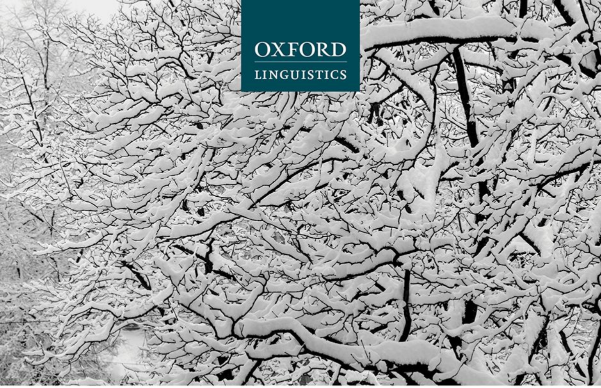

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Categories and Continua

KEVIN M. RYAN

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Series preface

The 'Oxford Studies in Phonology and Phonetics' series provides a platform for original research on sound structure in natural language within contemporary phonological theory and related areas of inquiry such as phonetic theory, morphological theory, the architecture of the grammar, and cognitive science. Contributors are encouraged to present their work in the context of contemporary theoretical issues in a manner accessible to a range of people, including phonologists, phoneticians, morphologists, psycholinguists, and cognitive scientists. Manuscripts should include a wealth of empirical examples, where relevant, and make full use of the possibilities for digital media that can be leveraged on a companion website with access to materials such as sound files, videos, extended databases, and software.

This is a companion series to 'Oxford Surveys in Phonology and Phonetics', which provides critical overviews of the major approaches to research topics of current interest, a discussion of their relative value, and an assessment of what degree of consensus exists about any one of them. The 'Studies' series will equally seek to combine empirical phenomena with theoretical frameworks, but its authors will propose an original line of argumentation, often as the inception or culmination of an ongoing original research program.

Weight has long been an important topic in the study of phonetics and phonology. In this book, Kevin M. Ryan provides a comprehensive analysis of prosodic weight: the categorization of syllables or larger prosodic constituents based on their patterning. Such categorization is often dichotomous (e.g. light vs. heavy) for certain phenomena, but can often be more complex, and Ryan demonstrates that factors such as length, complexity, and the onset contribute to scalar arrangements of weight, for constituents beyond the syllable such as the word and even the phrase. While most previous research on weight focuses on binary systems or the phonetic basis of categorization, this book places emphasis on the phonological analysis of complex and gradient scales for phenomena such as stress, prosodic minimality, quantitative meter, and prosodic end-weight. The book contributes thorough empirical and analytical depth, weaving together Optimality Theory analyses based on descriptive, typological data, as well as experimental and corpus-based statistics. The work stands for its fresh insights into traditionally studied languages, alongside the introduction of new sets of languages that have not figured into debates about the representation of weight.

Andrew Nevins
Keren Rice

Acknowledgments

Verse was first. I arrived at the topic of prosodic weight the same way that the field did historically, that is, from metrical verse. The codification of verse yielded the study of prosody, which in turn yielded the first formal theories of grammar. This happened first in India, but for me India happened first in Berkeley, where, as an undergraduate in 2002, I read Sanskrit with the Goldmans and Tamil with the Harts and decided to pursue phonology formally.

The present work has its origins in my 2011 UCLA dissertation 'Gradient weight in phonology', but only the sections on gradient weight in stress (§2.8), gradient weight in meter (§4.4), and Tamil minimality (§3.4)—less than a quarter of the present text—are direct descendants of that thesis, and they are reworked. Bruce Hayes and Kie Zuraw were my advisors at UCLA, and it is to them that I owe the greatest thanks for supporting and inspiring me during the early stages of this scholarship. Additionally, Matthew Gordon's and Donca Steriade's respective oeuvres on weight have been particularly influential, though it goes without saying that our views sometimes diverge. Gordon's work has in many ways served as my foundation, as evidenced by the 130 references to it below. The emphases of the present work have been shaped to some extent by a desire to complement rather than recapitulate this foundation, as described in §1.4.

I also wish to thank Adam Albright, Arto Anttila, Lev Blumenfeld, Megan Crowhurst, Robert Daland, Edward Flemming, Guilherme Garcia, Olav Hackstein, Jay Jasanoff, Paul Kiparsky, Paul de Lacy, Anya Lunden, Laura McPherson, Donka Minkova, Joe Pater, Russell Schuh, Stephanie Shih, Caley Smith, and Morgan Sonderegger, who contributed in various ways direct or indirect, as well as the 'Studies in Phonology and Phonetics' editors Andrew Nevins and Keren Rice. Additionally, Dieter Gunkel and Donca Steriade provided feedback on an earlier form of the manuscript. Needless to say, I bear full responsibility for any errors or omissions in the present version of the text. I gratefully acknowledge early support from a National Science Foundation graduate research fellowship and from a Humboldt Foundation fellowship for experienced researchers.

List of figures

Abbreviations and symbols

Phonetic transcriptions and symbols generally follow the IPA (International Phonetic Alphabet). Classical languages such as Latin and Sanskrit are usually presented in standard romanization, which is close to the IPA, except most notably that vowel length is marked by macrons (e.g. ā = aː).

.	syllable boundary
#	word boundary
ˈ	primary stress (printed before syllable, e.g. baˈta = baTA)
ˌ	secondary stress (printed before syllable)
ˌˌ	tertiary stress (printed before syllable)
´	stress (with symbols, e.g. H́, σ́, or orthographic forms), pitch accent, or lexical accent
ː	long vowel or consonant (same as macron)
ˑ	half-long vowel
|	boundary between feet or intervals
||	caesura
(...)	foot
[...]$_\omega$	prosodic word
<...>	extrametrical material
<	is lighter than
≤	is lighter than or equivalent to
≲	is lighter than, but not strictly
∼	varies with
>	is heavier than, or yields via historical change
≫	strictly dominates (as of constraints)
≻	is more harmonic than (as of candidates)
◡	light syllable or position
–	heavy syllable or position
ə	schwa or reduced vowels in general
☞	winner (or, with 💣, should-be winner)
💣	erroneous winner
2sg.	second person singular
ā	same as [aː]
AIC$_c$	Akaike information criterion (corrected)
A(P)	adjective (phrase)

[± *approx*]	the feature approximant
β	coefficient in a regression
C	consonant
C_0	any number of consonants
C^1	at most one consonant
D(P)	determiner (phrase)
f	foot
f_0	fundamental frequency
G	geminate
gen.	genitive
GV	syllable with an onset geminate (e.g. [kːa])
H	heavy syllable
HG	Harmonic Grammar
$\mathscr{H}$	harmony
iff	if and only if
L	light syllable (or lateral)
μ	mora
maxent	maximum entropy
MCL	*muta cum liquida*
ms	milliseconds
N	sonorant
N(P)	noun (phrase)
OT	Optimality Theory
φ	node at the level of the prosodic word or higher
φ_s	strong φ
p	probability
PEH	phonetically effective heavy syllables
PFL	phrase-final lengthening
pl.	plural
P(P)	preposition (phrase)
PWd	prosodic word
R	rhotic
σ	syllable
$\sigma_{\mu\mu}$	syllable with two or more moras
σ_s	strong or stressed syllable
σ́	stressed syllable
S	strong (position)
s	seconds

SE	standard error
sg.	singular
[± *son*]	the feature sonorant
SWP	stress-to-weight principle (penalize stressed lights)
T	obstruent
t	total perceptual energy of the weight domain
V (or V̌)	short vowel
V < VX	Latin criterion (light iff ends with V)
VC < VV	Khalkha criterion (heavy iff contains VV)
VG	rime closed by a geminate (e.g. [**ak**.ka])
V(P)	verb (phrase)
VV	long vowel or (heavy) diphthong
VX	rime comprising at least two timing slots
W	glide or weak (position)
WbyP	weight-by-position
WSP	weight-to-stress principle (penalize unstressed heavies)
$\chi^2(n)$	chi-square test with *n* degrees of freedom
X	segment of any type
×	position with any weight or grid mark
z	*z*-value in a logistic regression (β/SE)

1

Introduction

1.1 Preamble

The notion that syllables are divided into two categories, heavy and light, predates the introduction of writing in many traditions. This dichotomy was first evident from versification, but came also to be recognized in antiquity as critical for characterizing grammatical systems such as tone, stress, and morphology. In Sanskrit, for instance, heavy syllables are termed *guru* (cognate with *gravity*) and light syllables are termed *laghu* (cognate with *light*), and it is ultimately to Sanskrit rather than to Latin or Greek that anglophone phonologists owe the calques "heavy" and "light." Crucially, these terms are distinct from long (*dīrgha*) and short (*hrasva*), which refer to vowel or consonant length (e.g. short *i* vs. long *ī*, also notated [iː]). As Pāṇini specifies in his grammar, the Aṣṭādhyāyī (c. 500–300 BCE)—though the distinction is more ancient than that (Allen 1953)—a syllable is heavy if it contains a long vowel (which includes diphthongs) or a short vowel followed by a consonant cluster. The three relevant rules are given in (1) (Böhtlingk 1887, Vasu 1898).

(1)	1.4.10	hrasvaṃ laghu	'a short [vowel is] light [modulo 1.4.11]'
	1.4.11	saṃyoge guru	'before a consonant cluster, [a vowel is] heavy'
	1.4.12	dīrghaṃ ca	'and a long [vowel is also heavy]'

In modern terms, phonologists would usually say that a Sanskrit syllable is heavy if it contains a long vowel, diphthong, or CODA. For example, in *saṃyoga* 'cluster,' the first syllable is heavy. For Pāṇini, this is because the first vowel is followed by a cluster, namely, *ṃy*. In modern terms, by contrast, one would say that the first syllable of *saṃyoga*, which is syllabified [səŋ.joː.gə], is heavy by virtue of ending with a consonant, that is, a coda. Pāṇini's characterization of weight is INTERVAL-based, where the interval is the span between the beginning of a vowel and the beginning of the following vowel (or, lacking a following vowel, the end of the constituent), while the alternative is SYLLABLE-based. The two systems are not always equivalent. For instance, the final syllable of *saṃyogam* 'cluster (accusative)' would be considered light as an interval but heavy as a syllable. This book assumes the syllable theory of weight, which is the standard approach in modern phonology (e.g. Jakobson 1971/1931, Trubetzkoy 1958, Allen 1973, Hyman 1977, 1985, McCarthy 1979b, Steriade 1982, Zec 1988, Hayes 1989, 1995, and numerous others; for recent article-length surveys, see Ryan 2016 and Gordon 2017). Nevertheless, Interval Theory is being revived in some quarters, as discussed in §4.6.

The Sanskrit grammarians distinguished between heavy and light syllables for both metrical and grammatical reasons. In verse, certain positions of the line are required to be filled by a syllable of a particular weight. For example, each line of the Sanskrit epic meter, the *śloka*, is sixteen syllables, of which the last four must be light-heavy-light-× (where × is a syllable of any weight). The first four lines (two verses) of the Bhagavad Gītā are given in (2). Note that *vacanam* in the fourth line ends with a light syllable. In this context, *m* is not a coda; rather, it RESYLLABIFIES with the following vowel, the usual treatment of C#V sequences in archaic Indo-European languages. Note also that *abra* in the fourth line—and in any instance in Sanskrit—is syllabified [ab.ra] (but cf. Kessler 1998). In this respect, Sanskrit differs from other languages, such as Latin and English, in which such a cluster is at least sometimes syllabified [a.bra].

(2) 1.1 dharmakṣetre kurukṣetre || samavetā yuyutsavaḥ
māmakāḥ pāṇḍavaś caiva || kim akurvata sañjaya

1.2 dr̥ṣṭvā tu pāṇḍavānīkaṃ || vyūḍhaṃ duryodhanas tadā
ācāryam upasaṅgamya || rājā vacanam abravīt

As one example of weight affecting morphology in Sanskrit, consider the reduplicated aorist, as in (3) (Whitney 1889:308–12). Each verb form comprises four morphemes, namely, the augment *a*-, the reduplicant, the root, and the suffix *-am*, which indicates the first person singular. The second column provides a syllabic parse with IPA transcription. The reduplicant copies a consonant and a vowel from the root, with some irrelevant adjustments to quality. The length of the copied vowel varies according to the distribution of weight in the product (surface form). If the root syllable is light (as syllabified with the suffix), the reduplicant is heavy. This is achieved by lengthening the copied vowel, as in (a–c). If the root begins with a cluster, as in (d–e), the vowel does not lengthen, as the cluster furnishes a coda for the reduplicant, rendering it heavy without lengthening. Finally, if the root syllable is heavy (in context), the reduplicant is light (f–h).[1] This trading off in syllable weight between the reduplicant and its base is a type of QUANTITATIVE COMPLEMENTARITY, as termed by McCarthy and Prince (1986); see also (11).

(3)

a.	a-rī-riṣ-am	[ə.ɻiː.ɻi.ʂəm]	‘I have harmed’
b.	a-dū-duṣ-am	[ə.d̪uː.d̪u.ʂəm]	‘I have spoiled’
c.	a-jī-jan-am	[ə.ɟiː.ɟə.nəm]	‘I have begotten’
d.	a-ti-tras-am	[ə.t̪it̪.ɻə.səm]	‘I have trembled’
e.	a-cu-krudh-am	[ə.cuk.ɻu.d̪ʱəm]	‘I have antagonized’
f.	a-bu-bhūṣ-am	[ə.bu.bʱuː.ʂəm]	‘I have sought’
g.	a-ta-taṃs-am	[ə.t̪ə.t̪əŋ.səm]	‘I have drawn’
h.	a-da-dakṣ-am	[ə.d̪ə.d̪ək.ʂəm]	‘I have been skillful’

[1] If the root is both heavy-in-context and cluster-initial, as in *apapraccham* ‘I have asked,’ a heavy reduplicant is unavoidable. Lengthening would be doubly defeating in such cases.

Thus, both meter and morphology diagnose the same heavy vs. light distinction in Sanskrit, such that a syllable is heavy iff (if and only if) it contains a long vowel, diphthong, or coda. To generalize over these heavy types, it is commonly said that a heavy syllable comprises two MORAS, a mora being a unit of phonological length (the corresponding Sanskrit term being *mātrā* 'measure'). Canonically, a short vowel contributes one mora and a long vowel or diphthong contributes two (some analysts additionally recognize nonmoraic or trimoraic vowels; §2.3.1, §2.6.7). A coda canonically contributes one mora, though some systems treat (all or some) codas as nonmoraic (some analysts additionally recognize multimoraic codas; *ibid.*). Finally, onsets are irrelevant for weight in the foregoing examples. Nevertheless, I treat numerous cases below that support onsets as factors in weight elsewhere.

The same binary criterion for weight that is found in Sanskrit is also familiar from Latin. Once again, several systems converge on this classification, including the following. First, stress placement depends on weight. In words of three or more syllables, stress falls on the penult (second-to-last syllable) unless the penult is light, in which case it retreats to the antepenult (e.g. *praeféctīs*, *optā́tīs*, but *dígitīs*). Second, if a prosodic word is a monosyllable, it must be heavy (e.g. *dor*, *dā*, **da*; §3.1). Third, meters regulate the distribution of heavies and lights. For example, the penultimate syllable of a line of the epic meter, the hexameter, must be heavy.

Aside from this so-called LATIN CRITERION, which applies equally to Sanskrit and many other languages, another common binary criterion for weight treats a syllable as heavy iff it contains a long vowel or diphthong, ignoring the presence or absence of the coda. These are the two most frequent criteria, but numerous other schemes are attested, including sonority cutoffs, where only a subset of vowels or consonants induce heaviness. The specific criterion varies across languages and phenomena. Even within the same language, different processes often exhibit different criteria (Gordon 2006). But in every case, heavy syllables are aggregately longer or more sonorous than light syllables.

Beyond binary criteria, ternary and more complex scales for weight are also well attested. The most common ternary scale is V < VC < VV, as found in the stress systems of at least twenty languages (not counting extrametricality effects; Chapter 2) and additional cases from meter and end-weight (Chapters 4–5).[2] Quaternary V < VC < VV < VVC is also encountered in several languages and systems. In Kashmiri (Morén 2000) and Pulaar (Niang 1997, Wiltshire 2006), for instance, stress falls on the leftmost instance of the heaviest grade from this scale that is available nonfinally in the word. Finally, some scales are highly complex and quantifiable, effectively dissolving, in the extreme case, into gradient continua of weight, as treated in §2.8 for stress, §4.4 for meter, and Chapter 5 for end-weight.

In summary, PROSODIC WEIGHT refers to the categorization or scalar arrangement of syllables or larger prosodic constituents based on their prosodic behavior. Such categorization is often dichotomous; for some processes, such as stress, it is usually so.

[2] V refers to a short vowel, VV a long vowel or (heavy) diphthong, and C a consonant. Onsets are omitted. Throughout, I arrange scales from lightest to heaviest.

But it is often more complex. While most previous research on weight focuses on binary systems or the phonetic basis of categorization, the present volume puts greater emphasis on the phonological analysis of complex and gradient scales. Complex scales are more widespread than previously appreciated and yield critical insights into otherwise thinly evidenced weight universals.

The remainder of the chapter comprises four sections, which respectively survey the range of weight-sensitive phenomena (§1.2), enumerate weight universals (§1.3), outline the book's scope and major findings (§1.4), and overview the weight-mapping apparatus (§1.5).

1.2 Weight-sensitive systems in phonology

Phonological weight plays a role in several grammatical systems, including stress, prosodic minimality, meter, end-weight, tone licensing, compensatory lengthening, syllable structure, reduplication, and (non-reduplicative) allomorphy. These areas are briefly surveyed in this section. More in-depth introductions to the first four areas are provided at the beginnings of the next four chapters, respectively.

First, as just mentioned for Latin, syllable weight can affect stress placement. Roughly 40 per cent of the world's stress systems are QUANTITY-SENSITIVE. Consider Khalkha Mongolian (Walker 1997). Khalkha has codas, but they do not count for weight. A syllable is heavy iff it contains a long vowel or diphthong, sometimes referred to as the KHALKHA CRITERION. Primary stress (notated by ˈ at the beginning of the syllable) is attracted to a heavy syllable anywhere in the word, as in (4). If multiple heavies cooccur, the rightmost nonfinal heavy receives primary stress. If no heavy is present, the initial syllable receives primary stress. Additionally, secondary stress (notated ˌ) occurs on any remaining heavies and optionally on the initial syllable if it lacks primary stress.

(4) a. ˈxada 'mountain'
b. ˈunʃisan 'having read'
c. ˌgaˈluː 'goose'
d. ˌdoˈloːduˌgaːr 'seventh'
e. ˌuˌlaːnˌbaːtˈriːnxan 'residents of Ulaanbaatar'
f. ˈuitgarˌtae 'sad'
g. ˈaːˌruːl 'dry cheese curds'

Second, prosodic minimality refers to the minimum legal size of a prosodic word. For example, in some languages, a prosodic word must be at least two syllables long. In others, prosodic words are permitted to be monosyllables, but only syllables of a certain size qualify. Consider Thurgovian Swiss German (Kraehenmann 2001, 2003, Muller 2001, Ringen and Vago 2011, Topintzi and Zimmermann 2014). A monosyllable in this dialect must contain a long vowel or complex coda, as in (5) (similarly in Icelandic; Kager 1999:268). The productivity of such a minimum is evident from repairs. In Thurgovian, a subminimal input is repaired by lengthening the vowel, as in (6). One can tell that the vowel is underlyingly short in such cases from suffixed forms such as the plural. Other evidence rules out an analysis in terms of shortening in suffixed forms.

(5) a. ʃilf 'reed'
b. ʀuːʃ 'rouge'
c. jakə 'to hunt'
d. *ʃi, *ʃil, *ʀuʃ, *jak

(6) a. /has-e/ hase 'hares'
b. /has/ haːs 'hare'
c. /ttak-e/ ttake 'days'
d. /ttak/ ttaːk 'day'

Prosodic minimality is sometimes also invoked for prosodic constituents above the prosodic word. For example, BinMin(φ, ω) requires a prosodic phrase to dominate at least two prosodic words (Selkirk 2011; see also Zec and Inkelas 1990, Inkelas and Zec 1995).

Third, weight is regulated in quantitative meter. For example, a verse of Vedic Sanskrit *gāyatrī* is given in (7). In this meter, which is related to the *śloka* meter in §1.1, a verse comprises three octosyllabic lines, and lines normally (with some exceptions) observe the weight template in (8), in which ◡ notates a position that is typically light and _ one that is typically heavy (Oldenberg 1888, Arnold 1905). In fact, this schema is an oversimplification, as certain other tendencies apply, some of which are relational and therefore cannot be expressed by a unigram model. For example, the second and third positions are rarely both light (see also Kiparsky 2018).

(7) a. vā́.ya.v ā́ .yā.hi .dar.śa.ta (Ṛg-Veda 1.2.1)
b. i.mé .só.mā .á.raṃ.kr̥.tāḥ
c. té.ṣām .pā.hi ś.ru.dhī́ .há.vam

(8) ××××◡_◡×

Other quantitative meters lack a fixed syllable count by virtue of allowing moraic substitutions. For example, the Sanskrit/Prakrit *āryā* meter contains lines of eight metra each, where most metra are required to be four moras (i.e. ◡◡◡◡, ◡◡_, _◡◡, __, or ◡_◡). Further restrictions apply; for example, odd-numbered metra cannot be ◡_◡ (§4.1).

Fourth, prosodic end-weight describes the tendency of prosodically heavier constituents to be localized domain-finally, all else being equal. This tendency is widespread cross-linguistically, but not universal. For example, in English and many other languages, coordinate phrases favor heavy-final orders, as in (9) (cf. e.g. Benor and Levy 2006, Mollin 2012, Morgan and Levy 2016). To a first approximation, this means that words with more syllables, longer vowels, and/or more complex margins are favored finally. This continues to hold when one controls for other factors influencing word order (including semantics, frequency, syntactic complexity, phonological complexity, etc.), through regression or experiments such as nonce-word ordering tasks. When constituents are monosyllables, as in (a–d), gradations of syllable weight are revealed. But end-weight also implicates the weight of larger prosodic constituents.

(9) a. pick and choose
b. cap and gown
c. tit for tat
d. meet and greet
e. dead or alive
f. nook and cranny

Fifth, tone or pitch accent licensing is often treated as being weight-driven, usually in the sense that contour tones are confined to heavy syllables (e.g. Hyman 1985, Zec 1988, Zhang 2004, Gordon 2006). For example, in Thai, the full range of five tones (high, low, mid, rising, and falling) is available only on syllables with a long vowel or sonorant coda. The rimes V(ʔ) and VT (where T is an obstruent) support only two level tones, high and low (Gandour 1979). This Thai criterion, with its sensitivity to coda sonority, is perhaps the most widespread for tone licensing, unlike in stress and other systems, where it is also attested, but less commonly.

Sixth, compensatory alternations are usually taken to be weight-driven, in that they preserve mora count (e.g. Hayes 1989, Davis 2003, Beltzung 2008, Topintzi 2010, Kiparsky 2011). Perhaps the most common such pattern is the lengthening of a vowel to compensate for a lost coda, as in Ionic Greek *ēmi* 'am' (from earlier **esmi*; cf. Sanskrit *asmi*) or English *tooth* (Old English *tōþ*, from earlier Germanic **tanþ-*; cf. Sanskrit *dant-*). Consonant lengthening is another possible response, as in Aeolic *emmi* from **esmi*. Insofar as onsets do not bear weight, they are predicted not to participate in compensatory alternations, though several cases have been reported (e.g. Topintzi 2010 and references therein on Samothraki Greek, Pattani Malay, Trique, Trukese, Onondaga, etc.; cf. Loporcaro 1991:280, Kavitskaya 2002, Kiparsky 2011). Additionally, the duration or complexity of the onset trades gradiently with the duration of the vowel (Browman and Goldstein 1988, Katz 2010, 2012, Ryan 2014, Mai 2018). Figure 1.1 is based on the Buckeye corpus of conversational English (Pitt et al. 2007). It considers only primary stressed /ɪ/ in the initial syllables of disyllabic nouns. As onset size increases from zero to three consonants, /ɪ/ becomes shorter, the first two comparisons being significant (Mann-Whitney-Wilcoxon $p < .0001$). While this effect is phonetic, Ryan (2014), as here, maintains that onset complexity can affect weight in nearly every type of weight-sensitive phonological phenomenon. As an example of how onset-nucleus compensation plays out in the phonology of English, as onset complexity increases, the following vowel is increasingly less likely to be phonemically long (i.e. tense or diphthongal). Figure 1.2 is based on the initial syllables of all initially stressed, disyllabic nouns in CELEX (Baayen et al. 1993). The (near-)low vowels /æ, ɑ, ɔ/ are excluded, as their classification as long vs. short is less robust. The first two comparisons in Figure 1.2 are significant (Fisher's exact test $p < .0001$). Note the parallelism between phonetic trading off in Figure 1.1 and phonotactic trading off in Figure 1.2. The distinction between zero and one consonants is the most extreme, tapering off rapidly with greater onset complexity.

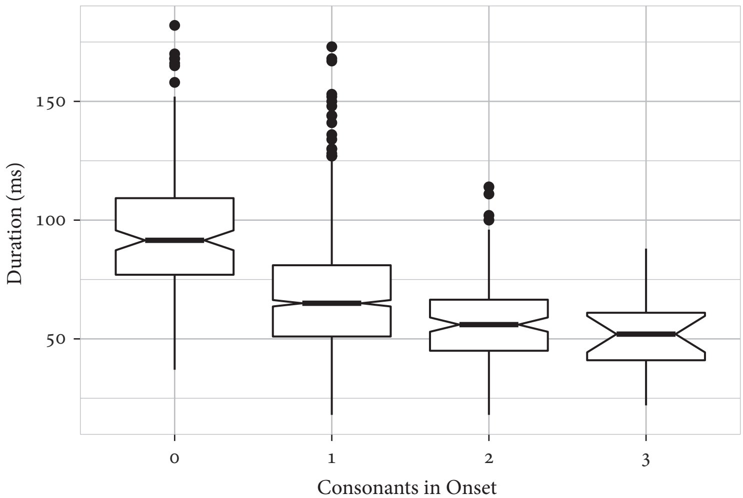

Figure 1.1 Primary stressed /ɪ/ in the initial syllable of a disyllabic noun is progressively shorter with progressively more complex onsets in the Buckeye corpus.

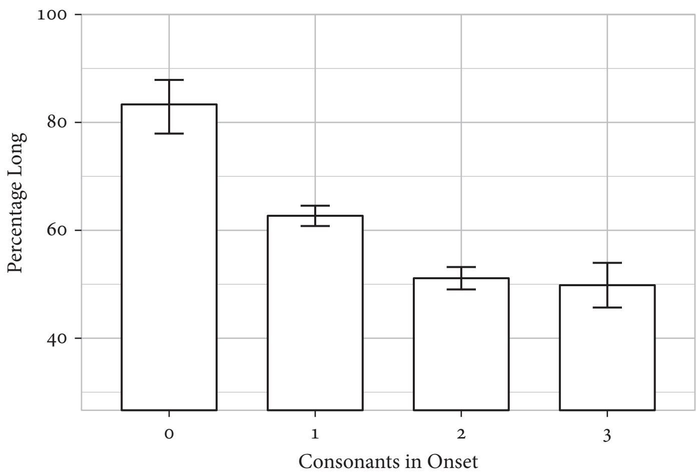

Figure 1.2 Long vowel incidence decreases as onset complexity increases. Based on the initial syllables of initially stressed, disyllabic nouns in English (CELEX).

Compensatory effects are documented also for prosodic constituents above the syllable. For example, even holding stress constant, the durations of two syllables composing a foot can trade off, as in Sami and Finnic languages (see Türk et al. 2018 for a survey) and in the Aŭciuki dialect of Belarusian and other Slavic languages (Borise 2017). Such effects can be phonologized in terms of moraic restrictions (Borise 2017, 2018). Moreover, as more material is added to the prosodic word, the constituents of that word are increasingly compressed, as with POLYSYLLABIC SHORTENING (Lehiste

1972, Lindblom and Rapp 1973, Port 1981, White 2002, White and Turk 2010). But this word-level DURATIONAL INVARIANCE ("smoothing" or "averaging" would be more apt)—regression towards the mean word duration by compressing long words or lengthening short ones—cannot explain the syllable- and foot-level compensatory effects just discussed, as they are local to their units. For instance, increasing onset complexity has a stronger effect on the immediately following vowel than on other vowels in the word. Compensatory processes obtain across levels of the prosodic hierarchy.

Seventh, and relatedly, languages often impose constraints on syllable structure that are related to weight, such as a maximum number of moras per syllable. For example, in Koasati (§2.7.1) and Prakrit (§3.3), a coda cannot cooccur with a long vowel. This type of restriction is usually explained in terms of a moraic maximum: Assuming that a coda contributes a mora, a long vowel plus coda would exceed the bimoraic cap on syllables. Pulaar, for its part, permits word-initial geminates, but only if the immediately following vowel is short (Niang 1997:70). In Icelandic, a stressed vowel cannot be long in a nonfinal syllable that contains a coda (e.g. *harður* 'hard'; **haːrður*), once again reflecting a bimoraic maximum for syllables (Kager 1999:268). In final position, a stressed vowel can be long before a simple coda, but not before a complex coda or geminate, reflecting the same constraint but with final consonant extrametricality (*ibid.*; §2.6.4).

Eighth, reduplication can be affected by weight. In Mokilese, for instance, the reduplicant must be a heavy syllable (McCarthy and Prince 1986, Blevins 1996). This heavy target is enforced on the surface by various strategies, as in (10). If the base is C-initial, copying the initial CVC is sufficient to ensure that the reduplicant is heavy (a–b). But if the base is C-initial and no following C is available to copy, the vowel must be lengthened, as in (c–d). If the base is V-initial, either a cluster must be copied (e) or, if no cluster is available, C must be lengthened (f). If a single C were copied but not lengthened before a V-initial base, it would resyllabify as an onset, yielding an illicit light reduplicant.

(10)	a.	**pɔd-**.pɔ.dok	'planting'
	b.	**pok-**.po.ki	'beating'
	c.	**paː-**.pa	'weaving'
	d.	**wiː-**.wi.a	'doing'
	e.	**an.d-**an.dip	'spitting'
	f.	**al.l-**a.lu	'walking'

Compare also quantitative complementarity in reduplication, as seen for Sanskrit in §1.1. Another case, from Ponapean, is exemplified in (11) (McCarthy and Prince 1986). If a monosyllabic base is heavy, the reduplicant is light (a–b). If the base is light, the reduplicant is heavy (c–d).

(11)	a.	**du-**duːp	'dive'
	b.	**ma-**mand	'tame'
	c.	**paː-**pa	'weave'
	d.	**lal-**lal	'make a sound'

Finally, (non-reduplicative) allomorphy is sometimes sensitive to the weight profile of the stem. Consider the Estonian genitive plural suffix of vowel-final stems in (12) (Mürk 1991, Kager 1996, Ryan 2016). In a word with no superheavy syllables, the suffix is *-te* when the base has an even number of syllables (a–b), and otherwise *-tte* (c). If the word contains a superheavy syllable, this parity is reversed (d–e). Kager (1996) analyzes this allomorphy as being foot-driven, as the parenthesized feet in (12) suggest. The suffix is geminated iff doing so would close a stressed syllable, making it heavy.

(12)
a. (vísa)-**te** 'tough (gen. pl.)'
b. (téle)(fòni)-**te** 'telephone (gen. pl.)'
c. (pára)(jà-**tte**) 'suitable (gen. pl.)'
d. (áasː)(tà-**tte**) 'year (gen. pl.)'
e. (áatː)(riùmi)-**te** 'atrium (gen. pl.)'

While many cases of weight-sensitive allomorphy reduce to metrical structure, as in Estonian, it is not clear that this always holds. In Finnish, for instance, nominalizing *-ntV* has high and low allomorphs (*-nti* and *-nta* ∼ *-ntä*, respectively; Anttila 2006). Anttila (2006) finds that the strongest predictor of the choice between these allomorphs is the weight of the ultima of the stem, not its stress or foot structure. Affix location may also be sensitive to weight. For example, in Amharic, a syllable is heavy iff it is closed by a geminate (Sande 2014, Sande and Hedding 2017). Adjective pluralization and verb iterativization is marked by an infixing CV reduplicant, but only if the base contains a geminate, in which case the reduplicant immediately precedes the geminate. If the base lacks a geminate, reduplication cannot be employed. As Sande (2014) argues, this attraction must be driven by weight, not stress: All bases have stress, but only those containing a heavy allow reduplication.

1.3 Universals of weight

This section reviews some properties of weight that hold across languages and processes. Some of these universals are non-controversial, though I adduce new evidence for nearly all of them in this book. Some, however, may not be widely acknowledged, such as the systematic reversal in the treatment of sonority between the onset and rime (see especially Gordon 2005 and Ryan 2014), or onset complexity effects, both of which receive further support from new studies here. I consider the nucleus, coda, and onset in turn. Each universal is labeled $x \leq y$, which indicates an implicational universal: If the weights of x and y are distinguished, x is lighter. Of course, x and y can also be conflated.

In the nucleus, greater length and sonority correlate with greater weight. Long vowels are if anything heavier than short vowels (V $\leq$ VV), and full (or peripheral) vowels are if anything heavier than reduced (or central) vowels (ə $\leq$ V). Weight can be sensitive even to subphonemic duration, as with end-weight in Figure 5.2. In terms of sonority, lower is if anything heavier (notated "I $\leq$ A"), with the exact cutoff(s) varying (e.g. de Lacy 2004:193). Note that duration and sonority are largely confounded in the nucleus, in that lower vowels are usually longer cross-linguistically

(Lehiste 1970, Westbury and Keating 1980), though height-conditioned length differences are not always significant (de Lacy 2007:294). When it comes to distinctive vowel length, however, there is perhaps no case in which a phonemically short vowel (e.g. [a]) outweighs a phonemically long vowel (e.g. [iː]) by virtue of the former's greater sonority.

The coda behaves like the nucleus, in that greater length/complexity and sonority correlate with greater weight. The presence vs. absence of a coda conditions heaviness in numerous cases (Ø ≤ C), including several already discussed. Coda complexity can also affect weight (C ≤ CC), though this is considerably less common. Most apparent cases of C ≤ CC can be attributed to final consonant extrametricality, such that the distinction is really Ø ≤ C, ignoring the word-final consonant. Nevertheless, word-internal C < CC is attested at least for stress (e.g. Hindi) and meter (e.g. Persian and Vedic Sanskrit) and is also characteristic of gradient systems (§2.8). Moreover, not all word-final complexity effects can be explained by extrametricality (e.g. English final Ø < C < CC < CCC in §2.8.3). Additionally, coda sonority can condition weight, as found in stress, meter, end-weight, tone licensing, and syllable structure. I notate this generalization "T ≤ N," though the cutoff need not coincide exactly with obstruents vs. sonorants.

While onsets are traditionally regarded as being inert with respect to weight, this book, like Topintzi's (2010) book on onset weight, supports a rather different outlook (see also Ryan 2014 and references therein). Onset weight is secure across the four metrical domains treated in detail in this book. In fact, weight effects based on sonority and complexity (as opposed to presence vs. absence) appear to be no less common for onsets than for codas. As in the coda, presence vs. absence can condition heaviness (Ø ≤ C). Onset complexity effects (C ≤ CC) are clear from gradient weight in stress, meter, and end-weight, as well as from categorical prosodic minimality and possibly categorical stress (Gordon 2005; cf. Topintzi 2010). Onset sonority can also affect weight in stress, meter, and end-weight, but in the opposite direction as in the coda: For the onset, less sonority correlates with greater weight (N ≤ T). As with the coda, the sonority cutoff is not necessarily sonorants vs. obstruents, but can fall at other sonority divisions (e.g. voiced < voiceless). In short, universally across languages and systems, sonority contributes to weight in the rime, but detracts from it in the onset. On possible phonetic rationales for this reversal, see §5.9.4.

Related to the weight-augmenting effect of sonority in the rime, the whole rime VC is if anything lighter than the whole rime VV (VC ≤ VV). The criterion VC < VV, that is, the Khalkha criterion, is common, but its reversal is arguably unattested for prominence mapping systems (see footnote d to Figure 1.3 and Chapter 2, especially §2.7.2, for further discussion). This (near-)universal continues to hold when further slots are appended to the rime, for example, VCC ≤ VVC and VCCC ≤ VVCC. Thus, a V slot is universally heavier (if anything) than a C slot, owing to the former's greater sonority.

Next, consider geminates. Intervocalically, a geminate (e.g. [ap.pa]) is if anything heavier than a cluster (e.g. [ak.ta]). In fact, the two are almost always equivalent (cf. the Principle of Equal Weight for Codas; Tranel 1991), but some cases of C.C < G are attested for stress (e.g. Amharic, Cahuilla, San'ani Arabic). The reversal is arguably unattested (on two ostensible exceptions from Ngalakgan and Tashlhiyt Berber, see §2.6.7). CC ≤ G also appears to hold in margins (e.g. onset G vs. CC; Topintzi and Davis 2017).

Beyond geminates vs. clusters, one might ask more generally whether geminates are always moraic. In this book, I tentatively support the Moraic Theory of Geminates, though I do not wish to take a strong position on the question, since I do not address every potentially relevant case here (see the end of §2.6.4 for one type of case I do not address, as it concerns syllable structure). I do, however, reanalyze most of the claimed exceptions. First, in some stress systems, including Malayalam, Selkup, and at least a dozen other languages (§2.6.1), VG is light for stress (with VC), while VV is heavy. A traditional response to this situation has been to treat geminates as nonmoraic in such cases (cf. Selkirk 1990, Tranel 1991, Blevins 1995). However, as I analyze these cases in Chapter 2, they reflect attraction of stress to the long vowel, permitting geminates to remain moraic. Indeed, in some such cases, syllables closed by geminates attract secondary stress, corroborating their moraicity even when they yield stress to heavier VV. Cases of alleged nonmoraic geminates in margins are similarly reanalyzed here. In Leti, for instance, VV but not GV is said to condition stress (though the facts are not secure), as I analyze via long-vowel attraction (§2.6.6). Certain prosodic minima, including Leti and Thurgovian Swiss German, are said to treat geminates as nonmoraic, but the evidence is ambiguous in these cases, as addressed in §3.1. Thus, while it is not a specific aim of this book to defend the Moraic Theory of Geminates, because I adopt Vowel Prominence as a theory of VC < VV, most of the claimed exceptions to that theory are subject to reanalysis, potentially vindicating it.

The aforementioned universals are summarized in Figure 1.3. A checkmark indicates that the given polarity is attested at least once in the given phenomenon. The reversals of the universals (e.g. VV < V) are also shown in shaded rows. I include these to make explicit that the reversals are, for the most part, unattested, though some of the cells have footnotes. After all, a potential universal of the form $x \leq y$ is not undermined by its lack of attestation in a particular phenomenon; it is undermined only if its reversal is attested. Including both polarities of each pair makes explicit this distinction between "absence of evidence" and "evidence of absence." The "cat." and "grad." headers stand for categorical and gradient, respectively, and indicate whether the attested cases arise from categorical criteria/scales, gradient weight systems, both, or neither. This distinction is largely irrelevant for minimality and end-weight. Prosodic minimality is canonically categorical and prosodic end-weight is canonically gradient, though see §6.4 on exceptions to both.

An implied ceteris paribus clause accompanies all of these universals. They might be locally violated when another factor interferes. For example, in Huehuetla Tepehua, only a coda containing a sonorant is moraic, entailing that a simplex coda containing a sonorant (e.g. [an]) outweighs a complex coda containing only obstruents (e.g. [aɬtʃ]) (Kung 2007; §2.7.2). Certain VC therefore outweighs certain VCC_1, but this does not violate the C ≤ CC universal for codas, since the ostensible counterexamples are not in a containment relation. If sonority is held constant, C ≤ CC holds. As a second example, in Nanti, the rime [a] attracts primary stress away from the rime

[in], reflecting the precedence of nuclear sonority over coda presence for primary stress (Crowhurst and Michael 2005:78). While in this case a particular V outweighs a particular VC, Nanti exhibits V < VC when one controls for sonority.

Figure 1.3 is not exhaustive, especially as concerns near-universals. For instance, one might add that if a weight scale is ternary or greater, it almost always includes V < VC < VV, as in dozens of cases from stress and meter. V < VX < VXX (where X is C or V), for its part, is rare as a ternary weight scale, being attested, for instance, in

		Stress		Meter		Minimality	End-Weight
		cat.	grad.	cat.	grad.	cat.	grad.
Nucleus	V < VV	✓	✓	✓	✓	✓	✓
	VV < V						
	ə < V	✓					
	V < ə						
	I < A	✓	✓		✓		✓
	A < I						
Coda	Ø < C	✓	✓	✓	✓	✓	✓
	C < Ø						
	C < CC	✓	✓	✓	✓	✓	✓
	CC < C						
	T < N	✓	✓[a]		✓		✓
	N < T						
Onset	Ø < C	✓	✓		✓	✓	✓
	C < Ø						
	C < CC	[b]	✓		✓	✓	✓
	CC < C						
	N < T	✓	(✓)[c]		✓		✓
	T < N						
Other	VC < VV	✓	✓	✓	✓	✓	✓
	VV < VC	[d]					
	CC < G	✓				[e]	
	G < CC	[f]			(✓)[g]		

FIGURE 1.3 Universals of weight across metrical weight phenomena. A checkmark indicates that the given contrast is attested in the given phenomenon. Both orders of each contrast are presented to make explicit the universality of the polarities. The illicit polarity is shaded. Evidence from categorical ("cat.") vs. gradient ("grad.") systems is distinguished.

[a] Hinton and Luthin (2002) suggest this for Yahi (§2.8.2). Garcia (2017a) suggests it for English (§2.8.3).
[b] Gordon (2005) mentions Bislama and Nankina as potential cases, but they may not be secure (Topintzi 2010:223).
[c] Ryan (2014) suggests this for English.
[d] Potential counterexamples from Dutch, Tiberian Hebrew, and Huehuetla Tepehua are tempered in §2.7.2. A handful of cases from pitch accent systems have also been put forth (*ibid.*).
[e] Initial geminates count as heavy for prosodic minimality in some languages, though I am not aware of such a case in which initial clusters are also available, to compare CC (cf. Topintzi and Davis 2017).
[f] Geminates are claimed to be lighter than certain clusters in Ngalakgan, but see §2.6.7 for further considerations.
[g] Geminates, unlike clusters, optionally scan as light in Tashlhiyt Berber. On a possible vowel length confound, see §2.6.7.