoana	kutoeana	kut^ʃítóa	kut^ʃítóéa	‘beat’
kuʃuntha	kuʃunthia	kuʃunthana	kuʃunthiana	kut^ʃíʃúntha	kut^ʃíʃúnthía	‘bathe’

‘to V’	‘to V for’	‘to V each other’	‘to V for each other’	
kukómá	kukóméa	kukómána	kukóméána	‘kill’
kufúá	kufúía	kufúána	kufúíána	‘launder’
kuʃíʃá	kuʃíʃía	kuʃíʃána	kuʃíʃíána	‘smear’
kufúmbátíʃa	kufúmbátíʃía	kufúmbátíʃána	kufúmbátíʃíána	‘pack’

3 Holoholo

Verbs have an infinitive prefix or a subject marker, an optional negative prefix, then an optional object pronoun, and lastly the verb stem. The stem is composed of a root, a number of optional derivational suffixes, plus the morpheme *-a* which means ‘nonpast verb’ or *-ile* meaning ‘past.’ Consonant mutation rules can be ignored (e.g. *il → in),* as well as some of the segmental changes (*kuhuulééna* from /kuhuulilana/, or *kumweenâ* from /kumonila/). What is important is tone and rules relating to vowel sequences. Assume a principle of compensatory lengthening for the language where glide formation and vowel fusion applying to an underlying V+V sequence lengthen the vowel -/i+o/ becomes [joo].

There are regularities regarding vowel length to consider. There are no surface representations such as *[kuponka], with a short vowel followed by the sequence nasal plus consonant, also no forms like *[kufjaka], with short vowel after a glide. Furthermore, no words end in a long vowel.

The data are divided into conceptually related groups illustrating a particular point such as a rule, a particular restriction on a rule, or the surface tone pattern of words of a particular syllabic structure. It is important to integrate the whole data set, and for example to relate *kumonánâ* 'to see other' to *kumoná* 'to see,' and also to *kulolana* 'to look at e.o,' since *kumonánâ* has morphemes in common with both words.

kumoná	'to see'	kusilá	'to forge'
kulola	'to look at'	kubula	'to draw'
kumonánâ	'to see e.o.'	kusilílâ	'to forge for'
kulolana	'to look at e.o.'	kubulila	'to draw for'
kusilílána	'to forge for e.o.'	kubulilana	'to draw for e.o.'
kutegéléla	'to listen'	kutegélésja	'to make listen'
kutegélélana	'to listen to e.o.'	kusololana	'to choose e.o.'
kuljá	'to eat'	kuhjá	'to carry'
kuliilâ	'to eat for'	kuhiilâ	'to carry for'
kubuusjâ	'to ask'	kukwaatâ	'to own'
kubiihâ	'to be bad'	kuhiita	'to be black'
kutuuta	'to hit'	kusjiika	'to bury'
kubiikâ	'to put'	kubiikílila	'to put for'
kuliilíla	'to eat for s.t. for s.t. else'	kukwaatána	'to own e.o.'
kusjiikana	'to bury e.o.'	kutuutila	'to hit for'
kwiitá	'to call'	kwiitánâ	'to call e.o.'
kweema	'to suffer'	kwaatíkâ	'to split'
kweelélâ	'to clean up'	kweelélána	'to clean e.o. up'
kwiihaga	'to kill'	kwiihagana	'to kill e.o.'
kooja	'to rest'	kuula	'to buy'
koogá	'to wash'	koogélâ	'to wash for'
koogéléla	'to wash for s.t. for s.t. else'	koogélélana	'to wash for e.o.'
kutoontá	'to fill'	kutoontámána	'to be full'
kuloombá	'to request'	kuloombélâ	'to request for'
kuloombélána	'to request for e.o.'	kusiindálâ	'to make disappear'
kusiingínâ	'to put across'	kusiingínína	'to put across for'
kwiimbá	'to sing'	kwiimbílâ	'to sing for'
kunjwiisâ	'to make drink'	kunjwiisííbwa	'to be made to drink
kuhuulééna	'to hit for e.o.'	kutimwíína	'to break for'
kuhimá	'to leave'	kuhimjâ	'to make leave'

kukwaatâ	‘to own’	kukwaatjâ	‘to make own’
koonká	‘to suck’	koonkjâ	‘to make suck’
kubusá	‘to miss’	kubusjâ	‘to make miss’
kukoloma	‘to irritate’	kumukoloma	‘to irritate him’
kubakólóma	‘to irritate them’	kulola	‘to look at’
kumulola	‘to look at him’	kubalólâ	‘to look at them’
kumumoná	‘to see him’	kubamóná	‘to see them’
kutegéléla	‘to listen to’	kumutegéléla	‘to listen to him’
kubatégéléla	‘to listen to them’		
kusimóná	‘to not see’	kulola	‘to look at’
kusilólâ	‘to not look at’	kusikólóma	‘to not irritate’
kusimúlóla	‘to not look at him’	kusibálólâ	‘to not look at them’
kusimúmóná	‘to not see him’	kusibámóná	‘to not see them’
kutiinína	‘to worry	kusitíínína	‘to not worry’
kwiitíínína	‘to worry oneself	kumutiinína	‘to worry him’
kwiilólâ	‘to look at oneself	kwiimóná	‘to see oneself’
kuula	‘to buy’	kusjuulâ	‘to not buy’
kusjuulána	‘to not buy e.o.’	kusimúúla	‘to not buy him’
kwiitá	‘to call’	kusiitá	‘to not call’
kusiilólâ	‘to not look at self’	kusiimóná	‘to not see self’
ulolilé	‘you (sg) looked’	usilílé	‘you (sg) forged’
tulolilé	‘we looked’	tusilílé	‘we forged’
mulolilé	‘you (pl) looked’	musilílé	‘you (pl) forged’
úlólilé	‘he looked’	úsílílé	‘he forged’
bálólilé	‘they looked’	básílílé	‘they forged’

4 Chumburung. The following data illustrate the pattern of phrase-level vowel deletion in Chumburung. The first part of the data gives the citation form of 13 nouns in the language, then noun combinations show what happens to vowel sequences. In these examples, ^{w} can either be interpreted as rounding on the preceding consonant, or as a separate segment [w], there is no phonetic difference. In your analysis, consider whether there is any reason to prefer a consonant plus glide analysis, or a rounded consonant analysis. It may aid your analysis to know that syllable onsets are never of the form [Cj].

kə̀kìnd͡ʒí	‘fish’	ɔ̀lʊ́pʊ́	‘weaver’
náátí	‘cow’	íd͡ʒó	‘yams’
nànát͡ʃísɛ́	‘grandmother’	ɔ́fɔ́	‘guest’
k͡páŋŋá	‘horse’	ók͡pé	‘witch’
kwə̀kú	‘Kwaku’	áfɔ́	‘guests’
áŋkò	‘parrot’	ə́k͡pé	‘witches’
ìk͡pá	‘paths’		

kəkìnd͡ʒíd͡ʒó	‘fish’s yams’	nànát͡ʃiséd͡ʒó	‘grandmother’s yams’
náátíd͡ʒó	‘cow’s yams’	ɔ́fʷéd͡ʒó	‘guest’s yams’
kwəkʷíd͡ʒó	‘Kwaku’s yams’	k͡páŋŋéd͡ʒó	‘horse’s yams’
ɔ̀lʊ́pʷíd͡ʒó	‘weaver’s yams’	áŋꜜkʷéd͡ʒó	‘parrot’s yams’
ók͡péd͡ʒó	‘witch’s yams’		
kəkìnd͡ʒíꜜk͡pá	‘fish’s paths’	nànát͡ʃisɛ́ꜜk͡pá	‘grandmother’s paths’
náátíꜜk͡pá	‘cow’s paths’	ɔ́fʷɛ́ꜜk͡pá	‘guest’s paths’
kwəkʷíꜜk͡pá	‘Kwaku’s paths’	k͡páŋŋɛ́ꜜk͡pá	‘horse’s paths’
ɔ̀lʊ́pʷíꜜk͡pá	‘weaver’s paths’	áŋkʷèk͡pá	‘parrot’s paths’
ók͡péꜜk͡pá	‘witch’s paths’		
kəkìnd͡ʒók͡pé	‘fish’s witch’	nànát͡ʃisók͡pé	‘grandmother’s witch’
náátók͡pé	‘cow’s witch’	ɔ́fók͡pé	‘guest’s witch’
kwəkók͡pé	‘Kwaku’s witch’	k͡páŋŋók͡pé	‘horse’s witch’
ɔ̀lʊ́pók͡pé	‘weaver’s witch’	áŋꜜkók͡pé	‘parrot’s witch’
ók͡pók͡pé	‘witch’s witch’		
kəkìndʒɔ́fɔ́	‘fish’s guest’	nànátʃisɔ́fɔ́	‘grandmother’s guest’
náátɔ́fɔ́	‘cow’s guest’	ɔ́fɔ́fɔ́	‘guest’s guest’
kwəkɔ́fɔ́	‘Kwaku’s guest’	k͡páŋŋɔ́fɔ́	‘horse’s guest’
ɔ̀lʊ́pɔ́fɔ́	‘weaver’s guest’	áŋꜜkɔ́fɔ́	‘parrot’s guest’
ók͡pɔ́fɔ́	‘witch’s guest’		
kəkìnd͡ʒə́k͡pé	‘fish’s witches’	nànát͡ʃisə́k͡pé	‘grandmother’s witches’
náátə́k͡pé	‘cow’s witches’	ɔ́fʷə́kpé	‘guest’s witches’
kwəkʷə́k͡pé	‘Kwaku’s witches’	k͡páŋŋə́k͡pé	‘horse’s witches’
ɔ̀lʊ́pʷə́k͡pé	‘weaver’s witches’	áŋꜜkʷə́kpé	‘parrot’s witches’
ók͡pə́k͡pé	‘witch’s witches’		
kəkìndʒáfɔ́	‘fish’s guests’	nànátʃisáfɔ́	‘grandmother’s guests’
náátáfɔ́	‘cow’s guests’	ɔ́fʷáfɔ́	‘guest’s guests’
kwəkʷáfɔ́	‘Kwaku’s guests’	k͡páŋŋáfɔ́	‘horse’s guests’
ɔ̀lʊ́pʷáfɔ́	‘weaver’s guests’	áŋꜜkʷáfɔ́	‘parrot’s guests’
ók͡páfɔ́	‘witch’s guests’		

Further reading

Clements and Hume 1995; Goldsmith 1990; Hayes 1986; Odden 1995.