Overview of Prosody

Prosody, in terms of theories of phonological representation, refers to syllabicity, length, syllable organisation, stress and related concepts, and certain sequencing relations between segment sequences, usually between adjacent syllables.

Skeletal positions: The problem. One of the basic questions of prosody is how segmental length should be represented. Length could be treated as a binary feature and is so treated in the SPE theory, analogous to nasality or voicing. However, it has long been recognised that to a considerable extent, long vowels behave the same as two short vowels and long consonants often behave like two short consonants. This fact is so widely recognised that it has become standard for long segments to be written *aa*, *uu*, *tt*, *nn* and so on. An example of this patterning is found in the fact that in Yawelmani, long vowels are shortened before clusters of two consonants as well as before geminate (long) consonants (see Chapter 7). This rule interacts with an epenthesis rule which inserts *i* or *u* (depending on the preceding vowel) between the first two of three consonants. This shortening rule explains why the underlying long vowel of /ʔa:ml-al/ and /ʔa:ml-it/ is short on the surface — [ʔamlal] 'help (dubitative)', [ʔaml-it] 'help (passive aorist)'. Examples like /ʔa:ml-hin/, /ʔa:ml-k'a/ which surface as [ʔa:mil-hin] 'help (nonfuture)', [ʔa:mil-k'a] 'help (imperative)' motivate the underlying long vowel. We find the same shortening before a long consonant, thus [dol:-al], [dol:-ut] 'climb (dubitative, passive aorist)', cf. [do:lul-hun], [do:lul-k'a] 'climb (nonfuture, imperative). This shortening makes sense if the long [l:] of [dol:-al] is really two *l*'s (and this is how they are traditionally spelled), thus /do:ll-hin/, /do:ll-al/. Cinching the argument for treating long cononants as two identical consonants is the fact that they can be separated by epenthesis, as in [do:lul-hun], [do:lul-k'a]. If long consonants are single consonants with a feature [+long], there is no expectation that they will act the same as two independent consonants in triggering pre-cluster chortening — this would require the disjunctive conditioning environment {CC,C:}. The change to C_iVC_i before another consonant is even less comprehensible.

A further example of the phonological equivalence of long consonants and consonant clusters is the conditioning environment of gradation in Finnish. Certain phonological changes affect postvocalic consonants which are followed by VCC, one of which is that /p/ becomes [v] — see Chapter 5 exercise 6 for further data on Finnish gradation. The facts of Finnish similarly show that a long consonant behaves phonologically like two consonants. In the data of (1), the underlying /p/ in /orpo/ 'orphan' is attested in the first set of examples where V(C)V follows and gradation does not apply. The second set of examples show a following sequence VC_iC_j, where /p/ becomes [v], and the third set of examples show /VC:/, i.e. /VC_iC_i/, which analogously triggers gradation

(1)

nominative	*partitive*	*essive*	*comitative*
orpo	orpo-a	orpo-na	orpo-inensa
translative	*elative*	*ablative*	
orvo-ksi	orvo-sta	orvo-lta	
inessive	*adessive*	*abessive*	
orvo-s:a	orvo-l:a	orvo-t:a	
=orvo-ssa	orvo-lla	orvo-tta	

Long vowels and diphthongs (divocalic sequences) similarly act alike in various languages. In Hausa, long vowels are shortened before CC, and diphthongs such as /ai, au/ are similarly simplified in the same context. This acounts for alternations such as *ɗa:* 'son', *ɗa:-n-a:* 'my son', *ɗa-n-ka* 'your (m.) son', and also *kai* 'head', *kai-n-a:* 'my head', *ka-n-ka* 'your (m.) head'. If long vowels are really two vowels, this process can be stated along the following lines:

(2) $V \rightarrow \varnothing$ / V__CC

If long vowels are single segments with a feature [+long], on the other hand, the shortening and diphthong simplification processes cannot be stated as a single rule.

Another argument for treating long vowels as two vowels comes from "mora-counting" tone systems such as that of Kimatuumbi, which have rules such as "assign H to the third vowel after the subject prefix", where long vowels count as two vowels for this purpose — see http://ling.osu.edu/~odden/IntroducingPhonology/Kimatuumbi%20Subjunctive%20Tone.pdf "Kimatuumbi" in the supplemental online tone problems.

Lithuanian presents a number of lines of evidence for treating long vowels and diphthongs the same way, as discussed in Kenstowicz 1970. On such fact is that the rising and falling contour tones of the language only appear on long vowels and diphthongs or syllables ending with a liquid or nasal.[1] Thus the language has words like *kâimas* 'village', *vãikas* 'child' with diphthongs, *kârtis* 'pole', *kãrtis* 'bitterness' with VR, and *maſ̂i:ti* 'to see', *maſ̃i:s* 'he will see' with long vowels. In contrast, only level H or L (unmarked) appears on short vowels, as in *mésti* 'to throw', *dúri:s* 'door'. Another argument for the equivalence of long vowels and vowel sequences comes from a progressive accent shifts in certain morphological contexts, which can be described very simply as moving H from the stem-final vowel to the suffix-initial vowel under an account where long vowels are equivalent to VV. The account becomes more complex if stated in terms of syllables and an atomic rising / falling / level distinction. There is no tone alternation in *kâim-a: ~ kâim-u* 'village (acc. sing. ~ instr. sing)' where the diphthong has a falling tone — in the vowel-sequence theory, this is because the H tone element is not at the end of the stem. There is an alternation in the rising tone of *vãik-as ~ vaik-ú* 'child (acc. sing. ~ instr. sing)', since in that example the H tone is at the end of the stem. There is an analogous tonal al-

[1] The inclusion of such VC sequences in the same class with V: and V_iV_j points to a particular account of vowel length based on the notion of 'mora', discussed below.

ternation on long vowels, so that there is no tone shift with a falling long vowel in *vê:j-a: ~ vê:j-u* 'wind (acc. sing. ~ instr. sing)' but there is tone shift from a rising long vowel in *pǒ:n-a: ~ po:n-ú* 'master (acc. sing. ~ instr. sing)'. Final short vowels also participate in this alternation: *mígl-a ~ migl-á* 'mist (acc. sing. ~ instr. sing)'. Retranscribing the data so that each vowel bears only one tone and long vowels are taken to be two vowels makes the nature of the alternation clearer: H tone moves from the last vowel of the stem to the suffix, thus *káim-aa ~ káim-u; vaík-as ~ vaik-ú*; *véej-aa ~ véej-u*; *poón-aa ~ poon-ú; mígl-a ~ migl-á*.

There are also shortening rules in Lithuanian similar to the previously mentioned one in Hausa, which treat long vowels and diphthongs analogously. One rule shortens a word-final falling-toned long vowel or diphthong, a rule which accounts for the final alternations in adjectives in their indefinite and definite forms. Examples of this alternation are *ger-**úo*** → *ger-ú* 'good (instr. sg. masc. indef)', *ger-úo-j-**úo*** → *ger-úo-j-u* 'good (instr. sg. masc. def.)'; *ger-**áa*** → *ger-á* 'good (instr. sg. fem. indef)', *ger-áa-j-**áa*** → *ger-áa-j-a* 'good (instr. sg. fem. def.)'. Long vowels and diphthongs also shorten before syllable-final liquids, cf. *gîr-ti* 'to praise', *gíir-ee* 'he praised'; *pûl-ti* 'to tumble', *púol-ee* 'he tumbled', again pointing to the functional identity of long vowels and diphthongs.

Long vowels and diphthongs are treated the same in attracting accent in a number of languages, including Mongolian and Ancient Greek. Finally, long vowels shorten and diphthongs lose their initial element before another vowel in the formation of the plural in Finnish, as shown by the following alternations involving the partitive suffix *-ta* and the plural suffix *-i*.

(3)

part. sg.	*part. pl*	
puu-ta	pu-i-ta	'tree'
maa-ta	ma-i-ta	'earth'
pää-tä	pä-i-tä	'head'
süü-tä	sü-i-tä	'reason'
pii-tä	pi-i-tä	'silicon'
suo-ta	so-i-ta	'swamp'
tüö-tä	tö-i-tä	'work'
tie-tä	te-i-tä	'road'

In short, there is substantial evidence that long vowels act the same as two short vowels.

One of the problems preventing analysts from simply saying that geminate consonants are always two adjacent identical consonants is that sometimes they do *not* act like clusters. One example is the fact that Trukese has no consonant clusters, but the language does have geminate consonants (see Davis & Torretta 1998, Muller 2001): consider *faat* 'shallow water' vs. *ffaat* 'be strung'; *ačawa* 'sp. fish', *ačča̍wa* 'make slow'. Since there are no consonant clusters in the language, we would not expect any genimates, if geminate consonants are always clusters of identical consonants. Thus the two-consonant account of Trukese requries an exception to the no-cluster generalization — no clusters *except* identical consonants.

Rules of consonant shortening generally pose a problem for the two-consonant account. Another aspect of Finnish gradation is that geminate consonants shorten in this same context as illustrated with *hiekka* 'sand'.

(4)

nominative	*partitive*	*essive*	*comitative*
hiekka	hiekka-a	hiekka-na	hiekko-inensa
translative	*elative*	*ablative*	
hieka-ksi	hieka-sta	hieka-lta	
inessive	*adessive*	*abessive*	
hieka-s:a	hieka-l:a	hieka-t:a	
=hieka-ssa	hieka-lla	hieka-tta	

This is a problem for the cluster view, in that special mechanisms are needed to identify long consonants, i.e. something like Greek letter variable notation is needed to identify a sequence of featurally identical consonants. The impact of this problem was of course ameliorated in the literature by the use of the informal notation C_iC_i. Analogously, Lithuanian also has a rule turning long *a:* into [o:], which applies to the output of a lexical rule lengthening the stem vowel of verbs in the non-present, and that rule accounts for the alternations *tup-ú* 'I perch', *tŭ:p-ti* 'to perch' and *vag^{y}-ú* 'I steal', *vŏ:g-ti* 'to steal' the latter derived via the form *va:gti*. Any reference to the property "long" is, in the sequence theory, equivalent to the more complicated expression "sequence of adjacent identical elements", which is a complication that weighs against the advantages resulting from the sequence theory.

The need to refer to a concept "short" also poses problems for the sequence theory, and an example of that nature is found in Biblical Hebrew, as pointed out in Sampson 1973. Postvocalic stops (allophonically) spirantize, resulting in alternations such as *melex* ← /melek/ 'king' ~ *malk-a:* 'queen'; *mi-xta:v* ← /mi-kta:b/ 'letter' ~ *ka:θav* ← /ka:tab/ 'he wrote'. Long consonants do not spirantize, as in *gid:e:l* 'he magnified' ~ *ga:ðal* ← /ga:dal/ 'he became great'. Note that if a consonant is followed by another nearly identical consonant differing only in voicing, there *is* spirantization, so /la:mad-ti/ → *la:maðti* 'I studied'. In order to identify short consonants in the sequence theory, you must state a disjunction of the following type:

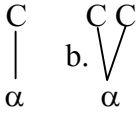
(5)
$$\begin{bmatrix} +\text{cons} \\ \alpha\text{voice} \\ \beta\text{nasal} \\ \gamma\text{cor} \\ \delta\text{ant} \end{bmatrix} \rightarrow [+\text{cont}] \; / \; \text{V}\_\_ \begin{Bmatrix} -\alpha\text{voice} \\ -\beta\text{nasal} \\ -\gamma\text{cor} \\ -\delta\text{ant} \end{Bmatrix}$$

Another example of the single-segment behavior of long consonants is found in Luganda (Clements 1986). Luganda presents evidence for a bisegmental representation of its geminates, but also has some evidence for a monosegmental representation. One example of the latter evidence is the fortition process discussed in Chapter 8 where long /yy, ww, ll/ become [j̃j̃, gg^{w}, dd] (cf. *ddaanga* 'lily', *ma-laanga* 'lilies'), which as we have seen raises the problem of identifying a 'long consonant'. A second process coronalizes velar and alveolar consonants before the un-

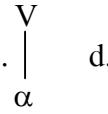
derlying *y* of the perfective suffix (cf. *tulimye ~ tulima* 'we cultivate (pres. perf ~ pres.)'), giving rise to alternations *tuleese ~ tuleeta* 'we bring (pres. perf ~ pres.)', *tweetaaze ~ tweetaaga* 'we need (pres. perf ~ pres.)'. When applied to a long consonant, the entire consonant is mutated, thus *tuyigga ~ tuyizze* 'we hunt (pres. perf ~ pres.)'.

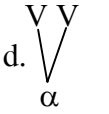
Another kind of problem involving geminate consonants is found in Berber (Saib 1974, Guersell 1978). Berber has an intensive-stem formation process, where roots in the plain form $C_1C_2əC_2$ have the shape $C_1əC_2C_2əC_3$ in the intensive, thus *šrəs ~ šərrəs* 'to tie', *zmər ~ zəmmər* 'to be able', *zdəγ ~ zəddəγ* 'to live'. Stems with only two consonants instead lengthen the first consonant and change the vowel to [a], as in *səγ ~ ssaγ* 'to buy'. The two-consonant account of geminates predicts that a root with an initial geminate consonant would have the intensive shape $C_1əC_1C_1əC_2$ and the single segment hypothesis predicts $C_1C_1aC_2$. In fact, both hypotheses are wrong: the prefix *ttə-* is added, instead, cf. *kkəs ~ ttə-kkəs* 'to remove', *zzər ~ ttə-zzər* 'to pluck'. An analogous case is noted by Kenstowicz & Pyle 1973 who point out that the Sierra Miwok present stem CVCVCC, which involves metathesis when a stem of the shape CVCCV has distinct consonants, but requires a separate process inserting glottal stop if the medial CC is composed of identical consonants — i.e. is a single long consonant. Thus *kicá:w* → *kicáww* 'bleed', *célku* → *celúkk* 'quit', but *hámme* → *hamé??* 'bury' and not **hamemm*. In these cases, geminate consonants act neither like two consonants nor like one.

The CV Theory of the Skeleton. These and other problems in the theory of length were addressed theoretically in a number of related ways, centering around the idea that with multiple layers of representation (autosegmental theory), long segments could be represented as two units on one level, and one unit on another. In what is known as CV theory (Clements & Keyser 1983), there is a *skeletal* representation and a *segmental* representation. Long segments would be single segments, but they would associate autosegmentally to two positions on the skeletal tier, which is populated with C's and V's. In addition to indicating length, the distinction between C and V corresponds to the (formerly) segmental contrast [-syllabic] ~ [+syllabic]. The basic conbinations in the theory are thus:

(6) a. 

b.

c. 

d. 

Structure (a) would be a short nonsyllabic segment — a consonant in the ordinary sense, and (b) would be long; (c) and (d) would be appropriate for short and long vowels respectively. Given this, rules which treat long segments as equivalent to two short segments would refer to the skeletal tier where long segment *are* two units. There is a considerable literature on the question whether it can be predicted that a rule treats long segments as two segments or one. See Hayes 1986, Schein & Steriade 1986 for further discussion of the one segment / two segment issue.

Evidence for the CV Theory: Templatic Morphology. One widespread use of CV theory is to describe templatic morphology, as found in Semitic and Miwok, among other languages. The classical application of this is Classical Arabic verb morphology, as proposed first by McCarthy

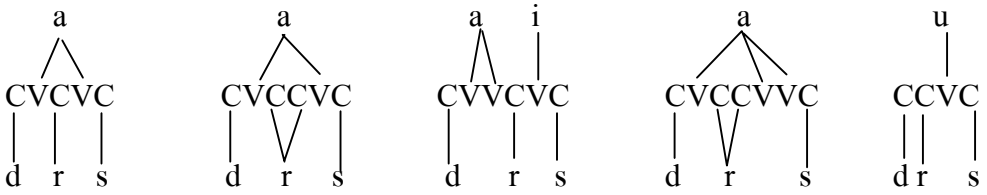
1979. The basic content of a root in Classical Arabic is an ordered set of 2 to 4 consonants. The presence of specific vowels, their position, and the length of segments is determined by inflectional morphology. Examples of this system are seen below.[2]

(7)	daras-a	ħamal-a	rasam-a	šarib-a	3ms perfective
	darras-a	ħammal-a	rassam-a	šarrib-a3ms	perfective causative
	daaris	ħaamil	raasim	šaarib	participle
	darraas-un	ħammaal-un	rassaam-un	šarraab-un	intensive/professional N
	drus	ħmil	rsum	šrab[3]	imperative
	'study'	'carry'	'draw'	'drink'	

Stem shapes correspond to particular morphological derivatives, for example CVCVC is the basic perfective verb form, CVCCVC with [a] as the stem vowel is the causative (second measure), CVVCVC with the vowel pattern [a...i] is gives an active participle, and so on.

Analogous to the idea of a tone melody, these different surface patterns can be explained by positing a lexical root morpheme composed of just consonants (/drs, ħml, rsm, šrb/) which carry certain aspects of word meaning, and these combine with CV skeletal patterns (CVCVC, CVCCVC, CVVCVC, CVCCVVC, CCVC) associated with other aspects of word-formation such as 'causative', 'imperative'. These elements (plus particular vowels, which also constitute morphemes in Classical Arabic), are then linked up:

(8)



This approach was also applied to reduplication (Marantz 1982, Clements 1985), by affixing a fixed arrangement of empty CV elements which caused copying, but further research on the subject indicated that reduplication per se does not provide evidence for the CV tier, and instead may provide some support for syllables, feet and other higher levels of prosody.

Compensatory Lengthening. Another major problem in phonology has been the account of compensatory lengthening (see Chapter 8), which is the process of lengthening a segment as a consequence of some other phonological operation. One example is found in Klamath (Kisseberth 1973), where glottal stop is deleted in syllable-final position and the preceding vowel is lengthened as a consequence. Data motivating this process include /sleʔ-a/ → [sleʔa] 'sees' ~ /sleʔ-ca-a/ → [sle:ca] 'goes to see', /hes-sleʔ/ → [hesle:] 'show!'. The problem which such alternations pose is how to capture the relationship between vowel lengthening and deletion of glottal stop. One general approach it to assume that the connection is fortuitous, for example

[2] Data from Kenstowicz 1994, Wright 1971.

[3] Phrase-initially there is an epenthetic vowel agreeing in roundness with the following vowel, hence *udrus, iħmil*.

maybe there is some rule lengthening vowels before certain syllable-final consonants, and then a separate rule deleting some of those consonants, so that the derivation procedes by steps: /sleʔ-ca-a/ → *sle:ʔ-ca-a* → [sle:ca]. This is the approach followed in Aoki 1974 for vowel contraction in Xhosa (albeit not with respect to vowel length, but rather for vowel quality), and to the extent that it can be shown that there is some independence to the individual postulated rules, this is a quite reasonable approach. Another tack that can be taken is to posit a transformational rule, such as the following rule of Glottal Lengthening from White 1973:140, posited to account for simultaneous lengthening and deletion in Klamath:

(9) $\begin{array}{lcl} \langle V\rangle\ \ ʔ\ \ C & & \langle 1\rangle\ \ \varnothing\ \ 3 \\ 1\ \ \ 2\ \ 3 & \rightarrow & +\text{long} \end{array}$

The theoretical objection to such a rule is that unrestricted rewrite rules are formally quite powerful, and overgenerate the class of "compensatory" actions. For example it is just as easy to describe a hypothetical and unattested process of glottal-stop deletion with compensatory vowel rounding. Recourse to unrestricted rewrite rule will almost always allow you to "grind out the facts" — vast numbers of imaginable but unattested processes are predicted with the power of unrestricted rewrite rules, and it has been a general desideratum to avoid them in phonology entirely. The autosegmental mechanisms invoked to account for compensatory lengthening were part of a general research program aimed at constraining the nature of phonological formalism, in order to avoid the highly powerful notational devices used in earlier SPE-style phonology.

In the autosegmental account (the spirit of which is first set forth in Ingria 1980 though using a different formalism), compensatory lengthening involves the detachment of a segment from a skeletal position, which then reattaches to a neighboring segment, resulting in a branching prosodic structure which is interpreted as length. For Klamath, the derivation of [sle:ca] is as follows.

(10)

Kimatuumbi presents a number of phonological processes relevant to the account of compensatory lengthening (see Odden 1996), especially data which prove the connectedness of the two operations involved in CL — it is not possible in these cases to decompose the processes into separate rules which apply independent of each other, as Aoki proposed for vowel fusion processes in Xhosa. The data below illustrate the Glide Formation rule of Kimatuumbi, whereby prevocalic high vowels become glides before another vowel.[4] The examples on the right show that the root-initial vowels are underlyingly short, and they surface as such after another vowel or word-initially. Thus this alternation is an example of compensatory lengthening arising from Glide Formation, and not a process of shortening applying in some other context.

[4] In these data, the cedilla diacritic is the traditional indicator of a super-high vowel. In featural terms Bantu <i̧> and <i> are equivalent to standard phonological [i] and [ɪ].

(11)						
	mi̱-kaáte	‘loaves’	my-oóyo	‘hearts’	ma-óyo	‘large hearts’
	li̱-ku̱n’u̱ú̱nda	‘filtered beer’	ly-oowá	‘beehive’	ma-owá	‘beehives’
	ki̱-kálaango	‘frying pan’	ky-u̱ú̱lá	‘frog’	ka-ú̱lá	‘small frog’
	lu̱-toóndwa	‘star’	lw-aaté	‘banana hand’	até	‘banana hands’

Additional examples strengthen the conclusion that application of Glide Formation results in compensatory lengthening of the following vowel. The data below show that there could not be a rule shortening a long vowel after a vowel or in word-initial position.

(12)				
	mw-eémbe	‘mango tree’	eémbe	‘mango fruit’
	ly-éeke	‘bin’	ma-éeke	‘bins’
	mw-eéla	‘in money’	eéla	‘money’

We see further examples of Glide Formation with compensatory lengthening in the verbs of (13), where the (C)V subject prefix changes its vowel into a glide, lengthening the following vowel.

(13)						
	ni̱-téli̱̱ike	‘I cooked’	ny-uúbili̱̱ile	‘I expected’	úbilya	‘to expect’
	tu̱-téli̱̱ike	‘we cooked’	tw-eéki̱te	‘we laughed’	éka	‘to laugh’
	u̱-téli̱̱ike	‘you(sg.) cooked’	w-aáki̱te	‘you(sg.) hunted’	áka	‘to hunt’

The next set of examples shows that the underlying short vowel remains short when preceded by a prefix that does not undergo Glide Formation.

(14)				
	ga-úbili̱̱ilwe	‘they (Cl. 6) are expected’	naaba-úbili̱̱ile	‘I expected them’
	ba-éki̱te	‘they laughed’	a-eké	‘he should laugh’
	aa-áki̱te	‘he hunted’		

And parallel to the noun examples in (12), (15) shows that underlying long vowels do not automatically shorten after another vowel or word-initially.

(15)				
	áandi̱ka	‘to write’	tw-áandi̱̱ike	‘we wrote’
	úuma	‘to win a case’	w-úumi̱te	‘you won’
	íimba	‘to dig’	ny-íimbi̱te	‘I dug’
	ba-íimbi̱te	‘they dug’	ba-úumi̱te	‘they won’

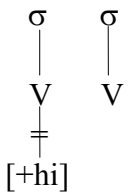
Further data strengthen the claim that lengthening of the following vowel is connected with desyllabification of the preceding high vowel. When the prevocalic high vowel is H toned, Glide Formation is optional. This results in the following patterns of free variation.

(16)

patu̯ekiíté	~ patw-éekiíté	'when we laughed'
chau̯akáé	~ chaw-áakáé	'what you were hunting'
pakiu̯tii̯ilwé	~ paky-u̯u̯tii̯ilwé	'when it (Cl. 7) was harvested'
aabíkite mu̯aanju̯ ~ aabíkite mwáanju̯		'he put it in the firewood'

The optionality of Glide Formation makes it impossible to account for the apparent connection between Glide Formation and vowel lengthening under an independent-rule analysis. A rule optionally lengthening vowels after prevocalic high vowels would incorrectly allow lengthening without Glide Formation, e.g. *chau̯akáé* could be subject to lengthening without Glide Formation, predicting impossible **chau̯aakáé*, as well as allowing Glide Formation without lengthening (**chawákáé*). Nor can there be a rule lengthening vowels after glides, see *baaéleewi̯te* 'they understood' inter alii. Some means is needed to encode lengthening as a side effect of the fact that the rule of Glide Formation has applied. Transformational-format rules are one way to accomplish this, as in the case of Klamath glottal deletion, and global rules accomplish the same thing (by stating the condition as involving glides derived from a particular rule), but the added generative power of those devices is unattractive. The autosegmental approach is to make use of representations that are already needed, and to treat this as analogous to tone preservation, in this case preservation and transfer of "V". The rule of Glide Formation could be formalized as follows, where V refers to one of the two elements V, C on the skeletal tier and σ refers to "syllable" (we consider syllables below).

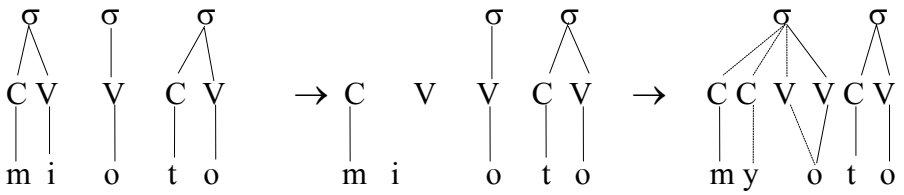
(17)



This rule delinks a [+hi] segment (a vowel) from its V-slot when it comes before a vowel. In this approach, there are a number of "virtual steps" which are automatically taken, in order to repair the result of such a delinking rule. In the derivation of *myooto* from /mi̯-oto/, the removal of a vowel from the first syllable's nucleus leads to the automatic deletion of the syllable's structure, on the principle that well-formed syllables need nuclear segments. The surviving material (segments and skeletal units) reassociate with the syllable that follows, analogous to how tones reassociate with the segments which cause them to float. The interpolation of a C-slot between the (stranded) high vocoid and the syllable reflects an automatic repair whereby segments in the onset (beginning) of a syllable link through the default node C.[5]

[5] There were other accounts of this reaffiliation of the glide as part of the onset, so that in Clements' 1986 account of analogous processes in Luganda, the glide segment would share a C-slot with the preceding consonant.

(18)

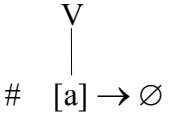


Kimatuumbi presents other compensatory lengthening phenomena, which are analysed roughly the same way in an autosegmental account of length. Another process is the optional deletion of the demonstrative prefix *a*, which causes lengthening of the preceding vowel.

(19)			
	atweṭi ách**i**	atweṭi**íi** chi	‘he took this’
	kịtabṵ́ ach**ó**	kịtabṵ́**ṵ** ch**ó**	‘that book’
	lwuúmo alwoólwo	lwuúmoo lwoólwo	‘that (remote) story’
	sụlé ay**í**	sụlé**e** y**í**	‘this school’
	ndó ayoóyo	ndóo yoóyo	‘that (remote) bucket’

The rule of deletion would be simply deletion of the segment [a] at the beginning of a demonstrative after another vowel: compensatory lengthening would then affect the previous vowel because that is the vowel that causes deletion of the segment [a] (which then sets into motion a series of syllable-structure deletions and reconstructions). Analogous directionality issues come up in tone preservation, where tones reassociate with the vowel that causes the tone to float.

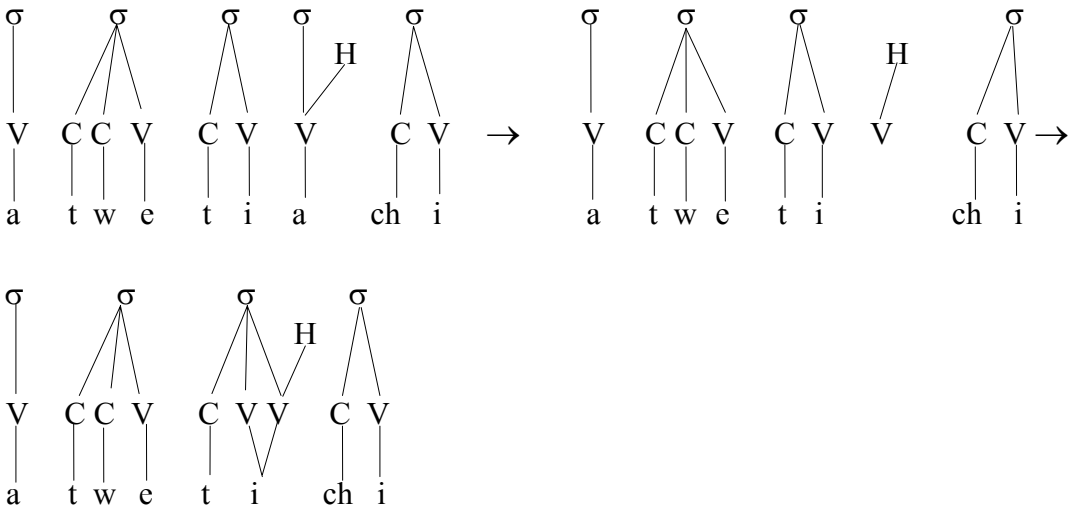
(20)



(in demonstratives)

In the first step, the prefix vowel /á/ is deleted, which leads to a V slot linked to a H tone, which then reassociates to the preceding syllable, leading again to compensatory lengthening.

(21)



There are a number of important technical details that need to be sorted out, for example exactly what algorithm determines the reassociation of segments and prosodic material into a syllable; what principle determines the syllable which is compensatorily lengthened; what determines whether there is compensatory lengthening vs. simple deletion; are C and V primitive elements; are there major asymmetries in the treatment of C and V. These and other issues were discussed extensively in the literature of the 70's into the 90's.

Empty Skeletal Slots. Another phenomenon which motivated the CV tier is the timing-tier equivalent of the floating tone, namely the empty skeletal slot. One example of this can be seen in the Bantu language Kikamba. Fundamental facts of Kikamba regarding phonological processes and surface contrast point towards the need for some enrichment of prosody beyond the linear-theory account of vowel length as a two-way contrast. One of the most basic problems of Kikamba phonology — a fairly significant challenge for binary feature theory — is the existence of more than two degrees of surface-contrastive vowel duration. The language presents surface forms such as [kokità] 'to thatch', [ko:kità] 'to fight' and [ko::lokà] 'to fly', where the length of the vowel in the first syllable varies between short, long and over-long — there are additional degrees of surface length such as quadruple-long vowels found in [ko:::ločà] 'to make it fly'.[6] In keeping with standard transcriptional practice and in recognition of phonological facts in the language supporting a two-unit representation of long vowels (see discussion of the V: ~ VV equivalence above), Kikamba long vowels will be transcribed as a sequence of adjacent identical vowels. Additional degrees of length will therefore be (for the moment) indicated with a raised plus sign.

The data in (22) illustrate some basic phonological patterns. The first two examples motivate prefixes: /ko/ 'infinitive', /mo/ 'him', /mó/ '2 pl. object', /má/ 'them', /ké/ 'it (object)'.

(22)	'to X'	'to X him'	'to X 2pl'	'to X them'	'to X it'	
	kotā́lā́	komotā́lā́	komótā́lā́	komátā́lā́	kokétā́lā́	'count'
	kokṓònzà	komokṓònzà	komókṓònzà	komákṓònzà	kokékṓònzà	'fold'
	kokonà	komokonà	komókonà	komákonà	kokékonà	'hit'
	kokaàða	komokaàðà	komókaàðà	komákaàðà	kokékaàðà	'praise'

In addition, (22) illustrates facts about tone. Kikamba has 4 levels of tone, Superhigh (v̋), H (v́), L (v) and Superlow (v̀). Roots come in two lexical tonal types, H and L (regardless of length). The exact tonal realization of that distinction depends partially on the presence of tense-aspect tonal inflections, and in the infinitive, two-syllable H stems with a penultimate short vowel have the tone pattern cv̋cv̋ and those with a penult long vowel have cv̋v̀cv̀. Similarly, two-syllable L stems with a penultimate short vowel have the tone pattern cvcv̀ and those with a penult long vowel have cvv̀cv̀. This distribution arises from underlying forms such as /cv́cv/, /cv́vcv/, /cvcv/ and /cvvcv/ plus a word-final affixal Superlow tone which marks the infinitive and certain other tenses. That Superlow tone spreads leftward to the end of a long penultimate syllable, which ex-

[6] Overlong vowels are approximately 40% longer than plain long vowels: see Robert-Kohno 2000.

plains the presence of Superlow on the second mora of the penult long vowels, and H is then raised to Superhi before a Superlow tone. Finally, Superhi before word-final Superlow spreads to the end, so that derives /kotā́là/ becomes [kotā́lā́].

Other examples illustrate combinations of these prefixes plus vowel-initial verb roots, where regular rules of hiatus-resolution apply. The vowels /e, o/ become [w,y] with compensatory lengthening of the following vowel; *w* deletes before *o*, *u* and *ky* becomes [č] (these processes are also seen in the data of Chapter 5). The vowel /a/ also merges with a following vowel, fusing segmentally with /o,e/ into [ɛ, ɔ]. Although it is not immediately obvious, /a/ also fuses syllabically with following /u/ into a monosyllabic diphthong, *au*.

(23)	'to X'	'to X him'	'to X 2pl'	'to X them'	'to X it'	
	kőőmyā́	komőőmyā́	komőőmyā́	komɔ̋ɔ̋myā́	kočőőmyā́	'dry'
	kűűmyā́	koműűmyā́	koműűmyā́	komā́űmyā́	kočűűmyā́	'bring out'
	kwɛɛ̀ndà	komwɛɛ̀ndà	komwɛ̋ɛ̀ndà	komɛ̋ɛ̀ndà	kočɛ̋ɛ̀ndà	'love'

Subtracting the effects of vowel fusion and also the effect of the tonal processes mentioned above and others to be discussed, these surface forms derive from the following more basic forms.

(24)	'to X'	'to X him'	'to X 2pl'	'to X them'	'to X it'	
	ko-ómyà	ko-mo-ómyà	ko-mó-ómyà	ko-má-ómyà	ko-ké-ómyà	'dry'
	ko-úmyà	ko-mo-úmyà	ko-mó-úmyà	ko-má-úmyà	ko-ké-úmyà	'bring out'
	ko-ɛɛndà	ko-mo-ɛɛndà	ko-mó-ɛɛndà	ko-má-ɛɛndà	ko-ké-ɛɛndà	'love'

Glide Formation and fusion apply to eliminate these vowel clusters (the question of [au] will be taken up later), yielding the following intermediate forms.

(25)	'to X'	'to X him'	'to X 2pl'	'to X them'	'to X it'	
	koómyà	komoómyà	komóómyà	komɔ́ɔ́myà	kočóómyà	'dry'
	kuúmyà	komuúmyà	komúúmyà		kočúúmyà	'bring out'
	kwɛɛndà	komwɛɛndà	komwɛ́ɛndà	komɛ́ɛndà	kočɛ́ɛndà	'love'

Given the aforementioned tone rules — spread of SL to the second half of a long vowel, creation and spread of SH before SL — the surface forms predicted so far would be as follows.

(26)	'to X'	'to X him'	'to X 2pl'	'to X them'	'to X it'	
	koőmyā́	komoőmyā́	komóőmyā́	komɔ́ɔ̋myā́	kočóőmyā́	'dry'
	kuűmyā́	komuűmyā́	komúűmyā́		kočúűmyā́	'bring out'
	kwɛɛ̀ndà	komwɛɛ̀ndà	komwɛ̋ɛ̀ndà	komɛ̋ɛ̀ndà	kočɛ̋ɛ̀ndà	'love'

The attested surface forms reflect the application of one further tone rule, one eliminating rising tones (L-H, L-SH or H-SH combinations), whereby the tone on the second mora of a long rising-toned syllable spreads rightward within the syllable, resulting in a level H.[7]

(27) *Rise Simplification*

Thus *komoőmyấ* and *komóőmyấ* become [komőőmyấ]. Given this rule, we can now understand the significance of the form *komấűmyấ* 'to bring them out', as opposed to predicted **komáűmyấ*. We see that the Rise Simplification rule has applied, which implies that the divocalic sequence *au* is — in these examples — a single syllable, structurally analogous to a long vowels, in a fashion quite similar to the treatment of long vowels and diphthongs in Hausa and Lithuanian, inter alios, discussed in the first section.

A number of verb stems pose an apparent problem for the analysis given so far. Representative examples are seen below.

(28)

'to X'	'to X him'	'to X 2pl'	'to X them'	'to X it'	
koő$^{+}$myấ	komoő$^{+}$myấ	komóő$^{+}$myấ	komáőmyấ	kokéőmyấ	'make bite'
koűmấ	komoűmấ	komóűmấ	komáűmấ	kokéűmấ	'curse'
koɛɛ̀ndyà	komoɛɛ̀ndyà	komóɛɛ̀ndyà	komáɛɛ̀ndyà	kokéɛɛ̀ndyà	'make go'

These forms present a number of problems. First, we observe a number of rising tones which would ordinarily be simplified to level H or SH tones (cf. *koő$^{+}$myấ* 'to make bite' vs. *kőőmyấ* 'to dry'). Additionally, we find forms with triply-long vowels: *koő$^{+}$myấ, komoő$^{+}$myấ, komóő$^{+}$myấ* vs. *kőőmyấ, komőőmyấ, komőőmyấ*. Vowel hiatus abounds, seen in *koűmấ, komoűmấ, komóűmấ, kokéűmấ, komáɛɛ̀ndyà* vs. *kűűmyấ, koműűmyấ, koműűmyấ, kočűűmyấ, komɛ̋ɛ̀ndà*. These differences fall out from one fact: the latter set of roots do not undergo any of the vowel-hiatus resolution rules of the language. Thus the underlying forms and surface forms are nearly identical, the former being as follows:

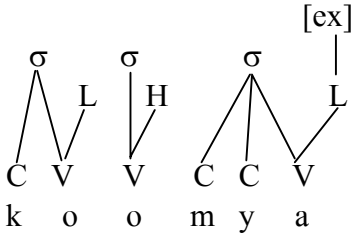
(29)

'to X'	'to X him'	'to X 2pl'	'to X them'	'to X it'
ko-ómyà	ko-mo-ómyà	ko-mó-ómyà	ko-má-ómyà	ko-ké-ómyà
ko-úmà	ko-mo-úmà	ko-mó-úmà	ko-má-úmà	ko-ké-úmà
ko-ɛɛndyà	ko-mo-ɛɛndyà	ko-mó-ɛɛndyà	ko-má-ɛɛndyà	ko-ké-ɛɛndyà

[7] The feature composition of tones in 4-level languages is poorly understood, but in Kikamba, SL and SH tones are reducible to the more familar H/L distinction, plus a hierachically-subordinate feature [extreme] whereby SH is H with [extreme]. In this rule, H spreads and takes with it any existing [extreme] specification.

These puzzles can be explained by preventing vowel-hiatus resolution from applying. Thus we can assume something like the following near-surface representation for 'to make bite'.

(30)



The failure of Rise Simplification follows from the fact that there is no long vowel and thus no rising-toned syllable in the representation. This representation also provides a basis for the surface distinction in duration between long and over-long vowels — a long vowel is a single vowel segment bearing two V-slots within a single syllable, whereas an overlong vowel is two adjacent vowel segments each with a single V-slot and being in separate syllables.[8] In the case of surface non-identical vowel sequences as in *kokéőmyá*, we encounter the anomolies that the vowel sequence remains unresolved, and therefore no long vowel and rising tone is created which could undergo Rise Simplification. As for the distinction between long and overlong vowels, these V_iV_j sequences do in fact have the same duration as disyllabic identical vowel sequences — since all V_iV_j sequences are disyllabic, there is no surface contrast between long and overlong, as there is with mono-vocalic length.[9] These data can therefore be retranscribed by introducing distinctive syllabification between vowels.

(31)

kőőmyá	komőőmyá	komőőmyá	komɔ̋ɔ̋myá	kočőőmyá
kűűmyá	koműűmyá	koműűmyá	komä̋ümyá	kočűűmyá
kwɛɛ̀ndà	komwɛɛ̀ndà	komwɛ́ɛ̀ndà	komɛ́ɛ̀ndà	kočɛ́ɛ̀ndà
ko.őmyá	komo.őmyá	komó.őmyá	komá.őmyá	koké.őmyá
ko.űmá	komo.űmá	komó.űmá	komá.űmá	koké.űmá
ko.ɛɛ̀ndyà	komo.ɛɛ̀ndyà	komó.ɛɛ̀ndyà	komá.ɛɛ̀ndyà	koké.ɛɛ̀ndyà

[8] The CV theory provides a representational basis for this vowel-duration contrast, but the actual rule which dictates that a bimoraic bisyllabic identical vowel sequence has a greater duration than a bimoraic monosyllabic vowel is outside the domain of phonology, and is in the domain of a theory of phonetics-phonology interface. It is not presently possible to decide on the basis of the known Kikamba data whether the additional syllable is the source of the added duration, or whether the extra vowel segment is: or, it may be a combination of these factors.

[9] There may be a difference in duration between the monosyllabic diphthong [au] and a bisyllabic *a-u* sequence, in *komáűmá* vs. *komáűmyá*, but this possibility has not been tested experimentally, and since there do not appear to be any tonally-controlled minimal or near-minimal pairs involving this diphthong, it is unclear whether literally all diphthongs are overlong. The evidence from the phonology of vowel fusion and rise-simplification indicates that in *komáűmyá* the penult has a divocalic long syllable. If the durations of the two kind of [au] are identical and comparable to other bisyllabic V_iV_j sequences, we will have evidence that the extra syllable is not the source of added duration of overlong vowels: if the durations are different, we will have evidence that the extra syllable *is* the cause of overlength.

Now the central question which remains to be answered is, why do some roots systematically maintain vowel hiatus and others systematically avoid it? The examples considered so far have focused on root-initial position, but unresolved hiatus is found in numerous positions within the word.

(32)				
	kokɔ.ɔmà	'to growl'	konɛ́.ɛnà	'to speak'
	kokɔ́.ɔɔ̀tà	'to stretch'	ko.ate.e.à	'to follow'
	konɔ.à	'to sharpen'	kwááto.a	'to split'
	kweeke.a	'to pour'	kokɛ.ɛlɛɛ̀lyà	'to scare away'
	kwɛ.à	'to scrape out'	kwí.ā́	'to be black'

Noting in particular examples like /ko-ɛ-a/ 'to scrape out' and /ko-í-a/ 'to be black', we cannot simply say that the root is an exception to the rules giving vowel-hiatus resolution: these roots are apparent exceptions seen from the right edge but not from the left edge.

The CV theory offers a simple account of the problem of selectively blocking the vowel-hiatus resolving rules, through the device of the empty C-slot, a prosodic C element with no segmental content.

(33)		
	C V -V C - V	C V - C V C V C -V
	k o - i - a	k o - k ɔ ɔ m - a

The empty C thus blocks Glide Formation and other rules merging adjacent vowels, since at the level of the skeletal tier, *i* and *a* in 'to become black' are not adjacent — whereas Glide Formation does apply between *o* and *i*, which are skeletally adjacent.

Robert-Kohno 2000 provides a number of additional pieces of evidence for the existence of empty C slots in the underlying representations of morphemes. One such fact is the treatment of the 1st singular object prefix /N/ when placed before a true vowel-initial root versus a root beginning with an empty C. The 1sg object prefix is a placeless nasal consonant which assimilates in place of articulation to a following consonant (also causing certain changes on that consonant — voicing and fortition). As the data of (b) show, when added to a true vowel-initial root, the consonant [b] is inserted, to which the nasal can assimilate. But a different consonant, [d], appears just on case the root begins with an empty C.

(34)		*to V*	*to V me*	*root*	*gloss*
	a.	kotā́lā́	koondā́lā́	tál	count
		kosuùngà	koonzuùnga	suung	guard
		kolɛ́ɛ̀syà	koondɛ́ɛ̀syà	léesi	make climb
		kokaàðà	koongaàðà	kaað	praise
		koboñà	koomboñà	boñ	pinch
	b.	kweèka	koombekà	ek	possess
		kwā́ā́kā́	koombā́kā́	ák	strengthen
		kwɛ́ɛ́nzā́	koombɛ́nzā́	ɛ́nz	shave
		kookità	koombokità	okit	fight

c.	ko.ebà	koondeba	Ceb	pay
	ko.ɛkà	koondɛkà	Cɛk	leave
	ko.o.e.à	koondo.e.à	CoCeC	buy for

Other rules giving evidence for empty C's in Kikamba include processes of lateral-harmony, assibilation, Ganda Law and initial shortening.

Similar evidence exists for an empty C slot in Finnish. The following data illustrate certain core processes of Finnish phonology which we have touched on in numerous places in this chapter and the book.. The first set of examples motivates basic roots and affixes, plus a phonological rule deleting *t* in the partitive after a short vowel. The endings are *-ta, -t, -ssa* and *-na*, and the illative minus *-na* best reveals the underlying form.

(35)	*nominative*	*partitive*	*nom. pl.*	*inessive*	*illative*	
	maa	maata	maat	maassa	maana	'land'
	koi	koita	koit	koissa	koina	'moth'
	lokero	lokeroa	lokerot	lokerossa	lokerona	'pigeonhole'
	arvelu	arvelua	arvelut	arvelussa	arveluna	'conjecture'
	talo	taloa	talot	talossa	talona	'house'
	muuri	muuria	muurit	muurissa	muurina	'wall'

The next set of examples motivate rules of *e*-deletion and final *e*-raising. Word-final /e/ raises to [i] (see also Chapter 4), and the underlying vowel usually emerges on the surface in an affixed form such as the inessive. Final /e/ deletes in the partitive, depending on the preceding consonant (as long as the consonant is not part of a consonant cluster and either *h*, a nasal or a coronal — this class relates to constraints on consonant clusters in the language). When /e/ deleted after /m/, the nasal assimilates in place of articulation to the following stop.

(36)	*nominative*	*partitive*	*nom. pl.*	*inessive*	*illative*	
	lapsi	lapsea	lapset	lapsessa	lapsena	'child'
	sormi	sormea	sormet	sormessa	sormena	'finger'
	yoki	yokeä	yoet	yoessa	yokena	'river'
	nimi	nintä	nimet	nimessä	nimenä	'name'
	lohi	lohta	lohet	lohessa	lohena	'salmon'
	kieli	kieltä	kielet	kielessä	kielenä	'tongue'
	kuusi	kuusta	kuuset	kuusessa	kuusena	'spruce'

Gradation is examplified below. When the last stem consonant begins a closed syllable, that consonant is weakened, so that geminate stops become single and single stops become voiced (in the case of /t/, /p/) or delete (in the case of /k/), and will also assimilate to a homorganic sonorant. Here, the underlying form is generally the same as the nominative singular, though the stem may have the final vowel /e/ which undergoes final *e*-raising.

(37)	*nominative*	*partitive*	*nom. pl.*	*inessive*	*illative*	
	mükkä	mükkää	mükät	mükässä	mükkänä	‘mute’
	kirkko	kirkkoa	kirkot	kirkossa	kirkkona	‘church’
	pappi	pappia	papit	papissa	pappina	‘priest’
	keŋkä	keŋkää	keŋŋät	keŋŋässä	keŋkänä	‘shoe’
	lintu	lintua	linnut	linnussa	lintuna	‘bird’
	poika	poikaa	poyat	poyassa	poikana	‘boy’
	parka	parkaa	parat	parassa	parkana	‘poor’
	silta	siltaa	sillat	sillassa	siltana	‘bridge’
	tähti	tähteä	tähdet	tähdessä	tähtenä	‘star’
	mäki	mäkeä	mäet	mäessä	mäkenä	‘hill’
	koti	kotia	kodit	kodissa	kotina	‘home’

Thus [kirkot] derives from /kirkko-t/ and [parat] derives from /parka-t/.

Finally, there are longer stems which underlyingly end in the vowel /e/, and that vowel is deleted word-finally and before the partitive ending. The vowel surfaces in the nominative plural; if the (derived) final consonant is /m/, it becomes [n] word-finally since no words in Finnish end in [m].

(38)	*nominative*	*partitive*	*nom. pl.*	*inessive*	*illative*	
	sammal	sammalta	sammalet	sammalessa	sammalena	‘moss’
	küünel	küünelta	küünelet	küünelessä	küünelenä	‘tear drop’
	üdin	üdintä	ütimet	ütimessä	ütimenä	‘nucleus’
	ahven	ahventa	ahvenet	ahvenessa	ahvenena	‘perch (fish)’

The underlying forms of these stems are /sammale, küünele, ütime, ahvene/. In /ütime/ and /ütime-tä/, the final vowel deleted giving *ütim* and *ütimtä*, which because of the derived closed syllable undergoes gradation, and the surface form results from change in place of articulation of the final nasal. This rule does not apply in disyllables like /lume/ since would give a monosyllable *[lun] — this is an instance of a minimality effect, found in many languages of the world (discussed further, in the final section).

There are a number of puzzling forms, which have common surface irregularities.

(39)	*nominative*	*partitive*	*nom. pl.*	*inessive*	*illative*	
	terve	tervettä	terveet	terveessä	terveenä	‘healthy’
	kirye	kiryettä	kiryeet	kiryeessä	kiryeenä	‘letter’
	huone	huonetta	huoneet	huoneessa	huoneena	‘room’
	ranne	rannetta	ranneet	ranneessa	ranneena	‘wrist’
	säde	sädetta	säteet	säteessä	säteenä	‘ray’
	vuode	vuodetta	vuoteet	vuoteessa	vuoteena	‘bed’
	ote	otetta	otteen	otteessa	otteena	‘grip’

liike	liikettä	liikkeet	liikkeessä	liikkeenä	‘shop’
vaate	vaatetta	vaatteen	vaatteessa	vaatteena	‘cloth’
parveke	parveketta	parvekkeen	parvekkeesa	parvekkeena	‘balcony’
perkele	perkelettä	perkeleen	perkeleessä	perkeleenä	‘devil’

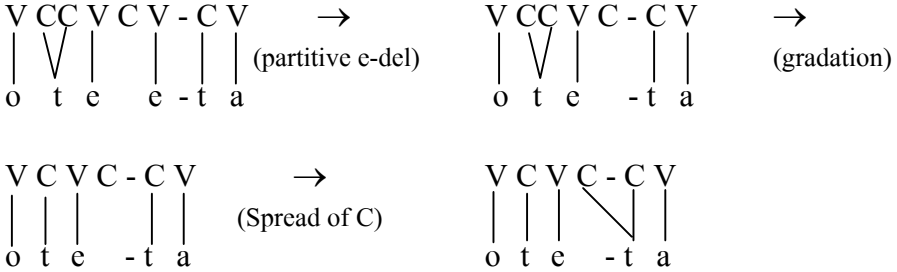
These stems have a further quirk that, at the phrasal level, they cause the initial consonant of the following word to lengthen. Compare *terve* with ‘regular’ *parka, pieni* ← /*piene*/.

(40)	terve llapsi	‘healthy child’	parka lapsi	‘poor child’
	pieni lapsi	‘small child’	pienet	‘small’ (nom. pl)

The first problem is that final /e/ does not raise to [i], contrary to the general pattern. Second, in trisyllabic nouns like [parveke, perkele], /e/ does not delete. Third, the partitive form appears irregular in having a geminate [tt] in the suffix. Fourth, the final vowel appears long in the nominative plural, inessive and illative forms. Fifth, the pattern of gradation is essentially backwards: the nominative and partitive usually exhibit the strong form but in these examples, they exhibit the weak form.

It is proposed in Keyser & Kiparsky 1984 that such anomalous nouns have an empty consonant — thus the underlying forms are /terveCe, kiryeCe, huoneCe, ranneCe, säteCe, vuoteCe, otteCe, liikkeCe, vaatteCe, perkeleCe/. In the nominative singular, final /e/ is deleted yielding *terveC, kiryeC, huoneC, ranneC, säteC, vuoteC, otteC, liikkeC, vaatteC, parvekeCe, perkeleC*. Because of the final empty C, *e*-raising cannot apply, and gradation does apply since the previous consonant begins a closed syllable. The derivation of the partitive is quite similar, with the exception that the empty C spreads to initial consonant of the partitive affix.

(41)



The extra vowel and failure of gradation in the nominative plural follows quite easily from the presumed underlying forms: /terveCe-t, kiryeCe-t, huoneCe-t, ranneCe-t, säteCe-t, vuoteCe-t, otteCe-t, liikkeCe-t, vaatteCe-t, parvekeCe-t, perkeleCe-t/. In fact, the underlying and surface forms are the same except that the empty C has no phonetic interpretation (and in Finnish, [ee] and [e.e] are not phonetically realized differently, as they are in Kikamba).

There are numerous further issues regarding the skeletal tier that have been discussed in the literature: see Broselow 1995 for an overview. There is a large literature on the representation of geminate consonants and vowels. The exact nature of the skeletal tier has been controversial. First, it has been proposed that a distinction between C and V is not optimal theoretically or empirically (Levin 1985), and it is argued that a generic marker X is all that is required, an ele-

ment which interacts with Levin's hierarchical theory of syllable structure which has a means of indicating syllable peakhood. It has also been argued that a prosodic unit 'mora' (μ) needs to be part of the theory and which replaces skeletal positions, where onset consonants have no mora, vowels do (and long vowels have two moras), and coda consonants may, depending on the language. See Hyman 1985 and especially Hayes 1989 for the leading ideas of moraic theory.

One argument for the mora pertains to defining heavy syllables. We noted above that in Lithuanian, syllable-final liquids and nasals are functionally analogous to the second V of VV syllables: they allow syllabled to have contour tones, and just as there are no triply-long vowels, there are no simple long vowels plus final sonorant consonant. Such fact can be explained if long vowels have two morae, and if — at least in Lithuanuan and languages like it — coda sonorants have a mora. Simple appeal to the C/V distinction does not provide a basis for uniting VV and VC while at the same time distinguishing some kinds of VC (those where C is an obstruent) from other kinds of VC (those where C is a sonorant). If long vowels have two morae and coda sonorants in Lithuanian are assigned a mora (via "Weight-by-position"), then the unity of VV and VR syllables is expressed by the fact that such syllable have two morae.

Another consideration arguing for the mora is related to the problem of onset-creation in the CV account of compensatory lengthening from Glide Formation. We discussed above the fact that Glide Formation in Kimatuumbi results in compensatory lengthening of the following vowel, so in particular /u̯-ákḭte/ becomes [w-aákḭte] 'you(sg.) hunted'. The problem is that the V-slot of /u̯/ must transfer to the following vowel in order to achieve compensatory lengthening (the point of compensatory lengthening is tat the existing timing slots are simply rearranged); but then, what skeletal position dominates surface [w] and where did it come from? The moraic theory can account for this based on the fact that the theory does not assign moras to onset consonants (this explains why consonantal onsets do not — generally — define syllable weight), so the mora simply transfers to the following vowel. A final argument for the mora is mora-based tone systems such as that of Kimatuumbi, where H tone is assigned by counting V's from the beginning of the verb — C slots play no role in the tonal computation.

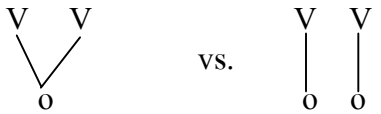
Syllables. Another level of prosodic structure is the syllable. While the term itself is one of the oldest in linguistics, originating from Ancient Greek *sullabe*, the nature of and arguments for the syllable have been elusive. At various points in contemporary linguistics, scholars have rejected or embraced the syllable: the syllable was not part of generative phonological theory until 1976 when Kahn produced strong arguments for it within autosegmental theory; it is not a recognised unit of the theory of Government Phonology (Kaye, Lowenstamm & Vergnaud 1990); its existence is denied by Ohala 1992 and is questioned by others (Steriade 1998). Levin 1995 provides an overview of arguments for and theories of the syllable.

One reason for skepticism about the syllable is its abstractness. With other aspects of phonological representation, you can hear for example voicing, nasality, glottalization, rounding etc. even if there are problematic cases (such as the voicing of certain consonants in certain positions for some speakers of English). In contrast, the syllable has no audible defining property. It is never possible to "hear" how many syllables are in [CVVVVC], and in [VCCCCV] you cannot "hear" where one syllable begins and ends. It is highly controversial whether speakers of English have untutored intuitions about syllables, although most trained linguists have very clear

albeit often conflicting judgments about certain syllable divisions or whether *towel, foul* have one syllable or two. This inability to reduce the syllable to some phonetic essence has made many people skeptical that the object exists — at the very least, this means that strong evidence will be needed to justify positing such an entity.

Besides the fact that the syllable does not have a defining phonetic property which allows the speech stream to be objectively inspected and syllables detected by a simple process, syllables are apparently never present in the dictionary. In contrast, other features such as nasality, voicing, laterality etc. as well as skeletal distinctions (/r/ vs. /r̥/; /a/ vs. /aa/) can be present and contrastive in dictionary entries. This is extremely suspicious, since it introduces into phonology a novel type of entity, namely a derived-only object (the syllable). It also has not been entirely clear whether syllable structure can have surface taxonomic contrastiveness status. Generally speaking, syllable structure is surface predictable, although it has long been recognised that "night rate" and "nitrate" are pronounced differently, which has engendered proposals in the taxonomic days about phonemic "juncture", corresponding to the fact that the former is two words and the latter is one. Similarly, one can form a contrast in English between 'mis-take' (meaning roughly 'take ineptly') vs. 'mistake' (error). Again, there are plenty of other phonetic factors that allow you to represent the difference — [mɪ̀st^{h}éyk] vs. [məstéyk] — without introducing syllables into transcriptions, so it is not clear that syllables are required for basic transcriptions.

Problematic cases such as the Kikamba difference [o:] ≠ [o.o] have previously been reported as involving multiple degrees of length, and even given the data presented here, it is not totally clear that syllables are required, and the difference may simply reside in the number of segments, i.e.:

(42) 

A case such as hypothetical [ai] vs. [a.i] might be handled as [ay] vs. [ai].[10] The question is whether languages have contrasts of the type [a.o] vs. [ao]. Barra Gaelic is reported (Kenstowicz & Kisseberth 1979) to have something that might be taken to be a surface syllabification contrast, but see Bosch & De Jong 1997.

The main argument for the syllable is its phonological utility, specifically the fact that generalizations can be stated more efficiently by reference to the syllable. One of the most widely-invoked arguments of this nature regards possible consonant clusters. The argument starts by considering possible word-beginnings and word-ends. In English, initial clusters may have the form sC (C=consonant), as in *stick, spit, skunk*, also *snow, smite, slay*, or they may be of the type CR (R=glide or liquid) *fray, through, fly, bleed, breed, pray, clue*, and thus initial clus-

[10] This argument is not so attractive for Kikamba since no words end in consonants, so it is standardly assumed that there are no codas in the language. However, this is a poor argument since it might be that glides and nasals are the only codas in the language — a common restriction — and word-ends are subject to even more stringent constraints (something that is attested in Kotoko, for example, which disallows coda obstruents only word-finally).

ters are maximally of the shape sCR (*sprint, sklerotic, strip, splice*). Words which violate these rules are excluded in English, thus consonant plus stop clusters other than sC are out (**bnick, *pnort, *ptack, *dbonk, *fnilge*) as are stop+fricative clusters (**kfimp, *ksunk*). Sonorants as the first member of a cluster are also out: **mbop, *rtot, *lfay, *yluck, *wnurge*. There are other restrictions that narrow the range of possible syllable-initial clusters, for example coronal stop plus *l* is excluded (**tluth, *dlifficult, *thlish, *chlormp*) as are voiced fricative+C (**zlip*, **vrank*) and labial+w: **pwang, *bwint, *mwerge*.

These restrictions are not just about word beginnings and they hold true word-medially as well, ruling out **catmbop, *fishrtot, *gasbnick, *lamdbonk, *gushkfimp*. The restrictions are not just in terms of adjacent consonants, see for example *camber, barter, Abney, Ledbetter, thankful*. The puzzle is how *thankful* can be admitted with *kf*, and not also admit that same cluster in impossible **gushkfimp*. Why is it at all possible to have [pn] in the marginally acceptable semi-English word *helpnik*, when initial [pn] is utterly impossible. The answer to these questions is based on reference to the syllable, and the fact that in the acceptable words the cluster does not come at the beginning of the syllable: [cam.ber, bar.ter, Ab.ney, Led.better, thank.ful, help.nik]. The unacceptable forms involve the intersection of constraints on syllable beginnings and syllable ends.

The end of the syllable (coda) in English is also subject to restrictions. Any consonant except *h* can be at the end of the syllable; clusters can be of the form glide+consonant (*height, cloud, mouse, life*); liquid plus consonat (*halt, harp, hart, bilk, false, film, born, farm, carl*) subject to a ordering principle that refers to the concept 'sonority' which rules out **calr, *calw, *boly*; NC sequences (*dance, runt, punk, brand, lamp, lymph, lense*) again subject to a sonority-sequencing principle (**baml, *wanr, *pony* where *y* is a glide); and certain obstruent sequences allowing *apt, act, depth, apse, raft, cast, cask* but disallowing **apt, *lithp, *ratf, *cashk*.

Consequently, the illegality of coda [šk] and onset [kf] combine to make **gushkfimp* an impossible word. Parsed as *[gush.kfimp] we would have an illegal syllable onset, and as *[gushk.fimp] we would have an illegal coda cluster. Thus no parsing of **gushkfimp* is possible according to the rules of English syllabification. Similarly, coda clusters of the type NC can have a voiceless stop (*pink, lint, bump*) or a voiced coronal stop (*land, lunge*) but not not a voices labial or velar (**simb, *ping* with *g* actually pronounced). Consequently, **ambnick* is an impossible word because the parse *[amb.nick] is out, as is *[am.bnick].

Consonant allophony in English also supports the postulation of the syllable, insofar as those rules are best stated with reference to the syllable. The best-known such rule is the aspiration rule. As is commonly recognised, voiceless stops are aspirated at the beginning of a syllable, explaining why there is aspiration in the *p* of *pit, plot, appear, apply* but not in *spit, split, asparagus, astrology, slap, apt*. There is more to be said about aspiration, as we will see. A second rule involves the distribution of glottalised stops, where /p,t,k/ → $p^{ʔ}$ $t^{ʔ}$ $k^{ʔ}$ after a vocoid in the same syllable. Examples involving *t* (which is in English dialects the most susceptible to glottalization) include *hit, heart, catkin, Atkins, light, clout, heights, hearts, atlas, atlantic, Watney's*. In comparison, there is no glottalization of *t* in *stem, apt, belt, mattress, atrocious*. In *stem*, *t* is clearly not preceded by a vocoid in the syllable; in *apt, belt*, again, the preceding segment is not a vocoid although the *t* is at the end of the syllable. In *mattress, atrocious*, the cluster *tr* forms the onset of the second syllable, so the preceding vocoid (the vowel of the first syllable) is not in

the same syllable. Compare consequent lack of glottalization in these examples with presence of glottalization in *atlas, atlantic*: since **tl* is not a legal onset in English, these words are syllabified as *at.las, at.lan.tic*, so *t* is in the same syllable as the preceding vocoid. A third argument for the syllable pertains to rounding of *r*: we find that /r^{w}/ unrounds after tautosyllabic nonround vowels, so *r* is round in *range, tray, stray, fray*, also in *core, pure*[11] where the vowe preceding *r* in the syllable is round, and in *array* where the preceding vowel is in a separate syllable; but, *r* is unrounded in *car, cart, carnage, carl*.

These arguments run into problems when you consider the context ́v__v̌. We find no aspiration in *happy* and we do find r-unrounding in *fairy*. One solution to this problem which has been proposed is that a consonant which is not in the onset of a stressed syllable and but is after a sonorant also becomes part of the coda of the preceding syllable, that is, it is in both syllables (hence is *ambisyllabic*), leading to representations like:

(43)

Under that account, there is no aspiration in *happy* because *p* is not strictly syllable-initial (ir is also syllable final), and there is r-unrounding in *fairy* because *r* is preceded by an unrounded vowel within its syllable (although it is also initial in the next syllable).[12]

Another argument for the syllable in English regards the context where you vowel reduction takes place in English. The data below illustrate how vowel reduction depends in part on stress — the relevant syllables are underlined.

(44)

Reduced	*Unreduced*
allow	aloe
annoy	analyst

A simple statement of the type "an unstressed vowel followed by another vowel becomes reduced" forms the core of the correct generalization, but the following data indicate that the matter is more complex, since the nature of the following consonants matters. In some cases, a CC cluster can stand between the target of reduction and the next vowel, but in other cases, a CC cluster blocks reduction.

[11] That is, for dialects where there is a round-vowel nucleus to the syllable.

[12] There is another approach to this problem, to be discussed in the next section, based on stating these rules in terms of the metrical foot.

(45)

Reduced	*Unreduced*
abrupt	admonish
atrocious	atlantic
astronomy	andean
afraid	artistic
	alpaca

If we take cognizance of syllable boundaries, especially the ends of consonant clusters that are allowed in the beginning of the syllable, then the generalization becomes much clearer. Unstressed vowels reduce to schwa in English when they are at the end of the syllable.

(46)

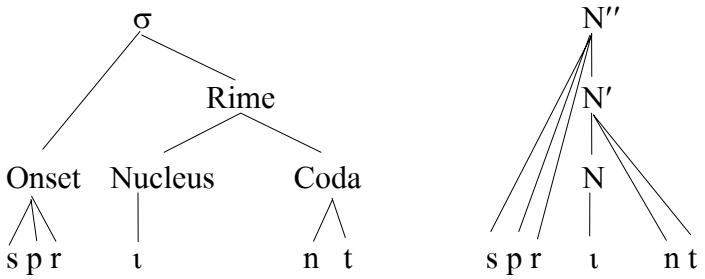
a.brupt	ad.monish
a.trocious	at.lantic
a.stronomy	an.dean
a.fraid	ar.tistic, al.paca

One of the most commonly encountered arguments for the syllable is based on the problem of the disjunction {C,#}. In many languages (for example, Turkish: see Chapter 7 exercises), rules refer to the context "/__C{C,#}", for example long vowels are shortened when followed by two consonants or one consonant at the end of the word. This statement gives way to the simpler expression "followed by a consonant in the syllable", assuming the syllable. This gives rise to the possibility that the brace notation is superfluous, if all legitimate uses of the notation are simply a way to say "when followed by a tautosyllabic consonant".

Another kind of argument for the syllable is the domain argument. One example is from Cairene Arabic, where pharyngealization (notated with a dot) spreads to all segments in the syllable (originating from some coronal sonsonant — *t* and *ṭ* are contrastive phonemes in Arabic, idem *d* and *ḍ*, *s* and *ṣ* and in some dialects *r* and *ṛ*). Examples of this distribution are [ṛaḅ] 'Lord' vs. [rab] 'it sprouted'; [ṭiịṇ] 'mud' vs. [tiin] 'figs'; see expecially the alternation [ḷaṭịịf] 'pleasant (m)' ~ [ḷaṭịịfa] 'pleasant (f)'. The reader is cautioned that since the argument hinges on the presence of noncontrastive phayngealization on a syllable-final consonant, close scrutiny of the phonetic facts is called for: see Al-Ani 1970 for an acoustic study.

Structure Within the Syllable. So far, we have only considered the syllable as a whole unit, without considering that it might have an internal structure (though we have spoken of such units, foreshadowing this discussion). One theory (Clements & Keyser 1983) is that it is flat: skeletal elements directly link to the syllable node. Other structures are given in (47).

(47)



The first theory is proposed by traditional Chinese scholars to represent and is advocated by Levin 1995 among others. The second structure, coming from Levin 1985, is based on X-bar theoretic notions of structure, where N represents "nucleus" and N″ is the "maximal projection" of the nucleus, namely the syllable. The fundamental issue is which subparts of the syllable function as constituents for some purpose, and which do not. In the X-bar version, the set of onset consonants are not a constituent, whereas on the structure on the left, they are. The question is whether there is solid evidence that the onset or the coda are phonological constituents. The evidence relevant for deciding on the correct structure is very complex and cannot be considered here, but one central fact will be noted, namely the evidence for a Rime constituent. That evidence consists of the fact that the notion "heavy syllable" as relevant for stress assignment depends on vowels and following consonants within a syllable — that is, on the rime constituent. In many languages, stress depends on whether there is branching in the rime, so VV and VC syllables define "heavy" syllables. Onsets, on the other hand, are held to be irrelevant to stress assignment.[13] This suggests that initial C's and a following V do not form a constituent (which would form the basis for computing "branchingness"), but V and following C's can.

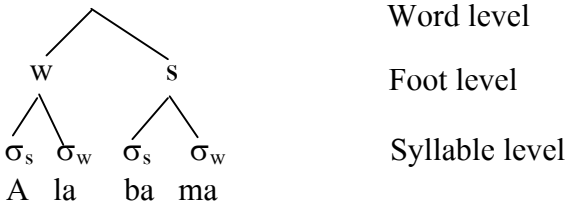
Stress and the Foot. The representation of stress has also been vexing for phonological theory. The literature of the SPE era is rich with discussions of the problem of English stress, and it is proposed that there are up to 5 degrees of stress in English (on the surface: it is also proposed in SPE that stress is predictable). Indeed, stress turned out to be one of the quirkiest features in phonology, suggesting that something was wrong with treating it as formally analogous to other features like [nasal] or [voice].

For example, stress systems often operate in terms of the syllable parity of words — stress goes here vs. there depending on whether the number of syllables in a word is even or odd. It has the quirk that — except for clitics and other minor words that are never said alone — every word in a stress language has one. In contrast you don't find languages where every word must have a lateral or a voiced obstruent. Stresses have peculiar spacing tendncies: they tend not to come right next to each other, and if a language allows multiple stresses in a word, they tend to appear on every other syllable. In addition, stresses come in primary and secondary varieties, where there is usually one primary stress and many secondary stresses — neven many primary stresses and one secondary stress.

[13] This turns out not to be entirely true, since there are a number of languages where onsetless syllables behave peculiarly, repelling stress. See Davis 1988, Downing 1993, 1998 for discussion.

The metrical theory of stress, originating in Liberman 1975, Liberman & Prince 1977 and Halle & Vergnaud 1978, provides a representational account of stress where stress is not a featural property of segments, but is a prosodic structural property of syllable relations. The basic analytic unit of metrical theory is the foot, a constituent containing one or two syllables.[14] Within a branching foot, one daughter is "strong" — is the head — and the other is weak: the strong syllable is the stressed syllable. Feet are themselves grouped into a tree structure encompassing the entire word, with daughters being labeled strong/weak. A stressed syllable is this one which is the strong branch in its foot, and the main stressed syllable is the one which the word-tree nodes dominating it are all strong. Accordingly, the word 'Alabamba' would be represented as:

(48)



Hayes 1980 develops a typology of stress systems which reduces the majority of stress systems to a relatively small number of types, governed by a small number of parameters for construction of metrical structure. The main parameters include directionality of tree construction (l-to-r or r-to-l), quantity sensitivity vs. insensitivity, foot labeling direction (w-s or s-w) and word-tree labeling labeling direction (w-s or s-w). In conformity with current (and more traditional) usage, we will speak of w-s or stress-final feet as "iambs" and s-w or stress-initial feet as "trochees".[15] Some of the other principle references on metrical stress theory include Hammond 1984, Prince 1983, Halle & Vergnaud 1987, Idsardi 1992, Halle & Idsardi 1995, Hayes 1995, and Kager 1995.

Quantity-Insensitive Stress. First we will consider the variations on quantity insensitive stress systems — systems which do not decide the position of stress based on whether a syllable is heavy or light. The first example is from Maranungku, which constructs trochaic (stress-initial) feet from left to right, and assigns word stress to the leftmost foot.

(49)

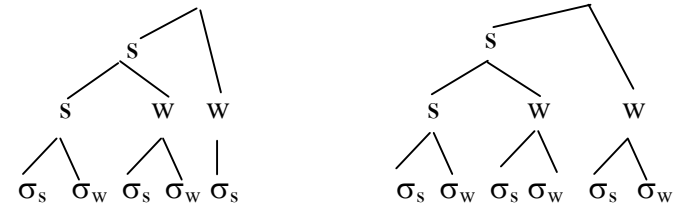
tíralk	'saliva'
mérepèt	'beard'
yángarmàta	'the Pleaiades'
lángkaràtetì	'prawn'
wélepènemànta	'duck (sp.)'

[14] Larger types of syllables have been proposed, such as the ternary foot and the unbounded foot: these will not be discussed here.

[15] The reader is advised that to simplify matters the theoretical analysis given here does not conform fully to that given in Hayes 1980, Hayes 1995 or other accounts of these languages published over the years.

Metrical parsings of two representative samples show how metrical constituency represents this pattern of stress markings.

(50)



The mirror-image of this is found in Weri, where the main stress is on the right, tree constructions starts from the right, and feet are iambic (stress-final).

(51)

ŋintíp	'bee'
kùlipú	'hair of arm'
ulùamít	'mist'
àkunètepál	'times'

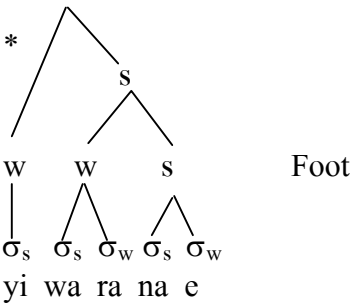
We can derive the stress system of Warao by varying the metrical parameters of Weri a bit, selecting trochaic feet instead of iambic feet.

(52)

yiwàranáe	'he finished it'
yàpurùkitàneháse	'verily to climb'
enàhoròahàkutái	'the one who caused him to eat'

This pattern also illustrates another common property of stress systems. The blind application of these metrical principles to /yiwaranae/ would in fact yield the incorrect form **yìwàranáe*:

(53)



Foot

The problem is that a unary foot is created initially, which results in two adjecent stresses — a stress clash. This is avoided in Warao by blocking the creation of a unary foot before another foot (thus, the extra syllable directly associates with the word tree.

Araucanian is typologically quite similar to Maranungku, in parsing feet left-to-right and having a left-dominant word tree, but feet are iambic rather that trochaic.[16]

(54)	(wulé)	'tomorrow'
	(ṭipán)to	'year'
	(elú)(muyù)	'give us'
	(elú)(aè)new	'he will give me'
	(kimú)(balù)(wulày)	'he pretended not to know'

In light of forms like *elúaènew* without a final stress-clash, we conclude that foot-formation is prevented from creating adjacent stresses.

Ojibwa is essentially identical to Araucanian (iambs build left-to-right, word stress left-dominant), except that this language, stress clash is allowed.

(55)	(niní)(bà)	'I sleep'
	(nibí)(mosè)	'I walk'
	(niná)(gamò)(mìn)	'we sing'

Quantity-Sensitive Stress. Quite a number of stress systems are sensitive to the distinction between light and heavy syllables. The definition of "heavy syllable" is subject to certain typologically-governed variation, but long vowels architypically make a syllable heavy.[17] Latin stress exemplifies one common kind of quantity-sensitive stress system. As we see in the following data, the word-final syllable is ignored entirely. Stress falls on the penult if the penult is heavy (has a long vowel or a syllable-final consonant), and is on the antepenult if the penult is light. The two vowels of vowel sequences are in separate syllables.

(56)	domésticus	'domestic'	sími̯ula:	'simulate (2s imp.)'
	inimi:kĭtia	'hostility'	amí̯:cus	'friend'
	guberná:bunt	'they will reign'	ornaméntum	'equipment'

Metrical theory employs the device of "extrametricality" to encode the fact that in some languages a syllable (or other constituent) is ignored, and conventionally an extrametrical unit is marked off in angled brackets. The metrical structure required for Latin is *do*(*mésti*)<*cus*>, (*símu*)<*la:*>, *inimi:*(*kĭti*)<*a*> vs. *a*(*mí:*)<*cus*>, *guber*(*ná:*)<*bunt*>, *orna*(*mén*)<*tum*>. The foot structure of Latin is trochaic (stress initial), but placing a two-syllable foot over *guberna:*<*bunt*> would result in a foot of the form (*bérna:*). The ideal two-syllable trochaic foot has a light second syllable, so in a quantity-sensitive trochaic stress system, foot construction would only in-

[16] In place of full metrical trees, only foot structure is indicated, by parsing together syllables within parentheses. It has been argued that full metrical trees as in (49) provide more information that is required, since all that is important is determining which foot within the word has the main stress.

[17] Tiberian Hebrew is an exception, in that long vowels are stress neutral but C-closed syllables attract stress.

clude one heavy syllable, which would be in the stressed position. Quantity-sensitive stress systems pay attention to syllable weight in determining whether a two-syllable foot would result in a heavy syllable in the wrong position.

Eastern Arabic also exemplifies a version of the Latinate pattern.

(57)				
	bána	'he built'	bánat	'she built'
	bané:t	'I built'	ma baná:š	'he didn't build'
	ma banátš	'she didn't build'	ma bané:tš	'I didn't build'
	kátab	'he wrote'	kátabat	'she wrote'
	katabátš	'she didn't write'	kátabo	'he wrote it'
	katábato	'she wrote it'	katábna	'we wrote'
	katabná:š	'we didn't write'	baná:	'he built it'

The strategy for stress assignment here is to assign stress to the last heavy syllable, within the last three syllables of the word. A heavy syllable in Arabic is defined as one containing a long vowel, or one with a final consonant. However, one word-final consonant is ignored — is extrametrical — in computing the weight of syllables. Therefore, two final consonants are required in word-final position to form a heavy syllable in Arabic.

In the case of *bána* and *kátabo*, stress goes back to the third syllable from the end because there are no heavy syllables. In *katábato*, stress appears on the third from last syllable, and not the initial syllable because stress must be within on the last three syllables. In *bánat*, *kátabat*, the final consonant is ignored in computing syllable weight, so those final syllables "count as light". On the other hand, in *katabátš*, only one consonant is ignored, still leaving the final syllable heavy (thus stressed). In *katábna*, the heavy syllable falls in the penult. In *baná*: and *ma baná:š*, stress is on the final syllable because that syllable is heavy (because of the long vowel: ignoring a consonant has no effect).

This pattern can be reduced to the construction of one metrical foot at the right edge of the word. That foot is trochaic and quantity sensitive, meaning that the weak branch (second syllable) cannot be heavy. In addition, in order to derive antepenultimate stress, we must be allowed to make a single light syllable at the end of the word extrametrical, thus (*káta*)<*bo*> and (*káta*)<*ba*<*t*>>. Recall that one final consonant is extrametrical, so that final *t* does not make the final syllable heavy. In penult-stressed *ka*(*táb*)<*na*>, the foot only includes the penult because that syllable is heavy.

These stress systems involve non-iterative footing — only a single foot is formed at the end of the word — but quantify sensitive stress can also have iterative foot construction. Fijian illustrates quantity-sensitive iterative footing, again trochaic footing which is built from right to left (with no extrametricality).[18]

[18] The NC clusters of Fijian are onset clusters, so there are no consonantally closed syllables.

(58)	(láko)	‘go’	βi(náka)	‘good’
	se(ŋái)	‘no’	ki(lá:)	‘know’
	(nrè:)(nré:)	‘difficult’	(ndìko)(nési)	‘deaconess’
	pe(rèsi)(té:ndi)	‘president’	(ndòke)(tá:)	‘doctor’
	(mìni)(sìti)(rí:)	‘minister’	(mbèle)(mbò:)(tómu)	‘bellbottoms’
	(mì:)(sìni)(ŋgáni)	‘machine-gun’		

An iambic quantity-sensitive system is found in Creek. Here, feet are constructed l-to-r, and only the last foot phonetically realises a stress. An iambic foot strives to be light-heavy, so iambic foot construction eschews a heavy first syllable, meaning that a heavy syllable must appear at the end of the foot, possibly being the only syllable within the foot. Additionally, a single light syllable is not a proper iamb, and such a syllable therefore remains unfooted.

(59)	(ifá)	‘dog’	(amí)fa	‘my dog’
	(osá)na	‘otter’	(pomo)(saná)	‘my otter’
	(apa)(taká)	‘pancake’	(ama)(patá)ka	‘my pancake’
	(fó:)	‘bee’	(nihá:)	‘lard’
	(hok)(tí:)	‘woman’	(hito)(tí:)	‘snow’
	(íč)ki	‘mother’	(kofóč)ka	‘mint’
	(ak)(čóh)ka	‘stork’	(ta:s)(kitá)	‘to jump (sg. subj)’
	(ati)(lo:)(yitá)	‘to gather (sg. obj)’	(naf)(kiti)(ka:)(yitá)	‘to hit (pl. obj)’
	(tokoł)(hokí)ta		‘to run (pl. subj)’	

Non-Stress Uses of the Foot. The metrical foot as prosodic constituent has also proven to have utility for other phonological purposes, besides being a means of deriving stress. One such use is found in Prince’s analysis of Estonian overlength and gradation. The classical puzzle of Estonian is that it has a surface three-way length contrast in vowels and consonants, thus [sada] ‘hundred’, [sa:da] ‘send!’, [sa::da] ‘to get’. Taking inspiration from Lehiste 1978, Prince 1980 shows that the apparent surface length constrast is best explained as involving a two-way phonological length contrast, where long vowels and consonants have two surface-contrastive metrical varieties, those which exhaust a metrical foot (the over-long segments: (*sa:*)*da* ‘to get’) and those which share a foot with another syllable (the plain-long segments: (*sa:da*) ‘send!’). Besides representing the three-way length contrast, the foot-based proposal also explains connection between consonant gradation and overlength-alternations, for example treating voicing-gradation as lenition of a stop between sonorants within a foot. In strong case (*ti::*)*pa* ‘wing (part. sg.)’, the first syllable exhausts the metrical foot, both deriving overlength and preventing lenition since *p* is not between sonorants within a foot. In contrast, in weak case (*ti:va*) ‘wing (gen. sg.)’, the long syllable is not the only syllable in the foot so there is no overlength, and because the stop is inter-sonorant within a foot, the stop lenites.

A foot-based analysis of English consonant allophones has also been proposed by Kiparsky 1979 and Selkirk 1980 where *t* and *d* become [ɾ] between sonorants within a foot. Aspiration can also be described in terms of foot structure, with aspirates appearing foot-initially (not syllable-initially). Akinlabi & Erua 2002 account for patterns of lenition in Ibibio by (indirect) refer-

ence to foot structure, and Harris 2003 shows how Danish consonantal contrasts are "weakened" foot-medially.

A recurring issue in phonology is the minimality effect, for example that words must either have at least two syllables or one long syllable. The example of Mohawk is discussed in Chapter 8. A similar example is Zezuru Shona, where the bare verb stem is used in thr imperative except is the stem is monosyllabic in which case there is an epenthetic *i*. The result is that a (trochaic) foot can be formed, one which satisfies the crosslinguistically observed desideratum of having two syllables.

(60)	ku-(rima)	'to plow'		(rimá)	'plow!'
	ku-vere(keta)	'to read'		veré(kétá)	'read!'
	(ku-pá)	'to give'		(i-pá)	'give'

Although Shona is a tone language, the Zezuru dialect does also have a predictable penultimate stress which results in sub-phonemic lengthening of the penult, making the postulation of foot structure plausible.

A related minimality effect is that in Bengali, an underlying short vowel is lengthened when the word would otherwise be monosyllabic, resulting in the following alternations.

(61)	c**a:**	'tea'	c**a**-e	'tea-OBL'
	r**a:**g	'anger'	r**a**g-i	'angry'
	n**ɔ:**ʈ	'dancer'	n**ɔ**ʈ-i	'dancer-FEM'

Damascus Arabic (see "Extended Analyses", the former 9th chapter)[19] in (62) similarly lengthens short vowels of the root or suffix, in would-be monomoraic words in (a). Compare (b) where the root vowel is underlying long, and (c) where the masculine imperative is supraminimal.

		masc. imp	*fem. imp.*	*pl. imp*	
(62)	a.	sʔ**á:**l	sʔ**á**l-i	sʔ**á**l-u	'ask'
		wṣ**á:**l	wṣ**á**l-i	wṣ**á**l-u	'arrive'
		ʔr**á:**	ʔr-**í:**	ʔr-**ú:**	'read'
		bn**í:**	bn-**í:**	bn-**ú:**	'build'
	b.	bá:n	bá:n-i	bá:n-u	'build'
		fí:ʔ	fí:ʔ-i	fí:ʔ-u	'wake up'
	c.	žárreb	žárrb-i	žárrb-u	'try'
		támm[20]	támm-i	támm-u	'remain'

The theoretical account often given to this phenomenon is that in these languages, every word must contain at least one foot and a foot must have either two syllables or a heavy syllable.

[19] Online at http://www.ling.ohio-state.edu/~odden/IntroducingPhonology/longer%20analyses.pdf.

[20] This form shows that when a monosyllabic root ends in a consonant cluster, the last consonant is extrametrical in terms of computing syllable weight, leaving (*tam*)<*m*>, which still satisfies the requirements of a heavy syllable.

When that condition is not satisfied, the vowel must therefore be lengthened. However, see Downing forthcoming for further discussion and an alternative theoretical account of the relationship between minimality and foot structure.

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