Vowel length

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Roughly a quarter of the world's languages feature contrastive vowel length, such that (at least some) vowels come in both short and long varieties, and the difference is phonemic (able to distinguish words). For example, the Finnish words *tuli* [tuli] "fire" and *tuuli* [tuːli] "wind" differ only in the length of the first vowel. The long vowel is not doubly articulated, but merely held longer. Writing systems employ numerous strategies to indicate length (e.g. doubling the letter or adding a diacritic such as a macron or acute), and sometimes do not indicate it at all. The International Phonetic Alphabet notates length using a double triangle, as in [uː]. While consonants may also be long (also known as GEMINATE), this chapter treats vowels. Note that while *syllables* are sometimes described as being long or short (as in Latin/Greek metrics), phonologists usually distinguish LENGTH, as a property of individual segments (e.g. long or short vowels), from WEIGHT, as a property of syllables (e.g. heavy or light syllables).

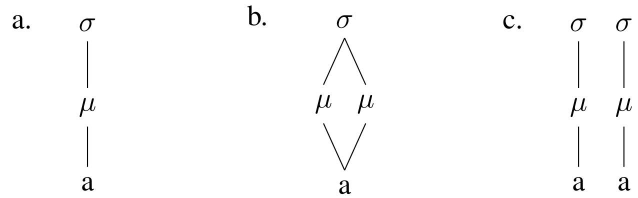
Long vowels are often said to be twice as long as short vowels, and indeed, this is how they are analyzed phonologically: A long vowel possesses two timing units (or MORAS), a short vowel one. In terms of actual phonetic duration, the ratio is sometimes closer to 1.5:1 (e.g. Maddieson & Anderson 1994:170), but moras are phonological abstractions, coming only in whole numbers. This abstraction is motivated by the fact that long vowels typically behave phonologically as if timed equivalently to two short vowels (or two light syllables), even if the phonetic ratio is not so round.

Since the late 1970s (in both rule- and, later, constraint-based phonology), phonologists have analyzed vowel length AUTOSEGMENTALLY (also known as SUPRASEGMENTALLY or NON-LINEARLY), separating a timing tier (comprising moras or other timing slots) from a segmental/melodic tier (encoding vowel quality) (e.g. Clements & Keyser 1983). In this chapter, I follow Hyman (1985), McCarthy & Prince (1986/1996), Hayes (1989), and many others in populating the timing tier with moras (μ), units of phonological length/weight[1] adopted from the Prague school (Jakobson 1937; Trubetzkoy 1939), which in turn took the mora from classical metrics – indeed, in Sanskrit, the mora (*mātrā*) has been in use for over 2,500 years.[2] The mora constitutes the lowest level of the PROSODIC HIERARCHY that continues up through the syllable, foot, prosodic word, and so forth.

Short [a] is monomoraic (1a), while long [aː] is bimoraic (1b). (Since length is not present on the segmental tier, "ː" is deliberately omitted from the transcription of the long vowel in (1b).) Moras are in turn dominated by the syllable (σ). For simplicity, the illustrated syllables do not contain any consonants. The moraic analysis distinguishes a long vowel such as [aː] from a sequence of short vowels such as [aa] (1c). As shown, [aː] is tautosyllabic, while [aa] is heterosyllabic. (On other logical possibilities, such as tautosyllabic [aa], see §4.)

[1] As the epigram attributed to James McCawley puts it, the mora is one of what heavy syllables have two of.

[2] Other approaches populate the timing tier by C and V slots (Clements & Keyser 1983) or X slots (Levin 1985). An offshoot of Government Phonology employs a version of the former in which the timing tier is strictly (CV)* (Lowenstamm 1996; Scheer 2004). At this point in the exposition, these approaches are largely interchangeable: They all treat a long vowel as being a segment linked to two elements on a timing tier (see further §8).

(1) 

The chapter begins by examining different types of length, whether phonological/moraic or phonetic/non-moraic, noting that these distinctions are not always clearcut. It then turns to the typology of long vowels in §2, with particular attention to gaps in inventories otherwise exhibiting length. The phonological representation of length is treated by §3 and §4, which argue that length is autosegmental (as opposed to featural) and that long vowels cannot in general be analyzed as sequences of vowels, though sequences of identical vowels do occur. The case for overlong (trimoraic) vowels is supported by §5. Typical causes of vowel lengthening and shortening and covered by §6. Finally, §7 and §8 treat the relationship between vowel length and weight, arguing that moras are not the whole story.

1 Distinctive length, allophonic length, and duration

Linguists usually distinguish between phonological LENGTH (e.g. one or two moras) and phonetic DURATION (in milliseconds). Differences of duration, even if systematic, do not necessarily translate into differences of phonological length. In practice, vowel length/duration is typically treated in one of three ways, as summarized by (2). First, if the length difference can distinguish words, as in Finnish, the vowel length is said to be CONTRASTIVE (or DISTINCTIVE). Length is then encoded as part of the underlying representations of words (e.g. using lexically pre-linked moras; Morén 2001), being at least partly unpredictable.

(2)

		Moraic	Distinctive
a.	Contrastive vowel length	✓	✓
b.	Allophonic phonological length	✓	
c.	(Phonetic) duration		

A second possibility is that vowels are phonologically long vs. short (as encoded by moras), but non-contrastively. For example, in Sanskrit, the mid vowels [eː] and [oː] are always long – there is no [e] or [o] (a situation found in many other languages, e.g. Dagbani, Kurdish, Ntcham; see §2). Their bimoraicity in Sanskrit is confirmed, for one, by poetic meter, where long vowels (of all varieties, not just mid) have a different distribution from short vowels.

In Sanskrit, non-distinctive length is associated with particular vowels. A more common situation is for non-distinctive length to be conditioned by context, in which case the length is known as ALLOPHONIC. For example, in Tiriyó, short vowels lengthen in stressed, open (i.e. vowel-final) syllables, as in (3) (Meira 1998:356). In the underlying forms (a) and (c), all vowels are short. In the surface forms (b) and (d), every other (even-numbered, unless final) vowel is long, reflecting rhythmic lengthening (§6). Parentheses mark iambic feet. In this case, length cannot be imputed to the input, since a given morpheme (e.g. /apoto/) exhibits different lengthening patterns, as predicted by its position in the word.[3] As Meira (1998) argues, lengthening is not only phonetic, but also phonological/moraic: For one thing, diphthongs do not lengthen, since they are already binary.

[3] Distinctive vowel length does occur elsewhere in Tiriyó, albeit infrequently (*ibid.*:360f).

(3) a. /m-apoto-ma-po-tə-ne/
b. [(maˈpoː)(toˈmaː)(poˈtəː)ne]
"you all made him/her help"
c. /kɨt-apoto-ma-po-tə-ne/
d. [(kɨˈtaː)(poˈtoː)(maˈpoː)təne]
"we all made him/her help"

In other cases, it is less clear whether length is implemented by moras. Consider Xitsonga. Vowel length is not distinctive, but the penultimate vowel of an intonation phrase is lengthened. In (4), for example, *phukuphuku* "fool" is lengthened in (a) but not (b) (Kisseberth 1994:142–8; Selkirk 2011). On the one hand, the vowel's additional duration puts it in the range of a typical moraic length contrast; moreover, its length is grammatically significant, in the sense that it cues clausal structure. Based on these facts alone, many linguists would be comfortable treating the vowel as bimoraic. On the other hand, I am not aware of any phonological criteria in this case that diagnose the lengthened vowel as being bi-elemental or metrically heavy, as would require two moras.[4]

(4) a. ndzi-rivalela svi-phukuphuːku
"I forgive fools"
b. ndzi-xavela xi-phukuphuku foːle
"I am buying tobacco for the fool"

As a similar case, in English and many other languages, phrase-final syllables significantly lengthen (e.g. Turk & Shattuck-Hufnagel 2007:455f). Once again, in terms of duration, such vowels may be as long as phonemically long vowels are in other contexts. At the same time, final lengthening is usually not regarded as adding a mora. For starters, it is outside of the metrical phonology: Lengthened final vowels do not pattern as phonologically long for stress assignment. Moreover, final lengthening affects short and long vowels alike, as an additive effect; it does not neutralize the long/short distinction (Paschen et al. 2022:13 find this to be true for all 13 languages with vowel length in their study).

Indeed, *most* systematic aspects of vowel duration are outside of the moraic system. The phonetic literature documents dozens of such factors. For example, Balasubramanian (1981) demonstrates that Tamil vowel duration is affected by the nine factors in (5). To be sure, (b–i) are all gradient adjustments; they do not alter vowels' categorical, moraic length in Tamil (though some of the same processes rise to moraic in other languages; §6). Because the factors intersect with each other (e.g. (e) and (f) jointly entail $\underline{\mathrm{V}} > \{\underline{\mathrm{V}}\mathrm{C}\ \mathrm{C}\underline{\mathrm{V}}\} > \mathrm{C}\underline{\mathrm{V}}\mathrm{C}$; *ibid*.:158), there are in principle dozens of grades of predictable duration (cf. also Lehiste 1970; Sammallahti 1998). Further, this list, being based on one source, is hardly comprehensive (e.g. it omits phrase-final lengthening). These durational adjustments are systematic in the sense that they are significant, regular, invoke natural classes, and are part of the speaker's implicit knowledge.[5] But in Tamil, only (a) is analyzed in terms of moras.

[4] Hyman (2009:196) argues that penultimate lengthening is moraic in other Bantu languages. In Ikalanga, for one, non-phrase-final [kutúmá] "send" (where acute is a high tone) corresponds to phrase-final [kutûːmá] (where circumflex is a falling tone, suggesting two moras; see §3).

[5] As an illustration of the cognitive reality of pre-voiced lengthening, English listeners are more likely to perceive [b̥ɛ] as *bed* rather than *bet* as the duration of the vowel increases. The same holds for nonwords such as *ked*/*ket*.

(5)	a.	Phonemic length	Long vowels are almost twice ($\sim$1.9x) as long as short vowels
	b.	Height	The lower the vowel, the longer (low > mid > high)
	c.	Stressed-syllable lengthening	Stressed vowels are longer than their unstressed counterparts
	d.	Polysyllabic shortening	The longer the word, the shorter the vowel
	e.	Closed-syllable shortening	Vowels are shorter before codas (more so before complex codas)
	f.	Onset/c-center effect	Vowels are shorter after a filled onset
	g.	Pre-voiced lengthening	Vowels are longer before voiced than voiceless consonants
	h.	Pre-retroflex lengthening	Vowels are longer before retroflexes than other places
	i.	Pre-labial shortening	Vowels are shorter before labials than other places

Three arguments support the non-moraic status of (b–i) in Tamil, and serve as heuristics for moraicity more generally. First, the magnitude of the adjustments in (b–i) is generally smaller than that of a typical moraic difference, which one would expect to be roughly 2:1 (or at least, say, 1.5:1). In other words, moras are not detached from phonetic reality – the smaller the adjustment, the less likely it is to be moraic (cf. Hubbard 1995; Broselow et al. 1997).[6] Second, moras come in whole numbers not exceeding two or three per syllable. They are not designed to capture numerous, fine-grained distinctions (Trubetzkoy 1939). The factors in (b–i) do not override phonemic length, but interact CUMULATIVELY with it (e.g. low long > high long > low short > high short). Without fractional or overnumerous moras, such adjustments cannot be moraic. Third, and most importantly, length differences are usually considered moraic only if they are *phonologically active*, playing a role in the metrical (e.g. stress) system, phonotactics, or other phonological processes (§6). In Tamil, even if vowel length were not lexically contrastive, it would still be clear that it is moraic, since it plays a role in stress placement, prosodic minimality, poetic meter, and phonotactics (e.g. a long vowel cannot immediately precede a long sonorant consonant) (Ryan 2019b:60f, 121–6).

The basis of the last heuristic is the widely adopted hypothesis that the phonology only sees length insofar as it is implemented by moras.[7] Length-sensitive phonological processes cannot, on this hypothesis, be directly sensitive to submoraic duration. The hypothesis reflects the traditional feedforward architecture of grammar, whereby phonology deals in discrete representations, prior to phonetic implementation (e.g. Chomsky & Halle 1968). Thus, phonetic implementation cannot influence phonology. This view, while it captures an important distinction, oversimplifies: There are cases of length-based phonological phenomena being sensitive to submoraic duration. Such cases suggest that the boundary between phonetics and phonology is porous, but do not necessarily undermine moras altogether (see further §7–8).

Finally, moras, being *abstract* length/weight, are not necessarily based on duration alone. For example, some languages treat CV: as being heavier (bimoraic) than CVC (monomoraic), even when the two syllable types have comparable durations (Davis 2011:132f). Moraicity in such cases is influenced by overall sonority/energy, not just raw duration. That said, in the context of vowel length, duration is by far the most important phonetic correlate of moraicity.

2 Vowel length in inventories: symmetry and its exceptions

This section treats the typology of vowel length, including restrictions of length to particular vowels. In most languages, length is all-or-nothing: Either all monophthongs may be long, or none may be. Either way, the inventory is fully SYMMETRIC. To the extent that certain vowels lack long (or short) counterparts in vowel systems otherwise exhibiting length, the exceptions tend to be systematic, being recurrent natural classes such as nasalized vowels or lax vowels. Rarely are exceptions scattered haphazardly about the vowel space. The data in this section are based on PHOIBLE 2.0 (Moran & McCloy 2019), a database of 3,020 invento-

[6] An adjustment of less than 1.5:1 might be argued to be moraic, especially in the context of a three-way distinction (§5), but there needs to be a case from the other criteria, particularly phonological relevance.

[7] A version of this hypothesis is put forth by Shih & de Lacy (2019), who argue that foot structure (i.e. stress assignment) can only be sensitive to moras, not to features (except insofar as features determine moras).

ries, of which 2,474 are employed here (taking only the first inventory provided for each language, as many languages have multiple entries). In this database, 37% of languages have at least one long monophthong (34% at least three).[8] The database does not indicate whether length in each case is contrastive or allophonic (§1). Thus, the percentage of languages with *contrastive* length is lower, perhaps between 20% and 30%.[9]

Among inventories with at least one long monophthong, 78% exhibit fully symmetric length – that is, every monophthong comes in a short-long pair – once a few caveats are taken into account. First, I set aside nasalized vowels. In systems with both length and nasalization, nasalized vowels come in short-long pairs only 29% of the time. Second, I ignore adjustments to quality that sometimes accompany length. For example, in Fulfulde (6a), long and short covary with tense and lax, respectively (McIntosh 1982:21f). Phonologically, however, length is fully symmetric; the quality adjustments are allophonic. (English and German are sometimes analyzed the same way, with further complications.) Third, reduced vowels (e.g. [ə, ɨ]) frequently lack long counterparts in inventories otherwise exhibiting length, as exemplified by Eton (6b) (van de Velde 2008:15). Reduced vowels are usually central/centralized in the vowel space and may be shorter than other short vowels (cross-reference). Similarly, a whole lax series may be exempt from length, as with Shabo (6c) (Teferra 1991:375, here using [ɨ] for "central" [ɪ]).

(6)	a.	ɪ, iː		ʊ, uː	b.	i, iː		u, uː	c.	i, iː	ɨ	u, uː
		ɛ, eː		ɔ, oː		e, eː	ə	o, oː		e, eː	ʌ	o, oː
						ɛ, ɛː		ɔ, ɔː				ɔ
			a, ɑː				a, aː				a, aː	

The remaining inventories — 22% of those with length — are asymmetric. Among them, one frequent cause of mixed length is that only the low vowel exhibits a length contrast, as in Gooniyandi (7a) (McGregor 1990:46f). This situation, found mostly but not exclusively in languages of Australia, accounts for 25% of the mixed-length systems. Another common source of mixed length is for some or all mid vowels to be exempt (Maddieson 1984:129f). Recall that in Sanskrit (7b), length is contrastive for all vowels except the mid vowels (Whitney 1889:11f). If (frequently unpaired) [æ] is counted along with the mid vowels (being sometimes close to [ɛ]), this second condition accounts for 39% of mixed-length systems. Third, vowels with marked rounding (e.g. front rounded vowels) are sometimes exceptions to length, as with [y] in Bongo (7c) (Abessolo Eto 1990). Together, these three exception types account for 72% of cases of mixed length. The remaining exceptions have diverse causes (e.g. in eight inventories, [u] alone fails to exhibit length).

(7)	a.	i		u	b.	i, iː		u, uː	c.	i, iː, y		u, uː
						eː		oː		e, eː		ɔ, ɔː
			a, aː				ə, aː				a, aː	

Figure 1 is based on mixed-length inventories as just defined (190 languages), showing only vowels with sample frequencies of at least ten. The x-axis is each vowel's LENGTH CONTRAST PROPENSITY, that is, the number of inventories in which it is paired for length (short and long) divided by the total number of mixed-length inventories in which the vowel quality occurs.[10] For example, [y(ː)] occurs in 23 languages

[8] As for other databases, UPSID (Maddieson 1984) is included in PHOIBLE. In LAPSyD, a successor of UPSID, the (first) rate is 33% of 692 languages (Maddieson et al. 2013:3025). In the World Phonotactics Database (Donohue et al. 2019), the rate is 34% of 4,082 lects. WALS does not have a feature for vowel length.

[9] Maddieson (1984:129) reports "62 languages in the [317-language] sample with length contrasts, or 19.6%." However, this figure excludes languages with fully symmetric length (e.g. Finnish), taking instead length in such cases to be extrinsic to the inventory. Paschen et al.'s (2022:2) low figure of 11%, based on a later version of UPSID, presumably reflects the same confound. In the Stress Correlate Database (Lunden et al. 2017:573), by contrast, 59% of 140 languages *with stress* have contrastive (not merely allophonic) vowel length.

[10] Vowel quality modifications contingent on length are ignored, letting the quality of the long version stand in for the quality for the pair (e.g. <ɪ, iː> is treated as <i, iː>).

(12% of the mixed-length sample); of those, 26% have both [y] and [yː]. Crucially, each vowel's x-value is based only on inventories containing that vowel, and is therefore not confounded by the vowel's typological frequency. As the x-values reveal (ignoring the y-values for now), the low vowel [a] is the most likely to exhibit a length contrast, followed by the high vowels [i] and [u].[11] Mid and lax vowels comprise the next cohort.[12] Interestingly, among open-mid/low vowels, [ɔ] is twice as likely as [æ] to exhibit a length contrast. Finally, vowels with marked rounding have the lowest length contrast propensities.

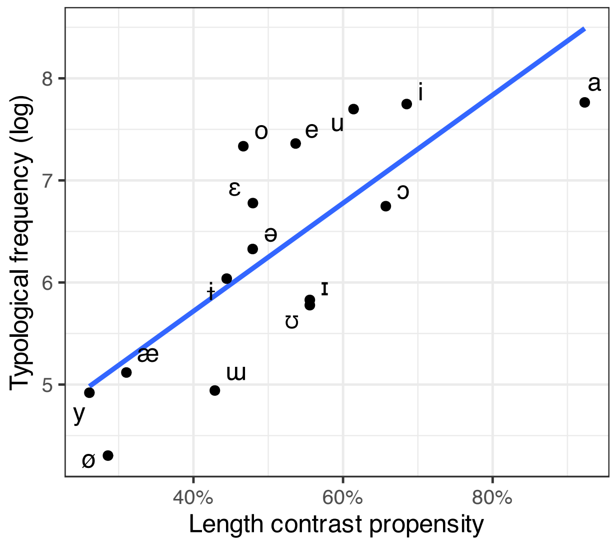


Figure 1: Length contrast propensity (each vowel quality's likelihood of coming in a short/long pair in inventories containing that vowel quality) plotted against overall typological frequency (logarithmic).

The y-axis in Figure 1 represents the typological frequency of each vowel quality, being the total number of PHOIBLE inventories in which the vowel quality occurs. As highlighted by the regression line, typological frequency correlates with length contrast propensity ($r = 0.78$). I term this correlation the PRINCIPLE OF UNMARKED LENGTH in (8). For example, given that [ɔ(ː)] is considerably more frequent than [æ(ː)], the principle correctly predicts that p(ɔ,ɔː|ɔ(ː)) should greatly exceed p(æ,æː|æ(ː)). The principle is not a tautology: There is no necessary correlation between the two variables in Figure 1.

(8) **Principle of unmarked length:** If an inventory contains a vowel quality *Q*, the likelihood of *Q* coming in a short-long pair is proportional to the typological frequency/unmarkedness of *Q*.

This tendency reflects synchronic pressures such as dispersion as well as common historical pathways. Consider the frequent lack of length contrasts in mid vowels such as [e, o]. This exclusion is consistent with dispersion for the same reason that three-vowel systems are usually /a, i, u/, excluding mid vowels. At the same time, one can often trace historical explanations. For example, in Sanskrit, mid vowels developed from diphthongs (e.g. ai > eː), explaining why they come only in long versions (Ryan 2021). As another example, the frequent absence of length contrasts in nasalized vowels can reflect a possible origin of nasalization in VN > Ṽ, especially if length was not originally possible in syllables with nasal codas.

[11] If Australian languages were set aside, [i] and [u] would be closer to [a] and more clearly set apart from all other vowels, including [ɔ].

[12] Although [ə] is part of this cohort, recall that I do not count an inventory as mixed-length if the only exception to length is the reduced vowel(s). Had I included such systems here, the rate for [ə] would be lower.

3 Length is not a feature

Prior to the 1970s, vowel length was commonly treated as a binary feature $[\pm long]$, akin to other distinctive features such as $[\pm voice]$ or $[\pm nasal]$ (e.g. Chomsky & Halle 1968). By the 1970s, the consensus shifted away from the featural analysis of length. For one, processes affecting length are unlike those affecting other features, and vice versa. For example, most features (voicing, place, manner, etc.) are frequently found to assimilate or harmonize between neighboring segments. Length, by contrast, rarely if ever assimilates or harmonizes (cf. Hyman & Udoh 2007).

Moreover, length-as-a-feature misses generalizations. Long vowels regularly comprise a natural class with other entities characterized as bimoraic (e.g. diphthongs, pairs of short vowels or light syllables, or branching rimes of the form VX), necessitating cumbersome disjunctions such as $\{V_{+long}, V_{-long}(C)V_{-long}\}$. Intuitively, long vowels share with the other entities the property of comprising *two units*. An autosegmental analysis of length captures this insight by allowing rules/constraints to operate directly on the prosodic level rather than on the diverse segmental configurations underlying it.

Consider four facts about Fijian, all of which treat long vowels – single segments[13] – like diphthongs and pairs of short-voweled syllables. First, primary stress (ˈ) falls on the penult unless the ultima contains a long vowel or diphthong, as in (9) (Dixon 1988:16). The parentheses anticipate the modern analysis, with a right-aligned bimoraic foot (MORAIC TROCHEE). In the earlier formalism, one would need a rule like $V \rightarrow [+stress]$ / $\{\underline{\quad}_{+long}$, __(C)$V_{-long}\}$#, where the disjunction hints at a missed generalization.

(9)	a.	ra(ˈᵐbeta)	"kick"
	b.	(ˌᵐbuta)(ˈʔoða)	"steal"
	c.	(ˌðau)ra(ˈβou)	"youth"
	d.	ʔi(ˈlaː)	"know"

Second, in certain types of prefixing reduplication, if the first vowel of the base is short, two syllables are copied (10a–b); if it is long or a diphthong, one syllable is copied (10c–d) (Dixon 1988:198). With moras, one can say that a moraic trochee is copied. With $[\pm long]$, the generalization that long vowels behave like pairs of short vowels is lost. One could just as easily condition disyllabic reduplication on a long vowel.

(10)	a.	(ðula)-ðula	"sew for a period"
	b.	(ᵐbuta)-ᵐbutaʔo	"steal on a number of occasions"
	c.	(maː)-maːrau	"be permanently happy"
	d.	(kau)-kau.a	"strong"

Third, a Fijian prosodic word (setting aside grammatical particles) must contain at least a long vowel, diphthong, or pair of syllables (e.g. [oː] "cloud," [wai] "water," [ʔoro] "village"); it cannot be merely (C)V, as Schütz (1985:553, 572) and Dixon (1988:25) make explicit. Finally, (C)Vː is interchangeable with (C)VV and (C)V(C)V in Fijian poetic meter (Gordon 1999:252f), a license found in (certain contexts of) many languages' quantitative meters (e.g. Arabic, Greek, Hausa, Latin).

The four phenomena just enumerated all involve metrical phonology, and hence feet. That said, the bi-elemental nature of long vowels is readily demonstrated from other domains. Five further examples from other languages will suffice.

First, consider tone assignment (localization). Kuria verbs in the inceptive ("about to X") receive a high tone (´) on the fourth mora after the stem boundary, marked by the left bracket in (11), even across words (d) (Mwita 2008:119, Marlo et al. 2015:253, 260).[14] A 1960s-style rule is in (12), clearly misguided both

[13] Long vowels in Fijian cannot be analyzed as sequences of vowels (see §4).
[14] Though not critical here, Marlo et al. (2015:262) and Rolle & Lionnet (2019:9) argue that this case is not foot-based.

in complexity (triple disjunction, with verbose terms to boot) and in arbitrariness (toggling any instance of $[\pm long]$ would yield an equally complex but unnatural rule, a type of "fundamental theoretical inadequacy" acknowledged by Chomsky & Halle 1968:400).

(11)	a.	to-ra-[teremek-á]	"we are about to be calm"
	b.	to-ra-[koː.ndokór-a]	"we are about to uncover"
	c.	to-ra-[turuːŋán-a]	"we are about to welcome"
	d.	to-ra-[rom-a] eɣétɔ́ːkɛ	"we are about to bite a banana"

(12) $$\text{V} \rightarrow [+high\ tone] \,/\, [_{stem}(C) \left\{ \begin{array}{c} V_{-long}(C)V_{-long}(C)V_{-long} \\ V_{+long}(C)V_{-long} \\ V_{-long}(C)V_{+long} \end{array} \right\} (C)\_\_$$

Second, consider contour tone licensing. Contour tones (e.g. rising or falling) are sometimes restricted to long vowels or diphthongs, as in Somali (Orwin 1994:164f). In autosegmental terms, the contour tone is itself compositional, with falling = high + low and rising = low + high. Thus, with moras, one can say that each component tone requires a mora host. With $[\pm long]$, by contrast, nothing intrinsically motivates the association of contour tones with $[+long]$ as opposed to $[-long]$ vowels.

Third, consider syllable structure. Many languages exhibit CLOSED-SYLLABLE SHORTENING, whereby long vowels (sometimes along with diphthongs) are illicit in syllables with codas (see §6). With moras, one can say that a syllable is capped at two (counting the coda as moraic), capturing the common essence of {Vː, VV, VC}. Featural length, by contrast, requires disjunctions. As a similar case, compensatory lengthening (see §6) is typically blocked if the vowel is already long or a diphthong (e.g. Kiparsky 2011:11).

Fourth, consider once again poetic meter. A Japanese *haiku* is 5-7-5 in terms of moras. A syllable with a long vowel (Vː), diphthong (VV), or vowel-plus-coda (VC) is bimoraic, equivalent to two light syllables (V(C)V). With featural length alone, characterizing legal lines would be onerous.

Finally, some languages shorten long vowels and simplify (i.e. delete an element of) diphthongs in the same context, suggesting that shortening involves removing an element, not just toggling a feature. In Lithuanian, a word-final, falling-tone long vowel shortens (e.g. /ger-âː/ → [ger-á] "with a good (feminine)"), and a diphthong in the same context simplifies (e.g. /ger-ûo/ → [ger-ú] "with a good (masculine)"). Similarly, in Finnish, before the partitive plural ending *-i-ta*, a long vowel shortens (e.g. [puː, pu-i-ta] "tree(s)") and a diphthong simplifies (e.g. [suo, so-i-ta] "swamp(s)") (Kenstowicz 1970; Odden 2011:3f). In Trukese, final short vowels delete, and long vowels shorten, in either case removing a mora (Topintzi & Zimmermann 2025:331).

4 Long vowels are not (usually) sequences of vowels

Given that long vowels frequently pattern as bi-elemental (§3), it is sensible to ask whether they can be analyzed simply as sequences of vowels (SEQUENCE THEORY), for example, treating [aː] as [aa]. As this section elaborates, sequence theory is not a viable analysis of vowel length in general.

Let us begin with Fijian, picking up from §3. While some early treatments analyzed long vowels as sequences (as reviewed by Schütz 1985:631–3), most modern treatments regard long vowels as single segments (e.g. *id.*:51, 616, 622f; Dixon 1988:16–8, 24f). Indeed, in Fijian, both long vowels and vowel sequences occur. Recall from (9) that the penultimate mora is stressed. [ua] is a vowel sequence, so stress falls on its second element in (13a) (Dixon 1988:18, 27, 178). [au], by contrast, is a (tautosyllabic) diphthong. Given that stress is syllable-level, [au] must be stressed as a whole in (b). If the penult contains an underlying long vowel, as in (c), the vowel is shortened (due to trochaic shortening; §6). Crucially, if the long vowel were a sequence of vowels, one would expect *[siˈiβi], akin to (a). Note additionally that adjacent identical sequences such as [ii] and [uu] *are* generally licit in Fijian, at least across morpheme boundaries, as in (d–e). Being sequences, they are stressable on their second elements.

(13)	a.	/lua-ða/	→	[luˈa-ða]	"vomit on"		
	b.	/tau-ða/	→	[ˈtau-ða]	"touch down on"		
	c.	/siːβi/	→	[ˈsiβi]	"exceed"	cf. [ˌsiːˈβi-ta]	"lead"
	d.			[ˌβuː-ni-ˈiβi]	"Tahitian chestnut"		
	e.			[ˌunu-ˈunu]	"gargle"		

Thus, one argument that long vowels cannot be reanalyzed as sequences of vowels is that the two structures may co-occur within a language, behaving differently. I offer five further examples. First, Vedic Sanskrit has both long vowels (e.g. [aː]) and vowel sequences (e.g. [aa]). Though the latter usually straddles word boundaries, it may be tautomorphemic, as with a form of the genitive plural, [-aam] (< **-oHom*; Kümmel 2013). A line from the Rig-Veda (8.70.12c) is given in (14). Its meter requires exactly 12 syllables, confirming that [aː] (one syllable) is distinct from [aa] (two syllables). Homeric Greek furnishes comparable examples. For one, [aáːatos] "inviolable" scans as four syllables, starting light-heavy-light (Nikolaev 2012).

(14) a. dʱaːnáːnaaṃ ná sáṃ gr̥bʱaːja asmajúr
"grab like grains for us"

Likewise, Matumbi distinguishes between long vowels vs. sequences of identical vowels within morphemes (Odden 2011:9). Long vowels, as in (a–b), trigger tone retraction (phrase-finally) or shorten (non-finally), while double vowels, as in (c–d), do neither. Kikamba too distinguishes between long vowels and adjacent identical sequences (e.g. [kokɔ́ɔ̀ːtà] "to stretch"; Roberts-Kohno 2000:87), as does Gokana (Hyman 1982, Odden 2011:7f).

(15)	a.	/ŋgaːsí/	ŋgăːsi	ŋgasí ɟăːŋgu	"(my) ladder"
	b.	/ŋkaːté/	ŋkăːte	ŋkaté ŋăːŋgu	"(my) bread"
	c.	/baará/	baará	baará ɟăːŋgu	"(my) ocean"
	d.	/baasá/	baasá	baasá lwăːŋgu	"(my) envelope"

A second argument against sequence theory is the fact that length contrasts are found just as commonly in languages that require onsets as in those in which onsets are not required.[15] In Supyire, for instance, the only permitted syllable type is CV(ː), with an onset, and diphthongs do not occur (setting aside onset palatalization or labialization) (Carlson 1994:7f). If Vː were VV, one might expect epenthesis of an onset (e.g. VʔV). Of course, one could also say that empty onsets *are* permitted, but only word-internally between identical vowels. But such a rule, besides being *ad hoc*, would be unnatural and at any rate untenable, since long vowels otherwise pattern as single segments (e.g. stress cannot be borne by the second part).

Further, some languages that allow onsetless syllables nevertheless forbid vowel hiatus (contact between vowels). In Middle Tamil, for instance, would-be hiatus is always RESOLVED (both within and across words), either by deleting the first vowel or by inserting a glide between the vowels. This holds even when the two vowels have the same quality. Long vowels, however, are permitted.[16]

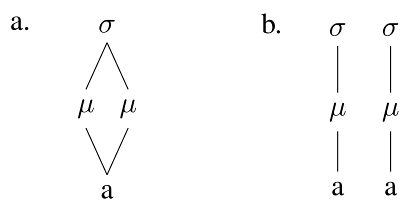
Finally, consider prosodic minimality. Some languages, such as Nyawaygi, require every prosodic word to be at least disyllabic (Hayes 1995:105). Nyawaygi has long vowels, but CVː is subminimal as a word, confirming that Vː is a single vowel.

[15] In a survey of 18 diverse languages with obligatory onsets, 61% had long vowels.
[16] Tamil's diphthongs, namely, [a(ː)j, e(ː)j, o(ː)j, aʋ], are best analyzed as VC rimes (Krishnamurti 2003:90).

In all the above cases, long vowels are tautosyllabic, whereas vowel sequences (if any) are heterosyllabic. The sequence apologist might therefore reply that long vowels can still be analyzed as sequences, just within the syllable. For example, one might maintain that Matumbi [aː] and [aa] are represented as (16a) and (16b), respectively – distinct, but still both sequences.

(16) 

For starters, note that even if such a move were viable, it abandons linear sequence theory: It is now an autosegmental theory, dependent on how segments link to a prosodic tier. (Compare the moraic analysis of [aː] vs. [aa] in (17).) Moreover, this TAUTOSYLLABIC SEQUENCE THEORY – if intended to explain vowel length in general – encounters various problems. First, in languages like Supyire (strictly CV(ː)), vowel sequences are not otherwise permitted, either across syllables or within them (as diphthongs), so there is a loss of generalization. Second, long vowels are phonetically unitary, lacking rearticulation or separate targets, even in careful speech.[17] Third, speech errors and language games support the unitary segmenthood of long vowels (Hayes 1986:323–30, with additional arguments).

(17) 

Fourth, long vowels typically exhibit INTEGRITY. As mentioned, they generally cannot be broken up by epenthesis. Moreover, they otherwise usually behave as melodic units (i.e. single segments). For example, in Yawelmani, long high vowels lower (e.g. /iː/ → [eː]), while short high vowels remain unaffected (McCarthy 1999:355). If /iː/ were /ii/, it would be cumbersome to lower each individual segment while keeping singleton /i/ intact. Importantly, this example is representative: Rules changing vowel quality are very common, and the vast majority treats long vowels as units. Another famous example is the Great Vowel Shift of early Modern English, whereby (to oversimplify) long vowels raised by one rung in the vowel space (if possible), while short vowels remained *in situ* (e.g. eː > iː, but e > e).

That said, exceptions to integrity do occur. For example, long vowels sometimes BREAK into diphthongs, as with Modern English [eː] > [eɪ] or (as part of the Great Vowel Shift) [iː] > [əi]. Some such cases might be argued to reflect phonetic implementation, or to be purely historical.[18] However, breaking *can* be synchronically active. In Sanskrit, for instance, /iː/ regularly alternates with [ai] (later [eː]) via a kind of ablaut (e.g. [niː-tʊáː] "having lead" vs. [nai-trá] "leader"). Sanskrit /iː/ → [ai] violates integrity only if one analyzes it as a change in quality of the first part of the long vowel. But there is better analysis: [a] is inserted as the head (first mora) of the syllable. Because a (tautosyllabic) sequence like [aiː] is illicit, /iː/ shortens. The insertion analysis is supported by the fact that short vowels also break (e.g. /i/ → [ai], as in [ɕivə] "Shiva" vs. [ɕaivə-] "Shaivite").

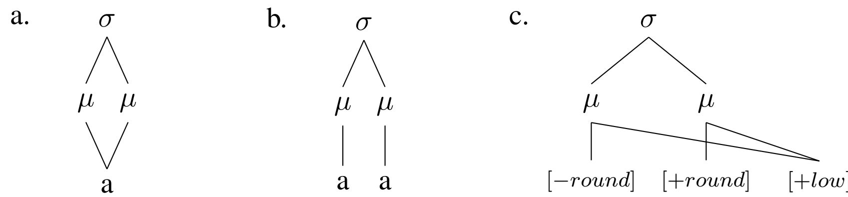
Other cases of long-vowel breaking appear less likely to involve insertion. For example, in Southern Paiute, the first part of /ɑː/ assimilates to a preceding /ɔ/ in rounding, as in [ɑɣɔŋ-qɒɑmpətsː] "fir-grouse," cf. [qɑːmpətsː] "grouse" (Sapir 1930:8). Given that short vowels also round, but without breaking, insertion

[17] As an exception, Sapir (1930:20) observes that long vowels may optionally be rearticulated in Southern Paiute.

[18] As an example of a possible case of phonetic implementation, contrasts in phonation (e.g. breathy vs. modal) are often realized late in vowels, after a modal portion. As for history, if the diphthong does not actively alternate with a monophthong, the diphthong might simply be posited as underlying.

is less plausible. As always, one might question whether such a process is productive (note Sapir's "rather infrequently"), and also whether it is phonetic (here, coarticulatory) rather than phonological (note Sapir's "acoustically midway between *ɑ* and *ɔ*"). At any rate, many other cases exist (e.g. Pyle 1970:137f; Hayes 1990:39; Mellander 2003:141–3), such that some analysts concede that there are genuine exceptions to integrity, necessitating a tautosyllabic identical sequence like (18b). (As established, however, (18b) could not replace (18a) in general.) Some analysts further recognize that diphthongs might share some features between moras but not others, as sketched in (18c), in which $[+low]$ should be visualized as projecting off the page, such that no lines cross (see Hayes 1990 for a related proposal).

(18)



In sum, long vowels cannot *in general* be analyzed as sequences. Virtually all phonologists nowadays endorse autosegmental length in some form, whether via moras or some other kind of timing slot. A two-level structure like (18a) captures the DUALITY OF LENGTH: Some phenomena (especially those concerned with timing/prosody) treat long vowels as being two units (§3), while others (especially those concerned with quality) treat them as being single units (this section). That said, the consensus also countenances adjacent identical vowels, at least across syllables, as in (17b). An open question is whether adjacent identical vowels are ever needed *within* syllables, as in (18b). Given the prevalence of integrity – long vowels are "far more likely" to be treated as units than as sequences for quality-altering rules (Pyle 1970:138) – along with the other evidence discussed in this section, within syllables, there is at least a bias (if not a requirement) for true length, as in (18a).[19]

5 Overlong/trimoraic vowels

Autosegmental length, unlike $[\pm long]$, predicts that vowels could in principle be trimoraic, quadrimoraic, and so forth. Trimoraic (OVERLONG) vowels, for their part, do exist, albeit uncommonly.

The existence of trimoraic syllables and diphthongs is somewhat less controversial, so I begin there. Several stress systems treat C_0Vː C syllables (SUPERHEAVIES) as heavier than C_0Vː syllables (e.g. Hindi, Kashmiri, Mankiyali, Nanti, Pulaar; Ryan 2019b:35–43, 59).[20] Quantitative meters can make the same distinction, gradiently or categorically (e.g. Finnish, Greek, Persian, Sanskrit, Tamil; *ibid.*:141, 148–51). (Ryan (2021) even observes that ultraheavies pattern as heavier than superheavies in Vedic meter.) Additionally, some of the same languages (Finnish, Pulaar, Sanskrit, Tamil) permit a long vowel to be followed by a geminate consonant. If geminates are moraic, as usually assumed (cross-reference), this fact too implies trimoraic syllables. Hayes (1989:291f) cites compensatory lengthening as further evidence for trimoraic syllables, since it can apply to syllables that would be already heavy without it. Further, diphthongs may be trimoraic, as in Vedic Sanskrit, where [aːi, aːu] pattern as superheavy, contrasting with heavy [ai, au] (Ryan 2021).

Turning to overlong monophthongs, let us first set aside three irrelevant types of case. First, a sequence of vowels across syllables does not qualify as an overlong vowel. The former is not hard to find (recall Greek

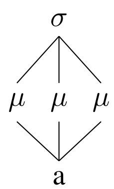
[19] The Obligatory Contour Principle (OCP; e.g. McCarthy 1986) is often mentioned in this connection – e.g. Hayes (1989:300–2) implies that it is a hard constraint within morphemes – since [aa] violates it, while [aː] does not. However, assuming a constraint-based framework, the OCP alone cannot explain a cross-linguistic bias for [aː] over [aa], as competing constraints (e.g. *LONG) could be ranked above it.

[20] None of the mentioned cases can be attributed to word-final consonant extrametricality.

[aáːatos], Kikamba [kokɔ́ɔ̀ːtà], and other cases from §4). Second, proper overlength is purely or primarily length-based, not duration contingent on some other contrast such as tone or phonation (Ni et al. 2025:2). Third, proper overlength is part of the core phonology (e.g. contrastive), not merely phonetic or stylistic. Consider overlong (*pluta*) vowels in Sanskrit, which the tradition explicitly treats as trimoraic (three *mātrā*-s). For example, [aːsiːːt] "was" occurs twice in Rig-Veda 10.129.5, both times scanning as disyllabic. However, such items are rare in Sanskrit, and at any rate stylistic; the same word is usually [aːsiːt].

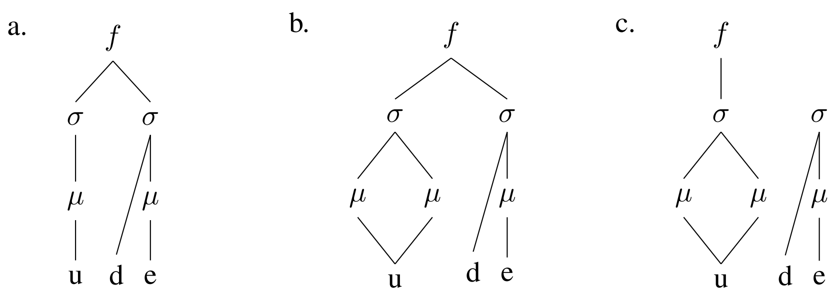
With those caveats aside, there is little doubt that empirically, three contrastive grades of vowel length exist in some languages. What is more debatable is the analysis: Is it necessary to analyze overlong vowels as trimoraic, as in (19), or is some other structure motivated?

(19)



Consider the classic example of Estonian, with three grades of vowel length, as in [ude] "fuzz," [uːde] "innovation," and [uːːde] "new (illative singular)." Based on stress, prosodic minimality, and other phenomena, Prince (1980) argues that an overlong (but not long) syllable comprises a foot by itself, as illustrated for the three grades by (20) (after Köhnlein & Cameron 2024:1063). This move allows Prince (1980) to maintain that both long and overlong vowels are bimoraic, but the latter receives additional (non-moraic) length due to being a foot.[21] For present purposes, what is important is not whether this analysis of Estonian is correct (cf. on other proposals Hayes 1989:293–7; Ehala 2003; Prillop 2013), but that it illustrates a general strategy (anticipated by Trubetzkoy 1939:180f) for maintaining a universal bimoraic maximum in the face of overlong vowels, which is to orthogonalize the vowels' extra length on another property.

(20)



Another example of this strategy is the analysis of East Frisian Low German by Ni et al. (2025). Short, long, and overlong vowels all occur in (ostensible) monosyllables (e.g. [ʃviːn] "pig" vs. [ʃviːːn] "pigs," alongside short [ɪ]). Both vowels of [ʃviːn] and [ʃviːːn], they claim, are bimoraic, but the latter is actually disyllabic: [ʃviːː$_{\mu\mu}$.nØ$_{\mu}$]. Here, long vs. overlong, they claim, is associated with a monosyllabic vs. disyllabic foot, respectively, the converse of the Estonian analysis just discussed, but another illustration of orthogonalizing overlength on prosody.

That said, the prosodic reduction of overlength appears not to be viable for all languages. A strong case for trimoraic monophthongs is furnished by Shilluk (Remijsen et al. 2019) and related Western Nilotic languages such as Dinka, Nuer, and Reel. Monosyllabic minimal triplets abound (e.g. [gút] "stab," [gúːt] "navel," and [gúːːt] "navels (pertensive)"). The three vowel grades have mean durations of 68, 111, and 150 ms. Using linear discriminant analysis, Remijsen et al. (2019:117f) show that the contrasts are borne by

[21] One drawback of this analysis – at least in the general case, if not in Estonian – is that it requires foot structure to be lexically listed, counter a putative universal (Köhnlein & Cameron 2024:1061).

vowel duration, not by vowel quality, tone, or coda duration. The grades interact richly with morphology. One common pattern is overlengthening, whereby an underlying short or long vowel becomes overlong in certain inflections (i.e. V(ː) → Vːː), as in (21a–b).[22] Furthermore, some long-voweled nouns pluralize by shortening the vowel, others by overlengthening it (c–d). But overlength is not determined entirely by morphology: All three grades may be underlying (*ibid.*:100). Related Dinka even exhibits what might be called incremental lengthening, whereby, for a given inflection, short becomes long, while long becomes overlong, suggesting in either case that a mora has been added.

(21)	a.	á-cə̂m	"ate (object voice)"	á-càːːm	"you (singular) ate"
	b.	á-lɛ̂ːŋ	"threw (object voice)"	á-lɛ̀ːːŋ	"you (singular) threw"
	c.	tûːŋ	"horn"	tùŋ	"horns"
	d.	kɛ̂ːl	"cheetah"	kɛ̂ːːl	"cheetahs"

Kadiwéu (Brazil) furnishes another example. Categorical overlength occurs, among other contexts, under stress shift, as with [(ˈdʒi-boː)] "I give" vs. variant [dʒi-(ˈboːː)] (Becker et al. 2021). Similarly, in St. Lawrence Island Yupik, iambic lengthening (§6) renders a long vowel trimoraic per Baković (1996:5), as with /qajaːni/ → [(qaˈjaːː)ni] "in his (another's) kayak."

The case for the existence of trimoraic vowels is therefore strong, even if one sets aside diphthongal and allophonic trimoraicity. Trimoraic vowels are somewhat rare, but "rare threes/fours" are commonplace in phonology (cf. contour tone complexity, onset or coda complexity, etc.). On the one hand, given the prevalence of binary length, cases of apparent ternary length should be put through the paces; strict binarity, after all, is more restrictive.[23] On the other hand, the *horror ternarii* concerning moras, dating back to Trubetzkoy (1939) but still epidemic, might be overwrought. First, from an autosegmental perspective, there is no intrinsic limit on linkages (cf. contour tones); any imposed limit would only *add* complexity to the theory. Second, metrically, duple and triple rhythms/groupings are both highly natural (Jacoby et al. 2024:872). Finally, most prosodic theories do not assume binarity in the general case. For example, most phonologists would not balk at a prosodic word containing three feet. The constraints BINMIN and BINMAX express the unmarkedness of binarity, but they are expressly violable (Selkirk 2011:35f). Even at the foot level, ternary feet (e.g. Martínez-Paricio & Kager 2015) are now popular. To be sure, ternary feet are binary-branching (i.e. $[[\sigma\sigma]\sigma]$ or $[\sigma[\sigma\sigma]]$), but the result is still that a foot may contain three syllables. Binary branching should therefore be distinguished from binary containment: The existence of trimoraic vowels does not preclude the possiblity of a binary-branching structure such as $[[\mu\mu]\mu]_\sigma$, but evidence distinguishing $[[\mu\mu]\mu]_\sigma$ from $[\mu\mu\mu]_\sigma$ might be hard to come by.

6 Processes and constraints affecting vowel length

Rules of vowel lengthening or shortening generally have (at least) one of four motivations, being rhythmic, positional/phonotactic, compensatory, or morphophonological.

The most frequent rhythmic adjustment is the lengthening of a stressed vowel (Prokosch 1939; Hayes 1995:83), which can affect either primary stress alone (e.g. Wargamay; Hayes 1995:84) or all stresses (e.g. Tiriyó above; §1). Ryan (2019b:31) analyzes the two cases using MAIN→$\sigma_{\mu\mu}$ and STRESS→$\sigma_{\mu\mu}$. These constraints are natural in the sense that increased duration is a frequent cue for stress even when moraic length is not at issue. Lengthening can be prevented by a coda, which (in some languages) already furnishes the needed second mora (e.g. Tiriyó above, §1).

The lengthening of stressed vowels occurs in both iambic and trochaic systems (see Mellander 2003 for several examples of each), but is more frequent/natural in the former, as IAMBIC LENGTHENING. To capture

[22] Tonal changes are also evident in some examples, but irrelevant.
[23] In practice, it is not necessarily more restrictive, since the analyst might shift the complexity to other domains.

this bias, various constraints have been proposed, one being RH-CONTOUR, which requires a foot to end with a strong-weak moraic sequence (Kager 1993, 1999:174). An assumption of this approach is that only the first mora of a stressed heavy syllable is strong, as depicted in (22) by two grid marks (×) above the mora. The constraint therefore favors EVEN (light-light) trochees but UNEVEN (light-heavy) iambs.[24]

(22) a. Even trochee b. Uneven trochee c. Even iamb d. Uneven iamb

Vowels can also lengthen to satisfy foot binarity (FTBIN), which requires a foot to contain (at least) two moras. For example, in Latin, the root /da/ "give" has a short vowel, judging by forms such as [(ˈda-re)] "to give." Nevertheless, unsuffixed, its vowel lengthens: [(ˈdaː)] "give!" Latin does not otherwise have stress-driven or word-final lengthening (as *dare* illustrates), but lengthens to avoid a monomoraic foot.

Rhythmic constraints can also trigger shortening, even of a stressed vowel. Recall (§4) Fijian /siːβi/ shortening to [(ˈsiβi)] "exceed" (or /ᵐbuː-ᵑgu/ to [(ˈᵐbu-ᵑgu)] "my grandmother") (Zuraw 2018). This TROCHAIC SHORTENING is motivated because it yields an even (light-light) trochee. The same process can be seen in early English (e.g. *tone*/*tonic*; Lahiri & Fikkert 1999). Thus, the head of a trochee may naturally lengthen or shorten, depending on the ranking of RH-CONTOUR and STRESS→$\sigma_{\mu\mu}$. Shortening can also affect the second syllable of a trochee. In early Latin, for instance, light-heavy trochees are optionally rendered light-light, as in /amoː/ → [(ˈamo)] "I love" (Mester 1994:11, cf. Weiss 2009:126f), once again due to RH-CONTOUR. This analysis captures that Latin shortening does not affect unfooted syllables or monosyllabic feet (cf. [(ˈkreː)doː] "I believe").[25]

Other length-regulating rules reflect positional or phonotactic constraints. For example, a language might license long vowels only in the word-initial syllable, shortening them elsewhere (e.g., with caveats, Warlpiri; Nash 1980:71). Alternatively, a language might license long vowels in all positions except the ultima (Baković 1996:18–20; Buckley 1998). As another case, in Zinza, a word can begin with a long but not short vowel (Odden 2006). Positional restrictions can interact with rhythmic constraints. In Italian, for instance, stressed vowels lengthen, but only in the penult (Buckley 1998:184).[26] Further, in some languages, a long vowel shortens when immediately preceding another vowel, a rule known as CORREPTION, as in Latin /pleː-oː/ → [ple-oː] "I fill" (Weiss 2009:126) (see also Finnish at the end of §3).

Compensatory lengthening refers to a vowel (or consonant) being lengthened to make up for the loss or shortening of another segment. In the most common type, a vowel lengthens immediately before a deleted consonant, as in (23a) (Gess 2011:2). Here, the mora that would be licensed by /s/ attaches instead to the vowel, preserving the mora count had no deletion occurred (Hayes 1989). As MORAIC PRESERVATION predicts, compensation can also be triggered by vowel deletion, shortening, or gliding, as in (b–d), respectively (Gess 2011:3, Kiparsky 2011:1). The account further correctly predicts that even if the deleted consonant *itself* is not potentially moraic, as long as its presence would induce a mora, its deletion can trigger compensation, as in (e) (Hayes 1989:265). Crucially, however, deletion of a non-mora-inducing segment, such

[24] A related proposal involves penalizing a foot that ends with a strong mora (Hyde 2007:290). Pretheoretically, the overrepresentation of iambic (vs. trochaic) lengthening is motivated by the Iambic-Trochaic Law (Hayes 1995; Hyde 2011; Crowhurst 2020).

[25] The Latin shortening is traditionally termed (in both cases confusingly) *brevis brevians* or iambic shortening. See Mellander (2003) for cases from other languages. Trochee-final lengthening, by contrast, is not expected, but is attested in Kadiwéu, where an additional constraint is needed (Becker et al. 2023).

[26] Italian dialects differ as to how much the antepenult lengthens under stress (cf. Faust & Ulfsbjorninn 2024:757).

as a word-initial or intervocalic consonant, is not predicted to trigger compensation.[27] A coda too can fail to induce compensatory lengthening if it is not moraic. In Huehuetla Tepehua, for instance, the loss of a sonorant, but not of an obstruent, triggers compensation, as in (f–g) (Kung 2007:139f). Tellingly, Huehuetla Tepehua's stress system likewise diagnoses only sonorant codas as moraic (*ibid.*). Finally, as argued by Borgeson (2022) for Slovak and Estonian, compensation can be long-distance, as in (h–i).

(23)	a.	Attic Greek	/es-mi/	→	[eː-mi]	"I am"
	b.	Middle English	/talə/	→	[taːl]	"tale"
	c.	Attic Greek	/poleː-os/	→	[pole-oːs]	"of the city"
	d.	Pali	/so ahaŋ/	→	[sʊ aːhaŋ]	"that I"
	e.	Homeric Greek	/odwos/	→	[oːdos]	"threshold"
	f.	Huehuetla Tepehua	/ʔa-lak-hun-ni-ya/	→	[ʔa-lak-uː-niː]	"he says it to them"
	g.	Huehuetla Tepehua	/t'aː-qot-t'i/	→	[t'aː-qo-t'i̥]	"you drank with him"
	h.	Slovak	/sud-ŏk-ŏ/	→	[suːd-ok]	"cup (diminutive)"
	i.	Estonian	/hiːla-ma-ha/	→	[hiːːla-ma]	"sneak (illative infinitive)"

While not usually described as compensatory, the common processes of OPEN-SYLLABLE LENGTHENING and CLOSED-SYLLABLE SHORTENING have a similar rationale. Some languages require long vowels in syllables without codas and/or prohibit them in syllables with codas (e.g. Icelandic; Kager 1999:267).[28] In a manner of speaking, lengthening compensates for the lack of a coda, while shortening compensates (in the other direction) for its presence, in either case achieving bimoraicity. Open-syllable lengthening may be confined to stressed syllables, as seen with Tiriyó (§1). Closed-syllable shortening may be restricted to moraic codas. For instance, vowels shorten before sonorant but not obstruent codas in Lithuanian and other Indo-European languages (Osthoff's Law; e.g. Zec 1995:101, Sayeed 2017).

Counterintuitively, vowels may also lengthen in closed syllables. Some such cases are argued to be historical artifacts (cf. Hayes 1995:220 on Menominee) or phonetic (e.g. Kawahara 2016:175 for several examples of pre-geminate lengthening). Other cases are phonological, but independently motivated. For example, FtBin can cause lengthening before a non-moraic coda (Ryan 2019b:122). Still other ostensible cases can be attributed to compensatory lengthening. In Luganda, for instance, a vowel lengthens before a nasal-consonant sequence (e.g. /mu-ntu/ → [muː-$^{\text{n}}$tu] "person"). On one analysis, the nasal is initially moraified as a coda, and then resyllabified with the following syllable (as prenasalization), triggering compensatory lengthening (Maddieson 1993, Hubbard 1995:249). However, in various Bantu languages, this account has been challenged both with respect to the syllabification of the nasal and the moraicity of the vowel (cf. Riehl 2008; Hamann & Kula 2022). Likewise, in Latin, a vowel lengthens before a nasal-fricative sequence (e.g. *consol* > *cōnsul*), compensating for the loss of the nasal, which nevertheless remains written (i.e. [konsol] > [kõː(n)sul]; Weiss 2009:129).

That said, there remain genuine cases of closed-syllable lengthening. In Serbian, for instance, vowels lengthen before sonorant codas under certain conditions (e.g. /bugar-ka/ → [bugaːr-ka] "Bulgarian"), which Milenković (2023) argues to be phonological (see also Zec 2002). Further, while pre-voiced lengthening may be phonetic (recall English [bɛt] vs. [bɛˑd] from footnote 5), it can also be phonological, as in Friulian (Lampitelli et al. 2021:98) or Latin (Lachmann's Law; Weiss 2009:175, Jasanoff 2004). One motivation for pre-voiced lengthening is that voiced codas are typically shorter than voiceless ones; in that sense, it

[27] Such cases are indeed uncommon, but attested (as discussed by Kavitskaya 2002; Beltzung 2008; Kiparsky 2011). Coalescence (VCV → Vː) does not count, since it is not compensation for the deleted consonant.

[28] In Icelandic, word-final consonants do not count as closing the syllable. That is, they are not moraic. Thus, one sees pairs such as [skiː<p>] "ship" vs. [skip<s>] "of the ship," ignoring the bracketed consonants (*ibid.*). Closed-syllable shortening is also found in Middle English (e.g. *keep/kept*), Cairene Arabic, Hausa, Kashaya, Kiowa, Koasati, Lithuanian, and Yawelmani.

is compensatory. Similarly, Ryan (2019b:135) attributes pre-rhotic lengthening in Tamil to the shortness of the flap. Another motivation, especially for pre-sonorant lengthening, is that higher-sonority consonants are more likely to be moraic, and might therefore induce vowel lengthening by mora-sharing with the vowel (Maddieson 1993; Milenković 2023).

To conclude, this section has enumerated *natural*, *phonological* processes affecting vowel length. Most reflect either rhythm or compensation/isochrony, as these phenomena concern time, and vowel length is time. The survey is not exhaustive. Some rules are more arbitrary, possibly reflecting an originally natural process obscured by layers of historical change. For example, Weiss (2009:128) posits of Latin: "A long vowel is shortened before final *t*, *r*, and *l* in polysyllables," which smacks of unstressed closed-syllable shortening, but not straightforwardly. Moreover, for reasons of space, I do not address morphologically-influenced vowel length (cross-reference), which includes phenomena such as mora affixation[29] (including infixation),[30] reduplication,[31] allomorph selection,[32] and templatic morphology,[33] among others. Finally, while this section focuses on vowel length alternations, it should be made explicit that vowel length also regularly factors into phonological rules even when length is not altered. For example, rules of vowel deletion (e.g. syncope and apocope) usually target only short vowels.

7 Vowels and weight: beyond the mora

While moras are well suited for binary/ternary phenomena such as contrastive length and foot form, they are insufficient to account for all aspects of phonologically relevant length/weight. Much evidence of this insufficiency comes from consonants, and is therefore beyond the present scope. For example, Ryan (2014, 2019a, 2022) demonstrates for English that increasing onset complexity – which does not add moras – correlates with increasing weight for stress, end-weight, and textsetting, respectively. That said, this section offers some examples of challenges posed by vowels for (exclusively) mora-based weight.

Tone licensing. As mentioned for Somali (§3), languages often restrict contour (e.g. rising or falling) tones to bimoraic syllables. Zhang (2004), however, critiques moraic licensing, arguing instead that contour tones are licensed by (canonical) duration. To be sure, moraicity and duration are correlated, but where they differ, the latter proves more important for licensing. For example, many languages restrict contour tones to final syllables (even when monomoraic) due to final lengthening. Second, languages can impose a hierarchy of licensing conditions amounting to four levels, beyond the reach of mora count. Third, different contours have different intrinsic durations (e.g. rises can require more material than falls), while moras predict no rise/fall asymmetry. Finally, the moras necessary for contour tone licensing sometimes conflict with the moras diagnosed by other phenomena (MORAIC INCONSISTENCY). In Ancient Greek, for instance, only vocalic moras count for tone licensing, whereas coda consonants count as heavy for other processes. Mora theorists can work around most of these problems by adding constraints (e.g. *NONFINAL-CONTOUR, *RISE) or by distinguishing types of moras (e.g. μ_V vs. general μ; Hayes 1995:299–305; Paramore 2025), but with a loss of generalization. Zhang's (2004) durational licensing seeks a unified account.

Stress. Stress placement is often conditioned by categorical vowel length, but less often (if ever) by durational adjustments such as pre-voiced lengthening (Trubetzkoy 1939, Davis 2011:132). While very short, REDUCED vowels can be less stressable than other short vowels, mora theorists sometimes analyze reduced vowels as being non-moraic (cross-reference). Thus, up to four degrees of length can be implemented moraically: reduced, short, long, and overlong. Beyond these distinctions, it is debated whether vowel duration enters into stress placement. Until recently, it was fairly uncontroversial that stress location could be

[29] E.g. San Pedro de Cajas Quechua [alqu] "dog" alongside [alquː] "my dog."
[30] E.g. Sanskrit [bʱaːrata] "descendant of [bʱarata]."
[31] E.g. Sanskrit [a-duː-duʂ-am] "I spoiled" and [a-riː-riʂ-am] "I harmed."
[32] E.g. Hausa pluralization with [-aːjeː] only if the stem contains a long vowel or geminate consonant (Davis 2011:124).
[33] E.g. Classical Arabic [kataba] "he wrote," [kaːtaba] "he corresponded with," and [kitaːb] "book."

influenced by vowel height, which is a kind of durational sensitivity, since height usually correlates with duration, such that higher = shorter = lighter[34] (e.g. Kenstowicz 1997; de Lacy 2004; Crowhurst & Michael 2005; Gordon 2006). Nowadays, however, some analysts (Shih 2016; Rasin 2018; Shih & de Lacy 2019; Faust & Ulfsbjorninn 2025) reject height-driven (or, more generally, feature-driven) stress on the grounds that claimed cases are either misdescribed (e.g. Shih 2018; Bowers 2019 on Gujarati) or misanalyzed (e.g. Rasin 2018:44–7 on Kobon). However, not every case has fallen (cf. Kiriwina, Mordwin; de Lacy 2004),[35] on top of which experimental evidence supports stress-height interactions (Carpenter 2010).[36] At any rate, even if one grants that stress location can be determined by vowel height, direct reference to duration is unnecessary; constraints can invoke sonority classes (e.g. *STRESS/$[+high]$).

Moraic inconsistency rears its head for stress too. Indeed, it can arise even *within* a stress system. Some languages treat long vowels (but not codas) as heavy for primary stress, while both long vowels and codas are heavy for secondary stress. Ryan (2020) analyzes such cases using MAIN→VV, which favors primary stress on long vowels (cf. also Hayes' 1995:299–305 proposal for layered moras).

Prosodic end-weight. Many languages, including English, favor locating phonologically heavier constituents at the ends of phrases. For example, in coordination *X and Y*, speakers prefer $Y \geq X$, modulo other factors (e.g. frequency, semantics, syntactic complexity). Numerous studies representing several languages have shown that end-weight is affected by vowel duration, not just categorical length (Ryan 2019b:169–71). For example, experiments by Oakeshott-Taylor (1984:228) reveal ɝ $>$ æ $>$ ɛ $>$ ɪ for South African English, consistent with duration. Ryan (2019a) argues that prosodic end-weight is a type of stress-weight mapping, except involving phrasal stress.

Meter. Ryan (2011, 2019b:148–50) shows that quantitative meters are sensitive not just to moraic weight, but to sonority and non-moraic elements (e.g. onset size). The evidence for sonority focuses on consonants (e.g. $\mathrm{V}_\mu \mathrm{N}_\mu > \mathrm{V}_\mu \mathrm{T}_\mu$), but one effect of vowel duration comes up: In the Latin epic meter, the short low vowel is heavier than other short vowels (2019b:152).

Textsetting. Ryan (2022) demonstrates that textsetting (the arrangement of syllables to music) invokes not just categorical length, but canonical duration: Increasingly long vowels are increasingly favored on quarter as opposed to eighth notes in anglophone pop music.

Allomorphy. Syllable weight can determine which form of an affix is used. For example, the Finnish genitive plural is usually *-den*/*-ten* after a heavy, but *-(j)en* after a light. In longer words, which are less strict, an ultima with a low vowel is more likely to pattern as heavy than one with a high vowel (Anttila 1997:5f).

8 Conclusion

Roughly one in four languages has *contrastively* long monophthongs, though at least one in three has bimoraic monophthongs more generally. For most languages with length, all monophthongs may be long. Insofar as exceptions occur, they tend to be marked categories such as nasalized, mid, reduced/lax, or front rounded vowels. Vowels may exhibit three degrees of phonological length: short (monomoraic), long (bimoraic), and overlong (trimoraic); additionally, reduced vowels are sometimes analyzed as non-moraic. Vowel length is autosegmental, not featural: Despite being single segments, long vowels are prosodically binary. At the same time, long vowels cannot in general be analyzed as sequences of identical vowels (e.g. [aː] as [aa]). For one thing, long vowels and identical sequences coexist within some languages. While sequences such as [aa] are undoubtedly possible across syllables, they rarely if ever occur within syllables.

Moras serve not only to encode phonological length, but also as terminal nodes of prosodic structure and as units of weight. This chapter does not engage with alternatives to the mora such as strict CV phonol-

[34] While higher vowels are usually shorter, de Lacy (2007:294) finds that this is not always the case.

[35] Additionally, some of the strongest candidates for sonority-driven stress involve consonant sonority, as in Huehuetla Tepehua (Kung 2007) and Pisaflores Tepehua (MacKay & Trechsel 2013; Ryan 2025).

[36] See also Shelton & Grant (2018) for experimental support of intermediately heavy diphthongs in Spanish.

ogy (e.g. Lowenstamm 1996; Scheer 2004; Faust & Ulfsbjorninn 2025), given both space constraints and the chapter's focus on vowels: Debates between moraic and strict CV phonology involve consonant-vowel interactions. For the same two reasons, I do not mount a general defense of moras here.[37] For overviews of the arguments that led to the widespread adoption of moras in generative phonology starting in the 1980s, see Broselow (1995), Davis (2011), and Odden (2011). Additionally, Hayes (1989) is the *locus classicus* for the most widely used version of moraic theory, and includes comparisons with other approaches.

This chapter takes the view that moras (and, for that matter, CV slots) are insufficient to account for all aspects of weight (§7). One solution is to allow weight-mapping constraints to refer both to moras and to sonority (Gordon 2002; Ryan 2019b; Paramore 2025). These proposals also address moraic inconsistency by restricting constraints to particular phenomena (e.g. $\text{STRESS}{\rightarrow}[\mu_V\mu_V]_\sigma$). Another solution is the DIRECT-INTERFACE approach, whereby constraints refer directly to duration or energy (Zhang 2004, Ryan 2014:330f). Ryan (2019b:234–7, 243–5) presents several challenges for a purely durational model of stress placement (e.g. $t{\rightarrow}\text{STRESS}$, where t is canonical duration). For example, it overgenerates criteria, overgenerates systems in which weight is relative[38] rather than categorial, fails to implement suboptimal (but learnable) rules, and requires a theory of normalization. Moreover, even in systems in which weight and duration are tightly correlated (e.g. textsetting), there is still partial polarization around categories, such that a hybrid duration + mora model outperforms one with duration alone (Ryan 2011:440–3, 2022:574–7).

References

Abessolo Eto, Roger. 1990. *Esquisse phonologique du bongo*: Université de Yaoundé MA thesis.

Anttila, Arto. 1997. Deriving variation from grammar. In Frans Hinskens, Roeland van Hout & Leo Wetzels (eds.), *Variation, change and phonological theory*, 35–68. Amsterdam: John Benjamins. https://doi.org/10.1075/cilt.146.04ant.

Baković, Eric J. 1996. Foot harmony and quantitative adjustments. MS., Rutgers Optimality Archive.

Balasubramanian, T. 1981. Duration of vowels in Tamil. *Journal of Phonetics* 9. 151–161. https://doi.org/10.1016/s0095-4470(19)30941-6.

Becker, Michael, Seoyoung Kim & Filomena Sandalo. 2021. A prosódia do verbo kadiwéu. MS, University of Massachusetts, Amherst.

Becker, Michael, Seoyoung Kim & Filomena Sandalo. 2023. The prosody of Kadiwéu verbs. MS, University of Massachusetts, Amherst.

Beltzung, Jean-Marc. 2008. *Compensatory lengthening in phonological representations: Nature, constraints and typology*: University of Paris-3 (Sorbonne-Nouvelle) dissertation.

Borgeson, Scott. 2022. *Long-distance compensatory lengthening*: Stanford University dissertation.

Bowers, Dustin. 2019. Positional vs. sonority-driven stress in Gujarati: new experimental evidence. *Phonological Data and Analysis* 1(1). 1–28. https://doi.org/10.3765/pda.v1art1.19.

Broselow, Ellen. 1995. Skeletal positions and moras. In John A. Goldsmith (ed.), *Handbook of phonological theory*, 175–205. Oxford: Blackwell.

Broselow, Ellen, Su-I Chen & Marie Huffman. 1997. Syllable weight: convergence of phonology and phonetics. *Phonology* 14. 47–82. https://doi.org/10.1017/s095267579700331x.

Buckley, Eugene. 1998. Iambic lengthening and final vowels. *International Journal of American Linguistics* 64(3). 179–223. https://doi.org/10.1086/466357.

Carlson, Robert. 1994. *A grammar of Supyire*. Berlin: Mouton de Gruyter. https://doi.org/10.1515/9783110883053.7.

[37] Just the same, key arguments are implicit in many cases above. For example, the mora preservation theory of compensatory lengthening (§6) is a classic argument for moras over other approaches (Hayes 1989).

[38] That is, stress shifts iff the difference between two syllables exceeds some threshold, regardless of the independent weights of the two syllables.

Carpenter, Angela C. 2010. A naturalness bias in learning stress. *Phonology* 27. 345–392. https://doi.org/10.1017/s0952675710000199.

Chomsky, Noam & Morris Halle. 1968. *The sound pattern of English*. Cambridge, Massachusetts: Massachusetts Institute of Technology Press.

Clements, G. N. & Samuel Jay Keyser. 1983. *CV phonology: A generative theory of the syllable*. Cambridge, MA: MIT Press.

Crowhurst, Megan J. 2020. The iambic/trochaic law: Nature or nurture? *Language and Linguistics Compass* 14. 1–16. https://doi.org/10.1111/lnc3.12360.

Crowhurst, Megan J. & Lev D. Michael. 2005. Iterative footing and prominence-driven stress in Nanti (Kampa). *Language* 81(1). 47–95. https://doi.org/10.1353/lan.2005.0013.

Davis, Stuart. 2011. Quantity. In John Goldsmith, Jason Riggle & Alan C. L. Yu (eds.), *The handbook of phonological theory, 2nd edition*, 103–140. New York: Blackwell Publishing. https://doi.org/doi.org/10.1002/9781444343069.ch4.

Dixon, Robert M. W. 1988. *A grammar of Boumaa Fijian*. Chicago: University of Chicago Press. https://doi.org/10.2307/414909.

Donohue, Mark, Rebecca Hetherington, James McElvenny & Virginia Dawson. 2019. World phonotactics database. Online resource (phonotactics.anu.edu.au), Australian National University.

Ehala, Martin. 2003. Estonian quantity: Implications for moraic theory. In Diane Nelson & Satu Manninen (eds.), *Generative approaches to Finnic and Saami linguistics*, 51–80. Stanford: CSLI Publications.

Faust, Noam & Shanti Ulfsbjorninn. 2024. A footless stroll through Italian stress. *The Linguistic Review* 41(4). 741–763. https://doi.org/10.1515/tlr-2024-2021.

Faust, Noam & Shanti Ulfsbjorninn. 2025. The typology of weight in strict CV metrics: A challenge to moraic theory. *Linguistic Inquiry* 56. 1–60. https://doi.org/10.1162/ling.a.58.

Gess, Randall. 2011. Compensatory lengthening. In Marc van Oostendorp, Colin J. Ewen, Elizabeth Hume & Keren Rice (eds.), *The Blackwell companion to phonology*, 1–24. New York: John Wiley & Sons, Ltd. https://doi.org/10.1002/9781444335262.wbctp0064.

Gordon, Matthew. 1999. *Syllable weight: phonetics, phonology, and typology*: University of California, Los Angeles dissertation.

Gordon, Matthew. 2002. A phonetically-driven account of syllable weight. *Language* 78. 51–80. https://doi.org/10.1353/lan.2002.0020.

Gordon, Matthew. 2006. *Syllable weight: phonetics, phonology, typology*. New York, NY: Routledge Press. https://doi.org/10.4324/9780203944028.

Hamann, Silke & Nancy C. Kula. 2022. Phonetic and phonological considerations on the moraic status of pre-NC vowels in Bemba. *Stellenbosch Papers in Linguistics* 62. 57–74. https://doi.org/10.5774/62-0-899.

Hayes, Bruce. 1986. Inalterability in CV phonology. *Language* 62. 321–351. https://doi.org/10.2307/414676.

Hayes, Bruce. 1989. Compensatory lengthening in moraic phonology. *Linguistic Inquiry* 20. 253–306.

Hayes, Bruce. 1990. Diphthongisation and coindexing. *Phonology* 7. 31–71. https://doi.org/10.1017/s0952675700001111.

Hayes, Bruce. 1995. *Metrical stress theory: Principles and case studies*. Chicago, IL: University of Chicago Press.

Hubbard, Kathleen. 1995. Prenasalised consonants and syllable timing: Evidence from Runyambo and Luganda. *Phonology* 12. 235–256. https://doi.org/10.1017/s0952675700002487.

Hyde, Brett. 2007. Non-finality and weight-sensitivity. *Phonology* 24. 287–334. https://doi.org/10.1017/s0952675707001212.

Hyde, Brett. 2011. The Iambic-Trochaic Law. In M. van Oostendorp, C. Ewen, E. Hume & K. Rice (eds.), *The blackwell companion to phonology*, 1052–1077. Wiley-Blackwell Publishers. https://doi.org/10.1002/9781444335262.wbctp0044.

Hyman, Larry M. 1982. The representation of length in Gokana. *Proceedings of the West Coast Conference on Formal Linguistics* 1. 198–206.

Hyman, Larry M. 1985. *A theory of phonological weight*. Dordrecht: Foris. https://doi.org/10.1515/9783110854794.

Hyman, Larry M. 2009. Penultimate lengthening in Bantu: Analysis and spread. *UC Berkeley Phonology Lab Annual Report* 5. 195–209. https://doi.org/10.5070/p73q00m84d.

Hyman, Larry M. & Imelda Udoh. 2007. Length harmony in Leggbó: A counter-universal? In Peter K. Austin & Andrew Simpson (eds.), *Endangered languages*, 73–92. Hamburg: Helmut Buske.

Jacoby, Nori, Rainer Polak, Jessica A. Grahn & et al. 2024. Commonality and variation in mental representations of music revealed by a cross-cultural comparison of rhythm priors in 15 countries. *Nature Human Behaviour* 8. 846–877. https://doi.org/10.1038/s41562-023-01800-9.

Jakobson, Roman. 1937. über die Beschaffenheit der prosodischen Gegensätze. In *Selected writings I*, 254–261. The Hague: Mouton.

Jasanoff, Jay H. 2004. Plus ça change...: Lachmann's Law in Latin. In J. H. W. Penney (ed.), *Indo-European perspectives: Studies in honour of Anna Morpurgo Davies*, 405–416. Oxford University Press.

Kager, René. 1993. Alternatives to the iambic-trochaic law. *Natural Language and Linguistic Theory* 11(3). 381–432. https://doi.org/10.1007/bf00993165.

Kager, René. 1999. *Optimality Theory*. Cambridge, U.K.: Cambridge University Press. https://doi.org/10.1017/cbo9780511812408.

Kavitskaya, Darya. 2002. *Compensatory lengthening: Phonetics, phonology, diachrony*. London: Routledge. https://doi.org/10.4324/9781315024141.

Kawahara, Shigeto. 2016. Japanese has syllables: A reply to Labrune. *Phonology* 33(1). 169–194. https://doi.org/10.1017/S0952675716000063.

Kenstowicz, Michael. 1970. On the notation of vowel length in Lithuanian. *Papers in Linguistics* 3. 73–113. https://doi.org/10.1080/08351817009389141.

Kenstowicz, Michael. 1997. Quality-sensitive stress. *Rivista di Linguistica* 9. 157–187. https://doi.org/10.1002/9780470756171.ch9.

Kiparsky, Paul. 2011. Compensatory lengthening. In Charles Cairns & Eric Raimy (eds.), *Handbook of the syllable*, 33–70. Leiden: Brill. https://doi.org/10.1163/ej.9789004187405.i-464.10.

Kisseberth, Charles. 1994. On domains. In Jennifer Cole & Charles Kisseberth (eds.), *Perspectives in phonology*, Stanford: CSLI Publications.

Köhnlein, Björn & Ian S. Cameron. 2024. What word-prosodic typology is missing: Motivating foot structure as an analytical tool for syllable-internal prosodic oppositions. *Natural Language and Linguistic Theory* 42. 1043–1079. https://doi.org/10.1007/s11049-023-09602-4.

Krishnamurti, Bhadriraju. 2003. *The Dravidian languages*. Cambridge, U.K.: Cambridge University Press. https://doi.org/10.1017/cbo9780511486876.

Kümmel, Martin. 2013. Zur Endung des Genitivs Plural im Indoiranischen. *Indogermanische Forschungen* 118. 192–212. https://doi.org/10.1515/indo.2013.118.2013.193.

Kung, Susan Smythe. 2007. *A descriptive grammar of Huehuetla Tepehua*: University of Texas, Austin dissertation.

de Lacy, Paul. 2004. Markedness conflation in Optimality Theory. *Phonology* 21(2). 145–199. https://doi.org/10.1017/s0952675704000193.

de Lacy, Paul. 2007. The interaction of tone, sonority, and prosodic structure. In Paul de Lacy (ed.), *The Cambridge handbook of phonology*, 281–307. Cambridge University Press. https://doi.org/10.1017/cbo9780511486371.013.

Lahiri, Aditi & Paula Fikkert. 1999. Trisyllabic shortening in English: Past and present. *English Language and Linguistics* 3(2). 229–267. https://doi.org/10.1017/s1360674399000234.

Lampitelli, Nicola, Paola Roseano & Francesc Torres-Tamarit. 2021. Vowel length in Friulian verbs: A case of mora affixation. *Morphology* 32. 93–120. https://doi.org//doi.org/10.1007/s11525-021-09388-4.

Lehiste, Ilse. 1970. *Suprasegmentals*. Cambridge, MA: MIT Press. https://doi.org/10.2307/412897.

Levin, Juliette. 1985. *A metrical theory of syllabicity*: Massachusetts Institute of Technology dissertation.

Lowenstamm, Jean. 1996. CV as the only syllable type. In Jacques Durand & Bernard Laks (eds.), *Current trends in phonology: Models and methods*, vol. 2, 419–441. Salford: ESRI.

Lunden, Anya, Jessica Campbell, Mark Hutchens & Nick Kalivoda. 2017. Vowel-length contrasts and phonetic cues to stress: An investigation of their relation. *Phonology* 34. 565–580. https://doi.org/10.1017/S0952675717000288.

MacKay, Carolyn J. & Frank R. Trechsel. 2013. A sketch of Pisaflores Tepehua phonology. *International Journal of American Linguistics* 79(2). 189–218. https://doi.org/10.1086/669628.

Maddieson, Ian. 1984. *Patterns of sounds*. Cambridge: Cambridge University Press. https://doi.org/10.2307/415176.

Maddieson, Ian. 1993. Splitting the mora. *UCLA Working Papers in Phonetics* 83. 9–18.

Maddieson, Ian & Victoria Anderson. 1994. Phonetic structures of Iaai. *UCLA Working Papers in Phonetics* 87. 163–182.

Maddieson, Ian, Sébastien Flavier, Egidio Marsico, Christophe Coupé & François Pellegrino. 2013. LAPSyD: Lyon-Albuquerque phonological systems database. *Interspeech* 3022–3026.

Marlo, Michael R., Leonard Chacha Mwita & Mary Paster. 2015. Problems in Kuria H tone assignment. *Natural Language and Linguistic Theory* 33. 251–265. https://doi.org/10.1007/s11049-014-9251-y.

Martínez-Paricio, Violeta & René Kager. 2015. The binary-to-ternary rhythmic continuum in stress typology: Layered feet and non-intervention constraints. *Phonology* 32. 459–504. https://doi.org/10.1017/S0952675715000287.

McCarthy, John. 1986. OCP effects: Gemination and antigemination. *Linguistic Inquiry* 17(2). 207–263.

McCarthy, John J. 1999. Sympathy and phonological opacity. *Phonology* 16(3). 331–399. https://doi.org/10.1017/s0952675799003784.

McCarthy, John J. & Alan Prince. 1986/1996. Prosodic morphology 1986. *Linguistics Department Faculty Publication Series* 13. 1–99.

McGregor, William B. 1990. *A functional grammar of Gooniyandi*. Amsterdam: John Benjamins. https://doi.org/10.1075/slcs.22.

McIntosh, Mary Hollis. 1982. *Aspects of Fulfulde syntax and morphology*: University of London, School of Oriental and African Studies dissertation.

Meira, Sergio. 1998. Rhythmic stress in Tiriyó (Cariban). *International Journal of American Linguistics* 64. 352–378. https://doi.org/10.1086/466366.

Mellander, Evan W. 2003. *A prosodic theory of prominence and rhythm*: McGill University dissertation.

Mester, Armin. 1994. The quantitative trochee in Latin. *Natural Language and Linguistic Theory* 12. 1–61. https://doi.org/10.1007/bf00992745.

Milenković, Aljoša. 2023. Closed syllable lengthening: A cross-linguistic survey of an unnatural prosodic process. Slides, Harvard University, March 24.

Moran, Steven & Daniel McCloy. 2019. *PHOIBLE 2.0*. Jena: Max Planck Institute for the Science of Human History. `https://phoible.org/`.

Morén, Bruce T. 2001. *Distinctiveness, coercion and sonority: A unified theory of weight*. London: Routledge. https://doi.org/10.4324/9781315023779.

Mwita, Leonard Chacha. 2008. *Verbal tone in Kuria*: University of California, Los Angeles dissertation.

Nash, David George. 1980. *Topics in Warlpiri grammar*: Massachusetts Institute of Technology dissertation.

Ni, Tianyi, Maike Rocker & Björn Köhnlein. 2025. A metrical analysis of ternary vowel quantity in East Frisian Low German. *Proceedings of the Annual Meeting on Phonology 2023/2024* 1–11. https://doi.org/10.7275/amphonology.3047.

Nikolaev, Alexander. 2012. Homeric aáatos: Etymology and poetics. *Die Sprache* 50(2). 182–239. https://doi.org/10.13173/SPR.50.2.182.

Oakeshott-Taylor, John. 1984. Phonetic factors in word order. *Phonetica* 41. 226–237. https://doi.org/10.1159/000261729.

Odden, David. 2006. Minimality and onsetless syllables in Zinza. *Phonology* 23(3). 431–441. https://doi.org/10.1017/S095267570600100X.

Odden, David. 2011. The representation of vowel length. In Marc van Oostendorp, Colin J. Ewen, Elizabeth Hume & Keren Rice (eds.), *The Blackwell companion to phonology*, 1–26. New York: John Wiley & Sons, Ltd. https://doi.org/10.1002/9781444335262.wbctp0020.

Orwin, Martin. 1994. *Aspects of Somali phonology*: University of London dissertation.

Paramore, Jonathan Charles. 2025. Codas are universally moraic. *Phonology* 42(e1). 1–36. https://doi.org/10.1017/s0952675724000204.

Paschen, Ludger, Susanne Fuchs & Frank Seifart. 2022. Final lengthening and vowel length in 25 languages. *Journal of Phonetics* 94. 1–22. https://doi.org/10.1016/j.wocn.2022.101179.

Prillop, Külli. 2013. Feet, syllables, moras and the Estonian quantity system. *Linguistica Uralica* 49(1). 1–29. https://doi.org/10.3176/lu.2013.1.01.

Prince, Alan. 1980. A metrical theory of Estonian quantity. *Linguistic Inquiry* 11(511–562).

Prokosch, Eduard. 1939. *A comparative Germanic grammar*. Baltimore: Linguistic Society of America. https://doi.org/10.2307/408825.

Pyle, Charles. 1970. West Greenlandic Eskimo and the representation of vowel length. *Research on Language & Social Interaction* 3(1). 115–146. https://doi.org/10.1080/08351817009389142.

Rasin, Ezer. 2018. *Modular interactions in phonology*: Massachusetts Institute of Technology dissertation.

Remijsen, Bert, Otto Gwado Ayoker & Signe Jørgensen. 2019. Ternary length in Shilluk. *Phonology* 36(1). 91–125. https://doi.org/10.1017/S0952675719000058.

Riehl, Anastasia. 2008. *The phonology and phonetics of nasal-obstruent sequences*: Cornell University dissertation.

Roberts-Kohno, Rosalind Ruth. 2000. *Kikamba phonology and morphology*: The Ohio State University dissertation.

Rolle, Nicholas & Florian Lionnet. 2019. Phantom structure: A representational account of floating tone association. *Proceeding of the Annual Meeting on Phonology* 1–10. https://doi.org/10.3765/amp.v8i0.4744.

Ryan, Kevin M. 2011. Gradient syllable weight and weight universals in quantitative metrics. *Phonology* 28(3). 413–454. https://doi.org/10.1017/s0952675711000212.

Ryan, Kevin M. 2014. Onsets contribute to syllable weight: Statistical evidence from stress and meter. *Language* 90(2). 309–341. https://doi.org/10.1353/lan.2014.0029.

Ryan, Kevin M. 2019a. Prosodic end-weight reflects phrasal stress. *Natural Language and Linguistic Theory* 37(1). 315–356. https://doi.org/10.1007/s11049-018-9411-6.

Ryan, Kevin M. 2019b. *Prosodic weight: Categories and continua*. Oxford: Oxford University Press. https://doi.org/10.1093/oso/9780198817949.001.0001.

Ryan, Kevin M. 2020. VV > VC > V for stress: Coercion vs. prominence. *Linguistic Inquiry* 51(1). 124–140. https://doi.org/10.1162/ling_a_00325.

Ryan, Kevin M. 2021. The development of diphthongs in Vedic Sanskrit. *Journal of the American Oriental Society* 141(2). 289–297. https://doi.org/10.7817/jameroriesoci.141.2.0289.

Ryan, Kevin M. 2022. Syllable weight and natural duration in textsetting popular music in English. *English Language and Linguistics* 26(3). 559–582. https://doi.org/10.1017/s1360674322000156.

Ryan, Kevin M. 2025. Sonority-driven stress in Tephua languages. MS, Harvard University, submitted.

Sammallahti, Pekka. 1998. *The Saami languages: An introduction*. Kárášjohka: Davvi Girji.

Sapir, Edward. 1930. Southern Paiute, a Shoshonean language. *Proceedings of the American Academy of the Arts and Sciences* 65(1). 1–296. https://doi.org/10.2307/20026309.

Sayeed, Ollie. 2017. Osthoff's law in Latin. *Indo-European Linguistics* 5. 147–177. https://doi.org/10.1163/22125892-00501005.

Scheer, Tobias. 2004. *A lateral theory of phonology: What is CVCV, and why should it be?* Berlin: Mouton de Gruyter. https://doi.org/10.1515/9783110908336.

Schütz, Albert J. 1985. *The Fijian language*. Honolulu: University of Hawai'i Press. https://doi.org/10.2307/jj.13568111.

Selkirk, Elisabeth. 2011. The syntax-phonology interface. In John Goldsmith, Jason Riggle & Alan C. L. Yu (eds.), *The handbook of phonological theory, 2nd edition*, 435–484. Oxford: Blackwell Publishing. https://doi.org/10.1002/9781444343069.ch14.

Shelton, Michael & Hannah Grant. 2018. Syllable weight in monolingual and heritage spanish. *Studies in Hispanic and Lusophone Linguistics* 11(2). 395–427. https://doi.org/10.1515/shll-2018-0015.

Shih, Shu-Hao. 2016. Sonority-driven stress does not exist. In Gunnar Ólafur Hansson, Ashley W. Farris-Trimble, Kevin McMullin & Douglas Pulleyblank (eds.), *Supplemental proceedings of the 2015 Annual Meeting on Phonology*, Washington, D.C.: Linguistic Society of America. https://doi.org/10.3765/amp.v3i0.3666.

Shih, Shu-Hao. 2018. On the existence of sonority-driven stress in Gujarati. *Phonology* 35. 327–364. https://doi.org/10.1017/s0952675718000064.

Shih, Shu-Hao & Paul de Lacy. 2019. Evidence for sonority-driven stress. *Catalan Journal of Linguistics* 18. 9–40. https://doi.org/10.5565/rev/catjl.256.

Teferra, Anbessa. 1991. A sketch of Shabo grammar. In M. Lionel Bender (ed.), *Proceedings of the Fourth Nilo-Saharan Linguistics Colloquium*, 371–387. Hamburg: Helmut Buske.

Topintzi, Nina & Eva Zimmermann. 2025. Reconciling "heavy" and "long": The typology of lexical geminates. *Linguistic Inquiry* 56(2). 311–351. https://doi.org/10.1162/ling_a_00499.

Trubetzkoy, Nikolai S. 1939. *Grundzüge der Phonologie*. Prague: Travaux du Cercle Linguistique de Prague. https://doi.org/10.1515/9783110226300.4.388.

Turk, Alice E. & Stefanie Shattuck-Hufnagel. 2007. Multiple targets of phrase-final lengthening in American English words. *Journal of Phonetics* 35(4). 445–472. https://doi.org/10.1016/j.wocn.2006.12.001.

van de Velde, Mark L. O. 2008. *A grammar of Eton*. Berlin: Mouton de Gruyter. https://doi.org/10.1515/9783110207859.

Weiss, Michael. 2009. *Outline of the historical and comparative grammar of Latin*. Beech Stave Press.

Whitney, William Dwight. 1889. *Sanskrit grammar*. Cambridge, MA: Harvard University Press.

Zec, Draga. 1995. Sonority constraints on syllable structure. *Phonology* 12(1). 85–129. https://doi.org/10.1017/s0952675700002396.

Zec, Draga. 2002. The role of prosody in morphologically governed phonotactic regularities. *Working Papers of the Cornell Phonetics Laboratory* 14. 250–277.

Zhang, Jie. 2004. Contour tone licensing and contour tone representation. *Language and Linguistics* 5(4). 925–68.

Zuraw, Kie. 2018. Beyond trochaic shortening: A survey of Central Pacific languages. *Language* 94(1). e1–e42. https://doi.org/10.1353/lan.2018.0011.