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57. Quantity-sensitivity

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1 Introduction

Quantity-sensitivity is an important property of prosodic constituents, which are subclassified along this dimension as either light or heavy. In a typical hierarchical organization of prosodic units, as in (1) (**Selkirk 1978, 1980**; **Nespor and Vogel 1986**), each of the prosodic levels may be instantiated by constituents that vary in length, segment quality, or structural complexity (see CHAPTER 33: SYLLABLE-INTERNAL STRUCTURE; CHAPTER 40: THE FOOT; CHAPTER 51: THE PHONOLOGICAL WORD; CHAPTER 84: CLITICS; CHAPTER 50: TONAL ALIGNMENT).

(1) *Prosodic hierarchy*

Prosodic phrase
Prosodic word
Foot
Syllable

This variation, in at least some of its aspects, introduces distinctions in quantity among constituents at the same level of the hierarchy, evidenced by distinctions in phonological behavior. While quantity-sensitivity is most clearly manifested at the level of the syllable, other prosodic levels exhibit this property as well. Quantity-sensitivity characterizes a wide range of phonological phenomena, including stress, tone, poetic meter, and various prosodic effects on morphosyntax. Moreover,

quantity-sensitivity can be manifested either as a binary or as a scalar property. For these and other reasons to be addressed in this chapter, prosodic quantity needs to have its place in the formal representation of prosody, and is a central issue in any discussion of phonological representations.

The chapter is organized as follows: §2 addresses crucial aspects of weight-sensitivity in the syllable, providing a typology of weight patterns supported by a wide range of attested cases. §3 focuses on formal representations of the syllable and its weight, while §4 addresses the relevance of vowel length for quantity-sensitivity. §5 shows that weight distinctions could be binary in some languages, and multivalued in others. §6 documents inconsistencies in weight patterns, both with respect to phonological processes and phonological contexts. §7 addresses quantity-sensitivity in feet, focusing on binary patterns, and §8 focuses on scalar patterns of quantity. §9 touches upon quantity-sensitivity at the higher levels of the prosodic hierarchy, in prosodic words and prosodic phrases. §10 offers some remarks on markedness, and §11 concludes.

2 The syllable and quantity-sensitivity

Phonological quantity is primarily associated with the syllable. One of the traditional classifications of syllables is into those that are light and those that are heavy. This distinction is motivated on empirical grounds and is brought to relief by a number of quantity-sensitive phonological phenomena, including stress, tone, and poetic meter. We focus here only on those languages that do exhibit quantity-sensitivity at the syllable level, as this is not a universal prosodic property. In §2.1 we present a paradigm case of syllable weight, and then, in §2.2, turn to the typology of syllable-based quantity-sensitivity, supported by a wide range of phonological phenomena.

2.1 A paradigm case of quantity-sensitivity

Quantity-sensitivity has figured prominently in studies of classical languages and their prosody (**Allen 1973**). Latin provides a paradigm case of quantity-sensitivity, already known to the early grammarians such as Quintilian.

Latin stress (CHAPTER 39: STRESS: PHONOTACTIC AND PHONETIC EVIDENCE) is quantity-sensitive, as illustrated in (2). If the penultimate syllable is heavy it is stressed, as in (2a), but if it is light the antepenultimate syllable is stressed, as in (2b).

(2) *Latin stress*

a. If the penultimate syllable is heavy, it is stressed.
for'tūna 'fortune (NOM SG)'
'gaudēns 'rejoicing (NOM SG)'
gau'dentem 'rejoicing (ACC SG)'

b. If the penultimate syllable is light, the antepenultimate is stressed.
'anima 'soul (NOM SG)'

Syllables that function as light are of the CV type, containing a short vowel, as the penultimate syllable in (2b). Syllables that function as heavy are more diverse, as shown in (2a). They are either of the CVV type, containing a long vowel or a diphthong, or of the CVC type, with a short vowel followed by a consonant. Significantly, syllables that are functionally equivalent may differ in their segmental content (CHAPTER 54: THE SKELETON). Within the set of heavy syllables, differences in segmental content are found not only across CVV and CVC syllables but also within the class of CVV syllables, which may contain either a long vowel or a diphthong. In this case, as in many others, onset consonants are excluded from the computation of weight (CHAPTER 55: ONSETS).

This same pattern of syllable weight also figures in Latin poetic meter. In one of the meters of Horace's *Odes*, known as the *First Asclepiad* (borrowed from Greek), a line of verse contains a sequence of metrical positions that admit either heavy or light syllables (marked as – and ∪, respectively, with ‖ marking the caesura), as in (3). In (3a), the first three metrical positions, all heavy, are filled with CVV syllables that contain either a diphthong or a long vowel, while in (3b) these same metrical positions are filled with CVC syllables. The light metrical positions, such as the next two, are filled in both lines with CV syllables. (The remaining metrical positions are filled in the same fashion, with the exception of the last vowel of *tollere* in (3b) which is elided, and therefore not scanned.)

(3) *Latin poetic meter: Horace,* First Asclepiad

a. – – – ∪∪ – ‖ – ∪∪ – ∪ x
Maecēnās atavīs ēdite rēgibus
'O Maecenas, born from kingly ancestors!' (*Odes* 1.1.1)

b. – – – ∪ ∪ – ‖ – ∪ ∪ – ∪ x
Certat tergeminīs tollere honoribus
'vies to lift [him] with triple magistracies.' (*Odes* 1.1.8)

Thus, in Latin, both stress and poetic meter are sensitive to distinctions in quantity, with weight characterized identically in the two phonological subsystems.

2.2 Patterns of quantity-sensitivity

The system of quantity in Latin exemplified in (2) and (3) was taken in much relevant work to be the standard mode of computing quantity, with broad empirical support. This is how syllable weight was characterized in **Kuryłowicz (1948)** and later in **Newman (1972)**, among others. **Newman (1972)**, in particular, identifies quantity-sensitivity in a number of languages, all exemplifying the pattern of quantity with light CV and heavy CVV and CVC syllables. In addition to Latin, the list includes Classical Greek, Finnish, Estonian, Classical Arabic, and Gothic, as well as three Chadic languages, Bolanci, Kanakuru, and Hausa. In fact, a number of researchers stated important generalizations about quantity-sensitivity solely in terms of the Latin pattern of weight (e.g. **Kiparsky 1979, 1981**; **Halle and Vergnaud 1980**; **Clements and Keyser 1983**).

The Latin pattern, however, is not the only empirically attested mode of computing quantity, as shown in **Hyman's (1977)** broad survey of stress systems and in much later work. In what follows we present the range of quantity patterns that have been empirically attested, and a typology of weight distinctions.

2.2.1 Weight patterns: A typology

McCarthy (1979) made the crucial theoretical statement that quantity-sensitivity can be instantiated in more than one way. In addition to the Latin weight pattern, with light CV and heavy CVV and CVC syllables as in (4a), henceforth type 1, there is a further weight pattern, one in which only CVV syllables are heavy and both CV and CVC syllables are light, as in (4b), henceforth type 2. A number of languages were identified to belong to this weight type: for example, Huasteco Mayan in **Hyman (1977)** and Yidin^{y} and Tiberian Hebrew in **McCarthy (1979)**. Many more such cases figure in **Hayes (1980, 1995)** and **Gordon (2006)**.

(4) *Possible weight patterns* (first approximation)
  a. Type 1: heavy CVV, CVC *vs.* light CV
  b. Type 2: heavy CVV *vs.* light CV, CVC

Thus the weight of CVC syllable is "parameterized": while in (4a) such syllables form a natural class with CVV, in (4b) they form a natural class with CV. This is crucially due to the status of the final consonant in a CVC syllable, which contributes to weight in (4a), but not in (4b) types of languages. **McCarthy (1979)** further identifies an important implicational relation: a language with heavy CVC syllables also has heavy CVV syllables. This supports the prediction about the following impossible weight pattern: no language can have heavy CVC but light CVV syllables.

But computation of quantity can be even more fine-grained than in (4), and in order to show this we invoke the sonority of segments. In particular, vowels are more sonorous than consonants, and within the class of consonants, sonorants (CHAPTER 8: SONORANTS) are more sonorous than obstruents. (For a general discussion of sonority, see CHAPTER 49: SONORITY.) In addition to the two weight systems in (4), one in which all consonants contribute to weight, and one in which no consonants contribute to weight, there is also a type 3 system, in which only some consonants contribute to weight (see **Prince 1983**; **Zec 1988, 1995**). In such split systems, the subset of consonants contributing to weight is generally sonorants. Such a case is exemplified by Kwakw'ala, to be discussed in §2.2.2, in which heavy syllables are CVV and CVR (sonorant), while light syllables are CV and CVO (obstruent). This yields the implicational relation that if CVO syllables are heavy, so are CVR syllables; and excludes the impossible system, with CVV and CVO syllables being heavy, and CV and CVR syllables being light (**Zec 1995**). Furthermore, while other splits in the hierarchy should in principle be possible, say, with liquids being weight-bearing to the exclusion of obstruents and nasals, such systems have not been attested. Only major splits within the sonority hierarchy appear to be exploited for distinctions in quantity, those in particular that correspond to splits imposed by the major class features (**Chomsky and Halle 1968**).

To summarize, a basic typology of weight patterns is given in (5). In type 1 languages, all segments contribute to weight, so that both CVV and CVC syllables are heavy; in type 2 languages only vowels are weight-bearing, which makes CVC syllables light; and in type 3 languages vowels and sonorant consonants are weight-bearing, to the exclusion of obstruents. The set of weight-bearing segments follows the sonority hierarchy: if a less sonorous segment contributes to weight, so does a more sonorous segment.

(5) *Typology of weight patterns*

	Heavy	*Light*
Type 1	CVV, CVC	CV
Type 2	CVV	CV, CVC
Type 3	CVV, CVR	CV, CVO

A special case of type 2 languages is those that lack CVC syllables. In a syllable inventory including only CV and CVV

syllables, the former are light and the latter are heavy, as in Fijian (**Hayes 1995**; among others). Likewise, a special case of type 3 languages consists of those that lack CVO syllables, with an inventory that includes light CV and heavy CVV and CVR syllables, as in Tiv (**Zec 1995**); or Manam, in which the set of heavy syllables includes CVV and CVN (nasal), but excludes syllables closed with liquids (**Lichtenberk 1983**; **Buckley 1998**).

Crucially, the onset is excluded from the computation of weight: the number of segments in the onset does not affect the weight status of a syllable. This empirically grounded property of onsets will need to be captured in the representation of the syllable, an issue to be addressed in §3. But although broadly attested, this is not a universal property of onsets; see **CHAPTER 55**: ONSETS for cases of weight-sensitive onsets, which constitute counterexamples to this claim.

To conclude, it has been shown that there is a measure of language-specificity, with different modes of quantity computation employed in different languages. It has also been shown that there is an implicational relation across occurring weight patterns, or, more specifically, across the sets of heavy syllables in different languages, as in (6):

(6) *Implicational relations among heavy syllables*

a. If a language has heavy CVC syllables, it also has heavy CVV syllables.

b. If a language has heavy CVO syllables, it also has heavy CVR syllables.

2.2.2 Weight patterns: Case studies

The three patterns of quantity in (5) are documented below with two types of quantity-sensitive phonological phenomena: stress and tone. We begin with stress, which provides the most striking cases of quantity-sensitivity. It should be noted though that only some stress systems are quantity-sensitive. According to **Gordon's (2006**: 20–21) extensive survey, based on 408 languages, 310 languages have culminative accent systems. Out of those, 136 (43.9 percent) exhibit quantity-sensitivity, and 86 belong to one of the three weight systems we exemplify here.

Languages with quantity-sensitive stress show a clear preference for placing stress on heavy syllables (cf. **Hyman 1977**; **Hayes 1980, 1995**; **Halle and Vergnaud 1987**; **Halle and Idsardi 1995**). Simply stated, heavy syllables attract stress (**Prince 1990**). Moreover, languages with quantity-sensitive stress systems are of either type 1 or type 2, and rarely of type 3. The Latin stress pattern illustrated in §2.1, which belongs to type 1, is found in a number of languages. Out of 86 languages with quantity-sensitive stress in Gordon's survey, 42 languages are of type 1. It is found, for example, in Modern Classical Arabic (as described in **Ryding 2005**), where stress falls on the penultimate heavy syllable, CVV or CVC, otherwise on the antepenultimate syllable. Note, however, the pattern in Classical Arabic, where stress falls on the rightmost (non-final) heavy syllable, as in (7a), otherwise on the first syllable, as in (7b) (**McCarthy 1979**, and the references therein).[1]

(7) *Type 1: Classical Arabic*

a.	ki'taabun	'book (NOM SG)'
	manaa'diilu	'kerchiefs (NOM)'
	ju'ʃaariku	'he participates'
	'mamlakatun	'kingdom (NOM SG)'
b.	'kataba	'he wrote'
	'balaħatun	'date (NOM SG)'

The type 1 weight pattern is also noted in English, although the overall stress system is rife with idiosyncrasies. A small portion of the English lexicon, the set of underived nouns, has a relatively regular stress pattern: stress falls on the heavy penult, either CVV as in *e'litist, ma'rina*, and *Ari'zona*, or CVC as in *a'genda, a'malgam*, and *co'nundrum*; otherwise on the antepenult, as in *'discipline, 'labyrinth*, and *A'merica* (**Hayes 1982**). This stress pattern is again reminiscent of Latin. Many more type 1 stress systems are documented in **Hayes (1995)** and **Gordon (2006)**.

Quantity-sensitive stress systems of type 2 are evidenced in a wide range of languages, just like type 1 (**Hayes 1995**;

Gordon 2006; among others): 40 out of 86 quantity-sensitive stress systems in Gordon's survey. It is found, for example, in the Mongolian language Buriat (Poppe 1960; Walker 1996), illustrated in (8): stress falls on the initial syllable in words with no long vowels, as in (8a), and on the rightmost *non-final* heavy syllable in words with more than one long vowel or diphthong, as in (8b). If a word has only one CVV syllable, stress falls on that syllable even if it is final, as in (8c). Note that CVC syllables figure in the language, yet do not attract stress, for example, the third syllable in /ta'ruulagdaxa/, in (8b).

(8) *Type 2: Buriat*

a.	'xada	'mountain'
b.	mo'r̥ooroo	'by means of his own horse'
	dalai'gaaraa	'by one's own sea'
	ta'ruulagdaxa	'to be adapted to'
c.	xa'daar	'through the mountain'

Another type 2 system is Huasteco Mayan (Larsen and Pike 1949; Hyman 1977; Hayes 1995: 296): stress falls on the rightmost CVV syllable, otherwise on the initial CV syllable. Again, CVC syllables pattern with CV rather than CVV syllables. And, in Aguacatec Mayan (McArthur and McArthur 1956; Hayes 1980, 1995), stress falls on a CVV syllable regardless of its position within a word, as in (9a); stress is final in words with no long vowels, as in (9b).[2]

(9) *Type 2: Aguacatec Mayan stress*

a. *Forms with* CVV *syllables*

ʔin'ta:	'my father'
'ʧi:bah	'meat'
'ʔe:q'um	'carrier'

b. *Forms with no* CVV *syllables*

wu'qan	'my foot'
ʔal'k'om	'thief'
tpil'taʔ	'courthouse'

Quantity-sensitive stress systems are very rarely of type 3. In Gordon's (2006) survey, only four out of 86 languages are of type 3. Here we illustrate the distribution of stress in Kwakw'ala, in which CVV and CVR syllables pattern as heavy, while CV and CVO pattern as light (Boas 1947; also Zec 1988 and references therein). Stress falls on the leftmost heavy syllable, either CVV, in (10a), or CVR, in (10b). In words that contain only light syllables, CV or CVO, stress is final, as in (10c) and (d).

(10) *Type 3 language: Kwakw'ala*

a.	'qa:sa	'to walk'
	'n'a:la	'day'
	'ts'e:kwa	'bird'
	t'ə'li:dᶻu	'large board on which fish are cut'
b.	'm'ənsa	'to measure'
	'dəlxa	'damp'
	'dzəmbətəls	'to bury in hole in ground'
	mə'xənxənd	'to strike edge'
c.	nə'pa	'to throw a round thing'
	bə'ha	'to cut'
	m'əkʷə'la	'moon'
	ts'əxə'laə	'to be sick'
d.	ts'ət'xa	'to squirt'
	təɬ'ts'a	'to warm oneself'
	kʷ'əs'xa	'to splash'

The three weight patterns in (5) can be further exemplified with tonal phenomena, those provided by languages with lexical, i.e. contrastive tone, in simpler systems commonly High, or High and Low (CHAPTER 45: THE REPRESENTATION OF TONE). Quantity-sensitive tonal phenomena differ substantially from quantity-sensitive stress.[3] Crucial evidence for quantity-sensitivity comes from the so-called contour tones. If no more than one tone is sponsored by a light syllable and no more than two by a heavy one, we can say that multiple tones, standardly referred to as contour tones, may occur on heavy, but not on light, syllables. In other words, we focus on those languages in which a light syllable has one tone-bearing unit and a heavy

syllable has two (see **Zhang 2002** for different characterizations of contour tones).[4] We further focus on those languages in which the mapping between tones and tone-bearing units is fairly straightforward: a tone-bearing unit may be associated with at most one tone. With this background, we turn to the evidence for the three weight patterns coming from the tonal domain.

We again rely on **Gordon's (2006**: 32–33) survey: out of 408 languages in his survey, 111 use contrastive tone and, of those, 61 use tone in a quantity-sensitive mode. Type 2 and type 3 weight patterns are widely exploited by weight-sensitive tonal phenomena, while type 1 is rarely associated with quantity-sensitive tone. Type 2 pattern is found in 28 languages (four without CVC syllables), and type 3 is found in 30 languages. In type 2 languages, contour tones occur on CVV syllables, but are absent from both CV and CVC syllables. In Navajo, contour tones occur only on CVV syllables as in (11a), while simple tones occur on all syllable types; (11b) exemplifies the absence of contour tones on CV and CVC syllables (**Zhang 2002**, based on **Young and Morgan 1987**).

(11) *Type 2: Navajo contour tone*

a.	sáànìì	'old woman'
	hákòónèè?	'let's go'
	tèíl?á	'they extend'
b.	háá?ált'è?	'exhumation'
	pìk^{h}ìn	'his house'

Another type 2 language is Ju|'hoansi, in which, as reported in **Miller-Ockhuizen (1998**; also **Zhang 2002**), contour tones are found only on long vowels and diphthongs, but not on CV syllables or syllables closed with nasals (the only type of closed syllable in the language).

Type 3 weight pattern is exemplified by a number of languages, including Nama (Khoisan), Lithuanian (Indo-European), and Tiv (Niger-Congo). Lithuanian has a pitch accent system, in which contour tones appear on heavy, but not on light, syllables. In particular, a Low High tonal contour, the so called circumflex accent, occurs on heavy syllables: CVV, as in /víinas/ 'wine', /zúikas/ 'rabbit', and CVR, as in /gársas/ 'sound', /bálsas/ 'voice', and /lánkas/ 'rainbow'. Syllables that pattern as light are CV and CVC, and those that pattern as heavy are CVV and CVR (**Zec 1995** and references therein).

We now turn to the tonal evidence for the type 1 weight pattern. Contour tones are rare, and phonetically difficult to realize, on syllables closed with an obstruent. In his broad survey of quantity-sensitive tone, **Gordon (2006)** documents only three such cases: Hausa, Luganda, and Musey. **Zhang (2002**: 51) also lists Ngizim, and **Yip (2002**: 141–142) mentions the Nilo-Saharan language Kunama (Eritrea). Here we present evidence from Hausa, based on **Gordon's (2006)** experimental data. Hausa has three tones, two level tones, High and Low, and a contour High Low tone. As shown in (12), on the targeted initial syllables, the two level tones occur on all syllable types, while the contour tone occurs on CVV, CVR and CVO, but not on CV syllables. That is, the contour tone occurs on heavy, but not on light syllables.

(12) *Type 1: Hausa contour tone*

	L	H	HL
CV	fàsá:	sáfú:	–
CVV	mà:má:	rá:ná:	lâ:lá:
CVR	ràndá:	mándá:	mântá:
CVO	fàská:	máskó:	râssá:

Of interest here is the fact that while sonorants, both vowels and consonants, are capable of phonetically realizing pitch, obstruents are not. As shown by **Gordon (2006**: 92), although the phonological weight of the CVO syllable provides the two tone-bearing units required for the realization of contour tone, the contour is phonetically realized on the vowel, which in this case has greater duration. No comparable increase in duration is evidenced in CVV and CVR syllables with contour tones. Thus, Hausa presents an interesting case of a mismatch between phonology and phonetics.

Other phonological phenomena that provide evidence for quantity-sensitivity include vowel shortening in closed syllables, to be addressed in §6, as well as compensatory lengthening (see **CHAPTER 64**: COMPENSATORY LENGTHENING) and poetic meter, which in §2.1 served as evidence for Latin. Onsets may on occasion exhibit quantity-sensitivity; for such cases, see **CHAPTER 55**: ONSETS and **CHAPTER 47**: INITIAL GEMINATES.

3 Representation of syllable quantity

The relevance of quantity-sensitivity, as well as its representation, was clearly recognized in early theoretical approaches to phonology. Both **Jakobson (1931)** and **Trubetzkoy (1939)** document weight distinctions among syllables, and cast them in terms of the unit of weight traditionally referred to as the mora: a light syllable contains one mora, and a heavy syllable contains two moras. Quantity-sensitivity was also recognized by **Kuryłowicz (1948)**, who pursued the characterization of

quantity in configurational terms, that is, in terms of a subconstituent of the syllable, the rhyme, whose structure is branching for heavy, and non-branching for light syllables. These two theoretical approaches to quantity-sensitivity, one in terms of constituency and the other in terms of arboreal configuration, emerged again in the 1970s and 80s, as competing representations of syllable weight, as well as the weight of other constituents in the prosodic hierarchy.

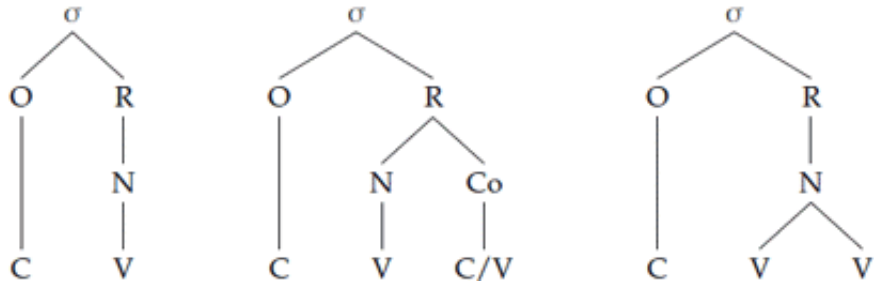
These two approaches both express an important intuition: that quantity formally corresponds to a binary structure. This will emerge as highly relevant in the representation of the syllable and its internal structure. This is also relevant for the representation of feet, as will be shown in §7.

The questions to be addressed in this section are: (i) how is weight computed from the representation of the syllable?; and (ii) how are different weight patterns represented? (For a general discussion of syllable structure and its representation, see CHAPTER 33: SYLLABLE-INTERNAL STRUCTURE.)

3.1 Quantity represented in configurational terms

We begin with the configurational approach to syllable weight. In the representation in (13), the syllable branches into an onset and a rhyme, with the latter obligatorily dominating the nucleus and, optionally, the coda. The sub-syllabic constituent which is taken to be the domain of weight is the rhyme: if the rhyme branches, the syllable is heavy (13b); otherwise it is light (13a). An alternative assumption has been that a branching nucleus, as in (13c), has its role in the computation of quantity.

(13) a. *Light* b. *Heavy: Branching rhyme* c. *Heavy: Branching nucleus*



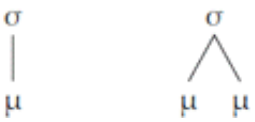
While this constituency was motivated on other grounds as well, capturing syllable quantity has been one of its important rationales. It was generally assumed that encoding weight distinctions is a crucial role of syllable structure. This representation was advocated, in this or somewhat modified form, by **Kiparsky (1979, 1981)**, **McCarthy (1979)**, **Halle and Vergnaud (1980)**, **Hayes (1980)**, **Steriade (1982, 1988)**, and **Levin (1985)**, among others. In all these approaches, the weight domain, provided by the rhyme subconstituent, crucially excludes the onset consonants, which do not participate in any of the weight patterns characterized in §2.2.

How does this representation capture the three weight patterns presented in (5)? In some proposals that primarily focus on type 2 languages (e.g. **Halle and Vergnaud 1980**), both CVV and CVC syllables are represented in terms of a branching rhyme, that is, as (13b). Capturing both type 1 and type 2 languages called for modifications. In one modification, CVV syllables are represented in terms of a branching nucleus, as in (13c), and CVC syllables in terms of a branching rhyme, as in (13b) (e.g. **Hayes 1980**). In another modification, different configurations are posited for type 1 and type 2 languages (e.g. **McCarthy 1979**). Type 3 language posed a special challenge: heavy CVR syllables in this language type were represented in terms of a branching nucleus (13c), with the weight-bearing sonorants residing in the nucleus together with vowels (**Steriade 1990**).

3.2 Quantity represented by constituency

Another way of capturing syllable weight is in terms of constituency. By positing the mora as a sub-syllabic constituent, syllable weight is represented in terms of the number of moras that the syllable dominates. A syllable with one mora is light, and a syllable with more than one mora is heavy.

(14) a. *Light* b. *Heavy*



While the mora as a unit of syllable weight goes back at least as far as the study of classical languages, it was introduced to theoretical phonology by **Jakobson (1931)** and **Trubetzkoy (1939)**. Arguments for representing the mora as a sub-

syllabic entity are primarily due to **Hyman (1985)**, **McCarthy and Prince (1986)**, **Hayes (1989)**, and **Zec (1988)**. Crucially, moras do not uniquely map to the level of segments. Moraic representations in (14) are thus sufficiently flexible to capture all three systems of syllable quantity. What needs to be stated is the set of segments that can be dominated by the second mora of the syllable: all segments, as in the type 1 weight pattern, only vowels, as in type 2, and vowels and sonorant consonants, as in type 3. How this is to be implemented varies with specific phonological models, which may rely either on rules or on constraints. Thus **Hayes (1989)** posits a weight-by-position rule, **Zec (1988, 1995)** posits language-specific sets of moraic segments that act as constraints on the second mora of a syllable, and **Morén (1999)** proposes optimality-theoretic constraints on moraic segments that parallel **Prince and Smolensky's (1993)** constraints on syllable nuclei.

4 Quantity-sensitivity and vowel length

Quantity-sensitivity is not a necessary property of the syllable. A number of languages, some listed in **Hayes (1995)**, do not exhibit quantitative distinctions at the level of the syllable, for example, Bulgarian (Indo-European), Piro (Arawakan), Garawa (Karawic), and Modern Greek (Indo-European). Significantly, all these languages also lack vowel length (CHAPTER 20: THE REPRESENTATION OF VOWEL LENGTH). This strongly suggests that the basic weight contrast is in fact that between short and long vowels, and raises the question of possible implicational relations between syllable weight and vowel length, either phonemic or non-phonemic.

A strong claim on the relation of CVV and CVC syllables, proposed by **Kuryłowicz (1948)** and **Newman (1972)**, among others, is that a language with heavy CVC syllables also has phonemic vowel length. While true in a number of specific cases, including Latin, Classical Arabic, and Fijian, this claim is too strong. A weaker claim is that the CVV syllable type is available in languages with heavy CVC syllables even if a language does not have phonemic vowel length (cf. **Hayes 1989**; **Zec 1988, 1995**). In such languages, vowel length could arise due to phonological processes such as compensatory lengthening, as in Ilokano (**Hayes 1989**), or iambic lengthening, as in Hixkaryana (**Hayes 1995**: 205 and the references therein). This claim rests crucially on a representation already available in a language (see §3), rather than on its phonemic distinctions.

5 Are weight distinctions binary or multivalued?

Cases of quantity-sensitivity presented thus far are characterized by two degrees of weight: a syllable is either light or heavy. The representations of syllable weight in §3 characterize quantity-sensitivity as a binary opposition, with two degrees of weight. However, a further question to be explored is whether there are cases of more than two degrees of weight, that is, whether quantity distinctions can be construed as scalar in nature.

Weight patterns with weight-bearing consonants, types 1 and 3, present an obvious point of departure. In a language with light CV and heavy CVV and CVC syllables, what is the status of CVVC and CVCC syllables? Are such syllable shapes allowed? And, if allowed, are they superheavy? That is, do they call for syllable structures that are either ternary branching or trimoraic? Likewise, what is the status of CVVR (and the less likely CVRR) syllables in type 3 languages?

Starting with type 1 languages, we find the following two cases. First, a language may have a syllable inventory that includes CVVC and CVCC syllables. In Hindi, such syllables give rise to three degrees of weight, as in (15a). Evidence for this ternary weight pattern comes from quantity-sensitivity in the stress system. Stress falls on a superheavy syllable if there is one, otherwise on a heavy syllable, otherwise on a light syllable (glossing over the complexities of this system, for details and examples, see §8). By contrast, Latin also has CVVC and CVCC syllables in addition to the standard type 1 inventory, yet exhibits only two degrees of weight, as in (15b). In this case, CVVC and CVCC syllables are functionally non-distinct from heavy syllables, CVV and CVC. This functional identity is supported by both stress and poetic meter.

(15) a. *Hindi*

light	CV
heavy	CVV, CVC
superheavy	CVVC, CVCC

b. *Latin*

light	CV
heavy	CVV, CVC, CVVC, CVCC

Newman (1972) claims that all weight distinctions are binary, pointing to languages like Latin. However, languages like Hindi clearly show that ternary weight distinctions are an attested reality.

Second, a language may have a restricted syllable inventory, with only CV, CVV, and CVC, excluding both CVVC and CVCC syllable shapes. Such languages impose binarity as an upper limit to syllable complexity both in terms of weight, or mora count, and in terms of the number of consonants that may occur at the right margin of the syllable. This situation is clearly illustrated by Turkish (**Clements and Keyser 1983**). The syllable inventory of Turkish, a type 1 language, includes light CV and heavy CVV and CVC syllables, and systematically lacks CVVC and CVCC syllables. If the prohibited syllable types arise by virtue of morpheme concatenation, they are eliminated by phonological processes. In (16a), the underlying long vowel is

shortened in a closed syllable, (nominative and ablative), but not in the open syllable (accusative). And in (16b), the two post-vocalic consonants in the underlying form are split by an epenthetic vowel (CHAPTER 67: VOWEL EPENTHESIS), in order to avoid a CVCC syllable (nominative and ablative).

(16) *Turkish*

			accusative	*nominative*	*ablative*
a.	CVVC → CVC				
	/zama:n-/	'time'	zama:nɯ	zaman	zamandan
	/ispa:t-/	'proof'	ispa:tɯ	ispat	ispattan
b.	CVCC → CVCVC				
	/karn-/	'abdomen'	karnɯ	karɯn	karɯndan

Type 3 languages, or at least the known cases, do not provide evidence for ternary weight distinctions. Lithuanian, for example, has the following syllable shapes in its inventory, classified in terms of weight:

(17) *Lithuanian*

Light	CV, CVO, CVOO
Heavy	CVV, CVR, CVVO, CVRO

This weight pattern, as we saw in §2, is supported by the system of Lithuanian pitch accents (CHAPTER 42: PITCH ACCENT SYSTEMS): only heavy syllables, that is, CVV and CVR, can have contour tones. Lithuanian also provides evidence for strict binarity. This is evidenced by the process known as ablaut which applies in verbal morphology, with the effect of lengthening the root vowels in the preterite and infinitive, but not in the present form (**Zec 1995**). Vowel lengthening due to ablaut takes effect in all preterite forms: the root vowel occurs in an open syllable, due to the vowel-initial ending *-ee*, and is free to lengthen. In the infinitive forms, the root vowel is in a closed syllable, due to the consonant-initial ending *-ti*. Lengthening takes place in (18a), i.e. in roots that end in an obstruent, but not in roots that end in a sonorant (18b).

(18) *Lithuanian: Ablaut in verbal forms*

		root	*present*	*preterite*	*infinitive*	
a.	CVO	tup-	tupia	tuupee	tuupti	'perch'
		dreb-	drebia	dreebee	dreebti	'splash'
b.	CVR	vir-	viria	viiree	virti	'boil'
		mir-	miria	miiree	mirti	'die'

That is, ablaut may not create a superheavy CVVR syllable, and is therefore prevented from taking effect in the infinitives of the roots in (18b).

While type 2 languages may tolerate CVCC and CVVC syllables in their syllable inventories, such syllables do not form a natural class: the former has the weight of CV, and the latter has the weight of CVV syllables.

The extended syllable inventories we document in this section call for representations richer than those discussed in §3. This was directly addressed in moraic representations of the syllable and its weight: a constraint restricts the number of moras per syllable to no more than two; and this constraint can be violated in some languages, giving rise to trimoraic syllables, as in Hindi. The syllable inventory in Latin is accommodated by allowing some non-moraic consonants at the syllable's right margin (for a detailed discussion, see **Sherer 1994**).

6 Inconsistencies in weight patterns

The representations in §3, despite some conceptual differences, make the strong prediction that quantity distinctions in a language will be of the same type across the board, that is, in all relevant phonological processes, and in all contexts. However, a challenge to this strong position comes from many known cases of weight inconsistencies.

6.1 Weight inconsistencies with respect to phonological process

In §2.1 we saw that Latin belongs to the type 1 weight pattern both in its stress system and in the system of poetic meter. The phenomenon of compensatory lengthening (CHAPTER 64: COMPENSATORY LENGTHENING) conforms to this same weight pattern, as in /kasnus/ → [ka:nus]. While not uncommon, weight consistency across different phonological processes, as evidenced in Latin, is not the general case. Weight inconsistencies are encountered in a number of languages, as noted by **Steriade (1990)**, as well as **Hayes (1995)** and **Gordon (2006)**. One such case is Kiowa (**Watkins 1984**). As shown in (19), vowels are shortened in syllables closed by sonorants (19a), as well as those closed by obstruents (19b) and (19c), suggesting a type

1 weight system that obeys strict binarity.

(19) *Kiowa short vowels in closed syllables: Type 1*

a.	gú:lê:	'write-IMPERF-FUT'
	gûl	'write-IMP'
	gúltɔ̀:	'write-FUT'
b.	cá:dɔ̀:	'from the doorway'
	cát	'entrance, doorway'
	cátpé	'against the doorway'
c.	$t^hɔ́$:	'beyond'
	$t^hɔ́$:dè$k^hì$:	'next day'
	$t^hɔ́p$	'away beyond'

However, the distribution of contour tones, shown in (20), clearly points to a weight system of type 3. Contour tones occur on CVV syllables and syllables closed by a sonorant, as in (20a), but not on either CV syllables or syllables closed with an obstruent, as exemplified in (20b).

(20) *Kiowa contour tones: Type 3*

a.	pá:lê:	'weak'
	sân	'child'
	$k^hûl$	'pull off'
b.	sà:né	'snake'
	sép	'rain'

Another case is Lhasa Tibetan (**Gordon 2006**, based on **Dawson 1980**), in which the stress system treats only CVV syllables as heavy, while the system of tone treats as heavy both CVV and CVR syllables (**Gordon 2006** and references therein). In other words, Lhasa Tibetan is a type 2 language in its stress system, and a type 3 language in its tonal system. According to **Steriade (1990)**, variability in weight is also found in Classical Greek, in which CVV syllables are heavy for the purposes of tone, yet all syllables are heavy for the purposes of stress distribution. Thus, stress falls on the penultimate syllable if the final syllable is heavy, either CVC(C) or CVV(C), otherwise it is antepenultimate. However, only CVV syllables can sustain tonal contours, either HL or LH.

Cases of weight variability in different phonological subsystems within a single language present an important challenge to formal representations, and call for fresh perspectives on the syllable and its quantity.

6.2 Weight inconsistencies with respect to phonological context

It has been noted in much work on stress that the weight of a syllable may be computed differently in word-internal and word-final positions. Thus in Classical Arabic, as shown in §2, stress falls on the rightmost CVV or CVC syllable, yet never on the final CVC. That is, CVC syllables are computed as heavy word-internally and as light word-finally. A further fact, not mentioned in §2, is that final CVCC syllables are always stressed, i.e. they are computed as heavy (CVCC do not occur word-internally). In other words, word-final consonants do not contribute to weight. Such cases of variable weight were subsumed in **Hayes (1980)** under the more general rubric of extrametricality (CHAPTER 43: EXTRAMETRICALITY AND NON-FINALITY), according to which certain phonological entities, segments as well as higher constituents, are "invisible" to phonological processes at word edges. There have been proposals, however, to treat contextual differences in weight as representational differences (**Davis 1987**; **Kager 1989**; **Rice 1995**; **Rosenthall and van der Hulst 1999**; see also CHAPTER 36: FINAL CONSONANTS). Under this view, the CVC sequence in Classical Arabic would be parsed as a heavy syllable word-internally, and as a light syllable word-finally.

It has been shown, however, that contextual weight differences are not restricted to word edges. Several cases of this type have been reported in **Hayes (1994, 1995)**, among them Cahuilla and Eastern Ojibwa, as well as Central Alaskan and Pacific Yupik. In the Pacific Yupik dialect of Chugach, CVV syllables are heavy in all positions, while CVC syllables are heavy only initially, and light elsewhere. The distribution of stress in Chugach is fairly complex, and there can be more than one stress per word (for details, see **Leer 1985**; **Kager 1993**; **Hayes 1995**). We focus here on the evidence for the variable weight of CVC syllables. While initial CVV and CVC syllables are stressed, as in /'taːtaˈqa/ 'my father' and /ʻanciku'kut/ 'we'll go out', initial CV syllables are not, as in /mu'luˈkuːt 'if you take a long time'. But in medial position, CVC syllables pattern with CV rather than CVV syllables. Note that the second syllable in/'kal'maːnuq/ 'pocket', a CVV syllable, is stressed. Neither CV nor CVC syllables are stressed in this same environment, as in the forms /'anku'taχtu'a/ 'I'm going to go out' and /ʻatmax'tʃiqu'a/ 'I will backpack'.

Another relevant case is Goroa (**Hayes 1980**; **Rosenthall and van der Hulst 1999**, and references therein), in which

stress falls on the leftmost CVV syllable, as in (21a), or on the final CVC syllable, as in (21b); or on the penultimate syllable, as in (21c). Crucially, CVC syllables in positions other than final are not heavy: the second CVC syllable in /giram'bo:da/ does not win over the following CVV syllable, nor do the CVC syllables in /axe'mis/ and /idir'dana/ attract stress.

(21) *Goroa stress: Variable weight of CVC syllables*

a. *Leftmost* CVV *stressed*

du:gnuno:	'thumb'
giram'bo:da	'snuff'
heni'nau	'young'

b. *Final* CVC *stressed*

a'dux	'heavy'
axe'mis	'hear'

c. *Penultimate syllable stressed*

oro'mila	'because'
am'rami	'ivory arm ring'
idir'dana	'sweet'

Contextually conditioned variation in syllable quantity affects CVC syllables, those that cross-linguistically could be either light or heavy. Thus the variability of the weight of CVC syllables found across languages has also been evidenced within individual languages. The phenomenon of contextually conditioned weight inconsistency of CVC syllables has been addressed, with a fair amount of success, in the Optimality Theory framework, most notably in **Rosenthall and van der Hulst (1999)**.

7 Quantity-sensitivity of the foot

Syllables are grouped into feet, which belong to the next higher level of the prosodic constituency in (1) (see CHAPTER 40: THE FOOT; CHAPTER 41: THE REPRESENTATION OF WORD STRESS). Quantity-sensitivity of the syllable is directly reflected at the level of the foot, as noted in **Hayes (1980, 1995)**, **McCarthy and Prince (1986)**, and **Prince (1990)**, among others. Feet play an important role in the characterization of stress and in prosodic morphology, and our examples will come from both domains.

As shown in a vast body of literature, feet tend to be binary. That is, feet are prosodic constituents resulting from grouping at most two constituents at the next lower level (**Hayes 1995**; **McCarthy and Prince 1986**; **Prince 1990**; among others). How this proceeds depends crucially on whether a language has a quantity-sensitive or a quantity-insensitive foot system (**Hayes 1980**). In quantity-insensitive systems, pairs of syllables are incorporated into feet regardless of their weight. Relevant for our discussion is foot formation in quantity-sensitive systems, in which syllable weight plays a crucial role. An important property of such systems is the commensurability of a heavy syllable with two lights. There are two types of quantity-sensitive feet, trochaic and iambic (CHAPTER 44: THE IAMBIC-TROCHAIC LAW).

In quantity-sensitive trochaic systems a foot corresponds to either one heavy syllable, as in (22a), or two light syllables, as in (22b); feet are left-headed, that is, have initial prominence, shown in (22b) by underlining.

(22) *Trochaic foot inventory*

a. σ_H

b. $\underline{\sigma_L}\ \sigma_L$

This receives a straightforward interpretation in moraic theory of syllable structure: a foot contains two moras, a condition met either by one heavy syllable, as in (22a), or by two lights, as in (22b). A heavy syllable has a dual status: it counts not only as a syllable but also as a foot. This foot inventory is active in the stress system of Fijian, a type 2 language (**Hayes 1995**, and references therein). In words with only a light syllable, pairs of syllables are incorporated into feet, computing from right to left, and foot-initial syllables are assigned stress. As a result, stress falls on every second syllable, computed from the right edge, as shown in (23). Parsing of syllables into feet obeys strict binarity, but is not necessarily exhaustive. In words with an odd number of syllables, as in (23c) and (23e), a syllable at the left edge is not footed. (The rightmost stressed syllable bears primary stress; others bear secondary stress.)

(23) *Fijian stress: Light syllables only*

a.	('lako)	'go'
b.	('talo)	'pour'
c.	βi ('naka)	'good'
d.	(ˌⁿdiko) ('nesi)	'deaconess'
e.	pe (ˌresi) ('teⁿdi)	'president'

(24) *Fijian stress: Light and heavy syllables*

a.	ki ('la:)	'know'
e.	(ˌᵐbe:) ('leti)	'belt'
c.	(ˌᵐbele) (ˌᵐbo:) ('tomu)	'bellbottoms'
d.	pa(ˌro:) ka ('ramu)	'program'
e.	(ˌmi:) (ˌsini) ('ᵑgani)	'machine-gun'

In words with both light and heavy syllables, each heavy syllable corresponds to a foot, and is stressed. Right-to-left footing is thus disrupted by heavy syllables, and has to work around them. In the disyllabic form with a heavy final syllable, in (24a), the initial syllable is left unfooted. And the form in (24d), which has five syllables, two light syllables, the first and the third, are left unfooted. All syllables are footed in the remaining forms in (24).

The inventory of feet in (22) captures the distribution of stress in a number of trochaic quantity-sensitive systems, including some of the cases presented in §2. In particular, stress in Latin follows the same pattern as in Fijian, with one notable difference: The final syllable is ignored for the purposes of stress (another case of so-called extrametricality, see §6.2). As a result, trisyllabic forms with only light syllables have initial stress, as in ('*ani*)*ma* 'soul (NOM SG)'. Likewise, final heavy syllables are not stressed: in ('*gau*)*dēns* 'rejoicing (NOM SG)' the penultimate heavy, but not the final heavy, is footed, and stressed (for a detailed analysis, see **Mester 1994**; **Hayes 1995**).

We also present a case of prosodic morphology that employs the foot inventory in (22). In the system of Japanese hypocoristic formation, as characterized in **Poser's (1990)** detailed study, hypocoristics are formed by adding the suffix *-tjan* to proper names, either to their full or modified form. As shown by Poser, what is considered to be modification is really a case of template satisfaction. Crucially, the template corresponds to a trochaic foot: either to two light syllables or one heavy syllable. Japanese, a type 1 language, has light CV and heavy CVV and CVC syllables. As shown by the truncated versions of the proper name *Hanako*, the suffix is added to two light syllables, as in (25a) or one heavy, as in (25b) and (25c). The truncated form cannot be smaller than a foot, corresponding to a single light syllable, as in the ill-formed (25d). Nor can the truncated form be greater than a foot, corresponding to three light syllables, as shown by the ill-formed (26b). Proper names corresponding to a light syllable are converted to a heavy syllable, that is, to a foot; in (27a) this is accomplished by vowel lengthening. Note that (27b) is also available, as *-tjan* can be added to any proper name in its full form regardless of its size.

(25) *Hypocoristic forms for* Hanako

a. hanatjan
b. haatjan
c. hattjan
d. *hatjan

(26) *Hypocoristic forms for* Takatugu

a. takatjan
b. *takatutjan

(27) *Hypocoristic forms for* Ti

a. tiitjan
b. titjan

Thus, in trochaic prosodic morphology, just as in trochaic stress systems, a heavy syllable is functionally equivalent with two light syllables.

Quantity-sensitive iambic feet differ somewhat in shape from the trochaic set, as shown by the inventory in (28). Iambic feet are right-headed, indicated by the underlining.

(28) *Iambic foot inventory*

a. σ_H
b. $\sigma_L\ \sigma_L$
c. $\sigma_L\ \sigma_H$

In this case, as well, syllable quantity plays a central role: for a foot to be well-formed, it needs to contain syllables of the correct weight. The iambic system of quantitative feet captures the distribution of stress in Asheninca (**Hayes 1995**; **Payne 1990**). Asheninca has a type 2 weight system, with only CVV heavy syllables. The forms in (29a) contain only light syllables: binary right-headed feet are computed from right to left. The final syllable is regularly left unfooted, which yields initial stress in disyllables, as in /'haka/ 'here'. Crucial are the forms in (29b), which contain both light and heavy syllables, and can therefore exemplify all members of the foot inventory.

(29) *Asheninca stress system*

a.	(pa.'me).(na.'ko).(wen.'ta).ke.ro	'take care of her'
	(ha.'ma).(nan.'ta).(ke.'ne).ro	'he bought it for her'
	(no.'ko).(wa.'we).ta.ka	'I wanted (it) in vain'
	(no.'ton).(ka.'men).to	'my gun'
	(ka.'man).ta.ke	'he/she said'
b.	(no.'ma).(ko.'rjaa).('wai).(ta.'paa).ke	'I rested a while'
	(pi.'ɲaa).('paa).ke	'you saw on arrival'
	(i.'kjaa).('piin).ti	'he always enters'
	('poo).(ka.'na).ke.ro	'you threw it out'
	('paa).(ti.'ka).ke.ri	'you stepped on him'

Quantity-sensitive iambic feet also figure in prosodic morphology. In Ulwa, which has a type 1 weight system, the suffix /-ka/ is attached to the leftmost iambic foot, as in (30). It occurs at the right edge of a stem only when the entire stem corresponds exactly to a foot, as in (30a). In (30b), the only way for /-ka/ to be attached to an iambic foot is to occur stem-internally.

(30) *Ulwa construct state* (from McCarthy and Prince 1990: 228)

	base	*possessed*	
a.	al	al-ka	'man'
	bas	bas-ka	'hair'
	kii	kii-ka	'stone'
	sana	sana-ka	'deer'
	amak	amak-ka	'bee'
	sapaa	sapaa-ka	'forehead'
b.	suulu	suu-ka-lu	'dog'
	kuhbil	kuh-ka-bil	'knife'
	baskarna	bas-ka-karna	'comb'
	siwanak	siwa-ka-nak	'root'
	anaalaaka	anaa-ka-laaka	'chin'
	karasmak	karas-ka-mak	'knee'

Trochaic and iambic systems differ with regard to the role of quantity, as noted in **Hayes (1985)** and **Prince (1990)** as well as **CHAPTER 44**: THE IAMBIC–TROCHAIC LAW. The preferred type of trochaic disyllabic feet includes two light syllables, while iambic feet optimally correspond to a sequence of a light and heavy syllable. Thus, disyllabic trochaic feet are preferably even, while iambic feet are preferably of uneven quantity. Evidence for even trochaic quantity comes from the so-called trochaic shortening, which makes an uneven trochee even by vowel shortening, as exemplified by Fijian. The form in (31a), with an underlying long vowel, undergoes shortening when integrated into a disyllabic foot, as in (31b).

(31) *Fijian: Trochaic shortening*

a. 'ta: 'chop'
b. 'ta-ja 'chop-TRANS-3SG OBJ'

By contrast, uneven quantity is an important feature of iambic systems. A number of iambic stress systems are characterized by iambic lengthening, including Menomini, Hixkaryana, and Kashaya (**Hayes 1995**). In Hixkaryana (Caribian), prominent CV

syllables undergo vowel lengthening, as in (32a) and (32b), and thus become heavy. Note that prominent CVC syllables, which are already heavy, are not subject to lengthening, as in the second foot in (32c), and the initial syllables in (32a) and (32b).

(32) *Hixkaryana: Iambic lengthening*

a.	owtohona	('ow)(to'ho:)na	'to the village'
b.	tohkurʲehonahaʃaka	('toh)(kuˈrʲe:)(ho'na:)(ha'ʃa:)ka	'finally in Tohkurye'
c.	mihananihno	(mi'ha:)(na'nih)no	'you taught him'

Generalizations about the quantity of trochaic and iambic groupings are stated in **Hayes (1995)** as the Iambic–Trochaic Law (see CHAPTER 44: THE IAMBIC–TROCHAIC LAW):

(33) *The Iambic–Trochaic Law*

a. Elements contrasting in intensity naturally form groupings with initial prominence.

b. Elements contrasting in duration naturally form groupings with final prominence.

8 Scalar quantity systems

While binary quantity systems are based primarily on grouping syllables into feet, scalar quantity systems are based on prominence, defined along some dimension (**Prince and Smolensky 1993**; **Hayes 1995**). A central prominence dimension is syllable weight, although other dimensions, such as tone and vowel height, have been evidenced as well.

We present two cases with syllable weight as the prominence dimension. One is Kashmiri, with examples given in (34) (**Kenstowicz 1993**; **Rosenthall and van der Hulst 1999**). In Kashmiri, CVV syllables are heavier than CVC, which in turn are heavier than CV. Thus, in words with only CV and CVV syllables, stress falls on the leftmost CVV, as in (34a). In words with only CV and CVC, stress falls on the leftmost CVC, as in (34b). In words with both CVC and CVV syllables, stress falls on the CVV syllable, as in (34c). Finally, with only CV syllables present, stress is initial, as in (34d). The final syllable is excluded from scansion. (None of the sources supply glosses for Kashmiri forms.)

(34) *Kashmiri stress:* CVV > CVC > CV

a.	mu'si:baθ	c.	am'ri:ka
	a'jo:gjə ta:		mas'ra:wun
b.	ba'gandarladin	d.	'tsaripop
	juni'varsiti		'paharadari:

Languages in which stress is assigned on the basis of scalar syllable prominence may have several degrees of syllable weight. Thus Hindi (for the dialect described in **Kelkar 1968**) has three degrees of syllable weight: superheavy syllables CVVC and CVCC are more prominent than heavy syllables, CVV and CVC, which in turn are more prominent than CV syllables, as stated in (35).

(35) CVVC, CVCC > CVV, CVC > CV

Excluding the final syllable from scansion, stress is assigned to the heaviest available syllable, as in (36). In both forms stress falls on a CVVC syllable, which in (36b) wins over a CVV syllable, and in (36a) over both a CV and CVV syllable.

(36) a. 'ʃo:xɖaba:ni: 'talkative'
b. 're:zga:ri: 'small change'

If there is a tie, stress is assigned to the rightmost (non-final) syllable: to a CV syllable in (37a), and a CVV syllable in (37b) and (37c).

(37) a. sa'miti 'committee'
b. ro:'za:na: 'daily'
c. ka:'ri:gari: 'craftsmanship'

Interestingly, when the final syllable is the heaviest in the word, it is not excluded from scansion, as in (38):

(38) ki'dʰar 'which way'
ru'pia 'rupee'
as'ba:b 'goods'

Quantity in Hindi is thus computed along a scale of syllable weight, with the superheavy syllable being most prominent, followed by the heavy syllable and then by the least prominent light syllable. This case is analyzed in precisely these terms in **Hayes (1995)** and **Prince and Smolensky (1993)**, although in different frameworks: in rule-based metrical theory and in Optimality Theory, respectively.

An interesting mode of computing prominence is found in Pirahã, a Mura language of Brazil (**Everett 1988**; **Hayes 1995**). The Pirahã prominence scale combines syllable weight and onset quality (on onsets, see **CHAPTER 55**: ONSETS). While CVV syllables are more prominent than CV syllables, voiceless onsets are more prominent than voiced onsets, and presence of onset is more prominent than its absence, yielding the scale in (39).

(39) KVV > GVV > VV > KV > GV [K = voiceless, G = voiced]

Stress falls on one of the last three syllables of the word that is highest on this scale, as in (40a). In the event of ties, the rightmost syllable wins, as in (40b).

(40) *Pirahã prominence-based stress*

a.		b.	
	'ka:gai		ko'po
	ʔapa'ba:si		ʔaba'pa
	'ʔibogi		paohoa'hai

Further dimensions for computing prominence are in no obvious way related to patterns of syllable quantity we surveyed here. Yet, because of their scalar nature, they are highly reminiscent of quantity-based systems of prominence. One such dimension is vowel quality: given the sonority scale, stress falls on the most sonorous vowel. Prominence systems of this type have been analyzed in **Kenstowicz (1997)** and **de Lacy (2004)**. In Mordwin, for example, non-high vowels are more prominent than high vowels (**CHAPTER 21**: VOWEL HEIGHT). In words with only non-high vowels, or with only high vowels, stress falls on the leftmost syllable. However, in words that contain both high and non-high vowels, stress falls on a non-high vowel, regardless of its position in the word. Another dimension is tonal prominence: syllables associated with High tones are more prominent than syllables associated with Low tones, and thus more likely to be associated with stress. Prominence systems of this type are described in **Hayes (1995)** and **de Lacy (2002)**; for a somewhat different perspective, see **Zec (2003)**. Of particular interest is the complex case of Nanti, a Kampa language of Peru: its stress system, which is of the iambic type, is also governed by several types of prominence, including syllable quantity and vowel quality (**Crowhurst and Michael 2005**).

9 Quantity-sensitivity at the higher levels of the prosodic hierarchy

When focusing on higher levels of the prosodic hierarchy, the prosodic word and the prosodic phrase, we are in fact dealing with morphosyntax/prosody interface. Quantity-sensitivity is a specifically prosodic phenomenon and is not known to play any role in other modules of the grammar. Any effects of quantity-sensitivity in either morphology or syntax are therefore to be attributed to prosody. We addressed the interfaces with morphology in §8, with two cases of affixes that select not only a morphological class, but also a prosodic type of the stem; both in this case select for the foot. Many more such cases are found in the literature (**McCarthy and Prince 1986, 1990, 1995**; among others).

The word level of the prosodic hierarchy is constituted by a grouping of feet (**CHAPTER 41**: THE REPRESENTATION OF WORD STRESS; CHAPTER 51: THE PHONOLOGICAL WORD). In practice, however, one foot is sufficient for a prosodic word to achieve the desired quantity, as documented by numerous cases of minimal word size. Moreover, in a number of languages, no minimal size beyond a single syllable is imposed on prosodic words. This is broadly documented in **Hayes (1995)** and **Downing**

(2006), among others. In sum, the prosodic word provides no evidence for quantity-sensitivity of the sort found at the level of the syllable and the foot: its binary structure is not distinct from that of a foot. There are no known cases of a prosodic word minimally branching into two feet, yet this would be expected, based on the situation at the lower end of the prosodic hierarchy.

However, quantity-sensitivity has been evidenced at the higher end of the hierarchy, that is, at the level of the prosodic phrase. The distribution of a syntactic constituent should not be affected by its length or internal complexity. When such effects arise, they are generally attributed to prosody. We focus here on cases of branching in prosodic phrases, typical cases of apparent quantity-sensitivity of syntactic constituents. Cases of binary branching prosodic phrases were reported by **Nespor and Vogel (1986)**, with evidence from Italian, French, and English. In Italian, for example, a prosodic phrase preferably contains more than one prosodic word, as shown by the following cases (**Nespor and Vogel 1986**):

(41) *Prosodic phrase formation in Italian*

a. *Av'ra trovato (il pescecane)*$_\Phi$
'He will have found the shark.'

b. *(I cari'bu nanni)*$_\Phi$ *sono estinti*
'Dwarf caribous are extinct.'

c. *Hanno dei (car'ibú)*$_\Phi$ *(molto piccoli)*$_\Phi$
'They have very small caribous.'

While complements that correspond to single prosodic words, as in (41a), form one-word prosodic phrases, multiple word complements, as in (41b) and (41c), correspond to branching prosodic phrases. The prosodic phrasing in (41c) further shows that complements with three prosodic words do not correspond to a single prosodic phrase, as branching prosodic phrases contain at most two prosodic words. By contrast, Serbo-Croatian sentence-initial topics have to include at least two prosodic words (**Zec and Inkelas 1990**), and thus exemplify obligatory branching in prosodic phrases. This line of research has been further continued by **Ghini (1993)**, **Selkirk (2000)**, and **Sandalo and Truckenbrodt (2002)**, among others.

10 Remarks on markedness

It is important to note that the markedness (CHAPTER 4: MARKEDNESS) of light and heavy constituents is not identical across prosodic levels: heavy constituents are marked at the level of the syllable, while light constituents are marked at the level of the foot. This is directly encoded in Optimality Theory. Constraints listed in (42) assign marked status to heavy syllables: to CVV syllables, as in (42a), and to syllables with coda consonants, as in (42b) and (42c). While (42b) targets any coda consonant, (42c) targets any weight-bearing segment.

(42) a. NoLongVowel (Rosenthall 1994)
A vowel should not be long, i.e. linked to more than one mora.

b. NoCoda (Prince and Smolensky 1993)
Syllables must not have a coda.

c. *Mora[seg] (Morén 1999)
Do not associate a mora with a particular type of segment.

These constraints, which belong to the markedness family, penalize binary structures at the syllable level, thus favoring a simple CV syllable, which is light. Thus, light syllables emerge as the unmarked case: all languages have light syllables, and some may also have heavy syllables. Superheavy, i.e. trimoraic, syllables are, of course, also marked, and are penalized as such by a constraint against trimoraic syllables proposed by **Sherer (1994)**.

By contrast, heavy feet are preferred over light ones. Binary constituents are highly desirable at the level of the foot, both in trochaic and iambic systems. Non-binary, or light, feet are permitted in some languages under very special conditions and banned in others. The unmarked condition for feet is thus to be binary, that is, heavy, either under moraic or syllabic analysis, and this is codified in Optimality Theory by a corresponding constraint:

(43) FootBinarity (**McCarthy and Prince 1993**)

Feet must be binary under a syllabic or moraic analysis.

At the higher prosodic levels, constituent size is largely determined by morphosyntax, as is the distribution of light and heavy constituents. However, where permitted by morphosyntax, heavy, i.e. branching, constituents are preferred over light ones (see §9).

11 Conclusion

Quantity-sensitivity is an important property of prosodic structure, evidenced at each of its levels. As we have seen, constituents at any level of the prosodic hierarchy can be classified into those that are light and those that are heavy. While quantity-sensitivity is typically associated with the syllable and the foot, all prosodic levels exhibit this property. Whether a syllable is light or heavy crucially depends on its segmental setup; quantity at the level of the foot relies on, and is largely characterized in terms of syllable quantity; quantity-sensitivity of the prosodic word is non-distinct from that of the foot; and quantity-sensitivity at the higher prosodic levels is heavily influenced by morphosyntax.

While characterization of quantity largely depends on level-specific criteria, a general property of heavy constituents is their greater size and complexity, and often their binary structure. It is interesting, however, that preference, or dis-preference, for heavy constituents varies across prosodic levels. The unmarked condition for syllables is to be light while the unmarked condition for feet is to be heavy. The latter condition persists through the higher levels of the prosodic hierarchy. Thus, while light syllables are preferred over heavy ones, feet and prosodic words are preferably heavy. Heavy prosodic phrases are preferred as well, although in a very weak sense.

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Notes

1 Final syllables have a special status, in at least two respects. Stress does not fall on final CVC syllables, but CVVC and CVCC syllables, which are only found word-finally, do bear stress. The special behavior of final elements is a more general issue, to be addressed in §6.2.

2 All examples are from **McArthur and McArthur (1956)**, who list no cases of final CV syllables. Also, they claim that stress falls on the rightmost CVV syllable, yet no words with more than one CVV syllable are found in this source.

3 It is not typical for tone to be attracted to a heavy syllable, although some cases have been interpreted in this light. Thus Hopi, as described in **Jeanne (1982)**, has been interpreted as a quantity-sensitive stress system (**Hayes 1995**): stress occurs on initial heavy syllables, either CVV or CVC, otherwise on non-final peninitial syllables; stress is initial in all disyllables. However, because stress is realized as tonal prominence, this system has also been interpreted as a tonal system in which High tone is attracted to the initial heavy syllable, otherwise to the second syllable, if non-final (**Yip 2002**: 245). This stress-like behavior of tone, if indeed correctly interpreted, is truly atypical.

4 Note, however, that tone languages vary as to what constitutes a tone-bearing unit. What we described here is one of several modes of selecting a tone-bearing unit. On tone and tone-bearing units, see CHAPTER 45: THE REPRESENTATION OF TONE.

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