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LINGUISTICS

PHONOLOGICAL TYPOLOGY

Matthew K. Gordon

Oxford Surveys in Phonology and Phonetics

Phonological Typology

OXFORD SURVEYS IN PHONOLOGY AND PHONETICS

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PUBLISHED

1 *Phonological Typology*
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OXFORD

UNIVERSITY PRESS

Great Clarendon Street, Oxford, OX2 6DP,
United Kingdom

Oxford University Press is a department of the University of Oxford.
It furthers the University's objective of excellence in research, scholarship,
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First Edition published in 2016

Impression: 1

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Published in the United States of America by Oxford University Press
198 Madison Avenue, New York, NY 10016, United States of America

British Library Cataloguing in Publication Data
Data available

Library of Congress Control Number: 2015950969

ISBN 978-0-19-966900-4 (hbk)
978-0-19-966901-1 (pbk)

Printed in Great Britain by
Clays Ltd, St Ives plc

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Phonological Typology

MATTHEW K. GORDON

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Acknowledgments

Many people have contributed to this book in a multitude of ways including conceptualizing the project, pointing out useful resources, discussing the ideas presented, reading and commenting on earlier drafts, conducting the typological surveys that figure prominently in the book, and proofreading and formatting the manuscript. Thanks to the following people for providing insightful and very useful feedback on prior versions of the manuscript: Eric Campbell, Germán Coloma, Danny Hieber, Bob Kennedy, Don Killian, Jaye Padgett, Bert Vaux, Jie Zhang, and an anonymous reviewer consulted by Oxford University Press. Thank you to Jeff Mielke and two other anonymous reviewers of the book proposal for providing invaluable aid in the conceptualization of the book. Caroline Crouch and Hannah Yates were essential contributors to the construction of the typological database on phonological patterns, and Daniel Chui, Megan Lukaniec, and Stefan Morse generously supplied some of the phoneme data frequency appearing in Chapter 3. Kaveh Varjoy provided helpful formatting assistance and Karen Tsai offered invaluable help with proofreading and indexing.

Many others have informed the contents of this book on various levels (my apologies to anyone I've forgotten), including Adam Albright, Ayla Applebaum, Wally Chafe, Bernard Comrie, Megan Crowhurst, Stuart Davis, Paul de Lacy, Edward Flemming, Carol Genetti, Stefan Gries, Bruce Hayes, Jeff Heinz, Harry van der Hulst, Larry Hyman, Junko Ito, Sun-Ah Jun, Pat Keating, Michael Kenstowicz, the late Peter Ladefoged, Anja Lunden, Ian Maddieson, Jack Martin, Armin Mester, Marianne Mithun, Pam Munro, Erich Round, Kevin Ryan, Russ Schuh, Donca Steriade, Richard Wright, Kie Zuraw, as well as participants in my 2012 seminar on phonological typology (Daniel Chui, Megan Lukaniec, Brad McDonnell, and Stefanie Morse), my advanced undergraduate phonology class in 2014 (Danny Epp, Yashua Ovando, Kaveh Varjoy, Meagan Vigus, and Alicia York), and my graduate phonology class in 2015 (Anna Bax, Kendra Calhoun, Caroline Crouch, Kayla Eisman, Danny Hieber, Jessi Love-Nichols, Phill Rogers, Kevin Schäfer, Nate Sims, Morgan Sleeper, and Brendon Yoder).

I gratefully acknowledge the financial support of the UCSB Academic Senate for generously providing a grant for compiling the typological survey.

Thanks to Bill Idsardi and Bert Vaux for conceiving this book and offering me the opportunity to write it, and to John Davey, Lisa Eaton, Jen Moore, Julia Steer, and Victoria Sunter of Oxford University Press for providing crucial logistical support in its preparation.

A heartfelt debt of gratitude is especially owed my wife, Rhonda, and two sons, Eamon and Brendan, for their unflagging support throughout the lengthy process of seeing this book through to completion.

List of abbreviations

ATR	advanced tongue root
CHT	Co-articulation Hypercorrection Theory
CMU	Carnegie Mellon University
GLA	Gradual Learning Algorithm
HG	Harmonic Grammar
IPA	International Phonetic Association Alphabet
OCP	Obligatory Contour Principle
OT	Optimality Theory
PHOIBLE	Phonetics Information Base and Lexicon
TBU	tone-bearing unit
ULSID	UCLA <i>Lexical and Syllabic Inventory Database</i>
UPSID	UCLA <i>Phonological Segment Inventory Database</i>
VOT	voice-onset-time
WALS	<i>World Atlas of Language Structures</i>

Introduction

Phonological typology is concerned with the study of the distribution and behavior of sounds found in human languages of the world. One thread of typological research in phonology involves defining the range of cross-linguistic variation and the relative frequency of phonological patterns. Another line of investigation attempts to couch these typological observations within theories designed to model and explain the human knowledge of and capacity to acquire phonological systems. Both of these research programs require a cross-linguistic database from which to draw generalizations. They often differ, however, in the ultimate purpose to which the typological data is put to use, a difference that has consequences for the methodology employed by the researcher. Because phonological theory dating back to work by Trubetzkoy (1939), Hockett (1955), Jakobson (1962), Jakobson et al. (1963) has characteristically been concerned with explaining and modeling cross-linguistic variation, typology has become largely inseparable from most research in phonology, a close bond that is obvious even in casual inspection of the phonology literature (Hyman 2007a). Most chapters in recent handbooks of phonological theory explore particular phonological phenomena, e.g. phoneme inventories, syllable structure, harmony processes, etc., providing an overview of the typology of the relevant phenomenon and a summary of theories designed to account for the range of patterns. One of the current dominant paradigms in phonological theory, Optimality Theory, is well suited to capturing typological variation since it employs a set of competing constraints on phonological well-formedness that can be prioritized differently in different languages (see Chapter 2 for discussion).

1.1 Phonological typology exemplified: the case of sonority

To illustrate the role of typology in phonological theory, let us consider the property of sonority, which, though difficult to pinpoint phonetically (see Parker 2002, 2008, 2011), corresponds roughly to a measure of acoustic loudness. Phonologically, sonority manifests itself through a number of phonological phenomena that are sensitive to a prominence scale like the one in Figure 1.1 (Clements 1990, Parker 2002, 2008).

One example of the sonority scale at work comes from the formation of diphthongs in the Austronesian language Tahitian (Bickmore 1995). In Tahitian, a sequence of vowels constitutes a diphthong if the first vowel is higher in sonority than the second vowel where sonority is determined by the following scale /a/ > /e,o/ > /i,u/ (1a). If the second vowel is higher in sonority, the two vowels are

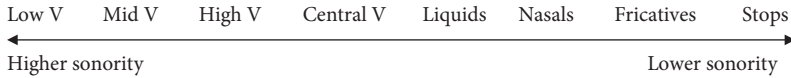


FIGURE 1.1. Sonority hierarchy

parsed into separate syllables (1b). If the two vowels are equivalent in sonority, they are generally also parsed into separate syllables (1c), though Bickmore reports diphthongal pronunciations as an optional variant in such cases (p. 414).¹

(1) Diphthongs in Tahitian (Bickmore 1995: 413–14)

- | | | |
|-----|--------------------|--------------------------------|
| (a) | ho.'roi | 'wash' |
| | pa.'rau | 'speak' |
| | ma.'hae | 'torn' |
| | ?a.'?ai | 'story' |
| | piri.'pou | 'pants' |
| | '?ae.to | 'eagle' |
| | fa.'rao.a | 'bread' |
| (b) | ti.'a.re | 'flower' |
| | mo.'a.na | 'ocean' |
| | te.'a.ta | 'theater' |
| | ?i.'o.re | 'rat' |
| | hu.'e.ro | 'egg' |
| | fe.pu.'a.re | 'February' |
| (c) | no.'e.ma ('noe.ma) | 'November' |
| | ?a'pi.u ('?a'piu) | 'sheet of <i>purau</i> leaves' |

As the examples in (1) show, the distinction between vowels forming a diphthong and vowels belonging to separate syllables is relevant for stress, which falls on the final syllable if it contains a long vowel or diphthong, otherwise on the penult. The entire diphthongal sequence in the forms in (1a) thus carries stress, whereas stress is localized to the second vowel in the vocalic sequences in (1b).

The stress system of Armenian provides evidence for another section of the sonority hierarchy: the lower sonority status of central vowels relative to all peripheral vowels whether low, mid, or high. Stress in most varieties of Armenian (Vaux 1998, Gordon et al. 2012) falls on the final syllable (2a) unless this syllable contains schwa in which case stress shifts to the penult (2b).²

(2) Armenian stress

- | | | |
|-----|----------------------|------------|
| (a) | hɑ'sɑk | 'age' |
| | sə'p ^h ɛl | 'to clean' |
| | hi'sun | 'fifty' |
| | hə'ɛi | 'pregnant' |

¹ The sequence /eu/ is an exception to these generalizations in that it is parsed as two syllables despite having a falling sonority profile: 'pe.u 'custom', 'pe.re.'u.e 'coat' (p. 414).

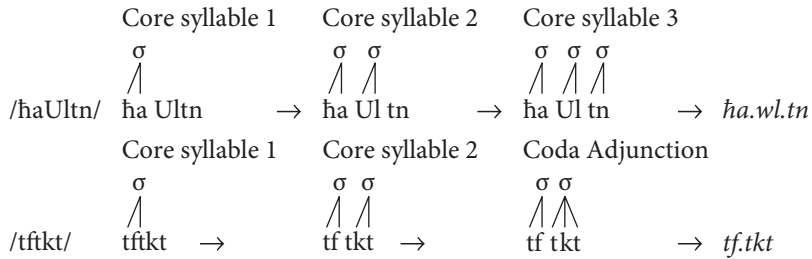
² Thanks to Bert Vaux for the forms in (2b).

- (b) 'lik^hə 'full'
- 'tasə 'ten'
- 'sarə 'cold'
- 'inə 'nine'

As the examples show, a low, mid, or high vowel all attract stress in final position whereas a schwa does not.

Sonority is also relevant for consonants, as syllabification in the Afro-Asiatic language Tashlhiyt Berber illustrates (Dell and Elmedlaoui 1985, 1988). Syllabification proceeds from left to right within a word selecting the leftmost sound of highest sonority as a syllable nucleus and the immediately preceding sound to form a core syllable consisting of an onset and nucleus. The parse continues moving from higher to lower sonority sounds with the proviso that all non-initial syllables must have a syllable onset. Leftover sounds that are neither syllabified as syllable onsets or nuclei are adjoined as syllable codas. The syllabification of two Tashlhiyt words, *ħa.wl.tn* 'make them (masc.) plentiful' and *tf.tkt* 'you suffered a sprain', is illustrated in (3).

(3) Syllabification of two Tashlhiyt words (Dell and Elmedlaoui 1985: 110, 113)



Looking first at *ħa.wl.tn*, its underlying form is /ħaUltn/ (Dell and Elmedlaoui 1985: 110), where U stands for a not-yet-syllabified high front vocoid. During the initial parse the sequence /ħa/ is grouped into a syllable (core syllable 1) with the highest sonority sound /a/ constituting the nucleus and the pharyngeal fricative the onset. The scan continues to the right of /a/ grouping together /l/, the next highest sonority segment that has an available highest onset preceding it, with the immediately preceding /U/ (core syllable 2). Finally, the sequence /tn/ is parsed as a syllable (core syllable 3) with /n/, the next most sonorous sound in the sonority hierarchy, serving as the nucleus. The resulting form is *ħa.wl.tn*, where [w] is the phonetic realization of /U/ in onset position.

The word *tf.tkt* (Dell and Elmedlaoui 1985: 113) illustrates typologically rarer types of syllable nuclei. In this word, /f/ is the highest sonority segment and accordingly is parsed as a nucleus with the preceding /t/ serving as its onset (core syllable 1). The next highest sonority segment to the right of /f/ that has an available preceding onset is /k/; they together thus form a syllable (core syllable 2). Finally, the only available option for the word-final /t/ is to be adjoined as a coda of the second syllable. The final parse is thus *tf.tkt*.

As we have seen in our discussion of Tahitian, Armenian, and Tashlhiyt, not all languages are sensitive to all distinctions projected along the sonority scale in Figure 1.1. A crucial prediction of the sonority hierarchy, however, is that no language will display sonority reversals. For example, no stress system should preferentially stress central vowels over high vowels, or high vowels over mid vowels, or mid vowels over low vowels. Stated another way, stress on central vowels in a given context implies stress on high vowels in the same context, which in turn implies stress on mid vowels, which in turn implies stress on low vowels. Similarly, the syllabification of a stop as a syllable peak implies that a nasal in the same context also syllabifies as a nucleus (see Chapter 4 on syllables for more discussion of sonority). All phonologists are interested in establishing implicational relations of the type governing stress and syllabification. Since discovering these implications crucially relies on a broad cross-linguistic database, one can say that the vast majority of phonologists are also typologists.

1.2 Frequency in phonology: phonology in typology

There is another type of research that is an integral part of linguistic typology but that has played a less prominent role in phonology: the investigation of frequency distributions across languages. (Frequency can also be examined within languages, a point to which we return in section 1.3.2.) One might thus ask whether languages like Armenian that are sensitive to vowel quality in their stress systems are common or not. (It will be shown in Chapter 6 that stress systems based on vowel quality are moderately common though less common than other types of stress systems.) Similarly, one might wonder whether languages like Tashlhiyt Berber that permit fricatives and stops as syllable nuclei are widely attested in the world. (Results presented in Chapter 4 indicate that they are quite rare.) A survey designed to investigate cross-linguistic frequency must control for factors such as genetic affiliation and geographic distribution in order to minimize confounds due to language contact or inheritance of a feature from a proto-language (see Bakker 2010 for discussion of language sampling). For example, a survey designed to establish whether syllabic obstruents are cross-linguistically common or not should be based on a broad cross-section of languages that is not biased toward the Afro-Asiatic family or the Berber sub-family of Afro-Asiatic to which Tashlhiyt belongs. Nor should the survey be skewed toward languages spoken in North Africa.

The investigation of cross-linguistic frequency has received less attention in phonology than in morphology or syntax (with some exceptions discussed in section 1.3). Because the investigation of frequency distributions plays such a prominent role in the field of linguistics defined as *typology*, it is not surprising that phonology is less visible in publications devoted to the study of typology.

As Hyman (2007a) observes, perusing recent issues of linguistic typology journals and recent introductory textbooks on linguistic typology reveals only a small portion of content devoted to phonological topics. Croft's (2003) introduction to typology does not have a single chapter that focuses on phonology. Whaley

(1997) similarly does not allocate any chapters to phonology. Velupillai (2012) devotes one chapter to phonology as opposed to seven that arguably fall under the rubric of morphology and syntax. Song (2010) contains a single chapter on phonological typology by Ian Maddieson (Maddieson 2010). The online version of *The World Atlas of Language Structures* (Dryer and Haspelmath 2013) contains only 19 chapters devoted to phonological topics (chapters 1–19) versus 109 chapters (chapters 20–128) focusing on morphosyntactic features. Moravcsik (2013) is more balanced in its coverage of phonology, allocating a single chapter each to phonology, morphology, and syntax.

The impoverished position of phonology in typology extends to research articles published in linguistic typology journals. In the five-year period from 2008 through 2012, there were only six articles dealing with phonology in the 19 issues of *STUF: Language Typology and Universals*. In the same five-year time frame (abstracting away from an outlier 2011 issue focusing on the relationship between phoneme inventory complexity and the origin and migration of the human species), there are only four research articles of 15 total issues of *Linguistic Typology*, the flagship journal of the Association of Linguistic Typology, that are devoted to phonology. Interestingly, this same journal published in 2007 an article by Larry Hyman “Where’s Phonology in Typology?” that examines the basis for the paradoxical prominence of typological research in phonological theory alongside its conspicuous rarity in venues devoted to typology (see Hyman 2007a for discussion). As Hyman’s paper suggests, surveying the fields of phonology and typology gives the impression that most phonologists are typologists but most typologists are not phonologists.

1.3 The present book

As primarily a typology work, the principal goal of this book is to provide a cross-linguistic description of phonological properties, exploring both the range of variation in these properties as well as their relative frequency. On the other hand, as a phonology book, discussion of the typological patterns is accompanied by an overview of the key assumptions, research questions, and relative merits and weaknesses of various approaches to explaining these patterns in the theoretical literature. This book thus represents an attempt to provide a synthesis of the fields of typology and modern phonological theory.

In linking the theory with the typological observations serving as the target of coverage by the theory, a practical distinction will be drawn between the orthogonal issues of phonological representations (e.g. phonological features and their geometry, models of the syllable, metrical structure, etc.) and the paradigms employing those representations whether in a substantive or a more tangential capacity. Chapter 2 is primarily devoted to overarching issues in phonological theory that transcend the particular representations assumed by a theory or the individual phenomena discussed in various chapters. These issues include the architecture of the phonology as a rule-based or a constraint-based system, the role of phonetic and other functional biases in phonology, the

relationship between synchrony and diachrony, and the formal modeling of probabilistic as opposed to categorical distributions. Representations, on the other hand, will be introduced in the relevant sections devoted to the phenomena that those representations have played a prominent role in treating, e.g. autosegmental phonology in the discussion of assimilation and dissimilation in the chapter on segmental processes (Chapter 5), moraic theory in the course of discussing compensatory lengthening processes in the segmental phonology chapter and again in the chapter on stress (Chapter 6), metrical grids and foot structure also in the chapter on stress. Space constraints preclude a full consideration of the relative merits of different types of representations proposed in the literature or of the broader architectural or philosophical issues that are topical in phonological theory.

Nevertheless, despite these practical constraints on the theoretical coverage afforded by this book, it is important for a book on typology not to ignore the theory since it has historically played a crucial role in making predictions that guide the hypothesis space in typological inquiry, especially those relating to the exploration of correlations between phenomena (see van der Hulst to appear for discussion of the role of research on correlations in informing phonological theory). This book contains data on a number of links between patterns and phenomena that were sparked by predictions made by particular theories. To name just a couple, the survey of the relationship between onset and coda complexity in Chapter 4 was conducted in response to the hypothesized link between onsets and codas advanced in the Split Margin Theory (Baertsch 2002, Baertsch and Davis 2003, 2009, Davis and Baertsch 2011). Furthermore, the entire conceptualization of Chapter 8 is grounded in the unified treatment of superficially diverse phenomena within the theory of prosodic morphology developed in work by McCarthy and Prince (1986/1996).

Because phonological theory is inherently typological, a point made earlier in this chapter and discussed at length in Hyman (2007a), there is overlap between the content of this book and the content of other introductions to phonology. However, the emphasis on quantitative cross-linguistic distributions likely differentiates this book from others providing an overview of phonology less directly focused on typology. At the same time, it is hoped that the scope of phonological properties covered in this book distinguishes it from other introductions to typology, which, as already discussed, characteristically devote only a small portion of their content to phonology.

The book examines a wide range of phonological phenomena, including the structure of phoneme inventories, positional restrictions on phonemes, phonological processes, syllable structure, stress, tone, intonation, and prosodic morphology. For some of these properties, there is already a well-developed typological literature consisting of broad quantitative investigation of cross-linguistic distributional properties. Most notably, phoneme inventories have been the subject of intensive cross-linguistic study first as part of the Stanford Language Universals project directed by Greenberg and Charles Ferguson between 1967 and 1976 and then subsequently in Ian Maddieson's seminal work *Patterns of Sounds* (1984) and its expanded offshoot project the UCLA Phonological Segment Inventory

Database (Maddieson and Precoda 1990) with an online interface (<http://web.phonetik.uni-frankfurt.de/upsid_info.html>). PHOIBLE (Moran et al. 2014) is a considerably larger online database of phoneme inventories and their phonological feature specifications containing over 1,600 languages. The World Phonotactics Database (Donohue et al. 2013) incorporates information on syllabification in over 2,000 languages in addition to phoneme inventories for another 1,700 languages.

Stress has also been the target of several extensive cross-linguistic surveys initiating with pioneering work by Larry Hyman (1977) and pursued most recently in the StressTyp databases: StressTyp (van der Hulst and Goedemans 2009) and StressTyp2 (Goedemans, Heinz, and van der Hulst 2015). The quantitative typological literature on other phenomena is sparser, consisting of isolated studies of particular sub-patterns, e.g. Greenberg (1965) on consonant phonotactics in word-initial and word-final consonant clusters, Bell (1978) on syllabic consonants, Hyman (1988), Gordon (2001), and Zhang (2002) on contour tone restrictions, Zec (1988) and Gordon (2006a) on various properties falling under the rubric of syllable weight, Bolinger (1978) on macro-intonational patterns, etc.

Certain phenomena have been the subject of quantitative typologies that are worth revisiting for various reasons. Phonological theory has advanced considerably since the typological work conducted in the 1970s under the auspices of the Stanford Universals project, raising new research questions for typological investigation. A striking example of the theory spawning a new domain of typological inquiry is provided by the moraic theory of syllable weight (Hyman 1985, Hayes 1989a; see Chapter 5), which has been claimed to unite a number of superficially unrelated phenomena (e.g. stress, compensatory lengthening, tone, prosodic morphology). Only with the theory of weight in place did it become possible to formulate testable hypotheses fleshing out the relationship between all these properties.

Other existing typologies of phonological phenomena are hampered by the coarseness of their pattern categorization, which limits the range of generalizations that can be extracted from them. For example, the WALS sample of syllable structure (Maddieson 2011; see also Maddieson 2007; see Chapter 4) employs a tripartite distinction of languages differing in the complexity of syllables that they permit. According to this classification, languages with simple syllable structures allow only open syllables and a single onset consonant (CV), those with moderately complex syllable structure permit single coda consonants (CVC) and/or onset clusters whose second member is either a liquid or glide (CLV, CWV), and those with complex syllables permit coda clusters and/or onset clusters beyond those consisting of two consonants the second of which is a liquid or glide. The advantage of dividing the set of languages into only three categories is that it allows for more robust statistical comparison of the relationship between syllable structure complexity and other properties. Working with this categorization, Maddieson (2007) observes a correlation between syllable structure and the number of consonants in the phoneme inventory of a language, whereby languages with more consonants characteristically tolerate more complex syllable

structures. One of the disadvantages, however, of employing a coarse tripartite division of the data is that it does not distinguish between sub-levels of complexity within the moderately complex and complex categories. For example, it is not sensitive to whether a language falls into the moderately complex category because it allows single codas or because it permits onset clusters whose second member is a liquid or glide. Similarly, the complex category encompasses a diverse set of syllable structures, including complex onsets whose second member is not a liquid or glide, codas consisting of two consonants, codas consisting of three consonants, etc. The cross-linguistic distribution of each of these subtypes can profitably be examined in order to draw an enriched set of generalizations about the typology of syllable structure.

A similar issue of category conflation arises in the WALS chapter on reduplication (Rubino 2013; see Chapter 8), which divides languages into only two groups: those with full reduplication, i.e. reduplication of entire words, and those with both full and partial reduplication, the latter of which entails copying of some substring of the word. This binary division obscures potentially interesting divergences between languages in the type(s) of partial reduplication they display. For example, a partial reduplicant could be a string of consonant–vowel–consonant (CVC) or it might be a string of consonant–vowel (CV) or it may be a single consonant (C). The Graz database on reduplication (Hurch 2005) provides a more nuanced picture of reduplication. This volume aims to enrich the typological findings by employing a finer grained categorization of patterns for several phenomena that might have previously been classified according to coarser divisions.

This section’s overview of the current state of phonological typology should not give the impression that there has been little research dealing with phonology on a cross-linguistic basis. The theoretical literature is rife with work, especially in the last 20 years, that explores the range of cross-linguistic variation for particular phonological phenomena, along the lines of the research program dealing with sonority that was discussed earlier. However, most of this literature is primarily concerned with the discovery of the range of cross-linguistic variation. Of only tangential relevance to much of this theory-oriented work is the relative frequency of different patterns across and within languages, though interest in frequency among theoreticians is gaining in traction and is continually being facilitated by the introduction of new online databases (e.g. PHOIBLE, The Graz Database on Reduplication, StressTyp, UPSID, WALS, The World Phonotactics Database).

1.3.1 Cross-linguistic frequency

A primary goal of the present work is thus to examine the frequency distributions for a wide range of phonological properties. Investigation of frequency potentially offers insight into various biases and conditioning factors (articulatory, perceptual, and cognitive) that shape and constrain human languages both synchronically and diachronically. The study of frequency has a much wider scope than the investigation of the limits of cross-linguistic variation since most once

purportedly universal generalizations of phonology have turned out to have exceptions (at least for those phenomena that are sufficiently widely applicable to allow for robust generalizations to even be formulated). For example, the claim that every language has at least one nasal consonant (Ferguson 1963) has been demonstrated to be false by Lakes Plains languages of Papua New Guinea, some of which lack even allophonic nasals, e.g. Obokuitai (Jenison and Jenison 1991) and Sikaritai (Martin 1991). The vulnerability of universal statements to refutation indicates that the most productive line of study in typological research is discovering which patterns are common and which ones are rare (and how rare or common they are) and explaining their relative frequency.

The study of frequency employed in this book is approached from two angles: language-internal frequency, which is discussed in section 1.3.2, and typological frequency, to which we now turn. The cross-linguistic distribution of various phenomena is surveyed for the 100-language sample that contributors to the *World Atlas of Language Structures* (WALS; Dryer and Haspelmath 2013) were encouraged to include in their chapters. This set of languages is designed to provide a genetically and geographically balanced set of languages for investigating linguistic features (see Comrie et al.'s introduction to WALS for discussion of the sample). The 100-language WALS sample is fairly faithfully followed in the present work with a few deviations. Following the suggestion of the WALS editors in their discussion of the sample, one member of each of the three pairs of languages in the 100-language sample (German and English, French and Spanish, Modern Hebrew and Egyptian Arabic) that did not satisfy criteria for genetic diversity but were nevertheless included in WALS due to their status as "major" languages was excluded in the present survey, leaving a total of 97 sampled languages. (Note that the survey will still be referred to as the WALS 100-language sample.) From these three pairs, German, Spanish, and Egyptian Arabic were included, an essentially arbitrary decision. In addition, in a few cases, languages in the WALS sample were substituted with closely related languages for which more complete phonological information was readily available either from published sources or through scholars with extensive experience working on the language in question. Kabardian was substituted for Abkhaz, Caddo for Wichita, Nuuchahnulth for Kw'akwala, and Seneca for Oneida. The list of languages (and their ISO codes) sampled for this book is given in Table 1.1 along with sources consulted for the survey and two levels of genetic classification provided in WALS. The family reflects the highest generally accepted level of classification and the genus reflects a lower level of classification that is intended to be roughly comparable across genera in terms of time depth of separation (<4,000 years) (see <<http://wals.info/languoid/genealogy>> for further discussion of the genetic classification adopted in WALS).

1.3.2 *Language-internal frequency*

The cross-linguistic survey of various phenomena is complemented by investigations of language-internal frequency for a subset of properties in order to determine whether features that are cross-linguistically common are also relatively

TABLE 1.1. Languages included in the typology

ISO	Language	Genus	Family	Source(s)
cha	Acoma	Keresan	Keresan	Miller (1965)
ala	Alamblak	Sepik Hill	Sepik	Bruce (1984)
ame	Amele	Madang	Trans-New Guinea	Roberts (1987)
apu	Apurinā	Purus	Arawakan	Facundes (2000)
aeg	Arabic (Egyptian)	Semitic	Afro-Asiatic	Watson (2007)
arp	Arapesh (Mountain)	Kombio-Arapesh	Torricelli	Fortune (1942), Conrad and Wogiga (1991), Arapesh grammar and digital language archive (http://www. arapesh.org/xml/ fortune/Entry)
asm	Asmat	Asmat-Kamoro	Trans-New Guinea	Voorhoeve (1980)
bag	Bagirmi	Bongo-Bagirmi	Nilo-Saharan	Stevenson (1969)
brs	Barasano	Tucanoan	Tucanoan	Jones and Jones (1991)
bsq	Basque	Basque	Basque	Hualde and de Urbina (2003)
shi	Berber (Tashlhiyt)	Berber	Afro-Asiatic	Dell and Elmedlaoui (1985, 1988, 2002)
brm	Burmese	Burmese-Lolo	Sino-Tibetan	Okell (1969), Lay (1978)
bur	Burushaski	Burushaski	Burushaski	Anderson (1997)
cad	Caddo	Caddoan	Caddoan	Chafe (1976)
ckr	Canela-Krahó	Ge-Kaingang	Macro-Ge	Popjes and Popjes (1986)
cha	Chamorro	Chamorro	Austronesian	Topping (1973)
chk	Chukchi	Northern Chukotko- Kamchatkan	Chukotko- Kamchatkan	Bogoras (1922), Skorik (1961), Krause (1980), Dunn (1999)
cre	Cree (Plains)	Algonquian	Algic	Wolfart (1973, 1996), Ahenakew and Wolfart (1983)
dag	Daga	Dagan	Dagan	Murane (1974)
dni	Dani (Lower Grand Valley)	Dani	Trans-New Guinea	Bromley (1981)
fij	Fijian	Oceanic	Austronesian	Milner (1972), Schütz (1985)
fin	Finnish	Finnic	Uralic	Suomi et al. (2008)

geo	Georgian	Kartvelian	Kartvelian	Hewitt (1995)
ger	German	Germanic	Indo-European	Wiese (2000), Kentner (2011)
goo	Gooniyandi	Bunuban	Australian	McGregor (1990)
grb	Grebo	Kru	Niger-Congo	Innes (1966)
grk	Greek (Modern)	Greek	Indo-European	Joseph and Philippaki- Warburton (1987)
grw	Greenlandic (West)	Eskimo	Eskimo-Aleut	Fortescue (1984)
gua	Guaraní	Tupi-Guaraní	Tupian	Bridgeman (1961), Hamidzadeh (2013)
hau	Hausa	West Chadic	Afro-Asiatic	Newman (2000)
hin	Hindi	Indic	Indo-European	Kachru (2006)
hix	Hixkaryana	Cariban	Cariban	Derbyshire (1979, 1985)
hmo	Hmong Njua	Hmong-Mien	Hmong-Mien	Lyman (1979)
imo	Imonda	Border	Border	Seiler (1985)
ind	Indonesian	Malayo- Sumbawan	Austronesian	MacDonald (1976)
jak	Jakaltek	Mayan	Mayan	Day (1973)
jpn	Japanese	Japanese	Japanese	Venditti (2005), Ichikawa and Kobayashi (2013)
kab	Kabardian	Northwest Caucasian	Northwest Caucasian	Colarusso (1992, 2006), Applebaum and Gordon (2007), Gordon and Applebaum (2006, 2010a, b)
knd	Kannada	Southern Dravidian	Dravidian	Sridhar (1990)
krk	Karok	Karok	Karok	Bright (1957), Macaulay (1993)
kay	Kayardild	Tangkic	Australian	Evans (1995), Round (2009)
kew	Kewa	Engan	Trans-New Guinea	Franklin (1971)
kha	Khalkha Mongolian	Mongolic	Altaic	Svantesson et al. (2005)
kho	Khoekhoe	Central Khoisan	Khoisan	Hagman (1977)
kio	Kiowa	Kiowa-Tanoan	Kiowa-Tanoan	Watkins (1984)
koa	Koasati	Muskogean	Muskogean	Kimball (1983, 1991)

(continued)

TABLE 1.1. *Continued*

ISO	Language	Genus	Family	Source(s)
kor	Korean	Korean	Korean	Lee (1989), Jun (1993, 2005a), Lee and Ramsey (2000)
kse	Koyraboro Senni	Songhay	Nilo-Saharan	Prost (1956), Heath (1999)
kro	Krongo	Kadugli	Kadugli	Reh (1985)
kut	Kutenai	Kutenai	Kutenai	Garvin (1948), Morgan (1991)
lkt	Lakhota	Siouan	Siouan	Boas and Deloria (1941), Rood and Taylor (1996), Albright (2004)
lan	Lango	Nilotic	Nilo-Saharan	Noonan (1992)
lav	Lavukaleve	Lavukaleve	Solomons East Papuan	Terrill (2003)
lez	Lezgian	Lezgitic	Nakh- Daghestanian	Haspelmath (1993)
luv	Luvale	Bantoid	Niger-Congo	Horton (1949)
mal	Malagasy	Barito	Austronesian	Rajaonarimanana (1995), Martin (2005)
mnd	Mandarin	Chinese	Sino-Tibetan	Li and Thompson (1989), Lin (2001)
myi	Mangarrayi	Mangarrayi	Australian	Merlan (1989)
map	Mapudungun	Araucanian	Araucanian	Smeets (2008)
mar	Maricopa	Yuman	Hokan	Gordon (1986)
mrt	Martuthunira	Pama-Nyungan	Australian	Dench (1995)
mau	Maung	Iwaidjan	Australian	Capell and Hinch (1970)
may	Maybrat	North-Central Bird's Head	West Papuan	Dol (2007)
mei	Meithei	Kuki-Chin	Sino-Tibetan	Chelliah (1997)
mxc	Mixtec (Chalcatongo)	Mixtecan	Oto-Manguean	Macaulay (1996)
ngi	Ngiyambaa	Pama-Nyungan	Australian	Donaldson (1980)
noo	Nuuchahnulth	Southern Wakashan	Wakashan	Stonham (1999), Kim (2003)
orh	Oromo (Harar)	Eastern Cushitic	Afro-Asiatic	Owens (1985)
otm	Otomí (Mezquital)	Otomian	Oto-Manguean	Sinclair and Pike (1948), Hensey (1972), Blight and Pike (1976), Wallis (1968)

pai	Paiwan	Paiwanic	Austronesian	Ferrel (1982), Egli (1990)
prs	Persian	Iranian	Indo-European	Perry (2005), Mahootian (2010)
prh	Pirahã	Mura	Mura	Everett and Everett (1984), Everett (1986, 1988)
qim	Quechua (Imbabura)	Quechuan	Quechuan	Cole (1985)
ram	Rama	Rama	Chibchan	Grinevald-Craig (1990)
rap	Rapanui	Oceanic	Austronesian	Du Feu (1996)
rus	Russian	Slavic	Indo-European	Jones and Ward (1969)
san	Sango	Ubangi	Niger-Congo	Samarin (1967)
snm	Sanuma	Yanomam	Yanomam	Borgman (1990)
see	Seneca	Northern Iroquoian	Iroquoian	Chafe (1977, 1996)
sla	Slave	Athapaskan	Na-Dene	Rice (1989)
spa	Spanish	Romance	Indo-European	Alarcos (1965), Harris (1969)
sup	Supyire	Gur	Niger-Congo	Carlson (1994)
swa	Swahili	Bantoid	Niger-Congo	Ashton (1944), Polomé (1967), Mohammed (2001)
tag	Tagalog	Greater Central Philippine	Austronesian	Schachter and Otones (1972)
tha	Thai	Kam-Tai	Tai-Kadai	Iwasaki and Ingkaphirom (2005)
tiw	Tiwi	Tiwian	Australian	Osborne (1974)
tuk	Tukang Besi	Celebic	Austronesian	Donohue (1999)
tur	Turkish	Turkic	Altaic	Clements and Sezer (1982), Kornfilt (1997), Demircan (1987), Wedel (1999)
vie	Vietnamese	Viet-Muong	Austro-Asiatic	Thompson (1965)
wra	Warao	Warao	Warao	Osborn (1966)
war	Wari'	Chapacura-Wanham	Chapacura-Wanham	Everett and Kern (1997)
wch	Wichí	Matacoan	Matacoan	Viñas Urquiiza (1970, 1974), Claesson (1994), Avram (2008)
yag	Yagua	Peba-Yaguan	Peba-Yaguan	Payne and Payne (1990)

(continued)

TABLE 1.1. *Continued*

ISO	Language	Genus	Family	Source(s)
yaq	Yaqui	Cahita	Uto-Aztecan	Dedrick and Casad (1999)
yor	Yoruba	Defoid	Niger-Congo	Bamgbose (1966)
zqc	Zoque (Copainalá)	Mixe-Zoque	Mixe-Zoque	Wonderly (1951)
zul	Zulu	Bantoid	Niger-Congo	Doke (1961), Poulos and Msimang (1998), Thomas-Vilakati (2010)

common even in languages that tolerate them. There are several reasons to believe that this hypothesis is worthy of study and that the quantitative investigation of distributions is likely to be fruitful in furthering our understanding of linguistic knowledge. First, given the largely shared physiological and cognitive capacities across humans, it is plausible that the same factors that contribute to categorical constraints on the occurrence of properties in certain languages might also render them statistically dispreferred in other languages. Furthermore, evidence continues to mount that language learners even under a year old are sensitive to distributional patterns in the ambient language and use these distributions to construct generalizations (e.g. Coleman and Pierrehumbert 1997, Zuraw 2000, Ernestus and Baayen 2003, Albright and Hayes 2003, Eddington 2004, Hayes and Londe 2006; see Diessel 2007 for an overview of the many ways in which frequency is relevant in shaping language). Finally, there is ample evidence that has corroborated the link between categorical phonological properties and statistical biases.

To take a compelling example of this link, consider the case of onset-sensitive stress, which is discussed further in Chapter 6. The crucial phonological observation is that certain languages preferentially stress syllables with an onset consonant over those lacking one (Davis 1988, Goedemans 1998, Gordon 2005a, Topintzi 2010). For example, in the Australian language Arrernte (Strehlow 1942, Davis 1988, Breen and Pensalfini 1999, Gordon 2005a), stress falls on the first syllable of a trisyllabic or longer word but only if that syllable begins with an onset consonant. If the word begins with a vowel, stress instead falls on the second syllable. Thus, we have initial stress in words like *'tukura* 'ulcer' and *'wora,tara* (place name) but second syllable stress in words like *er'guma* 'to seize' and *ar'tanama* 'to run' (Davis 1988: 1). (Stress falls on the first syllable of disyllabic words regardless of whether they begin with a consonant or not, e.g. *'kama* 'to cut', *'ilba* 'ear'.) In Arrernte, the attraction of stress by syllables with an onset consonant reflects a categorical feature that is predictable across most (if not all) of the vocabulary.

Interestingly, recent research by Ryan (2014) has shown that the preference for positioning stress on syllables with an onset is reflected in gradient but statistically

robust biases in other languages (e.g. English and Russian). Ryan finds that this bias against stress on onsetless syllables is observed both in the statistical distribution of lexical stress and in productivity experiments in which the felicity of stress on onsetless syllables is judged by speakers.

In this book, the language samples from which the frequency data are calculated stem from various sources. Existing sources containing frequency calculations were consulted whenever available, supplemented with my own values for certain languages in the interest of broadening the diversity of the data set. The consulted sources employ different types of corpora and different methods for calculating frequency. With respect to the latter dimension, a broad distinction can be drawn between type frequency and token frequency counts. Type frequency refers to the frequency of a pattern. In type frequency counts, a single item is counted only once regardless of the number of times that it occurs in the corpus. In a token frequency count, on the other hand, each occurrence of an item contributes to the aggregate count for that item. The corpora from which the frequency values are calculated are either dictionaries (or other types of word or root lists) or other written or spoken corpora.

Corpora other than dictionaries potentially provide either type or token frequency counts depending on whether duplicate entries have been eliminated or not. Even for type frequency data, methodologies may vary. Sources may differ in terms of their level of morphological redundancy, including or excluding morphologically derived forms containing the same root. For example, if one were determining the type frequency of [ks] clusters in English, the English words *comple[ks]* and *comple[ks]ity* could either count as one or two instances depending on whether duplication was evaluated at the level of the root or the word. Multiple examples of either of the two words in a corpus would not increase the type frequency of [ks], although they would be counted toward token frequency. Token (or type) frequency counts may also vary as a function of the genre in which the words containing those phonemes occur.

Despite the methodological variation between data samples it is hoped that the frequency data in this book will provide some useful confirmation of (or divergences from) the categorical patterns discussed. In support of this optimistic outlook, the frequency data considered in this work are for the most part quite similar across languages (with some divergences of course) regardless of the nature of the source. Indeed, several of the sources consulted present both type and token frequency data that line up closely in their distributions both on a casual level and (for those sources that quantitatively compare the different frequency counts) on a statistical level (see, for example, Shin et al. 2013 for English and Korean, Leung et al. 2004 for Cantonese, Duanmu 2008 for Mandarin, Tamaoka and Makioka 2004 for Japanese). Admittedly, type and token frequency data may diverge due to the numerical boost awarded to phonemes that occur in particularly high frequency items. For example, the voiced dental fricative /ð/ in English, which is otherwise rare in content words, occurs in a few highly frequent function words, e.g. *the*, *that*, *this*, which inflates its token frequency relative to its type frequency. It is the 23rd most frequent consonant in type frequency but is ranked 6th in token frequency (Shin et al. 2013). The promotion of English /ð/

in token frequency is particularly striking since /ð/ is a relatively rare sound cross-linguistically, not ranking among the 25 most common consonants cross-linguistically (see Chapter 3). A more typical divergence between type and token frequency is exemplified by the distribution of /n/ and /ŋ/ in Korean, the former of which is relatively overrepresented in token frequency relative to type frequency (20.4% vs. 11.6% of consonant tokens) and the latter of which is overrepresented in type frequency compared to token frequency (10% vs. 5.2%) (Shin et al. 2013). As we will see in Chapter 3, both the alveolar and velar nasal are common sounds in languages of the world, /n/ ranking first and /ŋ/ ranking 14th in terms of the percentage of languages containing it. Throughout the book, divergences between type and token frequency will be mentioned wherever apparent, though there will undoubtedly be some distributional patterns attributed to a particular method of calculating frequency that will have escaped my notice (see Berg 2014 for empirical comparison of type vs. token frequency). As a final procedural note, whenever both type and token frequency data for the same language were available, a decision was made to use a single source of data, type frequency whenever possible, in the interest of minimizing the number of confounding variables in the comparison of data across multiple languages.

1.3.3 Organization of the book

Chapter 2 presents an overview of the types of functional explanations and formal theories advanced in the literature to account for the generalizations gleaned through typological investigation. This chapter will illustrate these accounts through a few representative case studies exemplifying treatments of particular phonological phenomena. Analyses of additional phenomena are discussed in the individual chapters focusing on those properties.

The bulk of the remainder of the book is devoted to discussion of a broad range of phonological properties including phoneme inventories (Chapter 3), syllables (Chapter 4), segmental alternations (Chapter 5), stress (Chapter 6), tone and intonation (Chapter 7), and prosodic morphology (Chapter 8). Some conclusions are presented at the end.

2

Theory and explanation in phonological typology

There are many factors that shape the typology of phonological properties. Some of them stem from physiological considerations related to speech articulation and perception. Others are conditioned by cognitive factors such as those operative in the online processing and interpretation of the speech signal. Also relevant are usage factors related to the frequency of patterns and the contexts in which they occur. Yet, despite the explanatory power of all these grounding factors, certain synchronic patterns still elude a compelling account in independently supported functional considerations. Such cases have been used to support a view of synchronic phonology that appeals to the formal apparatus of the theory rather than theory-external factors to predict the typological distribution. In this chapter we examine various types of explanations, both synchronic and diachronic, that have been advanced in the literature to account for typological variation in phonology. We will also explore a few representative case studies illustrating the implementation of these accounts in formal models of phonology.

2.1 Types of explanations

2.1.1 *Phonetic factors*

Many typological properties in phonology are explicable in terms of articulatory and perceptual considerations. A common theme is for phonology to reflect a competition between two competing considerations: minimization of articulatory effort and maximization of perceptual distinctness. Reducing the articulatory difficulty of a particular phonological configuration characteristically comes at the price of making contrasts less perceptible. On the other hand, enhancing the salience of a distinction usually requires hyperarticulation of the gestures associated with that distinction.

The exploration of phonetic bases for phonological patterns has long been a productive area of research for phoneticians (see Ohala 1997 for an overview). In one of the earliest works in this research program, Liljencrants and Lindblom (1972) attempt to account for cross-linguistic biases in the structure of vowel systems evident in typological surveys conducted by Trubetzkoy (1929), Hockett (1955), and Sedlak (1969). Liljencrants and Lindblom (1972) hypothesize that languages prefer systems in which vowels are maximally distinct from each other

in the perceptual domain. Their computer simulations of vowel inventory construction employing the principle of maximum dispersion produce results for different size inventories that largely mirror the most prevalent attested system(s) containing the target number of vowels. For example, their simulation predicts the five-vowel inventory /i, ε, u, a/ and a fronter low vowel /a/ or /æ/, which is relatively close to the most common five-vowel system /i, e, a, o, u/ with the greatest mismatch between predicted /a/ and attested /o/ (see Chapter 3 for more discussion).

Lindblom and Maddieson (1988) incorporate an articulatory component (alluded to but not implemented in Liljencrants and Lindblom's model) into their account of consonant inventories. They sketch, but do not quantify a model in which the articulatory space is divided into regions of different complexity. Within each zone of articulatory complexity, Lindblom and Maddieson suggest that languages prefer sounds that are maximally distinct in the perceptual domain. As each articulatory subspace is perceptually saturated, inventories are expanded through the introduction of progressively more complex articulatory tiers. In this model, perceptual and articulatory factors conflict: maximizing perceptual distinctness comes at the price of greater articulatory difficulty, while minimizing articulatory effort reduces perceptual distinctness. Research on the role of articulatory and perceptual factors in shaping phoneme inventories (including more on Liljencrants and Lindblom's and Lindblom and Maddieson's accounts) is taken up again in Chapter 3.

2.1.2 *Speech processing and phonological typology*

In addition to purely phonetic factors, there are other functional considerations that play a role in shaping phonological systems. One such factor is the mechanism of speech processing. In work investigating consonant co-occurrence restrictions in Arabic roots, Frisch et al. (2004) and Frisch (2004) suggest that similar consonants are avoided because they are more easily confused in both perception and production than dissimilar consonants. In order to make explicit this confusion, Frisch assumes Dell's (1986) connectionist model of phonological encoding in which different levels of phonological structure, e.g. features, segments, syllable position, word, are represented as distinct but interlinked tiers each consisting of activation nodes. A node associated with a given property is activated, in gradient fashion, upon hearing or planning utterances containing that property or other similar properties. For example, the node corresponding to the segment /k/ is strongly activated by any word containing the sound /k/ and less strongly activated by the occurrence of a word containing a different voiceless stop and still less activated by sounds that are most distant from /k/. Because featurally similar segments overlap in their activation patterns, there is potential for them to be mistaken for each other. Frisch et al. (2004) quantify similarity in terms of number of natural classes shared by the segments in question. Segments that share a greater number of natural classes are more similar to each other and thus less likely to co-occur in the same root in their account.

Recent work by Pozdniakov and Segerer (2007) has shown that the avoidance of shared place features in consonants is statistically observed in roots in most, if not all, languages even if there are no active alternations providing evidence for

the restriction. The widespread existence of similar place restrictions suggests that the processing factors appealed to by Frisch to account for the well-known Arabic facts play a fundamental role, perhaps universal, in shaping the phonological composition of lexicons. Speech processing and place co-occurrence restrictions are discussed further in Chapter 5.

2.1.3 Frequency in phonology

One of the factors relevant in connectionist models of speech processing of the type appealed to by Frisch is word frequency; nodes associated with more frequent properties have lower thresholds of activation required for firing. As a result, frequent items are more likely to be produced or perceived when activated by items sharing similar properties. The relevance of frequency effects in speech production and perception finds independent support from psycholinguistic studies and plays an important role in the usage-based model of phonology developed by Joan Bybee (2001, 2007). Bybee assumes an exemplar-based model in which the cognitive representation of a word consists of a set of exemplars experienced by speaker and listener. The exemplar cloud associated with a particular word changes over time as tokens are experienced. More frequently occurring tokens will come to be associated with exemplar clouds shifted in the direction of lenited variants characterized by decreased gestural magnitude and increased overlap of gestures. Over time, the shifting of the exemplar cloud may lead the speaker to assume different phonological representations for different words according to their frequency. For example, a very common word like *every* is more likely to lack a vowel in the second syllable than a less frequently occurring word with an equivalent stress pattern, such as *cursor*. The result is an exemplar cloud for *every* that is shifted in the direction of reduction and/or deletion relative to the exemplar cloud for *cursor*. The eventual result of this shift is potentially a lexical entry for *every* that is disyllabic, although knowledge of spelling may complicate the situation by enabling the English speaker to “reconstruct” the original vowel that is typically absent on the surface.

Bybee’s model offers an explanation for a number of typologically common patterns that are sensitive either to morphology or to the individual lexical item concerned. For example, lenition is more likely to affect frequently occurring morphemes of a particular phonological shape than their less frequent counterparts of the same shape (Bybee 2002). For example, an /nt/ cluster in the contracted negation morpheme *-n’t* in English is characteristically shorter than the same cluster in final position of a particular root owing to the former’s greater frequency of occurrence. In keeping with its shorter duration, the coronal stop in *-n’t* is more likely to be deleted than its equivalent coronal stop in a root-final /nt/ cluster. Similarly, the coronal stop in the past tense suffix *-ed* is more likely to delete when it is affixed to a high frequency verb than to a low frequency one. For similar reasons, the [ð] in the very frequent 1st conjugation past participle suffix *-ado* in Spanish is more likely to delete than [ð] in other words including the 2nd and 3rd conjugation past participles, which are considerably rarer than their 1st person counterparts.

Another factor that Bybee suggests is relevant to phonetic realization is the relative frequency with which a particular word or morpheme occurs in different prosodic contexts. For example, she attributes the greater deletion rates of the coronal stop in the negative morpheme *-n't* relative to the deletion rates of the [t] allomorph of the past tense suffix *-ed* to an asymmetry between the two morphemes in the context in which they characteristically occur. The weak past tense morpheme occurs with greater frequency in prevocalic position, which allows for a more salient realization of the stop thereby contributing to an overall bias in favor of its preservation (see Chapter 5 for more on context as a factor in predicting neutralization and deletion).

The exemplar clouds associated with lexical items intersect with exemplar clouds for the phonemes comprising those lexemes. Pierrehumbert (2001) conducts an exemplar-based computational simulation of the lenition of a phoneme, demonstrating how lenition may produce substantial overlap between two phonological categories and potentially even their eventual merger into a single category. The merger of two categories is an extremely common phenomenon cross-linguistically, both diachronically and synchronically (see Chapter 5).

The relevance of frequency is also evident on a synchronic basis. A number of productivity experiments (e.g. Coleman and Pierrehumbert 1997, Zuraw 2000, Ernestus and Baayen 2003, Albright and Hayes 2003, Eddington 2004) indicate that speakers have access to relatively nuanced knowledge of frequency distributions when generalizing patterns to novel forms. To take just one recent example of work in this research program, Hayes and Londe (2006) find that gradient patterns governing the likelihood of vowel harmony in Hungarian are statistically mirrored in the responses of speakers asked to generate novel forms. Thus, although suffixal vowels in Hungarian normally agree with the final root vowel with respect to backness (e.g. *hɔl-unk* 'fish-our' vs. *ty:z-ynk* 'fire-our'), the front unrounded vowels /i:, i, e:, ε/ are "neutral" (see Chapter 5 for more on the neutral vowels of Hungarian) and may occur with either front or back vowel suffixes on either a lexeme-specific basis or, for some words, in free variation. Interestingly, the likelihood of a back vowel or a front vowel suffix being selected varies gradiently according to various factors. One relevant factor is the height of the neutral vowel: /ε/ is more likely to trigger a front vowel suffix than /e:/, which in turn is more likely to occur with a front vowel suffix than the two high front unrounded vowels /i:, i/. Furthermore, in roots ending in a neutral vowel but containing a back vowel earlier in the root, the number of neutral vowels intervening between the back vowel and the suffix impacts the likelihood of a front vowel suffix: a root consisting of a back vowel followed by two neutral vowels is thus more likely to occur with a front vowel than a root containing a back vowel followed by one neutral vowel. Hayes and Londe (2006) employ a search of the Web to calculate the relative type frequency of front and back vowel suffixes occurring with roots differing in the number and quality of neutral vowels. They then compare their results to those from a "wug"-type (Berko 1958) productivity study in which they visually (in a sentence frame) presented participants with the nominative form of a nonce root and prompted them to supply a suffixed counterpart, where both a front or back vowel suffix were available options. Their results indicated a close match between the statistical distribution of front

vs. back vowel responses in their experiment and the frequency patterns discovered in the Web search, suggesting that listeners employ their knowledge of statistical distributions in their native language when constructing novel forms.

2.1.4 Analytic biases

Cognitive or analytic biases have also been claimed to play a role in shaping the typology of phonological patterns. These biases can stem from different sources. They may involve analytic strategies, not necessarily language-specific, that guide language learners in their quest to extract phonological generalizations from data that they encounter. Alternatively, speakers may be constrained by architectural features of the phonology, either assumed to be innate or not, such as the inventory of phonological features or other predicates available to them in their inductive learning of patterns in the ambient data.

To illustrate one type of analytic bias, let us consider work by Hayes (1999) on the phonetic naturalness of obstruent voicing. Based on results of an aerodynamic modeling experiment, Hayes finds that the relative naturalness of stop voicing is contingent upon a number of factors, two of which are place of articulation and the context in which the stop occurs. Considering the first of these, ease of voicing is correlated with frontness of the constriction. Bilabials facilitate voicing because they are associated with a relatively large oral cavity, which delays the equalization of oral and subglottal pressure that triggers cessation of vocal fold vibration. Velars, on the other hand, inhibit voicing since the small cavity behind the velar constriction triggers a rapid equalization of the pressure below and above the glottis thereby eliminating the pressure differential necessary to sustain voicing. The second factor that predicts ease of voicing is the context in which the stop occurs. Voicing is facilitated in a postnasal context because the leakage of air through the nasal cavity delays the stoppage of voicing. Voicing is slightly more difficult following a non-nasal sonorant and still more difficult in utterance-initial position where subglottal pressure has not quite reached its maximum. The most difficult environment for voicing is after an obstruent, where intraoral pressure is already high. Combining the two dimensions of frontness and environment yields a matrix of stop voicing naturalness (expressed in arbitrary units based on aerodynamic modeling), as in (1), where larger numbers indicate increased difficulty of voicing.

(1) Phonetic map for obstruent voicing (after Hayes 1999)

Environment	b	d	g
[-son]__ (after obst)	43	50	52
#__ (initial)	23	27	35
[+son, -nas] __ (after non-nasal sonorant)	10	20	30
[+nas]__ (after nasal)	0	0	0

While Hayes finds that cross-linguistic patterns of stop voicing line up well with the aerodynamic modeling results, phonologies of individual languages typically display distributions that are sensitive to only one of the dimensions relative for

predicting voicing ease: either context or place of articulation. For example, Latin bans voiced obstruents after another obstruent while Chickasaw's only voiced stop is the bilabial [b]. Apparently absent are systems simultaneously sensitive to environment and place of articulation in predicting stop voicing patterns, even if these patterns are phonetically well grounded. For example, we do not find languages that ban all voiced stops after an obstruent, both /g/ and /d/ but not /b/ in initial position, and /g/ but not /b/ and /d/ after a non-nasal sonorant. Hayes suggests that the explanation for this gap in attested patterns lies in their complexity in terms of the factors, i.e. place of articulation and context, to which they are sensitive relative to other slightly less phonetically natural but more symmetrical patterns. As Hayes suggests, complexity may be viewed as a factor guiding the hypothesis space entertained by language learners: learners first test the phonetic efficacy of relatively simple and symmetrical characterizations of patterns before proceeding to formulate more complex phonological generalizations that might provide a closer fit to the phonetic map.

2.2 Typology in phonology: incorporating explanation into the theory

The various explanations for cross-linguistic patterns described in section 2.1 have been integrated into many theoretical analyses in recent years. There are several unresolved issues, however, that surround the formal implementation of the phonetic and cognitive biases that underlie typological distributions. These topical areas of research include the interrelationships between different types of biases, their encoding as synchronic grammatical effects as opposed to reflexes of diachronic pressures, the formal architecture of the grammar as a rule-based vs. constraint-based system, and the capacity of the theory to model frequency effects both within and across languages.

2.2.1 *The relationship between analytic bias and other functional biases in typology: the case of laryngeal neutralization*

In his account of postnasal voicing, Hayes appeals to one kind of analytic bias, a preference for symmetry, working in conjunction with articulatory considerations. Symmetry and other types of analytic bias can be made explicit through features and other phonological predicates. For example, in Hayes's account, a bias against voicing distributions simultaneously referencing place features and surrounding context make it less likely that a language adopts overly complex voicing distributions in obstruents. An important and unresolved issue among phonologists is the extent to which phonological predicates themselves are sufficient to explain patterns without recourse to phonetic or other functional factors. The predictions made by appealing to one as opposed to the other often overlap, which has led to situations in which both types of grounding are invoked to account for the same phenomenon. To illustrate these two alternative approaches to the same set of data, let us consider the case of laryngeal neutralization. Many

languages, such as Greek and Lithuanian, only have voicing contrasts in obstruents occurring in certain positions. For example, voicing contrasts are licit before a sonorant in Lithuanian, including vowels and sonorant consonants, e.g. *áukle* ‘governess’ vs. *auglingas* ‘fruitful’, *akmuó* ‘stone’ vs. *augmuó* ‘growth’. In other positions, including word-finally and before an obstruent, the voicing contrast is neutralized: to voiceless word-finally and to the voicing specification of a following obstruent word-medially, e.g. /daúg/ → *daúk* ‘much’, /atgal/ → *adgal* ‘back’ vs. /dégti/ → *dégti* ‘burn-inf.’

An adequate theory of voicing neutralization must characterize the contexts in which neutralization occurs and those in which it fails to occur. The theory must also account for the fact that the output of neutralization in word-final contexts, where there is no possibility of voicing assimilation, is a voiceless obstruent. One approach is to appeal to an analytic bias couched in terms of constituents of the syllable and the inventory of phonological features available to express neutralization. Thus, if one assumes a model of the syllable consisting of an onset, rime, nucleus, and coda (see Chapter 4), and a set of privative laryngeal features, such that only positive specifications are reflected featurally, voicing neutralization can be captured following Lombardi (1995) as a prohibition against the licensing of the feature [voice] in coda position. Under this approach, the output of neutralization is a voiceless consonant, which is the unmarked realization of obstruents that are not specified for [voice]. In pre-obstruent position, the [voice] feature that is shared with a following voiced obstruent is licensed by virtue of being linked to a consonant in the onset of a syllable (see Chapter 5 for more on the representation of features).

An alternative approach to voicing neutralization pursued by Steriade (1999) is to appeal to phonetic factors. Steriade explores the hypothesis that neutralization is more likely in contexts where laryngeal features are difficult to implement in a perceptually salient manner. Drawing on the results of studies on the perception of voicing (e.g. Raphael 1981, Slis 1986), Steriade suggests that the perceptual salience of laryngeal features in different environments depends on the acoustic properties associated with those environments (see Chapter 4 for further discussion). The accurate perception of an obstruent, in particular, a stop, relies heavily on cues realized on transitions from the obstruent to adjacent vowels. For voicing, these contextual cues include the following: the burst, which is less intense for voiced obstruents than for voiceless ones, voice-onset-time, which is negative for voiced stops and either zero or positive for voiceless stops, as well as fundamental frequency and first formant values during adjacent vowels, both of which are lower in proximity to voiced relative to voiceless obstruents. Internal cues to obstruents, i.e. properties temporally aligned with the consonant constriction itself, are less numerous and generally less salient perceptually; these internal cues to laryngeal features include voicing, present for voiced obstruents but not for voiceless ones, and closure duration, typically shorter for voiced obstruents than for voiceless ones. Presonorant position, where voicing contrasts are preserved in Lithuanian, is superior to pre-obstruent or final position (contexts where neutralization takes place in Lithuanian) for realizing a laryngeal contrast saliently, since several transitional cues are present: voice-onset-time (VOT), the

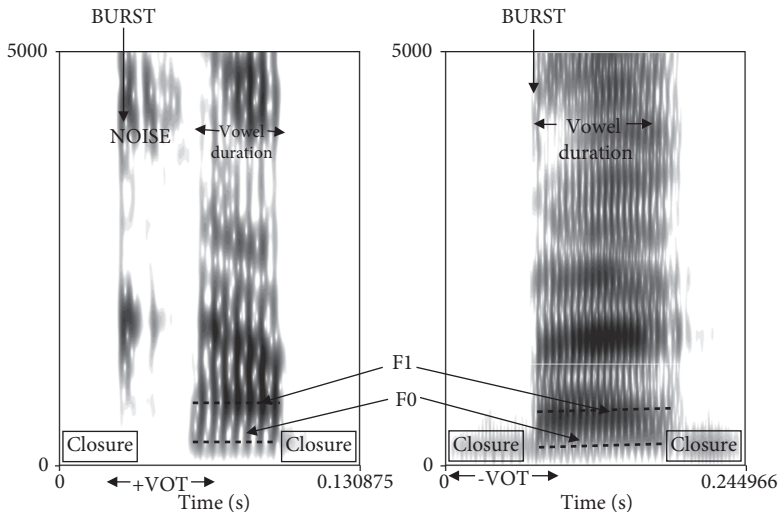


FIGURE 2.1. Perceptual cues to voicing in obstruents in prevocalic and postvocalic position illustrated for CVC sequences (voiceless stops on left, voiced stops on right)

burst, and fundamental frequency (F_0) and first formant (F_1) values at the offset of the consonant. The availability of internal and external cues to obstruents is illustrated for two CVC sequences in the spectrogram in Figure 2.1. The spectrogram on the left depicts a vowel flanked by voiceless stops and the spectrogram on the right a vowel surrounded by voiced stops.

Steriade suggests that speakers of a language may choose to eliminate a voicing contrast, or more generally any contrast, in contexts in which it is not likely to be perceptually robust rather than produce a contrast that will be difficult to perceive. The output of neutralization is a laryngeally unspecified consonant whose surface phonetic realization is determined by ease of articulation: voiced between voiced sounds and voiceless before a voiceless sound or in final position.

Although they have fundamentally different groundings, Lombardi's and Steriade's accounts make the similar prediction that neutralization will yield a voiceless consonant in final position. The two accounts diverge, however, in terms of the expected location(s) of neutralization. For Lombardi, all syllable-final consonants are predicted to undergo neutralization whether they are a word-final or a word-internal coda. Steriade's approach, on the other hand, leaves open the possibility of a language asymmetrically preserving a voicing contrast in word-final coda position but neutralizing it in word-medial position, since obstruents are more likely to have an audible release in final position than when preceding another obstruent.

In fact, Steriade shows that the neutralization pattern observed in Hungarian fits the profile predicted by her account. In Hungarian, voicing contrasts occur in word-final obstruents but not in word-medial coda obstruents. Another argument for Steriade's analysis over the Lombardi one comes from the Lithuanian data presented earlier showing that only a subset of coda consonants, those occurring

before obstruents and word-finally, undergo neutralization. Crucially, pre-nasal obstruents maintain a voicing contrast even though they belong to the coda. It is thus descriptively inaccurate to state that codas undergo neutralization in Lithuanian.¹ In summary, the syllable-based analysis of laryngeal neutralization does not adequately predict the range of typological variation in voicing contrasts (see Steriade 1999 for discussion of other patterns not covered by the syllable-based account).

2.2.2 *Typological over- and under-prediction in phonetically driven phonology*

Although the phonetically based analysis of voicing neutralization would appear to have a descriptive advantage over the syllable-based account, there are other cases where an appeal to phonetic biases in explaining typological patterns is less convincing. A phonetically driven theory may in some cases overpredict the existence of non-occurring patterns or, in other cases, incorrectly exclude patterns that are attested.

To take an example of the former type of shortcoming, let us consider the effect of two contextual factors on the height of a vowel: the voicing of an adjacent consonant and the height of a vowel in a neighboring syllable. Phonetically, both factors exert an influence on the first formant, which reflects vowel height: higher first formant values are associated with lower vowel qualities and lower first formant values with higher vowels. First formant values are characteristically lower in vowels adjacent to voiced consonants as we have seen in the last section. Due to coarticulation (the articulatory overlap of neighboring sounds), they are also lower when an adjacent syllable contains a higher vowel (see Chapter 5 for more on coarticulation and its role in phonology). Moreton (2008) compiles phonetic data from a series of studies indicating that consonant voicing and the height of a vowel in an adjacent syllable exert an effect of roughly similar magnitude on first formant values for vowels. Strikingly, though, cases in which the influence of consonant voicing on vowel height has been phonologized are far less common than cases of phonological vowel-to-vowel height harmony (see Chapter 5 on vowel harmony), suggesting that phonetic factors alone do not offer a complete story for the typology of harmony involving vowel height (see section 2.2.4 for further discussion of Moreton's findings).

A phonetically driven model of phonology also does not readily predict the existence of certain attested patterns. Consider the case of voicing neutralization described by Yu (2004) for the Nakh-Daghestanian language, *Lezgian*. In *Lezgian*, there is a four-way contrast between voiceless unaspirated, voiceless aspirated,

¹ Other criticisms have been leveled at Lombardi's account of syllable neutralization including its assumption that voicing is a privative feature and thus lacks a [-voice] counterpart (e.g. Wetzels and Mascaró 2001), its inability to capture laryngeal distinctions not based primarily on voicing, e.g. in German (Iverson and Salmons 1995, Beckman et al. 2013), voicing neutralization in onset position, e.g. in Lac Simon Algonquin (Iverson 1983), and neutralization to aspiration rather than voicelessness (Vaux and Samuels 2005), e.g. in Klamath (Blevins 1993).

voiced, and ejective stops in prevocalic position (2). (Note that fricatives also adhere to the same restrictions as stops, but they are not discussed here since they only display a two-way laryngeal contrast.)

- (2) Four-way laryngeal contrasts among Lezgian stops (Yu 2004: 75)

<i>Voiceless unaspirated</i>		<i>Voiced</i>	
a ^h qat ^h un	'come out'	ru ^h gud	'seven'
q ^w e ^h ter	'partridges'	di ^h de	'mother'
ta ^h k ^w ar	'turnips'	ba ^h de	'grandmother'
<i>Voiceless aspirated</i>		<i>Ejective</i>	
xa ^h t ^h ur	'respect'	wa ^h k'a	'pig'
ga ^h p ^h ur	'dagger'	a ^h q ^h altun	'go up, appear on'
		i ^h ts'i	'raw'

In coda position, the aspiration contrast for the voiceless stops is neutralized leaving a three-way laryngeal contrast between voiced, ejective, and voiceless aspirated stops (3).

- (3) Neutralization of aspiration contrast in coda position (Yu 2004: 75)

<i>Voiced</i>		<i>Ejective</i>		<i>Aspirated</i>	
k ^h yd	'nine'	jak ^w	'axe'	k ^h at ^h	'bitch'
t ^h ib	'owl'	kits ^h	'dog'	nek ^h	'milk'
ts ^h ig	'middle'	k ^h uk ^h	'peak'	net ^h	'louse'
t ^h ub	'finger'	k ^h wat ^h	'lump, ball'	peq ^h	'crow'

A typologically curious feature of Lezgian laryngeal neutralization is the existence of a set of monosyllabic noun roots that display an alternation between prevocalic voiceless stops and word-final (4a) and preconsonantal (4b) voiced stops (except if the following consonant is an approximant). (There are other laryngeal alternations between intervocalic ejectives and voiced stops that I do not discuss here.)

- (4) Alternations between voiced and voiceless stops (Yu 2004: 76)

(a)	pab	'wife'	pap-a	'wife (erg)'
	rad	'intestine'	ra ^h t-uni	'intestine (erg)'
	leg ^w	'tub'	le ^h k ^w -e	'tub (erg)'
(b)	xeb-mal	'animal-cattle'	xp-er	'sheep (pl)'
	gad-di	'all summer'	ga ^h t-u	'summer (erg)'
	ts ^h eg ^w	'ant'	ts ^h e ^h k ^w -re	'ant (erg)'

On the one hand, the fact that the voicing contrast is neutralized in final and preconsonantal position is predicted by Steriade's analysis in which neutralization sites adhere to an implicational scale projected from a universal scale of perceptibility. On the other hand, however, the Lezgian alternations are problematic for an account like Steriade's that predicts neutralization to the feature requiring the least articulatory

effort. As discussed in section 2.1.4, voicing requires *increased* articulatory effort in final position.

In fact, the inability to capture the Lezgian alternations is not unique to Steriade's analysis. Even the syllable-based theory of neutralization espoused by Lombardi (1995) is unable to account for the (near-)neutralization to the voiced category in Lezgian, since it assumes a bias against the licensing of the feature [voice] in coda position. Similarly problematic for both accounts are languages in which the neutralized series is apparently aspirated (Vaux and Samuels 2005).

The shortcomings of both the phonetically driven and the non-phonetically driven accounts of laryngeal neutralization reside in their inability to distinguish between unattested and extremely rare patterns. There is no straightforward way in a purely synchronic analysis to admit the pattern of final voicing in Lezgian while also capturing its status as a cross-linguistic outlier. The difficulties encountered by both approaches in accounting for the Lezgian data instantiate the more general difficulty in modeling cross-linguistic frequency effects.

As a final note on Lezgian, Yu's (2004) work demonstrates that it is important to verify phonological descriptions through phonetic data. He presents results of an acoustic study confirming that the word-final counterparts to the intervocalic voiceless stops are phonetically voiced in Lezgian. However, he also finds that the alternating voiced stops have slightly longer voiced phases and overall duration than underlying voiced stops in final position. Lezgian voicing thus falls into the class of near-neutralizing phenomena (see Chapter 5 for more on neutralization).² In any case, Yu's (2004) phonetic study indicates that there is a phonetic asymmetry that must be accounted for between the two obstruent series that he assigns to the phonologically voiced category.

2.2.3 *Typology as a reflex of diachronic change*

A more coherent understanding of frequency often emerges when one considers a phenomenon from a diachronic perspective, as in the Evolutionary Phonology framework developed by Juliette Blevins (2004, 2006). Under Blevins's approach, which builds on work by John Ohala (e.g. 1981, 1989, 1993, 1994) on the phonetic basis for sound change, phonologies evolve through a series of misapprehensions and phonological restructurings on the part of the listener. In this account, vowel harmony arises when normal low-level phonetic vowel-to-vowel coarticulatory effects are mistakenly assumed by the listener to be phonological targets intended by the speaker (Ohala 1994). For example, the listener might mistakenly assume that an /i/ that is phonetically retracted because it occurs between two syllables containing an /u/ was intended as a phonologically back vowel by the speaker. This could trigger a reanalysis by the listener of the phonetically retracted

² Kiparsky (2008) seizes upon this length difference to reanalyze the alternating voiced stops as underlying voiced geminates and derive the voiceless ones in non-final position by a process of devoicing and shortening. Blevins (2006) argues against Kiparsky's analysis on various grounds, which are countered by Kiparsky (2006).

/i/ as a phonological back vowel, potentially sowing the seeds of an incipient vowel harmony system (see Chapter 5 for further discussion of coarticulation and vowel harmony).

In the Evolutionary Phonology model, patterns that are typologically infrequent, such as final voicing in Lezgian, are rare because they are phonetically unnatural, but they are not impossible since a series of historical events, each of which might in isolation be phonetically natural, could conspire to produce a synchronic distribution that is phonetically anomalous. Yu (2004), in fact, shows that the Lezgian pattern of final voicing is likely the result of a confluence of diachronic changes that are all phonetically natural. On the basis of cognates shared with other Samurian languages of the Nakh-Daghestanian family, Yu reconstructs voiceless stops for the series that alternate with final voiced stops in modern Lezgian, suggesting that a process of intervocalic devoicing rather than final voicing created the synchronic voicing alternation. Although intervocalic devoicing is also typologically rare, Yu argues that it was one component in a more general phonetically natural process of fortition (or strengthening; see Chapter 5) affecting consonants in the onset of stressed syllables, characteristically the second syllable of a Lezgian word. Fortition manifested itself as gemination and devoicing of the stressed onset with a chronologically later process shortening the resulting geminates. Because monosyllabic roots in Lezgian typically take suffixes that begin with a vowel or an approximant, the result of this chain of events was an alternation between voiced consonants at the end of monosyllabic roots and voiceless ones when a suffix was added. Polysyllabic roots, on the other hand, did not develop voicing alternations since their root-final consonants would not occur in the onset of a stressed syllable. The historical conditions giving rise to the voicing patterns are summarized in (5).

- (5) Development of Lezgian intervocalic stops in monosyllabic and polysyllabic roots (Yu 2004: 87)

<i>Monosyllabic root</i>	<i>Polysyllabic root</i>
Root-suffix	Root-suffix
'CVD-V > CVT'T-V > CV'T-V	CV'CVD-V > CV'CVD-V

The exceptional case of final voicing in Lezgian and other cases of phonetically unnatural processes (e.g. Buckley 2000, Hyman 2001, Johnsen 2012) demonstrate that certain phenomena may not be amenable to a phonetically based synchronic analysis or even to a non-phonetically driven account that is overly restrictive in its predictions. Rather, as Blevins argues, only a historically grounded approach is in a position both to shed insight into typologically exceptional and apparently unnatural patterns while also predicting their relative rarity. In the case of Lezgian, it is the combination of three independent properties that conspires to produce the unusual voicing alternations: peninitial stress, which is typologically quite rare (Hyman 1977, Gordon 2002a, Goedemans 2010; see Chapter 6), vowel-initial suffixes that trigger resyllabification of root-final consonants, and devoicing of stressed onsets (see Blevins 2006 for other confluences of events that could conspire to produce final voicing).

Although cases like Lezgian undermine the strongest view of phonetic determinism in phonology, they do not themselves preclude the potential importance of phonetic factors on a synchronic level. Rather, the existence of seemingly phonetically unmotivated phenomena indicates that speakers have the ability to acquire patterns that could not be acquired purely on grounds of phonetic naturalness. The contributions of phonetic and cognitive biases to phonological learning are explored further in the next section.

2.2.4 Typology and learning biases: experimental approaches

The last decade has witnessed considerable expansion of the psycholinguistic research program that supplements traditional typological inquiry as a basis for theory development with the investigation of phonetic and analytic biases in phonological acquisition. I summarize here some work belonging to this line of research, which, though still in its relative infancy, has already produced some important results that potentially offer explanations for why certain patterns are more common than others across and within languages.

Pycha et al. (2003) presented native English listeners with one of three artificially constructed vowel distributions two of which involved vowel harmony and disharmony. In one condition, the presented forms illustrated a phonetically natural rule of palatal harmony of the type found in many natural languages (see Chapter 5) in which suffixes have two allomorphs varying in backness depending on the backness of the root vowel. In another condition, listeners were given forms instantiating a phonetically less natural and correspondingly rare (see Chapter 5) process of palatal disharmony in which the suffixal vowel had the opposite backness values of the root vowel. Finally, the third pattern involved an arbitrary interaction in which a mix of front and back vowels (i, æ, ʊ) triggered a front vowel suffix, while a different mix (i, u, a) triggered a back vowel suffix. Both the phonetically natural harmony and the phonetically unnatural disharmony processes are formally simple in terms of manipulating a single phonological predicate, the backness feature for vowels. The arbitrary distribution, on the other hand, is formally more complex since it requires reference simultaneously to height and backness of the vowels conditioning harmony.

After a training session in which examples of harmony were presented aurally, listeners were asked for their grammaticality judgments on a series of novel forms differing in their well-formedness according to the learned harmony rule. Results suggested difficulty in acquiring the formally complex and arbitrary rule of vowel harmony relative to the other two types of systems. Pycha et al. also found that the percentage of correct responses for listeners exposed to the phonetically natural harmony system was slightly greater, but not reliably so, than for speakers presented with the phonetically less natural but formally simple disharmony pattern. Crucially, because English does not have vowel harmony, results of their study are unlikely to be attributed to interference from preexisting knowledge of a harmony system.

Using a somewhat different type of experiment employing an Artificial Grammar paradigm, Wilson (2003) also attempted to address the role of naturalness in

the acquisition process. Listeners in his first experiment were presented with one of two different nasal harmony processes. In one condition, listeners heard tokens containing a suffix that had two allomorphs, [-na] and [-la], where the occurrence of each was conditioned by the nasality of the final consonant of the stem according to a widely attested and natural type of nasal harmony system (see Chapter 5) found in languages: a nasal consonant triggered the [-na] variant whereas an oral consonant triggered the [-la] variant, e.g. *gomena* vs. *gobela*. The other group of listeners was given forms in which the [-na] allomorph was triggered by a final dorsal consonant and the [-la] allomorph was conditioned by a non-dorsal consonant, e.g. *dogena* vs. *dobela* a less natural and unattested type of harmony system. After a training session in which the relevant grammar was illustrated, listeners were presented with novel forms either conforming to or deviating from the patterns of the training session, and asked whether they had heard these forms previously or not. Wilson found that listeners were far more accurate in recognizing forms conforming to the phonetically natural rule of nasal harmony than the unnatural alternation conditioned by the dorsality of the final consonant. In a follow-up experiment, listeners were presented with forms illustrating a process of nasal disharmony in which a nasal consonant in the root triggered the [-la] allomorph. Nasal disharmony is attested in several languages (Alderete 1997, Suzuki 1998; see Chapter 5). In keeping with the results of Pycha et al. (2003), listeners were better able to recognize grammatical forms displaying disharmony than listeners exposed to an unnatural rule in which the [-la] allomorph was conditioned by a dorsal consonant in the root. Wilson does not make a direct comparison of results for the nasal harmony and disharmony conditions.

The relative contribution of analytic as opposed to phonetic biases is difficult to assess in Pycha et al.'s (2003) and Wilson's (2003) studies due to a confound between phonetic naturalness and cognitive simplicity. The nasal harmony and disharmony patterns in Wilson's work are arguably both phonetically more natural and cognitively simpler in terms of the phonological features they manipulate than the less readily acquired dorsal-nasal harmony. In Pycha et al.'s study, the arbitrary mixed harmony system is both phonetically less natural and analytically more complex than the palatal harmony and disharmony systems more easily acquired by subjects in their experiment.

Moreton (2008) represents a rigorous attempt to tease apart the relative strength of analytical vs. phonetic biases in influencing both phonological acquisition and typology. He tests via an Artificial Grammar paradigm the relative ability of participants to acquire vowel-to-vowel harmony vs. consonant-to-vowel harmony patterns. The vowel harmony system in his experiment involves harmonizing of height between the two vowels in a set of CVCV stimuli, while the vowel-to-consonant harmony patterns involve an alternation of the first vowel in CVCV between a high vowel before a voiced consonant and a non-high vowel before a voiceless consonant.

Vowel height harmony systems (see Chapter 5) are far more common than those involving an interaction between vowel height and consonant voicing even though there is a phonetic precursor to both patterns, arguably stronger in the case of vowel-consonant harmony. Subjects in Moreton's experiment displayed a

greater capacity for mastering patterns reflecting vowel-to-vowel harmony compared to those instantiating vowel-consonant harmony. He interprets this result as evidence for an analytic bias favoring the vowel-to-vowel harmony system, speculating that the vowel harmony system may be simpler to acquire since it is sensitive to a single featural dimension, vowel height, as opposed to the height and voicing interaction embodied in the vowel-to-consonant harmony pattern.

In a follow-up experiment, Moreton compares the acquisition of the vowel-to-consonant harmony system with the acquisition of a voicing harmony system between the two consonants in CVCV. Consonant voicing harmony is rare and differs from vowel-consonant harmony in lacking a typologically robust phonetic precursor, i.e. there does not appear to be any cross-linguistic phonetic tendency for voicing agreement between consonants separated by an intervening vowel. Nevertheless, subjects performed better in learning the consonant voicing harmony than the vowel-to-consonant harmony, suggesting that the former type of pattern enjoys a cognitive advantage over the latter. Like the vowel-to-vowel harmony pattern, the voicing harmony system may be simpler to acquire since it is sensitive to a single featural dimension, voicing. Moreton's results suggest that both phonetic and analytic factors are necessary preconditions for a pattern to become typologically common. Although equivalent in analytic complexity (at least by a featural metric) to the vowel-to-vowel harmony pattern, the voicing harmony pattern lacks a sufficiently robust phonetic conditioning factor to become entrenched as a phonological pattern. On the other hand, despite possessing the necessary phonetic precursor, the vowel-to-consonant harmony pattern is analytically too complex to emerge as a typologically widespread phenomenon.

One of the difficulties in assessing the relative effect of analytic vs. phonetic biases in shaping phonological typology is the evaluation of the robustness of phonetic conditional factors. Yu (2011) challenges Moreton's assumption that the phonetic precursors to the vowel-to-vowel harmony system are no more robust than those motivating the typologically rare vowel-consonant harmony pattern. Yu suggests that the measurement of intracategory variability in first formant values employed by Moreton is insufficient as a diagnostic of phonetic precursor robustness. Rather, Yu proposes that what is at stake is the extent to which contextual variation creates overlap between a phonemic category and other neighboring categories. Under this approach, the robustness of a phonetic precursor is a measure of the degree of confusion induced by the presence of that precursor. For example, if the low vowel /a/ is raised both before a voiced consonant and before a high vowel in an adjacent syllable, the relative strength of the two contexts as potential phonetic precursors to a categorical vowel raising rule depends on how much perceptual ambiguity between the low vowel and a phonemic mid vowel is created by raising. Yu proposes a method for quantifying phonetic precursor robustness as a function of the effect of a context on the differentiation of phonological categories. He supports his proposal through a production study of the effects of vowel-to-vowel and consonant-to-vowel coarticulation in English and Turkish. Results of applying his method of calculating precursor robustness indicate that the phonetic effect of vowel-to-vowel

coarticulation on first formant values is greater than the effect of consonant-to-vowel coarticulation, in keeping with the greater typological frequency of vowel-to-vowel height harmony. Yu also suggests another way in which the phonetic precursor to vowel harmony is more robust than the precursor to voicing-induced vowel–consonant height harmony: vowel-to-vowel coarticulation effects characteristically have a longer temporal span than consonant–vowel coarticulation, a difference that potentially contributes to the relatively greater phonetic robustness of the vowel-to-vowel interactions. Yu’s research shows that the evaluation of phonetic precursor robustness is a complex issue and casts uncertainty about the hypothesis that it is really analytic bias rather than phonetic bias that conditions the greater typological frequency of vowel height harmony systems relative to vowel height shifts attributed to the voicing of an adjacent consonant.

Carpenter’s (2010) study of stress patterns sensitive to vowel quality offers further support for the important role of phonetic naturalness in both shaping typology and facilitating the acquisition of phonological patterns. She shows that English and Canadian French speakers are better able to master a phonetically natural stress rule in which low vowels preferentially attract stress over higher vowels than a phonetically unnatural one, but analytically equivalent in terms of number of features involved, in which high vowels attract stress from lower vowels. This result accords with the typology of vowel-quality-driven stress rules (Kenstowicz 1997, de Lacy 2004; see Chapter 6): some languages have stress systems that favor lower vowels over higher vowels while there do not appear to be any that favor higher vowels over lower ones.

In summary, the role of analytic and phonetic factors in shaping both the language acquisition process and the typology of phonological patterns is currently the subject of vigorous debate. Results are still inconclusive particularly concerning evidence for the role of analytic biases (see, for example, Pater and Tessier 2006, Wilson 2006, Peperkamp et al. 2006, Zhang and Lai 2010, Becker et al. 2011, Moreton and Pater 2012a, b, and Hayes and White 2013).

2.2.5 *Typological variation modeled: constraints or rules*

In addition to the debate about the synchronic contribution of different biases to the phonology, another contentious issue concerns the formal framework in which these biases should be couched: derivational or constraint-based. Although the issues of grammatical architecture and the role of substantive biases in phonology are logically orthogonal to each other, the constraint-based paradigm of Optimality Theory has figured prominently in analyses that grammatically encode the typological reflexes of competition between various types of phonetic and functional biases. Stochastic models of Optimality Theory have proved to be particularly promising in the modeling of frequency distributions, which increasingly appear to act as important predictors of many phonological patterns.

2.2.5.1 Steriade (1999) on laryngeal neutralization in Optimality Theory Steriade (1999) couches her analysis of laryngeal neutralization within an Optimality-theoretic paradigm (Prince and Smolensky 1993/2004), in which the loss of

laryngeal contrasts is driven by constraints on phonological well-formedness that ban laryngeal contrasts in contexts where they are perceptually less optimal (see Gordon 2007 for an overview of typology in Optimality Theory). She posits an implicational scale of constraints prohibiting laryngeal contrasts in different contexts varying in their capacity to realize those laryngeal contrasts in a perceptually salient manner. For example, the constraint banning laryngeal contrasts in positions before an obstruent is ranked above the constraint prohibiting laryngeal contrasts in final position, reflecting the fact that pre-obstruent position provides a worse backdrop for the realization of a laryngeal contrast than final position. In keeping with this perceptibility difference, recall from section 2.2.1 that Hungarian preserves voicing contrasts word-finally but not in pre-obstruent position. Competing with the markedness constraints banning laryngeal contrasts in different contexts is a faithfulness constraint requiring that underlying contrasts be preserved on the surface. By interleaving this faithfulness constraint with the implicationally ranked scale of markedness constraints banning voicing in different contexts different neutralization patterns are generated in Steriade’s analysis. For example, in Hungarian, faithfulness is ranked below the constraint against voicing contrasts in pre-obstruent position but above the constraint banning voicing contrasts in final position. In contrast, in Lithuanian, which neutralizes voicing distinctions both in pre-obstruent position and word-finally, faithfulness is ranked below both of the markedness constraints. The language-dependent ranking of the faithfulness constraint relative to the two markedness constraints is illustrated for Hungarian and Lithuanian in the tableau in (6). Following standard conventions in Optimality Theory, a potential form that fails to surface due to its violation of a constraint is indicated by an exclamation point and the actual surface form is indicated by a pointing finger. Note that for expository purposes the formulation of the constraints in (6) is simplified from Steriade’s (1999) original analysis.

(6) Optimality-theoretic analysis of voicing neutralization in Hungarian and Lithuanian

Hungarian	*VOICE/ __ [-son]	FAITH(VOICE)	*VOICE/ __ #
<i>Pre-obstruent:</i> /həbʃo:k/ ‘meringue’			
☞ həbʃo:k həbʃo:k	*!	*	
<i>Word-final</i> /rɔb/ ‘prisoner’			
rɔp ☞ rɔb		*!	*
Lithuanian	*VOICE/ __ [-son]	*VOICE/ __ #	FAITH (VOICE)
<i>Pre-obstruent</i> /dɛgti/ ‘burn-inf.’			
☞ dɛkti dɛgti	*!		*
<i>Word-final</i> /daúg/ ‘much’			
daúg ☞ daúk		*!	*

A key feature of Optimality-theoretic analyses like the Steriade (1999) one is the separation of constraints banning marked (i.e. less phonetically natural and thus less common) structures and the faithfulness constraints requiring preservation of underlying material. This separation predicts that languages might differ in the strategies they employ to satisfy highly prioritized faithfulness constraints.

2.2.5.2 Factorial typology in phonology: the case of syllable-contacts To explore this prediction further let us build on the discussion of sonority from Chapter 1 and consider consonant clusters at syllable boundaries, drawing on Gouskova's (2004) work on the typology of heterosyllabic clusters. As will be discussed further in Chapter 3, there is a cross-linguistic preference for heterosyllabic consonant clusters to display a falling sonority profile where the first consonant has greater sonority than the second one according to the sonority scale presented in Chapter 1. Languages differ both in the strictness of this preference, termed the Syllable Contact Law (Hooper 1976, Murray and Vennemann 1983, Vennemann 1988), and in their strategies for ameliorating violations of it. In the discussion that follows we will abstract away from cross-linguistic variation in the sonority thresholds that trigger changes in heterosyllabic clusters and instead focus on the varied responses to potential violations of the Syllable Contact Law.

Gouskova (2004) discusses one pair of strategies for circumventing syllable contact violations in the Cushitic language Sidamo. Rising sonority clusters (those in which the second member has greater sonority than the first) undergo metathesis (and place assimilation), which produces a falling sonority cluster: /duk-nanni/ → *duŋ.kanni* 'they carry', /huf-nanni/ → *hun.ɸanni* 'they pray/beg/request', /has-nemmo/ → *han.semmo* 'we look for', /hab-nemmo/ → *ham.bemmo* (Gouskova 2004: 226). Flat sonority clusters and falling sonority clusters in which the fall is insufficiently large, i.e. when the consonants in the cluster are adjacent on the sonority scale, display a different resolution, gemination: /af-tinonni/ → *affinonni* 'you (pl) have seen', /lellij-toti/ → *lellijɸoti* 'Don't show!', /ful-nemmo/ → *fullemmo* 'we go out', /um-nommo/ → *ummommo* 'we have dug' (p. 226). Gouskova assumes that geminates are a single sound and thus not subject to constraints on clusters.

Another strategy for dealing with ill-formed heterosyllabic clusters is found in the Turkic language Kirghiz, in which suffix-initial sonorants strengthen to stops when they follow any coda consonant, a shift that has the effect of improving the sonority profile of the coda-onset cluster. For example, the objective suffix *-nu* and the plural suffix *-lar* surface unchanged intervocalically but the first sound in each changes to a lower sonority plosive (/t/ or /d/ depending on voicing of the root-final consonant) when suffixed to a consonant final root, e.g. *to:-nu*, *to:-lar* 'mountain' vs. *kar-du*, *kar-dar* 'snow', *antan-du*, *antan-dar* 'gelded camel', *taf-tu*, *taf-tar* 'stone', *konok-tu*, *konok-tar* 'guest' (Gouskova 2004: 237). Note that Kirghiz suffixal vowels alternate due to vowel harmony (see Chapter 5).

Yet another response to a sub-optimal syllable contact is to delete one of the consonants participating in the offending transition. In Diola Fogany (Rice 1992), syllable contacts involving a sonority plateau or a rise are resolved through deletion of the first consonant. For example, the first stop deletes in the stop–stop cluster in /let-ku-jaw/ 'they

won't go', yielding *lekujaw* (p. 73); the nasal is lost in the nasal–lateral cluster in /na-laj̥-laj̥/ 'he returned', giving *nalalaj̥* 'he returned' (p. 74). A nasal does not delete if it precedes a lower sonority plosive (though it assimilates in place), e.g. /na-ti:ŋ-ti:ŋ/ → *nati:nti:ŋ* 'he cut (it) through' (p. 73).

Finally, epenthesis may also be employed to avoid heterosyllabic clusters with illicit sonority profiles (see Chapter 5 for an alternative perceptually driven account of epenthesis in rising sonority clusters). In Kabardian (Colarusso 1992, 2006), an epenthetic vowel is inserted in clusters of a consonant + sonorant consonant: /fəz-mv̄/ → *fəzəmv̄* 'if a woman', /məl-mv̄/ → *mələmv̄* 'if ice'. Sonorants in onset position word-initially or following a vowel do not trigger epenthesis: *nv̄* 'eye', *wənv̄ -mv̄* 'if a house'.

In summary, Sidamo, Kirghiz, Diola Fogy, and Kabardian together instantiate five different strategies for avoiding heterosyllabic clusters with impermissible sonority profiles: metathesis and gemination (Sidamo), fortition (Kirghiz), deletion (Diola Fogy), and epenthesis (Kabardian). The employment of varied mechanisms for dealing with the same ill-formed configuration fall out in straightforward fashion from a theory like Optimality Theory that formally separates the prohibition against a marked structure from the varied strategies for coping with that structure (see Kager 1999, McCarthy 2001). In Optimality Theory, the marked configuration is penalized by a highly ranked markedness constraint whose satisfaction entails violating at least one of a series of faithfulness constraints each banning different deviations from the underlying form. Metathesis occurs if the constraint requiring that the underlying order of segments be preserved on the surface, LINEARITY (McCarthy and Prince 1995), is ranked below other faithfulness constraints. Gemination or fortition are possibilities when the constraint requiring that lexical feature specifications of segments not change on the surface, IDENT (McCarthy and Prince 1995), is demoted below other faithfulness constraints. (In Gouskova's analysis, the choice between gemination and fortition depends on the status of another markedness constraint banning geminates.) Deletion reflects the relatively low ranking of a constraint mandating that all underlying sounds surface, MAX (McCarthy and Prince 1995). Epenthesis is attributed to the lower ranked status of the faithfulness constraint requiring that surface sounds have a correspondent in the underlying string, DEP (McCarthy and Prince 1995). The different responses to syllable contact violations and the constraint rankings that generate them are summarized in (7).³ Note that the syllable contact constraint in the analysis is actually an amalgam consisting of multiple members of a family of constraints banning different sonority distances between members of a cluster (see Gouskova 2004 for analysis).

³ Gouskova (2004) discusses one additional strategy, adopted in Faroese and Icelandic, for avoiding sonority violations across syllable boundaries: resyllabification as an onset cluster (see Gouskova's paper for details).

- (7) Constraint rankings yielding different responses to syllable contact violations

No change:

LINEARITY (NO METATHESIS), MAX (NO DELETE), IDENT (NO CHANGE), DEP (NO INSERT)
 \Downarrow
 σ -CONTACT

Metathesis:

σ -CONTACT, MAX (NO DELETE), IDENT (NO CHANGE), DEP (NO INSERT)
 \Downarrow
 LINEARITY (NO METATHESIS)

Gemination/Fortition:

σ -CONTACT, MAX (NO DELETE), LINEARITY (NO METATHESIS), DEP (NO INSERT)
 \Downarrow
 IDENT (NO CHANGE)

Deletion:

σ -CONTACT, IDENT (NO CHANGE), LINEARITY (NO METATHESIS), DEP (NO INSERT)
 \Downarrow
 MAX (NO DELETE)

Epenthesis:

σ -CONTACT, IDENT (NO CHANGE), LINEARITY (NO METATHESIS), MAX (NO DELETE)
 \Downarrow
 DEP (NO INSERT)

Instances in which multiple strategies are employed to cope with the same marked configuration are often referred to as “conspiracies” (Kisseberth 1970). The syllable contact cases discussed by Gouskova (2004) constitute a type of conspiracy operating across languages. Another arguably more compelling type of conspiracy is observed within languages (see Casali 1997, 1998 on language-internal conspiracies involving vowel hiatus).

The modeling of conspiracies in Optimality Theory through variable ranking of faithfulness constraints and well-formedness constraints diverges from rule-based treatments which package the ill-formed structure and the response to avoiding that structure together in a single rule. Thus, the five responses to syllable contact violations discussed above could be captured in the five rules in (8).

- (8) Five rules capturing different responses to syllable contact violations

Metathesis: $XY \rightarrow YX$

Gemination: $Y \rightarrow X / X _$

Fortition: $Y \rightarrow Z / X _$

Deletion: $X \rightarrow \emptyset / _ Y$

Epenthesis: $\emptyset \rightarrow V / X _ Y$

The rules in (8) all have in common that their output avoids the dispreferred configuration XY , yet this link is missed in the rule-based analysis in which the five conspiratory rules are formally independent of each other. In contrast, in the Optimality-theoretic account, the fact that all processes share the common goal of

avoiding a marked configuration can be encoded in the analysis as the reflex of a constraint against that configuration.

Although the existence of conspiracies would appear to give a decided advantage to the constraint-based OT framework over its derivational counterpart, the natural ability of OT to model conspiracies is not without its pitfalls. In fact, it turns out for many phenomena that only a subset of the logically possible responses to avoiding a marked structure is attested cross-linguistically. Although the example above from sonority contact illustrates a richly varied set of strategies for avoiding dispreferred clusters across syllable boundaries, there are still some apparent gaps between the typology of resolutions predicted by OT and those that are actually attested. For example, as we saw, Diola Fogy deletes the first consonant in a cluster to avoid sonority violations, yet there do not appear to be any languages that delete the second consonant instead, a strategy that would yield the same result in terms of eliminating a poor syllable contact. The architecture of the OT grammar, at least not as originally conceived, often overpredicts variation in the responses to a markedness constraint. Several other types of phenomena, notably those in which surface patterns are opaque given a one-step mapping between underlying and surface forms, are problematic for Optimality Theory but fall out in relatively straightforward fashion using ordered rules. The evaluation of the relative merits of constraint-based vs. rule-based frameworks is the basis of an ongoing debate in phonological theory.

2.2.5.3 Modeling frequency in a constraint-based grammar In its original conception (Prince and Smolenksy 1993/2004), Optimality Theory assumed a universal set of constraints that are discretely ranked on a language-specific basis. Free variation in this model is captured through optional re-ranking of constraints at the time of speaking. For example, in the case of syllable contact violations, hypothetical free variation between deletion and epenthesis as repair strategies within a language could be modeled as variability in the relative ranking of DEP (NO INSERT) and MAX (NO DELETE). On one occasion, a speaker might rank the former constraint over the latter and employ deletion, whereas on the next occasion, a speaker might employ the opposite ranking and opt for epenthesis. A drawback of this model is its limited capacity to model frequency distributions: there is thus no way of capturing the fact that epenthesis might be more commonly employed than deletion in a given language as a strategy for avoiding poor syllable contacts. Similarly, there is no possibility of modeling the relative typological rarity of one response to a well-formedness constraint compared to another response to the same constraint.

Modeling variation through discrete constraint ranking fails to capture the fact that variation is typically not arbitrary but is predictable based on a confluence of variables (e.g. contextual factors, speech rate, register, etc.) that either increase or decrease the likelihood of a particular variant in probabilistic fashion, ultimately yielding frequency distributions that emerge in corpora. More recent incarnations of Optimality Theory employ probabilistic constraint ranking algorithms that are capable of modeling frequency distributions.

One probabilistic constraint-based model of phonology is Boersma's (1997, 1998) stochastic version of OT in which constraint rankings are treated as probability distributions along a continuous linear scale rather than possessing a single ranking value relative to other constraints as in the traditional OT model. In the process of evaluating potential candidates to produce in speech, the actual ranking of each constraint, the selection point, is a function of its probability distribution with a random perturbation component that creates a unique ranking for each utterance. The odds of a particular selection point occurring decreases as the selection point moves away from the center of a constraint's ranking range. This conception of constraint ranking allows for the possibility of ranking "reversals" in which a constraint whose ranking range is higher than but overlaps with that of another constraint may be ranked either above or below that constraint when a selection point is set.

Random perturbation is also a key component in the Noisy Harmonic Grammar model (Pater 2009, Boersma and Pater to appear). Like Optimality Theory, the Harmonic Grammar (HG) framework (Legendre et al. 1990, Smolensky and Legendre 2006, Pater 2009) assumes a series of constraints against which candidates corresponding to an input form are evaluated. However, unlike in the original OT model, HG assumes that each constraint is associated with a numerical weighting reflecting how much a candidate is penalized for each violation of that constraint. The "harmony" of a candidate is determined by multiplying each constraint violation by the penalty associated with violating that constraint and then summing the totals over all the constraints. This calculation of harmony is illustrated in (9) for a subset of the Hungarian final devoicing data considered earlier. In the example, the voicing in both the pre-obstruent and the final stop is varied in the candidates and the penalty associated with each constraint is given as an integer above the constraint name.

(9) Hungarian final devoicing in Harmonic Grammar

	3	2	1	
/haptʃo:k/ 'meringue'	*VOICE/ __ [-son]	FAITH(VOICE)	*VOICE/ __ #	
☞ haptʃo:k		-1		-2
haptʃo:k	-1			-3
haptʃo:g	-1	-1	-1	-6
hapʃo:g		-2	-1	-5

The winning candidate violates only the faithfulness constraint, for which it receives a penalty of -2, the highest (i.e. closest to zero) harmony score of the four candidates. The second candidate violates only a single constraint as well, but the constraint it violates, the one banning pre-obstruent voicing, is associated with a greater penalty than faithfulness. The third candidate, in which the word-final obstruent has undergone voicing, violates all three constraints; its aggregate score of -6 is the sum of the penalties associated with each constraint. The final candidate with devoicing of the first obstruent and voicing of the second one receives a score of -5 reflecting the sum of its two violations of faithfulness and its

violation of the constraint against voicing in final position. In order to allow for variation in outputs, Noisy Harmonic Grammar incorporates a random component in the calculation of a candidate’s violation score for a given constraint by multiplying the exponent of the sum of the constraint by a noise factor.

A salient feature of the Harmonic Grammar model is its ability to model so-called “ganging” effects where multiple violations of a lower weighted constraint can gang up to eliminate a candidate that honors a higher weighted constraint. This differs from the traditional OT model in which satisfaction of lower ranked constraints cannot resuscitate a candidate that has been eliminated by virtue of violating a higher ranked constraint. The ganging effect can be illustrated using an example from the syllable contact data from Goukova (2004) considered earlier (though it cannot handle all the facts addressed by Gouskova). To exemplify the ganging effect, we consider the least relational of the data discussed by Gouskova. Recall that in Kirghiz suffix-initial sonorants change to stops when following a consonant-final root, e.g. *to:-nu* ‘mountain-objective’ vs. *kar-du* ‘snow-objective’ (Gouskova 2004: 237), where the vowel alternation reflects an orthogonal vowel harmony process. The strengthening of postconsonantal sonorants can be analyzed as an effect of two constraints: one banning sonorant onsets, *SONONSET, and one prohibiting codas, *CODA. Each of these constraints is ranked below the constraint banning changes in the underlying form, IDENT, as evidenced by the failure of onset sonorants not in post-consonantal position to strengthen to stops and the tolerance of codas in the language at large. However, if both *SONONSET and *CODA are violated, the candidate displaying fortition to a stop wins, a result that can be modeled as a ganging effect that eliminates the faithful candidate lacking fortition, a scenario that is depicted in (10).

(10) Kirghiz fortition as a ganging effect in Harmonic Grammar

/kar- du / ‘mountain-objective’	3.5 IDENT	2.5 *SONONSET	1.5 *CODA	
☞ kard <u>u</u>	-1			-3.5
karn <u>u</u>		-1	-1	-4

2.2.5.4 Modeling phonological acquisition An important metric for evaluating a theory is its ability to provide a framework in which a plausible model of the phonological acquisition process can be couched. Although phonological learning algorithms antedate the advent of constraint-based phonological paradigms, e.g. Dresher and Kaye’s (1990) model for setting metrical stress parameters, attempts to formally model the acquisition process have burgeoned within constraint-driven frameworks aided by parallel advances in computational resources.

One such learning model is the Gradual Learning Algorithm (Boersma 1997, 1998), which has been tested within both stochastic Optimality Theory (Boersma and Hayes 2001) and Harmonic Grammar (Boersma and Pater to appear) frameworks. In the Gradual Learning Algorithm (GLA), the constraint “strength”

(ranking in Stochastic OT and weighting in HG) is adjusted in response to each learning datum, where more frequently occurring data points exert greater influence. Boersma and Hayes (2001) run various simulations within an OT framework, drawing on frequency data of different types. In their most rigorous simulation, they feed the frequency distributions of various allomorphs of the genitive plural in Finnish based on Anttila's (1997a, b) data and employing constraints proposed by Anttila in his work. The GLA succeeds in constructing a constraint ranking that closely predicts the frequency patterns in Anttila's corpus, including word types that show no variation, e.g. *kala* 'fish' vs. *kalojen* 'fish (gen. pl.)', *ajattelijä* 'thinker' vs. *ajattelijoiden* 'thinkers (gen. pl.)', as well as those with differing degrees of optionality, e.g. *naapuri* 'neighbor' vs. *naapurien* (63.1%) or *naapureiden* (36.9%) 'neighbors (gen. pl.)', *korjaamo* 'repair shop' vs. *korjaamojen* (82.2%) or *korjaamoiden* (17.8%) 'repair shops (gen. pl.)'.

Building on the work within Stochastic OT, Boersma and Pater (to appear) successfully employ a version of the GLA within a Noisy Harmonic Grammar under different test conditions. One of these includes a long-standing challenge to learning models, the acquisition of hidden structure such as the type assumed in foot-based metrical stress theory (see Chapter 6; see Pater et al. 2007 and Boersma and Pater to appear on the relative merits of Harmonic Grammar and Optimality Theory).

An ambitious research program employs frequency data to model not only the acquisition of constraint rankings but also the learning of the constraints themselves. One promising probabilistic constraint learning and ranking algorithm proposed by Hayes and Wilson (2008) employs a Maximum Entropy grammar that uses weighted constraints to assign probabilities to output forms. In their model, the probability of a given candidate form is a function of its score, i.e. the weighted sum of its constraint violations, which determines the candidate's maxent value. A candidate with a larger share of the sum of maxent values of all competing candidates has a greater probability of surfacing than a candidate with a lower share of the total maxent values. A feature of Hayes and Wilson's model shared with Harmonic Grammar is its aggregate evaluation of candidates against all constraints, which allows for the possibility of constraints collectively ganging up to penalize a form.

In a number of learning simulations, Hayes and Wilson (2008) show that their model is able not only to establish a relative weighting of a set of constraints from input data distributions fed to the learning algorithm, but also to acquire the constraints given appropriate heuristics for limiting the search space for discovering constraints. In keeping with an important issue faced by language learners, their implementation of the constraint learning algorithm is sensitive to a trade-off between increasing the specificity of constraints in order to improve their accuracy in predicting attested forms while simultaneously maximizing the generality of individual constraints in order to offer broader empirical coverage.

Hayes and Wilson test their algorithm against various types of phonotactic patterns including onset consonant clusters in English, Shona vowel harmony, the typology of weight-insensitive stress systems, and a cross-section of phonotactic data from the Australian language Wargamay (Dixon 1981). For example, in the

test of their model against English word-initial onset cluster frequency data, Hayes and Wilson feed their learning algorithm frequency distributions for English onset clusters from the online CMU Pronouncing dictionary (<http://www.speech.cs.cmu.edu/cgi-bin/cmudict>). Their learning algorithm successfully constructs a grammar consisting of 23 constraints, whose weightings yielded scores for various potential clusters that correspond to the distinction between unattested and attested onset clusters. Clusters whose scores are relatively high are attested, whereas those with lower scores are generally either rare or unattested. Hayes and Wilson (2008) also test their learning algorithm against well-formedness intuitions for different clusters obtained by Scholes (1966) from a group of seventh-grade students. They find a strong correlation between the well-formedness probabilities obtained in the experimental setting with the probabilities obtained from the maxent grammar.

Not all current implementations of phonological learning algorithms take place within a constraint-based framework. Heinz (2009) adopts a learning algorithm for stress systems that focuses on modeling the inference procedure guiding the learner's hypothesis construction. Representing stress systems in terms of finite-state acceptors, Heinz runs a series of simulations in which the learner is fed stress data for words ranging from one to nine syllables long. Ultimately his Forward Backward Neighborhood Learner acquires 100 of the 109 targeted stress systems including both those with weight-insensitive and those with weight-sensitive stress (see Heinz and Riggle 2011 for more on learnability in phonology).

2.3 Summary

There are many factors that contribute to the typological distribution of various phonological phenomena. These can roughly be classed into two groups according to whether they are motivated by analytic biases or by substantive limitations imposed by the physiological system involved in the production, perception, or encoding of speech. Analytic biases encompass a wide spectrum of constraints including those imposed by the phonological formalism on the types of processes that are expressible using the formal apparatus available to the theory as well as preferences for simplicity or symmetry that may guide learning strategies employed in the discovery of phonological generalizations fitting the ambient data. Physiological biases include constraints on speech perception or articulation and on the encoding of speech at higher levels of speech processing. Many of these physical considerations may be influenced on a lexeme- or morpheme-specific basis by usage-based factors such as the relative frequency with which a particular word or morpheme occurs or the environment in which it tends to occur. Frequency asymmetries both shape the phonology over time and are also synchronically part of a speaker's knowledge of a language. In practice, the same phonological property is often amenable to various types of analyses, making it difficult to tease apart the relative contribution of analytic and physiological biases and inductive learning of the surrounding language. An additional complication is that not all patterns are equally productive on a synchronic level but may be

fossilized vestiges of historical changes. Recent research has yielded results suggesting that it may ultimately be possible to pinpoint the role of different factors, both synchronically and diachronically, in the shaping of typological biases. Furthermore, probabilistic implementations of constraint-based paradigms provide frameworks for modeling both intralanguage variation (and thus frequency effects) and the acquisition process.

3

Phoneme inventories

Examination of the IPA (International Phonetic Alphabet: <<https://www.langsci.ucl.ac.uk/ipa/fullchart.html>>) reveals great diversity in the types of sounds found in languages of the world. Sounds are differentiated along various dimensions, including place of articulation, manner of articulation, laryngeal setting, airstream mechanism, and timing of articulatory gestures. There are great disparities in the relative frequency with which different sounds are attested cross-linguistically. For example, click sounds are limited to the Khoisan languages of South Africa and some geographically adjacent languages that have borrowed them from Khoisan, while virtually every language of the world contains a set of voiceless plosives.

This chapter presents some of the salient cross-linguistic patterns identified in a number of cross-linguistic surveys of phoneme inventories, including Ian Maddieson's pioneering genetically balanced survey of 317 languages in *Patterns of Sounds* (1984), the online version (<<http://web.phonetik.uni-frankfurt.de/upsid.html>>) of its expanded 451-language counterpart *UCLA Phonological Segment Inventory Database* (UPSID) (Maddieson and Precoda 1990), several chapters of *World Atlas of Language Structures* (Dryer and Haspelmath 2013), and the *PHOIBLE* database (Moran et al. 2014), which contains segment inventories of 1,672 languages, of which those in UPSID constitute a subset. In addition, we examine frequency from a language-internal perspective to explore the hypothesis that sounds that are widely attested across languages also occur in individual languages with greater frequency relative to typologically less common sounds. Finally, we also explore a number of explanations, including phonetic, phonological, and historical ones, for the distribution of phonemes cross-linguistically and language-internally. Before proceeding a few cautionary notes are in order. First, the discussion in this chapter centers on phonemes, sounds that are used contrastively to differentiate words. (The typology of contextually governed variants of sounds, allophones, is considered in Chapter 5.) In practice, it is often difficult to determine which variant of a sound should be regarded as the basic phoneme or whether sounds largely confined to borrowings should be included (see Maddieson 1984: 160–3 for discussion). Vaux (2009) cites several cases of inconsistency in UPSID's treatment of a sound as phonemic or allophonic. More generally, because UPSID relies on a collection of language descriptions that vary considerably in their thoroughness and accuracy, it is susceptible to occasional erroneous or misleading data points (see Vaux 2009 for discussion). These criticisms also pertain to the other large-scale surveys consulted for this book. Despite these issues, however, it seems likely that the

quantitatively more robust typological generalizations gleaned from sizable databases and summarized in this chapter will hold up even if isolated individual cases turn out to require re-classification.

3.1 Cross-linguistic distribution of phonemes

In discussing the typology of phonemes, it is common to impose a broad bifurcation between consonants and vowels, where consonants involve a tighter constriction in the vocal tract than vowels. Consonants differ widely in the location and degree of the constriction ranging from those produced with a slight narrowing at the lips, i.e. bilabial approximants, to those associated with a complete closure at the larynx, i.e. glottal stops. In addition, other properties such as laryngeal setting (e.g. voiced vs. voiceless vs. ejective), nasalization, secondary articulations (e.g. labialization, palatalization, pharyngealization), and relative timing of gestures (e.g. prenasalized vs. postnasalized, preaspirated vs. postaspirated), can also differentiate consonants. Vowels can also be modified by certain of these properties, including nasalization, laryngeal setting (e.g. creaky and breathy voicing), and secondary articulations (e.g. pharyngealization).

Maddieson's (1984) survey of phoneme inventories in 317 languages reveals a wide range in the number of phonemes found in languages of the world from a low of 11 in the East Papuan language Rotokas (six consonants and five vowels) and in the Mura language Pirahã (eight consonants and three vowels) to a high of 141 in the Khoisan language !Xũ. The extensive inventory of consonants in !Xũ is due mainly to the large number of clicks and laryngeal contrasts exploited by both click and non-click consonants. Most languages (70%), however, have inventories that fall in the range of 20–37 phonemes with the cross-linguistic mean being 31 phonemes. Languages vary in their number of consonants between six (found in Rotokas) and 95 (in !Xũ) with a mean of 22.8, while vowels range from three (found in 18 languages) to 46 (in !Xũ) with a mean of 8.7. The expansive vowel inventory in !Xũ is attributed to the relatively large set of diphthongs and the use of nasalization and pharyngealization to signal contrasts.

Maddieson (1984) finds no tendency for a compensatory relationship between the number of vowels and the number of consonants in a language such that more vowels implies fewer consonants and vice versa. He does, however, observe that larger inventories tend to display a greater skewing in favor of consonants, such that there is a positive correlation between the consonant-to-vowel ratio and the number of consonants in a language.

3.2 Consonants

The 20 most common consonants according to Maddieson's (1984) survey of 317 languages are shown in Table 3.1, which conflates the dental vs. alveolar distinction into a "denti-alveolar" category since it is often difficult to discern from sources whether a sound is dental or alveolar or a combination of both. Relatively

TABLE 3.1. The 20 cross-linguistically most common consonants (Maddieson 1984)

	Labial		Denti-alveolar		Palatal	Velar		Glottal
Plosives	p	b	t	d	tʃ	k	g	ʔ
Fricatives	f		s		ʃ			h
Nasals	m		n		ɲ	ŋ		
Approximants	w		l r		j			

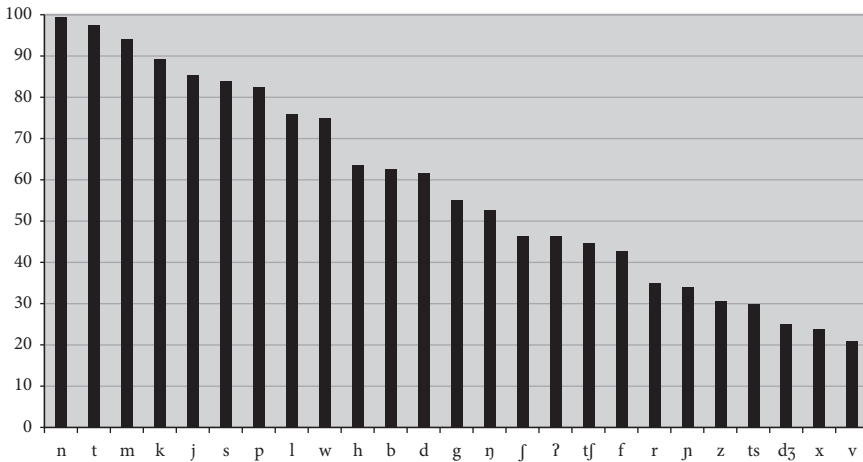


FIGURE 3.1. The percentage of languages possessing the 25 most common consonants (Maddieson 1984)

few languages (24 in Maddieson’s survey) contrast dental and alveolar places of articulation.

The modal number of consonants in an inventory is 21 (Maddieson 1984). No languages with 21 consonants in Maddieson’s (1984) survey, however, possess all 20 of the consonants in Table 3.1; the Mandé language Bambara comes closest with 19, lacking only glottal stop. The 21st and final consonant comprising the most “representative” inventory of consonants could be any of the five /z/, /ʒ/, /x/, /v/, /dʒ/, all of which occur with roughly equivalent frequency cross-linguistically.

The percentage of languages (out of 317 total) in Maddieson (1984) possessing the 20 most common consonants plus the next five most frequent consonants is plotted in Figure 3.1.

3.2.1 Plosives

As Table 3.1 and Figure 3.1 show, it is most common for languages to contrast unaffricated oral stops (i.e. stops other than glottal stop) at three places of

articulation (bilabial, denti-alveolar, and velar) adding a fourth place (typically palato-alveolar) if affricates are included. Excluding affricates, three places of articulation are exploited by 53.9% of languages in Maddieson's (1984) survey with the next most common number of places being four (32.5%). After the three most common places of articulation, palatal (or palato-alveolar) stops (18.6%) and uvulars (14.8%) are the next most common places of articulation for stops. Most languages (91.8%) possess a series of plain (unaspirated) voiceless stops and roughly two-thirds (66.9%) have voiced stops. A two-way contrast between voiceless and voiced stops (51.1% of languages) is far more common than a single series of voiceless stops (15.5%) (an additional language in the survey, the Australian language Bandjalang, is reported to have only voiced stops) or more than a two-way laryngeal contrast (24.0%). After voiceless unaspirated and voiced stops, the next most common laryngeal settings for stops are voiceless aspirated (28.7%), ejective (16.4%), and implosive (11.0%).

Among the voiceless stops, dental and/or alveolars are most common, found in 97.5% of languages (including 6.0% which contrast dentals and alveolars), followed by velars in 89.3% and then bilabials in 82.9%. Among voiced stops, velars are slightly dispreferred (55.2%) relative to both bilabials (62.8%) and dental/alveolars (61.5%) likely for aerodynamic reasons discussed in Chapter 2.

3.2.2 *Fricatives*

The preference for voiceless fricatives over their voiced counterparts is considerably greater than the bias toward voiceless stops for aerodynamic reasons discussed later in section 3.5.1.6. The dispreference for voiced fricatives, particularly at certain places of articulation, is manifested in different ways. One is in terms of the aggregate number of languages with a voiceless fricative relative to the number of languages with the voiced counterpart of that fricative. Figure 3.2 shows the cross-linguistic ratio of voiced-to-voiceless members of otherwise identical fricative pairs.

As the figure shows, the cross-linguistic frequency of the voiced fricative exceeds the frequency of its voiceless counterpart only for the bilabial pair β/ϕ and the non-sibilant dental pair δ/θ . Otherwise, the voiceless member of the pair is more prevalent. As Maddieson (1984) suggests, the voiced member of both of the exceptional β/ϕ and δ/θ pairs is likely not a true fricative but rather an approximant in many languages (see Chapter 5 for further discussion). These two pairs are also unusual in that the voiced member of the pair occurs without its voiceless counterpart in more languages than those that possess the voiceless but not the voiced member of the pair. For almost all otherwise matched fricatives, the voiced fricative typically implies the voiceless counterpart in a language. Figure 3.3 plots the percentage of languages in which a fricative that is unpaired for voicing is voiceless as opposed to voiced. There is a third exception to the generalization that the voiced member typically implies its voiceless counterpart, the palatal pair ζ, \jmath , but in this pair, the voiced sound is also plausibly an approximant in many languages.

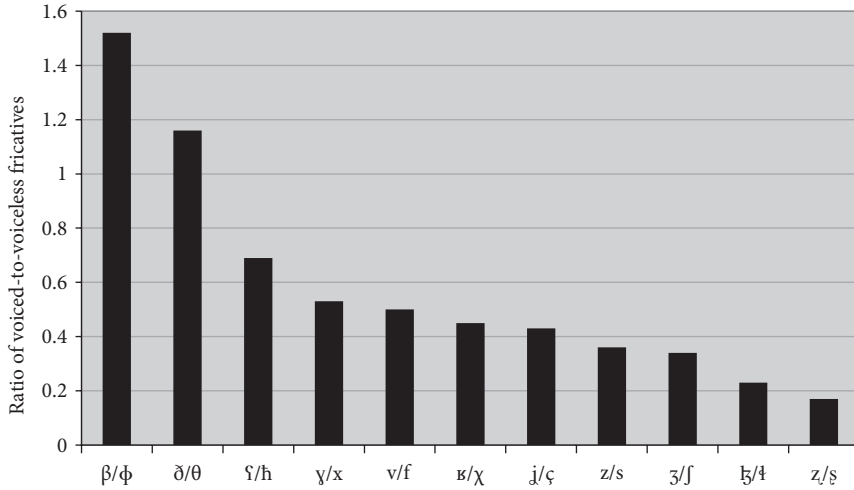


FIGURE 3.2. The voiced-to-voiceless ratio of occurrence aggregated across languages for various fricative pairs distinguished through voicing (adapted from a table in Maddieson 1984: 45)

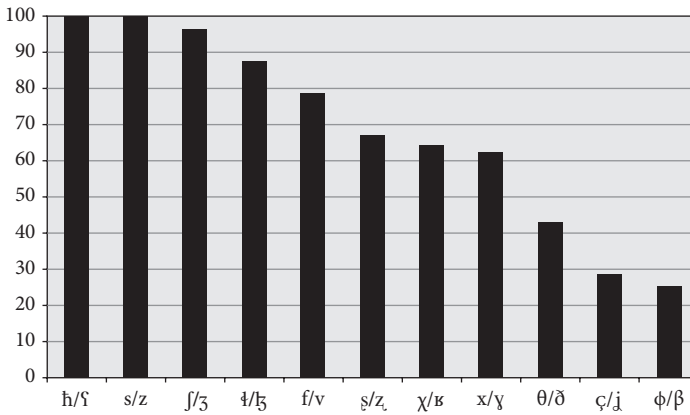


FIGURE 3.3. The percentage of languages in which a language lacking one member of a voiceless vs. voiced fricative pair lacks the voiced member of the pair (adapted from a table in Maddieson 1984: 47)

Languages vary considerably in their number of fricative phonemes as Figure 3.4 makes graphically clear.

The modal number of fricatives in a language is two with the most common fricatives being dental/alveolar /s/ (found in 83.9% of languages) followed by /ʃ/ (46.1%) and then /f/ (42.6%). A striking geographic fact about fricatives is their extreme rarity in Australia but in no other geographic area. Of the 19 Australian languages in Maddieson’s survey (where many linguists assume a single genetic

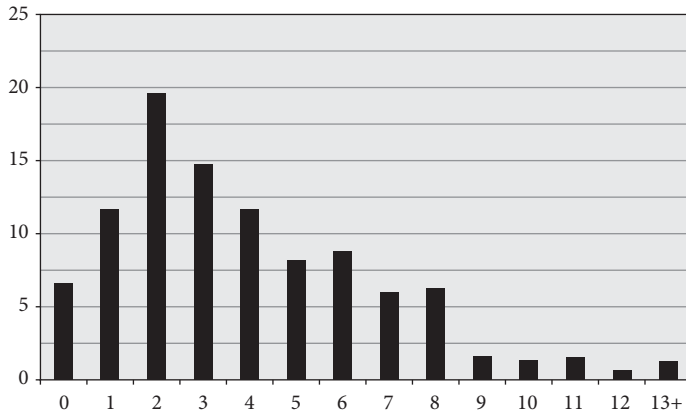


FIGURE 3.4. The number of languages (on y-axis) contrasting different numbers of fricatives (on x-axis) in Maddieson's (1984) 317-language survey (adapted from Maddieson 1984: 47)

grouping spanning all of the Australian continent), 15 lack fricatives, with the remaining 298 languages in the survey contributing only an additional six cases of fricative-less languages.

3.2.3 *Nasals*

In contrast to fricatives and plosives, both of which are biased toward voicelessness, the vast majority of the world's nasals are voiced. All 317 of the languages in Maddieson's (1984) survey that possess nasal consonants have one or more voiced nasals. There are only seven languages (2.2%) in his survey that lack phonemic nasal consonants. Considerably less common than plain (i.e. modal) voiced nasals are voiceless, laryngealized (i.e. those produced with creaky or some other glottal constriction), and breathy voiced nasals. Of the aggregate 1,057 nasals summed across places of articulation in Maddieson's survey, 984 (93.1%) are plain voiced, only 36 (3.4%) are voiceless, 34 (3.2%) are laryngealized, and three (0.3%) are breathy voiced. All of these non-modal nasals imply the presence of the corresponding plain voiced nasal at the same place of articulation.

Virtually all languages contrast nasals at two (31.9%), three (30.0%), or four (26.2%) places of articulation with the two most common nasals being a dental/alveolar one (found in 95.3% of languages) and a bilabial nasal (found in 94.3%). The next most common nasal is a velar one (found in 53.0% of languages) followed by a palatal or palato-alveolar one (39.4%).

There is a relationship proposed by Ferguson (1963) and confirmed by Maddieson (1984) between the place of articulation contrasts observed for plosives and those found for nasals, such that the number of places for nasals may equal or be less than those for oral stops (affricated and unaffricated) but never more. In most cases, this stems from there being a matching stop at the same place

of articulation of a nasal. Maddieson (1984) finds six exceptions to this generalization all involving a palatal nasal occurring in a language without a palatal or palato-alveolar stop.

3.2.4 Liquids

Most languages have one (23.3%), two (41.0%), or three (14.5%) liquids (laterals and rhotics), with laterals being slightly more common (found in 81.4% of languages) than rhotics, i.e. r-like sounds (found in 76.0% of languages). Nevertheless, despite the aggregate greater frequency of laterals, it is somewhat more common for a language with a single liquid to have a rhotic (56.8% of single liquid languages) than a lateral (43.2% of languages with one liquid). In languages with two liquids, it is most common to have one lateral and one rhotic (83.1% of languages with two liquids) with two lateral (13.8%) and two rhotic systems (2.3%) being rare. In languages with three liquids, it is slightly more common to have two laterals and one rhotic (50.0% of languages with three liquids) than one lateral and two rhotics (37.0%), with three liquid systems consisting entirely of laterals being much sparser (13.0%). Most laterals are plain voiced approximants (74.7% of laterals) with most of these occurring in the dental/alveolar region (86.6%). Although it is often difficult to discern from published sources exactly how a rhotic is produced, it seems clear that trills and taps predominate cross-linguistically, together constituting 85.8% of the rhotics in Maddieson's (1984) survey with the remainder being continuants. The dominant place of articulation for rhotics, as for laterals, is dental/alveolar, which comprises 87.9% of the rhotics in the survey.

3.2.5 Non-liquid approximants (glides)

Most languages (86.1%) in Maddieson's (1984) survey have a palatal glide /j/ and a large percentage (75.7%) have a labio-velar glide. Other non-liquid approximants such as labial-palatals or velars are quite rare, each occurring in fewer than 2% of languages in the survey, although it is likely that many of the sounds described as voiced non-sibilant fricatives are, in fact, voiced approximants (see section 3.2.2).

3.3 Vowels

The number of phonemic vowel qualities per language in Maddieson's (1984) survey is plotted in Figure 3.5. Although there are languages with as many as 15 contrastive vowel qualities, the vast majority of languages have between five and seven (64.7%) vowel qualities with the modal number being five (30.9%). The three most common vowels are the three corner ones: /i/ (found in 91.5% of languages), /a/ (88.0%), and /u/ (83.9%).

Figure 3.6 plots the 13 most common vowels aggregated across languages in the 451-language UPSID survey. Vowels are separated into three height categories (high, mid, and low) and, in the case of non-low vowels, three backness categories

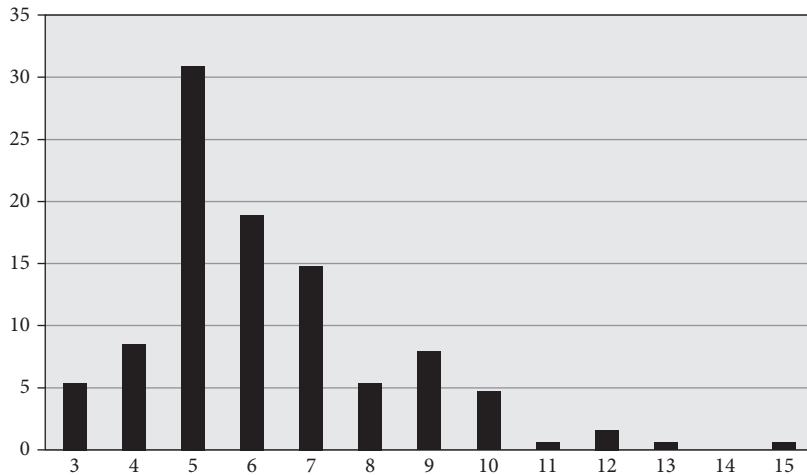


FIGURE 3.5. The number of languages (on y-axis) possessing different numbers of phonemic vowel qualities (on x-axis) in Maddieson's (1984) 317-language survey (adapted from Maddieson 1984: 127)

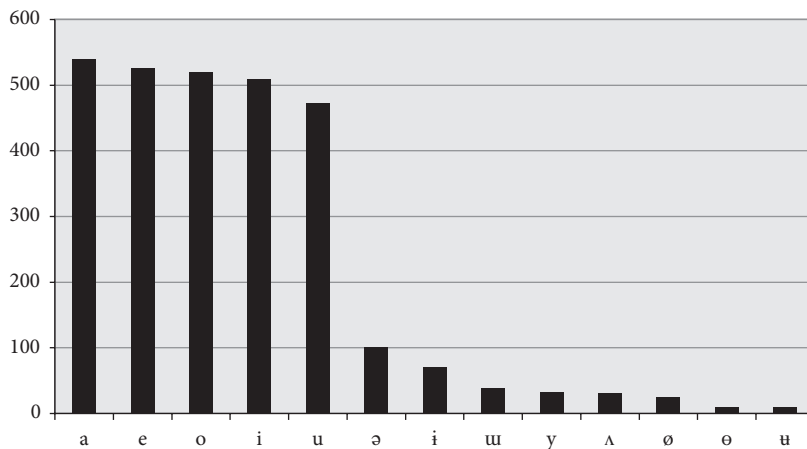


FIGURE 3.6. The number of languages in the 451-language UPSID survey (<<http://web.phonetik.uni-frankfurt.de/upsid.html>>) possessing the 13 most common vowels

(front, central, and back) and two rounding categories (rounded, unrounded). Vowels belonging to different subcategories within these three height and backness groups are collapsed. For example, the high front unrounded vowels include both high and lower high vowels, i.e. /i, ɪ/, the mid front rounded vowels comprise both /e, ɛ/, and the low vowels include low vowels of different backness, height, and rounding specifications, i.e. /a, ɑ, æ, ɐ, ɒ/. Both short and long vowels are included since height often co-varies with length. Secondary features such as nasalization and voice quality are not included.

The five most common vowels are (taking the cardinal vowel symbol as the prototype for each category) /a, e, o, i, u/. Note that the conflation of vowels of different heights within the mid categories inflates the aggregate number of mid front and mid back vowels since there are many languages (particularly those with at least seven vowels) that contrast two degrees of height in one or more of the mid vowel series. In contrast, relatively few languages contrast multiple degrees of height for high or low vowels. There is a considerable drop-off in frequency after /a, e, o, i, u/ to the next most common vowel /ə/, which is followed in turn by /i/, /u/, /ɣ/, /ʌ/, /ø/, /œ/, and /ʊ/.

3.4 Phonemic length

Many languages make length contrasts in vowels and/or consonants. For example, Finnish contrasts short and long (often termed “geminate”) consonants as well as short and long vowels, e.g. *kato* ‘dearth’ vs. *katto* ‘ceiling’, *laki* ‘law’ vs. *lakki* ‘cap’, *tuli* ‘fire’ vs. *tuuli* ‘wind’, *sali* ‘hall’ vs. *saali* ‘shawl’. In the 100-language WALS sample, there is a bias for phonemic length in vowels over consonants: a total of 56 languages could be reliably identified as contrasting length for one or more vowel qualities morpheme-internally, while only 21 were described as contrasting length tautomorphemically for one or more consonants. This skewing is also reflected in the larger 1,672-language PHOIBLE database (Moran et al. 2014), which serves as a better source of data on phonemic length than UPSID, since the latter survey only tabulates length if it does not fully cross-classify with segment type. Figure 3.7 plots the ratio of short-to-long vowels for the six typologically most common vowel qualities and Figure 3.8 the short-to-long ratio for the 13 most common consonants in the PHOIBLE database. Note that this ratio is based on a total of

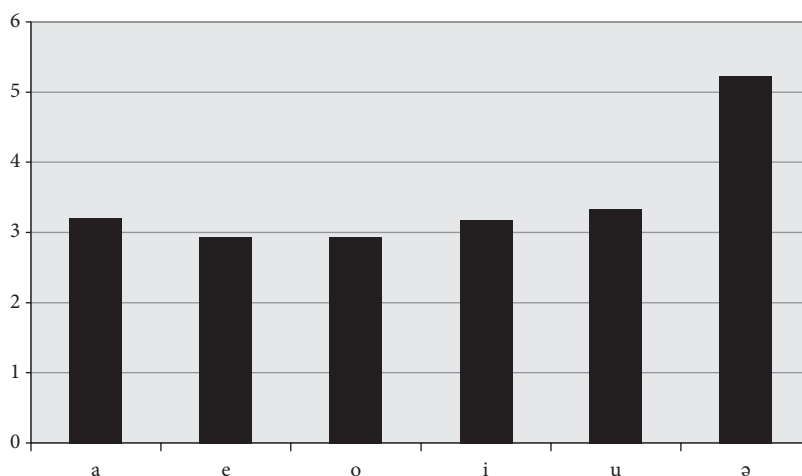


FIGURE 3.7. The ratio of short-to-long vowels aggregated over the PHOIBLE database for the six most common vowels according to UPSID

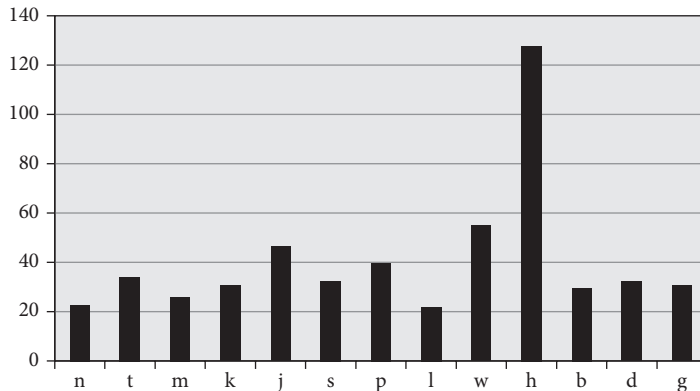


FIGURE 3.8. The ratio of short-to-long consonants aggregated over the PHOIBLE database for the 13 most common consonants according to UPSID

2,155 sources rather than 1,672 languages since more than one source was consulted for many of the languages in PHOIBLE. Because the ratio of short-to-long sounds rather than the absolute number of either is relevant, the duplication of languages is unlikely to impact the results substantially. Only in cases where sources on the same language disagree on the existence of phonemic length does the duplication matter.

As the figures show, the ratio of short–long vowels is under six-to-one for all of the vowel qualities while it is at least twenty-to-one for all the consonants. Among the vowels, the least frequent long vowel (relative to its short counterpart) is schwa, a fact that is not surprising in light of it being the vowel associated with the tongue position closest to rest (see the discussion of articulatory ease in section 3.5.1.2) and thus presumably least compatible with the greater effort likely entailed in lengthening a sound. Differences in the relative frequency of phonemic length for different consonants are considered below in the context of the discussion of language-internal frequency of length distinctions.

It should be noted that the number of languages that make length distinctions for consonants would increase considerably, however, if geminates arising across morpheme boundaries were also considered, e.g. English *mundaneness*, *cattail*. It should also be noted that length distinctions co-vary with qualitative distinctions in some languages, potentially making the source of certain vowel distinctions problematic to classify. For example, the tense high and mid vowels /i, u, e, o/ of English are phonetically longer than their lax counterparts /ɪ, ʊ, ɛ, ɔ/ (Peterson and Lehiste 1960).

Within languages that make length distinctions, short segments also tend to vastly outnumber their long counterparts. Figure 3.9 depicts the frequency ratio of short-to-long vowels in a sample of 19 relatively diverse languages genetically, while Figure 3.10 shows the frequency ratio of short-to-long consonants in five diverse languages. The languages surveyed, their genetic affiliations, and the kind and (approximate) size of the corpora from which the frequency counts are

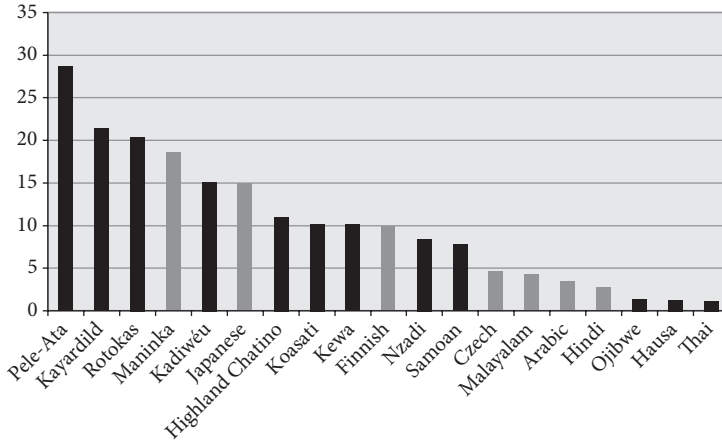


FIGURE 3.9. The ratio of short-to-long vowels in 19 languages

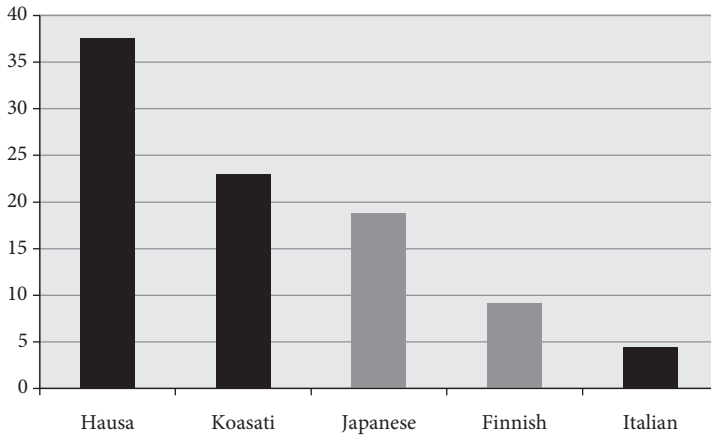


FIGURE 3.10. The ratio of short-to-long consonants in five languages

gleaned are listed in Table 3.2. Note that frequency values are classed as “type” frequency (represented as black bars) if redundant tokens of a single lexical item are eliminated from the counts, which, depending on the language, were compiled either from a lexicon or from a written or oral corpus. Values are regarded as based on “token” frequency (represented as gray bars) if duplicate tokens of a word are incorporated into the figures.

There is considerable variation between languages in how much short segments outnumber their long counterparts, but the clear trend is for a strong statistical bias in favor of short phonemes. The paucity of long exemplars is not merely due to the long segments constituting a subset of the short segments, since in most languages, either all or virtually all of the short sounds have phonemic long counterparts. (In one language, Ojibwe, the number of phonemic long vowels

TABLE 3.2. Languages sampled for frequency of length contrasts

Language	Family	Type	<i>n</i> words/roots	Source
Arabic	Afro-Asiatic	Token	31,055	Nahar et al. (2012)
Highland Chatino	Oto-Manguean	Type	3,000	Pride and Pride (2010)
Czech	Indo-European	Token		Kučera and Monroe (1968)
Finnish	Uralic	Token	2,500	Aoyama (2001)
Hausa	Afro-Asiatic	Type	7,397	Randell et al. (1998)
Hindi	Indo-European	Token	97,911	Ghatage (1964)
Italian	Indo-European	Type	120,000	Goslin et al. (2013)
Japanese	Japanese	Token	1,923	Aoyama (2001)
Kadiwéu	Guaykuruan	Token	3,700	Griffiths (2002)
Kayardild	Australian	Type	1,502	Round (ms) ¹
Kewa	Trans-New Guinea	Type	2,000	Franklin et al. (2006)
Koasati	Muskogean	Type	2,284	Martin et al. (2013)
Malayalam	Dravidian	Token	100,000	Ghatage (1994)
Maninka	Niger-Congo	Token	3,601	Rovenchak (2011)
Nzadi	Niger-Congo	Type	1,100	Crane et al. (2011)
Ojibwe	Algic	Type	3,696	Lippert and Gambill (2004)
Pele-Ata	Yele-West New Britain	Type	3,900	Hashimoto (2008)
Samoan	Austronesian	Type	1,640	Alderete and Bradshaw (2013)
Thai	Tai-Kadai	Type	61,222	Gandour and Gandour (1982)

even outnumbered the number of short ones by 4:3.) One exception to this generalization is Kewa, in which there is only one phonemic long vowel /a:/ but five short vowels. Even in Kewa, however, the skewed distribution of phonemic length does not completely account for the 10:1 bias in favor of short vowels.

There is also a tendency for a greater bias against phonemic length in consonants relative to vowels, although this skewing is not as great as in the typological data considered earlier. Three of the languages with phonemic length for both vowels and consonants (Hausa, Koasati, and Japanese) have a proportionately smaller number of long consonants than long vowels. Finnish, however, bucks the trend in having slightly more long consonants than vowels (relative to their short counterparts). Furthermore, Italian deploys contrastive length only for consonants and not vowels.

¹ Many thanks to Erich Round for generously making available a root list for Kayardild.

The greater statistical discrepancy between short and long consonants (relative to short vs. long vowels) is attributed in part to distributional restrictions holding of geminates that do not apply to single consonants. In many languages, including all those surveyed here, geminates are limited to intervocalic position, unlike singleton consonants. Positional constraints on phonemic length tend to be more limiting and more pervasive cross-linguistically for consonants than for vowels, although restrictions holding of long vowels are also attested in some languages. For example, many languages of Australia only contrast vowel length in word-initial syllables (Dixon 2010) (although this restriction does not hold of Kayardild, an Australian language included in Figure 3.9).

Recent surveys of geminates (Podesva 2002, Blevins 2004, 2005, 2008) suggest that certain consonants are cross-linguistically less likely to participate in length contrasts than others. In general, lower sonority sounds are more amenable to length contrasts than higher sonority ones. Thus, obstruents more commonly contrast in length than sonorants and, within the class of sonorants, nasals are more commonly involved in length distinctions than liquids, which in turn are more prone than glides to contrast in length. In addition, there is an orthogonal dispreference for voiced obstruents relative to both voiceless obstruents and sonorants that precludes characterizing asymmetries in the likelihood of gemination along a single sonority-driven scale. The scale of likelihood of length contrasts as a function of consonant type is thus summarized in Figure 3.11 along two axes, sonority and, in the case of obstruents, voicing.

The occurrence of geminates of a certain type typically implies the presence of geminates to the left along the sonority dimension and higher on the obstruent voicing dimension. As Blevins (2004, 2008) shows, however, there are exceptions to virtually all of the implicational statements embodied in the scales. For example, Somali has voiced geminate stops but not voiceless ones, and the only geminates in Palauan are liquids.

Kawahara (2007) finds perceptual grounding for the typological biases in geminate inventories from an experiment based on Arabic, which allows geminate consonants of all types along the hierarchy. Kawahara's results for reaction time correspond closely to those predicted by the geminate hierarchy. Listeners were able to perceive singleton vs. geminate distinctions faster for the voiceless obstruents (*t* vs. *tt*, *s* vs. *ss*) than for the voiced consonants, which adhere to a tripartite distinction in terms of their associated reaction times. Length contrasts between voiced obstruents and nasals (*d* vs. *dd*, *z* vs. *zz*, *n* vs. *nn*) were recognized more

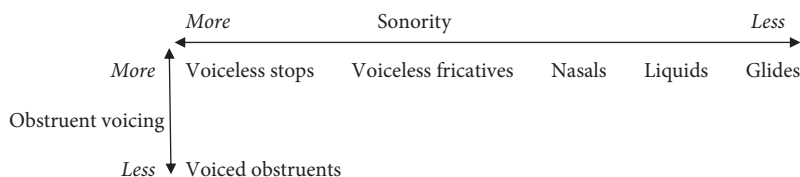


FIGURE 3.11. Intersecting scales based on sonority and obstruent voicing for predicting likelihood of length contrasts in consonants

rapidly than contrasts between the laterals (*l* vs. *ll*), which in turn were durationally disambiguated more readily than the glide pair (*j* vs. *jj*). Kawahara argues that her results follow from perceptibility factors. Length contrasts are more difficult to hear when they involve consonants that are acoustically more similar to flanking vowels. Looking at the sonority axis in Figure 3.11, because glides are acoustically most vowel-like, they are thus least well suited to participate in length contrasts. Moving to the left, the discontinuity between laterals and adjacent vowels is acoustically less defined than the boundary between nasals and flanking vowels, the disjuncture between voiceless fricatives and vowels is in turn sharper than the disjuncture between vowels and nasals, and stops are more clearly differentiated from vowels than fricatives. Along the voicing axis, voiceless sounds are less like adjacent vowels than voiced ones. In addition, aerodynamic considerations discussed in Chapter 2 further militate against voiced geminate obstruents.

Kawahara (2007) observes that her results are not attributed merely to biases induced by the relative frequency of geminates of different types. It is thus not the case that listeners can perceive length distinctions in voiceless obstruents most easily because voiceless obstruent geminates are statistically more prevalent than other geminates in Arabic. The type frequency of the best perceived geminate *tt* is, in fact, less than that of other geminates in her experiment, while geminate *jj* and *ll*, the least reliably perceived, are the most common of the geminates in Arabic.

Kawahara's (2007) examination of the relationship between perceptual biases and frequency raises the more general question of whether consonants that cross-linguistically more commonly occur as geminates also are statistically more likely to be geminated within languages that also allow for other cross-linguistically rarer geminate types. To address this question, Figure 3.12 depicts the frequency of geminates of different types relative to their singleton counterparts in the five languages in Figure 3.10 with length contrasts in consonants.

Results are mixed with the most consistent pattern being the relative rarity of voiced geminate stops compared to voiceless geminate stops, corresponding to the

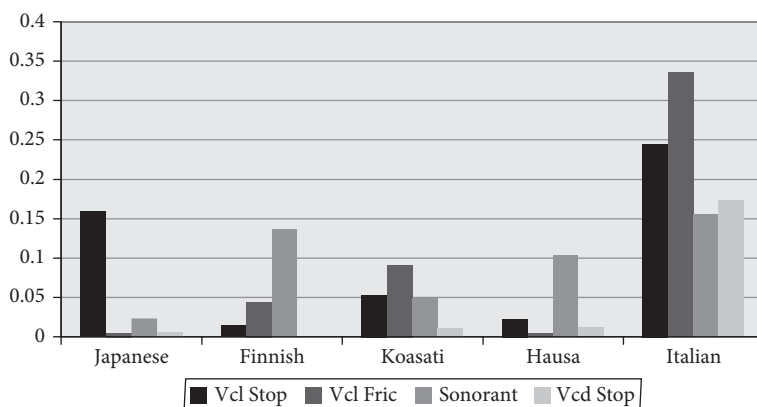


FIGURE 3.12. Ratio of long consonants with different voicing and manner features relative to their short counterparts in five languages

typological pattern that appears to be most robust (though not exceptionless, cf. Somali). One of the five surveyed languages, Finnish, in fact, completely lacks geminate voiced stops (though the significance of this gap is tempered by the fact that *d* is the only voiced stop in Finnish). Another recurring pattern identified by Blevins (2008) and replicated in the surveyed languages is a dispreference for laryngeal geminates, a bias that manifests itself as a complete absence in the five examined languages.

Language-internal frequency data fail to consistently line up with the sonority-sensitive continuum along the x-axis in Figure 3.11, an inconsistency that is perhaps not surprising given the existence of exceptions even on a categorical level. The relative frequency of geminate voiceless stops compared to geminate voiceless fricatives is thus mixed: in Japanese and Hausa, long voiceless stops are more frequent than long voiceless fricatives, whereas the opposite pattern obtains in Finnish, Koasati, and Italian. Similarly, geminate sonorants are more common than geminate voiceless stops in Finnish and Hausa, whereas the opposite trend is observed in Japanese and Italian.

Paradoxically, some of these inconsistencies between the cross-linguistic and language-internal frequency data can be made sense of in terms of the same perceptual factors to which Kawahara (2007) appeals in her work on Arabic. Liquids are acoustically similar to each other, which likely drives their propensity to be involved in assimilation, dissimilation, and metathesis (see Chapter 5). Total assimilation produces geminates, which Blevins (2004, 2008) shows is the most common historical source for geminates cross-linguistically. Given that liquids are prone to assimilation, it is thus not surprising to find languages like Palauan, in which the only geminates are liquids resulting from assimilation in liquid-liquid clusters. Along similar lines, a process of assimilation targeting the common past tense suffix *-nut/nyt* following a stem-final continuant (*/l/*, */r/*, or */s/*) in Finnish (e.g. *olen noussut* ‘I have gotten up’, *olen tullut* ‘I have come’ cf. *olen ostanut* ‘I have bought’; see Chapter 5) increases the frequency of sonorant and fricative geminates, likely contributing to the statistical prevalence of these geminate types in the Finnish token frequency data in Figure 3.12.

3.5 Explaining the typology of phoneme inventories

There is an extensive literature devoted to explaining cross-linguistic biases in the distribution of phonemes. Most of this research proposes explanations that are rooted in considerations of speech production and/or perception, although accounts differ in whether they appeal directly to phonetic factors or indirectly through the medium of phonological features. In practice, it is often difficult to tease apart the predictions of a direct versus an indirect phonetics approach since phonological features themselves ultimately are the formal expression of phonetic properties. In sections 3.5.1 and 3.5.2, we examine the empirical coverage offered by representative attempts, both directly and indirectly projected from phonetic factors, to derive the typology of phoneme inventories.

3.5.1 *Perceptual and articulatory factors*

Two (often competing) factors that have been argued to play a crucial role in the shaping of phoneme inventories are perceptual distinctness and articulatory effort. The assumption driving this appeal to perception and articulation is that speakers and listeners are engaged in a delicate balancing act. On the one hand, they are sensitive to the pressure for phonemes to be maximally differentiated in the perceptual space. Yet, on the other hand, efficiency favors minimizing articulatory effort. A reduction in effort often comes at the price of reducing perceptual distinctness since hypoarticulated sounds are characteristically less distinct perceptually than hyperarticulated ones.

3.5.1.1 (Adaptive) Dispersion Theory Targeting vowels as a case study, Liljencrants and Lindblom (1972) is the first typologically informed attempt to quantify the phonetic forces claimed to condition phoneme inventories. As introduced in Chapter 2, Liljencrants and Lindblom hypothesize that phoneme inventories are preferable to the extent they possess contrasts that are maximally distinct in the perceptual domain. Their account, commonly termed Dispersion Theory (or Adaptive Dispersion Theory), is intuitively appealing since it fits with the observation that five vowel inventories characteristically consist of the well-spaced set /i, e, a, o, u/ rather than other hypothetical inventories making less use of the vowel space, e.g. /i, ɪ, e, ε, a/ or /i, γ, u, ʊ, ʉ/. Liljencrants and Lindblom quantify the notion of perceptual distinctness by converting formant values expressed in Hertz to a perceptual scale captured in mels that is designed to more accurately reflect the perceptual manifestation of formants (see Johnson 2011 and Moore 2013 for introductions to audition, including perceptual units of speech). They run a computer simulation that produces vowel inventories of differing sizes in which vowels are maximally dispersed from a perceptual standpoint. Liljencrants and Lindblom compare the results of their simulation with the typology of vowel inventories to test the predictions of their theory.

Table 3.3 compares the inventories predicted by the Liljencrants and Lindblom model with the most common vowel inventories comprising from three to seven vowel qualities according to the 451 UPSID database (see Schwartz et al. 1997a for similar results based on the 317-language original survey by Maddieson 1984). Searches were conducted for vowel inventories possessing the targeted number of vowel qualities, filtering out distinctions based on length and limiting the search to monophthongs without any secondary constrictions (e.g. frication, pharyngealization, retroflexion), laryngeal modifications (laryngealization, breathy voicing, devoicing), or nasalization. For inventories of four vowels, the three most common inventories are shown in the table since they are virtually identical in frequency. Also given is the number of languages containing each of the most common inventories for a given size relative to the total number of languages possessing that number of vowel qualities. Note that the front mid vowels /e/ and /ɛ/ are collapsed, as are the back mid vowels /o/ and /ɔ/ in inventories in which the pairs are not contrastive. Similarly, low vowels are collapsed as /a/. Vowels that are

TABLE 3.3. Most common vowel inventories of different sizes compared with those of the same size predicted to occur by Liljencrants and Lindblom (1972)

Most common	Liljencrants and Lindblom predicted																	
3 vowels																		
<table border="1" style="display: inline-table; vertical-align: middle;"> <tr><td>i</td><td>u</td></tr> <tr><td>a</td><td></td></tr> </table> 19 of 24	i	u	a		<table border="1" style="display: inline-table; vertical-align: middle;"> <tr><td>i</td><td>u</td></tr> <tr><td>a</td><td></td></tr> </table>	i	u	a										
i	u																	
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i	u																	
a																		
4 vowels																		
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i	o																	
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<table border="1" style="display: inline-table; vertical-align: middle;"> <tr><td>i</td><td>u</td></tr> <tr><td>ə</td><td></td></tr> <tr><td>a</td><td></td></tr> </table> 6 of 34	i	u	ə		a													
i	u																	
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a																		
5 vowels																		
<table border="1" style="display: inline-table; vertical-align: middle;"> <tr><td>i</td><td>u</td></tr> <tr><td>e</td><td>o</td></tr> <tr><td>a</td><td></td></tr> </table> 113 of 130	i	u	e	o	a		<table border="1" style="display: inline-table; vertical-align: middle;"> <tr><td>i</td><td>u</td></tr> <tr><td>ɛ</td><td></td></tr> <tr><td>æ/a</td><td>ɑ</td></tr> </table>	i	u	ɛ		æ/a	ɑ					
i	u																	
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i	u																	
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6 vowels																		
<table border="1" style="display: inline-table; vertical-align: middle;"> <tr><td>i</td><td>u</td></tr> <tr><td>e</td><td>ə o</td></tr> <tr><td>a</td><td></td></tr> </table> 30 of 84	i	u	e	ə o	a		<table border="1" style="display: inline-table; vertical-align: middle;"> <tr><td>i</td><td>ʉ</td><td>u</td></tr> <tr><td>ɛ</td><td></td><td>ɔ</td></tr> <tr><td>a</td><td></td><td></td></tr> </table>	i	ʉ	u	ɛ		ɔ	a				
i	u																	
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a																		
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7 vowels																		
<table border="1" style="display: inline-table; vertical-align: middle;"> <tr><td>i</td><td>u</td></tr> <tr><td>e</td><td>o</td></tr> <tr><td>ɛ</td><td>ɔ</td></tr> <tr><td>a</td><td></td></tr> </table> 27 of 67	i	u	e	o	ɛ	ɔ	a		<table border="1" style="display: inline-table; vertical-align: middle;"> <tr><td>i</td><td>y/ʉ i</td><td>u</td></tr> <tr><td>ɛ</td><td></td><td>ɔ</td></tr> <tr><td>a</td><td></td><td></td></tr> </table>	i	y/ʉ i	u	ɛ		ɔ	a		
i	u																	
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i	y/ʉ i	u																
ɛ		ɔ																
a																		

predicted to occur with virtually equivalent likelihood in Liljencrants and Lindblom's simulation are separated by slashes.

The fit between the Liljencrants and Lindblom model and the most common three-vowel inventory is perfect. Their model also generates the most common four-vowel inventory. In the case of the five-vowel system, the mid back vowel that is most common cross-linguistically corresponds to a lower unrounded vowel in the Liljencrants and Lindblom simulation. More systematic issues arise for inventories larger than five vowels. One point of divergence concerns the central vowel that is common in inventories with an even number of vowels. The most common central vowel in languages of the world is schwa whereas the Liljencrants and Lindblom simulation predicts a higher central vowel, /ʉ/ for the six-vowel system and both /i/ and a high central /ʉ/ or high front /y/ in the case of the seven-vowel system. Furthermore, in predicting four high vowels /i, y or ɨ, i, u/ and only two central vowels /ɛ, ɔ/ for the seven-vowel system, the Liljencrants and Lindblom model diverges sharply from the cross-linguistically dominant pattern of two high /i, u/ and four central /e, ɛ, o, ɔ / vowels in seven-vowel inventories.

3.5.1.2 Dispersion Focalization Theory Drawing on results of an analysis of vowel inventories in Maddieson's original 317-language survey (Schwartz et al. 1997a), Schwartz et al. (1997b) propose a revised model for predicting vowel inventories, the Dispersion Focalization Theory. They retain the original insight of Liljencrants and Lindblom's (1972) Dispersion Theory according to which inventories containing perceptually dispersed vowels are preferred, but they introduce certain changes to their model in order to provide a better fit to attested patterns. In the Dispersion Focalization model, the total "energy" of various vowel systems is compared, where the energy is a function of two components: which vowels comprise the system and their perceptual proximity as quantified using the Bark scale, an alternative perceptual scale to the mel scale adopted by Liljencrants and Lindblom (see Johnson 2011 and Moore 2013 for an introduction to perceptual units of speech).

The first element in their model, the vowel inventory, crucially includes a notion of focalization, which incorporates a boost to the quantal vowels, i.e. vowels with two formants in close proximity (Stevens 1972, 1989; see section 3.5.1.4), including the three corner vowels /u/, /a/ (both with proximate first and second formants), and /i/ (close third and fourth formants). This focalization component also bestows a benefit upon front rounded vowels, which have close second and third formants relative to back unrounded vowels, in keeping with their finding (Schwartz et al. 1997a) that front rounded vowels are cross-linguistically slightly preferred over back unrounded vowels in languages with additional peripheral (non-central) vowels other than /i, e, o, u/. In practice, because the Bark scale de-accentuates frequency differences at the lower end of the spectrum, vowels with higher frequency formants that are close together, i.e. the front vowels /i/ and /y/, receive more of a focalization boost than vowels with lower frequency formants, i.e. low vowels, that are in close proximity.

The second component contributing to the aggregate energy of a vowel system in Dispersion Focalization Theory captures the overall auditory dispersion of the

vowels in a system. Dispersion is a function of first formant values and an integration of the second, third, and fourth formants, where formant values are expressed in Bark. In their dispersion function, Schwartz et al. (1997b) introduce a variable that allows for an increased weighting of first formant values (the acoustic correlate of height), capturing the fact that larger vowel systems, i.e. those consisting of peripheral vowels beyond just /i, e, a, o, u/, overwhelmingly tend to fractionate the vertical rather than the horizontal space to produce more height than backness contrasts.

Schwartz et al. (1997b) work backwards from patterns in the observed cross-linguistic vowel inventories to determine the range of permissible values for two parameters in their Dispersion Focalization function: one that determines the relative weight of the first formant vs. the integration of formants two, three, and four in the dispersion component, and the other that weighs the contribution of the focalization factor to the overall energy of the vowel system.

Subsequent research (see, for example, Roark 2001, Sanders and Padgett 2010, Becker 2010) has suggested further refinements to the implementation of the forces of dispersion and focalization in a model predicting vowel inventories. Areas for potential fine-tuning are numerous, including the type of perceptual scale into which formant values are transformed, the relative weighting of focalization and dispersion as measures of system optimality, the method of aggregating dispersion over the entire inventory, the search algorithm for locating different potential vowel inventories, and the integration of non-perceptual factors such as symmetry into the model.

Becker's (2010) enormous survey of formant patterns for vowels in 230 languages has dispelled certain fallacies suggested by typological surveys based on impressionistic transcriptions. For example, he finds no support for the purported distinction in the height of the back vowel between two of the most common four-vowel systems /i, e, a, o/ and /i, e, a, u/ (see Table 3.3). Rather, the back vowel in both systems tends to be intermediate in height between canonical /o/ and canonical /u/. Along similar lines, Becker observes that the distinction between systems with a single central vowel that is high, i.e. /i/, vs. those in which the central vowel is mid, i.e. /ə/, is not confirmed acoustically; instead, the vowel in question is intermediate in height between the two central vowels, i.e. IPA /ə/.

Becker's study also offers support for another prediction made by Adaptive Dispersion Theory: that the phonetic spacing of vowels that might impressionistically be perceived as belonging to the same phonemic category occupy different acoustic spaces depending on the vowel inventory of the language. For example, in three vowel inventories consisting of /i/, /u/, and a low vowel, the low vowel tends to be a slightly raised central vowel, e.g. /v/, whereas it tends to be a backer vowel, e.g. /a/, in four vowel inventories, presumably because the presence of a mid front vowel repels the low vowel from its articulatorily more neutral position toward the back of the vowel space, thereby increasing the dispersion of the vowel system.

One typological observation that has proven elusive to implement in a model incorporating dispersion and focalization is the preference for schwa over all

vowels other than /i, e, a, o, u/. Schwartz et al. (1997b) concede that another non-perceptual factor, namely ease of articulation, is likely important in predicting the popularity of schwa. In fact, as they observe in their companion typological survey, Schwartz et al. (1997a) note that schwa is typically simply added as an additional non-peripheral vowel without interacting with the spacing (at least in an impressionistically salient way) of the peripheral vowels. This observation suggests that perceptual distance is not the only factor guiding the construction of vowel inventories; otherwise, one might expect to see an avoidance of mid vowels, or possibly low central vowels, in languages with schwa.

The role of articulatory ease in shaping vowel inventories also appears to be evident in languages with so-called “vertical” vowel systems, e.g. Abkhaz (Hewitt 1979, Vaux and Psiypa 1997), Kabardian (e.g. Turchaninov and Tsagov 1940, Abitov et al. 1957, Catford 1948, Choi 1991, Colarusso 1992, Gordon and Applebaum 2006) and Marshallese (Choi 1992), in which the entire inventory of two or three vowels is central. An inventory based only on height distinctions is not predicted by a theory of dispersion that assesses perceptual distinctness along both the height and backness dimensions. More generally, theories of dispersion fail to predict the degree of asymmetry in the front–back dimension observed cross-linguistically or the considerable phonetic variation across languages between phonemically equivalent vowel inventories (Disner 1983). Vaux and Samuels (2015) provide a comprehensive critique of dispersion theory, which they demonstrate is not equipped to handle the full range of typological variation in vowel systems. Rather they endorse an evolutionary perspective (Blevins 2004; see Chapter 2) in which perceptual dispersion is just one of many pressures that shape vowel inventories over time.

3.5.1.3 Articulatory complexity and perceptual saturation As introduced in Chapter 2, Lindblom and Maddieson (1988) propose a model of consonant inventory construction incorporating maximization of perceptual distinctness and minimization of articulatory effort. They suggest that features can be broken down into three groups according to their articulatory complexity.

First, basic articulations encompass the least complex and typologically most common types of sounds, e.g. plain voiced and voiceless stops, voiceless fricatives, and voiced sonorants. They assign to the basic category of articulations the following 18 consonants (11 obstruents and seven sonorants), all of which are among the 20 most common consonants (excluding the postalveolar fricative /ʃ/ and the palatal nasal /ɲ/) cross-linguistically (see Table 3.1): p, t, k, ʔ, b, d, g, f, s, h, tʃ, m, n, ŋ, l, r, w, j.

The second tier of articulatory difficulty comprises elaborated articulations requiring deviation from the default setting associated with a particular manner of articulation. Breathy or creaky voicing, voicing associated with fricatives (but not stops), aspiration, and prenasalization all are examples of elaborated properties. In the place dimension, elaborated articulations involve increased deviation from the rest position of the lips, tongue tip, and tongue dorsum. These elaborated place attributes include labiodentals, retroflexes, palatoalveolars,

uvulars, and pharyngeals. Elaborated airstream mechanisms include clicks, implosives, and ejectives.

The third tier, the complex articulations, consists of sounds possessing more than one elaborated property, e.g. laterally released ejective stops, labialized uvulars, breathy voiced clicks, etc.

In the Lindblom and Maddieson model (1988), languages first introduce sounds belonging to tiers associated with lesser articulatory complexity before each articulatory subspace becomes perceptually saturated, i.e. sounds are no longer sufficiently distinct from each other, thereby forcing expansion into the next tier of complexity. Under this account, fractionation within an articulatory subspace is driven by the auditory consideration of maximizing perceptual distance, whereas the size of a subspace is driven by the pressure to minimize effort.

Lindblom and Maddieson test the predictions of their model by dividing the obstruent inventories for the languages in Maddieson's (1984) survey into basic, elaborated, and complex articulations and plotting the number of obstruents in each group for a given language against the total number of consonants in that language. Results indicate a strong cross-linguistic tendency for languages to possess the 11 basic obstruents before introducing obstruents belonging to the elaborated articulations. Similarly, complex articulations tend to come into play only after extensive exploitation of elaborated consonants, typically in consonant inventories of greater than 30 consonants.

Results of Lindblom and Maddieson's study complement the work of Liljencrants and Lindblom (1972) and Schwartz et al. (1997a, b) on vowel inventories by offering support for the role of both articulatory and perceptual factors in the shaping of consonant inventories. An important issue left unresolved in Lindblom and Maddieson's work, however, is how to quantify the distinction between basic articulations and their more complex counterparts.

3.5.1.4 Quantal Theory In lieu of a quantitative means for characterizing articulatory difficulty, one way to offer a principled definition of basic articulations is in terms of a discrete set of phonological features that are phonetically grounded. Stevens's Quantal Theory (1972, 1989) provides phonetic grounding for the still widely adopted articulatory-based feature set originally proposed by Chomsky and Halle (1968). Stevens proposes that phonological features define regions of acoustic and perceptual stability in which changes along a continuous articulatory dimension result in relatively little change in the acoustic output. For example, introducing even a tiny opening in the velopharyngeal port allows air to flow through the nose, thereby turning an oral stop into a nasal stop. Further lowering of the velum, though physiologically possible, does not noticeably enhance the percept of a nasal stop. Similarly, additional raising of the velum beyond the point required to seal off the nasal cavity from the oral cavity does not perceptually reinforce its identity as an oral stop. We can thus say that the point along the continuum of velum raising associated with the acoustic (and perceptual) shift from an oral to a nasal stop defines the boundary between stops that are nasal and those that are oral. In keeping with there being a single perceptual

transition zone between nasal and oral sounds, there are no languages that distinguish multiple degrees of nasality.

In vowel systems, the quantal vowels are /i/, /u/, and /a/ since they occupy stable articulatory regions where minor shifts in tongue position result in only negligible acoustic and perceptual changes. A further virtue of the quantal vowels that is incorporated into the Dispersion Focalization Theory of Schwartz et al. (1997b) (see section 3.5.1.2) is the fact that they possess two low frequency formants in close proximity (the first and second formant in the case of /u/ and /a/ and the third and fourth formant in the case of /i/), which evidence suggests may be perceptually integrated into a single salient auditory peak (Chistovich and Lublinskaya 1979).

Quantal Theory has not been developed as extensively as Dispersion Theory in its various incarnations. Evidence suggests, though, that it has some of the same shortcomings related to its failure to incorporate a notion of articulatory ease. The prevalence of schwa and the existence of vertical vowel systems are thus problematic for Quantal Theory. Furthermore, the considerable cross-linguistic variation in the production and the resulting acoustic properties (Disner 1983) of the quantal vowels are not predicted.

3.5.1.5 Feature enhancement Targeting consonants as a case study, Stevens and Keyser (1989) build on Quantal Theory by adding a complementary notion of featural enhancement. They propose that features can be divided into two groups, a primary and a secondary group. The primary features include the manner features [sonorant] and [continuant] and the place feature [coronal], all of which can be implemented independently of other features. This differs from secondary features, which may be restricted in their distribution as a function of the specification of primary features also associated with that sound. For example, only coronal consonants have the possibility of being contrasted in terms of the feature [distributed], which encodes the breadth of a consonant constriction in the front-back domain. Consonants that are [+distributed], typically dentals and palatoalveolars, have a broader constriction involving the tongue blade and the roof of the mouth than their [-distributed] counterparts, usually alveolars and retroflexes. Non-coronal consonants, e.g. bilabials and velars, never contrast with respect to the feature [distributed] since anatomical constraints mean that they are produced with a necessarily broad constriction. A further difference between primary and secondary features is that a change in the specification of a primary feature results in a more salient acoustic and thus auditory response than a change in a secondary feature. For example, a shift in the specification of the feature [continuant] is associated with an abrupt change in the energy profile of a sound throughout a wide range of frequencies since [-continuant] sounds are produced with an occlusion and [+continuant] ones are not. (Though sonorant, nasals acoustically pattern with other [-continuant] by virtue of having energy predominantly at low frequencies.) Thus, transitioning from a [-continuant] consonant, such as a plosive or nasal, to a [+continuant] consonant, such as a fricative, a liquid, or a glide, entails a sharp and auditorily salient discontinuity in a relatively

broad range of frequencies. Conversely, the feature [distributed] has less dramatic acoustic and auditory correlates.

The typology further supports a distinction between [continuant] and [distributed] in their salience. Virtually all languages use [continuant] to contrast phonemes whereas very few rely on contrasts in the feature [distributed]. Thus, 83.9% of languages in Maddieson's (1984) survey contrast /t/ with /s/, whereas only 7.6% have plosives at both dental (= [+distributed]) and alveolar (= [-distributed]) places.

Despite their lack of independent auditory salience relative to primary features, secondary features enhance the acoustic and auditory characteristics associated with the primary features. For example, a [-continuant] consonant is enhanced through the addition of a [-distributed] feature since a narrower constriction yields a more abrupt release phase and thus a sharper auditory response than a broader constriction. Similarly, a [+sonorant] consonant, which is characterized by continuous periodic energy at low frequencies, is enhanced by the feature [+voice], whose acoustic correlate is also low frequency energy. To take an example from vowel systems, the feature [+round] enhances the feature [+back] since lip rounding lengthens the front cavity, which works synergistically with the back constriction to increase the lowering effect on the second formant.

Stevens and Keyser's (1989) theory offers an account for why certain types of sounds are more common than others cross-linguistically. For example, sonorants are overwhelmingly voiced because the primary feature [+sonorant] ideally combines with the secondary enhancing feature [+voice]. On the other hand, voiceless obstruents are more common than voiced ones due to the synergistic relationship between [-voice] and [-sonorant], both of which are associated with reduced low frequency energy.

The consonants that result from the optimal combinations of primary and secondary features, /j, w, s, f, h, n, l, m, t, p, k/, are all typologically favored. Table 3.4 shows the 11 consonants predicted to be preferred by Stevens and Keyser (1989) along with the percentage of languages in Maddieson's (1984) survey containing those sounds.

The predictions made by Stevens and Keyser (1989) closely match the frequency patterns found in Maddieson's (1984) survey, the one mismatch being /f/, which is only found in 44% of the languages in the survey.

3.5.1.6 Feature economy Another common feature of phoneme inventories that was mentioned earlier in the context of vowel systems is symmetry. Five-vowel inventories overwhelmingly tend to have two front and two back vowels balanced for height, while seven-vowel systems are strongly biased toward adding a second mid vowel in both the front and back planes. Clements (2003, 2009) provides an explicit formalization of the principles that lead to the formation of symmetrical inventories. According to his theory of feature economy, which takes as a starting point long-standing observations about the structure of sound systems (de Groot 1931, 1948, Martinet 1955), languages prefer inventories that make maximal use of the minimum number of phonological features to expand their phoneme inventories. Clements proposes an economy index, which is

TABLE 3.4. Fit between Stevens and Keyser's Featural Enhancement model and cross-linguistic frequency patterns for consonants (adapted from Stevens and Keyser 1989: 103)

Stevens and Keyser predicted	Percentage of lgs. (in Maddieson 1984)
j	85
w	75
s	77
f	44
h	64
n	82
l	68
m	94
t	75
p	83
k	89

TABLE 3.5. Consonants of Chickasaw (n = 16)

p	b	t	tʃ	k	ʔ
	m	n			
f		s	ʃ		h
		ʈ			
	w		j		
		l			

calculated by dividing the number of segments in an inventory by the number of phonological features needed to characterize all the contrasts found in the inventory. The higher the economy index, the more economical the system is from a featural standpoint. For example, compare the relatively small 16-consonant inventory of the Muskogean language Chickasaw (Munro and Willmond 1994) in Table 3.5 with the relatively large set of 44-consonant phonemes found in the Turkish variety of the North Caucasian language Kabardian (Gordon and Applebaum 2006) in Table 3.6. Table 3.7 shows the minimal set of features needed to define the contrasts of each language. Note the following assumptions. First, I assume that secondary labialization in Kabardian can be captured through the [labial] feature. Second, it is assumed that affricated plosives are distinguished from unaffricated plosives by virtue of possessing a [+continuant] fricative phase following a [-continuant] closure phase. Finally, the primary place contrasts are captured through two place features, [labial] and [dorsal] in Table 3.7, where coronals are the default and presumed to be neither labial nor dorsal.

TABLE 3.6. Consonants of Kabardian (n = 44)

p ^h	p'	b	t ^h	t'	d		k ^j	g ^j	k ^{wh}	k ^w		q ^h	q'	q ^{wh}	q ^w		ʔ	ʔ ^w	
			t ^h	t ^s	d ^z														
		m			n														
f	f'	v	s		z	ʃ	ʃ'	ʒ	ç	x ^w	ɣ ^w	ɣ	χ		χ ^w	ɸ	ɸ ^w	h	h
			ʈ	ʈ'	l														
			r																
					j														

TABLE 3.7. Features used to defined the consonant contrasts in Chickasaw and Kabardian

	Chickasaw	Kabardian
Sonorant	√	√
Continuant	√	√
Voice	√	√
Constricted glottis	√	√
Spread glottis	√	√
Lateral	√	√
Labial	√	√
Dorsal	√	√
High		√
Back		√
Low		√

The economy index for Chickasaw is 2 (= 16 segments/8 features), whereas it is 4 (=44/11) for Kabardian. Even though Kabardian requires more features to express its contrasts, this increase is more than offset by the large number of additional phonemes generated by use of these extra features. Another way to increase the economy index would be to maximize the cross-classification of features to eliminate gaps in an inventory.

Clement’s notion of feature economy is not equivalent to symmetry as commonly conceived, though their effects overlap. To see the difference, consider the three obstruent inventories in Table 3.8 (Clements 2003: 292).

Inventory A is symmetrical in consisting of voiced and voiceless pairs of plosives and fricatives at three places of articulation. It is also maximally economical for an inventory with two manners of articulation, a voicing contrast, and a three-way place contrast. Assuming it is defined using two place features in addition to [voice] and [continuant], its economy index is 3 (= 12/4). Inventory

TABLE 3.8. Three sound inventories differing in symmetry and economy

Inventory A			Inventory B			Inventory C		
p	t	k	p	t	k	p	t	k
b	d	g	b	d	g	b	d	g
f	s	x	f	s	x	f	s	x
v	z	ɣ				v	z	

B is symmetrical in terms of having voiceless and voiced stops and fricatives at the same three places of articulation. However, its economy index is only 2.25 (=9/4) since it fails to cross-classify voicing with continuancy. Finally, inventory C is not completely symmetrical since it lacks a voiced velar fricative even though it has voiceless and voiced stops and a voiceless fricative at the velar place of articulation. Inventory C has an economy index of 2.75 (=11/4), higher than the symmetrical inventory B, however, because it exploits the feature [voice] more fully than inventory B by adding two voiced fricatives.

Clements tests the cross-linguistic validity of feature economy through case studies of certain combinations of sounds based on the 451-language UPSID database (Maddieson and Precoda 1990). In particular, he tests two predictions made by the theory of feature economy. The first of these, Mutual Attraction, predicts that sounds will occur more frequently if all of their features are present in other sounds in the same language. For example, a voiced labial fricative is predicted to be more common in inventories that already contain another labial sound, another fricative, and another voiced sound, since adding a voiced labial fricative boosts the economy index of the language by exploiting features that are independently employed in the language.

Clements explores the evidence for Mutual Attraction effects by testing whether pairs of plosives with the same laryngeal setting, e.g. voiceless, voiceless aspirated, voiced aspirated, implosive, ejective, but differing in place between labial, coronal, and velar, are more likely to co-occur than to occur in isolation without the other member of the pair. For example, /b/ is expected to more frequently occur in a language with /d/ and vice versa than in a language without /d/ assuming that the feature [labial] is contrastive for at least one other type of consonant (which it is in nearly all languages).

All of the pairwise comparisons made for the UPSID database support the predicted Mutual Attraction effect for plosives. Clements conducts a similar comparison of pairs of voiceless fricatives and pairs of voiced fricatives at the three major places of articulation (labial, coronal, and velar) with similar results.

The relevance of Mutual Attraction is supported by the Turkish Kabardian inventory in Table 3.6, which features a complete three-way laryngeal contrast between voiceless, voiced, and ejective plosives at the labial, coronal, and velar places of articulation, the last of which is associated with palatalization, and a two-way contrast between voiceless and ejective plosives at the uvular place. Mutual Attraction effects are also apparent in the extensive inventory of fricatives in Turkish Kabardian.

A companion prediction of Clements's theory of Feature Economy is that sounds will be less likely to occur if one or more of its features are not distinctively used elsewhere in the language. This effect of Avoidance of Isolated Sounds works against a plosive inventory like the one in Chickasaw (Table 3.5), which contains a single voiced stop, the only segment for which voicing is contrastive in Chickasaw. Clements finds support for the prediction that languages avoid isolated sounds by comparing in the UPSID database the likelihood of labial plosives (voiceless and voiced) and labial fricatives (voiceless and voiced) occurring in languages lacking both coronal and velar counterparts with their likelihood of occurrence in languages possessing at least one of the two other places of articulation for otherwise identical consonants. For example, /b/ is less likely to occur in a language without both /d/ and /g/ than in a language with at least one of the two. This means that Chickasaw is typologically unusual in having only a single voiced stop. On the other hand, labial is the favored place of articulation for voiced stops. In Maddieson's (1984) survey, there are thus six languages like Chickasaw in which the only voiced stop is /b/ compared with only two languages in which the only voiced stop is a coronal and two in which the only one is a velar. Thus, if a language has an isolated voiced stop, it is more than likely to be a labial one.

Clements recognizes that his theory of Feature Economy does not account for all the pressures that play a role in the construction of phoneme systems. One important factor that competes with Feature Economy is Marked Feature Avoidance, which works against certain feature combinations that may be dispreferred on independent grounds. For example, the feature bundle associated with voiced fricatives, [-sonorant, +continuant, +voice], is eschewed by many languages even though introducing a series of voiced fricatives would increase the featural economy of a system that already has voiceless and voiced stops and voiceless fricatives. The absence of voiced fricatives in many languages makes sense phonetically. Voiced fricatives require a delicate articulatory balancing act for aerodynamic reasons. It is difficult to simultaneously sustain voicing in the face of the pressure build-up behind a fricative constriction while also generating sufficient airflow through the constriction to make the fricative turbulence audible. The articulatory difficulty associated with voiced fricatives is reflected in the relative rarity of voiced fricatives compared to their voiceless counterparts (section 3.2.2).

A difficult issue arises in providing independent grounding for markedness since there are many potential factors, including articulatory, auditory, psycholinguistic, aerodynamic, and cognitive constraints, that could contribute to certain sounds being less frequent cross-linguistically. Clements (2009) hypothesizes that intra-language frequency plays a decisive role in determining markedness, such that sounds that are less frequent in a language are more marked than others. This appeal to frequency as a diagnostic for markedness potentially accounts for asymmetries between different classes of segments both in their phonological behavior and in their ease of acquisition (see Vihman 1996 on phoneme acquisition). However, the issue still remains how the frequency distributions that Clements suggests underlie markedness come to develop, a broader issue related to the relationship between synchrony and diachrony in phonology (see Chapter 2).

Two other factors to which Clements (2009) appeals in his theory are Robustness and Enhancement. Robustness entails the existence of a hierarchy of features

ordered in terms of their phonetic salience. The work by Stevens (1972) and Stevens and Keyser (1989) discussed in 3.5.1.4 potentially serves as the backbone for an explicit metric of Robustness, though Clements suggests that the mapping between perceptual salience and typological frequency is not always transparent. For example, clicks would appear to be perceptually salient (though they are difficult to temporally order relative to adjacent sounds) since they involve a rapid increase in energy at their release, but nevertheless they are cross-linguistically rare. Under Lindblom and Maddieson's account (section 3.5.1.3) incorporating articulatory ease in addition to perceptual salience, clicks are typologically rare due to their articulatory difficulty.

The last ingredient in Clements's account, Enhancement, is also rooted in phonetic factors laid forth in Stevens and Keyser (1989; see section 3.5.1.3). Certain features (the secondary features in Stevens and Keyser's theory), even if they are typologically marked, may frequently occur in combination with certain other features (the primary features in Stevens and Keyser's account) in order to enhance the acoustic and auditory realization of the primary feature. For example, the feature [strident], though not commonly contrastive in languages, frequently co-occurs with voiceless fricatives because the addition of the teeth as an upstream obstacle during the production of a fricative boosts the energy of the fricative noise.

Clements (2003) addresses the issue of whether the economy that he captures with reference to phonological features could actually reflect a phonetic preference for gestural economy. In other words, it could be the case a priori that featural economy is really articulatory economy that could be modeled more directly with reference to gestures rather than indirectly via phonological features encoding the articulatory gestures. To tease apart the two possibilities, Clements compares the predictions of the Browman and Goldstein (1989) model of articulatory phonology in which gestures are captured via features referencing properties such as the primary articulator and the location and degree of the constriction. In the Browman and Goldstein model, labiodental and labial articulations are distinguished since only the former involves the upper teeth. In contrast, labiodental and labial consonants are both [labial] in standard feature theory. One would thus expect under the feature-based characterization of economy that the labiodental fricative would be more common in languages that have another fricative and a bilabial since the addition of a labiodental fricative to an inventory already making use of the features [continuant] and [labial] would increase the economy index. In a direct gestural account, on the other hand, no such interaction is predicted since the addition of a labiodental fricative would entail the deployment of another feature not used in defining bilabials. Clements tests the predictions of the two theories of economy by assessing the likelihood of /f/ occurring in a language with /p/ and /s/ (both extremely common sounds) versus one in which either /p/ or /s/ is missing. As the feature-based theory of economy predicts, /f/ is in fact more common in languages with at least one bilabial and one other fricative.

In general, Clements (2009) argues that a theory of inventory construction that relies on phonological features rather than more finely grained phonetic differences provides a tighter fit to the typology. For example, although the IPA recognizes a large number of different types of coronal consonants if place and

breadth of contact in the front–back dimension are cross-classified (e.g. apical dental, apical alveolar, laminal dental, laminal alveolar, laminal palato-alveolar, apical retroflex, and laminal palatal), no language appears to contrast all of the logical possibilities. Rather only a subset of coronal contrasts, up to four in rare cases as in certain languages of Australia, are found cross-linguistically. Phonological features predict a more constrained set of coronal contrasts, up to four (in keeping with the typology) if the place feature [anterior] and the contact feature [distributed] are cross-classified.

Despite its apparent restrictiveness, however, a feature-based theory of phoneme typology is potentially undermined by uncertainty surrounding the set of phonological features upon which the theory is based. There are numerous unresolved issues in feature theory including the role of articulatory vs. auditory features, the encoding of redundant (i.e. non-contrastive) information, the universality of features, and the relationship between natural classes and phonological features (see Mielke 2011 for an overview of distinctive feature theory). In a survey of 549 languages, Mielke (2008) finds that there is no single feature theory that adequately characterizes all of the 6,077 classes of sounds patterning together in phonological alternations in the examined languages. The original articulator-based feature theory of Chomsky and Halle (1968) offers the best empirical coverage but still fails to account for 29% of the classes of sounds in Mielke's typology.

3.6 Frequency of sounds within languages

Thus far we have considered the relative frequency of sounds across languages and explored various types of explanations for the observed frequency distributions. It is also instructive to assess the frequency of sounds within languages to determine the extent to which sounds that are typologically more common are also relatively common in languages that have other cross-linguistically rarer types of sounds. Following the discussion in Chapter 1, it is a reasonable hypothesis (already explicitly proposed in 3.5.1.6 in the discussion of Clements's notion of feature markedness) that the frequency of phonemes within a language mirrors their cross-linguistic frequency.

In order to quantify the relative commonness of sounds within languages, frequency of occurrence was examined for a set of 34 languages whose genetic diversity is roughly commensurate with that of the WALS sample.² Of the 34 languages surveyed, almost half (16) are in fact among those in the WALS survey. Information about the 34 languages and the source or corpus from which the frequency values are drawn appears in Table 3.9. Consonant frequency was examined for 32 of the 34 languages (excluding Arabic and Czech), while vowel frequency was tabulated for 29 of the 34 languages (excluding Martuthunira,

² There are two Slavic languages included in the survey, Czech and Russian, but Czech is only used in the tabulation of vowels and Russian only in the figures for consonants.

TABLE 3.9. Languages surveyed for frequency of consonants and vowels

	Language	Family	Type	<i>n</i> word/root	Source
1	Arabic	Afro-Asiatic	Token	31,055	Nahar et al. (2012)
2	Basque	Isolate	Token	96,467 (phonemes)	Aske (2002)
3	Chatino, Highland	Oto-Manguean	Type	3,000	Pride and Pride (2010)
4	Czech	Indo-European	Token	100,000 (phonemes)	Kučera and Monroe (1968)
5	Dobu	Austronesian	Type	2,000	Lithgow and Lithgow (1998)
6	English (RP)	Indo-European	Type	70,646	Shin et al. (2013)
7	Finnish	Uralic	Token	2,500	Aoyama (2001)
8	Hausa	Afro-Asiatic	Type	7,397	Randell et al. (1998)
9	Hindi	Indo-European	Token	97,911	Ghatage (1964)
10	Japanese	Japanese	Token	1,923	Aoyama (2001)
11	Kadiwéú	Guaykuruan	Token	3,700	Griffiths (2002)
12	Kaiwá	Tupian	Type	5000 (phonemes)	Sigurd (1968)
13	Kayardild	Australian	Type	1,502	Round (ms)
14	Kewa	Trans-New Guinea	Type	2,000	Franklin et al. (2006)
15	Koasati	Muskogean	Type	2,284	Martin et al. (2013)
16	Korean	Korean	Type	47,401	Shin et al. (2013)
17	Malayalam	Dravidian	Token	100,000	Ghatage (1994)
18	Mandarin	Sino-Tibetan	Type	2,500	Duanmu (2008)
19	Maninka	Niger-Congo	Token	3,601	Rovenchak (2011)
20	Martuthunira	Australian	Type	1,300	Dench (1995)
21	Mixtec, Xochapa	Oto-Manguean	Type	500	Stark et al. (2003)
22	Salish, Montana	Salishan	Type	236,227 (phonemes)	Tachini (2010)
23	Nzadi	Niger-Congo	Type	1,100	Crane et al. (2011)
24	Ojibwe	Algic	Type	3,696	Lippert and Gambill (2004)
25	Pele-Ata	Yele-West New Britain	Type	3,900	Hashimoto (2008)
26	Quechua	Quechuan	Token	22,866	Jacobs (2006)
27	Romanian	Indo-European	Type	88,580	Renwick (2011)
28	Rotokas	North Bougainville	Type	9,800	Firchow and Firchow (2008)
29	Russian	Indo-European	Token	42,217	Kučera and Monroe (1968)

30	Samoaan	Austronesian	Type	1,640	Alderete and Bradshaw (2013)
31	Setswana	Niger-Congo	Token	49,358	Palai and O'Hanlon (2004)
32	Thai	Tai-Kadai	Type	61,222	Gandour and Gandour (1982)
33	Tiwi	Australian	Type	1,000	Osborne (1974)
34	Wyandot	Iroquoian	Type	117,048	Barbeau (n.d.), (phonemes) Koprís (2001)

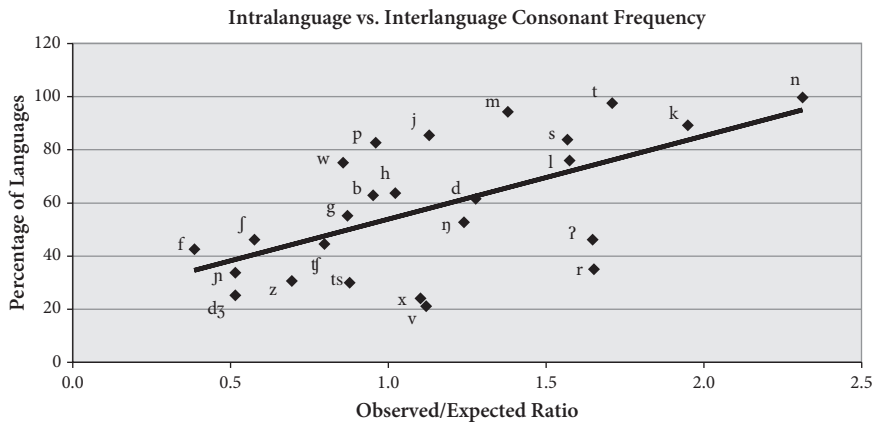


FIGURE 3.13. Language-internal frequency in a sample of 32 languages (reflected on the x-axis as the observed-to-expected ratio) vs. cross-linguistic frequency (reflected on the y-axis as the percentage of languages possessing the sound) of the 25 cross-linguistically most common consonants according to Maddieson (1984)

Xochapa Mixtec, Quechua, Russian, and Setswana). Frequency values are for phonemic short segments and exclude long segments (see earlier Figures 3.9 and 3.10 for comparative frequency of short vs. long vowels and consonants, respectively). Figures for vowels do not include nasalized vowels.

Figure 3.13 plots the frequency of occurrence of the 25 consonants most frequently attested cross-linguistically (see Figure 3.1) as compared to the intralanguage frequency (computed as the ratio of the observed number of tokens relative to the number of expected tokens were each sound to occur with equal frequency) for the surveyed languages. For the small set of languages (Basque, Kayardild, Malayalam, Martuthunira, and Tiwi) contrasting dental and alveolar sounds, frequency values reflect the place associated with the higher relative frequency of the two since the typological frequency data conflates the dental and alveolar categories for languages not contrasting the two (which is most languages of the world). Similarly, for the language contrasting dental/alveolar trills and taps (Basque), the intralanguage frequency data corresponds to the

frequency of the more frequent of the tap or trill, since sources providing the cross-linguistic frequency data on /r/ are often inexplicit about whether the rhotic is a trill or tap.

As the figure shows, there is a strong correlation ($r=.601$, $p=.001$) between the typologically most common consonants and their type frequency in languages. Among the more salient sources of divergence between the two frequency metrics are glottal stop and /r/, which are ranked 5th and 4th, respectively, in language-internal frequency but 15th and 19th, respectively, in cross-linguistic frequency. Similarly, the velar nasal /ŋ/ has an average observed-to-expected ratio of 1.24 but occurs in only 53% of languages in UPSID, and /x/ and /v/ are both attested in fewer than 25% of UPSID languages but occur at greater than chance levels within languages. On the other hand, there are certain sounds that are typologically widespread but have observed-to-expected ratios of less than one, e.g. /p/, which is found in 83% of languages, and /w/, which is found in 75% of languages.

Various factors potentially contribute to divergences between cross-linguistic and language-internal frequency. One consideration relates to contextual biases. Thus, in some of the sampled languages, /ŋ/ (found in 11 surveyed languages) and /ʔ/ (found in ten languages) benefit from being among a subset of consonants occurring in a broader range of environments than other consonants. The velar nasal is one of only two nasals allowed in coda position in Mandarin (Duanmu 2008); it has an observed-to-expected ratio of 2.67:1 in Mandarin. Roughly 80% of closed syllables in Thai are closed by either a sonorant or /ʔ/ with glottal stop and the velar nasal constituting two of the three most common codas (Munthuli et al. 2013); glottal stop and the velar nasal have observed-to-expected ratios of 2.05:1 and 1.33:1, respectively, in Thai. Similarly, the velar nasal in Korean is the most common coda consonant comprising 29.1% of codas in the lexicon (Shin et al. 2013); its observed-to-expected ratio is 1.9:1 in Korean.

Historical sound changes may also play a role in boosting (or reducing) language-internal frequency. For example, glottal stop in Samoan is descended from proto-Polynesian *k which has the second highest mean frequency among the sampled languages. Assuming no confounding historical changes, the frequency level of glottal stop in Samoan (observed-to-expected ratio = 1.3:1) thus reflects the inherited frequency of /k/, a consonant that tends to be more common than glottal stop within languages.

The frequency of a sound may also be inflated due to historical mergers. For example, intervocalic /l/ from Latin merged with /r/ in Romanian, a sound change that contributes to /r/ being by far the most common consonant in Romanian occurring at a level more than three times greater than chance (Renwick 2011).

Finally, it is conceivable that some discrepancies between cross-linguistic and language-internal frequency could be an artifact of limitations on the phonetic detail or phonemic analysis of the consulted language sources. For example, /x/ and /v/, which are statistically overrepresented within languages relative to their cross-linguistic frequency, are phonetically similar to /h/ and /w/, respectively, which are considerably more common typologically. It is possible that the /x/ cited in sources examined for either the language-internal frequency survey or in UPSID could be amenable to reanalysis as a glottal. Conversely, the cross-linguistic frequency of /x/ could be underestimated in UPSID if glottal fricatives

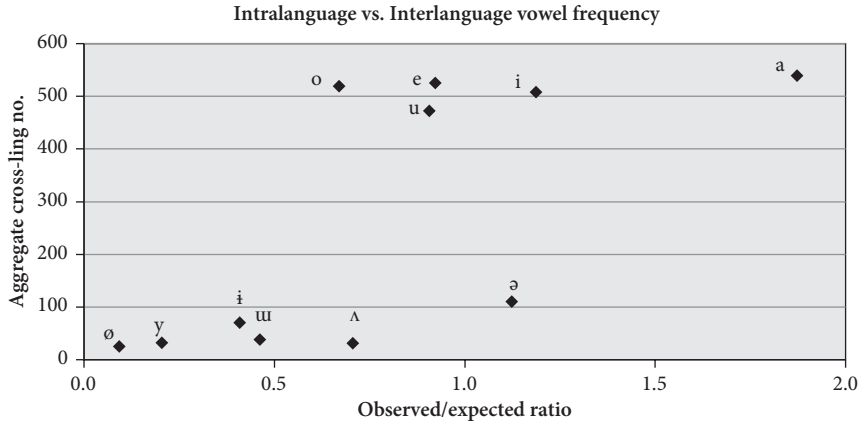


FIGURE 3.14. Language-internal frequency (reflected on the x-axis as the observed-to-expected ratio) averaged over a sample of 29 languages vs. cross-linguistic frequency (reflected on the y-axis as the aggregate number of languages possessing the sound) of the 11 cross-linguistically most common vowels according to the UPSID database

in some languages were open to reanalysis as phonemic /x/. Similar possibilities for reanalysis hold for the phonetically similar /w/ and /v/.

Figure 3.14 plots the number of occurrences of the 13 most common vowels from the 451-language UPSID survey against their frequency (relative to other vowels) in the 29-language frequency sample. To be consistent with the UPSID values, vowels in the frequency sample are separated into three height categories (high, mid, and low) and, in the case of non-low vowels, three backness categories (front, central, and back) and two rounding categories (rounded, unrounded). Vowels belonging to different subcategories within these three height and backness groups are collapsed. For example, the high front unrounded vowels include both high and lower high vowels, i.e. /i, ɪ/, the mid front rounded vowels comprise both /e, ɛ/, and the low vowels include low vowels of different backness, height, and rounding specifications, i.e. /a, ɑ, æ, ɐ, ɒ/. Secondary features such as nasalization and voice quality are not included. One methodological difference between the language-internal frequency survey and the cross-linguistic UPSID survey is that the former excludes long vowels for all languages not just those in which length cross-classifies with all vowel qualities. In practice, though, there is only one language, Ojibwe, for which vowel length was excluded in the language-internal frequency survey but which would not be if the UPSID methodology were adopted.

The four least frequent vowels within languages, /ø, ɣ, ɨ, ʉ/, are also among the five least frequently attested vowels (of the top 11). The two frequency metrics diverge, however, in certain respects.

Most striking is the clear separation in frequency between the five cardinal vowels /a, e, i, o, u/ and other vowels in the UPSID survey contrasted with the more gradual cline in language-internal frequency proceeding from more common vowels to rarer ones.

Furthermore, schwa occurs with greater frequency within languages than three of the cardinal vowels /e, o, u/, even though schwa is considerably less common across languages. The averaged language-internal frequency of schwa depicted in the figure is misleading, however, as there are only five languages in the sample that were analyzed as having phonemic schwa in the source consulted for frequency data (English, Malay, Mandarin, Romanian, and Thai) and in only one of these languages, English, does schwa occur at much higher than chance levels (>3:1). Furthermore, schwa in English is often regarded as a non-phonemic surface vowel resulting from vowel reduction in unstressed syllables (see Chapter 5 on vowel reduction), even though, in most lexical items, it does not engage in any productive alternations with a non-schwa vowel.

Finally, although low vowels (largely attributed to /a/) are the most common vowel in both UPSID and in the language-internal frequency data, the difference between /a/ and all other vowels is appreciably greater in the language-internal data. The discrepancy between low vowels and other vowels in the language-internal frequency survey would be even greater if long vowels were included in the figure, as long low vowels occur at higher than chance levels in all of the surveyed languages except for Japanese. Figure 3.15 plots observed-to-expected (relative to other long vowels) ratios for long /a:/ in 12 languages.

The prevalence of low vowels in the language-internal frequency data is plausibly linked to the position of low vowels at the top of the sonority hierarchy (see Chapter 1 on sonority) reflecting their greater acoustic prominence relative to other vowels. This interpretation is supported by the statistical bias in favor of long low vowels over other long vowels, a bias that can be explained in terms of a natural synergy between duration and qualitative prominence.

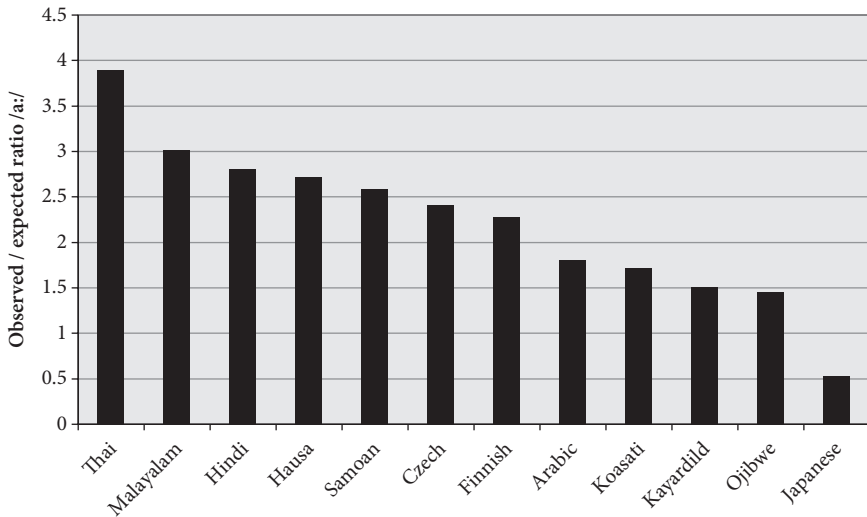


FIGURE 3.15. Observed-to-expected ratios for long /a:/ relative to other long vowels in a sample of 12 languages

3.6.1 Explaining the frequency distributions within languages

An interesting issue raised by the relatively close parallel between interlanguage and intralanguage frequency concerns the mechanism by which frequency distributions within languages arise and develop over time. As discussed in the last section, sound changes typically alter frequency patterns. For example, a merger of two phonemes inflates the frequency of one while either eliminating the other (in the case of an unconditioned merger) or reducing its frequency (in the case of a conditioned merger). (Potentially the frequency of both phonemes could be reduced if the output of the merger were a phoneme that differs from either of the merged ones.) Under the assumption that sound change is characteristically driven by phonetic and functional considerations (see Chapter 2), one would predict that languages would display an overall drift (with local deviations) toward an increase in both the number of phonetically preferred phonemes (according to various criteria discussed in section 3.5) and their frequency relative to other phonetically less advantaged phonemes.

Martin (2007) advances the hypothesis that frequency distributions are not necessarily attributed only to a confluence of phonetically natural sound changes that conspire to create a distributional bias in favor of phonetically preferred phonemes. He suggests that speakers are sensitive to considerations of phonetic naturalness even at the lexical level when choosing words to borrow and coining new words. Martin hypothesizes that words with phonetically advantaged phonemes are preferentially introduced into languages, thereby increasing the frequency of those preferred phonemes relative to others. He explores this hypothesis through a study of Romance historical phonology and models the diachronic development of frequency distributions through a series of computer simulations employing a neural network speech processing model.

An interesting property of phonemes noted by Martin (2007) and others (see Tambovtsev and Martindale 2007 for a study of phoneme distributions in 95 languages) is that they display a consistent distribution that can be mathematically modeled by a power law function of the basic form $1/r^a$, where r is the frequency rank ranging from 1 to the number of phonemes in the language, and a is a parameter estimated from the data. The actual power law modeling the distribution is typically taken to be Zipf's Law (Zipf 1935), although based on a survey of phoneme frequencies in 95 languages, Tambovtsev and Martindale (2007) show that a slightly different power law, Yule's Law, actually provides a marginally better fit to phoneme frequency than Zipf's Law, which tends to overestimate high and low frequency phonemes and underestimate mid-frequency phonemes.

Figure 3.16 (adapted from Martin 2007) plots the distribution of the 25 consonant phonemes in English as a function of their relative frequency in the CELEX lexical database (Baayen et al. 1995). If all consonants occurred with equal frequency, one would expect each consonant to represent 4% of the total number of consonants in the lexicon. Strikingly, however, the five most frequent ones /t, s, n, r, l/ together comprise over half of the English consonants occurring in the vocabulary, a pattern that we saw is common cross-linguistically. Conversely, the bottom five /dʒ, tʃ, θ, ð, ʒ/ together make up only just over 3% of

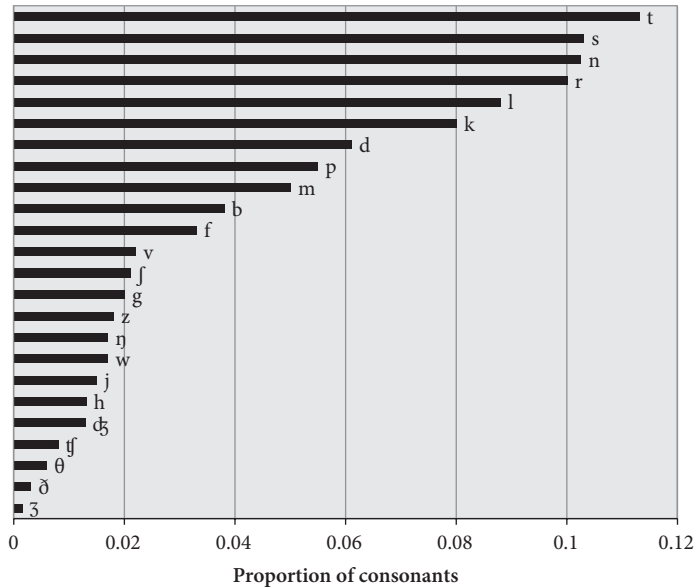


FIGURE 3.16. Relative frequency of different consonants in English (adapted from Martin 2007)

consonants in the lexicon. The distribution is thus highly skewed in favor of more frequent consonants as a power law would predict.

Interestingly, the distributions have remained largely the same over time even with wholesale lexical changes, a property that Lahiri (2002) labels *pertinacity*. This can be seen in the comparison in Figure 3.17 of consonant frequency in Old English and Modern English (from Martin 2007).

The distribution of phonemes is quite consistent at the two stages of English, though there are some differences that Martin (2007: 7) discusses. One difference is that voiceless obstruents are more common in modern English, which is due to the loss in modern English of a once productive rule of intervocalic voicing. Another difference is the sharp reduction in instances of the palatal glide /j/, which Martin attributes to the loss of the past participial prefix *ge-* in modern English. Despite these isolated divergences between the two stages of English, the consonant distributions are remarkably similar at the two stages of English even though 85% of the Old English lexicon has been lost (Baugh and Cable 1993) and 80% of Modern English vocabulary consists of borrowings from other languages (Stockwell and Minkova 2001).

Martin (2007, 2009) provides an account of the distribution of phonemes using a spreading activation model of speech encoding (Dell 1986). In this type of model, nodes encoding various levels of linguistic representation ranging from high-level semantics down to low-level phonological features are hierarchically interlinked via weighted connected nodes. Nodes become activated as linguistic information is encoded by the speaker during the speech production process and

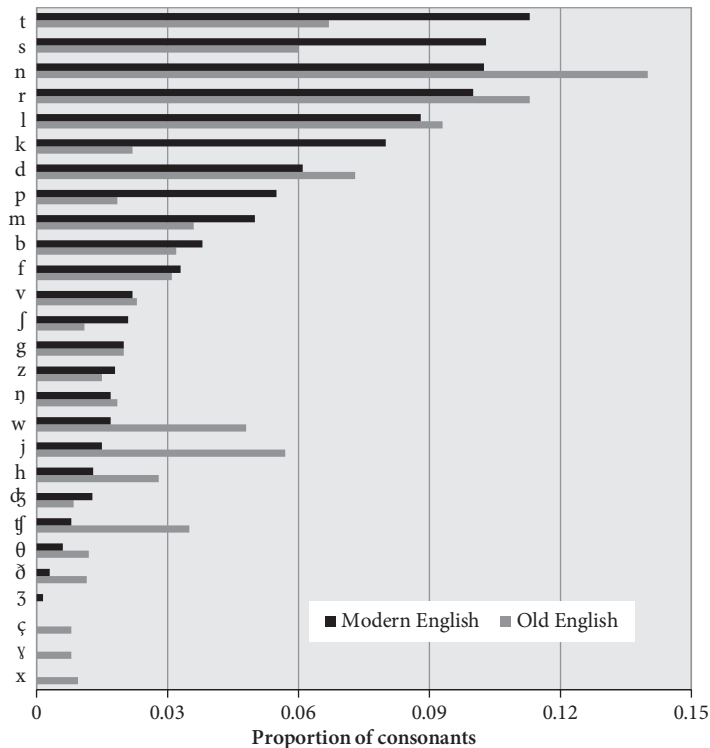


FIGURE 3.17. Relative frequency of different consonants at two diachronic stages of English (based on Martin 2007)

by the listener during perception. Activation spreads between nodes as information is accessed. For example, the word *zebra* would activate the lexical node associated with the word, those associated with other lexemes belonging to the same semantic field (e.g. lion, giraffe, cheetah, etc.), those associated with the CV and CCV syllable structures of *zebra*, those associated with the morphological category noun, with the phonemes /zib.ɪ.ə/, with the features comprising those phonemes, etc. A particular lexical item is selected when its activation level reaches a certain threshold, where nodes associated with more frequently occurring properties have higher resting activation levels. Items associated with higher resting activation reach the threshold level of activation needed to trigger selection faster than those with lower resting activation. The result is a “rich-get-richer” schema at the lexical and phonemic level. Of course, there are other factors that counteract the progressive skewing in favor of higher frequency phonemes, meaning that a situation in which there is a single phoneme never arises. These pressures include the avoidance of an overly impoverished lexicon and an overly small phoneme inventory from which the lexicon may draw upon. Furthermore, constraints against homophony as well as sociolinguistic factors may help to preserve relatively rare phonemes or lexical items that might otherwise continue

to diminish in frequency. There is also the potential for less common phonemes in the lexicon to still display high token frequency counts if they occur in very frequently attested morphemes, e.g. the case of the English voiced dental fricative, which is found in the high frequency definite article and demonstratives but is otherwise rare.

In Martin's account, words that enter the lexicon tend to contain commonly occurring phonemes. A key factor that contributes to the likelihood of a lexical item gaining traction in the community of speakers is its phonetic attributes. Martin proposes that given a choice between two synonyms, speakers will opt for the phonetically more euphonious one. Phonetic effectiveness is thus another factor that may either work synergistically with or, as we will see below, antagonistically toward the natural tendency for frequency to beget greater frequency.

Martin (2007) illustrates the role of phonetic factors in lexicon construction through a case study of obstruent voicing in Romance. As we have seen, there is a slight cross-linguistic bias toward voiced bilabial stops over voiced coronal stops, which stems from aerodynamic considerations: the larger cavity behind the bilabial constriction facilitates the pressure drop across the glottis that is necessary for voicing to be sustained during the closure. In a lexical study of ten genetically diverse languages with both /b/ and /d/ word-initially, Martin (2007) shows that the statistical bias in favor of /b/ is consistent across languages and that this bias does not reflect a more general skewing toward labial stops over coronal ones since /p/ is not consistently more frequent than /t/ across the same set of languages.

Martin suggests two potential mechanisms by which an asymmetric statistical skewing in favor of /b/ over /d/ could emerge diachronically assuming a starting point without this bias and no systematic sound change that would have eliminated /p/ in certain contexts. One possibility is that /d/ could have phonetically less voicing than /b/ for articulatory reasons just discussed, which could lead to the misperception of /d/ as voiceless /t/ (but not /b/ as /p/) over time on a lexeme-specific basis, thereby asymmetrically lowering the frequency of /d/. Alternatively, it is conceivable that speakers preferred to retain, borrow, or coin words that began with /b/ over those that began with /d/, a bias that would lead to a synchronic skewing in favor of /b/.

To test the two alternative accounts of the bias toward /b/, Martin (2007) examines the history of word-initial voiced bilabial stops in French. Very few tokens of *b are reconstructed for proto-Indo-European, though there are many instances of /b/ in Latin owing to the shift of proto-Indo-European *d^w to /b/ and an influx of borrowings from Greek. Interestingly, a bias in favor of /b/ over /d/ is observed in borrowings from Greek into Latin: 35 words with initial /b/ were borrowed compared to only 15 with initial /d/. This is striking for two reasons. First, /b/ was relatively rare in Latin, meaning frequency effects should bias against its borrowing in the "rich-get-richer" scenario predicted by Martin's model. Furthermore, words with initial /b/ were relatively rare in the donor language Greek, which had only 3,090 words with initial /b/ vs. 8,860 with initial /d/.

To account for the increase in lexical items beginning with /b/, Martin suggests that a phonetically grounded preference for /b/ over /d/ made words containing /b/ preferential targets for borrowing. Even with this phonetic factor at work,

however, Latin still had fewer words (both in terms of type and token frequency) with initial /b/ than words with initial /d/, a distribution that had reversed itself by modern French. Martin counts 866 words with initial /b/ in Latin vs. 1,022 with initial /d/, whereas a sample consisting of every 10th word (prefixes excluded) from a modern French dictionary yields 338 words with initial /b/ vs. 205 with initial /d/. Words with initial /b/ in Latin were also no more frequent in token frequency than those with initial /d/. In fact, words with initial /b/ in Latin that survived into French were less frequently attested than those with initial /d/ that persisted into French.

Focusing first on inherited words, Martin suggests two possible reasons for the shift from a bias in favor of /d/ in Latin to one in favor of /b/ in French words inherited from Latin. First, it is possible that Latin words might have shifted their initial /d/ to another sound, such as /t/ through the phonetic drift mechanism discussed above. Another possibility is that more Latin words with initial /b/ survived in French relative to those with initial /d/. Martin counts only two words that fall into the first category and shifted their initial sound from /d/ to some other sound, in both cases, to a palatal, e.g. Latin *diurnum* > French *jour*. This finding argues against the hypothesis that phonetic drift shifted instances of /d/ to /t/ on a lexeme-by-lexeme basis. Consideration of survival rates among inherited words is also not the crucial factor as the number of Latin words preserved in French that contain initial /b/ is only marginally greater than the percentage of words that begin with /d/: slightly over 5% with /b/ vs. just under 4% with /d/.

This suggests that the bias in favor of /b/ in French stems from other sources beyond inheritance, including borrowings and the creation of new words from existing ones through word-derivation processes such as compounding and suffix addition or loss, e.g. *bêche* 'spade' from *bêcher* 'to dig', *dureté* 'hardness' from *dur* 'hard'. Borrowings in fact show a split in their behavior depending on the source of the borrowed word. Words that were re-borrowed from Latin, predominantly consisting of religious or scientific terms, were skewed in favor of initial /d/ (77 borrowings from Latin beginning with /d/ versus 31 starting with /b/), a bias that Martin suggests might be an artifact of the documented statistical bias in favor of /d/ (by roughly three to one) that existed in the Latin vocabulary. On the other hand, borrowings from other languages were biased in favor of initial /b/ by a count of 64 to 31, although Martin cautions that this result could also reflect undiscovered biases in favor of /b/ in the donor languages rather than a preference among French speakers for borrowing words beginning with /b/. This leaves word formation processes as the remaining potential source for the bias toward /b/. Strikingly, word formation is in fact the dominant factor contributing to the shift in favor of /b/, with 212 newly coined words by Martin's count (excluding prefixed words) containing initial /b/ vs. only 77 with initial /d/. This result suggests that during the development of French from Latin, speakers preferred to create words with /b/ over those with /d/.

Drawing on this finding from French, Martin incorporates a notion of articulatory ease into his spreading activation model by assigning higher resting

activation levels to nodes associated with articulatory gestures that are easier to implement. Through a series of computer simulations of his model, Martin shows that the addition of a sufficiently weighted factor of articulatory ease is able to allow even a comparatively rare but phonetically preferred phoneme to gain eventual statistical prevalence, as in the case of /b/ in the progression from Latin to French.

Martin's (2007) model also suggests a mechanism by which language-internal frequency patterns are potentially linked to cross-linguistic distributions. A phonetically less optimal phoneme could become marginalized as it gradually loses ground in the lexicon to its phonetically more privileged counterparts. As its frequency of occurrence diminishes, a phoneme would presumably become more vulnerable to merger with another more phonetically similar but more robustly attested phoneme to yield a categorical change in the phoneme inventory. Aggregated over multiple languages, the outcome would be a shift in the cross-linguistic frequency of phonemes.

3.7 Phoneme inventories: a summary

Although there are a large number of sounds attested in languages of the world, most languages only employ a relatively small subset of them to make contrasts. The modal number of consonants across languages is 21 and the modal number of vowels is five, though the number of vowels ranges from three to 46 and the number of consonants from six to 95. There are certain consonants and vowels that are much more common than others both cross-linguistically and within languages, an observation that has sparked an extensive literature exploring the phonetic and phonological motivations shaping phoneme inventories. Although accounts differ in how they delegate responsibility to various pressures influencing sound systems, evidence suggests that some combination of the competing factors of minimizing articulatory effort while maximizing perceptual differentiation is pivotal in predicting the structure of phoneme inventories. The extent to which these physical constraints impact sound systems directly or indirectly through the medium of phonological features is still an open issue. It is also plausible that the constantly evolving nature of the lexicon leads to the perpetuation and enhancement of biases in the intralanguage frequency distribution of phonemes through more general (non-language-specific) cognitive mechanisms.

4

Syllables

Syllables have long played a prominent role in phonological theory in accounting for a wide array of generalizations about the distribution of sounds and their behavior. Although the quest for a physical definition of the syllable has remained elusive, syllables not only have proved useful in describing many phonological properties cross-linguistically but they also bear a strong psychological reality for speakers of many languages. For example, virtually any speaker of English has the intuition that the word *elephant* has three syllables whereas *alligator* has four syllables. Less consistent across speakers, however, is the location of syllable boundaries in many cases. For example, many English speakers would posit a syllable break before the medial /n/ in the disyllabic word *dinner* [dɪnə], whereas others might place the boundary after the /n/ and still others might treat the /n/ as spanning both syllables. The universality of the syllable is also open to debate, as languages sharply diverge in the strength of the phonological evidence for syllables and native speaker intuitions about syllabification. Certain phenomena that have traditionally been analyzed with reference to the syllable have more recently been reanalyzed without appealing to the syllable. For example, as we saw in Chapter 2, voicing neutralization, which was described by Lombardi (1995) in syllable-based terms as a constraint against the licensing of the feature [voice] in coda position of the syllable, has been reanalyzed by Steriade (1999) with reference to the linear ordering of segments. Languages also diverge considerably in the degree to which the syllable is useful for characterizing phonological generalizations. Hyman (2011a), for example, shows that the syllable plays a minimal role, if any, in the phonology of the Niger-Congo language Gokana. Despite the uncertainty surrounding the scope of phonological coverage provided by the syllable, it seems clear that some notion of the syllable is useful in characterizing at least certain phonological phenomena cross-linguistically.

4.1 Internal structure of the syllable

In describing syllable typology, it is useful to divide the syllable into three parts: the nucleus (or peak), the onset, and the coda. The nucleus is the most prominent, i.e. loudest, part of the syllable and is typically a vowel, though it need not be in certain languages. For example, the nucleus of the first syllable in the English word *little* is a vowel but the nucleus of the second syllable is a syllabic [l]. The nucleus is the only obligatory part of a syllable, as a syllable may consist only of a nucleus,

e.g. the first syllable in the words *eagle* and *about*. The onset consists of consonants that precede the nucleus, e.g. the two consonants /tʃ/ at the beginning of the word *treat*, while the coda is made up of post-nuclear consonants, e.g. the /mp/ cluster at the end of the word *pump*. Restrictions on syllabification can be captured in terms of implicational constraints on the complexity of the nucleus, the onset, and the coda (Blevins 1995). The three positions within the syllable operate to a large extent (but see section 4.2.2) independently of each other such that one language may permit a richer range of complexity in one position but an impoverished set of options in another position, whereas another language may display exactly the opposite distribution. For example, although Italian allows more than one consonant in onset position, e.g. *pro.fon.do* ‘deep’, *tro.no* ‘throne’, *blat.ta* ‘cockroach’, only a single consonant is allowed in coda position, e.g. *san.to* ‘saint’, *pal.ko* ‘platform’, *tor.ta* ‘cake’. On the other hand, Khalkha Mongolian allows only a single consonant in the onset (excluding in loans), but permits two tautomorphic consonants in coda position and a third in suffixed forms, e.g. *maiɣs* ‘cypress’, *ɔims* ‘sock’, *nomx-tʰ* ‘to become tame’, *iɣs-tʰ* ‘sandy’, *farx-ɣʰ* ‘coroner’, *taws-tʰ* ‘salty’ (Svantesson et al. 2005: 64, 67–8). One of the issues arising in evaluating complexity of syllable structure is that certain consonants are often treated as being external to the core syllable when they violate sonority sequencing conventions, an issue to which we return in section 4.4.2.

4.2 Syllable margins

Looking first at the syllable margins, i.e. the onset and coda, tolerance of greater complexity, i.e. more consonants, at one edge of the syllable in a language implies the existence of syllables of lesser complexity at the same edge in that language (Cairns and Feinstein 1982). For example, if a language permits two consonants in the onset it will also allow onsets consisting of a single consonant. A language that permits three consonants in the onset will also tolerate two consonant clusters in the onset as well as onsets consisting of a single consonant. The same implications hold of codas such that a coda cluster of greater complexity implies a coda type of lesser complexity. The converse of these statements is not true. Thus, a language could allow simple codas but not complex codas, or a language could possess single consonant onsets but not onset clusters. One point of divergence between onsets and codas resides in the relationship between empty margins, i.e. those lacking a consonant, and those with a single consonant. In the case of codas, the occurrence of a syllable with at least one consonant (termed a *closed* syllable) implies the existence of codaless syllables (termed *open* syllables). In onsets, on the other hand, the occurrence of syllables with a simple onset consonant does not imply the existence of syllables lacking an onset. Rather, the opposite is true: if a language permits onsetless syllables, it will also allow syllables containing an onset. Thus, we can say that syllables with an onset are typologically more basic (or less “marked”) than those without an onset, whereas syllables without a coda (open syllables) are more fundamental than those with a coda (closed syllables). The preference for syllables with an onset coupled with the marked status of coda



FIGURE 4.1. Implicational scales of markedness of the onset

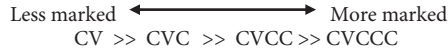


FIGURE 4.2. Implicational scale of markedness of the coda

consonants has the consequence that a single intervocalic consonant will be syllabified as the onset of the syllable containing the following vowel, i.e. V.CV not *VC.V, a preference termed “The Maximal Onset Principle” (Kahn 1976). Certain languages of Australia, e.g. Arrernte (Breen and Pensalfini 1999), have been claimed to preferentially syllabify VCV as VC.V rather than V.CV, although the arguments in favor of this syllabification have been called into question (Nevins 2009, Topintzi and Nevins 2014). Many languages, e.g. Tashlhiyt Berber (Dell and Elmedlaoui 1985, 1988), asymmetrically permit onsetless syllables word-initially but ban them word-medially where an onsetless syllable would entail vowel hiatus, a sequence of adjacent vowels belonging to different syllables (see Casali 1997, 1998, 2011 for typology and analysis of hiatus resolution).

The implicational relationships holding of the onset and coda position are summarized in Figures 4.1 and 4.2, respectively, where languages draw different cut-off points between permissible and impermissible levels of complexity for each of the positions.

If one conflates complexity of the onset and coda, the most basic syllable structure is CV (Jakobson 1962), i.e. a syllable with a simple onset consonant and no coda. In Maddieson’s (2013b) WALS survey of syllable structure in 486 languages, 61 (12.6%) languages permit only CV syllables, whereas the remaining 425 (87.4%) also allow greater complexity along the onset and/or coda markedness scale. Maddieson’s survey does not differentiate languages on the basis of the locus of the increased complexity. Figure 4.3 plots the percentage of languages in the 100-language WALS sample allowing for syllable types more marked than the basic CV syllable. Results are presented for languages possessing onsetless syllables and those with onset clusters consisting of two and three consonants and for codas ranging from one to three consonants.

As the figure shows, languages with CVC syllables are more common than languages with CCV syllables (87% of languages vs. 60%), suggesting that simple codas are typologically less marked than complex onsets. On the other hand, more languages tolerate complex onsets, at least certain types, than complex codas by a 3:2 margin (60% vs. 40% of languages in the survey). Onsets and codas consisting of three or more consonants are equally rare, each occurring in 11% of languages. Languages tolerating onsetless syllables are also as common as those permitting at least singleton codas, although the results for onsetless syllables should be regarded with some caution since they include languages where syllables that

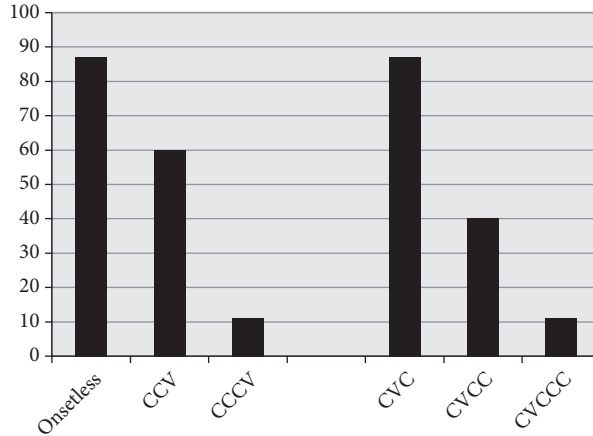


FIGURE 4.3. The percentage of languages in the WALS 100-language sample that permit syllable types more marked than CV

would otherwise be vowel-initial are automatically preceded by a glottal stop. In such cases, it is unclear whether this glottal stop is a property of lexical items or reflects allophonic glottalization that is sensitive to domains larger than the word, as in English (Dilley et al. 1996).

A query of the World Phonotactics Database (Donohue et al. 2013) yields similar findings for complexity of syllable margins but calculated over a larger data set (>2,000 languages), which allows for a more nuanced view of complexity. Figure 4.4 plots the number of languages in the database that permit onsets (on the left) and codas (on the right) of different complexity. The data is plotted on a logarithmic scale due to the sharp discrepancy in frequency between languages allowing less complex margins and those tolerating more elaborate margins.

Overall the results from both WALS and the World Phonotactics Database suggest two generalizations. First, the frequency of a given syllable type decreases as it deviates further from the least marked CV syllable. In the case of both the onset and the coda, each consonant constitutes a step in the direction of increased complexity: starting with one coda but with two onsets. The WALS survey demonstrates that the absence of an onset also represents a step in the direction of decreased frequency. Second, coda complexity is less marked than onset complexity, since each step away from the most common pattern (a single onset and a codaless syllable) is more widely attested along the coda continuum than along the onset continuum, i.e. CVC is more common than CCV, CVCC is more frequent than CCCV, etc.

It should be noted that the results in Figures 4.3 and 4.4 do not distinguish between clusters either on the basis of their location in the word or the consonants composing the cluster. Some languages display asymmetries between syllables at the periphery of the word, i.e. initial or final position, and those that are non-peripheral. For example, syllable-final clusters are limited to word-final position in Maricopa (Gordon 1986). Furthermore, many languages limit clusters in either the onset or coda (or both) to certain types as a function of the sonority of the

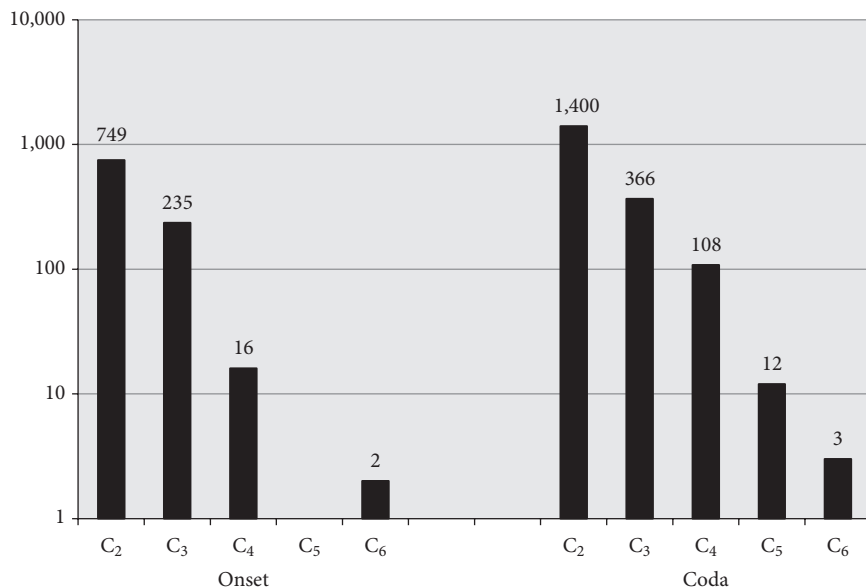


FIGURE 4.4. The proportion of languages in the World Phonotactics Database that permit syllable margins of differing complexity. The number of languages instantiating each pattern appears above the corresponding bar.

consonants. For example, onset clusters in Chamorro are limited to those in which the second member is either a liquid or a glide (Topping 1973) and the only triconsonantal onsets in Greek have /s/ as their first member (Joseph and Philippaki-Warbuton 1987). Location-driven constraints on syllabification are discussed in section 4.2.3, while sensitivity to cluster composition is addressed in section 4.2.4. Clusters that are restricted to final position, as in Maricopa, or clusters that violate sonority constraints, like sCC clusters in Greek, are often analyzed as containing an appendix external to the onset. Under this view, Maricopa CC final clusters would consist of a simple coda plus an appendix, while Greek sCC clusters would comprise /s/ in the appendix plus a biconsonantal onset. The appendix is discussed further in section 4.4.2. In an analysis assuming an appendix, the source of complexity would reside in the incorporation of an appendix rather than the number of consonants in the onset or coda.

4.2.1 Intralanguage frequency of syllable types

Both the status of CV as the most basic syllable and the stronger bias against increased onset markedness relative to coda markedness are observed not only across languages but also on a statistical level within languages.

In a study of ten diverse languages, Redford (1999) finds that CV outnumbers CVC in eight of the nine languages that allow both (all except the Niger-Congo

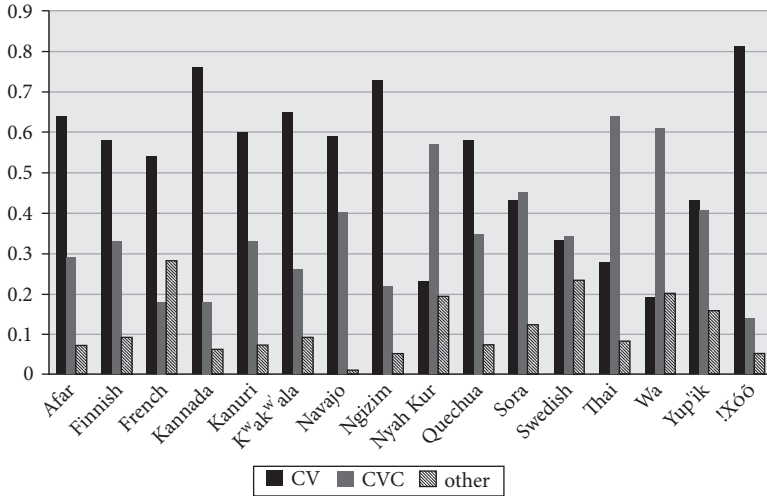


FIGURE 4.5. The proportion of CV, CVC, and other syllable types in the lexicon of 16 languages (adapted from a table in Rousset 2004: 116)

language Efik). Furthermore, in all eight languages permitting both CVC and CCV syllables, CVC syllables are more common.

Rousset (2004) contains data from a more extensive study of the type frequency of different syllables in the lexicon of 16 genetically diverse languages contained in the UCLA Lexical and Syllabic Inventory Database (ULSID) (Maddieson and Precoda 1992). Figure 4.5 plots the proportion of CV, CVC, and other syllable types in the 16 languages in her survey. Note that Rousset's work does not distinguish between short and long vowels in calculating the distribution of syllable types. Nor does Rousset distinguish between clusters on the basis of the consonants comprising the cluster.

As the figure shows, CV and CVC syllables are the most common syllable types in most of the 16 languages, even though all of the languages possess other more complex syllables. All of the languages except the Eskimo-Aleut language Yup'ik permit syllables with complex onsets, all except the Austro-Asiatic language Nyah Kur allow onsetless syllables, and nine of the 16 tolerate syllables with complex codas. In the majority of the languages, CV is preferred statistically to CVC, constituting over 50% of the occurring syllables in the lexicon of ten of the 16 languages. In three of the remaining six (the Austro-Asiatic language Sora, the Indo-European language Swedish, and Yup'ik), the number of CV and CVC syllables is nearly equivalent: in Sora, CV = 42.86% vs. CVC = 45.44%; in Swedish, CV = 33.05% vs. CVC = 33.56%; in Yup'ik, CV = 43.13% vs. CVC = 41.28%. In only three languages are there substantially more CVC than CV syllables: in Nyah Kur, CV = 22.64% vs. CVC = 57.11%; in the Tai-Kadai language Thai, CV = 18.71% vs. CVC = 64.41%; in the Austro-Asiatic language Wa, CV = 18.71% vs. CVC = 60.94%. Interestingly, two of the three languages with more CVC than

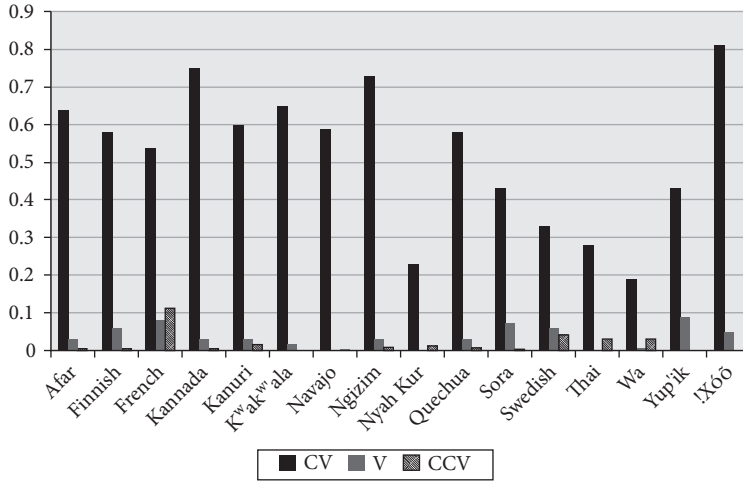


FIGURE 4.6. The proportion of syllables instantiating varying degrees of onset markedness in the lexicon of 16 languages (adapted from a table in Rousset 2004: 116)

CV syllables, Nyah Kur and Wa, possess either only monosyllabic words (Wa) or predominantly monosyllables (66.5% in Nyah Kur). In Thai, the most common length of word is one syllable (40.9%), though there are also a significant minority of disyllabic words (34.5%). It is thus plausible that the preference for CVC in these three languages is attributed to an independent (non-categorical) constraint requiring monosyllabic words to be minimally CVC (see section 4.2.3 for further discussion and Chapter 8 for prosodic minimality conditions).

Setting aside the two most common syllable types CV and CVC, other syllable types are vastly underrepresented in ULSID. Figure 4.6 (based on data from Rousset 2004: 116) plots the proportion of syllable types (relative to the entire corpus of syllables) in the 16-language sample as a function of onset markedness comparing onsetless syllables, syllables with a simple onset, and syllables with a biconsonantal cluster. Syllables with a triconsonantal cluster are omitted since they are only attested in four (Finnish, French, Nyah Kur, Swedish) of the 16 ULSID languages, and in none of the four do they constitute more than 0.3% of syllables.

As the figure shows, onsets that deviate at all from the maximally unmarked CV, either by lacking an onset or having a complex onset, are very rare cross-linguistically.

Figure 4.7 depicts the type frequency of occurrence of syllable types varying in coda complexity from one to three consonants in Rousset's survey.

As the figure shows, coda types that deviate more than one step from the maximally unmarked profile of CV are exceedingly rare in languages that tolerate them. Conflating the results of Figures 4.6 and 4.7 also demonstrates a language-internal analog to the cross-linguistic pattern whereby CVC is more frequent than CCV.

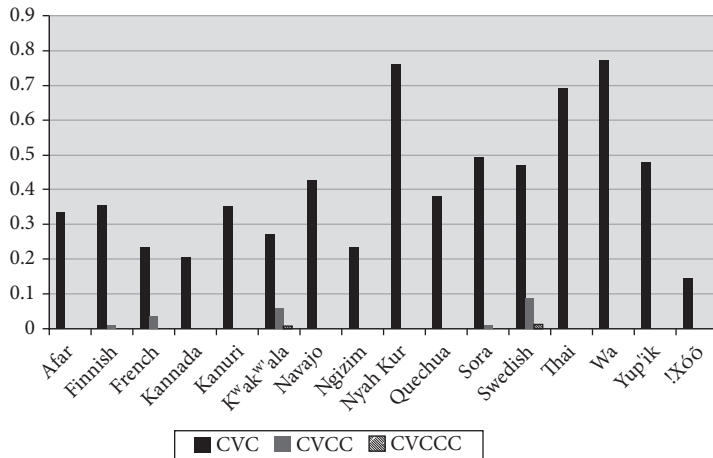


FIGURE 4.7. The proportion of syllables instantiating varying degrees of coda complexity in the lexicon of 16 genetically diverse languages (adapted from a table in Rousset 2004: 116)

4.2.2 Relationship between onset and coda markedness

There do not appear to be any languages that impose restrictions on the overall length of the syllable such that an increase in the number of segments in the coda is compensated for by a reduction in the number of sounds in the onset, or vice versa. A language instantiating this type of hypothetical relationship might, for example, allow syllables with either a complex onset or a complex coda but not both. Based on this observed independence of the onset and coda, most theories of the syllable treat the two margins as separate dimensions. An exception to this is the Split Margin Theory of the syllable (Baertsch 2002, Baertsch and Davis 2003, 2009, Davis and Baertsch 2011), which hypothesizes that the second consonant in a CC onset cluster patterns with the leftmost consonant of the coda with respect to restrictions. In their model of the syllable, the consonant in both of these positions falls in the second syllable margin slot, while the first consonant of the onset occupies the first margin slot. A CCVCC syllable is thus represented in their approach as $M_1M_2VM_2M_3$. This link between the second consonant in an onset cluster and the coda finds support in the observation that, in many languages, consonants in both positions are restricted to high sonority consonants. For example, in Krongo (Reh 1985), the only permissible onset cluster has a glide as its second member and the only coda (apart from some word-final ones arising through apocope and a suffixal velar nasal) is also a glide. This parallel restriction holding of both the onset and coda can be captured as a constraint limiting consonants in M_2 to a glide.

Extending the predictions of the Split Margin Theory to the typology of syllables, we might hypothesize that there is a link between restrictions against complex onsets and restrictions against codas, such that languages that permit

TABLE 4.1. Relationship between onset and coda complexity in the 16-language ULSID sample (Rousset 2004)

		Onsets			<i>Total</i>
		One	Two	Three	
Codas	Zero	0	0	0	0
	One	1	5	1	7
	Two	0	5	1	6
	Three	0	1	2	3
	<i>Total</i>	1	11	4	16

TABLE 4.2. Relationship between onset and coda complexity in the 100-language WALS sample

		Onsets			<i>Total</i>
		One	Two	Three	
Codas	Zero	8	6	0	14
	One	28	20	1	49
	Two	5	13	6	24
	Three	2	0	8	10
	<i>Total</i>	43	39	15	97

complex onsets are especially likely to tolerate codas and, conversely, languages banning complex onsets will tend to prohibit coda consonants. More generally, it is possible to explore other potential correlations, both positive and negative, between onset and coda restrictions.

The matrix in Table 4.1 plots the maximal number of consonants in the onset against the maximal number in the coda for the 16 languages in the ULSID sample to assess whether there is a relationship between onset and coda complexity within languages. The same matrix but for the 100-language WALS sample appears in Table 4.2.

Results of the two surveys are similar in most respects, differing mainly in the relative popularity of languages permitting only a single coda (CVC) and a single onset (CV). In the larger WALS survey, 28 languages fit this profile while only a single language in the ULSID sample adheres to it. Otherwise, in both samples, languages allowing a simple coda and a two-consonant onset cluster are relatively well represented: five languages in the ULSID survey and 20 in the WALS survey. Also relatively well attested are languages permitting two consonants in both the onset and coda: five in the ULSID sample and 13 in the WALS database.

Synthesizing the results of the two surveys suggests a few patterns. First, the majority of languages allow at least one syllable type that is more complex than the maximally unmarked CV syllable. No language in the ULSID sample allows only CV and only eight of 97 (8.2%) languages in the WALS sample permit only CV syllables. The relative rarity of languages permitting only CV syllables is consistent

with Maddieson's (2013b) survey of 486 languages, in which only 61 (12.6%) tolerate only CV. Most common are languages permitting syllables that reflect a single step in the direction of increased markedness: a complex onset and/or a simple coda. Thus, 49 languages in the WALS survey and seven in ULSID allow a simple coda consonant, while 39 languages in WALS and 11 in ULSID permit a complex onset. The relatively high frequency of languages allowing both a complex onset and a simple coda in both surveys (20 in WALS and five in ULSID) is consistent with the Split Margin Theory of the syllable, which could treat such a pattern as reflecting the language-specific licensing of the M_2 position.

A further finding more evident in the larger WALS survey is that an increase in markedness at the right edge of the syllable is more common than at the left edge, echoing a pattern observed earlier in the aggregated results in Figures 4.3 and 4.4 treating the onset and coda as separate dimensions. Thus, a simple coda is more common than an onset cluster and a doubly closed syllable is more widely permitted than a triconsonantal onset. There are thus 49 languages in the WALS sample that allow a simple coda vs. only 39 that allow complex onsets (including 26 that allow CVC but not CCV) and 24 languages that permit a two-consonant coda vs. 15 in which a triconsonantal onset is licit. This asymmetry between the left and right margin appears to contradict the split-margin theory of the syllable, which would predict that most languages allowing a simple coda would also permit a complex onset and vice versa.

It is also interesting to note that languages permitting the richest array of syllable types tend to allow complexity at both margins. Of the 15 languages allowing triconsonantal onsets in the WALS survey, 14 also allow at least two consonants in the coda. Similarly, three of the four languages in the ULSID sample tolerating triconsonantal onsets also permit codas consisting of at least two consonants.

If one considers the statistical frequency of different syllable types within languages included in the ULSID sample, additional patterns emerge. We consider these now via scatterplots depicting frequency relationships between the onset and coda. Some of these relationships are linear but others are apparent only if one dimension (or in certain cases both dimensions) is plotted on a logarithmic scale. Note further that for some comparisons only a subset of languages is probative because others lack the relevant property, e.g. complex onsets or complex codas.

Figure 4.8 plots the token frequency of the number of syllables with complex onsets against the number of syllables with complex codas in the seven ULSID languages that allow both syllable types plus the two languages, Swedish and French, which also allow triconsonantal clusters in syllable margins (either within the onset or coda entirely or shared between the syllable margin and an appendix; see section 4.4.2). For Swedish and French, results are separated according to whether the syllable margins contain two or three consonants.

If Swedish and French are excluded, an inverse correlation between the two parameters is evident (Pearson's correlation coefficient $r = -0.59$), such that the occurrence of a greater number of syllables with a complex onset implies a reduction in the number of syllables with a complex coda. This pattern

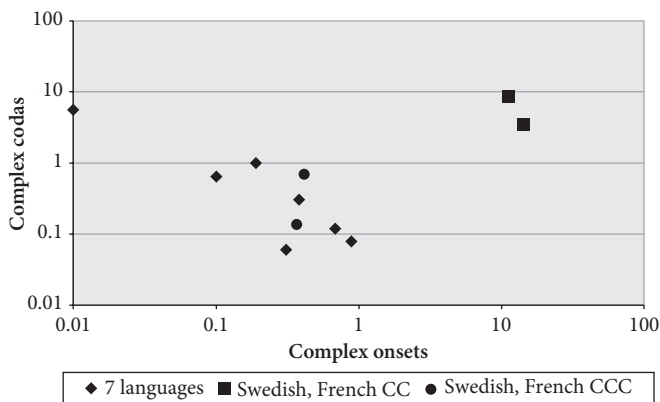


FIGURE 4.8. Token frequency (plotted on a logarithmic scale as a percentage of the total number of syllables) of syllables with complex onsets (x-axis) vs. those with complex codas (y-axis) in seven languages plus Swedish and French

superficially contradicts the cross-linguistic tendency pointed out above for languages tolerating very complex syllable margins, i.e. triconsonantal or larger onsets or codas, to permit extreme complexity in both margins.

However, the two languages in the ULSID survey with the most complex syllable structures, French and Swedish, do not observe the negative correlation between onset and coda complexity holding of the seven other languages in ULSID allowing only moderately complex biconsonantal margin clusters. (Neither French nor Swedish is included in the WALS sample considered in Table 4.2.) It thus may be the case that there is an inverse correlation in frequency of occurrence between onset and coda complexity only for languages whose tolerance of syllable complexity falls under a critical threshold. For languages like French and Swedish exceeding this threshold, the correlation no longer holds. This statement should clearly be regarded as a very tentative hypothesis given the small size of the ULSID sample and the fact that French and Swedish are genetically related, albeit distantly.

Figure 4.9 suggests another correlation ($r=0.52$), a positive one holding between the token frequency of onsetless syllables and the frequency of syllables with complex codas.

This correlation is consistent with the negative correlation between complex onsets and complex codas shown in the previous figure if one conceives of syllable complexity not merely in terms of markedness (i.e. deviation from CV through either subtraction or addition) but also as an isochrony effect whereby length at the two margins stands in a compensatory relationship (see Nespor et al. 2011 for an overview of speech timing). A syllable that lacks an onset permits greater length in the coda and, conversely, greater duration in the coda exerts a shortening effect in the onset (where segment count in the figure serves as a categorical proxy for gradient duration).

An isochrony-driven account of the relationship between onsets and codas is unlikely to be the entire story, though. As we have seen, onset and coda

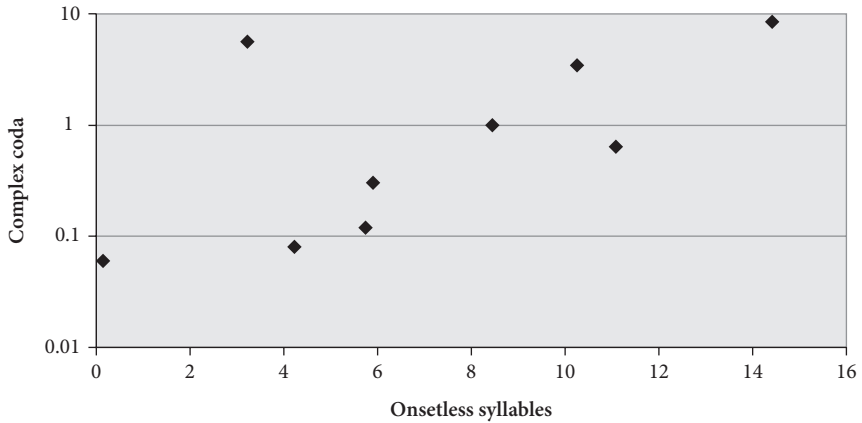


FIGURE 4.9. Token frequency (as a percentage of total number of syllables) of onsetless syllables (x-axis) vs. the token frequency (on a logarithmic scale) of syllables with complex codas (y-axis) in nine languages

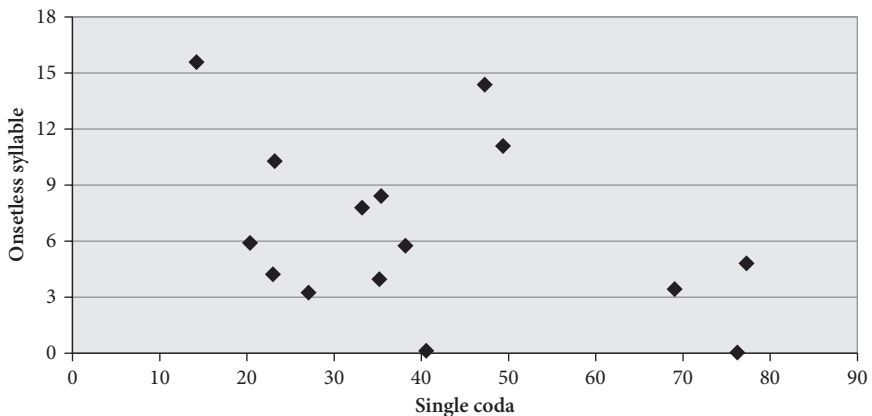


FIGURE 4.10. Token frequency (as a percentage of total number of syllables) of syllables with a simple coda (x-axis) on a logarithmic scale vs. syllables with no onset (y-axis) in 15 languages

complexity are not inversely correlated for the two ULSID languages, Swedish and French, allowing the richest array of syllable types. Furthermore, there does not appear to be any language-internal relationship between the token frequency of onsetless syllables and those with a simple coda, as Figure 4.10 shows.

Furthermore, there is a relatively strong positive correlation ($r=0.623$) between the token frequency of syllables with a complex onset and those with a simple coda (see Figure 4.11), a relationship that provides some support for a version of the Split Margin theory of the syllable operating on a gradient scale such

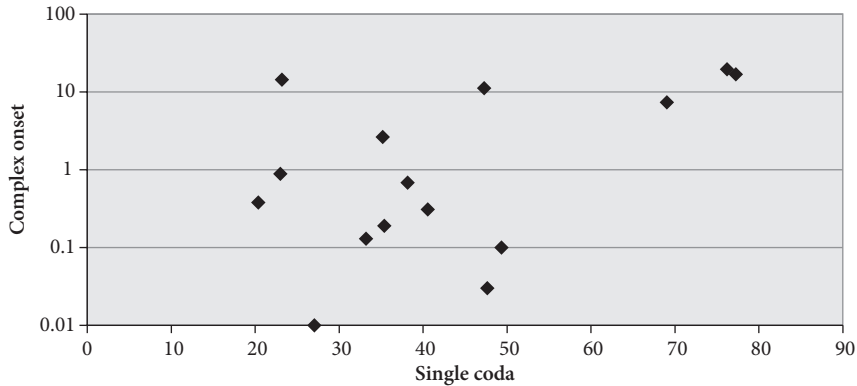


FIGURE 4.11. Token frequency (as a percentage of total number of syllables) of syllables with a simple coda (x-axis) vs. syllables with a complex onset (y-axis) in 15 languages

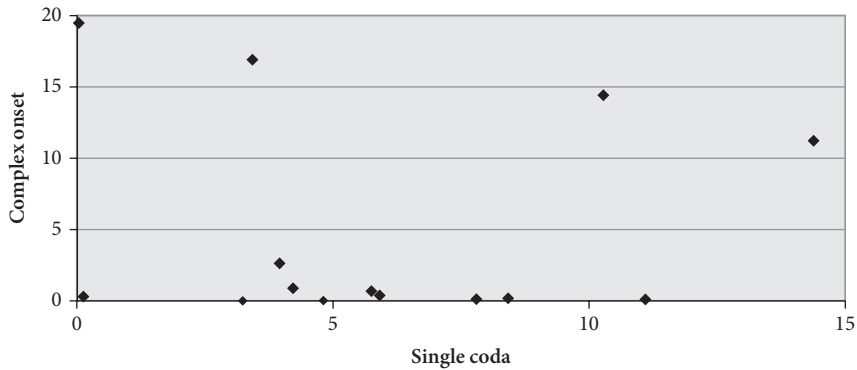


FIGURE 4.12. Token frequency (as a percentage of total number of syllables) of onsetless syllables (x-axis) vs. syllables with complex onsets (y-axis) in 14 languages

that complexity (in moderation) in one syllable margin begets complexity in the other margin.

To complete the picture, there does not appear to be any relationship between the token frequency of onsetless syllables and those with a complex onset (Figure 4.12).

In summary, syllable frequency data from ULSID and WALS suggest certain relationships between onset and coda complexity that are not predicted by a theory that treats the two margins as independent dimensions. Admittedly, however, the data sets on which these apparent correlations are based are relatively small, particularly in the case of the language-internal frequency data from ULSID. Future research employing larger databases will be required to provide a more comprehensive assessment of the relationship between onsets and codas.

4.2.3 *Final vs. non-final coda asymmetries*

Syllable structure varies in many languages between non-final and final syllables where the relevant domain bounding the asymmetry, e.g. stem, word, phrase, differs between languages (see Côté 2011 for an overview). These position-sensitive restrictions may reflect constraints holding of the lexicon that are potentially violable on the surface due to phonological processes. For example, all roots in the Muskogean language Koasati (Kimball 1991, Gordon et al. 2015) underlyingly end in a vowel (but may contain medial consonant clusters that syllabify as a coda-onset sequence). A process of final vowel deletion (apocope) applying to verbs at the end of statements and imperatives, however, creates root-final closed syllables on the surface (see Chapter 5 on deletion phenomena).

Alternatively, positionally governed syllabification asymmetries may not be attributed to conditions on the lexicon but may manifest themselves on the surface due to deletion or insertion processes. In *Tukang Besi* (Donohue 1999), syllables are open but word-final closed syllables arise through an optional morpheme-specific process of final vowel deletion that has been generalized to all final vowels in certain dialects. Syllable constraints may also be limited to certain classes of words or morphemes. *Kayardild* (Evans 1995, Round 2009) and *Koasati* (Kimball 1991) restrict closed syllables within roots to medial position, but allow suffixes ending in a consonant. A similar case of greater restrictiveness (but not morphologically governed) in final position is found in Finnish, which limits CVCC to non-final syllables in the native lexicon, although, as in *Koasati*, a common colloquial process of final vowel deletion often creates final CVCC on the surface (Suomi et al. 2008).

The *Tukang Besi* case in which closed syllables only arise through final vowel deletion illustrates a situation in which coda restrictions are more liberal in final than non-final position. In the Tupi-Guaraní language *Kamayurá* (Everett and Seki 1985), codas are also limited to word-final position, a restriction that triggers consonant deletion when reduplication would otherwise create a word-medial coda (see Chapter 8 on reduplication). *Cairene Arabic* (Watson 2007) only allows CVCC syllables phrase-finally; non-phrase-finally, only singly closed syllables are permitted.

In the 100-language *WALS* sample, there are several languages displaying an asymmetric ban on CVC in either final or non-final position but not in both positions. There are four languages (*Arapesh*, *Krongo*, *Sanuma*, and *Tukang Besi*) that only allow codas in final position, where, in three of the four (all except *Arapesh*), the only codas arise through word-final vowel deletion. On the other hand, in three languages (*Koasati*, *Kayardild*, and *Otomí*), codas are limited to medial position (of roots in *Koasati* and *Kayardild*), though, as we have seen, apocope creates root-final codas in *Koasati*. Note that these restrictions only include those encompassing all consonants (including the first half of geminates) and not those that affect only certain consonants (see section 4.2.4 for sonority-sensitive syllabification constraints).

Rousset (2004) presents statistical evidence from certain languages in support of greater leniency toward CVC in final position than in non-final contexts.

For the 16-language ULSID sample, Rousset (2004: 191–2) presents the percentage of different word types (relative to the entire corpus) varying as a function of their length and their syllable composition for all word types that constitute more than 2% of the corpus. In her data, an interaction between syllable type and position in the word is evident such that there is a greater likelihood of final syllables being closed relative to non-final syllables both in languages with an overall statistical bias in favor of CVC (Nyah Kur and Thai) as well as in languages with a roughly equivalent number of CV and CVC syllables (Sora, Swedish, and Yup'ik). This discussion excludes Wa, which also displays a strong skewing in favor of CVC but which has only monosyllabic words.

Looking at the latter group first, in Yup'ik, all final syllables (in word types constituting greater than 2% of the data) are CVC, while in Sora 89.5% of final syllables are CVC. In Swedish, the range of word shapes in the corpus is so diffuse that it is difficult to draw reliable conclusions from the data Rousset presents, but 72.2% of the final syllables found in word shapes attested in at least 2% of the data (only 25.9% of the entire corpus) are CVC.

Turning to languages with a clear overall bias in favor of CVC, in Nyah Kur, 96.1% of the monosyllables consist of a closed syllable (either CVC or CCVC) and all disyllables (which constitute less than a third of the data) end in CVC. In non-final syllables, on the other hand, there is a bias in favor of CV: 82.5% of non-final syllables are open. In Thai, 84.8% of monosyllabic words are CVC and 78.3% of disyllabic words end in CVC. Furthermore, all of the trisyllabic words (which together constitute only 7.3% of the lexicon) in Thai end in CVC. For Thai, the preference for final syllables to be closed does not completely account for the overall bias toward CVC, as 62.9% of non-final syllables in disyllabic words are also CVC, but this figure is considerably lower than the percentage of CVC relative to CV in final position.

The preference for CVC over CV in final position in certain languages is likely reducible to independent factors, either synchronically active or diachronically vestigial. For example, the strong skewing in favor of CVC in Wa is likely due to a minimal word requirement (see Chapter 8 for discussion of minimal word requirements), while the bias in favor of CVC in final position in Thai is plausibly attributed to a preference for final syllables, which are stressed (Schiering and van der Hulst 2010), to be heavy (see Chapter 5 on syllable weight).

The tendency for CVC to be preferred over CV in final position can even be observed in Navajo, a language with an overall bias toward CV. Although nearly 60% of its syllables overall are CV, Navajo strongly prefers monosyllabic words to be CVC (89.3%) and prefers final CVC to final CV in disyllables (70.6% vs. 29.4%). In the case of Navajo, this preference is likely attributed to a preference for roots, which typically are monosyllabic and word-final due to the heavily prefixing nature of the language, to consist of a heavy syllable.

4.2.4 *Sonority and place in syllabification*

Thus far, we have treated consonants as a unified class of sounds in terms of their occurrence in onsets and codas. In fact, most, if not all, languages are sensitive to

the type of consonants that may occur in syllable margins, either on a categorical or probabilistic level. One prevalent cross-linguistic pattern is for the set of coda consonants to be more restricted than the set of onset consonants. These restrictions may be sensitive to either sonority or place or a combination of both sonority and place and may interact with positional constraints on codas, e.g. whether the coda is word-final or not.

To take an example of a sonority-driven coda constraint, in the Australian language Ngiyambaa (Donaldson 1980), only sonorants may occur in coda position. The Ngiyambaa pattern is representative of most sonority-sensitive coda restrictions in that the coda must be populated by a high sonority consonant. On the other hand, within the class of obstruents, voicing neutralization of the type discussed in Chapter 2 (and again in Chapter 5) may eliminate higher sonority voiced obstruent codas in favor of lower sonority voiceless obstruents.

Place-sensitive restrictions on codas may be subdivided into two groups according to whether codas may bear their own independent place feature or must share it with a following onset. To take an example of the former type, only the coronal consonants /t, s, n, r, l/ may occur word-finally in the native vocabulary of Finnish. Word-medially, only the coronals may disagree in place with a following onset. In Japanese, on the other hand, the only permitted medial codas are the first half of a geminate or nasals that are homorganic to a following consonant. The only word-final coda is a nasal that has a dorsal realization. Following Ito (1986/1988), Japanese can be treated as a language that does not license place features in coda position; rather, only the [nasal] feature is licensed with the dorsal articulation in final position reflecting the default realization of a nasal unlicensed for place. In Finnish, on the other hand, only the place feature [coronal] is licensed, and there are no manner restrictions unique to codas.

In her survey of syllable structure in the ULSID database, Rousset (2004) found that all but one language (Afar) allowed a smaller set of consonants in coda position than onset position. Figure 4.13 plots the proportion of the total number of consonants in the phoneme inventory that occur in onset and in coda position for the 15 languages (all except Swedish) for which Rousset presents data on onset vs. coda asymmetries.

As the figure shows, all of the surveyed languages allow every or nearly every phonemic consonant in onset position. With the exception of Afar, all languages permit only a subset of consonants in coda position where the discrepancy between the onset and coda inventories varies considerably from language to language.

Coda clusters are typically subject to even more stringent restrictions than simple codas where the relative sonority of the members of the cluster is relevant in many languages. Figure 4.14 depicts a typical sonority scale that is relevant in characterizing restrictions on consonant clusters at a syllable margin.

The most typical pattern is for coda clusters to have a falling sonority profile such that the second consonant is lower in sonority than the first consonant. For example, coda clusters in Burushaski end in an obstruent and are preceded by a higher sonority consonant (e.g. nasal + obstruent, liquid + obstruent, fricative + stop), while coda clusters in Finnish consist of a sonorant plus an obstruent.

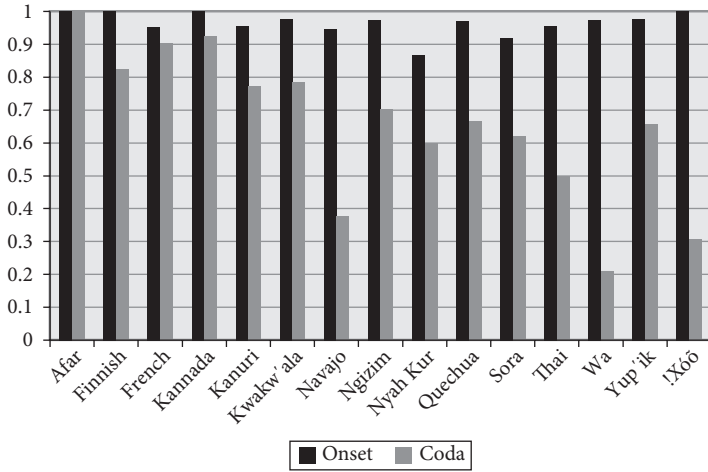


FIGURE 4.13. Proportion of total number of consonant phonemes that can occur in onset and coda position in 15 languages (adapted from a table in Rousset 2004: 127)



FIGURE 4.14. Consonant sonority scale relevant for onset and coda restrictions

Conversely, onset clusters are often restricted to sequences with a rising sonority profile. For example, in Krongo (Reh 1985), the only permissible complex onsets consist of a lower sonority consonant plus a glide. Similarly, in Thai (Iwasaki and Ingkaphirom 2005), onset clusters are limited to those containing a stop followed by a liquid or glide.

Both onset and coda clusters share a preference for the higher sonority member of the cluster to occur closer to the nucleus. Thus, a syllable optimally displays a rising sonority profile moving from its left edge to the nucleus and then a fall in sonority going from the nucleus to its right edge. Greenberg’s (1965/1978) survey of word-initial and word-final consonant clusters in 104 languages demonstrates the robustness of sonority conditions in predicting several implicational statements and frequency trends characterizing tautosyllabic clusters cross-linguistically. First, he observes that clusters involving a liquid plus stop overwhelmingly tend to place the liquid closer to the nucleus. In all 77 languages surveyed by Greenberg with clusters comprising a liquid and stop in initial position, 65 only allow clusters in which the stop precedes the liquid and the other 12 allow clusters in which the stop may either precede or follow the liquid. Greenberg does not find any languages in which only liquid + stop and not stop + liquid clusters are attested word-initially. In final position, conversely, he finds 27 languages that possess liquid + stop clusters, 18 that allow both liquid + stop and stop + liquid clusters, but none that only permit stop + liquid clusters. Similarly, Greenberg identifies 16

TABLE 4.3. Sonority plateaus and reversals in three languages

<i>Stát'imcets</i>		<i>Koasati</i>		<i>Laz</i>	
sqajt	'summit'	sfaplitʃi	'electric fan'	mʃk'ela	'happiness'
ptakʷɬ	'to tell a legend'	stintijapka	'can opener'	bteli	'completely'
kʷtamts	'husband'	ho:fn	'S/he is smelling it'	ntkirua	'fade, wilt'
χʷʔutsin	'four'	bi:tl	'S/he is dancing'	mzguda	'plant'
zətp	'jelly-like'	ho:kf	'S/he is putting it (clothing) on'		

languages with nasal + liquid clusters word-initially, seven with both nasal + liquid and liquid + nasal clusters initially, but only one potential case of a language, Mitla Zapotec, in which only liquid + nasal and not nasal + liquid clusters are found initially (although Greenberg suggests that the “fortis” nature of the liquid may explain its exceptional behavior). Conversely, in final position, Greenberg finds 19 languages with liquid + nasal clusters, 14 with both liquid + nasal and nasal + liquid clusters, and no languages with only nasal + liquid clusters.

As Greenberg's (1965/1978) survey shows, not all onset and coda clusters cross-linguistically have ideal sonority profiles. Certain languages have clusters containing either a sonority plateau (i.e. consonants of equivalent sonority) or a sonority reversal (i.e. clusters in which a lower sonority consonant is closer to the nucleus than a higher sonority one). Table 4.3 shows examples of sonority plateaus and reversals in three languages: the Salishan language *Stát'imcets* (van Eijk 1997), the Muskogean language *Koasati*, and the South Caucasian language *Laz* (forms from Laz are from Bucaklışı and Uzunhasanoğlu 1999).

Despite the existence of languages like *Stát'imcets*, *Koasati*, and *Laz* that permit clusters with typologically less common sonority profiles, Greenberg's (1965/1978) results establish the existence of a series of implicational universals for initial and final clusters, which are formulated by Berent et al. (2007). These are summarized in (1) for initial clusters; analogous ones can be formulated for final clusters as well:

- (1) Implicational universals regarding sonority profiles in typology. In any given language:
 - (a) The presence of a small sonority rise (nasal + liquid and obstruent + nasal clusters in Greenberg's survey) in the onset implies that of a large one (obstruent + liquid clusters in Greenberg's survey).
 - (b) The presence of a sonority plateau (stop + stop and fricative + fricative clusters in Greenberg's survey) in the onset implies that of some sonority rise.
 - (c) The presence of a sonority fall in the onset (liquid + obstruent and liquid + nasal clusters in Greenberg's survey) implies that of a plateau.

Greenberg's (1965/1978) study also established that not all rising sonority initial clusters and not all falling sonority final clusters are equally common. Rather, clusters in which there is a greater sonority difference between the two consonants are preferred over those with a small sonority discrepancy. Assuming the sonority scale presented in Figure 4.14, this means that an initial cluster consisting of an obstruent + liquid is preferred over one comprising an obstruent + nasal or a nasal + liquid. Similarly, within the class of obstruents, voiceless ones are predicted to be preferred over voiced ones as members of clusters. Greenberg does not present statistical evidence for all the predictions entailed in this preference for greater sonority dispersion within clusters. However, he does present data supporting several. First, let us consider Greenberg's results supporting the relevance of manner features in predicting clusters. Of the 75 languages in Greenberg's survey with obstruent + liquid initial clusters, 25 lack obstruent + nasal clusters initially. There is only a single language in his survey (Santee Dakota) that permits obstruent + nasal onsets but lacks obstruent + liquid initial clusters; this language, however, lacks liquids altogether. Similarly, all 23 of the languages with nasal + liquid clusters in initial position also have obstruent + liquid initial clusters, while there are no languages with nasal + liquid clusters initially that do not also permit obstruent + liquid clusters in initial position. In final position, all 34 languages with liquid + nasal clusters also have liquid + obstruent clusters, while there are no languages that permit liquid + nasal but not liquid + obstruent clusters. Greenberg's data also point to a preference for voiceless obstruents over voiced ones as members of clusters. For example, all 24 of the languages with initial clusters consisting of a voiced obstruent + nasal also allow clusters consisting of a voiceless obstruent + nasal and there are no languages with voiced obstruent + nasal initial clusters but not voiceless obstruent + nasal initial clusters. Similarly, in final position the occurrence of sonorant + voiced obstruent clusters implies the occurrence of sonorant + voiceless obstruent clusters.

The data from ULSID analyzed in Vallée et al. (2009) supports the cross-linguistic preference for rising sonority initial clusters and falling sonority final clusters. Aggregated over the nine languages in the ULSID database with at least a moderate number of complex onsets (Vallée et al. adopt a cut-off of 30 or more tokens), there is a strong preference for rising sonority clusters in the onset. Averaged over the nine languages with at least 30 tokens of complex onsets in ULSID, the observed-to-expected (based on the occurrence of each consonant individually in the same context) ratio for stop + liquid clusters in the onset is 6.93, whereas there are no occurrences of liquid + stop onset clusters. Conversely, for the five languages with at least 30 tokens of complex codas in ULSID, there is a bias in favor of falling sonority coda clusters: nasal + stop coda clusters have a higher observed/expected ratio than stop + nasal clusters (3.89 vs. 0.03 observed/expected ratios).

Vallée et al.'s (2009) work also confirms Greenberg's (1965/1978) finding that the binary distinction between rising and falling sonority clusters is too coarse to account for certain typological patterns observed in clusters. Consistent with Greenberg's results, Vallée et al. find that stop + liquid onset clusters are preferred over stop + nasal onsets (6.93 vs. 0.01 observed-to-expected ratios). They also

observe, however, that the *opposite* preference obtains in coda position, where nasal + stop clusters occur more frequently than liquid + stop clusters though the latter are also robustly attested (3.89 vs. 1.66).

Noting this asymmetry between onset and coda clusters in their ideal sonority profiles, Clements (1990) offers a quantitative method for assessing the relative goodness of different onsets and codas, including clusters in both of these positions. He proposes that syllables may be broken into two demisyllables, one consisting of the onset and the nucleus and the other consisting of the nucleus and coda. In Clements's account, the ideal initial demisyllable has the *greatest* aggregate sonority difference between its members whereas the ideal final demisyllable has the *smallest* aggregate sonority difference between its members. He adopts a standard sonority scale (but collapsing fricatives and stops) according to which vowels are highest in sonority followed in turn by glides, liquids, nasals, and obstruents. Each level in the scale is assigned a numerical value in proportion to its sonority, i.e. obstruents = 1, nasals = 2, liquids = 3, glides = 4, and vowels = 5. To quantify the idealness of a particular demisyllable, Clements (1990: 304) employs the equation in (2) adopted by Liljencrants and Lindblom (1972) (see Chapter 3) to calculate perceptual dispersion in their simulation of vowel systems.

$$(2) \quad D = \sum_{i=1}^m 1/d_i^2$$

In the equation, D is the dispersion in sonority within a demisyllable, d is the distance in sonority rank between each pair of segments in the demisyllable (adjacent and non-adjacent pairs), and m is the number of pairs in the demisyllable, equal to $n(n-1)/2$, where n is the number of segments. Given Clements' sonority values, the scale of felicitousness $ta > na > la > ja$ (where $x > y$ indicates that x is preferred to y) emerges for onsets, whereas in codas the hierarchy is reversed: $aj > al > an > at$.

In the case of onset and coda clusters, the acceptability of a demisyllable containing a consonant cluster is a function of the combination of the sonority difference between the two consonants in the cluster and between the vowel and the immediately adjacent consonant. Thus, the scale of goodness of onset clusters, where maximal sonority differences are preferred, is $pl > pm/pj > ml/mj > lj$ and in coda clusters, where minimal sonority differences are favored, is reversed, i.e. $jl > lm/jm > jp/mp > lp$.

Clements's proposal accounts for many of the observations made by Greenberg (1965/1978) and Vallée et al. (2009) in their surveys of onset and coda clusters. In particular, Clements's work provides a method for quantifying Greenberg's finding that clusters consisting of consonants that are more divergent in their sonority profiles are preferred over those with less of a sonority difference between members. The preference for stop + liquid over stop + nasal onsets observed by both Greenberg (1965/1978) and Vallée et al. (2009) falls out from Clements's proposal, as does the bias in favor of nasal + stop over liquid + stop codas. It also predicts a preference for lower sonority onsets, which is observed in

languages possessing restrictions against high sonority onsets (see Smith 2003, 2005) as well as in CV reduplication, where a lower sonority onset is preferentially chosen over a higher sonority one in cases where the base has a complex onset (see discussion of Sanskrit reduplication in Chapter 8). Furthermore, it accounts for the observation that, in languages in which coda restrictions are sonority-driven, higher sonority codas typically are allowed to surface preferentially over lower sonority codas. Finally, Clements's analysis offers a means for quantifying the Syllable Contact Law (Hooper 1976, Murray and Vennemann 1983, Vennemann 1988, Gouskova 2004, Seo 2003, 2011), according to which consonant sequences spanning a syllable boundary preferentially consist of a higher sonority coda followed by a lower sonority onset, e.g. *al.pa* > *ap.la* (see Chapter 2). On the other hand, Greenberg's implicational relationship holding between liquid + nasal and liquid + obstruent final clusters, such that the former implies the latter but not vice versa, is not predicted by Clements's account, which assumes that smaller distinctions in coda sonority are more felicitous than larger ones. It is conceivable that the obstruents in the 13 languages in Greenberg's survey with liquid + obstruent but not liquid + nasal codas are extra-syllabic, i.e. appendices (see section 4.4.2), an analysis that would salvage Clements's sonority dispersion theory at least applied strictly within the syllable.

Greenberg's (1965/1978) study also revealed hints of a pervasive exception to the sonority preferences that otherwise appear to govern cluster formation. In his assessment of the distribution of different types of obstruent clusters, Greenberg did not find evidence for any implicational relationships governing the ordering of fricatives relative to stops. Although he noted a typological preference for fricative + stop clusters in which the fricative, the higher sonority obstruent, appears closer to the nucleus, Greenberg's tables indicate that the occurrence of clusters in which the fricative appears further from the nucleus does *not* imply within the same language analogous clusters with the fricative nearer to the nucleus. Thus, English has many words beginning with an /s/ + stop sequence, e.g. *stop*, *spam*, *skunk*, but none that are uniformly produced with a stop + /s/ cluster by all speakers. Potential loanwords instantiating examples of the latter type, e.g. *tsunami*, *tse tse fly*, undergo cluster simplification to a fricative for many speakers. As the English data suggest, the sonority reversals involving fricatives typically involve a subset of fricatives, the sibilants. For example, in standard German, the culpable onset clusters involve the postalveolar /ʃ/ rather than /s/, e.g. [ʃ]tille 'quiet, peace', [ʃ]pannen 'tighten'.

In her comprehensive overview of sibilant clusters, Goad (2011) observes that /s/ is actually *more* likely to appear before a stop than before a higher sonority consonant in onset position, i.e. that sibilants are more likely to be part of onset clusters that contain a fall in sonority than a rise in sonority, a pattern that contradicts preferences that are otherwise observed in other types of tautosyllabic consonant clusters. For example, Acoma (Miller 1965) allows /s/ + stop clusters in onset position but not clusters consisting of /s/ + any other type of consonant. In fact, Goad (2011) does not cite any languages that allow onset clusters consisting of /s/ followed by a consonant of equivalent or higher sonority but that do not permit /s/ + stop clusters. This result indicates that /s/ (and other sibilant fricatives) is largely

exempt from sonority sequencing constraints governing other sounds, an observation that has been the focus of many attempts to explain and formally analyze (see section 4.4.2 for discussion).

Greenberg (1965/1978) also observes a relationship between place of articulation in clusters, finding that, in any language with final clusters, a cluster with a dental/alveolar as the second member is attested. A similar pattern holds of initial clusters such that all languages with initial clusters have at least one type with a dental/alveolar as the first member. This bias in favor of dental/alveolar consonants at the periphery of onset and coda clusters is observed in English, which only permits obstruent + obstruent clusters (i.e. fricative + stop clusters in the onset and both fricative + stop and stop + stop clusters in the coda) in which the more peripheral member is an alveolar. Thus, English has the words *stop*, *lapse*, and *act*, but no words like *shtop*, *lapsh*, or *atk*. Cross-linguistically, sibilants and coronals are not the only types of consonants that display a wider distribution in clusters. In Armenian clusters, for example, /s/, /k^h/, /m/, /r/, and /ʁ/ are licensed in positions in which other consonants are banned (Vaux 2003a).

In summary, research on syllabification indicates that sonority is important in predicting onset and coda clusters on two levels. First, clusters in which a lower sonority consonant are closer to the nucleus are cross-linguistically dispreferred and imply within the same language clusters in which a lower sonority consonant is further from the nucleus. Second, higher (but still falling) sonority clusters tend to be preferred in coda position (although this finding appears to be contradicted by Greenberg's results for liquid + nasal and liquid + obstruent final clusters), whereas clusters allowing for more balanced incremental increases in sonority predominate in onset position. Sonority, however, is not the only factor relevant in predicting cluster composition. Most commonly, sibilant fricatives disobey sonority sequencing principles and dental/alveolar consonants are more freely tolerated than other consonants at the periphery of clusters.

4.2.5 Syllable repair processes

Many languages have productive processes to ensure that their syllables adhere to language-internal constraints on syllable structure. These are summarized here and discussed further in Chapter 5. One of these processes entails the insertion (or epenthesis) of vowels in order to eliminate closed syllables or consonant clusters, especially those with more complex sonority profiles. For example, most varieties of Arabic have restrictions against complex onsets and codas, (the latter of which is relaxed in word-final position). In case morpheme concatenation brings together three consonants intervocalically, an epenthetic /i/ is inserted to break up the clusters, where the location of the epenthetic vowel depends on the dialect (Broselow 1980, Ito 1989). In Cairene Arabic (3a), the vowel is inserted after the second consonant, whereas in Iraqi Arabic (3c), the vowel is added after the first consonant. Both insertion sites obviate the occurrence of a complex onset or coda. In both Cairene and Iraqi Arabic, the vowel is inserted in the middle of clusters consisting of four consonants (3b, 3d), the only location that avoids the creation of both a complex onset and a complex coda.

(3) Vowel epenthesis in two varieties of Arabic (Ito 1989: 242)

Cairene Arabic

(a)	/ʔul-t-l-u/	ʔultilu	‘I said to him’
	/katab-t-l-u/	katabtilu	‘I wrote to him’
(b)	/ʔul-t-l-ha/	ʔultilha	‘I said to her’
	/katab-t-l-ha/	katabtilha	‘I wrote to her’

Iraqi Arabic

(c)	/gil-t-l-a/	gilitla	‘I said to him’
	/katab-t ma-ktu:b/	katabit maktu:b	‘I wrote a letter’
(d)	/gil-t-l-ha/	gilitilha	‘I said to her’
	/katab-t-l ma-ktu:b/	kabtil maktu:b	‘I wrote the letter’

Although apparently rarer than vowel epenthesis, consonant epenthesis is also employed to eliminate onsetless syllables. For example, the Arawakan language Axininca Campa (Payne 1981) inserts /t/ to break up vowel sequences (4).

(4) Consonant epenthesis in Axininca Campa (Payne 1981)

	/noN-pisi-i/	nompisiti	‘I will sleep’
	/noN-pijo-i/	nompijoti	‘I will heap’
cf.	/noN-kim-i/	noŋkimi	‘I will hear’
	/noN-pok-i/	nompoki	‘I will come’

Another alternation that leads to an improvement in syllable structure involves deletion of a segment. For example, a consonant might be deleted if it would otherwise trigger a violation of a constraint against closed syllables or against codas of a certain type. For example, root-final consonants in the Austronesian language Samoan (Bloomfield 1933, Harris 2011) delete when they are not shielded from the edge of the word by a suffix (5a) (see also Hale 1973, Round 2011 for a striking example of erosion of material from the right edge of the root in the Australian language Lardil). The roots in (5b) underlying end in a vowel as demonstrated by their lack of a consonant before the suffix *-ia*.

(5) Consonant deletion in Samoan (Bloomfield 1933)

	<i>Simple</i>	<i>Perfective</i>	<i>Gloss</i>
(a)	api	apit-ia	‘be lodged’
	sopo	sopoʔ-ia	‘go across’
	milo	milos-ia	‘twist’
	oso	osof-ia	‘jump’
	ŋalo	ŋalom-ia	‘forget’
(b)	olo	olo-ia	‘rub’
	aŋa	aŋa-ia	‘face’
	tau	tau-ia	‘repay’

Vowels delete in many languages in hiatus contexts where their preservation would potentially create an onsetless syllable (Casali 1997, 1998, 2011). For example, the first vowel deletes in hiatus contexts in the Niger-Congo language Yoruba (Pulleyblank 1988) (6).

- (6) Hiatus resolution in Yoruba (Pulleyblank 1988)
- | | | |
|----------|------|----------------------|
| /bu ata/ | bata | ‘pour ground pepper’ |
| /gé olú/ | gólú | ‘cut mushrooms’ |
| /ta epo/ | tepo | ‘sell palm oil’ |

There are, in fact, other processes attested cross-linguistically that eliminate onsetless syllables; these are described and analyzed by Casali (1997, 1998, 2011), and include glide formation of the first vowel in a sequence, coalescence of two vowels into one, diphthongization, and consonant insertion, the last of which was exemplified above in Axininca Campa.

In certain cases, syllable structure may be improved not through deletion or insertion but rather a change in the realization of a segment. In addition to glide formation, which was just mentioned, consonants often undergo changes in coda position in order to honor sonority- or place-driven coda restrictions. An example of a sonority-driven shift in coda consonants is provided by Bolivian Quechua (Bills et al. 1969, Delforge 2011), in which stops lenite to fricatives in syllable-final position. The process of coda debuccalization (loss of place features) in Slave (Rice 1989) provides an example of a shift in coda consonants consistent with the reduced capacity of coda position to support place features. Epenthesis, deletion, and segmental changes may be triggered not only by intrasyllabic constraints on well-formedness but also by trans-syllabic constraints on coda-onset sequences (see Chapter 2). Chapter 5 provides a more comprehensive discussion of epenthesis, deletion, and segmental shifts, all of which can serve various functions beyond repairing syllables.

4.2.6 *Pseudo-syllable repair processes*

Although the processes described in the last section can often be ascribed to syllabification constraints, this is not always the case. In her survey of cluster simplification, Côté (2004) finds a number of deletion patterns that are not readily explainable in terms of syllable structure or syllable contact. For example, in Hungarian, a plosive optionally deletes in a triconsonantal cluster when the plosive is preceded by another obstruent or by a nasal and is followed by a plosive or a nasal (7a), where the likelihood of deletion is greater if the plosive and the preceding consonant are homorganic (Törkenczy and Siptár 1999, Siptár and Törkenczy 2000, Côté 2004). Fricatives and affricates are retained in all contexts (7b) as are plosives in the middle of a triconsonantal cluster if the preceding consonant is a liquid or glide (7c), or if the following consonant is a fricative, liquid, or glide (7d).

- (7) Consonant deletion in Hungarian (Côté 2004)
- | | | |
|-----------------|------------------------|---------------------|
| (a) /lɒmbdɔ/ | lɒmbdɔ ~ lɒmdɔ | 'lambda' |
| /rɒndʒɛn/ | rɒndʒɛn ~ rɒŋɛn | 'X-ray' |
| /domptɛtø:/ | domptɛtø ~ domtɛtø: | 'hilltop' |
| /ɔstmɔ/ | ɔstmɔ ~ ɔsmɔ | 'asthma' |
| (b) /sɛnftɛlɛn/ | sɛnftɛlɛn, *sɛntɛlɛn | 'indifferent' |
| /ɛksta:zɪf/ | ɛksta:zɪf, *ɛkta:zɪf | 'ecstasy' |
| /pɔrɔntʃnok/ | pɔrɔntʃnok, *pɔrɔnnok | 'commander' |
| /la:ntstɔlp/ | la:ntstɔlp, *la:ntɔlp | 'caterpillar track' |
| (c) /tɔlpɲɔlo:/ | tɔlpɲɔlo:, *tɔlpɔlo: | 'lackey' |
| /bɔzɔltkø:/ | bɔzɔltkø:, *bɔzɔlkø: | 'basalt stone' |
| /ʃɛjtmɔg/ | ʃɛjtmɔg, *ʃɛjmɔg | 'cell nucleus' |
| (d) /hɔŋkʃɔr/ | hɔŋkʃɔr, *hɔŋʃɔr | 'sound sequence' |
| /pa:ntlikɔ/ | pa:ntlikɔ, *pa:ntlikɔ | 'ribbon' |
| /kompju:tɛr/ | kompju:tɛr, *komju:tɛr | 'computer' |

Crucially, there is no reason to assume any difference in syllabification between nasal + stop + stop clusters, which optionally undergo deletion, and liquid + stop + stop clusters, which do not undergo deletion, that would predict the deletion asymmetries. If anything, Clements's (1990) algorithm for calculating sonority preferences (section 4.2.5) would predict that a coda nasal + stop cluster would be preferred to a liquid + stop cluster, but it is the former that undergoes optional deletion of the stop. Côté (2004) appeals to perceptual factors to account for the Hungarian facts and other similar data, arguing that sounds are more likely to delete where they are auditorily less robust, following the lines of similar argumentation in Steriade's (1999) account of laryngeal neutralization (see Chapter 2).

Vowel syncope also inevitably creates cross-linguistically less common syllable structures. A productive process of apocope in Koasati (Kimball 1991, Gordon et al. 2015) not only creates closed syllables in violation of a lexical restriction against word-final consonants but it also produces coda clusters, including ones with rising sonority, e.g. *bi:tl* 's/he is dancing', *hò:fn* 's/he is smelling it', *tà:lw* 's/he is singing', *hò:kb* 's/he's stringing them'.

Metathesis also often results in clusters that are worse than the original ones from the perspective of sonority sequencing. There are many instances of final fricative-stop clusters reversing their order, a change that entails a shift from a falling sonority coda cluster to a rising sonority one. For example, Faroese (Lockwood 1955, Árnason 2011) displays metathesis of /sk/ clusters when they precede /t/, e.g. *fɛsk-ur* 'fresh (masculine)' vs. *fɛkst* 'fresh (neuter)', *baisk-ur* 'bitter (masculine)' vs. *baisk-t* 'bitter (neuter)' (Lockwood 1955: 23–4).

Many segmental changes also lead to a deterioration of syllable well-formedness. For example, the pervasive phenomenon of intervocalic lenition increases the sonority of onsets contrary to the cross-linguistic preference for low sonority onsets.

In summary, the jury remains out on the scope of coverage of segmental phenomena afforded by the syllable. Although many phonological processes are amenable to accounts that appeal to the well-formedness of syllables and/or

transitions between syllables, instances of similar processes in other languages do not lead to any improvement in syllable structure and may, in fact, create dispreferred syllables (see Chapter 5 for discussion of alternative motivations for these processes).

4.3 Nucleus

Turning now to the nucleus, complexity in the nucleus adheres to the basic principles governing complexity in the onset and coda whereby a complex nucleus, i.e. a long monophthong or a diphthong, implies a simple nucleus, i.e. a short monophthong in the same language. Among the complex nuclei, the occurrence of triphthongs implies the existence of diphthongs in a language. Diphthongs and long monophthongs, however, do not stand in an implicational relationship to one another, as some languages have long monophthongs but not diphthongs, e.g. Chickasaw (Munro and Willmond 1994), while other languages possess diphthongs but not long monophthongs, e.g. Romanian (Chitoran 2001, 2002). There is also cross-linguistic (and even language-internal) variation in terms of whether diphthongs pattern with short vowels or long vowels in terms of their phonological behavior. Some languages even contrast short diphthongs with long diphthongs, e.g. Maori (Bauer 1993) and certain varieties of Finnish (Mielikäinen 1981). Finnish dialectology (Mielikäinen 1981) presents an interesting case of divergence in the patterning of diphthongs relative to long monophthongs. In certain varieties, all diphthongs behave like long vowels both in their phonetic duration and in their phonological behavior. In other dialects, there are two types of diphthongs, one type that patterns with long vowels and the other type that patterns with short vowels. The split in the behavior of diphthongs depends on their position in the word and the historical source of the diphthongs. Diphthongs in initial syllables are treated as long vowels as are chronologically newer diphthongs that arose through intervocalic consonant loss. Diphthongs in non-initial syllables that are inherited from proto-Balto-Finnic, those consisting of a vowel plus the preterite or plural suffix (both /i/), pattern as short. The situation is complicated further by the fact that the difference in phonological behavior of the diphthongs is reflected in phonetic duration differences in some but not all dialects.

4.3.1 *Syllabic sounds*

Another source of typological variation involving the syllable nucleus concerns the type of sounds that may serve as syllable nuclei. In many languages, only vowels are permitted to serve as syllable peaks. Others, however, allow consonants to occupy the nucleus, where the types of consonants that may constitute a peak adhere to an implicational scale similar but not identical to the hierarchy governing cluster formation in syllable margins (Bell 1978, Blevins 1995, Zec 2007, Parker 2011). Unlike in the sonority scale from which onset and coda cluster constraints are projected (see section 4.2.4), cross-linguistic evidence suggests that the position of liquids and nasals relative to one another in the sonority scale

governing syllable nuclei may vary on a language-specific basis, a point to which we return below. The tolerance of nuclear consonants that are less sonorous on the scale implies the possibility of consonantal nuclei that are more sonorous. Languages draw different demarcation points separating permissible and impermissible nuclei. At one extreme, many languages, e.g. Hawaiian, Chickasaw, only allow vowels to serve as syllable peaks. Languages that restrict syllable nuclei to vowels far outnumber those that allow any type of consonantal nucleus. A query of the World Phonotactics Database (Donohue et al. 2013) indicates that 1935 (88.7%) languages in the survey allow only vocalic syllable nuclei compared to 246 (11.3%) that permit consonantal nuclei of some type.

After vowels, the evidence for the second position on the sonority scale of syllable nuclei is conflicted. In a survey of syllabic consonants in 85 languages, Bell (1978) finds a considerable bias in favor of syllabic nasals over syllabic liquids, identifying 35 languages allowing syllabic nasals but not syllabic liquids, e.g. Swahili, and only a single language, Lendu (but see below), with syllabic liquids and not nasals. Blevins (1995), cites Sanskrit as another language with syllabic liquids but no syllabic nasals and Zec (2007) also adds Slovak to this list. Greater cross-linguistic uniformity is observed in languages that draw the division between permissible and impermissible nuclei moving down the sonority scale. Thus, some languages, such as English, allow both nasals and liquids but not obstruents to constitute nuclei, e.g. *butt*[ŋ], *pris*[ŋ], *litt*[l], *butt*[ɹ] (where the syllabic rhotic in the last word is phonetically more accurately described as a rhotacized vowel). Yet another possibility is for a language, e.g. Lendu (Kutsch Lojenga 1989, Demolin 2002), to permit consonants as low in sonority as fricatives to be syllable peaks. A final type of (rare) pattern is observed in languages that allow any segment to be a nucleus. For example, Tashlhiyt Berber (Dell and Elmedlaoui 1985, 1988, Ridouane 2008), which was discussed in Chapter 1, permits even voiceless stops to function as a nucleus, e.g. *tqs.sf* ‘it shrunk’, *ʃq.qʃt* ‘irritate him’, *tʃ.sk.ʃf.tʃtt* ‘you dried it (fem.)’

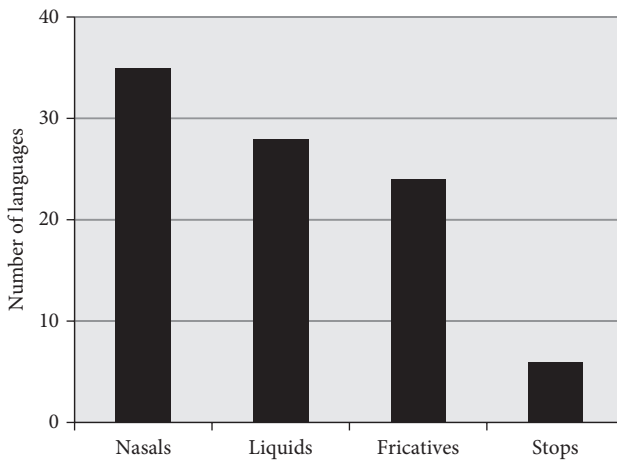


FIGURE 4.15. Permissible consonantal syllable nuclei in a sample of 85 languages in Bell (1978)

(Ridouane 2008: 332). Figure 4.15 shows the number of languages in Bell's survey of 85 languages possessing syllabic liquids, nasals, fricatives, and stops.

As the figure shows, the most prevalent type of syllabic consonant is a nasal, followed in turn by liquids, then fricatives, then syllabic stops, which are quite rare. In the 100-language WALS sample, only 13 languages (13.4%) were cited as allowing syllabic consonants with the majority (10) of these possessing only syllabic nasals, lending support to the view that nasals are characteristically higher than liquids on the sonority scale from which syllabic consonants are projected. Of the remaining three, German allows both liquids and nasals to function as nuclei, Tiwi has syllabic rhotics and nasals, and Tashlhiyt Berber tolerates all consonants as nuclei.

Even in languages permitting consonants as syllable nuclei, higher sonority sounds are preferentially chosen as peaks whenever possible over lower sonority sounds. For example, as we saw in Chapter 1, nucleus formation in Tashlhiyt (Dell and Eldmedlaoui 1985, 1988) proceeds from left to right selecting the highest sonority still un-syllabified sound that allows for satisfaction of the requirement that all non-initial syllables have an onset.

One caveat about Bell's survey concerns his criteria for classifying a consonant as being syllabic. He treats any sound as being syllabic "when it functions phonetically as a syllable peak from the point of view of the native speakers" (Bell 1978: 156). Sources on which his survey are based, however, are likely to be inconsistent in the assumptions they adopt in determining the syllabic status of different sounds. One problematic issue explored by Scheer (2008) is the fact that nuclear status on a phonetic level may not necessarily correspond to syllabic status on a phonological level.

Bell (1978) explores a number of other issues related to syllabic consonants, including their historical origins and distinctions (e.g. based on place, stridency) made by certain languages among members of the broad manner classes of nasals, liquids, fricatives, and stops in their capacity to function as syllable peaks. For example, among fricative nuclei, he observes that the presence of non-sibilant fricative nuclei implies the presence of sibilant fricative nuclei, i.e. /s/ or /ʃ/, in languages that have one or more sibilant fricatives in their inventory. This finding lines up with the tendency for sibilants to occur preferentially over non-sibilant fricatives in sonority reversals in onset and coda clusters (section 4.2.4).

Bell's survey also indicates that many languages require syllabic nasals to be homorganic in place to a following consonant: 21 of the 67 languages in his survey with syllabic nasals fit this profile. Furthermore, bilabials are more likely to be syllabic than alveolars or velars. In the 22 languages in his survey with syllabic nasals at a single place of articulation, the nasal is bilabial in 12 languages, while in five languages each, it is alveolar or velar. In 16 of the 17 languages with syllabic nasals at two places of articulation, one of the places is bilabial. The bias in favor of bilabial syllabic nasals is noteworthy since alveolar nasals are the most common nasal overall (Chapter 3).

Bell (1978) suggests various possible historical explanations for the distribution of syllabic nasals. One possibility is that a process of vowel deletion might target a single morpheme or a small set of morphemes (perhaps highly frequent ones; see

Chapter 2). If only certain nasals occur in the morphemes undergoing syncope, the result will be an impoverished inventory of syllabic nasals relative to nasals in non-syllabic contexts. Bell finds that the most likely type of nasal + vowel sequence to undergo syncope of the vowel and consequent syllabification of the nasal as a nucleus is /mu/, an observation that helps to explain the bias in favor of bilabial syllabic nasals. Another factor that likely contributes to the increased propensity of bilabial nasals to serve as syllable nuclei relates to their characteristically long duration, which is attributed to the large mass of the lips and their consequent relatively slow gestural velocity. The greater duration of bilabials makes them less susceptible to deletion or assimilation and also makes them inherently better suited to function as syllable peaks (see Chapter 5 for discussion of how durational asymmetries governed by place of articulation predict consonant cluster simplification patterns).

4.4 Representations of the syllable

The literature on syllable structure contains several different models of the syllable (see Bosch 2011 for an overview of representations of syllable structure). The differences between theories of the syllable become more salient as the complexity of the syllable structures that they seek to model grows. Thus, it is clear that any adequate theory of the syllable must be able to represent CV syllables, which are found in all languages of the world and are the only licit syllables in many languages. The preferred status of CV syllables has, in fact, been deployed as an important piece of evidence in favor of the theory of Government Phonology, which treats all syllables as CV and allows for the possibility of empty phonetically null nuclei separating adjacent consonants, e.g. in closed syllables or complex onsets (e.g. Lowenstamm 1996, Scheer 2004, Scheer and Szigetvári 2005). The notion that CV is the most fundamental syllable is also embodied in other theories of the syllable through the use of the term ‘core’ syllable to refer to CV (see, for example, the discussion of Tashlhiyt in Chapter 1).

Theories diverge as more elaborate syllable structures are encountered. There are various types of evidence that have been brought to bear on theories of syllable structure, including phoneme co-occurrence restrictions, sonority sequencing constraints, epenthesis and deletion, stress, poetry, native speaker intuitions, language games, and psycholinguistic experiments. I focus here on two of the more problematic issues in syllable theory and how they have been informed by the typology. One of the central areas of contention is the hypothesis that the nucleus and the coda form a constituent, termed the rime (or rhyme), to the exclusion of the onset. Another source of disagreement concerns the treatment of clusters in syllable margins, especially clusters that involve sonority reversals of the type discussed in section 4.2.4, e.g. fricative + stop onset clusters and stop + fricative coda clusters.

4.4.1 *The syllable rime as a constituent*

4.4.1.1 Prohibitions against CVVC syllables Looking first at the evidence for the rime as a constituent, complexity of syllable structure in many languages is

considered in aggregate over the nucleus and coda such that there are restrictions against long vowels (or diphthong that patterns as a long vowel) in closed syllables. Restrictions against long vowels in closed syllables may assume different guises. In some languages, e.g. Hausa (8), there is a process of vowel shortening and diphthong simplification targeting phonemic long vowels and diphthongs, respectively, that would otherwise come to stand in a closed syllable (Newman 2000).

(8) Vowel shortening in closed syllables in Hausa (Newman 2000)

kâi	‘head’	kântà	‘his (m) head’
gida:	‘house’	gidanmù	‘our house’
dʒàka:	‘sack’	dʒàkarmù	‘our sack’
ɽâi	‘life’	ɽânsà	‘his life’

In other languages, such as Chickasaw, vowel lengthening (e.g. of stressed vowels) is suppressed in closed syllables (see Chapter 6). In still others, the restriction against CVVC holds at the lexical level but may be violated on the surface, as in Koasati, where apocope creates CVVC syllables.

Restrictions against CVVC rimes are relatively common in languages of the world. Gordon (2006a) identifies 55 languages in his approximately 400-language survey that have both CVC and CVV but lack CVVC. A variant of this pattern found in Finnish (Suomi et al. 2008) involves a prohibition against complex codas after long vowels, i.e. CVVCC is banned but both CVCC and CVVC are licit.

There do not appear to be any languages that allow complex onsets in both open and closed syllables containing a short vowel but not in syllables containing a long vowel, i.e. allow CCV, CCVC but not *CCVV, a distribution that would provide evidence for a constituent comprising the onset and the nucleus to the exclusion of the coda. Rather, limitations on the occurrence of CVVC provide evidence for grouping the nucleus and coda into a constituent, the rime. If one conceptualizes CVC and CVV as both containing two units of timing, one each for a short vowel and coda consonant and two for a long vowel or diphthong, the restriction against CVVC can be characterized as a limit of two timing units in the rime. This is illustrated in Figure 4.16 using the skeletal slot model of Levin (1985).

In moraic theory (Hyman 1985, Hayes 1989a), the rime is not assumed to be a constituent but in most languages only segments after the onset are associated with a mora (see Chapter 6 for more on moraic theory), as shown in Figure 4.17.

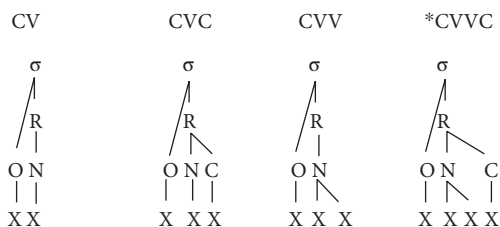


FIGURE 4.16. The constraint against CVVC as an upper limit of two timing slots per rime in a skeletal slot model of the syllable (Levin 1985)

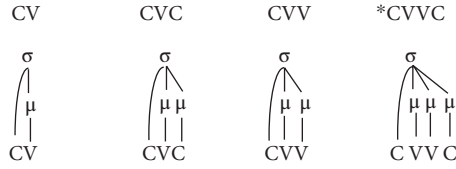


FIGURE 4.17. The constraint against CVVC as an upper limit of two moras per syllable in moraic theory (Hyman 1985, Hayes 1989a, Hayes 1995)

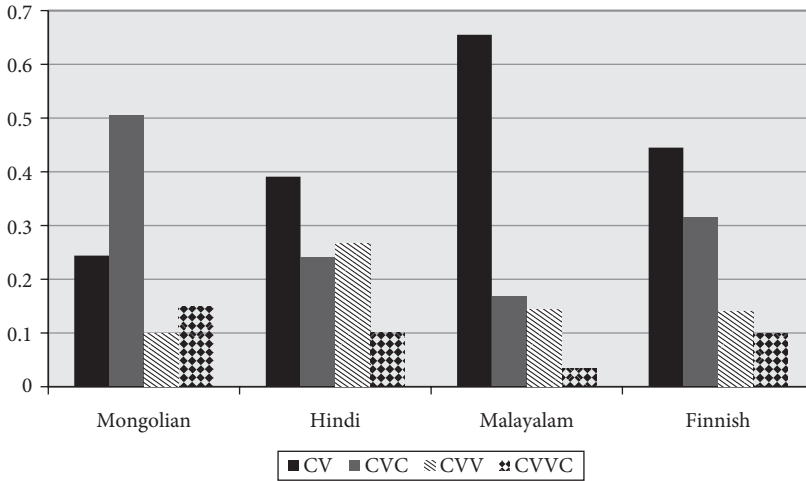


FIGURE 4.18. The proportion of CV, CVC, CVV, and CVVC syllables in corpora from four languages

A constraint against CVVC is captured as a mora population limit of two per syllable within moraic theory (Hayes 1995).

Restrictions against CVVC syllables and the generally rare status of syllables more complex than CVC provide the underpinning for theories of the syllable that impose a hard universal limit of two timing positions in the rime (e.g. Clements and Keyser 1983, Duanmu 2007) and treat other complexity-increasing sounds as appendices or as part of contour segments parallel to affricates.

Despite the predictions of these theories, there are nevertheless many languages that do allow CVVC syllables. A survey of the frequency of different syllable types was conducted based on corpora from four such languages (Finnish, Malayalam, Hindi, and Khalkha Mongolian) in order to test whether the categorical restriction against CVVC is mirrored by a statistical dispreference in languages that allow CVVC. Figure 4.18 plots the token frequency of CV, CVC, CVV, and CVVC syllables in the four languages expressed as proportions relative to each other. Other syllable types, to the extent that they occur at all, are less common than the plotted syllable types in all four languages. The data on Finnish come from summary

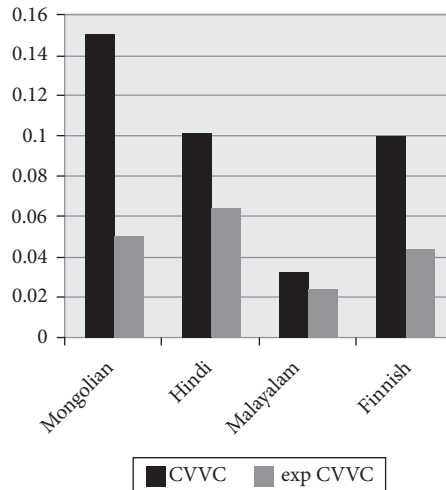


FIGURE 4.19. Observed vs. expected frequency of CVVC syllables in corpora from four languages

results of Häkkinen (1978) appearing in Suomi et al. (2008), the data for Malayalam (Ghatage 1994) and Hindi (Ghatage 1964) are compiled from published sources (a 57,000-syllable corpus for Malayalam and a 50,000-syllable corpus for Hindi), and the data for Khalkha Mongolian are based on a sample of approximately 17,000 syllables from newspapers available on Mongolia Online (<www.mol.mn>).

In terms of absolute frequency, CVVC syllables are clearly in the minority in three of the four languages, Khalkha Mongolian being the exception in possessing slightly more CVVC than CVV tokens. However, if the frequency of CVVC is viewed in terms of the combinatorial frequency of closed syllables and syllables containing a long vowel, it turns out that CVVC is actually *more common* in all four languages than would be expected based on the predicted frequency of combining a coda consonant with a long vowel. Figure 4.19 plots the actual frequency of CVVC relative to its expected frequency calculated as a combination of both CVC and CVV. In Khalkha Mongolian, in fact, CVVC is considerably more commonly attested than expected based on the frequency of closed syllables and long vowels in isolation.

In summary, the language-internal frequency data (at least for the four examined languages based on token frequency counts) do not support a bias against CVVC that is any stronger than the bias against the two marked components, long vowels and coda consonants, comprising CVVC. This differs from the situation observed earlier for CVC, which was shown to be avoided both statistically within languages (section 4.2.1) and also across languages (section 4.2).

4.4.1.2 Co-occurrence restrictions and the rime Another potential source of typological evidence for the rime comes from co-occurrence restrictions holding of the nucleus and coda. English possesses several such restrictions reported by Hammond (1999). For example, the diphthongs /aʊ, ɔɪ/ do not occur before a

coda consonant other than a coronal. Nor does the vowel /ʊ/ occur with a coda nasal. However, there are also many co-occurrence restrictions that hold between the onset and nucleus or between a nucleus and an intervocalic consonant that is arguably the onset to the following syllable. For example, the diphthong /aʊ/ does not occur before an intervocalic non-coronal consonant. Nor do tense vowels or diphthongs occur before intervocalic /s/ + non-coronal clusters. Although it is possible to follow Hammond (1999) in analyzing syllabification in such a way that these vowel–consonant co-occurrence restrictions can be characterized in terms of the rime, this requires certain typologically unusual assumptions about syllabification. For example, expressing the restriction against tense vowels or diphthongs followed by intervocalic /sp/ and /sk/ clusters as a rime-based constraint entails treating /sp/ and /sk/ as coda clusters, e.g. syllabifying *raspy* and *musket* as [ræsp.i] and [mʌsk.ət], respectively. Clements and Keyser (1983: 20–1) also mention other restrictions that hold of vowels and *preceding* consonants that clearly belong to the onset. For example, stop + /w/ clusters are excluded before the vowels /u, ʊ, əʊ, ɜ/ and the sequence /vu/ is limited to the two words *voodoo* and *rendez-vous*. Looking beyond English, there are many languages, e.g. Hawaiian, Mandarin, Shipibo, and Jeh, that ban sequences of /w/ + rounded vowel and many, e.g. Mandarin, Polish, Shipibo, and Jeh, that prohibit the string /ji/ (Maddieson and Precoda 1992). One outstanding issue in assessing unattested (or rarely attested) sequences is whether they are truly viewed as aberrant by native speakers or merely reflect accidental lacunae (paucities).

Rousset (2004) and Vallée et al. (2009) survey co-occurrence restrictions between the nucleus and both the onset and the coda in the ULSID languages. They find a statistical preference (based on observed/expected ratios) for front vowels to occur next to coronal consonants, central vowels to occur adjacent to bilabials, and back vowels to co-occur with velars. Averaged across languages, the mutual attraction of velars and back vowels is the strongest one. Their result mirrors patterns observed in Janson's (1986) text study of token frequency in five languages (Finnish, Latin, Latvian, SeTswana, and Turkish) and also complements results from two studies conducted by Ian Maddieson (Maddieson and Precoda 1992, Maddieson 1992). The first of these (Maddieson and Precoda 1992) is a study of the combinatorial frequency of consonants at three places of articulation (bilabial, dental/alveolar, velar) with the three corner vowels /i, a, u/ in the lexicon of five genetically and geographically diverse languages, three of which (Hawaiian, Rotokas, and Pirahã) have comparatively small segment inventories and two of which (Kadazan, Shipibo) have larger inventories. Based on observed/expected ratios, they find that bilabials show a slight preference for occurring with /a/ (Pirahã being exceptional) and velars display a strong tendency not to occur with /i/ in three of the five languages (Rotokas, Pirahã, and Shipibo). They do not, however, find any reliable preference or dispreference for dental/alveolar stops to occur with any of the three vowels /i, a, u/, a result that runs contrary to Janson (1986), Rousset (2004), and Vallée et al. (2009). In a follow-up study of the lexical frequency of the four sequences /ki, ku, ti, tu/ in 17 languages, Maddieson (1992) finds further support for the bias against velar + /i/ sequences. Duplicating results of the earlier Maddieson and Precoda (1992) study, Maddieson (1992) also

fails to find evidence of a relationship between dental/alveolars and the two high vowels in their likelihood of co-occurrence.

Rousset (2004) and Vallée et al. (2009), which are the only two of the studies discussed in the preceding paragraph that compare co-occurrence biases between the nucleus and onset with those between the nucleus and coda, find an overall stronger effect of the coda than the onset when data are averaged across the languages in their sample. However, the differences based on syllable affiliation are fairly small and their size and direction vary depending on the language and the sequence involved. There is also an interaction between place and position such that the mutual attraction between back vowels and velars is stronger when the velar is an onset but, in the case of the coronal + front vowel and the bilabial + central vowel biases, it is the coda consonant that acts as a better predictor of co-occurrence biases.

Considered as a whole, the statistical evidence for the rime considered above is inconclusive. Although there might be a general tendency for the rime to be a better predictor of both categorical and statistically gradient biases against certain combinations of vowels and consonants, it is clear that co-occurrence constraints between the onset and nucleus are also pervasive cross-linguistically. More compelling evidence for the rime can be adduced from syllable maximality conditions such as the constraint against long vowels in closed syllables. Other potential sources of evidence for the rime from speech errors, word games, and psycholinguistic experiments are also inconclusive (see Bosch 2011 and references therein). Stronger support for the rime comes from a series of phenomena that along with constraints on the maximal size of the rime are typically assumed to fall under the rubric of syllable weight, compensatory lengthening (Chapter 5), including stress (Chapter 6), tone (Chapter 7), and prosodic morphology (Chapter 8).

4.4.2 *Sonority sequencing violations: the syllable appendix and perceptual salience*

A problematic issue in representing the syllable is the treatment of clusters displaying sonority plateaus or reversals where a more peripheral member of a cluster is either equivalent in sonority to or more sonorous than one closer to the nucleus. As we have seen in section 4.2.4, the most prevalent type of sonority reversal cross-linguistically involves sibilant fricatives. We have also seen in section 4.2.6 that metathesis may target sibilant + stop clusters to create sonority reversals (as in Faroese). Furthermore, it will be shown in Chapter 5 that, when epenthesis is triggered by /s/ + stop clusters, it is common for languages to insert the epenthetic vowel to the left of the cluster rather than between members of the cluster, which is the more common epenthesis site for other types of consonant clusters. Finally, it was shown in section 4.3.1 that sibilant fricatives display a greater amenability than other fricatives to serving as syllable nuclei.

It has been widely proposed in the literature that sounds that are involved in sonority reversals, as sibilants commonly are, function as an appendix to the syllable rather than part of the core syllable. Theories diverge in exactly how the appendix is linked (or not linked) to the rest of the syllable or to higher-level prosodic structure (see Vaux and Wolfe 2009 for a review of proposals), but the

fundamental function of the appendix in capturing the exceptional behavior of certain consonants with respect to syllabification and other syllable-based phenomena is similar across models of the syllable that assume appendices.

From a perceptual standpoint, the capacity for sibilants to function as syllable peaks and their ability to be positioned farther from the syllable nucleus than other types of obstruents is explicable in terms of their acoustic properties (see Wright 2004 for an overview of the phonetic basis for syllabification preferences). Because sibilants are characterized by relatively intense noise whose frequency provides place of articulation information, accurate perception of their identity relies less than other consonants on external acoustic cues present during transitions into adjacent sounds (see Chapters 2 and 5 and the next section of this chapter for more on the acoustic cues to consonants).

4.4.3 *Syllable typology and perception*

As Wright (2004) shows, perceptual considerations offer an independently grounded account of many typological biases in syllable structure. Consequently, they have been appealed to by phonologists proposing phonetically informed theories of various phenomena traditionally analyzed in syllable-based terms. We have already discussed representative examples of these phonetically driven approaches to syllable typology: Steriade's (1999) analysis of laryngeal neutralization (Chapter 2) and Côté's (2004) account of final consonants and final clusters (this chapter; see also Fleischhacker's 2001 theory of epenthesis).

Two crucial perceptual factors that appear to play a role in shaping syllable typology are, first, the ability of listeners to identify sounds based on their external and internal cues and, second, the response of the auditory system to the acoustically fluctuating signal characteristic of speech. These factors work synergistically to privilege certain syllable types perceptually while putting other syllable types at an auditory disadvantage.

We first consider the predictions made by considerations of the relative auditory recoverability of sounds in different contexts, drawing heavily on the discussion in Wright (2004). An advantage of CV, the cross-linguistically most basic type of syllable, is that the only consonant occurs in prevocalic position, a context that provides the best external cues to a consonant's identity. Coda consonants, on the other hand, do not benefit from the transitional cues provided by a following vowel, a fact that is in line with the bias against CVC relative to CV. Consonant clusters at syllable margins are even more perceptually disadvantaged since they contain at least one consonant (or more depending on the complexity of the cluster) that is not adjacent to any vowel, which renders them impoverished in terms of the external cues available to aid the listener in establishing their identity. As we have seen in this chapter (section 4.2.6), Côté (2004) appeals to the reduced perceptibility of the consonant sandwiched between adjacent consonants in her account of Hungarian cluster simplification patterns. Among complex onsets, the preference, observed by Greenberg (1965/1978) and quantified in terms of sonority sequencing by Clements (1990), for clusters consisting of an obstruent followed by a liquid or glide is sensible in light of the relatively salient external cues to the preceding obstruent that the liquid or glide generates.

Another perceptual advantage conferred upon CV syllables relates to the virtues of having a speech signal that consists of alternating periods of low intensity, the consonants, and high intensity, the vowels. These modulations maximize the firing rates of auditory nerve fibers (and perceived loudness), which display the greatest response to a sound at its onset before adaptation gradually reduces sensitivity to a sustained stimulus. A period of low intensity, as during an onset consonant, affords the auditory system a chance to recover so that it is maximally responsive to the next phase of relatively high intensity in the speech signal. Auditory recovery offers an explanation for the cross-linguistic preference for lower sonority onsets, which, because of their reduced intensity, enhance the response of the auditory system to the following vowel. Conversely, adaptation effects suggest an account for the restriction against low sonority codas found in many languages. The perceptual prominence of a low sonority coda is especially attenuated because it follows a high intensity vowel that has already triggered auditory adaptation. The greater intensity associated with a high sonority coda, in contrast, helps to offset the adaptation effect. Smith (2002, 2003) appeals to auditory recovery and adaptation in her account of positional markedness (see Chapter 5), as does Gordon (2005a) in his analysis of onset-sensitive stress (see Chapter 6).

Articulatory factors complement perceptual considerations in explaining syllable structure biases. MacNeilage's Frame/Content theory of speech production (MacNeilage 1998) hypothesizes that the (near-)universal preference for CV syllables stems from a fundamental predisposition for sinusoidal mandibular oscillations alternately involving jaw opening and closing, where the open phase corresponds to a vowel and the closed phase to a consonant. Speech gestures, which are produced in large part by movements of articulators within the oral cavity, provide the "content" to the alternating opening and closing movements of the jaw that comprise the "frame" upon which the segmental content is superimposed. MacNeilage suggests that canonical infant babbling, which consists of CV strings, represents a developmental stage at which rhythmic cycles of opening and closing the jaw are present but have not yet been associated with linguistic content other than phonation.

Redford (1999) builds on the hypothesis that the syllable can be defined in terms of cyclic opening and closing gestures of the jaw by examining the relationship between jaw movement and syllable complexity. In a study of Russian rising and falling sonority onset clusters consisting of a sonorant (a lateral) and a voiced plosive (in either order) followed by a vowel, e.g. *gluxa* 'deaf (fem.)' vs. *lgu* 'I lie', she finds evidence of pressure for both types of clusters to be produced within a single jaw opening phase, subject to limitations imposed by the demands of the individual segments comprising the clusters. In the case of the typologically rare onset cluster of falling sonority (e.g. *lgu*), the combination of the sonorant, which requires greater jaw displacement to produce, and the following plosive, which is associated with lesser jaw displacement, creates a conflict with the preference for a single jaw opening gesture moving from the beginning of the syllable to the vowel. This contrasts with the typologically more

common rising sonority cluster (e.g. *gluxa*), which can more easily be accommodated within a single jaw opening phase. In a complementary study of sibilant + plosive onset clusters and plosive + sibilant coda clusters produced by English speakers, Redford finds that clusters of both types are associated with greater jaw displacement and increased gestural velocity despite temporal compression effects that shorten the duration of individual segments. She suggests that the greater displacement and velocity increase the articulatory effort required to produce clusters and hypothesizes that this is the source of their reduced frequency relative to CV syllables. Redford's results thus offer an articulatorily based account of syllable preferences that complements the perceptually driven account offered by Wright (2004), Côté (2004), and others.

4.5 Correlations between syllable complexity and other properties

Maddieson (2007) does not find any correlation, either positive or negative, between the complexity of syllables and the number of vowels in a language. He finds, however, a positive correlation between complexity of syllable structure and the number of consonants such that languages permitting more complex syllable types tend to have a greater number of consonants. Drawing on data from 559 languages, he divides languages into three groups according to the richness of their inventory of syllables and into five groups based on the size of their consonant inventories. The group with the simplest syllable structure allows only CV, the group with syllables of intermediate complexity additionally permits CVC and/or CCV where the second C is a liquid or glide (the least marked sonority profile in onset clusters), and the group with greatest syllable complexity allows one or more syllable types of even greater complexity. Maddieson (2007, 2013b) finds that the languages with only simple syllables have a mean of 17.66 consonants, those with syllables of intermediate complexity have on average 21.30 consonants, and those with greater complexity possess a mean of 25.28 consonants. Table 4.4 shows the relationship between syllable structure complexity

TABLE 4.4. The relationship between the number of consonants and the complexity of syllable structure in a sample of 481 languages

		Syllable structure			Total
		Simple	Moderate	Complex	
Consonants	Small	20	42	16	78
	Mod. small	13	70	17	100
	Average	16	90	55	161
	Mod. large	3	56	37	96
	Large	8	15	23	46
	<i>Total</i>	60	273	148	481

(divided into three categories) and size of the consonant inventory (broken down into five categories) gleaned from intersecting Maddieson's WALS chapters on consonant inventories and syllable structure using the WALS Interactive Reference Tool (<<http://www.eva.mpg.de/lingua/research/tool.php>>).

The table shows a general trend for an increase in syllable structure complexity to be accompanied by an expansion in the size of the consonant inventory and vice versa. Thus, 49 of the 60 (81.7%) languages with simple (CV) syllable structure have from small to average size consonant inventories (≤ 25 consonants) and 115 of the 148 (77.7%) languages with complex syllable structures have consonant inventories in the average to large bins (>25 consonants). The majority of the languages (216 of 273; 79.1%) tolerating moderately complex syllables have consonant inventories that range from moderately small to moderately large (15–33 consonants). Maddieson (2011) shows that a similar relationship holds between consonant inventory size and syllable structure complexity using a more finely grained hierarchy of syllable complexity in which complexity is computed as the sum of the maximal complexity of the nucleus (a value of 1 for monophthongs and 2 for diphthongs), the onset (0 for CV, 1 for CCV, 2 for CCCV, and 3 for CCCC) and the coda (0 for CVC, 1 for CVCC, 2 for CVCCC, and 3 for CVCCCC).

The relationship between consonant inventory size and syllable structure is examined in Figure 4.20 for the WALS 100-language sample. The data in the figure is divided into six blocks (the dark bars at the bottom of the graph)

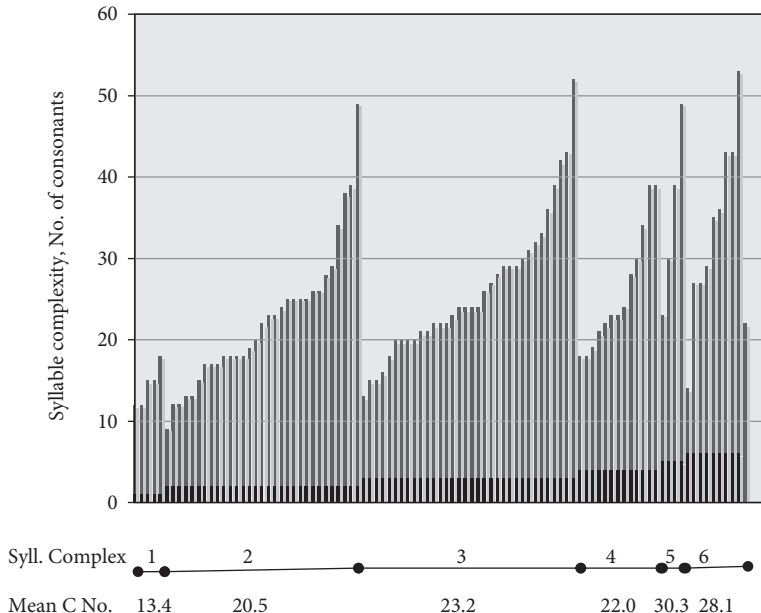


FIGURE 4.20. The relationship between complexity of syllable margins and the number of consonant phonemes in the 100-language WALS sample

according to aggregated complexity of the syllable margins. At one extreme, the value of one (the leftmost bin) corresponds to languages that allow only CV syllables. At the other end of the spectrum (the rightmost bin) are those with an aggregate complexity of six reflecting the possibility of triconsonantal clusters in both the onset and the coda. Within each of the six blocks, languages are sorted (from lowest to highest) according to the number of consonant phonemes (the light bars) they possess. Means for languages possessing different degrees of syllable complexity appear under the corresponding regions in the graph.

There is considerable overlap in the range of consonant inventory sizes between languages with differing degrees of syllable complexity. Nevertheless, consistent with Maddieson's (2007, 2011, 2013b) surveys, there is a general trend for increased complexity in the syllable margin to be associated with larger numbers of consonants, though not all stepwise increases in complexity are matched by a corresponding increase in number of consonants. It should be noted that the link between syllabic margin complexity and consonant inventory is stronger if the outlier case of Seneca (a margin complexity value of six but only eight consonants) is excluded. Separate comparisons for the onset and coda indicate the same link between consonant inventory size and increased complexity for both margins. Languages with only simple onsets have a mean of 20.4 consonants, those with two consonant onsets have an average of 22.6 consonants, and those with three consonant onsets average 28.8 consonants. Languages with no codas have a mean of 17.1 consonants, those with simple codas 21.8 consonants, those with two consonant codas 22.6, and those with three consonant codas 28.9 consonants.

It is unclear if the general trend for increased syllable complexity to be associated with expanded consonant inventories is an artifact of genetic or areal biases, though its emergence in different surveys suggests that it might reflect a genuine design feature of phonologies. The exploration of correlations, both positive and negative, between phonological properties belongs to a more general and burgeoning research program searching for the source of typological biases in various factors ranging from the purely linguistic to those grounded in other diverse considerations such as climate, population density, and human migration patterns (see Maddieson 2011 for an overview).

4.6 Summary

The syllable has played an important role in phonological theory in describing cross-linguistic patterns in the ordering of sounds. Languages differ considerably in the types of syllables that they allow but certain implicational relationships characterize the range of variation in syllable structure. The most basic syllable type found in all languages consists of a consonant followed by a vowel (CV), with certain languages also allowing for additional more complex syllable types such as those lacking an onset consonant and/or those containing a complex onset and/or one or more coda consonants. Languages also vary in the sonority requirements they impose on syllabic sounds, with tolerance of less sonorous sounds as nuclei implying the existence of higher sonority sounds as syllable peaks. Even those

languages that allow more elaborate syllable structures show a statistical bias in favor of simpler syllable types, barring some independent restrictions that would privilege more complex syllables, e.g. a word-minimality constraint in a language that has predominantly monosyllabic words favors CVC over CV.

Syllabification is also sensitive to sonority. The ideal sonority profile of a syllable consists of a minimally sonorous onset followed by a steep increase in sonority for the nucleus and then a relatively small decrease in sonority moving to the coda, e.g. *pam* is preferable to *map*, *pap*, or *mam*. Languages vary in the stringency of their sonority requirements governing syllabification and consonant sequences spanning a syllable boundary.

Restrictions on syllable structure trigger various segmental alternations, including epenthesis, deletion, fortition, and metathesis, though not all cases of segmental alternations are driven by syllabification constraints. An ongoing debate in phonological theory concerns the extent to which syllabification preferences are explicable in terms of phonetic pressures rooted in articulatory and/or perceptual biases. There is also disagreement about the representations best suited for capturing typological variation in syllable structure; two salient areas of contention in syllable theory involve the syllable rime and appendices. Finally, syllable structure co-varies with certain phonological properties; one interesting (but thus far unexplained) trend is for more complex syllable margins to be associated with larger consonant inventories.

5

Segmental processes

The typology of segmental phonology covers a broad range of phenomena that can be classified along various dimensions. In this chapter, a division into three coarse categories will be adopted based on the level at which the relevant phenomena operate:

- alternations and constraints on the *featural* properties of sounds induced either by adjacent or nearby sounds (assimilation and dissimilation) or by position (fortition and lenition)
- changes in the *number* of sounds (deletion, insertion)
- alternations in the *ordering* of adjacent or nearby sounds (metathesis)

The first set of phenomena, those that operate at the level of features, may be manifested either as active processes creating allophonic alternations or as static constraints on the occurrence of certain sounds in particular environments. This group of patterns is quite large and can be further divided according to whether they are conditioned by prosodic position (e.g. a certain position in the syllable or word) or by other sounds (in the vicinity or at a distance). The second group of patterns is characterized by paradigmatic alternations involving loss or insertion of an entire sound. The third and final class of phenomena, which is considerably less common than the first two, involves changes in the order of sounds.

Most, but not all, segment-level phonology is local in the sense that the sound undergoing an alternation or subject to a restriction is triggered by an immediately adjacent context, whether another sound or a prosodic context. Most phenomena affecting segments are amenable to explanations appealing to factors shown in earlier chapters to play an important role in shaping phonological systems, e.g. the articulatory goal of minimizing effort and the auditory goal of enhancing perceptual salience.

5.1 Assimilation

Assimilation involves a sound becoming more like a nearby sound with respect to one or more properties. Assimilation is typically motivated by considerations of articulatory ease, although directionality asymmetries in assimilatory patterns appear to reflect perceptual considerations. Sharing one or more articulatory properties minimizes transitions required of the speech articulators. For example, assimilating the place of a nasal to that of a following oral stop allows the same

constriction to be maintained for both consonants. Assimilation may apply between consonants, between vowels, or between a consonant and a vowel.

Both static and active assimilatory phenomena are found in all languages. One difficulty in assessing the typological frequency of assimilation is that many types of assimilation are so natural that they potentially escape the notice of the researcher describing the phonology of a language. For example, languages like Japanese that require nasals to agree in place with a following plosive may be more common than those that permit heterorganic nasal plus plosive clusters, although this restriction may be glossed over in a phonological overview of a language.

There are many types of assimilatory processes that can be characterized along several dimensions: whether consonants or vowels serve as triggers or targets of assimilation, the features that assimilate, the directionality of assimilation, and the distance between the target and the trigger of assimilation. The last of these parameters refers to the fundamental distinction between local assimilation, in which the target and trigger of assimilation are adjacent, and long-distance assimilation, in which one or more sounds separate the target and trigger. Long-distance assimilation is typically referred to as “harmony” and has been the subject of intensive debate due to the challenges it presents for phonological theories designed primarily to handle local phenomena. Harmony will be discussed later in section 5.1.6 since it is typologically less common than local assimilation and displays different characteristics.

5.1.1 Consonant–consonant assimilation

We first explore consonant-to-consonant assimilation since it encompasses a richer range of subtypes than consonant–vowel assimilation. Among cases of consonant–consonant assimilation, there is a clear typological bias in favor of regressive assimilation, in which one or more features spread backward from one sound to a previous sound, over progressive assimilation entailing the forward spreading of a feature (see section 5.1.4 for possible explanations for this directional asymmetry). Regressive assimilation of the place features of a stop onto a preceding nasal is exemplified in (1) by the alternations in the 1st person singular possessive prefix /am-/ in Chickasaw (Munro and Willmond 1994).

(1) Regressive nasal place assimilation in Chickasaw

iti	‘mouth’	am-iti	‘my mouth’
okla	‘town’	am-okla	‘my town’
paska	‘bread’	am-paska	‘my bread’
pinti?	‘mouse’	am-pinti?	‘my mouse’
tali?	‘rock’	an-tali?	‘my rock’
tanʃi?	‘corn’	an-tanʃi?	‘my corn’
koni	‘skunk’	aŋ-koni	‘my skunk’
kowi?	‘cat’	aŋ-kowi?	‘my cat’

Progressive assimilation is illustrated in (2) by the alternations in the Finnish past participle suffix /-nut/, which assimilates completely to a preceding oral continuant (/l/, /r/, or /s/).

(2) Progressive nasal assimilation in Finnish

olen rakasta-nut	'I have loved'
olen osta-nut	'I have bought'
olen puhu-nut	'I have spoken'
olen pur-rut	'I have bitten'
olen sur-rut	'I have mourned'
olen nous-sut	'I have gotten up'
olen tul-lut	'I have come'
olen kuul-lut	'I have heard'

Laryngeal features very commonly engage in assimilation. For example, obstruents in the ergative prefixes in Kabardian assume the voicing feature of a following consonant (Abitov et al. 1957, Colarusso 1992, 2006). This process is bidirectional, turning both voiceless obstruents, e.g. /s/ of the first person singular ergative prefix, to voiced ones and voiced obstruents, e.g. /d/ of the first person plural ergative prefix, to voiceless ones.

(3) Regressive voicing assimilation in Kabardian obstruents

s-owfç	'I eat it (habitual)'	d-owfç	'We eat it (habitual)'
z-das	'I sewed it'	d-das	'We sewed it'
z-bʒas	'I counted it'	d-bʒas	'We counted it'
s-ʎay ^w as	'I saw it'	t-ʎay ^w as	'We saw it'

Another feature that may spread between consonants is nasality. Consonant-to-consonant nasal assimilation is found in Korean, in which a plosive assimilates to a following nasal, e.g. /kwuk-mul/ 'soup-water' → *kwuŋmul* 'broth', /pat-nunta/ 'receive-ing' → *pannunta* 'is receiving', /pɛp-man/ 'law-net' → *pɛmman* 'the reaches of the law' (Lee and Ramsey 2000: 70).

Changes from a continuant to a stop adjacent to a nasal may be viewed as assimilation of the feature [continuant]: the [-continuant] feature of the nasal spreads onto the [+continuant] fricative yielding a [-continuant] plosive. A process of "post-nasal hardening" in Kikuyu (Clements 1985) illustrated in (4) provides an example of assimilation in continuancy.

(4) Progressive continuancy assimilation in Kikuyu (Clements 1985: 244)

<i>Imperative</i>	<i>1st sg. Imperfect</i>	<i>Stem (Gloss)</i>
βur-a	mbureete	'lop off'
reh-a	ndeheete	'pay'
ɣor-a	ŋgoreete	'buy'

Of the features used to describe consonants, one that appears not to participate in assimilation is [sonorant] (McCarthy 1988). For example, there do not appear to be any languages in which all and only the sonorant consonants spread their

[sonorant] feature to a preceding consonant, e.g. /patma/ → *panma*, /patla/ → *palla* but /patsa/ → *patsa*, /papka/ → *papka*

There are also many cases of total assimilation in which all features assimilate, the result being a geminate consonant, e.g. the Finnish progressive assimilation data in (2). A commonly cited case of complete assimilation that involves regressive spreading is found in Arabic, in which the consonant in the definite article prefix assimilates to a following root-initial coronal, e.g. in Cairene Arabic, /il-turki/ → *it-turki* ‘the Turk’, /il-sitt/ → *is-sitt* ‘the woman’, /il-nas^s/ → *in-nas^s* ‘the text’, /il-fams/ → *if-fams* ‘the sun’ (Watson 2007: 217).

5.1.2 Consonant–vowel assimilation

Turning now to assimilation involving consonants and vowels, many of the types of features that are involved in consonant–consonant assimilation also are active in consonant–vowel assimilation. Consonants often induce place assimilation in neighboring vowels. For example, uvulars trigger lowering of high vowels in Central Alaskan Yup’ik (Miyaoaka 2012: 44): *amik* ‘door’ vs. *ameq* ‘skin’, *ukuk* ‘these (dual)’ vs. *oqoq* ‘oil’. In Hupa (Golla 1970), uvulars trigger backing of vowels: *nma:ʔ* ‘your eye’ vs. *na:q* ‘gravel’. Laryngeal features may also spread from a consonant to a vowel. The common process of vowel devoicing, e.g. in Japanese (Han 1961, Beckman 1982, Tsuchida 1994) and Korean (Jun and Beckman 1993, 1994, Jun et al. 1997, 1998), adjacent to voiceless consonants (see Gordon 1998 for a typological overview of vowel devoicing) represents a type of laryngeal assimilation.

Lip rounding is another feature that often propagates from consonants to vowels. For example, in Hupa, the high front vowel /i/ surfaces as [u] before labialized consonants, e.g. /ʔitʃ^lɪm/ → ʔitʃ^luɪm ‘sand’, /t^ha:kʃ^lɪw/ → t^ha:kʃ^luw ‘sweathouse’, /ʃ^lɪtʃ^{wh}ɪw/ → ʃ^lɪtʃ^{wh}uw ‘he is crying’ (Golla 1970, Gordon 1996). Consonants often trigger nasalization in adjacent vowels, e.g. in English words like *m[æ̃]n*, *p[ɛ̃]n*, *r[ũ]m*.

There appears to be a cross-linguistic bias in favor of regressive over progressive spreading of features from consonants to vowels, at least when the source of the feature is a secondary articulation on the consonant. Thus, in Oowekyala (Howe 2002), labialized consonants trigger rounding in a preceding vowel but not in a following vowel. Similarly, in Kabardian, the rounding of vowels triggered by labialized consonants is stronger when the consonant follows than when it precedes the vowel.

Interestingly, most cases of assimilation characterized by spreading of features between vowels and consonants are reported to involve vowels assimilating to consonants rather than vice versa (Ní Chiosáin and Padgett 1993, Padgett 2011). This difference is plausibly related to the relatively small and continuous nature of the vowel space, which renders small articulatory differences induced by surrounding consonants more perceptible than the corresponding effects of vowels on consonants. Those that contradict this pattern typically involve a consonant adopting a *secondary* articulation such as labialization, as in Nupe (Hyman 1970), Oowekyala (Howe 2002), and Hupa (Golla 1970, Gordon 1996) or palatalization,

as in Nupe (Hyman 1970) and Russian (see examples in (5)), rather than a primary articulation, i.e. /ku/ → *k^wu* not *pu*, /ki/ → *kⁱi* not *ti* (Padgett 2011).

(5) Palatalization of consonants in Russian (from Padgett 2011)

Nom. sg.	Dim. (nom.sg.)	Loc.sg.	
stol	stol ^j ik	stol ^j e	'table'
dom	dom ^j ik	dom ^j e	'house'
šar	šar ^j ik	šar ^j e	'ball'
zont	zont ^j ik	zont ^j e	'umbrella'

A systematic exception to the generalization that consonants typically assimilate secondary rather than primary features from adjacent vowels is provided by palatalization, which in many languages involves a shift in the location of the primary constriction. For example, in Slovak (Rubach 1993), the velar obstruents /k, g, x, ɣ/ surface as [tʃ, dʒ, ʃ, ʒ] before the front vocoids /j, i, e, æ/ (6).

(6) Palatalization of consonants in Slovak (from Padgett 2011)

Nom. sg.	Dim. (nom.sg.)	Loc.sg.	
vnuč	'grandson'	vnuč ^j ik	diminutive
strach	'fright'	strach ^j it ^j	'to sound'
bože	'god'	bože	vocative

Another type of process that affects consonants adjacent to a vowel, particularly a preceding vowel, that may be viewed as assimilation is lenition, which often involves voicing or spirantization of an obstruent after a vowel, or in many cases, a liquid as well. Since lenition is often subject to additional prosodic restrictions on its application, such as stress or the presence of a two-sided context, it will be considered in section 5.4 as a special type of assimilation.

5.1.3 Typological frequency of assimilation patterns

In order to assess the relative frequency of assimilatory changes on a cross-linguistic basis, a survey was conducted of assimilation processes described in the 100-language WALS sample. The results of this survey should be regarded with caution, since the absence of a particular assimilatory pattern from a description does not necessarily mean that the pattern does not exist. It might merely have been subtle enough to escape the notice of the author(s) or might have been deemed by the author(s) to be insufficiently important to warrant space in the description. Indeed, assimilation is almost certainly a universal phenomenon on a phonetic level: all sounds have slightly different allophones occurring in different contexts. However, despite the underestimation factor inevitably present in a large-scale survey of assimilation, distributional asymmetries in the relative frequency of different types of assimilation are of interest since they likely reflect differences in at least phonetic magnitude if not categorical frequency of occurrence.

Bearing the limitations of the survey in mind, we now consider the results. In the 100-language WALS sample, only three types of assimilation account for over two-thirds of the 112 assimilatory processes identified in the consulted sources. The first two classes of assimilation involve place features. The assimilation of a nasal to the place of a following consonant is described for 27 languages, while the palatalization of a consonant by an adjacent vowel is mentioned for 25 languages.

Among the consonants undergoing place assimilation to an adjacent consonant, after nasals there was a sharp drop-off in likelihood of assimilation with stops being targeted for place assimilation in four languages, followed by continuants in two cases. In all but one of the cases of consonant-to-consonant place assimilation (one targeting stops), the direction of assimilation was regressive.

After place features, the next most common type of feature to be engaged in consonant-to-consonant assimilation was voicing in 14 languages. In nine of the 14 cases, the direction of assimilation was regressive and three of the five instances of progressive voicing assimilation involved postnasal voicing of an obstruent. A single case of manner assimilation, involving hardening of /l/ to a stop after a nasal in Maung (Capell and Hinch 1970), was identified.

Total assimilation was also relatively rare, described for only 11 languages. Five of these cases involved nasals (of which three were, interestingly, progressive), four involved more than one manner of articulation, and one each affected glottal stop and laterals.

Among the cases of cross-category (i.e. consonant-to-vowel and vowel-to-consonant) assimilation, palatalization (25 instances) of a consonant, either involving backing of a dental/alveolar or fronting of a velar, far outnumbered its closest competitors. Voicing assimilation affecting a consonant in a vocalic context, either intervocalically or adjacent to a vowel, comprised only nine cases (see section 5.4.1 on lenition for more on voicing in vocalic contexts) and labialization of a consonant by a neighboring vowel amounted to only six cases. The source of the large numerical discrepancy between palatalization and labialization in the consulted descriptions is plausibly related to phonetic factors. Coarticulatory effects involving lip rounding are characteristically less intrusive because rounding is executed by a different articulator than the tongue, which plays a role in conveying most primary place contrasts. In contrast, palatalization affects the tongue and thus has greater potential to induce shifts in the primary constriction. In support of this explanation, virtually all of the cases of palatalization evident in the survey involve a shift in the primary constriction of a consonant (as in the Slovak case discussed earlier). In fact, palatalization processes involving superimposition of a secondary gesture are likely underreported in language descriptions for the same reason that labialization is scarcely represented in the survey: a relative lack of perceptual salience associated with secondary articulations.

Cases of cross-category assimilation in which a consonant acted as a trigger on vowels are less widely described (ten cases were discovered), although, as suggested earlier, such cases are in all likelihood underrepresented in the survey, since vowels in all languages have different realizations depending on their consonantal context, e.g. backer allophones adjacent to dorsals, fronter allophones in coronal contexts, etc.

5.1.4 Implicational scales of assimilation: the phonetic grounding

The typological preference for regressive over progressive consonant assimilation finds an explanation in terms of auditory factors similar to those claimed in Chapter 4 to be relevant in explaining certain syllabification biases. Much of the information about the identity of consonants, particularly in the case of stops and nasals, resides in the transition from the consonant into adjacent vowels (see Wright 2004 for an overview). Especially valuable are the formant transitions from the consonant into a *following* vowel. Given the perceptual primacy of the formant transitions coming out of a consonant into a following vowel, it follows that the second consonant in a cluster, the one benefiting from those transitions, would be more resistant to assimilation than the first consonant, which lacks those transitions. The bias toward regressive assimilation is observed for most assimilating features (see, for example, Beckman 1998/1999 and Steriade 1999 on laryngeal assimilation and Jun 1995, 1996, 2004 on place assimilation). It is also evident in the statistical dominance of regressive assimilation in the WALS 100-language sample.

Because certain consonants rely more than others on transitions from adjacent vowels to establish their identity, it is not surprising that certain clusters are more vulnerable to assimilation than others. Jun (1995, 1996, 2004) explores the impact of these asymmetries on the typology of place assimilation and finds certain implicational scales governing the trigger and target of place assimilation.

First, Jun finds that different manners of articulation show different degrees of susceptibility to place assimilation. He finds that nasals are most likely to be targeted for assimilation followed by plosives. Least likely to assimilate are continuants. Thus, some languages (e.g. Diola Fogny, Lithuanian) assimilate only nasals, while in others (e.g. Korean, Malay, Thai) both nasals and stops undergo assimilation. The greater likelihood of nasals to assimilate relative to other consonants follows from two facts: first, they are poorly discriminated on the basis of their internal distribution of energy and, second, because the nasal cavity introduces anti-formants that diminish the energy of the adjacent vowel in key frequency ranges contributing to the perceptibility of the nasal. At the other extreme, continuants (fricatives, laterals, rhotics, glides), are most robust because they have strong internal cues to their identity, noise in the case of fricatives and internal formant structure in the case of sonorant continuants.

Figures 5.1 and 5.2 illustrate the relative phonetic robustness of place contrasts in four types of postvocalic consonants varying in their susceptibility to assimilation. Figure 5.1 depicts from left to right the vowel + nasal sequences /am/, /an/ and the vowel + plosive sequences /ap/, /at/, while Figure 5.2 shows from left to right the vowel + voiced continuant strings /al/, /aɣ^w/ followed by the vowel + voiceless continuant sequences /as/, and /ax^w/.

The difference between consonants in the relative robustness of the cues to their identity is evident in the figures. Neither the pair of nasals nor the pair of stops are well differentiated from each other on the basis of their internal cues, but rather rely for their identification on the formant transitions from the preceding vowel, transitions whose perceptibility is adversely affected by the introduction of a nasal cavity. On the other hand, the two voiced continuants are distinguished well by

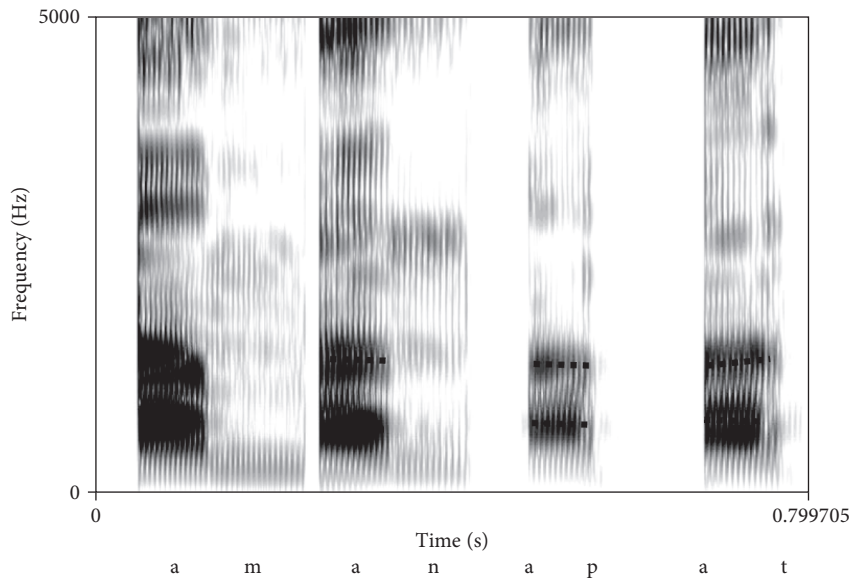


FIGURE 5.1. Two vowel + nasal pairs differing in the place of the nasal (on left) and two vowel + plosive pairs differing in the place of the plosive (on right). Vowel formants are indicated by dashed lines.

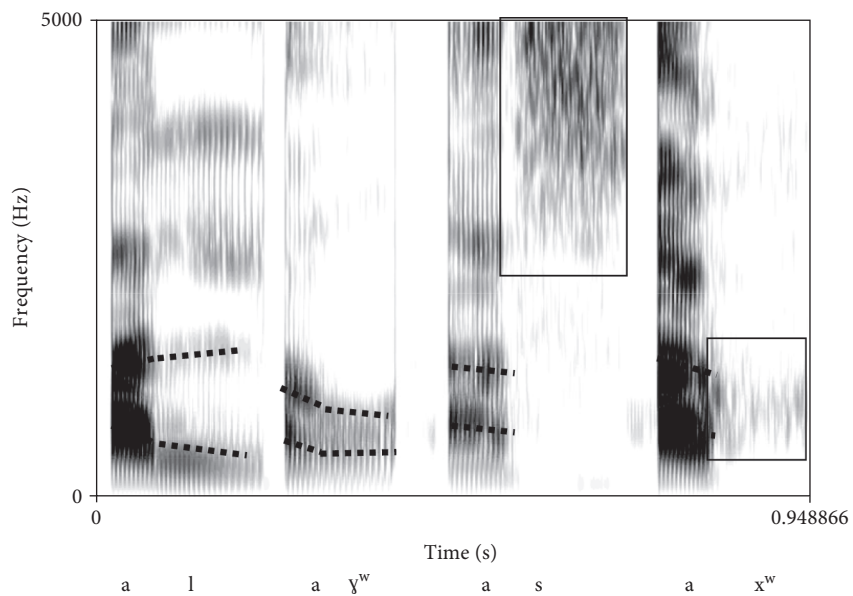


FIGURE 5.2. Two vowel + voiced continuant pairs differing in the place of the continuant (on left) and two vowel + voiceless continuant pairs differing in the place of the continuant (on right). Formants are indicated by dashed lines and noise by boxes.

their internal cues, in particular, their formant structure. Similarly, in addition to differing in their formant transitions, the two voiceless fricatives distribute their noise differently throughout the spectrum. The predominant locus of energy for the /s/ is thus much higher in frequency than the noise for /ax^w/.

The implicational scale of regressive assimilation targets predictable from the acoustic differences in perceptual robustness is shown in (7). It is consistent with the cross-linguistic prevalence of nasal assimilation, on the one hand, and the extreme rarity of continuants undergoing assimilation (a single case), on the other hand, in the WALS sample (see section 5.1.3).

- (7) Manner hierarchy of consonants targeted by assimilation (Jun 1995, 1996, 2004)



Jun also finds implicational relationships governing the likelihood of assimilation as a function of place. Most saliently, the occurrence of assimilation of non-coronal consonants implies the existence of coronal assimilation. This distinction is predictable from the relative velocity of the articulators involved in the production of consonants at different places of articulation, which leads to differences in the degree of overlap with adjacent consonants (cf. the discussion of syllabic nasals in Chapter 4). A smaller articulator like the tongue blade, which is responsible for producing coronal consonants, executes faster gestures that are more prone to be overlapped by neighboring sounds than gestures associated with larger articulators (such as the tongue dorsum or the lips). Many languages thus assimilate only coronals and not velars or labials. For example, assimilation of a pre-consonantal coronal is common in casual speech in English, e.g. *right*[k] *call* for *right call*, *right*[p] *pillow* for *right pillow*, but it is rarer for a labial or velar to assimilate, e.g. **to*[k] *call* for *top call*, **so*[p] *pillow* for *sock pillow*. Korean (Jun 1996, 2011) provides evidence for a further distinction between labials and velars in likelihood of assimilation: both coronals and labials, but not velars, optionally assimilate in casual speech to a following stop. The implicational hierarchy of assimilation targets as a function of place is summarized in (8), where the ranking of labials and velars relative to each other is based on more limited evidence.

- (8) Place hierarchy of consonants targeted by assimilation (Jun 1995, 1996, 2004)



The place hierarchy proposed by Jun (1995, 1996, 2004) is largely though not completely supported by results of the 100-language WALS sample. Of the 27 languages described as having nasal assimilation in the survey, there are ten cases of nasal assimilation applying asymmetrically to nasals at one place of articulation alone. Of these ten, eight involve a coronal nasal being the only target. Nevertheless, there are two languages in which a non-coronal nasal appears to

asymmetrically undergo nasalization without coronals being affected: a velar nasal in Kayardild (Evans 1995) and a bilabial nasal in Maybrat (Dol 2007). It is unclear if there are language-specific facts that account for this typologically exceptional behavior.

Articulator velocity also manifests itself, albeit more rarely, in asymmetries between different places of articulation in their likelihood of triggering assimilation. Jun observes that in Korean, non-coronal consonants optionally trigger assimilation in a preceding consonant but coronals do not, an asymmetry that follows from the greater gestural overlap between a non-coronal and a preceding consonant. In the WALS survey, there are six cases of nasal assimilation being asymmetrically triggered by certain places; consistent with Korean, in all six of the cases, a coronal fails to trigger assimilation. In four of them, only a velar acts as a trigger, whereas in one, Chalcatongo Mixtec (Macaulay 1996), only a labial induces assimilation in a preceding nasal and in another, Burushaski (Anderson 1997), retroflexes and palatals trigger assimilation.

There are certain conditions that trigger exceptions to the dominance of the second consonant in assimilation. One of these is found in certain languages at stem-suffix boundaries, where the second consonant may undergo assimilation to the first rather than vice versa. As Jun points out (1995, 2004), this pattern follows from a more general typological tendency for stems to resist alternations that otherwise affect affixes.

Another phonologically conditioned type of assimilation that is typologically skewed toward being progressive rather than regressive entails assimilation *between* two coronals. Steriade (2001) shows that the second consonant overwhelmingly tends to assimilate to the first consonant in such clusters. For example, in Sanskrit coronal clusters involving two coronals with the same manner of articulation (fricative + fricative, stop + stop, nasal + nasal) but produced at different places (alveolar + retroflex and retroflex + alveolar), the second consonant assimilates to the first: e.g. /avid^hi/ 'favor' → avid^hi, /ṣaṅna:m/ 'of six' → saṅṅa:m, /jjotiṣsu/ 'in planets' → jjotiṣsu (Steriade 2001: 246). In nasal + obstruent clusters, however, the susceptibility of nasals to assimilation trumps the progressive directionality bias and a nasal assimilates to the following obstruent: /kaṛaṅti/ → kaṛanti, /dʒaṅdʒaṅa/ → dʒaṅdʒaṅa (Steriade 2001: 231).

Steriade (2001) suggests that the acoustic cues to contrasts between retroflex and anterior (dental or alveolar) coronals account for their directionality bias in assimilation. The formant transitions that distinguish anterior coronals from retroflexes differ principally during the transition from the preceding vowel into the closure. Most saliently, the third and fourth formants are lowered going into a retroflex closure. During the retroflex constriction, the tongue tip slides forward reaching a position at the point of release that is virtually identical to that of a dental or alveolar consonant, thereby largely eliminating differences in the formant transitions into a following vowel. Thus, unlike in clusters consisting of consonants differing in major class features (coronal, labial, and dorsal), it is the *first* consonant rather than the second one that is more readily perceptible in a cluster consisting of a dental or alveolar and a retroflex in either order. For this reason, Steriade (2001) reasons, place assimilation tends to be progressive rather than regressive in coronal + coronal clusters.

5.1.5 The phonetic basis for assimilation: synchronic or diachronic

While there is a consensus that articulatory and perceptual factors play a role in explaining assimilation, it is less clear whether these phonetic forces act as historical pressures shaping the phonology or whether they are also part of speakers' linguistic knowledge on a synchronic basis. The former view, espoused, for example, in work by Ohala (1981, 1989, 1993, 1994), Blevins (2004, 2006), assumes that articulatory and perceptual constraints create the conditions that give rise to assimilation as a diachronic process. Under this approach, coarticulation between adjacent sounds renders the two sounds perceptually less distinct from each other, leading to the potential for a phonological reanalysis by the listener according to which the two sounds share the assimilating property. The sound in a perceptually less salient position, e.g. the first consonant in most consonant clusters (or the second consonant in a cluster involving two coronals), would be particularly vulnerable to a reanalysis in which it is assumed to possess the same feature as the sound occurring in a more perceptible context, e.g. the prevocalic consonant (or the postvocalic consonant in coronal clusters). This 'innocent misapprehension' mechanism of historical change is sketched in Figure 5.3 for the phonemic sequence /nk/ reanalyzed by the listener as /ŋk/ in the face of coarticulatory backing of the nasal before the velar stop.

Another view of the role of phonetics, one adopted by, for example, Jun (1995, 1996, 2004) and Steriade (2001), assumes a more teleological approach in which speakers are aware of the perceptual constraints and biases that the listener confronts and shape their phonologies in response to those constraints and biases. In the case of assimilation in consonant clusters, this awareness includes the knowledge that the second consonant is perceptually more salient than the first one in most clusters (except those consisting of two coronals). This knowledge motivates the choice to assimilate the first consonant to the second one (or vice versa in coronal clusters), a case of effort expenditure on the consonant with the greatest perceptual payoff.

The jury is still out on the extent to which the phonetic forces underlying assimilation (and other phonological phenomena) act on a synchronic level or only diachronically. It seems clear, however, from an examination of the typology of sound change (see Blevins 2004, 2006), that considerations of articulatory ease and perceptual distinctness play an important role in conditioning assimilation at least on a historical level.

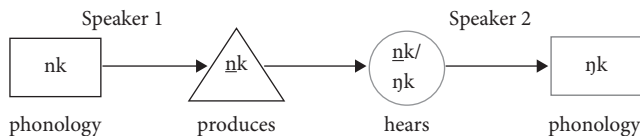


FIGURE 5.3. The 'innocent misapprehension' model of assimilation (à la Ohala and Blevins)

5.1.6 Long-distance assimilation: harmony systems

Assimilation can also be a long-distance process in which the trigger and target are non-contiguous, in which case the assimilatory process is often termed “harmony.” Harmony patterns can affect both vowels and consonants; both subtypes of harmony present challenges to phonological theory due to their non-local nature (see Archangeli and Pulleyblank 2007 and Rose 2011 for general discussion of harmony systems).

5.1.6.1 Vowel harmony A common type of non-local assimilation is vowel harmony. As in the case of local assimilatory phenomena, vowel harmony can manifest itself either as an active alternation or as a static restriction on the shape of morphemes.

There are various types of vowel harmony that differ in the spreading feature (see Gafos and Dye 2011 for an overview of vowel harmony). Front/back (or palatal harmony) involves the spreading of backness (or frontness) features between vowels. For example, vowel suffixes containing a low vowel in Finnish have two allomorphs, one containing the front vowel [æ] and the other the back vowel [ɑ]. The choice of allomorph depends on whether the stem to which it attaches contains front or back vowels, e.g. *kylæ-ssæ* ‘in the village’, *pöly-ssæ* ‘in the dust’ vs. *suo-ssa* ‘in the swamp’, *talo-ssa* ‘in the house’.

Another type of vowel harmony involves the spreading of rounding. For example, the 1st person possessive suffix in Turkish has four allomorphs {-*m*, -*im*, -*ym*, -*um*} differing in the backness and rounding of the vowel. Only high vowels participate in rounding harmony in Turkish, even though all vowels participate in backness harmony. Thus, the dative suffix has only two allomorphs {-*ε*, -*a*}. Turkish palatal and rounding harmony is illustrated in (9).

(9) Turkish palatal and rounding harmony (Gordon 2006b: 421–2)

ip- <i>m</i>	‘my rope’	ip- <i>ε</i>	‘rope (dative)’
kiz- <i>m</i>	‘my girl’	kiz- <i>a</i>	‘girl (dative)’
syt- <i>ym</i>	‘my milk’	syt- <i>ε</i>	‘milk (dative)’
buz- <i>um</i>	‘my ice’	buz- <i>a</i>	‘ice (dative)’

Height harmony is illustrated in (10) for Buchan Scots (Paster 2004), in which an unstressed vowel in the second syllable surfaces as high when the preceding stressed vowel is high and as non-high when the preceding vowel is non-high. In (10), the suffix -*y* has two variants [i] and [e]; the choice between depends on the height of the first vowel.

(10) Buchan Scots height harmony (Paster 2004: 365)

her- <i>e</i>	‘hairy’	snut- <i>i</i>	‘snooty’
mæs- <i>e</i>	‘messy’	ril- <i>i</i>	‘really’
røk- <i>e</i>	‘rocky’	mil- <i>i</i>	‘wheelie’
las- <i>e</i>	‘lassie’	kuθ- <i>i</i>	‘couthy’

Tongue root harmony (ATR harmony) is exemplified in (11) for Yoruba (Archangeli and Pulleyblank 1989), in which mid vowels come in [+ATR] and [-ATR] pairs that do not mix with each other. In (11), the nominalizing prefix has two allomorphs differing in their [ATR] value, where the allomorphy is conditioned by the [ATR] value of the root.

- (11) Yoruba ATR harmony (Archangeli and Pulleyblank 1989: 188)
- | | | | |
|------|--------------------|----|-------------|
| ɔ-dɛ | 'hunter' | dɛ | 'hunt' |
| ɛ-rɔ | 'machine' | rɔ | 'fabricate' |
| è-rò | 'a thought' | rò | 'think' |
| ò-kú | 'corpse of person' | kú | 'die' |

Certain languages have vowel harmony systems that are not neatly characterized in terms of a single dimension. In these “dominant-recessive” harmony systems, found, for example, in Nez Perce (Aoki 1966, 1970) and Chukchi (Bogoras 1922, Skorik 1961, Krause 1980, Kenstowicz 1979, Bobaljik 2009), vowels come in dominant-recessive pairs and vowels within a word must all belong either to the dominant or to the recessive set. In case word formation processes bring dominant and recessive vowels together in the same word, the dominant vowels induce a shift of the recessive vowels to their corresponding dominant vowel. For example, in Chukchi (Bogoras 1922, Skorik 1961, Krause 1980, Kenstowicz 1979, Bobaljik 2009), the dominant vowels /e, o, a/ are paired with the recessive vowels /i, u, e/, respectively, where the vowel /e/ is dominant when paired with /i/ but recessive when paired with /a/. The designative suffix *-(n)u* thus is realized as *-nu* in *milute-nu* ‘rabbit (desig)’ but as *-no* in *wopqa-no* ‘moose (desig)’ (Bobaljik 2009: 2). On the other hand, the root /milute/ ‘rabbit’ in *ya-melota-ma* surfaces with dominant vowels when the dominant vowel comitative circumfix (j)a- . . . -ma is added (p. 2).

A total of 26 vowel harmony systems were identified in the 100-language WALs sample. These could be divided into five groups according to their characteristics plus one additional heterogeneous group of harmony alternations. One group (found in six languages) involves complete matching of vowel features. Another group (consisting of five languages) falls in the class of backness harmony systems, while a third type (also instantiated in five languages) engenders height harmony. A fourth (with three languages) involves rounding harmony, while a fifth type (also found in three languages) falls under the heading of ATR harmony. The remaining three include one dominant-recessive harmony system (Chukchi), one pharyngeal harmony system (Khalkha Mongolian), and one involving a laxness alternation localized to a single vowel phoneme (Imbabura Quechua). It is interesting to note that three of the six languages with harmony alternations involving complete matching rather than harmonizing along a single dimension limit harmony to a small set of morphemes while in a fourth case there are no alternations but rather a static constraint against non-matching vowels.

A common feature of many vowel harmony systems is the existence of “neutral vowels”, which may co-occur with both sets of vowels involved in the harmony system. For example, in Finnish, the neutral vowels are the two non-low front

vowels /i, e/, which may co-occur with either front or back vowels, e.g. *tila* ‘condition, room’ but *silmae* ‘eye’. In these examples, the neutral vowel is followed by a non-neutral vowel. It is also possible for a neutral vowel to appear after a non-neutral vowel, which determines at a distance the choice of suffixal allomorph e.g. *kassi-ssa* ‘in the bag’ vs. *kæde-ssæ* ‘in the hand’.

Neutral vowels are also found in other types of harmony systems. For example, in ATR vowel harmony systems it is common for only a subset of vowels to participate in harmony and for other vowels to co-occur with either [+ATR] or [-ATR] vowels. Thus, in Yoruba (Archangeli and Pulleyblank 1989), the two high vowels /i, u/, both of which are phonetically [+ATR], may co-occur with either [-ATR] or [+ATR] vowels: *ebi* ‘hunger’ vs. *ẹbi* ‘guilt’, *eku* ‘bush rat’ vs. *ẹwù* ‘clothing’ (p. 176). A low vowel in Yoruba can also occur with either [+ATR] or [-ATR] mid vowels to its right (*ate* ‘hat’ vs. *àjẹ* ‘paddle’) but a mid vowel to its left must be [-ATR] (*ẹpà* ‘groundnut’), an asymmetry that follows from the [-ATR] feature of the low vowel and the leftward spreading of [ATR] in Yoruba (see Archangeli and Pulleyblank 1989 for analysis).

The high front vowel /i/ is neutral with respect to rounding harmony in Khalkha Mongolian (Svantesson et al. 2005). The round feature thus propagates rightward over an intervening /i/ to the next vowel: e.g. *piir-ig-e* ‘brush (acc.refl.)’, *poor-ig-o* ‘kidney (acc.refl.)’, *c^haa-ig-a* ‘paper (acc.refl.)’, *хэж-иг-г* ‘food (acc.refl.)’ (p. 50).

In the system of height harmony found in Pasiego Montañes Spanish (Penny 1969, McCarthy 1984), high and mid vowels are restricted from occurring in the same word, a restriction that manifests itself in static constraints on root structure and in active alternations in the quality of root vowels before stressed suffixes, as shown in (12). Low vowels, however, may occur with either high or mid vowels.

- (12) Neutral low vowels in Pasiego Monatañes Spanish height harmony (McCarthy 1984: 295–6)
- | | | | |
|-----------|---------------------|------------|--------------------|
| bindíθir | ‘to bless’ | kolór | ‘color’ |
| lubúkus | ‘young wolves’ | destorθér | ‘to wring’ |
| ʃipúdos | ‘hunchbacks’ | kalór | ‘heat’ |
| abidúl | ‘birch tree’ | xelétʃa | ‘fern’ |
| kumída | ‘lunch’ | belórta | ‘hay-rake’ |
| kuxir-ían | ‘take (3pl. cond.)’ | koxer-émus | ‘take (1pl. fut.)’ |
| | | koxer-án | ‘take (3pl. fut.)’ |

In the dominant–recessive harmony system of Chukchi, epenthetic schwa co-occurs with both dominant and recessive vowels, e.g. *ya-tw-ə-len* ‘he has said’ vs. *yə-nt-ə-lin* ‘he has cut off’, although underlying schwa patterns as a dominant vowel, e.g. /milute/ ‘rabbit’ → *melota-ytə* ‘to the rabbit’ (Bobaljik 2009: 3).

Another common feature of harmony systems is the occurrence of opaque segments that block the propagation of the harmonizing feature. For example, in the height harmony system of Buchan Scots (Paster 2004), a voiced obstruent

occurring either intervocally or after a sonorant causes the following vowel to surface as high even if the preceding vowel is non-high, e.g. *bendi* ‘bendy’, *hezi* ‘hazy’, *dogi* ‘doggie’, *ladi* ‘laddie’ (p. 366). Paster attributes this effect to larynx lowering associated with obstruent voicing, which triggers lowered first formant values characteristic of high vowels.

Similarly, in Turkish, certain consonants, termed “disharmonic” consonants by Clements and Sezer (1982), block the rightward propagation of backness harmony and instead initiate their own harmony span. For example, a non-velarized /l/ following the last vowel of the stem triggers a front vowel suffix even if the vowels in the root are back, e.g. *usul-y* ‘system (acc.sg.)’, *sual-i* ‘question’ (acc.sg.), *kalp-i* ‘heart’ (acc.sg.) vs. *okut-u* ‘school’, *karakot-u* ‘police station’ (acc.sg.) with a velarized /l/ (Clements and Sezer 1982: 241). In Sundanese (Robins 1957, Cohn 1990, 1993), nasalization propagates rightward across vowels, glides, and glottal consonants but is blocked by oral consonants (13).

- (13) Oral consonants as blockers of nasal harmony in Sundanese (Cohn 1993: 55)

<i>pīār</i>	‘seek’
<i>māhāl</i>	‘expensive’
<i>mīhāk</i>	‘take sides’
<i>ṅātur</i>	‘arrange’
<i>mārios</i>	‘examine’
<i>ṅōbah</i>	‘change’

5.1.6.2 Consonant harmony Consonants also engage in long-distance assimilation. Many of the same features that spread between vowels also participate in consonant harmony (see Rose 2011 and Rose and Walker 2011 for overviews of consonant harmony systems). As in the case of vowels, a coarse bifurcation between place and non-place features can be drawn. Laryngeal harmony is found in many languages, including Chaha, a Semitic language of Ethiopia, in which coronal and velar plosives within a root agree with respect to both [constricted glottis] and [voice] features (Rose and Walker 2004). As the forms in (14) show, ejectives co-occur with ejectives, voiceless plosives occur with voiceless plosives, and voiced plosives occur with voiced plosives.

- (14) Laryngeal harmony in Chaha (Rose and Walker 2004: 475)

<i>ji-kətf</i>	‘he hashes (meat)’
<i>ji-kəft</i>	‘he opens’
<i>ji-dəg(i)s</i>	‘he gives a feast’
<i>ji-dərg</i>	‘he hits, fights’
<i>ji-t’ək’ir</i>	‘he hides’
<i>ji-t’əβk’</i>	‘it is tight’

Nasal harmony is illustrated in (15) for the Bantu language Yaka (Hyman 1995). The perfective suffix has two allomorphs, where the nasal variant is conditioned by a nasal in the root, even over one or more intervening voiceless plosives.

- (15) Nasal harmony in Yaka (Hyman 1995: 6, 9)
- | | |
|-----------|-----------------------|
| tsúb-idi | ‘wander’ |
| kúd-idi | ‘to banish (someone)’ |
| kás-idi | ‘to tie up’ |
| tsúm-ini | ‘to sew’ |
| kún-ini | ‘to plant’ |
| mák-ini | ‘to climb’ |
| nútúk-ini | ‘to bow’ |

One type of harmony that consonants display but is not applicable to vowels since they lack the relevant feature is liquid harmony. In Sundanese (Cohn 1992), the infix /-ar-/ surfaces as *-al-* after a root-initial lateral, e.g. *l-al-itik* ‘little (plural)’, *l-al-aga* ‘wide (plural)’ (p. 206) vs. *k-ar-usut* ‘messy (plural)’ (p. 200).

Place features also participate in consonant harmony systems. Long-distance harmony in consonants involves assimilation among members of a single major place class. For example, coronal harmony is instantiated by sibilant harmony systems. Sibilant harmony in Navajo (Sapir and Hoijer 1967, McDonough 2003) is both responsible for the restriction against roots mixing alveolar and palato-alveolar obstruents and also creates alternations between the two types of coronals in certain morphemes such as the 1st singular imperfective prefix, e.g. *jif-y’it* ‘I scratch it’ vs. *jis-dz’is* ‘I drag it’ (McDonough 2003: 50). Dorsal harmony creates alternations between velar and uvular consonants, as in the Austronesian language Truku Seediq (Lee 2009), where /k/ shifts to [q] in the prefix *mək-* before a uvular consonant anywhere in the root, e.g. *məq-ə’qoγan* ‘from Qowgan village’, *məq-ədə’yijaq* ‘from the mountains’ vs. *mək-əbə’səγan* ‘from Bsngan village’, *mək-əγə’silunγ* ‘from the seashore’ (p. 574). Consonant place harmony may also involve spreading of secondary articulations such as labialization, palatalization, velarization, or pharyngealization. For example, in the Turkic language Northwest Karaim (Nevins and Vaux 2004), the first consonant of a root for which palatalization is contrastive spreads its palatalization rightward producing alternations in suffixes, e.g. *suv-dan* ‘water-ablative’ vs. *k^hiun^j-d^jan^j* ‘day-ablative’.

5.1.6.3 Directionality and morphology in harmony Both morphological and directional biases play a role in predicting harmony patterns, although languages vary in terms of which of these two factors is most crucial (see Hyman 2002 for an overview). The role of morphology manifests itself in the tendency for harmonizing features to propagate from the root outward to affixes. Most of the examples we have considered thus far involve spreading of a feature from the first vowel or consonant of the root rightward to the rest of the root and/or to suffixes. This morphological bias holds of both vowel and consonant harmony and is explicable in terms of a more general propensity for roots to preserve their features over affixes, presumably due to the psycholinguistic primacy of roots in lexical access (see Beckman 1998/1999 and Smith 2005 for an overview of this bias and its implications for various phonological properties).

On the other hand, when morphology does not predict harmony patterns, long-distance harmony is overwhelmingly anticipatory, i.e. involves spreading of

features from right to left. We have seen examples of leftward feature spreading in the vowel height harmony system of Pasiego Montañes Spanish, the sibilant consonant harmony of Navajo, and the dorsal harmony of Truku Seediq. However, only in one of these cases, harmony in Pasiego Montañes Spanish, does the feature spread from an affix to a root. In the Navajo and Truku Seediq cases, because the harmonizing feature spreads right to left from a root to a prefix, harmony could either be interpreted as a root-dominance effect or a right-to-left effect. In fact, the cross-linguistic bias toward suffixation over prefixation renders the role of morphology as opposed to directionality underdetermined for many cases of harmony.

In a typological study of consonant harmony, Hansson (2001a, b) suggests that all cases of consonant harmony are either anticipatory or root-controlled (or ambiguously both) and that there are no convincing cases of a consonantal feature spreading from left to right from a prefix to a root. Patterns of this type also appear to be rare among vowel harmony systems, although Hyman (2002) cites an example of left-to-right harmony propagating from a prefix to a stem in Kinande.

5.1.6.4 The phonetic basis for harmony Parallel to local assimilation, harmony also can be explained in terms of coarticulation coupled with reanalysis by the listener. Ohala (1994) suggests that vowel harmony arises from normal vowel-to-vowel coarticulatory effects (Öhman 1966), which listeners at some point mistakenly fail to ascribe to a coarticulation effect. Instead listeners assume that the speaker planned to produce a different vowel than the one intended (but not actually achieved). Listeners then produce this unintended vowel thereby initiating a sound change. This scenario of diachronic change is schematically shown in Figure 5.4 for the phonemic sequence /ypu/ reanalyzed by the listener as /ypy/.

An alternative account of harmony is the more teleologic approach adopted in work by Suomi (1983) on front-back vowel harmony and Kaun (1995, 2004) on rounding harmony. Their work hypothesizes that harmony arises as speakers attempt to bolster the perceptibility of a phonological property by extending its temporal domain. This type of analysis could be assumed to operate either as a historical impetus to a sound change or as a synchronic strategy pursued by current generations of speakers.

5.1.6.5 Harmony as a local vs. long-distance phenomenon An issue lurking in any phonetically driven account of harmony appealing to feature spreading, whether in the guise of a diachronic spur to sound change or as a synchronic

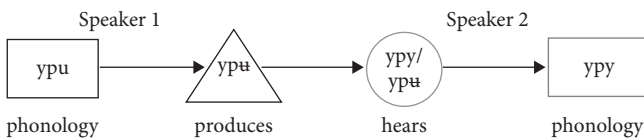


FIGURE 5.4. The diachronic listener-driven analysis of harmony (Ohala 1994)

process actively implemented by speakers to aid the listener, is the extent to which long-distance harmony truly operates over a distance and ignores intervening segments. One might thus ask whether consonants are truly phonetically transparent in vowel harmony systems and, conversely, whether vowels are transparent in consonant harmony systems. A related question is whether neutral vowels are truly equivalent when surrounded by vowels belonging to different harmonic sets.

In an articulatory study of Turkish rounding harmony, Boyce (1990) finds that contraction of the orbicularis oris muscle, which is responsible for executing lip rounding, persists throughout consonants intervening between rounded vowels, a result that is consistent with the view that rounding harmony is a local process with an extended domain that also includes consonants. Building on this result, Gafos (1999) advances the hypothesis that coronal consonant harmony (e.g. sibilant harmony in Navajo) is a local phenomenon that also affects vowels separating the coronal consonants that are most saliently affected by the harmony process. He grounds his hypothesis in the observation that coronal gestures are implemented primarily using the tongue tip with little involvement of the tongue body, the portion of the tongue most critical to the articulation of vowel contrasts. It is thus possible to produce different coronal consonants with a minimal effect on the perceptual characteristics of neighboring vowels.

Recent acoustic and articulatory studies have explored the transparency of segments in harmony processes (see Gordon 2006b and Gafos and Dye 2011 for overviews of phonetic studies of harmony systems). In an acoustic study of neutral vowels in Finnish, Gordon (1999) finds that the neutral vowels /i, e/ have lower second formant values, suggestive of a retracted tongue position, in back vowel contexts than in front vowel contexts. He finds a directionality effect that parallels the left-to-right nature of harmony in Finnish: a neutral vowel is affected by the preceding vowel but not the following vowel, though the effects are consistent in magnitude with low-level coarticulatory effects of the type found in languages without vowel harmony. Beňuš and Gafos (2007) use magnetometry and ultrasound to directly investigate the articulation of neutral vowels of Hungarian. They find evidence for contextual variation in the tongue backness of neutral vowels as a function of whether they occur in front or back vowel contexts. Strikingly, they discover differences between neutral vowels occurring in words differing in whether they require front or back vowel suffixes *even when the suffixes are not present*. For example, *i:v* 'bow', which takes front vowel suffixes, has a fronter vowel than *vi:v* 'fence', which selects for back vowel suffixes. The fact that the difference in backness is present even in the bare unsuffixed form indicates that it is not reducible merely to coarticulatory effects of adjacent vowels. In an acoustic and ultrasound study of the ATR harmony system of Kinande, Gick et al. (2006) find that the low vowel /a/, traditionally regarded as a neutral vowel that co-occurs with both +ATR and -ATR vowels, actually has two distinct allophones depending on the ATR context.

Not all evidence, however, supports the hypothesis that long-distance harmony can be reduced to local assimilation effects operating over an extended domain. In particular, certain types of consonant harmony systems appear to truly operate at a distance passing over intervening vowels. Nevins and Vaux (2004) fail to find

any acoustic difference in vowels as a function of whether they occur between palatalized or non-palatalized consonants in the consonant harmony system of Karaim. Furthermore, in long-distance dorsal harmony systems, local assimilatory lowering rules that target high vowels adjacent to uvulars (see section 5.1.2) apparently fail to affect high vowels between a uvular trigger and a uvular target *unless the vowel is adjacent to a uvular*. For example, in Truku Seediq, the /u/ fails to lower in *qən-rubiəq* ‘being like Rubiq’ (Lee 2009: 575) despite occurring in the span of the dorsal harmony domain bounded by the initial and final uvulars. This contrasts with *məqə'qoyan* ‘from Qowgan village’ (p. 574) in which a uvular triggers lowering in an immediately following high vowel. These data suggest a distinction between the phonetic implementation of long-distance consonant harmony and the implementation of local consonant–vowel assimilation. From an articulatory standpoint, it is plausible that coronal and dorsal harmony differ fundamentally in their effect on adjacent vowels since the tongue dorsum, more so than the tongue blade, plays an important role in executing place contrasts in vowels.

Hansson (2001a, b) and Rose and Walker (2004) propose an alternative account of long-distance consonant harmony grounded in speech planning considerations made explicit in connectionist models of speech processing (e.g. Dell 1986) and discussed earlier in Chapter 3 in the context of Martin’s (2007, 2009) work on phoneme distributions. Hansson (2001a, b) and Rose and Walker (2004) follow work by Frisch (2004) and Frisch et al. (2004) on long-distance dissimilation (see section 5.2.2) in assuming that consonant assimilation reflects a phonologized version of a priming function whereby properties associated with a later segment are prematurely activated in an earlier segment. Support for this account comes from various recurring features of harmony systems that are also observed in speech error data, which provide insight into the nature of the speech planning mechanism. First, consonant harmony systems that are not morphologically controlled are overwhelmingly anticipatory following a pattern also seen in speech errors, whether naturally occurring or experimentally induced. Second, parallel to speech errors, consonant harmony is more likely to involve segments that already share similar features. For example, in Ganda (Katamba and Hyman 1991), voiced stops agree in nasality in CV(V)C roots but only if the stops are homorganic. Furthermore, asymmetries in the directionality of certain types of harmony are mirrored in speech error data. For example, Hansson (2001a, b) observes a palatal bias in the typology of sibilant harmony systems that is also observed in speech error data. While many languages, e.g. Navajo (Sapir and Hoijer 1967, McDonough 2003), symmetrically change both /s/ to [ʃ] and /ʃ/ to [s] in harmony contexts and many others asymmetrically convert /s/ to [ʃ] but not /ʃ/ to [s], Hansson identifies only a single language that appears to asymmetrically shift /ʃ/ to [s] but not /s/ to [ʃ].

5.2 Dissimilation

The antithesis of assimilation, dissimilation, involves the shift of a sound such that it becomes less like an adjacent or nearby sound.

5.2.1 Local dissimilation

First, we consider cases of local dissimilation, which may involve virtually any of the features that participate in assimilation, including place, manner, and laryngeal features. Dissimilation is relatively rare. In the WALS survey, only ten cases of local dissimilation were discovered compared to 112 instances of assimilatory phenomena. Seven of the ten instances of local dissimilation involve a single type of cluster, e.g. /tʰ/ > [nʰ] in Koasati (Kimball 1991), /ʂʂ/ > [tʂ] in Maricopa (Gordon 1986).

One of the three more broadly applicable instances of local dissimilation in the WALS survey is the optional process of manner dissimilation involving the [continuant] feature in Modern Greek (16). In this process, one member of an obstruent cluster sharing the same manner features, either stop + stop or fricative + fricative, optionally changes its manner feature (Joseph and Philippaki-Warbuton 1987, Tserdanelis 2001). In a stop + stop cluster, the first stop becomes a fricative, while, in a fricative + fricative cluster, the second fricative becomes a stop. If, however, the second fricative is /s/, the first fricative dissimilates to a plosive.

(16) Manner dissimilation in Modern Greek (Tserdanelis 2001: 4, 6)

ptero ~ ftero	'feather'
ktena ~ xtena	'comb'
okto ~ oxto	'eight'
xθes ~ xtes	'yesterday'
fɣaristo ~ fkaristo	'I thank'
anixθika ~ anixtika	'I was opened'
sxini ~ skini	'rope'
kafsimo ~ kapsimo	'burning'

Two cases of labial dissimilation were identified in the WALS 100-language sample. One of these occurs in Tashlhiyt Berber (Selkirk 1988, 1993, Odden 1994), in which labialized velars lose their rounding after either a labial consonant or a round vowel (17).

(17) Tashlhiyt Berber labial dissimilation (Odden 1994: 317)

g ^w ra	'gleaned'	im-gra	'gleaners'
gg ^w ra	'trained'	im-grad	'those trained'
aq ^w lil	'rabbit (free form)'	uqlil	'rabbit (construct form)'

Chukchi (Bogoras 1922, Skorik 1961, Kenstowicz 1979, Krause 1980), has a process of place dissimilation involving the feature [coronal], whereby the coronal glide /j/ becomes a velar glide [ɰ] before a coronal consonant (18).

(18) Coronal dissimilation in Chukchi

wʔej-ək	'grass'	wʔeɰ-ti	'grasses'
ɲin-qej	'boy'	ɲen-qaɰ-tʃən-tʃən	'big boy'
tʃaj	'tea'	tʃaɰ-nalk-ək	'to make tea'

Liquid dissimilation is also widely attested. Sundanese, which we saw earlier, displays an assimilatory process turning the plural infix /-ar-/ to [-al-] after a root-initial lateral, has the same shift in the form of dissimilation triggered by any /r/ in the word unless either of the first two syllables of the root begins with /r/, e.g. *p-al-ərceka* ‘handsome (pl)’, *c-al-ombrek* ‘cold (pl)’, *b-al-ocor* ‘leaking (pl)’, *s-al-iduru* ‘sit by a fire (pl)’, but *r-ar-ahit* ‘wounded (pl)’, *c-ar-uriga* ‘suspicious (pl)’ (Cohn 1992: 206–7).

Dissimilation involving nasality appears to be rare, although it is attested in Chukchi (19), in which a velar nasal dissimilates to [ɣ] before another nasal (Krause 1980, Odden 1988, Bye 2011).

(19) Nasal dissimilation in Chukchi (Bye 2011)

taraŋ-ək	‘build a dwelling’	nə-taraŋ-mori	‘we built a dwelling’
inawrəŋ-ək	‘to give as a gift’	inawrəŋ-nin	‘he gave it’
pitʔiŋ	‘cold’	pitʔiŋ-ŋinqij	‘boy with a cold’

Interestingly, laryngeal features appear not to be involved in local dissimilation even though, as we have seen (cf. voicing assimilation in Kabardian in section 5.1.1), they commonly participate in assimilation.

5.2.2 Long-distance dissimilation

5.2.2.1 Long-distance consonant dissimilation Nasality and laryngeal features, are more prone to dissimilate at a distance. For example, Schuh (2002) describes an alternation in the voicing of prefixes in western varieties of the Chadic language Bade triggered by a constraint against obstruents with identical voicing features. Voiced obstruents thus devoice when attached to roots beginning with a plain voiced (i.e. not implosive) obstruent (20).

(20) Laryngeal dissimilation in Bade (Schuh 2002: 7)

gə-k ^w tú	‘you took’	ká-dək ^w ú	‘you heard’
gə-làgú	‘you stopped’	ká-gàfó	‘you caught’
gə-fəbdú	‘you sold’	ká-vèrú	‘you went out’

Interestingly, Bade displays laryngeal assimilation rather than dissimilation in case of *adjacent* obstruents. For example, the intransitive form *kádú* ‘snap in two’ corresponds to the transitive form *əgdú* ‘snap in two, pluck’ (Schuh 2002: 11).

Among the various types of long-distance dissimilation, the most widely studied involve place features for consonants. Many of these effects are manifested in gradient morpheme structure constraints. Arabic (Greenberg 1950, Frisch 2004, Frisch et al. 2004) is a well-studied example of a language with a bias against roots containing homorganic consonants and a virtual prohibition against roots containing identical consonants. The Arabic dissimilatory co-occurrence restrictions display a number of interesting properties that are manifested on a statistical level in the actual number of roots displaying particular combinations of consonants relative to the expected number based on the frequency of the individual

consonants comprising the combination (Frisch et al. 2004). First, the bias against shared place features is stronger for consonants that are adjacent as opposed to those that are non-adjacent. Furthermore, the dissimilatory bias is stronger between the first two consonants in the root than the last two. Finally, the restriction against co-occurring alveolar consonants differs from other places of articulation in being sensitive to a division between obstruents and sonorants, such that coronals may freely appear in the same root as long as they differ with respect to the [sonorant] feature.

Although this last property is observed in certain languages other than Arabic, including English (Berkley 2000) and Samoan (Alderete and Bradshaw 2013), it is not shared with all languages. In the Austronesian language Muna (Coetzee and Pater 2008), the co-occurrence of nasals and voiced stops sharing the same place of articulation is dispreferred over co-occurring voiced and voiceless stops with the same place of articulation. It thus appears that differences in voicing confer some degree of immunity to similar place avoidance constraints in Muna, whereas differences in the specification for the feature [sonorant] play an important role in allowing consonants produced at the same place of articulation to co-occur in languages like Arabic, English, and Samoan.

Work by Pozdniakov and Segerer (2007) suggests that avoidance of shared place features between consonants in a root may be a universal property. In their survey of 15 different language families and language isolates, they find that roots in all of their sampled languages are underrepresented if they contain multiple consonants produced at the same place of articulation.

They also find a somewhat weaker dispreference for combinations of the two peripheral major places, labials and velars, and combinations of the two coronal ("medial" in their terms) articulations, palatal/palato-alveolars and dental/alveolars. The dispreference for multiple coronals is easily stated as a constraint against multiple consonants sharing the articulator-based feature [coronal]. On the other hand, there is no articulatory feature that groups together labials and velars, leading Pozdniakov and Segerer (2007) to suggest that a restriction against multiple occurrences of the acoustic feature [grave] (Jakobson et al. 1963), which characterizes sounds associated with lower frequency energy than their [acute] counterparts, might play a role in the bias against labial-velar combinations. Another recurring property that Pozdniakov and Segerer (2007) identify is the relevance of ordering of consonants in predicting the magnitude of dissimilation effects. Thus, orderings in which a coronal consonant precedes a peripheral (either labial or dorsal) consonant are statistically preferred to those in which the peripheral consonant precedes the coronal (see also Alderete and Bradshaw 2013 for the relevance of order in consonant dissimilation in Samoan).

Pozdniakov and Segerer (2007) primarily focus on static place dissimilation effects observed in roots. Some languages undergo active alternations induced by similar place avoidance. For example, within the derivational morphology of Tashlhiyt Berber (Selkirk 1988, 1993, Odden 1994), /m/ belonging to a prefix changes to [n] when followed by any other consonantal labial (i.e. not the glide /w/) anywhere in the word. The forms in (21) show alternations in the reflexive prefix /m/ conditioned by the consonants that follow.

(21) Labial dissimilation in Tashlhiyt Berber (Odden 1994: 319)

yza	'dig'	m-yza
ʃ ^h awr	'ask for advice'	m-ʃ ^h awr
xalf	'place crosswise'	n-xalaf
fra	'disentangle'	n-fara
ħaffm	'be shy'	n-ħaffam

Although place co-occurrence restrictions appear to exert more of an effect cross-linguistically than other types of co-occurrence constraints, many languages also display a dispreference for other types of shared features.

An interesting feature of long-distance dissimilation in many languages is the greater immunity of completely identical consonants to otherwise strong co-occurrence restrictions against similar consonants. For example, in Russian (Pozdniakov and Segerer 2007) and English (Berkley 2000), words containing the two labials /b/ and /p/ are avoided more than words consisting of the two identical labials /p/. The special status of identical consonants is also evidenced by the cross-linguistically pervasive phenomenon of reduplication (Chapter 8).

MacEachern (1999) and Gallagher (2010) discuss languages with mixed laryngeal harmony and disharmony restrictions in which co-occurring sounds must possess different laryngeal features if they are heterorganic but must have matching laryngeal features if they are homorganic. For example, in Peruvian Aymara (MacEachern 1999), two aspirated stops may not occur in the same root unless they share the same place features, in which case both must be aspirated or both must be unaspirated. Roots like *k^hapi* 'strong, skillful' and *p^husp^hu* 'boiled beans' (MacEachern 1999: 35) are thus licit whereas their hypothetical counterparts **k^hap^hi* and **p^huspu* are not.

5.2.2.2 Long-distance vowel dissimilation Long-distance vowel dissimilation appears to be much less common than both vowel harmony and long-distance consonant dissimilation. There were only two cases of vowel dissimilation, both involving the height dimension, reported in the sources consulted for the 100-language WALS survey. Lynch (2003) discusses a number of cases of vowel height dissimilation found in Austronesian languages of Vanuatu, manifested in most languages as fossilized reflexes of earlier historical sound changes but realized in a few languages as productive synchronic alternations. For example, in Maskelynes, there are three monosyllabic prefixes that contain the vowel /a/, which surfaces instead as [ə] if the first syllable of the root contains /a/. The forms in (22) illustrate vowel allomorphy in the negative /sa-/ and the purposive /va-/ dependent on the first vowel in the root.

(22) Vowel height dissimilation in Maskelynes (Lynch 2003: 366)

sa-voi	'it isn't good'	sə-jar	'he doesn't walk'
sa-ləŋon-i	'he doesn't want it'	sə-kad-e	'he doesn't have it'
va-vux-e	'in order to unwrap it'	və-parex	'in order to cook laplap'
va-bətax	'in order to sit'	və-pat	'in order to sleep'

Vowel backness dissimilation is found in Ainu, in which the transitive suffix consists of a high vowel that assumes the opposite backness value from a non-low vowel of certain lexically marked roots (Ito 1984) (23).

(23) Vowel backness dissimilation in Ainu (Ito 1984: 506)

hum-i	'to chop up'	mus-i	'to choke'
pok-i	'to lower'	hop-i	'to leave behind'
pir-u	'to wipe'	kir-u	'to alter'
ket-u	'to rub'	rek-u	'to ring'

Though less studied than consonant co-occurrence restrictions on a statistical level, existing evidence does not support a statistical tendency for similarity avoidance for vowels. Rather, the limited available data suggests a bias in favor of *increased* similarity for vowels within lexical items. Alderete and Bradshaw (2013) find that vowels in adjacent syllables that agree in backness also strongly tend to agree in height in Samoan (see also Krupa 1967). Thus, the combinations /u-u/, /o-o/, /i-i/, and /e-e/ are statistically overrepresented, whereas the pairs /u-o/, /o-u/, /i-e/, and /e-i/ are underrepresented. This bias toward agreement in vowel height contrasts with the dissimilatory place bias for consonants in Samoan. The asymmetry between vowels and consonants in Samoan on a statistical level is consistent with an apparent asymmetry between the two classes of sounds in their behavior on a categorical level cross-linguistically. Vowel harmony is typologically common while consonant harmony is rare. In the WALS 100-language sample, there were a total of 26 cases of vowel harmony but no clear cases of long-distance consonant harmony. In contrast, vowel disharmony is relatively rare (only two cases in the WALS survey) compared to consonant disharmony (eight instances).

5.2.3 Explaining dissimilation

Various phonetic and psycholinguistic explanations for dissimilation have been advanced in the literature. Ohala (1981) suggests that, like assimilation, dissimilation also has its roots in coarticulation. Under his account, the Co-articulation Hypercorrection Theory (CHT), dissimilation arises when a listener, armed with a tacit awareness of coarticulatory effects, mistakenly attributes to coarticulation a property that was actually intended by the speaker and introduces a hypercorrection that undoes the perceived coarticulation. Taking the Chukchi case of /j/ dissimilation before coronals as an example (see above), Ohala's theory would assume that the listener is aware of the acoustic correlates of coronal consonants, including the formant trajectories characteristic of the transition from a preceding vowel into the coronal constriction. Dissimilation occurs when the listener mistakenly assumes that the formant structure of the /j/ preceding the coronal is a coarticulatory effect of the following coronal rather than a feature of the palatal glide itself. Assuming that the speaker intended to produce a more posterior glide, the speaker phonologically reanalyzes it as velar and produces it as such in her own speech thereby setting in motion a dissimilatory sound shift. This mechanism is depicted schematically in Figure 5.5.

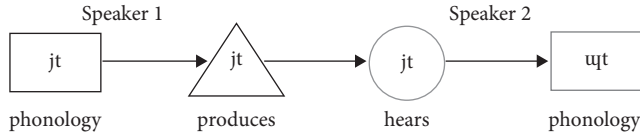


FIGURE 5.5. Dissimilation in the Co-articulation Hypercorrection Theory (Ohala 1981)

A key assumption of this account is that the domain of the coarticulatory effect temporally encompasses both the trigger and target of the dissimilation. Local place dissimilation of the Chukchi type is thus amenable to explanation by the Co-articulation Hypercorrection Theory. Subtypes of long-distance dissimilation involving features that are acoustically realized over an extended temporal domain also fall out from this account. For example, the long-distance liquid dissimilation of Sundanese (see above) which triggers a shift from /r/ to [l] in the vicinity of another /r/ lends itself to a hypercorrection account since rhotics and laterals influence formant structure even multiple syllables away from the liquid triggering the coarticulation (Tunley 1999, Hawkins and Smith 2001).

There are, however, other types of dissimilatory changes, both local and long-distance, that are less readily explained in terms of coarticulatory hypercorrection. One such process is the obstruent manner dissimilation in Greek (see above). Tserdanelis (2001) offers an alternative account of the Greek dissimilation in terms of well-documented perceptual factors. First, as discussed in Chapter 4 in the context of the preference for CV syllables, the auditory system is more attuned to a modulated acoustic signal characterized by varied spectral characteristics than to an invariant stimulus, a bias that would confer a perceptual benefit on a stop + fricative or fricative + stop cluster over a stop + stop or fricative + fricative cluster (see Bladon 1986). The direction of dissimilation is explicable in terms of cue robustness following a similar line of reasoning adopted to account for directionality asymmetries observed in assimilation. The shift of the first stop to a fricative in a stop + stop cluster and the conversion of the second fricative to a stop in a fricative + fricative cluster converge on the same output: a fricative + stop cluster. A fricative + stop cluster is perceptually preferred over the hypothetical alternative, a stop + fricative cluster, since the stop in a prevocalic fricative + stop cluster appears before a vowel, which provides the consonant-to-vowel transitional cues that are important for recovering the identity of the stop. The fricative with its more robust internal cues is in less need of the transitions into an adjacent vowel. Tserdanelis suggests that the failure of /s/ to undergo dissimilation even when following another fricative, i.e. /xs/ to [ks] not *[xt], is attributed to the particularly robust internal cues of sibilants (cf. the tendency of /s/ to disobey sonority sequencing conventions in syllabification clusters; see Chapter 4), which make them resistant to transformation.

Tserdanelis finds support for his account from a perception experiment in which Greek and English listeners were asked to provide same/different judgments in response to pairs of intervocalic clusters that were either identical or differed with respect to the first or second consonant. The general finding

(with some variation as a function of language background and whether the difference in pairs resided in the first or second consonant) was that clusters with a sonority plateau, i.e. stop + stop and fricative + fricative clusters, triggered slower reaction times, suggestive of greater perceptual difficulty, than clusters with either rising (stop-fricative) or falling (fricative-stop) clusters. Fricative + fricative clusters were perceptually most challenging, as reflected both in reaction and in error rates in identification. Fricative + stop clusters were associated with shorter reaction times than their stop + fricative counterparts. Greek listeners performed slightly better than English listeners, a difference that is plausibly attributed to English listeners' unfamiliarity with some of the occurring Greek clusters, such as those containing the velar fricative /x/. One finding, however, that did not accord with predictions was the failure of clusters containing /s/ to trigger faster reaction times than other fricatives.

In his work on long-distance dissimilation, Frisch (2004) suggests that speech planning constraints play a role in accounting for dissimilation at a distance. Parallel to work by Hansson (2001, b) and Rose and Walker (2004) on assimilation, Frisch proposes that dissimilation reflects an attempt to avoid highly similar sounds in close proximity. Citing evidence from speech error data and perception experiments, Frisch hypothesizes that both the speech production and perception systems experience interference from multiple occurrences of similar sounds. This confusion may be modeled in a spreading activation model of speech encoding in which the speaker or listener is both planning ahead but is also primed by what she has just produced or heard. The simultaneous processing of current, past, and future information potentially leads to confusion in the temporal sorting of data, confusion that is heightened by sounds sharing similar properties. Under Frisch's account, dissimilation reflects an attempt to ease the burden of serial encoding by reducing the number of sources of a particular feature or set of features.

Frisch's analysis of long-distance dissimilation appeals to the same speech planning mechanisms invoked by Hansson (2001a, b) and Rose and Walker (2004) to account for long-distance assimilation (see section 5.1.6.5). Assimilation and dissimilation merely reflect different responses to speech encoding constraints. Assimilation arises from the premature or perseverative intrusion of properties associated with an earlier or later segment. Dissimilation, on the other hand, reflects an attempt to avoid the types of configurations that are prone to lead to assimilatory speech errors.

Gallagher (2010) attempts to link assimilation and dissimilation in a single perceptually driven analysis of laryngeal harmony and disharmony. She proposes that both processes have in common that they conspire to reduce the number of possible laryngeal contrasts between roots, thereby easing the perceptual burden of recovering the laryngeal properties differentiating roots. To illustrate Gallagher's proposal, consider a CVCV root in a language with a contrast between ejective and plain voiceless stops. A language with an assimilatory constraint on ejectives has roots with two ejectives and roots with no ejectives, e.g. *papa* vs. *p'ap'a*. A language with a dissimilatory ban on ejectives has roots with a single ejective (either the first or second consonant) and other roots with no ejectives, i.e. *p'apa* vs. *pap'a* vs. *papa*. In contrast, a language with no co-occurrence restrictions

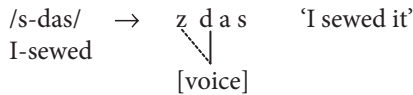
on ejectives has four possible configurations: roots with two ejectives, roots with a single ejective as either the first or second consonant, and roots with no ejectives, i.e. *p'ap'a* vs. *p'apa* vs. *pap'a* vs. *papa*. Assimilation and dissimilation have in common that they reduce the number of laryngeal contrasts by eliminating the contrast between roots with two ejectives and roots with a single ejective. Gallagher proposes that the contrast between one ejective and two ejectives is perceptually disadvantaged relative to the contrast between zero ejectives and either one or two ejectives.

To test her proposal, Gallagher conducts a perception experiment using stimuli spliced together from recordings of a speaker of Bolivian Quechua, a language with a dissimilatory ban on multiple ejectives within a root. The stimuli consisted of various combinations of ejective and plain voiceless stops in CVCV roots, which were played in pairs to listeners who were asked to make same or different judgments. Listeners of English, a language without phonemic ejectives, were recruited as subjects in order to avoid any biases due to linguistic experience. Results confirmed Gallagher's hypothesis that pairs differing in whether they possessed one or two ejectives were more difficult to process than pairs contrasting in having zero vs. either one or two ejectives. In other words, pairs like *k'ap'i* vs. *kap'i* or *k'api* (two vs. one ejective) were more difficult to distinguish than either pairs like *kapi* vs. *k'api* or *kap'i* (zero vs. one ejective) or pairs like *kapi* vs. *k'ap'i* (zero vs. two ejectives). Of the latter two pairs (zero vs. one and zero vs. two), the contrast between zero and two ejectives was more readily differentiated by subjects, a result that suggests a perceptual advantage conferred to assimilation over dissimilation. Gallagher did not, however, find experimental support for the perceptual grounding of mixed assimilatory and dissimilatory patterns, such as the one found in Peruvian Aymara whereby heterorganic stops must disagree with respect to laryngeal features while homorganic stops must agree. Listeners in Gallagher's study thus were equally adept at distinguishing a contrast between zero and one ejective regardless of whether they shared place features or not, i.e. the pairs *papi* vs. *p'api* or *pap'i* were not more difficult to distinguish than the pairs *kapi* vs. *k'api* or *kap'i*.

5.3 The formal representation of assimilation and dissimilation

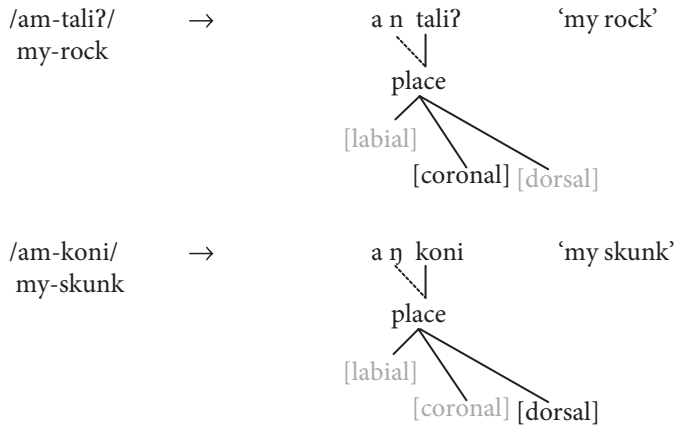
The typology of assimilation and dissimilation provided important evidence for the development of Autosegmental Phonology (Goldsmith 1976/1979), in which phonological predicates are assumed to operate on orthogonal representational tiers and phonological features are grouped together into a hierarchical configuration or geometry (see McCarthy 1988 and Uffman 2011 for overviews of feature geometry). Although much of the early evidence for autosegmental phonology came from tone (see Chapter 7), assimilatory and dissimilatory patterns also turned out to be cogently analyzed within an autosegmental framework. A key insight of autosegmental phonology is its modeling of assimilation as the spreading of a feature or group of features from one segment to another. For example, Kabardian regressive voicing assimilation (section 5.1.1) is captured as leftward spreading of [voice], as in (24).

- (24) Autosegmental analysis of voicing assimilation in Kabardian



Groups of features that assimilate together are assumed to be dominated by a node that spreads together with its subordinate branches. For example, assimilation of the 1st person possessive prefix in Chickasaw (section 5.1.1) is captured as spreading of the place node from the first consonant of the root to the prefixal consonant, as in (25).

- (25) Autosegmental analysis of nasal place assimilation in Chickasaw



Long-distance assimilation can also be accounted for if one assumes that segments intervening between the trigger and target are unspecified for the spreading feature(s). For example, Yaka nasal harmony (section 5.1.6.2) involves spreading of a [nasal] feature from a consonant in the root to a suffixal consonant across an intervening vowel.

An important issue in feature theory (see Padgett 2011 for discussion) concerns, on the one hand, the reconciliation of the transparency effects in harmony systems that suggest that consonantal and vocalic features operate on separate planes with, on the other hand, the interaction between consonants and vowels both in certain assimilatory phenomena (e.g. palatalization of consonants by front vowels, labialization of vowels by labial consonants, etc.) and in the cross-class blocking effects between consonants and vowels (or vice versa) in certain harmony systems (e.g. the inhibition of vowel lowering by voiced obstruents in the vowel height harmony system of Buchan Scots), both of which suggest that consonants and vowels may share at least certain features.

Dissimilation can be captured as a prohibition against identical adjacent features, either associated with immediately adjacent sounds in the case of local dissimilation or across intervening transparent sounds in long-distance dissimilation. An important constraint on autosegmental representations that is

commonly invoked to account for dissimilation, not just of segmental features but also of tones, is the Obligatory Contour Principle (or OCP) (e.g. Leben 1973, Goldsmith 1976, McCarthy 1986, 1988, Odden 1988), which bans adjacent identical elements. Dissimilation may be viewed as the delinking or deletion of a feature (with subsequent insertion of a default feature) in order to satisfy the OCP (see Odden 1994). For example, the Tashlhiyt delabialization of labialized consonants following a labial consonant or a round vowel (section 5.2.1) can be analyzed as delinking of the [labial] feature of the labialized consonant following another [labial], as in (26).

(26) Autosegmental analysis of labial place dissimilation in Tashlhiyt

$$\begin{array}{ccc}
 /im-g^wra/ & \rightarrow & \begin{array}{cc} i & m & & g & ra \\ & | & & \neq & \\ & [labial] & & [labial] & \end{array}
 \end{array}$$

5.4 Fortition and lenition

Fortition and lenition are two phenomena that are characterized by changes in the “strength” of a sound: fortition entails strengthening of a sound and lenition involves weakening of a sound. The phonetic dimension along which strength is assessed is commonly assumed to involve articulatory effort, which is notoriously difficult to quantify but presumably is the net product of a constellation of properties, including the mass of the articulator(s) producing a sound, the degree of displacement of articulators from their rest position, and the velocity and duration of articulatory gestures (see Kirchner 1998 for discussion). Grounding fortition and lenition in articulatory effort means that the classification of a process as fortition or lenition potentially depends on the context in which it occurs. For example, the common process of voicing of an obstruent between two voiced sonorants constitutes a type of lenition since it is easier to maintain the laryngeal adduction gesture responsible for voicing through the obstruent than to abduct the vocal folds in this context. On the other hand, in final position, it is more difficult to voice an obstruent due to aerodynamic considerations that conspire against voicing (see discussion of final devoicing in Chapter 2). Final devoicing may thus be viewed as a type of lenition, though it is not the prototypical case of lenition that adheres to the traditional scale of strength along which voiced sounds are considered weaker than voiceless sounds.

Changes in the strength of a sound have consequences for acoustic intensity (and its perceptual analog loudness) that are also invoked in certain accounts of fortition and lenition. Kingston (2008) suggests, for example, that lenition and fortition assist in demarcating prosodic constituents. The pervasive phenomenon of lenition between sonorants thus reflects an attempt to minimize fluctuations in loudness domain-internally whereas fortition (i.e. the suppression of lenition) in domain-initial position aids in marking the beginning of prosodic units.

There is not a consistent mapping between articulatory effort and intensity, since the relationship between the two properties depends on the nature of the fortition or lenition process and whether it affects a vowel or a consonant. In the case of consonants, fortition characteristically involves a shift in the direction of a narrower articulatory constriction, e.g. the change of a glide to a fricative or a fricative to a stop, which results in a decrease in intensity. Conversely, lenition typically involves increased aperture in a consonantal constriction, which is associated with greater intensity. Yet, a process like final devoicing, which would be regarded as a lenition process under an effort-based view of strength, decreases intensity (see Cser 2003 and Smith 2008 on the distinction between intensity-increasing lenition and positionally governed lenition processes that do not increase intensity). Inconsistencies in the relationship between an acoustic-based and an articulatory-based definition of strength also are observed in the fortition and lenition of vowels. Lenition of vowels in unstressed syllables can entail shortening and qualitative shifts. Shortening, a nearly universal correlate of lack of stress, decreases perceived loudness, which is a function of both intensity and duration. However, varied qualitative shifts are observed in unstressed vowels with different consequences for intensity (see section 5.4.2). Vowel lowering increases intensity whereas vowel raising decreases intensity all else being equal. Both vowel lowering and raising could be argued to entail increased articulatory effort depending on the relative effort that is assumed for lowering the jaw to produce a lower vowel versus raising the tongue body to articulate a higher vowel. We will not concern ourselves here with the complex issue of attempting to evaluate the articulatory costs in effort associated with the various types of lenition and fortition processes observed cross-linguistically.

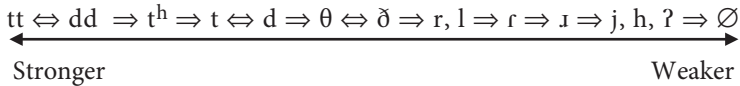
Rather, sections 6.4.1 (consonants) and 6.4.2 (vowels) provide an overview of a wide range of phenomena that involve changes in the relative strength of sounds as defined along dimensions commonly assumed in scales of strength. These processes will include those that are defined by changes in manner of articulation and voicing for consonants, place of articulation for vowels, and duration for both vowels and consonants. A property unifying many, but not all, cases of lenition and fortition is that they are linked to certain prosodic positions and not just to surrounding segmental context. Lenition is thus often associated with prosodically weak positions such as unstressed or domain-final syllables or syllable codas. Fortition, on the other hand, characteristically occurs in strong positions, such as stressed syllables, domain-initial syllables, or syllable onsets. This prosodic conditioning differentiates many of the phenomena discussed here from the assimilatory and dissimilatory processes discussed earlier in this chapter, although assimilation and dissimilation can also be characterized in terms of their effect on the strength of a sound. For example, lenition often targets intervocalic obstruents, triggering voicing or spirantization, which are assimilatory changes in that they involve the spreading of voicing or continuancy from flanking vowels. Fortition, on the other hand, often devoices prevocalic consonants or increases their degree of constriction, both dissimilatory processes that increase the phonetic divergence between the consonant undergoing fortition and the following vowel. Another feature of many lenition processes is that they have a two-sided

context, e.g. intervocalic position, as opposed to a single-sided environment, e.g. post-vocally.

5.4.1 Consonants

The quintessential cases of fortition and lenition pertaining to consonants involve changes in manner and/or laryngeal features. A schematic articulatory-based hierarchy of strength for coronal consonants is shown in (27). Differences in the directionality of the arrows are discussed below.

(27) Scale of strength for coronal consonants motivated by articulatory factors



A shift in manner or laryngeal specification to another consonant anywhere to its right constitutes a leniting change while a shift leftward is a fortiting change. At the weak end of the scale is deletion (see section 5.5). An exception is provided by the three bi-directional arrows connecting voiceless/voiced pairs, which reflect shifts that may be regarded as either lenition or fortition depending on context. Thus, voicing of an obstruent is a form of lenition between sonorants where it is easier to produce a voiced consonant, but is a type of fortition in final position where a voiced consonant requires greater effort. A shift in either direction may involve a one-step change or may involve skipping over one or more sounds on the scale to one more distant on the scale. For example, /d/ may lenite all the way to a glide or /t/ may lenite to a /h/ or /ʔ/. Similar scales hold of other places of articulation that are impoverished relative to coronals in lacking certain consonant types on the scale in (27).

Setting aside deletion, the changes captured in (27) can be grouped into a few different categories according to the features involved. Degree of constriction may shift either in the direction of increased narrowing in the case of fortition or increased aperture in the case of lenition. Shifts in constriction degree (and potentially duration concomitantly) include changes between a stop, a fricative, a liquid approximant, a tap, or a glide. Alternatively, a shift may primarily involve duration, as in the shift between a geminate and a singleton consonant. Another possibility is for laryngeal features, including voicing and aspiration, to be involved in a shift. For example, debuccalization, or loss of supralaryngeal features with the result being /h/ or glottal stop, is a type of lenition. An additional type of change not represented in (27) involves a change in affrication, either the shift from an unaffricated stop to an affricated one (fortition) or the loss of affrication (lenition).

Despite the relatively diverse range of alternations in consonant strength attested cross-linguistically, there are certain types of shifts that are unattested. These gaps are more likely to be meaningful in the case of lenition, which is more common than fortition. Kirchner (1998) notes several cross-linguistic generalizations that hold of lenition. Among them, he finds that geminate stops fail to undergo qualitative lenition without also undergoing quantitative

lenition, i.e. degemination. Furthermore, Kirchner observes that the output of lenition of an unaffricated stop is never a strident fricative. For example, /t/ may shift to non-strident [θ] (or another weaker consonant on the strength scale) but not to strident [s].

Kirchner hypothesizes that both of these gaps in the range of attested patterns exist because they would not entail a reduction in articulatory effort and thus would not satisfy the primary goal of lenition. In explaining the failure of lenition to output a strident fricative, Kirchner argues that the narrow constriction necessary to produce the noise associated with stridents necessitates considerable effort: “for the strident fricative, in order to achieve the delicate balance of holding the articulator in closely constricted position, but preventing it from going all the way to closure, isometric tension, i.e. exertion of force in opposition to the main constriction gesture, is required. The total effort cost of the constriction gesture plus the opposing force is greater than the effort cost of the corresponding stop” (Kirchner 1998: 111). Similarly, Kirchner suggests that a hypothetical voicing or spirantization process targeting geminate obstruents without concomitant shortening of the geminate does not result in a net reduction in articulatory effort. Producing a voiced geminate obstruent requires considerable articulatory effort to compensate for the aerodynamic factors that make it difficult to sustain voicing during a narrow constriction (see discussion of the typological bias against voiced obstruents in Chapter 3). Kirchner hypothesizes that the production of a sustained partial constriction like that associated with a geminate voiceless fricative also requires greater effort than articulating a geminate stop, which requires a less precise gesture. In support of his claim that voiceless geminate stops fail to lenite to either voiced geminate obstruents or to voiceless geminate fricatives because such changes would not lead to a reduction in articulatory effort, Kirchner observes that both voiceless geminate fricatives and voiced geminate obstruents imply the existence of voiceless geminate stops in languages of the world (although Somali appears to contradict this statement in having voiced but not voiceless geminate stops; see Chapter 3). Under Kirchner’s account these static implicational constraints on geminates stem from the same articulatory biases driving lenition.

There is a recurring set of contexts that are associated with lenition cross-linguistically. Environments in which the targeted sound is adjacent to a sound produced with a relatively open vocal tract on one or both sides commonly trigger lenition. Intervocalic position is thus a classic lenition-inducing environment, with many languages generalizing lenition to also apply when either the preceding or following sound is a sonorant continuant, such as a liquid or glide. On the other hand, some languages limit lenition to positions adjacent to lower vowel qualities. In some languages, the context for lenition is one-sided rather than two-sided, triggered by either a preceding vowel (or sonorant continuant) or a following one. The general pattern linking all these cases of lenition is that they occur when adjacent sounds, either on one or both sides, are associated with a relatively open vocal tract (see Kirchner 1998 and Lavoie 2001 for more on the typology and analysis of lenition).

Another context often associated with lenition of consonants is final position. Lenition of final stops to fricatives or sonorants is common. Debuccalization is also widely attested syllable- and word-finally. A salient difference between lenition in open aperture contexts and in final position is that the latter context is characteristically associated with devoicing whereas the former often involves voicing. More generally, final position triggers other types of laryngeal neutralization involving features other than just voicing. For example, ejective and/or aspirated stops are often absent in final position either lost as part of a paradigmatic alternation between ejective and/or aspirated stops and plain voiceless stops or missing due to a static restriction against final ejectives and/or aspirates (see Chapter 2 on laryngeal neutralization).

Positions of increased strength include stressed syllables and initial position (Beckman 1998, Smith 2003, 2005, 2008). Fortition triggered by stress is attested in West Tarangan (Nivens 1992) in which /j/ affricates to /dʒ/ and /w/ occlusivizes to /g/ in the onset of stressed syllables. The latter change also applies to word-initial consonants. Similarly, in the development from proto-Samurian to pre-Lezgian (Topuria 1974, Giginejshvili 1977, Yu 2004), voiced stops in the onset of stressed syllables underwent devoicing and gemination (see Chapter 2). In Urubú Kaapor (Kakumasu 1986) and optionally in *Tukang Besi* (Donohue 1999) oral stops lengthen in the onset of primary stressed syllables. Flapping in English is similarly suppressed in the onset of stressed syllables.

5.4.2 Vowels

Like consonants, vowels are also subject to lenition and fortition. Furthermore, parallel to consonants, stress characteristically induces lengthening in vowels, whereas lack of stress triggers shortening. The effect of stress differences on vowel quality, however, is complicated by the fact that the same context can produce different results depending on the language (Crosswhite 2001, 2004, Barnes 2006). These differences point to varied articulatory and perceptual forces at work. Articulatory effort minimization likely plays an important role in the tendency for vowels to centralize in unstressed contexts. The shorter duration of unstressed vowels allows less time for the tongue and jaw to reach articulatory targets farther from their rest position, leading to articulatory undershoot (Lindblom 1963, Flemming 2002, 2004). For example, most vowels, both high and low, in English reduce to a schwa-like vowel in unstressed syllables. Articulatory undershoot can also contribute to an overall raising of the vowel space under temporal duress particularly adjacent to consonants, which are produced with a relatively high jaw position that is more conducive to higher vowel qualities (Lindblom 1963, Flemming 2002, 2004, Padgett and Tabain 2005). For example, in Bulgarian, the mid vowels /e, o/ raise to /i, u/ and the low vowel /a/ raises to /ə/ in unstressed syllables (Crosswhite 2001, 2004, Barnes 2006). This reduction pattern reflects a blanket upward shift of the vowel space (see Padgett and Tabain 2005 for phonetic data demonstrating this effect for Russian).

Evidence suggests that perceptual considerations also likely play a role in vowel reduction. First, raising of low and mid vowels in unstressed syllables reduces

sonority and thereby prominence in a context that is inherently less prominent (Crosswhite 2001, 2004). More tellingly, the fact that vowel reduction is often step-wise, as in Bulgarian, such that not all contrasts found in stressed syllables are completely neutralized suggests a role for contrast maintenance in vowel reduction (Crosswhite 2001, 2004, Flemming 2002, 2004, Padgett and Tabain 2005). Crosswhite (2001, 2004) hypothesizes that reduction in the direction of increased peripherality has a perceptual basis in that it helps offset a reduction in salience in unstressed positions attributed to decreased duration and intensity. In support of this view, Crosswhite (2001, 2004) describes a pattern of vowel reduction in Belorussian involving *lowering* of the unstressed mid vowels /e, o/ to /a/ (Kryvitskii and Podluzhnyi 1994). This type of reduction presumably comes at the cost of increasing articulatory effort, a contradiction to the normal pattern observed for consonants in unstressed contexts. Furthermore, in contrast to the reduction of duration and intensity associated with raising (Lehiste 1970) and centralization (Gordon et al. 2012), vowel lowering of the type observed in Belorussian likely increases prominence.

The conflicted nature of vowel reduction patterns does not appear to have an analog among consonants. I am thus unaware of any languages that turn approximants or non-strident fricatives in unstressed syllables to perceptually more salient but articulatorily more challenging strident fricatives. This apparent difference between consonants and vowels plausibly lies in the smaller perceptual space occupied by vowels compared to consonants (i.e. vowels are differentiated along fewer dimensions than consonants) coupled with the characteristically greater effect of stress (or lack of stress) on vowels. Vowels are thus potentially more susceptible to perceptual obfuscation when unstressed; this vulnerability plausibly motivates the type of reduction entailing increased peripherality in unstressed syllables.

Final position is associated with multiple potentially antagonistic phonetic effects that conspire to create a varied typology of phonological patterns (Barnes 2006). On the one hand, final vowels appear to be more resistant to coarticulation effects (Cho 2001), suggesting increased strength. Barnes (2006) discusses several languages in which unstressed vowel reduction is either suspended or less extensive in final position. For example, whereas virtually all (non-prevocalic) unstressed vowels in English reduce to schwa, final position licenses certain unstressed vowels, including /i/ (e.g. *city*, *cóuntry*), /u/ (e.g. *ígloo*, *jujítsu*), and /o/ (e.g. *mótto*, *flamíngo*) (Hammond 1999). Similarly, certain languages, e.g. Javanese (Horne 1974) and Yupik (Reed et al. 1977), ban schwa, the shortest and lowest sonority vowel, from word-final position.

Final position is also a locus of phonetic lengthening that would seem to provide the phonetic precursor for fortition effects such as phonological lengthening and more peripheral vowel qualities. Interestingly, though, this strength appears to be manifested uniformly as an increase in vocal tract aperture, i.e. lowered tongue and jaw position, which would predict peripheralization only in the direction of lowering. Barnes (2006) cites several languages with lowering of vowels in final position consistent with an increase in aperture. For example, the Cushitic language Dasenech (Sasse 1976) displays a lowering chain shift whereby word-final /i, u/ lower to [e, o] and /e, o/ lower to [ɛ, ɔ].

On the other hand, final position is also associated with weakening effects such as devoicing, non-modal phonation, and decreased intensity. These lenition traits likely contribute to patterns of final vowel deletion (see section 5.5) or vowel centralization either by reducing the overall perceptibility of contrasts or, in the case of non-modal phonation, through an effect on vowel quality (see Barnes 2006 for discussion). For example, in the Witotoan language Muinane (Walton and Walton 1967), word-final /a/ can optionally be realized as schwa. Barnes hypothesizes that this raising type of reduction, in apparent contradiction to the generalization that final position is associated with increased vocal tract aperture, may be caused by a combination of reduced intensity plus non-modal phonation and/or final devoicing that increases in magnitude as the vowel progresses. These temporally progressive weakening effects potentially obscure the first formant, the primary correlate of tongue height, before the tongue reaches its target position, leaving the lowered first formant values (indicative of a higher vowel quality) transitioning out of the preceding vowel to provide the dominant percept of the vowel (see Barnes 2006 for more discussion of phonetic and phonological properties of final vowels).

5.5 Deletion

Deletion of a sound may be viewed as an extreme version of lenition. Not surprisingly, the same environments that induce lenition, e.g. final position, unstressed syllables, and contexts adjacent to sounds produced with wide vocal tract aperture, often trigger deletion. For example, sonorant consonants delete intervocalically in Sango (Samarin 1967), word-final vowels optionally delete in *Tukang Besi* (Donahue 1999), and unstressed /i, u/ delete in Malagasy (Rajaonarimanana 1995). The same articulatory factors that motivate lenition are plausibly at work in deletion, a parallel that is evidenced by speech rate- and register-dependent lenition processes that produce outputs ranging from lenited sounds all the way to deletion, e.g. American English *p[ə]^htato* with vowel reduction vs. *p[Ø]^htato* with deletion (see also Kirchner 1998, 2004 on variable consonant lenition in Florentine Italian). Deletion often leads to a degradation of syllable structure (see Chapter 4) by either creating closed syllables (in the case of vowel deletion) or eliminating syllable onsets (in the case of consonant deletion).

Similar to laryngeal neutralization (see Chapter 2), deletion in final position is subject to debates concerning its grounding in phonetic factors vs. syllabification constraints. Chapter 4 discussed certain deletion processes that improve syllable structure or syllable contacts by eliminating all coda consonants (e.g. Samoan) or a subset of them depending on either the type/number (e.g. *da[m]* vs. *da[mn]ation*, *hy[m]* vs. *hy[mn]al* in English) of coda consonants or the onset of the following syllable (e.g. Diola Fiogny). We also saw that deletion arising in sequences of vowels (e.g. Yoruba) has the benefit of eliminating onsetless syllables. Even those cases of deletion that can be analyzed in terms of syllabification factors often display asymmetries that support the role of perceptual considerations in driving the deletion patterns. We discussed in Chapter 4 the case of Hungarian

cluster simplification argued by Côté (2004) to be explicable in terms of the relative perceptual robustness of different consonants. Furthermore, many languages asymmetrically delete a vowel preceding another vowel but not word-initially (Casali 1998, 2011) suggesting that a dispreference for vowel hiatus rather than for onsetless syllables plays a role in many cases of vowel deletion.

Côté (2011) also observes that certain languages display asymmetries in the domain associated with deletion of final consonants. For example, Kamayurá (Everett and Seki 1985) permits consonants phrase-finally but deletes them at the end of phrase-medial words. Similarly, Cairene Arabic permits consonant clusters only at the end of words that are also in phrase-final position (Watson 2002). Côté (2011) suggests that there are no clear cases of the opposite pattern whereby simple and complex codas are licit phrase-medially but only simple consonants are permitted phrase-finally. Côté (2000) attributes the increased licensing capacity of phrase-final position relative to phrase-medial position to the greater perceptual robustness of the former position relative to the latter one. Perceptibility is not the entire story, however, as there are also languages such as Hixkaryana (Derbyshire 1979, 1985) that permit coda consonants word-internally but not word-finally.

5.5.1 Deletion and compensatory lengthening

Deletion of a sound is often associated with lengthening of an adjacent or nearby sound. There are several types of this “compensatory lengthening”, which can be described along multiple dimensions: the type of sound that triggers compensatory lengthening, the target of compensatory lengthening, and the position of the trigger and target relative to one other (see Gess 2011 for a summary). The two most prevalent types of compensatory lengthening are, first, those that involve loss of a coda consonant with lengthening of an adjacent vowel and, second, cases in which the loss of a vowel after a consonant triggers lengthening of the vowel preceding the lost consonant. An example of the former type is provided by Supyire (Carlson 1994), in which loss of coda /r/ in certain morphological contexts triggers lengthening of the preceding vowel: *cer-ré* → *ce:ré* ‘little calabash’, *cer-ga* → *ce:ga* ‘big calabash’ (p. 33). In her survey of compensatory lengthening, Kavitskaya (2002) identifies 58 cases of compensatory lengthening triggered by loss of a coda consonant and targeting the immediately preceding vowel. The second type of common compensatory lengthening, attested in 21 languages in Kavitskaya’s survey, is exemplified by the following alternations (accompanied by final devoicing) between the masculine and feminine forms in the Romance language, Friulian (Hualde 1990): *lôve* ‘wolf (fem)’ vs. *lô:f* ‘wolf (masc)’, *rúde* ‘pure (fem)’ vs. *rú:t* ‘pure (masc)’, *fréde* ‘cold (fem)’ vs. *fré:t* ‘cold (masc)’ (from Kavitskaya 2002). Kavitskaya finds that this type of compensatory lengthening, unlike the type triggered by consonant loss, is attested primarily as a historical sound change rather than an active synchronic process. Note that we abstract away from a third type of length alternation that is also common and could be viewed as compensatory: complete assimilation of one consonant to another in a cluster (see section 5.1).

The loss of certain types of sounds is more likely to trigger compensatory lengthening than others. De Chene and Anderson (1979), Riialand (1993), and Kavitskaya (2002) note a tendency for sonorants to trigger compensatory lengthening more than obstruents. The obstruents that are most likely to induce compensatory lengthening are the glottal consonants /h/ and /ʔ/, which often have an approximant-like articulation in coda position. These observations about the nature of lengthening triggers provide evidence for Kavitskaya's (2002) view of compensatory lengthening as a historically natural process of phonological reanalysis of durational tendencies that initially exist as low-level phonetic effects. Kavitskaya points out that the types of consonants that tend to trigger compensatory lengthening are prone to induce lengthening in a preceding vowel and/or are acoustically similar to an adjacent vowel, which makes them more prone to merge with that vowel to create a long vowel. For example, in the Supyire case of compensatory lengthening triggered by consonant loss, the coda /r/ potentially triggered phonetic lengthening of the preceding vowel, which was reanalyzed as phonemic length of the vowel once the /r/ was lost. The loss of the /r/ was potentially facilitated by the blurry acoustic boundary between the rhotic and the preceding vowel. Similarly, in Friulian, the common process of vowel lengthening in open syllables (Maddieson 1985) likely was the phonetic precursor for reanalysis of the phonetically lengthened vowels as phonemic long vowels once the vowel in the following syllable was lost.

In support of Kavitskaya's analysis, compensatory lengthening induced by vowel loss is often limited to apply before certain consonants that tend to trigger greater lengthening of the preceding vowel. For example, in Friulian, compensatory lengthening is only triggered by the loss of voiced consonants, which commonly cause lengthening in the preceding vowel (Lehiste 1970).

5.5.2 The representation of compensatory lengthening

Compensatory lengthening has provided important evidence for moraic representations of phonological weight (Hyman 1985, Hayes 1989a). Moraic theory assumes that moras are projected from segments in the rime as a function of their length and sonority. Short vowels are associated with one mora and long vowels with two. A single consonant in an onset is non-moraic, whereas a geminate shared between two syllables is linked to one mora, owing to the half belonging to the rime. A short consonant in the rime may either be moraic or not depending on the language. These possibilities are shown schematically in (28).

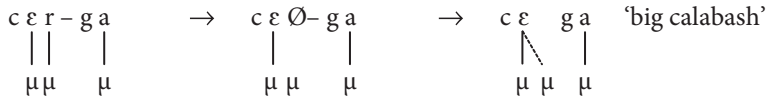
(28) Schematic moraic representations of different syllable types

/ta/	/ta:/	/tata/	/tat:a/	/tat/
t a	t a:	t a t a	t a t : a	t a t or t a t
	\			
μ	μ μ	μ μ	μ μ μ	μ μ μ

Compensatory lengthening may be viewed, following Hayes (1989a), as preservation of mora count. A schematic example of compensatory lengthening

triggered by coda loss in Supyire is depicted in (29). The postvocalic /r/ in the first syllable deletes leaving its associated mora stranded. The preceding vowel then associates with the stranded mora to yield a long vowel.

(29) Compensatory lengthening in Supyire (Carlson 1994)



One of the interesting predictions made by moraic theory is that loss of onset consonants will not trigger compensatory lengthening since onsets are non-moraic (see Beltzung 2008 and Topintzi 2010 for possible counterexamples to this prediction). Another prediction made by moraic theory's parameterization of mora assignment on a language-specific basis is that compensatory lengthening will not be triggered by coda loss in languages that treat codas as non-moraic for other processes, such as stress assignment or minimal word requirements (Gordon 2006a). Moraic theory is discussed further in Chapter 6 and Chapter 8.

5.5.3 Lenition and deletion as frequency effects

As we have seen in this chapter, lenition and deletion are often variable processes that are more likely to occur at faster speech rates, when less time is available for articulators to reach their canonical targets associated with a particular sound. Several important predictors of likelihood of lenition/deletion relate to usage factors explored by Bybee in a series of works (Hooper 1976, Bybee 2000a, b, 2001, 2002, 2007). Following earlier discussion in Chapter 2, one relevant observation is that weakening is more likely in high frequency than in low frequency words. For example, the non-final post-tonic vowel is more likely to either reduce or delete in a high frequency word like *memory* than in a lower frequency lexeme like *mammary* (Hooper 1976). Similarly, deletion of intervocalic /d/ in New Mexican Spanish is more likely in higher frequency words than in lower frequency items (Bybee 2002).

Another observation is that the same sound occurring in the same context is less likely to undergo weakening/loss if it occurs in a productively employed affix than if it occurs in a root. Thus, post-consonantal /t, d/ in English is more commonly lost in root-final position than when it is a regular past tense suffix (Bybee 2002).

Furthermore, the same affix is more prone to lenition/deletion when it occurs with a high frequency root than with a low frequency one, e.g. past tense /t, d/ in English (Bybee 2002).

The likelihood of deletion as a function of these different conditions is reducible to differences in duration. Gestural overlap between segments occurring *within* morphemes is greater and gestural magnitude is concomitantly smaller as articulatory sequencing becomes increasingly automated with repetition of the

morpheme. The result is shortening of sequences of segments in roots relative to their counterparts spanning morpheme boundaries (Losiewicz 1992). Similarly, repetition induces decreased gestural magnitude and duration in high frequency words (Jurafsky et al. 2001) and in the same affix when it occurs with high frequency roots (Losiewicz 1992). The speaker's awareness of the listener's ability to access a lexical item likely acts synergistically with the gestural reduction effects associated with increased frequency: the speaker is aware that articulatory effort may be safely reduced for words that are more predictable given their high frequency or the discourse context (Bybee 2002).

Stochastic implementations of Optimality Theory of the type discussed in Chapter 2, e.g. the Gradual Learning Algorithm of Boersma and Hayes (2001) and the maximum entropy OT grammar of Hayes and Wilson (2008), offer a promising means for formally modeling the predictive factors often driving lenition and deletion. The relative weight of these factors can be quantitatively integrated into the constraint ranking algorithm to either enhance or inhibit the likelihood of a given pattern emerging under different circumstances.

Another way in which certain types of frequency effects, particularly those sensitive to morphological complexity, can be implemented in the grammar is to assume that differences in frequency reflect differences in prosodic constituency. Zuraw (2009) explores the distribution of three optional phonological processes in Tagalog, showing that the application of these processes is sensitive to both morphological factors and the frequency of words. Focusing first on the phenomenon of tapping, Zuraw shows that tapping consistently applies at stem-suffix boundaries, consistently fails to apply in reduplicated forms, and applies variably in prefixed words and at stem-clitic boundaries. She also observes an interaction between morphology and frequency such that tapping is more likely in higher frequency items in prefixed words and at stem-clitic boundaries. Zuraw relates the frequency and morphological effects on tapping to differences in prosodic constituency between environments where tapping applies and where it fails to apply, suggesting that tapping applies within prosodic words but is blocked across prosodic word boundaries. Under this account, more frequent words where tapping is more likely are accessed as single prosodic words, while less frequent ones where tapping is less likely do not form a single prosodic word. Working within an Optimality-theoretic grammar Zuraw derives the variable tapping process of Tagalog by appealing to a phonotactic constraint banning non-tapped stops internal to prosodic words in combination with other constraints governing prosodic constituency. Zuraw extends her constituency-based account to two other variable processes in Tagalog: vowel raising and nasal substitution.

5.6 Epenthesis

Parallel to deletion, epenthesis (or insertion) may be motivated by various factors, some phonetic and some prosodic. Both vowels and consonants may be introduced by epenthesis and epenthetic segments may either interact with or be ignored by other phonological processes.

5.6.1 Epenthesis as syllable repair

Epenthesis is often employed as a strategy for repairing ill-formed syllables. Chapter 4 discussed the case of epenthesis in many Arabic varieties (e.g. Cairene and Iraqi Arabic), which is motivated by a prohibition against complex onsets and complex codas word-internally. In fact, many dialects undergo epenthesis even across word boundaries within an utterance. Thus, in Cairene Arabic, a vowel, typically [i] but [u] if followed within the same word by /u/, is inserted after the second consonant in a triconsonantal cluster both within (30a) and across (30b) morphological words (Watson 2007).

- (30) Epenthesis in Cairene Arabic (Watson 2007: 64)
- | | | | |
|-----|----------------------------|-------------------------------|----------------------------|
| (a) | ʔult-lak | ʔul.ti.lak | ‘I told you m.s.’ |
| | kull-hum | kul.lu.hum | ‘all of them’ |
| (b) | jaʕb suri:ja | jaʕ.bi.su.ri:ja | ‘the people of Syria’ |
| | kunt hina | kun.ti.hi.na | ‘I/you m.s. was/were here’ |
| | bint lat ^h i:fa | bin.ti.la.t ^h i:fa | ‘Latifa’s daughter’ |

Epenthesis in this case can be viewed as insertion of a vowel to allow an otherwise unsyllabified consonant to be parsed into a syllable (Broselow 1980, Ito 1989).

Consonants may also be epenthetic (see Picard 2003, Uffman 2007, Casali 2011). In many languages, epenthesis occurs in hiatus contexts in order to break up vowel sequences. In Chapter 4, we saw an example of epenthesis of /t/ to avoid hiatus in Axininca Campa. In Axininca Campa, epenthesis does not apply word-initially: *ana* ‘black dye’, *airi* ‘bee’ (Payne 1981: 77). A different epenthetic consonant, /g/ (/G/ before vowels other than /i/ in words containing pharyngealized vowels), is employed in Khalka Mongolian (Svantesson et al. 2005) to break up clusters of vowels arising at stem-suffix boundaries (see example (31)).

- (31) Epenthesis in Khalkha Mongolian (Svantesson et al. 2005: 55)
- | | |
|------------|------------------|
| xu: | ‘boy’ |
| xu:-g-er | ‘boy (instr.)’ |
| xu:-g-inj | ‘boy (gen.)’ |
| sana | ‘thought’ |
| sana-g-inj | ‘thought (gen.)’ |

5.6.2 Other prosodic functions of epenthesis

In many languages epenthesis is employed at the beginning of prosodic constituents where the size of the unit(s) triggering epenthesis varies. It is particularly common for glottal stop, often accompanied by transitional creak, to be inserted before vowels in initial position of prosodic domains larger than the word. Glottal epenthesis in this case is characteristically a gradient phenomenon that is predictable based on a series of factors such as phrasal position, stress, speech rate, segmental context, and gender (see Zygis 2010 for an overview). Final position is also

often associated with epenthesis of a glottal segment, such as glottal stop or /h/, subject again to similar gradience characteristic of initial glottal insertion.

There are other species of prosodic epenthesis that are not boundary phenomena. Many languages insert a vowel to satisfy a word-minimality constraint (see Chapter 8). For example, a prothetic /i/ is inserted in Seneca at the beginning of verbs to ensure satisfaction of a disyllabic word minimum holding of verbs (Chafe 1996), e.g. *dje:t* → *idje:t* ‘she’s standing there’ (p. 557).

Epenthesis may be sensitive to domains larger than the word. As we saw above, Cairene Arabic epenthesis applies across word boundaries. The domain of epenthesis in Galician (32) is even larger. An epenthetic [i] is optionally inserted at the end of an Intonational Phrase (corresponding to boundaries marked by a comma or period in the examples) if the final word of the phrase ends in a stressed vowel-final syllable (Martínez-Gil 1997). Epenthesis does not occur Intonational Phrase-medially as the last example in (32) shows.

- (32) Intonational Phrase-final epenthesis in Galician (Martínez-Gil 1997: 288–9)
- | | |
|---|---|
| Ela vai trael-o pan(i). | ‘She’s going to bring the bread.’ |
| O pan(i), fixo-no onte. | ‘(As for) the bread, (s)he made it yesterday.’ |
| Dille que traia pan(i), non viño. | ‘Tell him/her to bring bread, not wine.’ |
| Ela vai trae-lo pan(*pani) que comprou. | ‘She’s going to bring the bread that she bought.’ |

Martínez-Gil (1997) suggests that phrase-final epenthesis in Galician serves the purpose of creating a canonical disyllabic trochee containing the strongest stress, the rightmost one, in a phrase (see Chapter 6 for discussion of stress and foot structure).

An analog to this rhythm-sensitive epenthesis is also observed in Dutch, where optional processes of schwa epenthesis and schwa deletion increase in likelihood if they create rhythmic alternations between stressed and unstressed syllables (Kuijpers and van Donselaar 1997). For example, insertion of an epenthetic vowel into the cluster in a word like /tylp/ ‘tulip’ is more likely if the following word begins with a stressed syllable than if it starts with an unstressed syllable. Thus, *Ester zet de [ˈtylɔp]* ‘*liever op een tafel*’ ‘Ester puts the tulip rather on the table’ is more likely than *Ester heeft de [ˈtylɔp]* *ver’geten af te geven* ‘Ester has forgotten to leave the tulip’. Conversely, schwa deletion is favored where it eliminates a sequence of two consecutive unstressed syllables. Thus, *ˈkɪm.də.rən* ‘children’ is more likely to be realized without schwa, i.e. as *[ˈkɪm.drən]*, than *ˌbɑ.tə.ˈrɛi* ‘battery’ is to lose its schwa. Both the application of schwa epenthesis in *[ˈtylɔp]* and schwa deletion in *[ˈkɪm.drən]* avoid a stress lapse, or, in foot-based terms, they create a canonical disyllabic trochee (see Chapter 6).

Gordon and Nafi (2012) propose that one type of epenthesis found in Tashlhiyt Berber (see below in section 5.6.6 for another variety of epenthesis in Tashlhiyt triggered by voiced consonants) serves a higher-level function in the intonation system. They find that an optional process of epenthesis occurring either between a word-final cluster of voiceless consonants or after a final voiceless consonant is far more likely if the word occurs in the final position of an Intonational Phrase

than in other positions. For example, epenthesis occurs with regularity in *tftxt* ‘She rolled it (masc.)’ to produce *tftəxt* or *tftxtə* but not in *tf.txt bilad* ‘She rolled it (masc.) now’. Gordon and Nafi suggest that epenthesis phrase-finally provides a docking site for a H* pitch accent on the final syllable of a phrase that could otherwise not be realized on a voiceless consonant (see Chapter 7 for more on pitch accents and prosodic constituency).

5.6.3 Morphological constraints on epenthesis

Epenthesis may be limited to certain morphological contexts. In Axininca Campa (see Chapter 4), epenthesis of /t/ is sensitive to the distinction between prefixes and suffixes and between nouns and verbs (see Zygis 2010 for other languages with morphologically conditioned epenthesis). Epenthesis does not apply in nouns: the addition of the diminutive suffix *-iriki* thus fails to trigger epenthesis, e.g. *hito* + *iriki* → *hitoiriki* ‘small spiders’, *mapi* + *iriki* → *mapiiriki* ‘small rocks’ (Payne 1981: 110). Furthermore, even in verbs, epenthesis does not apply at the prefix-stem boundary, where vowel sequences are resolved instead through deletion of the prefixal vowel: e.g. *no* ‘my’ + *ana* ‘black dye’ + *ni* ‘possessive’ → *nanani* ‘my black dye’ (Payne 1981: 77).

5.6.4 Segmental constraints on epenthesis

It is common for languages to restrict epenthesis to particular segmental environments. In Chickasaw, speakers optionally insert an epenthetic vowel (schwa or, following /h/, often a copy of the preceding vowel) in clusters consisting of a /k/ + sonorant or /h/ + voiced consonant (Munro 1996, Gordon et al. 2000), e.g. *hakəlo* ‘s/he hears’, *lakəna* ‘brown’, *tohəbi* ‘white’. In such clusters, the obstruent is a syllable coda while the sonorant serves as a syllable onset. Epenthesis does not break up other coda + onset clusters, however, indicating that syllabification is not the only factor conditioning epenthesis.

Based on data from loanword adaptation and interlanguage phonology, Broselow (1983, 1987) and Fleischhacker (2001) find that epenthetic vowels tend to be inserted before sibilant + stop clusters (prothesis) but between members of other clusters (anaptyxis). For example, this difference is observed among speakers of Egyptian Arabic (Broselow 1987) in their adaptation of loanwords containing word-initial clusters, e.g. *iski* ‘ski’, *istadi* ‘study’ vs. *bilastik* ‘plastic’, *tiransilet* ‘translate’, *silajd* ‘slide’ (p. 294, 300). Sibilant + sonorant clusters display variation both cross-linguistically and even across lexical items within the same language in the locus of epenthesis. Fleischhacker (2001) reports that Kazakh displays variation between prothesis and anaptyxis on a lexeme-specific basis among loanwords from Russian beginning with a sibilant + nasal cluster, e.g. *ismen* from *smena* ‘change’ but *šimorodina* from *smorodina* ‘currant’. Sibilant + liquid clusters, however, uniformly are resolved through anaptyxis: *silesir* from *slesar* ‘metalworker’, *šilija* from *šleja* ‘breech’ (p. 4).

Fleischhacker (2001) examines the relative merits of syllable- vs. sonority-based analyses of epenthesis in onset clusters. Although appealing to a ban on complex onsets offers an explanation for why epenthesis is triggered at all by

onset clusters, it fails to account for the observed asymmetries in the location of the epenthetic vowel. Nor are the facts derived by assuming a prohibition against rising sonority clusters across syllable boundaries (see Chapter 4), since certain rising sonority sibilant + sonorant clusters may pattern (as in the case of Kazakh sibilant + nasal clusters in certain lexical items) with falling sonority sibilant + stop clusters in triggering prothesis. Furthermore, Fleischhacker mentions the case of Persian, in which voiceless sibilant + stop clusters are unique among onset clusters in triggering prothesis, whereas other clusters (those consisting of a sonority plateau, voiced sibilant + stop clusters, and non-sibilant fricative + stop clusters) all trigger anaptyxis. This distribution, which distinguishes between voiced sibilants and voiceless ones and between voiceless non-sibilant fricatives and voiceless sibilants) cannot readily be explained purely in terms of syllable structure.

Rather than being grounded in syllabification preferences, Fleischhacker proposes that the prothesis vs. anaptyxis asymmetry is instead grounded in perceptual factors. She hypothesizes that epenthesis occurs in the site that yields a surface form that is perceptually more similar to the underlying form. Anaptyxis is thus preferred in obstruent + sonorant clusters since the resulting CVC string represents less of a perceptual deviation from the input cluster than the alternative pattern of prothesis. Conversely, there is a bias toward prothesis in clusters of voiceless sibilant + stop since the insertion of a vowel between the sibilant + stop would be too divergent from the underlying sequence. In order to test her hypothesis, Fleischhacker (2001) conducts a perception experiment in which English listeners were asked to rate the similarity on a seven-point scale between a real English word beginning with a consonant cluster and a hypothetical English word that was otherwise identical to the real word except for containing either an epenthetic schwa before the cluster or between the two members of the cluster, e.g. [stok] 'stoke' vs. [əstok] or [sətok], [smək] 'smirk' vs. [əsmək] or [səsmək]. The cluster was varied such that different types varying in their behavior cross-linguistically were represented in the experimental corpus. Fleischhacker's results largely support her hypothesis. Listeners tended to judge obstruent + sonorant clusters as being more similar to their counterparts with an anaptyctic vowel than their counterparts with a prothetic vowel. On the other hand, listeners found sibilant + stop clusters to be more similar to versions with a prothetic vowel than tokens with an epenthetic vowel intervening between the sibilant and stop.

5.6.5 *The quality of epenthetic segments*

Certain types of sounds are more commonly deployed in an epenthetic capacity than others. Among vowels, schwa (or another acoustically similar central vowel) appears to be the most common epenthetic vowel followed by /i/ then /a/ according to a survey of epenthesis in 67 languages conducted by Kitto and de Lacy (1999). Epenthetic vowels may also shift in quality according to surrounding vowels. For example, in the Austronesian language Selayarese (Mithun and Basri 1985), the epenthetic vowel mirrors the vowel to its left (33).

(33) Epenthesis in Selayarese (Mithun and Basri 1985)

/sahal/	→	<i>sahala</i>	‘profit’
/potol/	→	<i>potolo</i>	‘pencil’
/lamber/	→	<i>lambere</i>	‘long’

One of the difficulties in assessing the relative frequency of different epenthetic vowels is that descriptions are often based on impressionistic observations that might not necessarily be corroborated acoustically. Gouskova and Hall (2009) thus find that the epenthetic vowel of Lebanese Arabic that is usually transcribed as /i/ is actually more back than a lexical /i/ and is more accurately transcribed as /i/. Similarly, Coleman (1999) observes diversity in the realization of Tashlhiyt epenthetic vowels, predictable in large part, though not exclusively, from the surrounding consonants.

The prevalence of schwa as an epenthetic vowel makes sense from an articulatory standpoint: being the vowel closest to the rest position of the tongue, schwa requires the least effort to execute. The relevance of articulatory effort minimization in predicting epenthetic vowel quality is supported by the qualitative variability of epenthetic vowels in languages like Selayarese and Tashlhiyt.

In the WALS 100-language sample, 28 cases of vowel epenthesis were identified. The most prevalent epenthetic vowel is schwa, which is reported for eight languages, although other epenthetic vowels are also attested: /e/ and /i/ in two languages each and /u/ and /a/ each in a single language. For two languages, the quality of the epenthetic vowel cannot be reliably inferred. Most common are languages (11 in the WALS survey) in which the epenthetic vowel varies as a function of context, either harmonizing (completely or along one or more dimensions) with a vowel in an adjacent syllable or varying as a function of the surrounding consonants. This type of contextual variation is expected if epenthetic vowels primarily serve as short transitional vocoids.

The motivations behind the choice of epenthetic consonant are more complex as evidenced by the diversity of consonants that are employed in an epenthetic role cross-linguistically. Most commonly, epenthetic consonants fall into one of three classes (Casali 2011): the glides /j/ or /w/, the glottals /h/ or /ʔ/, and coronal consonants, such as /t/, /n/ or a rhotic. In the WALS 100-language sample, 19 cases of consonant epenthesis were identified. The most common epenthetic consonants are glottal stop (observed in eight cases, in one of which glottal stop varies with a glide depending on context) and a glide (seven instances, in one of which a glide varies with glottal stop, and in another of which a glide varies with a rhotic). The remaining cases of epenthesis represent a diverse group: two languages with epenthetic /t/, one with a dorsal stop, one with a velar fricative, and one with [h].

De Lacy (2006) develops a theory of epenthesis in which context-free markedness principles interact with context-sensitive factors to produce variation in epenthetic consonants. For example, a universal markedness scale according to which glottals are least marked accounts for the prevalence of glottals in epenthesis. However, because glottals are higher in sonority than other consonants under de Lacy’s approach (an assumption supported by the common phonetic

realization of glottal consonants as non-modal vowels), they may be avoided in onset position where lower sonority consonants are preferred (see Chapter 4). Yet another potential competing factor is a requirement that an epenthetic consonant share features with a neighboring vowel, a constraint that motivates selection of a glide for insertion.

Vaux (2003b) shows, however, that although certain consonants may be more prevalent in epenthesis cross-linguistically, the array of attested epenthetic consonants is strikingly diverse. He presents an extensive list of epenthetic consonants including [t, d, n, ŋ, r, l, j, w, v, b, ʃ, ʒ, g, s/z, x, k]; this diversity is problematic for theories of epenthesis that attempt to constrain the set of potential epenthetic consonants by appealing to markedness or naturalness.

5.6.6 *The interaction between epenthesis and other phonological phenomena*

Epenthetic sounds vary in terms of their phonological behavior. In many languages, epenthetic sounds are ignored by processes that target full-fledged lexical segments. The epenthetic vowels intervening between /k/ or /h/ + sonorant clusters in Chickasaw are completely transparent to the phonology. The left-to-right weight-sensitive iambic stress system (see Chapter 6) ignores them, stressing the syllable that was originally heavy (CVC) before an epenthetic vowel was introduced, e.g. (*lak*)ə('na) not *(*la,kə*)('na) 'brown', (*hak*)ə('lo) not *(*ha,kə*)('lo) 's/he listens to it', and continuing the scan with the vowel after the epenthetic vowel, e.g. (*tʃi,hak*)ə(lo'tok) not *(*tʃi,ha:*)(*kə'lo:*)(*,tok*) 's/he listened to you'.

Similarly, Tashlhiyt has a second process of vowel insertion in addition to the one claimed earlier in section 5.6.2 to provide a docking site for an intonational pitch accent. A vowel in Tashlhiyt is optionally inserted between voiced consonants (Dell and Elmedlaoui 2002), where the location of these inserted vowels (termed "voiced transitional vocoids" by Dell and Elmedlaoui) varies in a way that is not necessarily predictable from syllable structure. For example, a vowel may be added before a voiced consonant that is a syllable onset (syllable nuclei are indicated by an underline in the examples), e.g. *tʃə.bɪ* 'she painted' (Dell and Elmedlaoui 2002: 144), before a syllable nucleus, e.g. *il.kəmt* 'You arrived' (Gordon and Nafi 2012: 722), before a syllable coda, e.g. *i.ʃəx* 'He is dirty' (Dell and Elmedlaoui 2004: 144), or even in two positions within the same syllable, e.g. *i.xənəg* 'He strangled' (Dell and Elmedlaoui 2002: 145). Other aspects of the phonology (e.g. the metrical system, the system of templatic morphology) are blind to these transitional vowels and speakers are largely unaware of them.

Inserted vowels that are invisible to the phonology are often regarded as "excrecent" in order to distinguish them from "true" epenthetic vowels that may be inserted to satisfy phonological constraints (e.g. constraints on syllabification, minimality, the metrical parse) and/or that interact with the phonology (see Hall 2011 for an overview of this distinction).

In practice, the division between excrecent and epenthetic segments is often difficult to discern since an inserted vowel may be transparent to certain phonological phenomena but opaque to others or may even differ in its visibility to the

same process depending on conditioning context. For example, an epenthetic vowel inserted to break up a cluster of three consonants in Lebanese Arabic is ignored by the stress system (which normally places stress on a heavy penult), e.g. /katab-t-l-a/ → ka.'ta.bit.la 'I wrote to him', |ʔalf-na/ → 'ʔa.lif.na 'our thousand', whereas an epenthetic vowel in a cluster of four consonants is eligible to receive stress by the normal stress rules of the language, e.g. /katab-t-l-ha/ → ka.tab.'til.ha 'I wrote to her' (Gouskova and Hall 2009).

5.7 Metathesis

Metathesis refers to a reversal in the ordering of segments. Metathesis is less common than the other processes we have discussed in this chapter (there were only ten cases in the WALS 100-language survey) and is often a sporadic phenomenon associated with particular lexical items. Much of the literature devoted to metathesis has concentrated on diachronic sound changes (e.g. Ultan 1978b, Hock 1985, Blevins and Garrett 1998, 2004). A notable exception is Buckley's (2011) overview of metathesis, which focuses on synchronic alternations.

Metathesis can be broadly divided into two subtypes according to whether the transposed sounds are adjacent or separated by one or more intervening sounds. Of the two types, local metathesis is more common compared to non-local metathesis, which is largely confined to the diachronic domain and displays a more circumscribed range of variation than its local counterpart.

There are two varieties of local metathesis that are clearly attested: metathesis involving a consonant and vowel and metathesis of two consonants. Unambiguous cases of vowel–vowel metathesis appear to be lacking (see Buckley 2011 for discussion). Hume's metathesis database (<<http://metathesisinlanguage.osu.edu/database.cfm>>) cites 65 languages with consonant–consonant metathesis as either an active synchronic process or a diachronic sound change compared to 47 involving metathesis of a consonant and vowel.

Metathesis commonly targets consonant clusters in which one member is a sibilant fricative. For example, Faroese (Lockwood 1955, Árnason 2011) displays reordering of a root-final sibilant + stop cluster in the neuter form of monosyllabic adjectives ending in *-t* (34a). In polysyllabic adjectives, the stop is deleted (34b).

(34) CC metathesis in Faroese (Lockwood 1955: 23–4)

	<i>Masculine</i>	<i>Neuter</i>	<i>Gloss</i>
(a)	fɛsk-ur	fɛks-t	'fresh'
	baisk-ur	baiks-t	'bitter'
	svensk-ur	svɛŋks-t	'Swedish'
(b)	førisk-ur	føris-t	'Faroese'
	røsis-k-ur	røsis-t	'Russian'

Other types of consonant clusters may be targeted by epenthesis. Blevins and Garrett (2004) cite an optional pattern of metathesis of /pk/ clusters to /kp/ in the

Austronesian language Mokilese (Harrison 1976): e.g. /*apkas*/ ‘now’ → *apkas* or *akpas*, /*dipkelkel*/ ‘to stumble’ → *dipkelkel* or *dikpelpel*.

Consonant vowel metathesis is observed in the historical process by which sequences of vowel + liquid in Late Common Slavic were transposed in most daughter languages if a consonant (other than /j/) followed (Townsend and Janda 1996). The data in (35) show representative examples of this metathesis in Polish and Bulgarian.

(35) VC metathesis in Late Common Slavic (Townsend and Janda 1996: 60–1)

<i>Late Common Slavic</i>	<i>Gloss</i>	<i>Polish</i>	<i>Bulgarian</i>
<i>gôrdû</i>	‘enclosure’	<i>grod</i>	<i>grad</i>
<i>golvá</i>	‘head’	<i>gwowa</i>	<i>glavá</i>
<i>sólma</i>	‘straw’	<i>wwoma</i>	<i>sláma</i>
<i>melkó</i>	‘milk’	<i>mleko</i>	<i>mláko</i>

The Slavic case entails a shift from a VC to CV. It is also possible, though rarer typologically, for CV to undergo reordering to VC. A famous case of metathesis of this type occurs in Rotuman (Churchward 1940), where verbs occur in two forms, termed the ‘complete’ and ‘incomplete’, where the former is used to convey greater finality, certainty, or emphasis (36). The complete forms contain the historically more conservative CV sequence, whereas the incomplete forms display metathesis (Blevins and Garrett 1998).

(36) CV metathesis in Rotuman (Blevins and Garrett 1998: 531)

<i>Complete</i>	<i>Incomplete</i>	<i>Gloss</i>
<i>mofa</i>	<i>moaf</i>	‘rubbish, refuse, garbage’
<i>mure</i>	<i>muer</i>	‘(of wind) to blow gently’
<i>peka</i>	<i>peak</i>	‘to be scarce or rare’

Liquids are most commonly involved in cases of long-distance metathesis. Liquid metathesis has occurred in some lexical items in the course of the development of Latin into Spanish, e.g. Latin *peri:kulum* > Spanish *peligro* ‘danger’, Latin *parabola* > Spanish *palabra* ‘word’ (Ullán 1978b).

Other cases of long-distance movement of segments, often assumed to fall under the rubric of metathesis, entail displacement of a sound from its original location to a new one rather than transposition of two sounds. For example, Blevins and Garrett (2004) discuss long-distance metathesis of liquids occurring in the variety of Greek spoken in southern Italy (Rohlf's 1950, 1964). Metathesis moved a non-initial liquid to an immediately prevocalic position in the first syllable (subject to certain constraints) if the first syllable contained a prevocalic non-coronal obstruent (37a). Only /r/ and not /l/, however, was targeted if the first syllable contained a prevocalic /t/ (37b). Note that Classical Greek words, either native (unmarked) or borrowed from Latin (marked with ‘L’), show the pre-metathesis counterparts to the metathesized variants in South Italian Greek.

- (37) Liquid displacement in South Italian Greek (Blevins and Garrett 2004)

	<i>Classical Greek</i>	<i>South Italian Greek</i>	<i>Gloss</i>
(a)	gambrós	grambó	'son-in-law'
	k ^h ondrós	xrondó	'thick'
	pastríkós	prástiko	'clean'
	fakula (L) > (*fákla)	fláka	'torch'
	spékula (L) > (*spékla)	spékla	'elevated place'
(b)	tágistrón	trástina	'food bag'
	but tábula (L) > tábla	távla	'table'

Metathesis can serve morphological purposes in some languages (Thompson and Thompson 1969). For example, in the Salishan language Klallam, the difference between the two aspects labeled 'actual' and 'non-actual' (roughly corresponding to imperfective and perfective, respectively) by Thompson and Thompson are conveyed through metathesis (38). Note that the final /t/ in all forms is a suffix indicating that the agent is in control of the action.

- (38) Morphologically driven metathesis in Klallam (Thompson and Thompson 1969: 216)

<i>Non-actual</i>		<i>Actual</i>	<i>Gloss</i>
tʃk ^w u-t	'shoot'	tʃuk ^w -t	'shooting'
χtʃ ^w i-t	'scratch'	χitʃ ^w -t	'scratching'
q ^w x ^w i-t	'tie up'	q ^w ix ^w -t	'tying up'
tʃ ^w k ^w ə-t	'grasp'	tʃ ^w ək ^w -t	'grasping'
tʃsə-t	'shatter'	tʃəts-t	'shattering'

5.7.1 The phonetic source of metathesis

Blevins and Garrett (2004) propose a typology of metathesis classified into four groups according to its phonetic motivations. In Blevins and Garrett's typology, one common type of metathesis arises from the misinterpretation of the phonological source of a feature whose phonetic cues are potentially realized over an extended temporal domain. For example, the liquid shift of South Italian Greek plausibly arose when the long-distance coarticulatory effects of the liquid on the formant structure of other vowels in the word created uncertainty about the location of the liquid. This 'perceptual metathesis' account appeals to the same coarticulatory patterns that Ohala (1981) hypothesizes motivate assimilation (section 5.1) and dissimilation (section 5.2). Metathesis arises when the listener identifies the presence of coarticulation but misinterprets the source of the coarticulating feature, a scenario depicted schematically in Figure 5.6 for the Slavic vowel + liquid metathesis.

Given the tendency for liquids to alter formant structure over extended domains, it is not surprising that liquids are commonly involved in long-distance dissimilation (see the discussion of Sundanese in section 5.2.1) and metathesis.

Another source of metathesis in Blevins and Garrett's taxonomy is gestural overlap between consonants in a stop + stop cluster, which potentially leads to perceptual transposition of the consonants. For example, the Mokilese optional

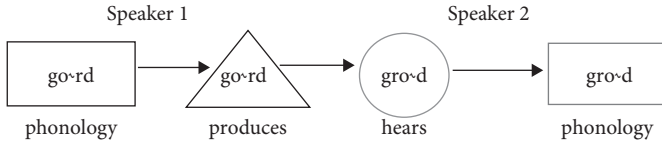


FIGURE 5.6. Perceptual misapprehension model of Slavic liquid metathesis

metathesis of /pk/ to [kp] is plausibly attributed to an articulatory tendency for the velar gesture for [k] to overlap substantially with the [p], eventually to the point where a perceptual bias potentially leads the listener to infer that the closure for [k] precedes the closure for [p]. Blevins and Garrett note that the typology of metathesis involving stop clusters is unidirectional: *pk* becomes *kp* and *tp* becomes *pt* but *kp* does not transpose to *pk* and *pt* does not shift to *tp*. It also mirrors patterns seen in doubly articulated stops, in which labial velars always phase the velar before the labial (i.e. $k\bar{p}$ not $*\bar{p}k$), and in regressive place assimilation (section 5.1.2), where velars are most resistant and coronals least resistant to assimilation. The parallel between metathesis and assimilation suggests that certain timing patterns are articulatorily more natural than others (see Zsiga 1994 and Byrd 1994 for evidence of articulatory biases from English, which allows various types of stop + stop clusters) and may act synergistically with perceptual biases in temporal ordering to set the stage for metathesis.

A third type of metathesis, termed “compensatory metathesis” by Blevins and Garrett (1998, 2004), involves the migration of a postconsonantal vowel to the position immediately in front of the consonant, as in the Rotuman morphological alternations between complete and incomplete forms discussed above, e.g. *'mofa* vs. *'moaf* ‘rubbish, refuse, garbage’, *'mure* vs. *'muer* ‘(of wind) to blow gently’. Blevins and Garrett (1998, 2004) propose that this type of metathesis results from coarticulation between two vowels across an intervening consonant whereby the gestures associated with a hypoarticulated unstressed vowel gradually migrate to a preceding stressed (and lengthened) vowel. Blevins and Garrett present detailed case studies of the historical development of metathesis in Rotuman (and the Oceanic language Kwara’ae) showing that the alternations between complete and incomplete that are now morphologically governed were once likely prosodically predictable. The complete forms were at one time followed by monosyllabic suffixes whereas the incomplete forms can be traced back to positions in which they were followed either by no suffix or by a disyllabic suffix (Hale and Kissonck 1998). Primary stress was consistently penultimate and secondary stress preante-penultimate, meaning that the complete forms followed by a monosyllabic suffix had stress on the final vowel of the stem, e.g. $*mo'se-\sigma$, whereas their incomplete counterparts followed by no suffix or by a disyllabic suffix had either primary stress (when unsuffixed, e.g. $*'mose$) or secondary stress (when followed by a disyllabic suffix, e.g. $*'mose^{-1}\sigma\sigma$) on the penultimate vowel of the stem. Assuming that perceptual metathesis results from leeching of properties from an unstressed to a stressed vowel, coarticulatory spreading of features from the second to the first vowel of the stem would only induce diphthongization if the stem were followed by a monosyllabic suffix. Subsequent processes of apocope targeting

unstressed vowels, leveling of stress to the penult, and absorption of the vowel copy in the definite then produced the doublets found synchronically. In addition, certain diphthongs were monophthongized, e.g. *'fuit* > *'fyt* (cf. complete form *'futi*) 'to pull', *'moes* > *'møs* (cf. complete form *'mose*) 'to sleep' (Blevins and Garrett 1998: 527). This historical progression is illustrated schematically in (39) for two pairs of unsuffixed stems and their counterparts followed by the definite suffix, realized as a copy of the final vowel of the stem (based on Blevins and Garrett 1998: 533).

(39) Historical development of CV metathesis in Rotuman

	No suffix (incomplete)		σ -suffix (complete)	
Original	* <i>'mose</i>	* <i>'peka</i>	* <i>mo'se-e</i>	* <i>pe'ka-a</i>
Diphthongization	<i>'moese</i>	<i>'peaka</i>	n.a.	n.a.
Apocope (and monophthongization)	<i>'møs</i>	<i>'peak</i>	n.a.	n.a.
Stress leveling	n.a.	n.a.	<i>'mosee</i>	<i>'pekaa</i>
Synchronic	<i>'møs</i> 'to sleep'	<i>'peak</i> 'to be rare'	<i>'mose</i>	<i>'peka</i>

In support of their account, Blevins and Garrett (1998) cite Churchward's (1940: 88) observation that the complete form is used in contexts calling for "positiveness, finality, or emphasis or (in questions) the desire to be positive or certain" and suggest that these conditions are likely to disrupt the normal prosodic patterns of the language, including the regular rule of penultimate stress that gave rise to metathesis. Further evidence for their analysis is provided by a typological link that Blevins and Garrett identify between compensatory metathesis and other structural properties of the languages in which it occurs. They find that it is limited to languages, such as Rotuman, which possess properties that likely enhance the magnitude of vowel-to-vowel coarticulation, thereby providing the phonetic precursor to compensatory metathesis. Such properties include small vowel inventories, and the absence of secondary articulations, consonant clusters, and diphthongs.

The final type of metathesis in Blevins and Garrett's (2004) catalog involves sibilant + stop sequences (in either order), which they suggest are often targeted by metathesis due to the auditory difficulty of temporally ordering noise relative to other acoustic events in the speech string. This type of metathesis, which Blevins and Garrett term "auditory metathesis," is common cross-linguistically and was illustrated earlier for Faroese, in which an intervocalic /sk/ cluster metathesizes to /ks/ before /t/ in monosyllables.

5.7.2 Metathesis as perceptual optimization

Noting that cases of metathesis involving sibilants and stops characteristically place the stop adjacent to a vowel (prevocally if possible, otherwise postvocally), Steriade (2001) suggests that metathesis serves the goal of enhancing the perceptibility of the less salient member of the cluster, the stop, by moving it to a context where it benefits from transitional cues from an adjacent vowel. Ideally, the more informative transition into a following vowel is available (hence, the

preference for sibilant + stop ordering prevocalically), but, if not, a preceding vowel is preferable to no vowel at all (hence, the preference for a stop + sibilant sequencing before another consonant). The Faroese data is compatible with Steriade's account, since the root-final stop occupies a prevocalic position intervocalically and shifts to a postvocalic position before the neuter suffix /-t/.

However, not all metathesis data follow the pattern predicted by Steriade's analysis. Blevins and Garrett (2004) cite an example from Grammont (1923) of a word-final stop shifting out of its postvocalic position in certain colloquial varieties of French, e.g. *fiks* → *fisk* 'fixed' *lyks* → *lysk* 'luxury'. Blevins and Garrett contrast the French pattern with late West Saxon varieties of Old English which underwent exactly the opposite change (one predicted by Steriade's account) in final position, e.g. *frosk* → *froks* 'frog', *husk* → *huks* 'insult'. It is plausible that the coexistence of both directionalities in the typology may be attributed to the possibility of final position providing for a salient release burst, which might be deemed on a language-specific basis to be more informative than a vocalic transition. Yet, the same shift from sibilant + stop to stop + sibilant occurred intervocalically in late West Saxon, e.g. *aske* → *akse* 'ash', *fiskas* → *fiksas* 'fish', where one would presumably expect, according to Steriade's account, the stop to remain in prevocalic position where it would benefit from the more informative transition into a following vowel.

Other types of metatheses in Blevins and Garrett's (2004) typology are also potentially amenable to a perceptual optimization analysis along the lines of Steriade's account of stop-sibilant metathesis. For example, perceptual metathesis could plausibly be implemented as a strategy to enhance a feature or segment by moving it to a more salient position (cf. Flemming's 1996 analysis of Cherokee laryngeal metathesis and Steriade's 1999 account of glottal displacement to stressed syllables in Shuswap). Similarly, the directional asymmetries in stop + stop metathesis could be argued to reflect an attempt to bolster the perceptibility of inherently less salient consonants, labials in velar + labial clusters, and coronals in coronal + labial clusters, by moving them to prevocalic position, where they benefit from the formant transitions provided by a following vowel. Finally, compensatory metathesis of an unstressed vowel to a stressed position, as in Rotuman, also enhances the perceptibility of an unstressed vowel by moving it to a position where it escapes deletion.

Metathesis is merely one venue in which the broader debate about the relative merits of the historically driven innocent misapprehension approach to phonology espoused by Ohala (1981, 1989, 1993, 1994), Blevins (2004, 2006), and Blevins and Garrett (1998, 2004) as opposed to the more teleologically driven perceptual optimization account of Jun (1995, 1996, 2004), Steriade (1999, 2001), Fleischhacker (2001), and others is being played out.

5.8 Summary

Phonological phenomena applying at the segmental level can be broadly divided into three classes, which can be further subdivided along multiple dimensions.

The first broad set of phenomena operates at the level of features. Assimilation involves a sound assuming one or more features of an adjacent or nearby sound, whereas dissimilation involves a sound adopting one or more properties that are unlike those of a neighboring sound. Assimilation and dissimilation can be further differentiated according to whether the target and trigger are local or at a distance from each other. Fortition involves the strengthening of a sound or class of sounds in prosodically strong contexts (e.g. stressed syllables, initial position), whereas lenition is characterized by the weakening of a sound or class of sounds or by the loss of contrast in positions of reduced strength (e.g. unstressed syllables, final position). Assimilation, dissimilation, fortition, and lenition may manifest themselves either as active alternations or as static co-occurrence restrictions. The second coarse class of feature-level phonological operations involves a change in the number of segments induced either by deletion or insertion of a sound. Deletion of one sound is often accompanied by compensatory lengthening of another sound. The final type of feature-level phonology is characterized by a reordering, or metathesis, of sounds either locally or at a distance.

Segment-level phonology is sensitive to a number of asymmetries. Certain types of sounds are thus more likely to be targeted and certain types of environments are more prone to act as triggers. Phonetic and functional considerations such as ease of articulation, perceptual distinctness, and the nature of speech processing predict many of the observed asymmetries, although it is a matter for debate whether these factors exert their influence primarily as precursors for historical changes or act as productive synchronic triggers for speakers aware of their own physical constraints and the perceptual challenges faced by listeners. It is also unclear whether all alternations and constraints affecting segments are amenable to phonetic and functional explanations; certain patterns are parsimoniously accounted with reference to phonological predicates such as hierarchically arranged features and prosodic constituents like the syllable.

6

Stress

Stress refers to greater prominence associated with certain syllables. This prominence may be manifested through various acoustic properties and their perceptual analogs, such as increased duration, higher fundamental frequency (the acoustic analog to the perceptual property of pitch), and/or increased intensity (i.e. greater loudness perceptually) (see Gordon 2011 for an overview of acoustic and perceptual correlates of stress). Consonants and vowels in stressed syllables may also undergo various fortition processes in stressed syllables, while consonants and vowel in unstressed syllables may conversely display lenition effects (see Chapter 5). Stressed syllables also are characteristically eligible to receive intonational pitch accents in larger prosodic constituents (see Chapter 7 on intonation).

The majority of languages appear to possess some type of stress system, although there is considerable cross-linguistic variation in the role of stress and its relation to other prosodic properties such as tone and intonation. According to Goedemans (2010: 649), of the 176 languages among the 200-language WALS sample for which prosodic information was available, 141 (roughly 80%) use stress (some in addition to tone) compared to 28 that have only tone or pitch accent. (Goedemans identifies seven further languages for which it is “explicitly stated that they have no (fixed) stress while no information on tones was found either”).

Stress patterns can be described according to various phonological dimensions, including the location of stress, the degree to which stress is phonemic (contrastive) or not, whether primary and secondary stress are differentiated, whether stress is sensitive to the internal structure (weight) of syllables, and how stress interacts with other prosodic properties such as tone and intonation. The literature on stress typology is rich in terms of quantifying the range of cross-linguistic variation observed in stress systems. One of the largest typological surveys of any phonological property is the StressTyp database (van der Hulst and Goedemans 2009), which includes information on stress patterns in 510 languages, and its successor StressTyp2 (Goedemans et al. 2015), which comprises data from over 750 languages. There is also a relatively long history of typologically informed theories of stress. This chapter provides an overview of the typology of stress patterns and their treatment in phonological theory.

6.1 The descriptive typology of stress

In considering the typology of stress systems, it is useful to make an initial distinction between languages in which stress is largely predictable based on

phonological properties such as the structure (weight) of syllables and/or their location in a word and those in which stress is used to contrast lexical items or different morphological forms in a paradigm. In practice, most languages have neither purely predictable stress nor purely contrastive stress, but fall somewhere along a continuum of degree of predictability. At (or close to) one end is a language like Finnish in which words have primary stress on the initial syllable. At the other end is a language like Russian in which stress is lexically and morphologically specified (Halle 1973). Somewhere in between is Spanish, which largely adheres to the generalization that stress is penultimate unless the final syllable ends in a consonant other than /n/ or /s/ (Harris 1969), but has a fair number of words that do not follow this pattern. Peperkamp et al. (2010) estimate that the predictable stress rule accounts for roughly 83% of the vocabulary of Spanish, leaving a substantial minority of cases that do not. Interestingly, though, even lexical exceptions conform to the generalization that stress falls on one of the final three syllables. Limitations of this type are typical of languages with lexical stress; stress appears never to be truly free; rather it is constrained to a subset of positions. Conversely, even in languages like Finnish in which stress consistently falls on the same syllable, there are typically corners of the phonology in which irregularities crop up. In the case of Finnish, some polysyllabic loanwords trigger deviations from the predictable secondary stress pattern characterized by weight-sensitive rhythmic stress (Kiparsky 2003).

In practice, most descriptions of stress found in grammars and other primary sources do not contain the level of detail available for more thoroughly studied languages like Spanish, Russian, and Finnish. Rather, the typologist must rely on the primary researcher's overall assessment of the degree to which stress is predictable. It is also often unclear from published descriptions how stress was diagnosed by the researcher, e.g. based on impressionistic judgments or verified through acoustic analysis and/or phonological diagnostics (see de Lacy 2014 for an overview of issues concerning the empirical basis of stress typology). With these caveats in mind, we first consider the typology of predictable stress patterns in sections 6.2–6.6 before looking at lexical and morphological stress in section 6.7.

6.2 Phonologically predictable stress

Among languages that have phonologically predictable stress systems, a basic distinction can be drawn between those that are sensitive to the internal structure (or weight) of syllables, typically termed “quantity-sensitive” or “weight-sensitive” stress systems, and those that are not, the “quantity-insensitive” or “weight-insensitive” systems. Both weight-insensitive and quantity-sensitive systems are well represented in languages of the world. Of the 510 languages in the StressTyp database, Goedemans (2010) classifies 278 (55.5%) as having strictly weight-insensitive stress compared to 222 (44.5%) incorporating some degree of sensitivity to other factors. The latter group consists predominantly (54%) of languages with “prototypical” weight-sensitive stress, for primary or secondary stress or both,

but also includes languages (18%) with lexical stress and languages (28%) in which properties other than weight, e.g. tone (see section 6.6), govern stress.

6.2.1 *Weight-insensitive stress*

The simplest type of weight-insensitive system positions a single stress a fixed distance from the edge of the stress domain, which for expository purposes I will refer to here as the word though it may be a larger prosodic constituent in some languages (see section 6.3 for discussion). There are five uncontroversial locations of stress that have been identified in typological surveys of stress: the initial syllable, e.g. Chitimacha (Swadesh 1946), the last syllable, e.g. Atayal (Egerod 1966), the penultimate (second-to-last) syllable, e.g. Albanian (Hetzer 1978), the antepenultimate (third-to-last) syllable, e.g. Macedonian (Lunt 1952, Franks 1987), and the peninitial (second) syllable, e.g. Koryak (Zhukova 1972). Figure 6.1 plots the relative frequency of languages (expressed as a percentage of the different stress locations) positioning stress on each of these five syllables according to three surveys: Hyman (1977: 306 total languages), Gordon (2002a: 186 languages), and the online version of StressTyp (van der Hulst and Goedemans 2009: 211 languages) as determined by querying (without any additional filters) each stress position in the StressTyp database. Note that Hyman's survey differs from the other two surveys in the figure in including languages with weight-sensitive stress and it also differs from the figures in Gordon's survey in encompassing languages with alternating (binary) stress.

As the figure shows, all three surveys of stress are consistent in that initial, penultimate, and final stress together account for the vast majority of fixed stress languages with peninitial and antepenultimate stress both being considerably rarer. The most salient difference between surveys is the strong bias in favor of

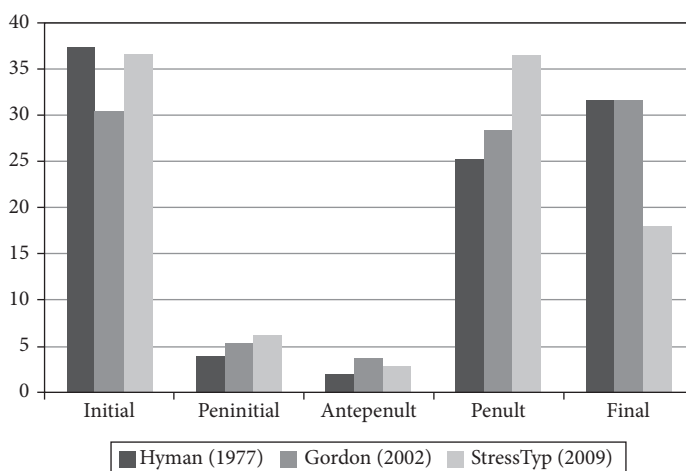


FIGURE 6.1. Relative frequency (expressed as percentage of the total cases) of different stress locations in three surveys of stress

penultimate over final stress in the StressTyp database compared with the slight preference for final over penultimate stress found in the Hyman (1977) and Gordon (2002a) surveys. This difference may be due to StressTyp's bias in favor of the Austronesian and Australian language families (Goedemans 2010), in both of which penultimate stress predominates. In addition to the five stress locations shown in Figure 6.1, we might add one other represented in StressTyp (van der Hulst and Goedemans 2009), the third syllable from the left, instantiated by Ho-Chunk (but see Hayes 1995 for reanalysis as peninitial stress).

Considerably rarer than languages that have a single fixed stress per word are "hammock" (Elenbaas and Kager 1999) or "dual" (Gordon 2002a) stress systems, which position a stress at or near each edge. For example, Lower Sorbian (Janas 1984) places primary stress on the first syllable and secondary stress on the penultimate syllable (1). The secondary stress is suspended in trisyllabic words in order to avoid a sequence of adjacent stresses, a stress "clash."

- (1) Initial and penultimate stress in Lower Sorbian (Janas 1984)

'pɪsɑs ^j	'write
'dɔbri	'good
'wɔs ^j tsɔjska	'fatherland'
'ps ^j ijas ^j ɛl	'friend'
'spewa ^j utsi	'singing'
'dɔpred ^j karski	'progressive'

In his survey of 262 weight-insensitive stress systems, Gordon (2002a) identifies only 14 (5.3%) such "dual stress" languages, a small number in comparison to the 167 (63.7%) languages in his survey with a single fixed stress per word.

There are also many languages that rhythmically place stress at regular intervals in a word, thereby ensuring that there are no extended sequences of unstressed syllables in longer words. In most languages with rhythmic stress, stress adheres to a binary alternation of stressed and unstressed syllables. For example, in Osage (Altshuler 2009), stress falls on even-numbered syllables with the first stress in the word being the primary one (2).

- (2) Stress on even-numbered syllables in Osage (Altshuler 2009)

ɑ:'le:	'I left'
nā:'xɔ	'break by foot'
^h pɑ:ʃ ^j 'tsɛka	'strawberry'
ðy:' ^h ka:mā	'to ring the bell'
xɔ:'tsɔði:b,rā	'smoke cedar'
ā:'wāla:xyyɛ	'I crunch up my own (e.g. prey) with teeth'

Gordon cites only 38 languages (14.5% of his 262 surveyed languages) with alternating stress. The percentage of languages with alternating stress may not, however, be accurate for two reasons. First, secondary stress is potentially under-reported in primary language sources due to its lesser perceptual salience.

Conversely, there is also the possibility of secondary stress being overreported (see, for example, Newlin-Łukowicz 2012 on Polish).

There are four logically possible types of strict alternating systems if one cross-classifies the edge from which the alternating stress pattern propagates and whether it commences with a stressed syllable, i.e. “peak-first”, or unstressed syllable, i.e. “trough-first”: stress on odd-numbered syllables counting from left to right, stress on even-numbered syllables counting from right to left, stress on odd-numbered syllables from right to left, stress on even-numbered syllables from left to right. These four possibilities are shown schematically in (3).

(3) Typology of alternating stress systems

Pattern	Schematic forms	Example languages
1. Odd-numb'd from L to R	'σσ,σσ,σ, 'σσ,σσ,σσ	Czech (Kučera 1961), Maranungku (Tryon 1970)
2. Even-numb'd from L to R	σ'σσ,σσ, σ'σσ,σσ,σ	Sirenikski (Menovshchikov 1975)
3. Odd-numb'd from R to L	,σσ,σσ'σ, σ,σσ,σσ'σ	Chulupí (Stell 1972), Urubú Kaapor (Kakumasu 1986)
4. Even-numb'd from R to L	σ,σ'σσ, ,σσ,σσ'σσ	Cavineña (Key 1961, 1967), Warao (Osborn 1966)

There are discrepancies in the frequency with which these four logically possible binary patterns are represented. Languages with stress on odd-numbered syllables counting from the left (pattern 1) and even-numbered from the right (pattern 2) are far more common than the other two patterns. There is also a bias toward

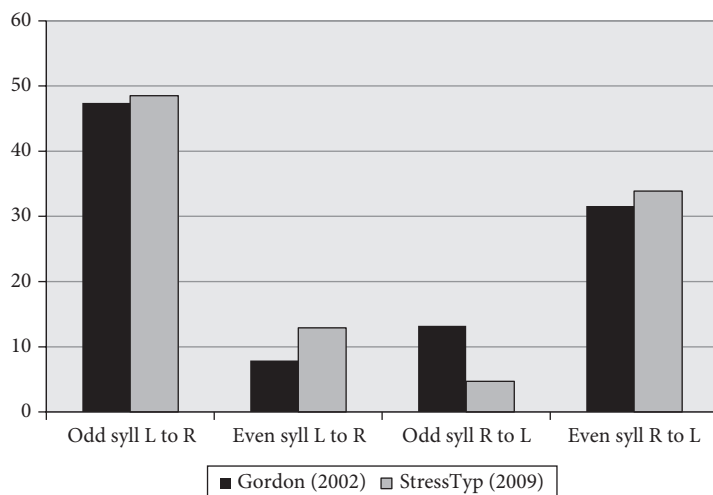


FIGURE 6.2. Relative frequency (expressed as percentage of the total cases) of different binary stress patterns in two surveys of stress

left-to-right binary stress systems over right-to-left systems. These biases can be seen in Figure 6.2, which plots the relative frequency (expressed as a percentage of the total cases of binary stress) of the four binary patterns in Gordon's (2002a) survey of 38 binary stress languages and Goedeman's (2010) summary of the StressTyp database, which includes 171 binary stress systems.

In addition to the strict binary stress patterns, there are some languages in which stress adheres to a binary rhythm except at one edge of the word where either an expected stress is missing or an unexpected one is added. One of these modified binary stress patterns, exemplified by Pintupi (Hansen and Hansen 1969, 1978), involves stress on odd-numbered syllables counting from the left with the exception of final syllables. Interestingly, the inverse of this pattern involving right-to-left footing but with no stress on the initial syllable appears to be unattested.

There are also hybrid systems in which a single fixed stress at one edge co-occurs with a binary pattern initiating at the other edge. For example, stress in the South Conchucos variety of Quechua spoken in Peru (Hintz 2006) falls on the penultimate syllable and on even-numbered syllables counting leftwards from the penult. The initial syllable is also stressed. There is variation between discourse data and elicited data in which stress is the primary one. In elicited data, the penultimate stress is the strongest, whereas the initial stress is the primary one in discourse data. Forms illustrating stress in South Conchucos Quechua appear in (4), with the location of the primary stress reflecting discourse pronunciations.

- (4) Hybrid binary plus fixed stress in South Conchucos Quechua (Hintz 2006)
- | | |
|---|---|
| ' \int umaq | 'pretty' |
| 'ima,kuna | 'things' |
| ' \int upan,kiman, \int achi | 'you would likely have just gotten drunk' |
| ' \int akran,tsik:u,nata,ra: \int fir | 'yet our gardens supposedly' |
| 'pi,tapis | 'anybody' |
| 'tu, \int uku,naqa | 'dancers' |
| 'wa,ra:ka,munqa,nat \int i | 'I crunch up my own (e.g. prey) with teeth' |

A variant of the South Conchucos Quechua pattern is reported for Garawa (Furby 1974), in which the alternating pattern is suspended where it would result in a stress clash. The difference between South Conchucos Quechua and Garawa can be seen by comparing stress in words with an odd number of syllables. For example, South Conchucos Quechua has the stress pattern ' $\sigma_1\sigma_2\sigma_3\sigma_4$ ' in a word of five syllables, whereas the Garawa counterpart to this form lacks the secondary stress on the peninitial syllable, i.e. ' $\sigma_1\sigma_2\sigma_3$ '. Systems like the one in South Conchucos Quechua in which rhythmic stress is found even in clash contexts are termed "binary plus clash" patterns by Gordon (2002a), while systems like the Garawa one in which a rhythmically placed stress fails to appear where it would clash with an adjacent fixed stress are referred to by Gordon as "binary plus lapse" systems.

There is also a small number of languages that display a ternary stress system, in which every third rather than every other syllable is stressed. For

example, Cayuvava (Key 1961, 1967) stresses every third syllable counting from the right edge of a word.

(5) Ternary stress in Cayuvava (Key 1961, 1967)

'eje	'tail'
'ʃakahe	'stomach'
ki'hibere	'I ran'
ari.'u.utʃa	'he came already'
,ɕihira'ri.ama	'I must do'
ma,rahaha.'e.iki	'their blankets'
iki,tapare'repeha	'the water is clean'
,ʃa.adi,roboʃu'urutʃe	'ninety-five (first digit)'
me,darutʃe,tʃe.iro'hi.iɲe	'fifteen each (second digit)'

Rice (2011) identifies only two other languages with systematic ternary rhythm but in both of these, Tripura Bangla (Das 2001) and Chugach Alutiiq (Leer 1985, Rice 1988, 1992), heavy syllables can interrupt the ternary stress count. Rice also mentions three other languages, Ho-Chunk, Sentani, and Munster Irish, in which ternary rhythm is found in some subset of data.

6.2.2 *Weight-sensitive stress*

In many languages, the internal structure of syllables plays a role in predicting the placement of stress. In these languages, certain “heavy” syllable types preferentially attract stress. For example, stress in the Northwest Caucasian language Kabardian falls on either the penultimate or the final syllable of a word (Turchaninov and Tsagov 1940, Jakovlev 1948, Abitov et al. 1957, Colarusso 1992, 2006, Gordon and Applebaum 2010a): the final syllable if it is heavy (6a), i.e. contains either a long vowel (CVV) or a coda consonant (CVC), and the penult if the final syllable is light (6b).

(6) Weight-sensitive stress in Turkish Kabardian (Gordon and Applebaum 2010a: 38)

(a) sɐ'bən	'soap'
tɐp'ʃɛg	'plate'
sa:'bi:	'baby'
na:'nu:	'kid'
(b) 'pa:sɐ	'early'
'sa:bɐ	'dust'
'mɐʃɐ	'bear'
?ɐ'da:q'ɐ	'rooster'
χɐr'zənɐ	'good'

The effects of syllable weight can also be observed in languages with different types of stress systems. In many binary stress languages, the alternating stress

pattern is interrupted by heavy syllables, which attract stress even if they are immediately adjacent to a stressed syllable. After the heavy syllable, the normal alternating stress pattern resumes. For example, stress in Chickasaw (Munro and Ulrich 1984, Munro and Willmond 1994, Gordon 2004a) falls on even-numbered syllables counting from the left and on heavy syllables, which are CVC and CVV in Chickasaw (7). In addition, the final syllable is stressed, where its stress is the primary one unless a long vowel occurs to its left.

(7) Weight-sensitive stress in Chickasaw (Gordon 2004a: 7–8)

,in,tik'ba	'sibling'
,tʃon'kaʃ	'heart'
tʃo,kof'pa	'story'
a'bo:ko,ʃiʔ	'river'
'ʃi:ki	'buzzard'
tʃi,kaʃ'ʃaʔ	'Chickasaw'
,ok,fok'kol	'type of snail'
'na:ʔto,kaʔ	'policeman'
'a:,tʃom,paʔ	'trading post'

Weight may be relevant for secondary stress or primary stress or both. In the Uralic language Vach Ostyak (Gulya 1966), primary stress is weight-sensitive, falling on the first syllable of a word, unless the first syllable contains a central vowel and the second syllable has a peripheral vowel, in which case the primary stress falls on the second syllable, e.g. 'emtər 'small pond', 'nipik 'book' vs. wər 'tul 'cranberry'. Secondary stress adheres to an alternating left-to-right pattern after the primary stress, e.g. 'kaləy,pulnə 'by a grandchild (in passive construction)', 'werəy,səylə,min 'slowly dressing oneself'. Koya (Tyler 1969), on the other hand, assigns primary stress to the first syllable (of the phrase) regardless of weight and secondary stress to all heavy syllables (CVV and CVC) after the first.

In languages with weight-sensitive stress but only a single stress per word, the stress algorithm must address two types of cases, one involving words with at least one heavy syllable and the other involving words with only light syllables. The edge toward which stress is attracted may either be the same or different for both types of words. The former type of system is termed “default-to-same” and the latter type “default-to-opposite”. The language isolate Yana (Sapir and Swadesh 1960) provides an example of default-to-same stress: stress falls on the leftmost heavy (CVV and CVC) syllable, otherwise on the first syllable, e.g. si 'bumk'ai 'sandstone', tsini'ja: 'no' vs. 'p'udiwi 'women'. The Wakashan language K^wak^wala (Boas 1947, Bach 1975, Wilson 1986, Shaw 2009) instantiates a default-to-opposite system: stress falls on the leftmost full vowel (or schwa followed by a sonorant coda), otherwise on the rightmost syllable, e.g. 'k^wak^wala 'K^wak^wala', sə'baju 'searchlight', bəq^wətə'la 'sleepy, drowsy' vs. tsəgət'm'əs 'thimbleberry plant'.

In many weight-sensitive stress systems stress is limited to a window at a word edge, as in the Vach Ostyak case discussed above. The Vach Ostyak case discussed above represents a default-to-left edge system calculated over

only the first two syllables. This can be seen in the attraction of stress to the initial syllable both in words beginning with two full vowels and in words beginning with two schwa vowels. The North Caucasian Archi (Kodzasov 1999), on the other hand, employs a variant two-syllable left-edge “default-to-right edge” window, in which stress falls on the second syllable if the first two are either both heavy (/a, e/) or both light (/i, y, u/) or if the second is heavier than the first: *an'sa* ‘bull’, *zu'lu* ‘spring’, *di'ja* ‘father’. Only if the first is heavy and the second is light does stress migrate onto the first syllable: *'gatu* ‘cat’. Similar window-sensitive stress systems are found at the right edge. One such language with a two-syllable right-edge stress window is Javanese, which is discussed below.

Building on a typology of weight-sensitive stress windows in van der Hulst (2010), Kager (2012) conducts a survey of window-based stress systems in StressTyp (van der Hulst and Goedemans 2009). He identifies 54 languages with two-syllable windows at the right edge vs. only 25 with a two-syllable window at the left edge. There is a further asymmetry between the left- and right-edge windows in the relationship between syllable weight and stress. Of the 54 languages with right-edge windows, most (48) have in common that they do not stress a final light syllable regardless of the weight of the penult. At the left edge there is not a similar aversion to stressing a peripheral light syllable. Only nine (Archi being one of them) of the 25 languages with two-syllable left-edge windows position stress on the second syllable if the first syllable is light. The asymmetric bias against peripheral stress on lighter syllables at the right but not left edge is consistent with a general typological tendency toward greater stringency of weight in final position (see section 6.2.2.4).

Stress windows may also be three syllables in size. For example, stress in Pirahã (Everett and Everett 1984, Everett 1988) falls on the heaviest syllable within a three-syllable window at the right edge of a word. Three-syllable windows are considerably less common than two-syllable ones. Kager (2012) finds in his survey that, of the 108 languages with phonologically conditioned stress (not limited strictly to syllable weight, e.g. including tone; see section 6.6) applying within a window, 85 are two syllables in size vs. only 23 that are three syllables. All but one of these 23 occur at the right edge. The bias in favor of two-syllable windows and right-edge windows is consistent with the statistical dominance of penultimate stress in relation to antepenultimate stress and the vanishing rarity of third syllable stress (section 6.2.1).

Languages vary in the set of syllables that count as heavy for stress (Zec 1988, Gordon 2006a). For example, unlike Kabardian and Chickasaw, only long vowels count as heavy in the Aguacatec stress system (McArthur and McArthur 1956). In Aguacatec, stress by default falls on the final syllable of a word (8a), but a pre-final long vowel attracts stress away from the right edge (8b).

(8) Weight-sensitive stress in Aguacatec (McArthur and McArthur 1956: 73–4)

- (a) *ʔal'k'om* ‘thief’
wu'qan ‘my foot’
pu'hul ‘one who unties’
- (b) *'mi:tuʔ* ‘cat’
'ʔe:q'um ‘carrier’
'ʔa:t's'um ‘salt’

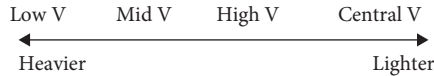


FIGURE 6.3. Hierarchy of weight for nucleus

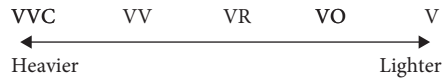


FIGURE 6.4. Hierarchy of weight for rime

As the forms in (8a) show, a closed final syllable containing a short vowel fails to attract stress, indicating that CVC is light in Aguacatec.

The behavior of CVC is the primary source of variation in syllable weight cross-linguistically (Gordon 2006a, Goedemans 2010), although there are some languages that are sensitive to other weight criteria in their stress systems. For example, in certain languages, non-low central vowels such as schwa or /i/ reject stress. Stress in Javanese (Herrfurth 1964, Horne 1974) thus falls on the penultimate syllable (9a) unless the penult has a schwa, in which case stress shifts to the final syllable (9b).

- (9) Weight-sensitive stress in Javanese (examples from Gordon et al. 2011: 242)
- (a) 'pantun 'rice plant'
'kates 'papaya'
- (b) kə'tes 'slap'
kə'tan 'sticky rice'
jən'tən 'cumin, caraway seed'

Among non-central vowels, lower vowel qualities are heavier than higher vowel qualities in certain languages (Kenstowicz 1997, de Lacy 2004).

Two implicational scales capture the hierarchy of syllable weight for stress cross-linguistically (Gordon 2006a): one sensitive to just the nucleus and the other to the rime as a whole. According to the first of these scales (shown in Figure 6.3), low vowels are heaviest, followed in turn by mid vowels, then high vowels, and then non-low central vowels. According to the second weight hierarchy (shown in Figure 6.4), long vowels in closed syllables are heaviest (VVC), followed in turn by long vowels in open syllables (VV), syllables closed by a sonorant (VR), syllables closed by an obstruent (VO), and open syllables containing a short vowel (V).

Along both of these continua, a syllable type is (nearly) universally at least as heavy as its neighbors to its right. For example, an open syllable containing a long vowel is always at least as heavy as a syllable containing a short vowel, whether it is open or closed. Similarly, a mid vowel is at least as heavy as a high vowel or a

central vowel.¹ Languages draw different cut-off points separating heavy and light syllables along the weight scales. For example, Kabardian's division between heavy and light syllables falls between syllables closed by an obstruent (VO) and open syllables containing a short vowel (V), whereas Aguacatec draws the split between long vowels (VV) and short vowelized syllables closed by a sonorant consonant (VR). The dividing line between heavy and light in Nuuchahnulth (Stonham 1999) falls between VR and VO.

It is also possible for a stress system to be sensitive to more than a binary weight distinction. In these scalar systems, the weight hierarchy may be viewed compositionally such that there are two divisions between heavy and light. For example, in Klamath (Barker 1964) words of at least three syllables, stress falls on the penultimate syllable if it is either CVV(C) or CVC(C) (10a) and otherwise on the antepenult (10b). However, a long vowel in final position or to the left of the antepenult attracts stress away from both a CVC penult and the antepenult (10c). Disyllabic words have stress on the first syllable unless the final syllable contains a long vowel, which attracts stress (10d):

- (10) Klamath stress (Barker 1964: 35–7)
- | | | |
|-----|----------------|------------------------|
| (a) | sa'gapɕɔl | 'to play cat's cradle' |
| | se'sadwi | 'to sell' |
| | ga:'mo:la | 'finishes grinding' |
| (b) | 'tʃ'awiga | 'is crazy' |
| (c) | ga'ba:tambli | 'goes back to shore' |
| | ga'wi:napbabli | 'is going among again' |
| | sak'amsi'ne:ʔ | 'to be lonesome' |
| (d) | 'lojal | 'to lie' |
| | 'glegatk | 'dead' |
| | 'gepgi | 'come!' |
| | nis'q'a:k | 'little girl' |

The stress facts suggest a three-way weight hierarchy with CVV being heaviest, since it can attract stress in any position, CVC being intermediate in weight, since it can attract stress in penultimate position, and CV being lightest, since it does not attract stress in either penultimate or final position.

An interesting feature of scalar weight systems is that they are almost universally projected along only one of the scales in Figures 6.3 and 6.4. There are thus languages such as Klamath that are sensitive to a weight hierarchy based on rimal complexity and sonority, and others based on multiple distinctions in vowel quality, e.g. Kobon (Davies 1981, Kenstowicz 1997) and Chukchi (Skorik 1961,

¹ Goedemans (2010) cites three potential exceptions to the generalization that CVV is always at least as heavy CVC for stress but only expresses confidence in one of the three cases, that of Amele (Roberts 1987).

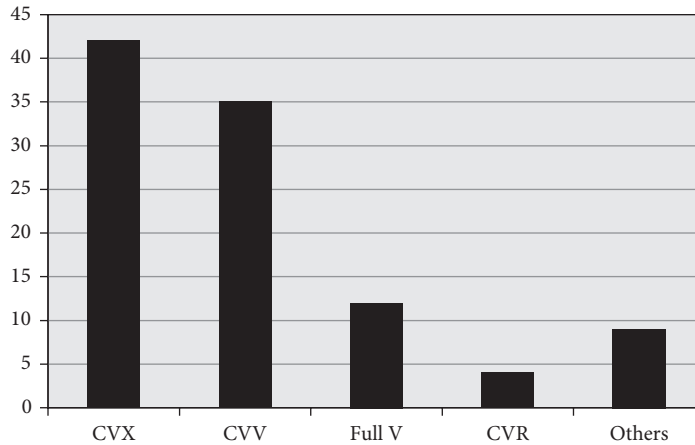


FIGURE 6.5. Number of languages possessing the four most common weight distinctions for stress in Gordon's (2006a) survey of syllable weight

Kenstowicz 1997). Few and far between are languages like Nanti (Crowhurst and Michael 2005) that employ weight scales sensitive simultaneously to rime shape and vowel quality (see section 6.2.2.3 for further discussion).

Gordon's (2006a) survey of syllable weight indicates that certain weight distinctions are more common than others. Figure 6.5 depicts the number of languages (based on the 127 languages in Gordon's survey displaying weight-sensitive stress) employing the four most common weight distinctions for stress (plus an 'Others' category): CVV heavy, CVX (=CVV and CVC) heavy, Full V (=non-low central vowels) heavy, and CVR (=CVV and CVR) heavy. Note that the total number of languages represented in the figure exceeds 127 since certain languages make more than a binary weight distinction (18 of the 127 languages in Gordon's survey) and each distinction comprising the hierarchy in these languages is counted separately in the figure.

Among stress systems, the distinction that treats both CVV(C) and CVC as heavy, as in Kabardian, and the one that treats only CVV(C) as heavy, as in Aguacatec, constitute the vast majority of weight distinctions cross-linguistically. There is a sharp drop-off in frequency to the two next most common weight distinctions, one involving full vowels and one sensitive to coda sonority.

An interesting feature of syllable weight is that it is almost universally sensitive to only the syllable rime and not the onset (Hyman 1985, Hayes 1989a). Thus, with few exceptions, a syllable does not become heavier in a language by virtue of either having an onset as opposed to being onsetless, i.e. CV is typically no heavier than V, or because it has a complex onset rather than a single one, i.e. CCV is usually not heavier than CV. Gordon's (2006a) survey cites only three languages with onset-sensitive stress, Pirahã, Júma, and Nankina, although other cases of onset weight for stress have surfaced in the literature (see Gordon 2005a, Topintzi 2010). Most of these, e.g. in Arrernte (Strehlow 1942, Davis 1988; Chapter 1), involve a syllable with an onset being heavier than a syllable without

one. Strikingly, where the quality of the onset consonant matters for weight, syllables with lower sonority onsets preferentially attract stress away from syllables with higher sonority onsets, e.g. Pirahã, a pattern that is exactly the opposite of the situation holding of the rime, where higher sonority codas make a syllable heavy in a small set of languages, e.g. the Wakashan languages Nuuchahnulth (Stonham 1999) and K^wak^wala (Boas 1947, Bach 1975, Wilson 1986, Zec 1988, Shaw 2009, Gordon et al. 2012). A possible phonetic basis for this asymmetry between onset and coda weight is discussed in section 6.2.2.3.

6.2.2.1 Syllable weight as a statistical bias Recent work by Ryan (2011, 2014) has shown that the same weight distinctions that are treated as categorical properties of many stress systems are also observed on a statistical level as biases in the lexicon and poetic meter of certain languages. Poetic (and musical) meter in these languages is sensitive to restrictions in which syllables can occur in different positions; these restrictions often parallel those seen in stress systems and thus provide insight into phonological weight (see Hayes 1989b for an overview).

In a corpus study of poetic verse from four languages traditionally described as being sensitive to only a binary weight distinction between heavy CVX (=CVV and CVC) and light CV (Homeric Greek, Kalevala Finnish, Old Norse, and Middle Tamil), Ryan (2011) finds distributional evidence for a more finely grained hierarchy of weight that is consistent with the hierarchy of rimal weight shown earlier in Figure 6.4. In the meter of all four languages, heavier syllables are more likely to occur in certain positions and lighter syllables are more likely in other positions, where weight is sensitive to the scale CVVC > CVV > CVC > CV.

In a complementary study of non-categorical weight distinctions based on the onset, Ryan (2014) finds statistical weight effects that mirror the categorical distinctions found in some languages. Within the lexicon of English and Russian, both onset complexity and voicing of the onset influence the likelihood of a syllable carrying primary stress. Greater complexity of the onset (ranging from zero, i.e. onsetless, to three consonants) thus increases the probability of a syllable being stressed. Furthermore, syllables with voiceless onsets are more likely to be stressed than those with voiced onsets. Ryan (2014) documents similar onset sensitivities in the Finnish epic poem Kalevala and in three Sanskrit meters. He also finds onset-governed biases in stress judgments in an experiment involving nonce words presented to English-speaking listeners.

6.2.2.2 Representations of syllable weight The phenomenon of weight-sensitive stress and, more generally, the notion of syllable weight (see Chapter 7 for weight-sensitive tone and Chapter 8 for weight-sensitive morphological operations) have provided the impetus for the development of one of the most widely adopted models of the syllable, moraic theory (Hyman 1985, Hayes 1989a). Moraic theory was briefly introduced in Chapter 4 in the context of constraints against long vowels in closed syllables and again in Chapter 5 in the discussion of compensatory lengthening. In moraic theories of the syllable, weight distinctions are represented as differences in mora count. Syllables with two (or more) moras are heavy and thus stress-attracting, while those with one (or none)

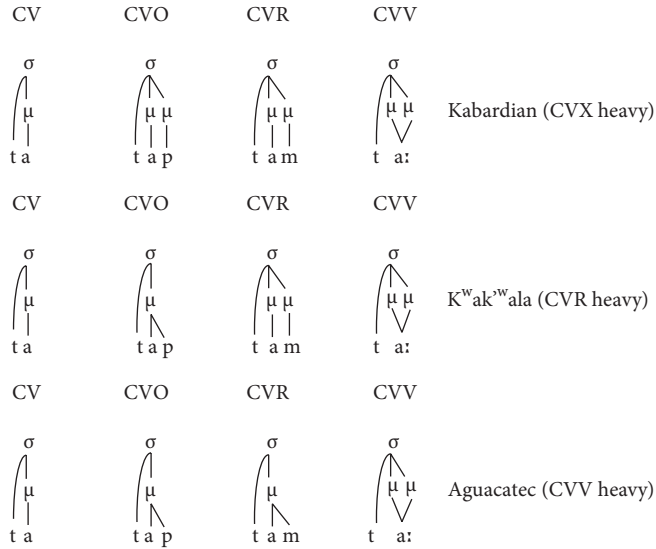


FIGURE 6.6. The parameterization of coda weight in moraic theory

are light. Moras are projected from phonemic contrasts in length, such that a short vowel is associated with one mora and a long vowel with two. The primary source of cross-linguistic variation, the weight status of CVC, is reflected in the parameterization of coda weight on a language-specific basis. In some languages, e.g. Kabardian, coda consonants are moraic, whereas in others, e.g. Aguacatec, they are not. Another possibility is for only a subset of coda consonants, the sonorants, to be moraic (Zec 1988), as in K^wak^wala. The variation in coda weight is shown schematically in Figure 6.6.

The ranking of CVV above CVC along the hierarchy of weight in Figure 6.4 follows from the encoding of phonemic vowel length in mora count. A long vowel thus invariably has at least as many moras as CVC, whereas a coda consonant may or may not be moraic depending on the language. One issue that has proven problematic for the assumption that moras are projected from phonemic length contrasts is the treatment of length contrasts in consonants. Hayes (1989a) proposes that geminate consonants are underlyingly associated with a mora while singleton consonants are not but may receive one on a language-specific basis when they surface as a coda. If geminate consonants are universally moraic, however, this predicts the existence of languages in which syllables closed by the first half of a geminate are heavy while those closed by codas that are not the first half of a geminate are light. Although there are a couple of potential cases corroborating this prediction, syllables closed by a geminate by and large do not seem to preferentially attract stress (see Tranel 1991, Davis 2011 for discussion).

The most parsimonious version of moraic theory in which moras are projected from a combination of phonemic length contrasts and, on a language-specific basis, coda consonants, is more generally unable to handle the richness of weight

distinctions found in stress systems (see Gordon 2006a for discussion). For example, weight distinctions based on vowel quality do not readily fall out from moraic theory without stipulating that heavier vowel qualities receive a second mora in certain languages. Furthermore, stress systems sensitive to a three-way weight hierarchy of the Klamath type $CVV > CVC > CV$ are not easily captured in moraic theory since they require that the heaviest syllable type in the hierarchy, CVV, is trimoraic even though, as we have seen, long vowels are only predicted to be bimoraic. In fact, there are even more finely grained weight hierarchies that necessitate higher mora counts if represented strictly in moraic terms. For example, the stress system of the Kampa language Nanti (Crowhurst and Michael 2005) is sensitive not only to the rimal weight hierarchy $CVVC > CVV > CVC > CV$ but also to more nuanced interactions between rimal structure and vowel quality.

One type of approach to scalar weight distinctions of the Klamath and Nanti type is to represent certain weight divisions in terms of differences in mora count while simultaneously appealing to orthogonal prominence scales to account for additional distinctions in weight. For example, Hayes (1995) proposes that in Klamath the distinction between CVV and CVC, on the one hand, and CV, on the other hand, reflects a difference in mora count, i.e. bimoraic CVV and CVC vs. monomoraic CV, while the greater weight of CVV is attributed to its higher ranking on a separate prominence scale. Similarly, Crowhurst and Michael (2005) suggest that the core moraic weight distinction in Nanti is between bimoraic CVV and monomoraic CVC and CV and that separate prominence scales sensitive to coda strength and vowel quality create additional weight distinctions.

One potential drawback to assuming prominence scales in addition to “true” moraicly based weight within the same language is that it is unclear what principles (other than the desire to maintain a constrained version of moraic theory) motivate the relegation of certain weight distinctions to orthogonal prominence scales and the promotion of others to full-fledged moraic differences. An alternative approach adopted by Gordon (2005a, 2006a) maintains a relatively simple theory of syllable representations at the price of losing the capacity to capture weight distinctions directly in terms of mora count. Adopting a skeletal slot model of the syllable with a rime (e.g. Levin 1985; see Chapter 4), Gordon captures weight distinctions in terms of a combination of skeletal slot count and features as illustrated for representative weight distinctions in Figure 6.7. For example, the distinction that treats both CVV and CVC as heavy (e.g. Kabardian) is captured in terms of rimal timing slots: heavy syllables are those with at least two rimal timing slots. In languages in which only CVV is heavy (e.g. Aguacatec),

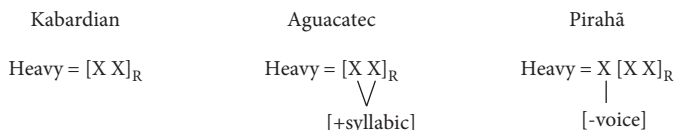


FIGURE 6.7. Weight distinctions in a skeletal slot model of the syllable (Gordon 2005a, 2006a)

heavy syllables are those with two timing slots associated with the feature [syllabic]. In Pirahã (Everett and Everett 1984, Everett 1988), which preferentially stresses syllables containing a voiceless onset plus a long vowel over all other syllable types, the heaviest syllable type possesses a branching rime preceded by a voiceless onset.

Complex weight hierarchies of the Klamath and Nanti type are treated compositionally as the intersection of two separate weight distinctions. In Gordon's approach, unlike in moraic theory, there are no phonological predicates devoted uniquely to encoding weight, but rather weight distinctions are projected from a combination of timing units and segmental features.

6.2.2.3 Phonetic underpinnings of syllable weight In addition to research exploring the representation of syllable weight, there is also a growing body of literature that examines the phonetic basis for weight. The general hypothesis guiding most of this research, either explicitly or implicitly, is that heavy syllables possess certain properties that make them perceptually more prominent. It is still a matter of considerable debate, however, which property or combination of properties is crucial in predicting weight.

Broselow et al. (1997) explore the hypothesis that differences between languages in the weight of CVC correspond to differences in duration. They find that vowels in closed syllables in Malayalam, a language in which CVC is light, are substantially shorter than vowels in open syllables, while vowels in closed syllables in Hindi, which treats CVC as heavy, are not shortened. Broselow et al. propose that this phonetic difference corresponds to a difference in moraic structure between the two languages as shown in Figure 6.8. In Malayalam, CVC syllables are monomoraic; the sharing of the mora between the vowel and coda consonant is reflected phonetically in the shortening of the vowel in CVC. In Hindi, on the other hand, the vowel and the coda each have their own mora in CVC; hence, there is no shortening of the vowel in CVC.

Ahn (2000) offers a functional account of weight-sensitive stress that also appeals to duration but in a different guise. She suggests that the functional pressure of ensuring that phonemic vowel length contrasts are sufficiently salient constrains the natural phonetic tendency to lengthen in certain contexts in a way that explains the variable cross-linguistic behavior of CVC. As a starting point in her study, Ahn finds an asymmetry in the type of stress systems in which both CVV and CVC are treated as heavy versus those in which only CVV is heavy. Stress systems employing the CVV heavy weight criterion may be either

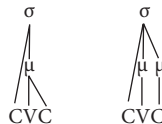


FIGURE 6.8. Moraic representations for light (on left) and heavy (on right) CVC (Broselow et al. 1997)

unbounded, i.e. position stress anywhere in a word depending on the relative weight of syllables, or bounded, i.e. limit stress to a window at a word edge (see section 6.2.2). On the other hand, in virtually all stress systems that treat both CVC and CVV as heavy, stress is bounded by a window at the periphery of a word. In the majority of these cases of bounded weight-sensitive stress, the weight distinction manifests itself as the repulsion of stress from a light syllable that is closer to the periphery to an adjacent heavy syllable that is further removed from the edge, particularly for right-edge windows (Kager 2012). For example, stress in Kabardian retracts from a light CV final syllable to the penult.

Ahn hypothesizes that CVV is free to carry stress anywhere in a word; hence the prevalence of the CVV heavy criterion in unbounded stress systems. On the other hand, CV tends to repel stress in positions where stress-induced lengthening would be most likely to jeopardize the potential salience of a duration contrast with a phonemic long vowel. Unlike CV, CVC may retain stress since vowel lengthening effects are characteristically smaller in closed syllables (Maddieson 1985). In fact, as we have seen in Chapter 4, many languages lack vowel length contrasts in closed syllables. Positions already predisposed to lengthening independent of stress, e.g. the initial, final, or penultimate syllable, are particularly eschewed as docking sites for stressed CV. A key feature of Ahn's account is that it is not the inherent prominence of CVC that makes it heavy in many languages, but rather the avoidance of stressed CV in certain contexts that makes CVC heavy by default. Her account also crucially relies on there being a phonemic vowel length contrast as a phonetic precursor to a weight distinction that treats CVC as heavy.

Gordon (2002b, 2006a) explores a different phonetic correlate of syllable weight: auditory energy. Drawing on work by Beckman (1986) demonstrating a correlation between word-level stress and total amplitude (the integral of intensity and time) in English, Gordon shows that a measure of prominence incorporating both duration and loudness, a measure that he terms total auditory energy (Figure 6.9), predicts a variety of weight distinctions in several languages.

Gordon proposes a model in which speakers evaluate all potential weight distinctions on the basis of two criteria: phonetic effectiveness and phonological simplicity. The first ingredient, phonetic effectiveness, is assessed in terms of the separation of heavy and light syllables along a given phonetic dimension. Phonetically effective distinctions divide syllables into heavy and light groups that are maximally different from each other in their distribution, quantified by Gordon in terms of mean values. A weight distinction with a greater difference between

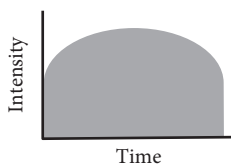


FIGURE 6.9. Total energy (the integration of intensity over time) as a predictor of syllable weight (Gordon 2002b, 2006a)

heavy and light syllable in mean values is thus superior to a weight distinction with a smaller difference in mean values.

The **second ingredient** in Gordon's account, **phonological simplicity**, constrains the hypothesis space of language learners evaluating various potential weight distinctions. On the basis of the typology of attested weight distinctions, Gordon proposes that **weight distinctions that refer to place features in addition to another phonological dimension, such as duration or other non-place features, are avoided due to their complexity**. Thus, whereas **many languages make weight distinctions based on vowel height or on vowel length, distinctions based simultaneously on vowel height and length, e.g. long, non-high vowels heavy, are exceedingly rare**, if not completely unattested. Gordon suggests that the bias against distinctions relying on place features in combination with other properties has a cognitive basis in the high-functional load of place features in marking contrasts in both vowels and consonants.

In Gordon's model, each generation of speakers evaluates the phonetic effectiveness of all logically possible weight distinctions that fall under the complexity threshold while simultaneously receiving exposure to the weight distinctions of the ambient language. In cases where the ambient weight distinction that would be inductively learned by speakers is not the phonetically most effective distinction, there is the possibility of a new phonetically superior distinction being introduced.

Gordon's study includes phonetic data from one language (Khalkha Mongolian) that treats CVV as heavy, two (Finnish and Japanese) that treat both CVV and CVC as heavy, and two (Chickasaw and Telugu) that have a complex weight hierarchy in which CVV is heavier than CVC which, in turn, is heavier than CV. In all of these languages, Gordon finds a **close match between auditory energy and weight (better than the link between duration and weight)**, such that, among a large set of logically possible weight distinctions, those that create the best phonetic separation of heavy and light syllables correspond to the actual phonological distinctions in the examined languages. **Gordon further proposes that differences between languages in the relative phonetic effectiveness of weight distinctions ultimately stem from differences in other phonological properties**. For example, **languages with more sonorous coda inventories are more likely than those with a larger proportion of low sonority codas to treat CVC as heavy because of their greater aggregate energy averaged over the set of CVC syllables** (Gordon 2002c). This grounding of interlanguage phonetic variation in independent differences in other phonological properties serves to address the potential circularity in assessing the source of observed links between phonological weight and phonetic properties. The resulting model is summarized in Figure 6.10.

Gordon (2005a) **extends his energy-driven account** of weight-sensitive stress to account for the **role of onsets in the calculation of weight**. He appeals to the **auditory adaptation and recovery effects** described in the context of syllabification in Chapter 4 (see Wright 2004 and Moore 2013 for overviews of these effects) to account for both the attraction of stress by syllables containing an onset over onsetless syllables as well as the heavier status of low sonority onsets relative to higher sonority ones. **The auditory system is most sensitive to a stimulus, as reflected in auditory nerve firing rates and perceived loudness judgments, at its**

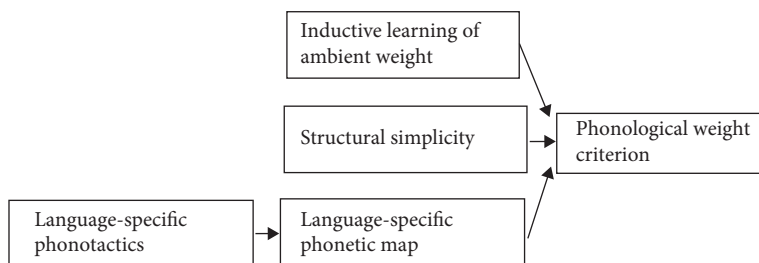


FIGURE 6.10. A model of the development of weight criteria (Gordon 2006a)

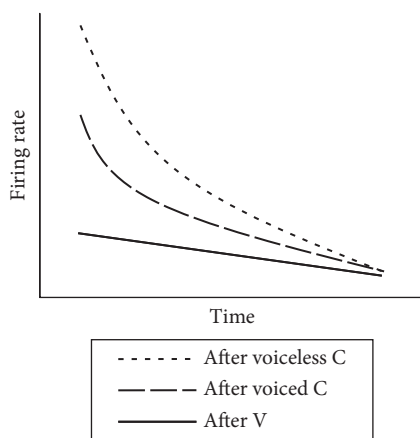


FIGURE 6.11. Schematic illustration of the auditory nerve response to a vowel following a voiceless onset consonant (dotted line), a voiced onset consonant (dotted-dashed line), and another vowel (solid line)

onset before sensitivity gradually wanes over prolonged exposure to the same stimulus, a phenomenon termed “auditory adaptation”. A period of reduced energy, on the other hand, provides the auditory system a chance to recover before the next relatively loud stimulus. A vowel immediately following an onset consonant thus benefits from an auditory boost relative to one that immediately follows another vowel, i.e. in a hiatus context. This auditory recovery effect offers an explanation for the attraction of stress by syllables with an onset over onsetless syllable in languages like Pirahã (Everett and Everett 1984, Everett 1988). Similarly, a vowel following a low sonority onset receives an auditory boost relative to a vowel preceded by a high sonority onset in keeping with the attraction of stress by syllables with voiceless onsets in languages like Pirahã and Tümpisa Shoshoni (Dayley 1989). Figure 6.11 is a schematic diagram showing the auditory response to a vowel in three different contexts: after another vowel (i.e. in a hiatus position), after a voiced onset, and following a voiceless onset.

Gordon (2005a) proposes a quantitative perceptual model incorporating auditory adaptation and recovery and tests the predictions of his theory against

phonetic data from three languages with onset-sensitive stress: Arrernte, Banawá, and Pirahã. Employing the same metric of phonetic effectiveness from his work on rimal weight, Gordon finds a match for the three languages between phonetic effectiveness and language-specific weight distinctions involving the syllable onset. A key component of Gordon's (2005a) account of onset-sensitive stress is that the onset does not itself directly contribute to the perceptual prominence of a syllable but rather influences prominence (and thus weight) indirectly through its effect on the following rime. In his model, the onset exerts less of an effect on perceived loudness than the rime, in keeping with the typological observation that onset weight effects typically imply sensitivity to rimal weight as well. For example, long vowels attract stress over short vowels in Pirahã regardless of the presence or type of onset in the syllable containing the long vowel. The primacy of rimal weight is also supported, albeit along a different phonetic dimension, by experiments in Goedemans's (1998) demonstrating that listeners are relatively insensitive to changes in the duration of the onset compared to changes in the duration of segments in the rime.

Ryan (2014) offers a duration-based account of onset weight that complements Goedemans (1998). Ryan suggests that the domain over which weight is calculated begins not with the left edge of the rime but rather with the perceptual center (p-center) of the syllable (Morton et al. 1976), the perceived beginning of a syllable as deduced from experiments designed to assess isochrony effects. Drawing on the existing literature on p-centers, Ryan proposes that lengthening the onset, e.g. when adding an onset consonant or one with greater length such as a voiceless consonant, shifts the p-center of the syllable leftward relative to the beginning of the rime thereby increasing the span over which weight is calculated. Because the durational increase provided by augmenting the onset is relatively small relative to the effect of increasing the length of the rime, it is predicted that changes in the onset will exert less of an effect on the weight of a syllable than changes in the rime, in keeping with the typological dominance of rimal weight.

The relative effect of lengthening the onset vs. rime on the p-center is depicted schematically in Figure 6.12 (employing the same p-center factors used by Ryan), which shows a CV syllable with four different durational profiles: from top to bottom, a 200 millisecond onset consonant followed by a 200 millisecond vowel, a 100 millisecond onset followed by a 200 millisecond vowel, a 200 millisecond onset followed by a 100 millisecond vowel, and a 100 millisecond onset followed by a 100 millisecond vowel. Increasing the duration of the onset by 100 milliseconds leads to only a 35 millisecond increase in the perceptual duration of the syllable (the material following the p-center), whereas a 100 millisecond lengthening of the vowel increases the perceived duration of the syllable by 75 milliseconds.

6.2.2.4 Final vs. non-final weight asymmetries There are some languages in which weight criteria are different in final syllables from non-final syllables. The typical pattern involves heavy syllables in final position constituting a subset of those that are heavy non-finally. Klamath (Barker 1964) is one such language with greater stringency of final weight criteria. Recall from section 6.2.2 that only long

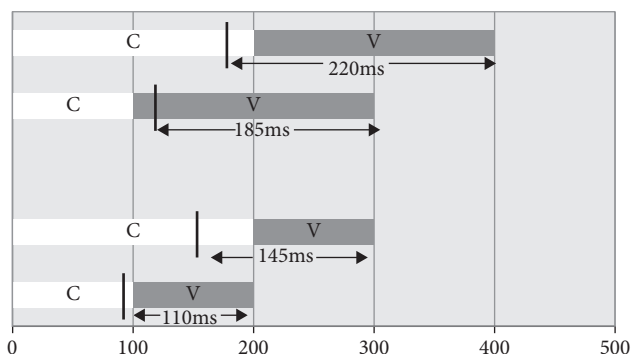


FIGURE 6.12. Perceived duration of the syllable from p-center (indicated by vertical line) to the end of the syllable for a CV syllable differing in the length of the onset consonant and the vowel (time in milliseconds on x-axis) (based on Ryan 2014)

vowels attract stress in final syllables, e.g. *nis'q'a:k* 'little girl' but *sa'gapɬol* 'to play cat's cradle', whereas both long vowels and closed syllables in the penult are stressed (provided there is no long vowel in the final syllable), e.g. *se'sadwi* 'to sell', *ga:'mo:la* 'finishes grinding'. Crucially, a final syllable is not stressed if it contains a short vowel even if it is closed by two consonants (CVCC), e.g. '*glegatk* 'dead'.

There are certain languages in which, unlike in Klamath, CVCC is heavier than CVC word-finally. For example, in Cairene Arabic (Mitchell 1960, McCarthy 1979a, b, Watson 2007), a penultimate syllable attracts stress if it is either closed (CVC) or contains a long vowel (CVV) (11a). A final syllable attracts stress, however, only if it contains a long vowel or is closed by a geminate consonant or by a cluster (CVCC) (11b). A final CVC syllable is not stressed (11c), even though it attracts stress in the penult.

(11) Egyptian Arabic stress (examples from Funk 1985)

- (a) *mu'darris* 'teacher (m.sg.)'
ɬa'mi:la 'beautiful (m.sg.)'
- (b) *mu'himm* 'important'
xa'bi:r 'specialist'
- (c) *'barid* 'cold'
'asxan 'hotter'

Klamath and Egyptian Arabic instantiate the two major types of weight asymmetries between final and non-final syllables. In certain languages, such as Klamath and Chickasaw (Gordon 2003, 2006a), CVV is heavier than both CVC and CVCC word-finally, whereas in others, such as Egyptian Arabic and Norwegian (Lunden 2010, 2013), CVV and CVCC are heavier than CVC.

In practice, most of the evidence for the heavy status of CVV in Egyptian Arabic and Norwegian comes from CVCC syllables, i.e. closed syllables containing a long vowel, since final long vowels (and diphthongs where they occur) have a marginal status in both languages. In the variety of Estonian described by Hint

(1973), however, both final CVV (as well as final CVVC) and final CVCC are heavier than final CVC. On the other hand, final CVVC but not final CVV attracts stress in San'ani Arabic (Watson 2007).

Traditionally, there have been two separate analyses of final weight criteria depending on which criterion is involved: both CVV(C) and CVCC heavy vs. CVC light (e.g. Egyptian Arabic, Norwegian) or only CVV(C) heavy vs. both CVCC and CVC light (e.g. Klamath, Chickasaw).

To handle the former type of pattern, the notion of extrametricality is typically invoked, whereby a word-final consonant is extrasyllabic and thus invisible to the stress system (Hayes 1979, 1982, 1995). In moraic theory (Hyman 1985, Hayes 1989a), this means that CVC is monomoraic, and thus light, in final position, while non-final CVC and final CVCC are both bimoraic and heavy (see Figure 6.13). Final syllables containing a long vowel are also bimoraic and heavy, since extrametricality is typically assumed to affect syllables (e.g. in cases of antepenultimate stress) and segments and not moras, e.g. the second half of a long vowel (see Hayes 1995 on the exclusion of mora extrametricality). Crucially, the predictions of extrametricality are constrained by the assumption that only peripheral elements may be extrametrical.

The other type of final weight criterion, the Klamath one according to which CVV but neither CVC nor CVCC are heavy, does not readily fall out from an account appealing to extrametricality since it would entail that the final two consonants in CVCC are extrametrical. Allowing for the possibility of chained extrametricality of this type weakens the restrictiveness of the theory (see Hayes 1995) since it would not be clear how to preclude other types of apparently unattested extrametricality, e.g. extrametricality of the final two consonants of the word but not the third consonant from the end or extrametricality of the final two syllables of a word with the result being preantepenultimate stress in a language with trochaic feet.

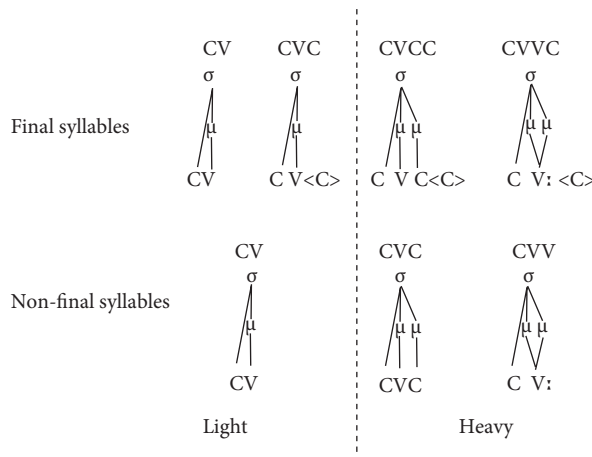


FIGURE 6.13. Extrametricality of final consonants in moraic theory

To account for the Klamath facts, Hayes (1995) suggests that CVV outranks other syllables along a prominence scale distinct from the moraic tier (cf. Crowhurst and Michael's analysis of Nanti; section 6.2.2.2), thereby accounting for its capacity to attract stress in final position. As discussed earlier, however, there does not appear to be any principled reason for appealing to orthogonal representations (moras vs. prominence scales) to account for the greater weight of CVV relative to both CVC and CV (captured through a prominence scale), on the one hand, and the greater weight of both CVV and CVC relative to CV (captured through differences in mora count), on the other hand. An alternative account of the Klamath-type weight asymmetry grounded in the intonational factors considered in the next section is proposed in section 6.4.

6.3 Stress domains: the intonational basis for left-edge vs. right-edge asymmetries

An important issue in stress typology is the domain of stress assignment. Stress is traditionally conceived of as a word-level phenomenon. However, the breadth of the typological database on which this view is based is quite circumscribed since most descriptions of stress are likely derived from words in isolation where the word and larger prosodic constituents are confounded (see Gordon 2014 for discussion). The extent to which our knowledge of the typology of stress reflects true word-level stress as opposed to larger intonational prominence thus remains to be determined. There are certain properties of the stress typology that are in fact more consistent with the known typology of intonation systems (see Chapter 7).

One of these features is the asymmetric inventory of stress positions found in fixed stress systems. Thus, as we have seen, only the first two syllables are potential stress locations (setting aside the outlier case of Ho-Chunk see also Kager (2012) for a few cases of lexical stress falling with a three-syllable left edge window), whereas the final three syllables are eligible for stress. Furthermore, both the final and penultimate syllable are common right-edge oriented docking sites for stress but only the initial syllable is a frequent left-edge oriented position for stress.

Hyman (1977) and Gordon (2000, 2014) offer insight into this left vs. right asymmetry based on intonational factors, in particular, the concept of tonal crowding. There are three basic ingredients in the intonationally driven account of stress. First, stress serves a demarcative function as a marker of prosodic (and often syntactic) constituents. Second, the default terminal pitch contour at the end of an utterance in most languages is a pitch fall. Third, stress is characteristically realized through raised pitch, phonologically analyzable as a high pitch accent (see Chapter 7 on intonation).

Given the demarcative nature of stress, it follows that initial and final position are cross-linguistically preferred as docking sites for stress. Intonational factors, particularly in final position, may conspire, however, against peripheral stress. The articulatory and perceptual demands (see Chapter 7 for discussion of these demands in the context of tone languages) associated with transitioning from the high pitch of stress to the low pitch at the end of a statement make it potentially

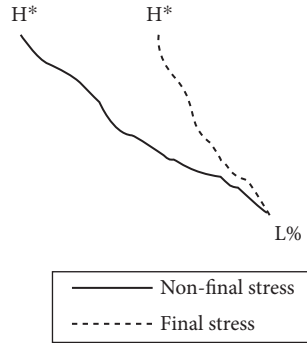


FIGURE 6.14. The intonational conditions associated with non-final and final stress

advantageous to retract the stress to a pre-final syllable to allow greater time for the terminal pitch fall. The tonal conditions present under non-final and final stress are shown schematically in Figure 6.14.

The intonational analysis offers an explanation for the fact that penultimate stress is common cross-linguistically. On the other hand, because large pitch excursions are characteristic of the end and not the beginning of an utterance, there is far less pressure to move stress from the initial to the second syllable; hence, the rarity of peninitial stress relative to initial stress. Gordon (2014) suggests that antepenultimate stress, which is also rare, potentially reflects some advantage associated with further distancing of the pitch peak from the end of the domain. Under the intonational account of stress, final stress reflects a language-specific tolerance of tonal crowding.

The tonal crowding account of final stress avoidance draws support from similar tonal crowding avoidance effects observed in tone languages that either ban contour tones or restrict them to syllables that are better suited to supporting tonal excursion, e.g. those containing long vowels or sonorant codas (see Chapter 7 for discussion). Furthermore, it is consistent with the asymmetry observed earlier for binary stress patterns whereby certain languages, e.g. Pintupi, fail to stress the final syllable but no languages appear to suspend stress on an initial syllable that is in a rhythmically strong position. Gordon (2000, 2014) also describes an asymmetry between statements and questions in Chickasaw that is consistent with the tonally driven account of final stress avoidance. Statements in Chickasaw end in a pitch rise whereas questions end in a pitch fall. As the tonal crowding analysis predicts, prominence, phonetically a high pitch accent, retracts leftward from the final syllable at the end of questions but not statements.

One potential limitation of the intonational analysis of final stress avoidance is that it appeals to a property, namely a terminal pitch fall, that is present only in final position of large prosodic constituents, including isolation forms (see Chapter 7 for discussion of prosodic constituency). True word-level penultimate stress thus does not fall out from this approach. To account for word-level penultimate stress, Gordon (2014) thus appeals to the grammaticalization of prominence patterns operative at the utterance level to the word level. This type

of extension of properties characteristic of the utterance to the word is not unique to stress (see Blevins's 2006 discussion of final devoicing) and draws support from a recent experimental study by Myers and Padgett (2014) demonstrating that speakers productively generalize a pattern of final devoicing delimited by the utterance to the word level. Gordon (2014) also cites several languages, e.g. Chickasaw, Cayuga, Onondaga, in which stress asymmetrically avoids final syllables of words at the end of a phrase but not phrase-internally as the intonationally driven account would predict. It is also plausible that true word-level stress may be less common than currently thought since descriptions of stress in many grammars are likely to be based on forms uttered in isolation, where the intonational factors claimed to underlie final stress avoidance would be present (Gordon 2014).

6.4 The phonetic basis for extrametricality

The intonational account of final stress avoidance can potentially be extended to account for the greater weight of CVV in final position relative to other syllables in languages like Klamath. Gordon (2000) suggests that CVV is a better docking site for final stress than either CVC(C) or CV because CVV has a more sonorous rime that is better equipped to support the transition from the high pitch associated with stress to the low pitch associated with the right edge of an utterance in unmarked declaratives. This approach finds an analog in tone languages that allow contour tones only on syllables containing a long vowel (see Chapter 7). Barker's (1964) description of Klamath stress is consistent with an intonationally based analysis of final stress avoidance. Barker suggests that the reported stress patterns reflect the pronunciation of words in isolation, a context where tonal crowding is potentially an issue. Furthermore, he indicates that stressed vowels are realized with higher pitch than unstressed vowels and that the unmarked intonation contour ends in a final fall, precisely the type of pitch excursion that the intonationally driven analysis claims is avoided in languages with pre-final stress.

It is less clear whether the tonal analysis can be extended to account for languages like Egyptian Arabic in which final CVCC is heavier than final CVC, since it is not obvious why CVCC should have any advantage over CVC in supporting a pitch transition. Consonants, especially obstruents, do not offer much assistance in realizing pitch (see Chapter 7), so there is no transparent intonational explanation for why CVCC syllables should preferentially attract stress in final position.

Drawing on phonetic data from Norwegian, which, like Egyptian Arabic, asymmetrically treats CVCC as heavier than CVC word-finally but not medially, Lunden (2010, 2013) hypothesizes that the variable status of CVC as light word-finally but heavy non-finally is predictable from phonetic duration. She shows that in Norwegian, the duration ratio of the rime in final CVC to the rime in final CV is much smaller than the ratio of the rime in non-final CVC to the rime in final CV. She attributes this positional difference in the duration ratio between CVC and CV to the nearly universal phenomenon of final lengthening (Wightman et al.

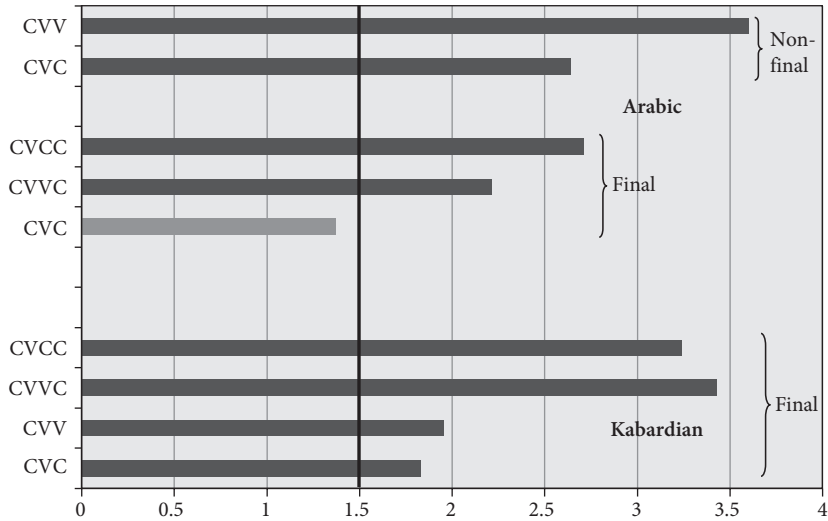


FIGURE 6.15. Duration ratio of heavy (black lines) and light (gray lines) syllables relative to CV in Arabic and Kabardian (Gordon et al. 2010)

1992), which reduces the CVC-to-CV duration ratio in final position. Lunden suggests that there is a threshold duration ratio relative to CV in the same position that a syllable must exceed in order to attract stress in a given position. Non-final CVC and final CVCC and CVVC exceed this threshold thereby accounting for their heavy status, whereas final CVC does not and is thus light.

Gordon et al. (2010) builds on Lunden's work by presenting results of two phonetic case studies, one of Egyptian Arabic, which as we have seen treats CVCC but not CVC as heavy for stress in final position, and the other of Kabardian, a language that treats both final CVC and final CVCC as heavy. Their results (see Figure 6.15) show that the difference between the two languages in the stress-attracting ability of final CVC is associated with a phonetic difference in vowel length patterns. In Egyptian Arabic, final CV shows substantial phonetic vowel lengthening, which has the effect of reducing the length difference between final CVC and final CV to such a degree, they suggest, that CVC in final position fails to reach the threshold (represented as a vertical line in the figure) necessary to be stress attracting in final position. In Kabardian, on the other hand, there is relatively little lengthening, which results is a larger CVC-to-CV duration ratio in final position in keeping with the ability of CVC to attract stress word-finally.

Gordon et al. (2010) support their phonetic results with a cross-linguistic study of the relationship between the weight of final CVC and the presence of phonemic length contrasts in final position. They find that all ten languages in their survey that asymmetrically treat final CVCC but not final CVC as heavy lack a phonemic vowel length contrast in final open syllables. This lack of a length distinction means that vowels are free to substantially lengthen in final position, which reduces the duration ratio between final CVC and CV and thus the likelihood

of final CVC attracting stress. On the other hand, of the 30 languages they survey that treat final CVC as heavy, roughly two-thirds have a phonemic vowel length contrast in final position. In these languages, final lengthening is likely to be smaller in magnitude since substantial lengthening could potentially obscure a phonemic contrast in vowel length. Gordon et al.'s account appeals to similar functional principles to those claimed by Ahn (2000) (see section 6.2.2.3) to account for the variable cross-linguistic weight of CVC.

6.5 Representations of stress

6.5.1 Stress and metrical feet

There is a broadly held view that stress patterns are the phonetic manifestation of constituents called metrical feet, which historically have played a prominent role in the description of many poetic traditions, e.g. Latin and Greek (Allen 1973). The two most fundamental foot types in metrical theory are the “trochaic” foot and the “iambic” foot. Trochaic feet consist of a stressed syllable followed by an unstressed syllable, whereas iambic feet consist of an unstressed syllable followed by a stressed syllable. A representative form illustrating trochaic feet in the English word *Apalachicola* within one widely adopted theory (Hayes 1995) appears in (12) (see Halle and Vergnaud 1987, Idsardi 1992, and Halle and Idsardi 1995 for slightly different versions of foot structure; see also Hammond 2011 for an overview of different formalisms of word-internal constituency).

- (12) Trochaic feet in the polysyllabic word *Apalachicola*
 Word level (. . . . x .)
 Foot level (x .) (x .) (x .)
 ,A pa ,la chi 'co la

In the lower foot-level tier of the representation, the first two syllables are grouped into a trochaic foot in which the first syllable is the more prominent (i.e. stressed) one. Similarly, the middle two syllables and the last two syllables each form trochaic feet. The penultimate syllable, the head of the rightmost trochee, receives a grid mark on the upper word-level tier, which differentiates its primary stress from the secondary stress associated with the other two foot heads.

Iambic feet, constructed from left to right and with primary stress on the leftmost foot head, are illustrated for the Osage (Altshuler 2009) word *xo: 'tso ði: b, rã* ‘smoke cedar’ in (13).

- (13) Iambic feet in a polysyllabic Osage word (Altshuler 2009)
 Word level (. x . .)
 Foot level (. x) (. x)
 xo: 'tso ði: b, rã ‘smoke cedar’

Feet can also be used to model other types of stress patterns that are not strictly binary. Initial and penultimate stress may be assumed to reflect a single trochaic

foot at the left and right edge, respectively, of the word. Peninitial and final stress can be analyzed as a single iambic foot at the left and right edge, respectively. Antepenultimate stress also may be regarded as a right-aligned trochaic foot except that the final syllable is extrametrical (see section 6.3). Final syllable extrametricality also offers an account of the failure of the final syllable to be parsed in certain otherwise regular left-to-right binary stress systems. The foot structures typically assumed for the five fixed stress patterns attested cross-linguistically are shown schematically in (14).

(14) Foot structure associated with the five fixed stress locations

Stress location	Foot type	Schematic example
Initial	Trochaic	#('σσ) . . .
Peninitial	Iambic	#(σ'σ) . . .
Antepenultimate	Trochaic (with extrametricality)	. . . ('σσ)<σ>#
Penultimate	Trochaic	. . . ('σσ)#
Final	Iambic	. . . (σ'σ)#

Binary feet can also be used to capture ternary stress patterns, e.g. in Cayuvava, under Hayes's (1995) weak local parsing approach, according to which a single light syllable is skipped after the construction of each binary foot. Under a weak local parsing analysis, the Cayuvava word *ma,rahaha.e.iki* 'their blankets' would be footed as *ma(,raha)ha.(e.i)<ki>* with the final syllable being marked extrametrical. Other alternatives to the weak local parsing approach are to posit ternary feet (e.g. Halle and Vergnaud 1987, Levin 1988) or to admit internally layered feet (Dresher and Lahiri 1991, Ito and Mester 1992/2003, Blevins and Harrison 1999, Kager 2012, Buckley 2014). In the latter approach, ternary feet consist of a disyllabic head (or monosyllabic in case of a heavy syllable in a weight-sensitive stress system) and a monosyllabic non-head, i.e. $[(\sigma^{\mu}\sigma^{\mu})\sigma]$ or $[(\sigma^{\mu\mu})\sigma]$ (where the foot head is surrounded by brackets). The Cayuvava word *ma,rahaha.e.iki* would thus be parsed as *ma([,raha]ha)([e.i]ki)* (see Rice 2011 for an overview of weak local parsing and other alternative approaches to ternary feet).

6.5.2 Stress and the metrical grid

An alternative to a foot-based theory of stress is a model employing a constituent-less rhythmic grid structure (e.g. Liberman and Prince 1977, Prince 1983, Selkirk 1984, Gordon 2002) involving sequences of strong, i.e. stressed, and weak, i.e. unstressed, syllables. For example, the representation of *ˈApalachiˈcola* in a grid-based approach to stress would be as in (15).

(15) The word *Apalachicola* in a grid-based metrical theory

Level 1 (Primary stress)					x
Level 2 (Secondary stress)	x	.	x	.	x
	ˌA	p	ˌl	a	ˈchi
					ˈco

The lower level of stress reflects the secondary stress, where any syllable dominated by an "x" only on the lower grid level has secondary stress, e.g. the

first and third syllables in *ˌApɑˌlɑchiˈkɔlə*. The higher grid level captures primary stress.

Weight-sensitive stress has provided evidence for foot-based theories of stress over grid-based ones. There are cross-linguistic asymmetries in the relationship between syllable weight and foot type: iambic feet are heavily biased toward weight-sensitivity, whereas trochaic feet can either be weight-sensitive or not (Hayes 1995). In a foot-based approach to stress, the binary stress count is calculated at the level of the mora rather than the syllable in weight-sensitive stress systems. Heavy syllables consist of two moras, while light syllables have one mora. Feet are canonically bimoraic, consisting of one heavy syllable or two light syllables. For example, Chickasaw, which stresses heavy (CVV, CVC) syllables and parses words into iambic feet from left to right (Gordon 2004), would have the foot structure in (16) for the word *ˌissoˈbɑ* ‘horse’.

- (16) Weight-sensitive metrical parse for the Chickasaw word *ˌissoˈbɑ*
- | | |
|---------|---------|
| (x) | (. x) |
| (μ μ) | (μ μ) |
| ˌ i s | so ˈ bɑ |

In keeping with their inherent sensitivity to weight, there is an interesting feature of iambic systems that differentiates them from trochaic systems. Many iambic stress languages lengthen stressed syllables in a foot, thereby creating feet consisting of a light syllable followed by a heavy syllable. Chickasaw, for example, lengthens vowels in stressed non-final open syllables (Munro and Ulrich 1984, Munro and Willmond 1994). Thus, the second and fourth vowels in the word /ʃipisalitok/ ‘I looked at you’ undergo lengthening to produce the surface form *(ʃiːpiː)(sɑːliː)(ˌtok)*. Lengthening of stressed syllables, particularly when it applies to all stressed syllables in a word and not just the primary stress, is less prevalent in weight-sensitive trochaic systems (Mellander 2001). This apparent difference between trochaic and iambic stress systems supports an asymmetric foot inventory in which iambs preferentially consist of a light unstressed syllable followed by a heavy stressed whereas trochees prefer to consist of two light syllables (Prince 1990). In fact, certain trochaic stress languages actually display shortening of stressed syllables, which creates durationally balanced feet consisting of a light stressed syllable followed by a light unstressed syllable. For example, in Fijian (Schütz 1985), phrases that underlyingly end in a heavy penult (one containing a long vowel) followed by a light ultima shorten the long vowel in the penult; thus, underlying /mbuːngu/ ‘my grandmother’ surfaces as *ˈmbu.ngu* (Schütz 1985: 528). Hayes (1995), following the spirit of a proposal advanced by Schütz (1985), offers an explanation for this a priori anomalous process of stressed syllable shortening in terms of the rhythmic principles underlying the trochaic foot (Prince 1990). In Hayes’s analysis, the penult and the final syllable initially form a trochaic foot, which then shortens in order to create a trochaic foot (*ˈmbu.ngu*) consisting of two syllables of equivalent weight. By shortening the stressed syllable of the foot the pressure for balanced trochaic feet is satisfied (see Mester 1994 for analysis of a number of rhythmic alternations in Latin in foot-based terms).

The durational asymmetry between trochees and iambs finds support not only from stress systems, but also from psycholinguistic experiments, music, and poetry (see Hayes 1995: 79–81 for an overview). In the grid-based theories of stress proposed thus far, there is no mechanism for accounting for this difference (but see Kager 1993 for an account that links iambic/trochaic asymmetries to mora-level rhythmic considerations expressed using grid marks). The iambic/trochaic durational asymmetry may thus constitute one of the strongest pieces of evidence for the foot.

Additional evidence for the foot comes from segmental alternations that are not predictable from stress but that fall out from analyses assuming metrical constituency distinct from stress. For example, Alutiiq dialects of Yupik (Leer 1985) have a process of fortition affecting consonants in a position that can be described as foot-initial. Leer (1985: 84) describes “two major distinguishing characteristics of the fortis consonant: complete lack of voicing with voiceless consonants (stops and voiceless fricatives), and preclosure”, which is a voiceless interval following the preceding segment “during which the mouth also assumes the configuration of the [fortis] consonant” (p. 85). Feet in Alutiiq are iambic with long vowels and word-initial (but not word-medial) CVC counting as heavy. A key feature of stress that has implications for footing and by extension the analysis of fortition is that stress adheres to a ternary pattern in which there are consecutive light syllables word-medially. For example, stress (indicated here uniformly as primary stress since it is unclear which stress is most prominent) falls on the first and fourth syllables in the four-syllable Chugach Alutiiq word *'anʃiq'kut*, ‘we’ll go out’ (Leer 1985: 84). The strengthened consonant (in bold) occurs in the onset of the pretonic syllable, which is analyzed under Hayes’s (1995) weak local parsing approach (see section 6.5.1) as the first syllable in a disyllabic foot comprising the pretonic and the tonic syllable, i.e. *'anʃiq'kut* is footed as (*'an*)ʃi(*qu*'kut). A virtue of this analysis is that fortition in Alutiiq can be characterized as a foot-initial phenomenon, thereby bringing it into line with the general cross-linguistic pattern of strengthening associated with initial position of prosodic domains (e.g. Pierrehumbert and Talkin 1992, Byrd 1994, Dilley et al. 1996, Cho and Keating 2001, Keating et al. 2003). In contrast, the locus of fortition is not easily defined with reference to stress; it would need to be described as fortition in the onset of pretonic syllables, which would not appear to be a natural phenomenon with parallels in other languages (see Vaysman 2009 and Hermans 2011 for other segmental alternations that require reference to foot structure to adequately characterize).

6.5.3 Factorial typology and metrical structure

The relatively well-documented typology of stress coupled with an increase in computing power have made possible a productive research program devoted to establishing the empirical coverage offered by metrical theories. These studies have been instructive in teasing apart the relative merits of different theories, including the division between foot-based and grid-based models of stress.

Gordon (2002) enlists OTSoft (Hayes et al. 2000) to calculate the predictive power of a set of 12 grid-based Optimality-theoretic constraints by permuting the constraint rankings in all possible orders, over 479 million (see Chapter 2 for more on Optimality Theory). His constraint set includes constraints requiring alignment of stresses with word edges and constraints against stress clashes and lapses. The anti-lapse constraints include versions specific to word edges in order to capture stress window effects (see section 6.2.2). OTSoft generated a total of 79 distinct stress systems for words consisting of between one and eight syllables. All of the systems found in Gordon's survey of weight-insensitive stress systems were generated. Some unattested systems were also predicted by the constraint set but most of these can plausibly be reviewed as "accidental gaps" reflecting the combination of attested elements at least one of which is rare. For example, one such unattested system is characterized by stress on both the peninitial and final syllable, two stress locations that are found in languages of the world albeit only rarely in the case of the former.

In his study of window-sensitive stress systems, Kager (2012) employs OTSoft to assess the typological predictions of three different constraint sets: a foot-based constraint set lacking feet larger than two syllables, a foot-based constraint set allowing for internally layered feet (see section 6.5.1), and the grid-based constraint set of Gordon (2002) modified to include an additional anti-lapse constraint to capture the left-edge three-syllable window found in a small set of languages. He also introduces in all the simulations a faithfulness constraint requiring preservation of lexical stress. Kager (2012) finds that the account employing internally layered feet offers the most accurate predictions of the three. A recurring problem of the other two sets is their susceptibility to the "midpoint pathology", the variable (by word length) attraction of stress to the middle of the word to either minimize stress lapses or metrically unparsed syllables at word edges. An interesting result of Kager's study is that the constraint requiring faithfulness to lexical stress triggers the midpoint pathology in Gordon's (2002) grid-based approach, which had been successful as long as it contained only output-sensitive metrical well-formedness constraints.

6.5.4 Typological asymmetries as a reflex of foot structure

In a foot-based analysis of stress, the relative typological frequency of initial and penultimate stress, both of which reflect trochaic feet, can be attributed to a bias in favor of trochaic feet at both edges of the word. Indeed, there is evidence, though not uncontroversial, that trochaic feet are privileged during the acquisition process even when iambic feet statistically predominate in the adult language (see, for example, Adam and Bat-El 2009 on Hebrew). In contrast, because there are no constituents in the grid-based account of stress, initial and penultimate stress do not constitute a natural class of stress locations since they differ both in terms of their directionality of grid construction and whether the grid initiates with a stressed or unstressed syllable.

Appealing to a trochaic bias also offers a potential explanation for the asymmetry in the relative cross-linguistic frequency of the four core binary stress

patterns. The two common stress systems (see Figure 6.2), one of which is characterized by stress on odd-numbered syllables counting from the left and the other of which involves stress on even-numbered syllables from the right, both reflect trochaic feet, whereas the two rarer patterns, stress on even-numbered syllables from the left and stress on odd-numbered syllables from the right, correspond to iambic footing. The footings associated with the four binary systems are shown in (17).

(17) Foot structure in binary stress systems

Pattern	Footing	Schematic forms	Number of languages	
			<i>Gordon (2002a)</i>	<i>StressTyp (2009)</i>
1. Odd-numb'd from L to R	Trochaic	('σσ)(,σσ)(,σ), (,σσ)(,σσ)(,σσ)	18	83
2. Even-numb'd from L to R	Iambic	(σ'σ)(σ,σ)σ, (σ'σ) (σ,σ)(σ,σ)	3	22
3. Odd-numb'd from R to L	Iambic	(,σ)(σ,σ)(σ'σ), (σ,σ)(σ,σ)(σ'σ)	5	8
4. Even-numb'd from R to L	Trochaic	σ(,σσ)(,σσ), (,σσ) (,σσ)(,σσ)	12	58

On the other hand, the trochaic bias does not account for the substantial number of single-stress languages that have final stress (see Figure 6.1), which would be analyzed (in foot-based terms) with an iamb at the right edge. Another typological observation that fails to fall out from the foot-based analysis is that the stress lapse in binary-plus-lapse systems such as the one found in Garawa (section 6.2.1) is invariably adjacent to the primary stress (Kager 2001, 2007), e.g. 'σσσ,σσ,σσ or ,σσ,σσσ'σσ but not *,σσσ,σσ'σσ or *'σσ,σσσ,σσ. Dual systems involving stress on both the initial and final stress, e.g. Canadian French (Gendron 1966), Armenian (Vaux 1998), and Udihe (Kormushin 1998), are also problematic for a foot-based theory (but not a grid-based approach) since there is no footing algorithm that would produce the two monosyllabic feet that are necessary to account for a disyllabic word in which both syllables are stressed.

It is also not clear that the cross-linguistic preference for trochaic feet in binary stress systems constitutes a piece of evidence for a foot-based theory of stress that is distinct from the evidence provided by languages with a single stress per word. The reason for this is that in most languages with binary stress the primary stress is oriented toward the same edge from which the alternating stress pattern propagates (van der Hulst 1984, 1997). For example, in languages with left-to-right trochaic rhythm, the stress on the initial syllable is almost universally the primary one, while in languages with left-to-right iambic rhythm, the primary stress is characteristically the stress on the second syllable. Conversely, in languages with right-to-left trochaic rhythm, the primary stress falls on the penult, and in languages with right-to-left iambic rhythm, the primary stress docks on the final syllable. As van der Hulst suggests, the link between directionality of

rhythm and alignment of primary stress supports the view that primary stress is positioned first and serves as the anchor point for rhythmic secondary stress. In a sample of 154 languages with rhythmic footing, including both quantity-sensitive and weight-insensitive systems, Goedemans (2010) finds that primary stress is oriented toward the same edge as foot construction in 116 (75%), a far greater number than one would expect if directionality for primary and secondary stress were independent of each other.

The correlation between directionality of foot and main stress alignment becomes even stronger when only weight-insensitive stress languages are considered. Results of a survey of the relationship between the edge at which primary stress falls and the starting edge of binary stress assignment in 101 quantity-insensitive stress systems are presented in (18), along with corresponding figures for weight-sensitive stress systems (see below for more on weight-sensitive stress). The survey was conducted using the WALS Interactive Reference Tool (<<http://www.eva.mpg.de/lingua/research/tool.php>>) and reflects the intersection of querying fixed stress location and rhythm type.

(18) Number of languages as a function of orientation of primary stress and binary stress

<i>Weight-insensitive</i>		Starting edge of rhythm		
		Left	Right	<i>Total</i>
Primary stress edge	Left	56	1	57
	Right	0	44	44
	<i>Total</i>	56	45	
<i>Weight-sensitive</i>		Starting edge of rhythm		
		Left	Right	<i>Total</i>
Primary stress edge	Left	10	2	12
	Right	14	22	36
	<i>Total</i>	24	24	

Results indicate that in 100 of 101 weight-insensitive binary stress systems (the Australian language Malakmalak being the exception) primary stress is oriented toward the same edge at which the rhythmic stress pattern originates. In quantity-sensitive stress systems, on the other hand, the link between the orientation of primary stress and the source of the secondary stress alternation is less strong. Rather there is a bias toward rightward orientation of primary stress regardless of orientation of rhythm, though the rightward pull is stronger in languages with right-aligned binary stress. Thus, 22 of 24 languages with right-aligned secondary stress have right-aligned primary stress compared with 14 of 24 languages with left-aligned rhythmic secondary stress but right-aligned primary stress.

One interpretation of these results is as follows. First, there is a bias toward rightward alignment of primary stress, which is consistent with the cross-linguistic bias toward rightward orientation of intonational pitch accents (see Chapter 7). Trumping the rightward attraction of primary stress, however, is a tendency to position stress a consistent distance from the edge of a domain across the

vocabulary, which is only possible in languages with weight-insensitive stress. Thus, in a language with left-to-right weight-insensitive rhythm, promoting the leftmost stress to primary stress will result in uniformity in the location of stress, either the initial or the second syllable depending on whether feet are trochaic or iambic. Conversely, in a language with right-to-left weight-insensitive rhythm, promoting the rightmost stress to primary stress ensures that primary stress is either on the penult (if feet are trochaic) or the final syllable (if feet are iambic). The potential benefit of positioning stress a consistent distance from a domain edge is an increase in the transparency and reliability of stress as a marker of prosodic boundaries.

Uniformity of stress placement is not possible, however, in a language with weight-sensitive stress, as the location of stress will shift depending on the weight of syllables. For example, in a left-to-right weight-sensitive trochaic system, the first syllable will attract stress in words beginning with a sequence of two light syllables or a heavy syllable, i.e. # ('_ _), #(' _), but if the first two syllables consist of a light-heavy sequence, stress will fall on the heavy second syllable, i.e. #_(' _), in order to avoid an ill-formed foot in which the stressed syllable is lighter than the unstressed syllable. Given that uniformity in the location of stress cannot be attained in weight-sensitive stress systems while also honoring rhythmic preferences, the bias toward rightward alignment of the pitch accent comes into play in languages with weight-sensitive stress.

6.6 Tone-sensitive stress

Another factor in conditioning stress besides syllable weight is tone. Tone-sensitive stress is a relatively rare phenomenon accounting for only 3% of the 300 stress languages in Gordon's (2006a) survey. The 100-language WALS sample contains only two languages (Krongo and Oromo) in which tone is relevant for stress. Despite its scarcity, there are nevertheless a sufficient number of cases of tone-driven stress in the literature to draw certain generalizations about the relationship between tone and stress. Foremost among these is the preference for higher tones (or contour tones consisting of a high component) to attract stress (de Lacy 2002, Gordon 2006a). Stress in some tone languages seeks out high tones that are adjacent to low tones, an effect that de Lacy (2002) captures in terms of footing. For example, stress in the Otomanguean language Ayutla Mixtec (Pankratz and Pike 1967, de Lacy 2002) is limited to a syllable within the domain consisting of the root plus suffixes. Within this domain, stress falls on the leftmost high tone followed by a low tone (19a). If there are no HL tone sequences, stress falls on the leftmost high tone (19b). Otherwise, if there are no high tones in a word, stress falls on the leftmost mid tone followed by a low tone (19c). If there are no high tones and no ML sequences, stress lands on the leftmost syllable (19d).

(19) Tone-sensitive stress in Ayutla Mixtec (Pankratz and Pike 1967, de Lacy 2002)

- | | | | |
|----|-------|--------------|------------------------------|
| a) | H'HL | lú'lúra | 'he is small' |
| | 'HLH | 'ʃinirà | 'his hat' |
| | 'HLHL | 'sátàkàràrì? | 'he is buying animals again' |

b)	'HHH	'ʃínirá	'he understands'
	M'HH	jā'tará	'is he old'
	ML'H	kūnù'rá	'his tobacco'
c)	'MLLL	'kāhkākàrà	'he will ask again'
	L'ML	tì'káfíʔ	'whirlwind'
	M'ML	('lùlù) lā'ʃàrà	'his orange (is small)'
d)	'LL	'kàʃíʔ	'to eat'
	'MM	('lùlù) 'tíkū	'the needle (is small)'

In de Lacy's account, trochaic (left-strong) feet are constructed over stressed syllables and a following syllable, if present. Higher tones are preferentially selected over lower tones as foot heads (i.e. as stressed syllables in a foot); hence, the stress-attracting hierarchy of $H > M > L$. Low tones, on the other hand, are the only tones eligible to occur in the weak position of the foot. As a result, a foot consisting of a stressed high tone followed by an unstressed low tone, i.e. $lù('lùrà)$, is preferable to one containing a stressed high tone followed by an unstressed high tone, i.e. $*('lùlù)rà$. Similarly, a foot consisting of a mid tone followed by a low tone is preferable to one comprised of two mid tones: $lā('ʃàrà)$ not $*('lāʃà)rà$. However, the attraction of stress by H tone, even if it results in a monosyllabic foot, is stronger than the preference for a canonical disyllabic foot: $kūnù('rá)$ not $*('kūnù) rá$.

6.7 Lexical and morphological stress

In many languages, stress is not predictable on purely phonological grounds but rather is sensitive to morphological factors or the particular lexical item. For example, English has a small number of word pairs that are differentiated solely on the basis of stress (and the properties such as vowel reduction and lenition that are predictable from stress). Most of these minimal pairs consist of noun–verb doublets based in which the verb has final stress and the noun initial stress, e.g. *im'port* 'verb' vs. *'import* 'noun', *per'mit* 'verb' vs. *'permit* 'noun', *con'flict* 'verb' vs. *'conflict* 'noun'. This difference has been analyzed in terms of an extrametricality condition holding of the final consonant in nouns but not verbs (or unsuffixed adjectives) (Hayes 1982; see section 6.2.2.4). However, there are also a small number of lexical items belonging to the same class that are distinguished through stress, e.g. *cor'ral* vs. *'coral*, *in'cite* vs. *'insight*.

As suggested in section 6.1, languages differ considerably in the functional load carried by contrastive stress and the extent to which stress is predictable on purely phonological grounds. In English, there are very few minimal pairs for stress and there are generalizations (see Liberman and Prince 1977, Hayes 1982, Hammond 1999) that account for the majority of stress patterns based on factors such as syllable weight and distance from the word edge. However, there are some words that present exceptions to these patterns, where the number of exceptions can be

reduced as the generalizations refer to more specific properties. Furthermore, morphosyntactic category (as the noun–verb pairs above illustrate) and suffix type also affect stress in English (see Smith 2011 for an overview of phonological asymmetries based on lexical category). English can thus be described as a language with reasonably, though not completely, predictable stress.

A language with far less predictable stress is Russian, in which stress is lexically marked for both nouns and certain affixes (Halle 1973, Brown et al. 1996). The result is a large number of minimal and near minimal pairs for stress among roots in addition to a number of paradigmatic alternations in stress for a given root depending on affixation patterns. In a cross-linguistic study of morphologically governed stress, Alderete (2001) finds that the majority of the Russian stress data is consistent with a recurring cross-linguistic pattern whereby a lexically stressed affix cedes its stress to a lexically stressed root when the two types of lexical stress co-occur.

This bias in favor of stressing roots over affixes is a common feature of stress systems, including those without inherently stressed affixes. Many languages limit stress to a syllable in the root. For example, stress in Supyire (with few exceptions) falls on the first syllable of the root (Carlson 1994), whereas stress in Maricopa (Gordon 1986) is on the final syllable of the root. It is also possible for syllable weight effects to be sensitive to the distinction between roots and affixes. In the Athabaskan language Tahltan (Alderete and Bob 2005), a stem-final heavy (CVV and CVC) syllable carries stress while the penultimate syllable of the stem is stressed if the final syllable is light. A CVV syllable to the left of the stem, however, may attract stress from a stem syllable. In the 100-language WALS sample, at least seven languages are described as having stress systems that preferentially select a syllable in the root to be stressed.

Lexical stress may also be delimited by stress windows. For example, stress in Choguita Rarámuri (Caballero 2008, 2011) is lexically specified within a three-syllable window at the beginning of a word. Kager's (2012) survey of stress windows reveals similar distributional biases in lexical stress to those found in weight-sensitive stress (section 6.2.2). In a survey of the StressTyp database, he finds 20 languages with a two-syllable window at the right edge, 12 with a three-syllable right-edge window, ten with a two-syllable left-edge window, and no languages with a three-syllable left-edge window.

Given the propensity for roots to attract stress in many languages, one might hypothesize that the location of affixes in a language might exert an influence on the location of stress. For example, it is possible that heavily suffixing languages are more likely to orient stress toward the left edge of a word, whereas predominantly prefixing languages might be expected to show a bias in favor of rightward orientation of stress.

In order to explore this hypothesis, the location of stress in languages included in Goedemans and van der Hulst's WALS chapter on fixed stress (Goedemans and van der Hulst 2013) was examined as a function of the dominant location of inflectional affixes according to Dryer's WALS chapter (Dryer 2013) using the WALS Interactive Reference Tool (<<http://www.eva.mpg.de/lingua/research/tool.php>>). Dryer's chapter contains results of a survey of affixation patterns in 971

languages. He considers a number of different types of affixes in his survey including case affixes on nouns, pronominal subject affixes on verbs, tense-aspect affixes on verbs, plural affixes on nouns, pronominal possessive affixes on nouns, definite or indefinite affixes on nouns, pronominal object affixes on verbs, negative affixes on verbs, and interrogative affixes on verbs. In order to quantify the extent to which the surveyed languages are biased toward prefixing or suffixing (or neither), Dryer determines the dominant position of each type of affix and assigns a point to either the prefixing or suffixing index or .5 points to each in case neither position is dominant. Case affixes on nouns, pronominal subject affixes on verbs, and tense-aspect affixes on verbs are assigned two points rather than one (one rather than .5 in case neither prefixing nor suffixing is dominant). **Dryer tabulates the prefixing and suffixing indices for each language and assigns languages into one of six groups: languages with little or no inflectional morphology (total affixing index, prefixing plus suffixing, less than two), predominantly prefixing languages (prefixing index greater than 80% of total affixing index), languages with a moderate preference for prefixing (prefixing index between 60 and 80% of total affixing index), languages with approximately equal amounts of prefixing and suffixing (prefixing index between 40 and 60% of total affixing index), languages with a moderate preference for suffixing (suffixing index between 60 and 80% of total affixing index), and predominantly suffixing languages (suffixing index greater than 80% of total affixing index).**

To examine the relationship between affix location and stress, the five core attested stress locations (initial, peninitial, antepenult, penult, and final) plus the marginal third syllable stress pattern (attested in one language: Ho-Chunk) were divided into two groups based on whether they are left-oriented (initial, peninitial, third syllable stress) or right-oriented (antepenult, penult, and final). Languages that appeared in both Dryer's affixation survey and Goedemans and van der Hulst's stress sample were coded according to their stress orientation and their affixation patterns according to Dryer's classification. Results are presented graphically in Figure 6.16 in terms of the proportion of languages with stress oriented toward the left edge as a function of biases in the position of inflectional affixes. The total number of languages belonging to each affixal category is also provided.

As the figure shows, all but the strongly suffixing languages are biased against left-oriented stress. The bias against left-oriented stress wanes as languages move from strongly suffixing to weakly suffixing before plateauing in the progression from weakly suffixing to equally prefixing/suffixing and then falling again moving to the weakly prefixing category. Curiously, however, the weakly prefixing languages actually show a greater preference for right-oriented prominence than the strongly prefixing languages. In interpreting the distinction between strong and weak prefixing bias, however, caution should be exercised given the small sample of strongly prefixing languages (only ten).

The most secure results of the survey appear to be the following. First, there is a strong typological bias in favor of right-oriented stress, a bias which can be observed in the two groups of languages that essentially serve as controls: those with little affixation and those with roughly equal amounts of prefixing and

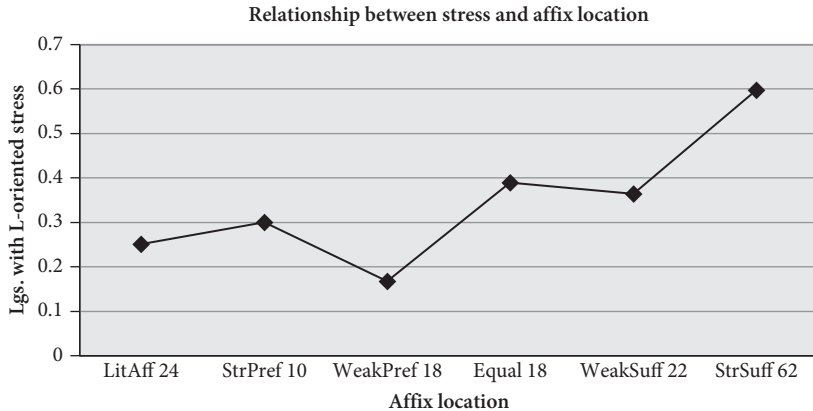


FIGURE 6.16. Proportion of languages with left-oriented stress (initial, peninitial, or third syllable) as a function of directional biases in inflectional affixes (as extracted from WALS interactive reference tool)

suffixing. This finding is consistent with the stress typology results discussed earlier in section 6.2.1 and plausibly reflects a preference for pitch accents to occur near the end of an utterance (see section 6.3). Second, the bias toward right-edge orientation of prominence is greater in prefixing languages (as a whole) than in suffixing languages, although there is not a steady cline correlating the degree of right-edge stress prominence with the strength of the directional bias in affixation. One should be wary, however, of attaching too much significance to the absence of such a correlation, since it could merely be an artifact of the cut-off points in Dryer's survey between the affixation categories.

Clearly the suggestive result that there is a relationship between affixation patterns and stress location should be regarded as tentative since it is based on a coarse taxonomy of affix location with arbitrarily imposed boundaries between categories. Furthermore, the interpretation of this relationship is incomplete since it fails to provide an explicit mechanism for how an overall tendency in affix placement may condition a broadly applicable stress pattern that is insensitive to morphology. It is nevertheless intriguing that a correlation between affixation and stress placement should exist even on a typological level.

Another way in which affixation interacts with stress is found in languages in which binary stress patterns are sensitive to boundaries between roots and affixes. Pensalfini (1999) describes differences between predominantly suffixing Australian languages, all of which employ binary feet from left to right, in the degree of coherence between the root and suffix and between suffixes (see also Crowhurst 1994b). At one extreme is Pintupi, in which feet are seamlessly constructed over all morpheme boundaries, while at the other extreme is Diyari, in which feet may never span a morpheme boundary.

There are also languages, like English, in which different word classes have different stress patterns. For example, Rice (1989, 2005) describes an asymmetry

between nouns and verbs in the Hare dialect of Slave. In this variety of Slave, stress falls on the stem in nouns but on the pre-stem syllable in verbs. Rice offers an historical account of this stress asymmetry that appeals to intonational factors of the type discussed in section 6.3. Word order in Slave is characteristically SOV, the unmarked final boundary tone is low, and as in other Athabaskan languages (like Tahltan discussed above) affixes are prefixes. Slave is also a two-tone (high vs. low) language in which the bulk of the tonal contrasts reside in the stem and high tone can be regarded as lexically marked and low tone as the default. Parallel to the asymmetry in stress, nouns and verbs are asymmetrical in their tonal properties such that a lexical high tone occurs on the stem syllable in nouns and on the pre-stem syllable in verbs. Rice hypothesizes that the lexical high tone associated with certain verb stems, which are characteristically phrase-final, was pushed leftward to the pre-stem syllable in order to avoid crowding with the intonational low tone marking the end of phrases. Noun stems, in contrast, were not under pressure to shift a lexical high tone leftwards since they were typically shielded from the right edge of the phrase by a following verb. Given that one of the phonetic correlates of stress is often higher pitch, Rice suggests that it was natural for prominence in verbs to also shift leftward along with high tone and that this shift might have been generalized to all verbs regardless of their lexical tone.

In some languages, prefixes may differ from suffixes in their stress behavior. In Kabardian (Colarusso 1992, 2006, Gordon and Applebaum 2010), noun suffixes are unstressed even if the general stress rule (stress on final CVX otherwise the penult) would predict suffixal stress: *'q'a:lɛ-kʲv* 'city-instrumental', *'da:mɛ-hɛm* 'wing-ergative pl.' (Gordon and Applebaum 2010: 59), cf. *sɛ' bən* 'soap', *məʔə' rəsɛ* 'apple' (p. 50). Many prefixes, on the other hand, are free to carry stress if the stress rule positions stress on them: *'zə-p'v* 'one-bed', *'si:-fɛ* 'my-skin'. The tone-sensitive stress system of Ayutla Mixtec (section 6.6) also draws a distinction between suffixes, which are part of the stress domain, and prefixes which are not.

Prefix vs. suffixing asymmetries can also be observed in some binary stress systems. For example, in Cahuilla (Seiler 1957, 1965, 1977), a binary trochaic pattern (where CVV and CV? are heavy) propagates from left to right through the domain encompassing both the stem and suffixes with the first syllable of this domain attracting primary stress: *'taxmu, ʔat* 'song', *'taxmu, ʔaʔ, tih* 'song (objective case)' (Seiler 1965: 57), *'qa:m, kicem* 'palo verde (pl.)', (p. 53), *'haʔa, tisqal* 'he is sneezing' (p. 52). Prefixes constitute their own prosodic domain with the proviso that stress does not fall on a light prefixal syllable immediately before the stem: *ˌpapen-ˈtule, qale, veh* 'where I was grinding it' (p. 52), *pen-ˈki:n, qale, veh* 'I going with him' (p. 53) where *papen-* and *pen-* are prefixes.

6.8 Summary

Stress is reported for the majority of languages of the world, even many languages that also use tone contrastively. Stress patterns may be broadly bifurcated into two groups: weight-sensitive systems, in which syllable weight is relevant in conditioning stress, and weight-insensitive systems, in which weight does not

influence stress placement. Among the weight-insensitive stress systems, further divisions can be made between languages with a single stress per word, those with two stresses per word, and those with rhythmic stress, either on alternating syllables or on every third syllable. The most common positions for stress cross-linguistically are the initial, the penultimate, and the final syllable with peninitial and antepenultimate stress being considerably rarer. Among the quantity-sensitive stress systems, languages differ in their weight criteria, i.e. which preferentially attract stress. Most commonly, languages treat either syllables containing a long vowel as heavy (CVV heavy), syllables containing a long vowel or a coda consonant as heavy (CVX heavy), or syllables containing a full (non-schwa) vowel as heavy. Certain languages also employ more stringent weight criteria in final position relative to non-final position. In many languages, stress is sensitive to morphology. This sensitivity to morphology may manifest itself in different ways: a preference for stressing the root, differential treatment of prefixes and suffixes, or variation in stress patterns as a function of the morphosyntactic class to which a word belongs. There are several possible phonetic explanations for the distribution of both weight-insensitive and weight-sensitive stress appealing to factors such as intonation, relative duration, perceptual duration, and auditory energy. An ongoing source of debate in stress theory concerns the representation of stress in terms of constituents or merely prominence relations expressed as grid marks.

Tone and intonation

Tone and intonation have in common that they are both conveyed by the acoustic property of fundamental frequency and its perceptual correlate, pitch. Tone languages vary considerably in the role played by tone. In some languages, e.g. Thai and Mandarin, tone carries a high functional load in conveying lexical contrasts, while in others, e.g. Swedish and Koasati, tone plays a more circumscribed role. Yip (2002: 1) suggests that up to 60–70% of the world's languages are tone languages. However, tone languages are not distributed evenly throughout the world. In certain regions, e.g. Africa, Central America, and Southeast Asia, they are widespread, while in other areas, e.g. Eurasia, North America, and Australia, they are sparse or non-existent.

Like tone, intonation is signaled through differences in fundamental frequency. Unlike tone, however, intonation is used to communicate higher level information not lexically associated with morphemes. The functions of intonation are extremely broad. It is used to mark differences between questions and statements, to indicate whether someone is done speaking or not, to convey emotional states and attitudes, to signal information as being novel or not, etc. In contrast to tone, intonation is found in all languages, even those in which tone is used on a lexical level. Despite its universality, however, our typological knowledge of intonation is less developed than our understanding of tone. This chapter examines the phonology of tone and intonation, starting with tone in sections 7.1–7.9 before proceeding to intonation in sections 7.10–7.12. Issues of tonal crowding shared between tone and intonation systems are addressed in section 7.13.

7.1 Tone and the taxonomy of prosodic systems

Although the majority of languages use tone to convey lexical contrasts, their statistical prevalence shrinks in more genetically balanced surveys of prosodic systems. In Maddieson's (2013c) survey of 526 languages, 220 (41.8%) are classified as tonal. In the genetically balanced 100-language WALS survey, 29 of the 97 languages (29.9%) are tonal. Traditionally, linguists have assumed a bifurcation between stress and tone languages, where a cluster of properties has been used to place a language into one of these two coarse categories. Separating all languages into stress and tone groups has proven problematic, however, as there are many languages that possess properties typically regarded as being diagnostic for both

groups. These “hybrid” languages are often bundled together under the rubric of pitch-accent languages. As Hyman (2006) points out, however, pitch accent is not a coherent category that can be explicitly defined to the exclusion of stress and tone languages; rather, the pitch accent class serves as a repository for languages that are neither prototypically stress nor prototypically tone languages. Hyman (2006: 229) proposes a broad definition of a tone language as one in which tone must be lexically specified for certain morphemes, a definition that encompasses languages that have often been regarded as possessing pitch accent systems. However, Hyman suggests it is ultimately more fruitful to describe the characteristics of a prosodic system directly rather than creating a tripartite taxonomy of languages as stress, tone, or pitch accent based on a cluster of properties that may or may not converge in their diagnosis. Adopting this view, we will now explore some of the ways in which tone languages, including those traditionally considered pitch accent languages, vary in their use of tone.

7.2 The organization of tone languages

The quintessential tone language is one in which every syllable in a word is differentiated solely on the basis of tone such that the number of tonal contrasts multiplies as word length increases. In practice, as will be shown below, most tone languages display constraints on the distribution of tones. It is possible, however, to find nearly prototypical tone languages in which tone carries a high functional load in conveying contrasts. For example, the following set of five Thai words contrasts on the basis of tone (Gandour 1975: 170): *k^hā:* ‘to be stuck’, *k^hà:* ‘a kind of spice’, *k^hā:* ‘to kill’, *k^há:* ‘to engage in trade’, *k^hǎ:* ‘leg’. Similarly, the three tones of Yoruba occur in various combinations in the following quintuplet of disyllabic words (although they do not completely cross-classify): *ìgbá* ‘calabash’, *ìgbā* ‘two hundred’, *ìgbá* ‘Locust-bean tree’, *ìgbà* ‘time’, *ìgbà* ‘climbing-rope’ (Pulleyblank 1990: 974).

In other languages, tone has a much smaller functional load and/or may be constrained in its occurrence. For example, in the Na Dene language Navajo, tonal contrasts are limited to roots and certain affixal domains and there are very few minimal pairs distinguished solely on the basis of tone, e.g. *ʔani:ʔ* ‘face’ vs. *ʔani:ʔ* ‘waist’, *ʔazè:ʔ* ‘medicine’ vs. *ʔazé:ʔ* ‘mouth’. In the Muskogean language Koasati, there is a relatively small set of nouns that is lexically marked for tone (phonetically a rising tone) on the penultimate syllable of the root, e.g. *hopó:ni* ‘a cook’, *tálwa* ‘singer’, *athómma* ‘Indian’, and aspectual contrasts in verbs are signaled in part through tone differences (along with length differences), e.g. *hallà:tkal* ‘I am holding it’ and *ʃokkò:lil* ‘I am seated’ with rising tone on the penult vs. *halà:tkál* ‘I am grabbing hold of it’ and *ʃokò:lil* ‘I am getting seated’ with rising tone realized over the penult and ultima.

7.3 The relationship between tone and stress

Classifying languages as possessing tone or stress systems is often problematic when one moves beyond prototypical instantiations of the two systems. In many

tone languages, tone serves a demarcative function, falling a predictable distance from a prosodic boundary much as stress in many languages consistently falls on a certain syllable at or near a word edge. For example, a high tone contributed by a verbal prefix in the Bantu language Xhosa (Cassimjee and Kisseberth 1998) docks on the antepenultimate syllable. Thus, the high-toned prefix *bá-* often realizes its tone to the right of the prefix, e.g. *ba-ja-móne:la* ‘they are jealous’, *ba-ja-xóle:la* ‘they forgive’, *ba-ja-qononóndi:sa* ‘they emphasize’. Similarly, in another Bantu language, Giryama (Cassimjee and Kisseberth 2000), a lone high tone in a word migrates to the penult: *a-na-zí:ra* ‘s/he hates’, *a-na-lamú:sa* ‘s/he greets’ (where the underlined prefix contributes the high tone). In a word with two high tones, the leftmost one docks on the initial syllable of the stem and the rightmost one on the penult: *a-na-[kú]baliyá:na* ‘s/he agrees’, *a-na-[tsúndzulú:ka* ‘s/he becomes sober’ (where the beginning of the stem is marked with []). This system bears striking resemblance to dual stress systems with both initial and penultimate stress (see Chapter 6).

In addition to being demarcative, tone may also be culminative in that there may be a single high tone per stem or word, a situation that parallels stress languages in which there is usually assumed to be a single primary stress per word (see Chapter 6). For example, it is common for Bantu languages to impose a limit of a single high tone per word or stem (Downing 1996).

Tone may even be rhythmic, falling on alternating syllables much like stress in many languages. Thus, in the Bantu language Lamba (Bickmore 1995), a lexical high tone docks predictably on the leftmost mora of certain prefixes, called “attractor” prefixes, and on every odd-numbered mora thereafter until the root is reached. For example, the high tone of the leftmost prefix in /tá-tu-{luku-mu}-kom-a/ ‘we are not hurting him’ docks on the leftmost mora of the attractor prefix domain (delimited by curly braces) and spreads rightward to dock on every other mora up until the left edge of the root (marked by []), yielding *tatu {lúkumú}[koma*. A high tone can also migrate from the root leftward to an attractor prefix, as in /u-{ku-}[léemb-a/ ‘to write’ → *u{kú}[leemba* ‘to write’. In words lacking an attractor prefix, a high tone attributed to the root simply docks on the first syllable of the root: /tu-tji-[léemb-a/ ‘we still write’ → *tutji[léemba* ‘we still write’.

A more elaborate rhythmic counting system guiding tone placement is found in the Muskogean language, Creek (Haas 1977, Martin and Johnson 2002, Martin 2011), in which a high tone plateau spans from the first through the last metrically strong syllable according to a weight-sensitive (CVX is heavy) left-to-right iambic parse (see Chapter 6 on iambic rhythm): (*nokó*)(*sótfi*) ‘bear cub’, (*awá*)(*náji*)*ta* ‘to tie to’, (*i:*)(*káná*) ‘land’, (*honán*)*wa* ‘male’, (*tapás*)(*só:la*) ‘daddy longlegs’ (Martin 2011).

The demarcative, culminative, and/or rhythmic nature of tone in some languages lends itself to an analysis (pursued by many researchers) in which certain syllables are assumed to be metrically prominent much like stressed syllables. For example, the attraction of the high tone to the penult in a language like Giryama can be attributed to stress on the penult. This analysis finds support from the pervasive positioning of stress on the penult in

many Bantu languages (Downing 2010). Similarly, the high tone plateau in Creek can be ascribed to a system of iambic footing initiating at the left edge of a word, while the Lamba pattern of rhythmic high tone can be attributed to a trochaic foot structure operative in certain domains.

There is no a priori reason to exclude a metrical analysis of tone as there are many languages in which stress and tone coexist. In certain languages, tone and stress may function completely orthogonally to each other. For example, Pirahã (Everett 1986) has a two-way tone contrast, between high tone and unmarked low tone, e.g. *hói* ‘small quantity’ vs. *hoí* ‘large quantity’. Pirahã also has a weight-sensitive stress system (Everett and Everett 1984, Everett 1988) that functions separately from the tone system (see Chapter 6). Stress is confined to a three-syllable window at the right edge of a word, falling on the rightmost syllable that is heaviest according to the following hierarchy: KVV > GVV > VV > KV > GV, where K is a voiceless onset consonant and G a voiced one. Crucially, a low-toned vowel may attract stress from a high-toned vowel given the right weight configuration in the word, e.g. *'hoa.gái* ‘come’, *paó.hoa.'hai* ‘anaconda’.

Tone and stress in some languages intersect, where this intersection may manifest itself in one of two ways. Tonal contrasts may be limited to stressed syllables as in the Curaçao dialect of the Caribbean Creole language, Papiamentu (Remijsen and van Heuven 2005). The stress system of Curaçao Papiamentu is predictable from a combination of morphological and weight factors, and stressed, but not unstressed, syllables may be marked with a lexical tone, phonetically a high–low fall. The combination of tone and stress yields such triplets as *'lôra* ‘parrot’ vs. *'lora* ‘to turn’ vs. *lo'ra* ‘turned’. Another possibility is for stress to be positioned on the basis of tone, where high tone is cross-linguistically prone to attract stress (de Lacy 2002; see Chapter 6).

More problematic are systems in which tone placement appears to suggest a certain metrical structure that conflicts with the metrical system diagnosed through stress. For example, stress in the Bantu language Zulu falls on the penult but, as seen above for Zulu’s Bantu relative Xhosa, high tone migrates to the antepenult (Hyman 1989). In cases of this sort, where the tone-attracting syllable and the stressed syllable are adjacent to each other, it may be possible to appeal to foot structure to account for the two-syllable domain of prominence. For example, an iambic foot plausibly spans the antepenultimate and penultimate syllables in Zulu where the stressed syllable is lengthened while the foot-initial syllable attracts a high tone, plausibly a tonal manifestation of the phenomenon of domain-initial fortition (Dilley et al. 1996, Fougeron 2001, Keating et al. 2003, etc.) at the level of the foot (Gordon 2011, Bennett 2013). Such an analysis raises broader questions about the relationship between metrical structure and tone. Ideally, there is independent support for the metrical structure posited to account for the location of tones.

Languages in which tone is lexically contrastive but obeys culminativity in terms of its distribution traditionally fall under the category of “pitch accent” languages (see van der Hulst 2011 on pitch accent), interpreted by Hyman (2006) as a subtype of tone language in which tone has a restricted distribution. The Koasati tone system described above fits the profile of a pitch accent or restricted

tone system since there is a maximum of a single lexically marked tone per morpheme and there are many morphemes that lack tone completely. These characteristics are shared with other more familiar languages, such as Swedish and Japanese, which have been presented in the literature as prototypical pitch accent languages. The facultative nature of lexically marked tone is also shared with the tone languages described above that display culminative and/or demarcative tonal assignment. This optionality distinguishes restricted tone systems from canonical stress languages in which metrical prominence is obligatory, a property that Hyman (2006) takes as most definitional for a stress system. Nevertheless, at least a few isolated languages display tone assignment conventions that are both culminative and obligatory, such that each word has one and only one high-toned syllable, e.g. the creole language Nubi (Gussenhoven 2006), and the Bantu languages Safwa (Voorhoeve 1973) and Kinga (Schadeberg 1973). As Hyman (2006) points out, the last two languages can be excluded as stress languages by defining stress as a property of syllables, since tone in Safwa and Kinga is assigned to moras (see Chapter 5 and 6 on moras). However, this still leaves Nubi, in which high tone is a property of syllables. A language like Nubi presents a challenge to the taxonomist interested in retaining a clearly delimited distinction between stress and tone languages (see Gussenhoven 2006 for discussion). One possible way to distinguish stress and tone is to fall back on the assumption that the phonetic realization of prominence in the two types of languages differs, such that a tone language relies exclusively (or predominantly) on fundamental frequency rather than other properties such as intensity or duration, which cue prominence in a stress language (see Beckman 1986 for comparative phonetic analysis of tonal prominence in Japanese vs. stress-based prominence in English).

7.4 Number of tones

One dimension along which tone languages differ is in the number of tones that are used to distinguish lexical items. Maddieson's (2013c) survey breaks languages into three groups based on their tonal complexity. Of the 220 languages in his survey that use tone to signal lexical or morphological contrasts, roughly 60% (132 languages) fall into the "simple" category and draw just a binary contrast between two tones. Many of these languages fall into the traditional "pitch accent" category discussed above. This leaves 40% (88 languages) that belong to Maddieson's "complex" category in distinguishing three or more tones. Tone languages of different complexity are not distributed evenly throughout the world as the map in Figure 7.1 shows.

Most languages with complex tone systems are found in Southeast Asia and in a band extending across Central Africa. Meso-America is another locus of complex tone systems: seven Oto-Manguean languages in Maddieson's sample have complex tone inventories as opposed to only two with simple tone systems. At the other extreme, tone languages of any type are very sparsely represented in North and South America, Europe, and northern Asia. Tone languages are completely

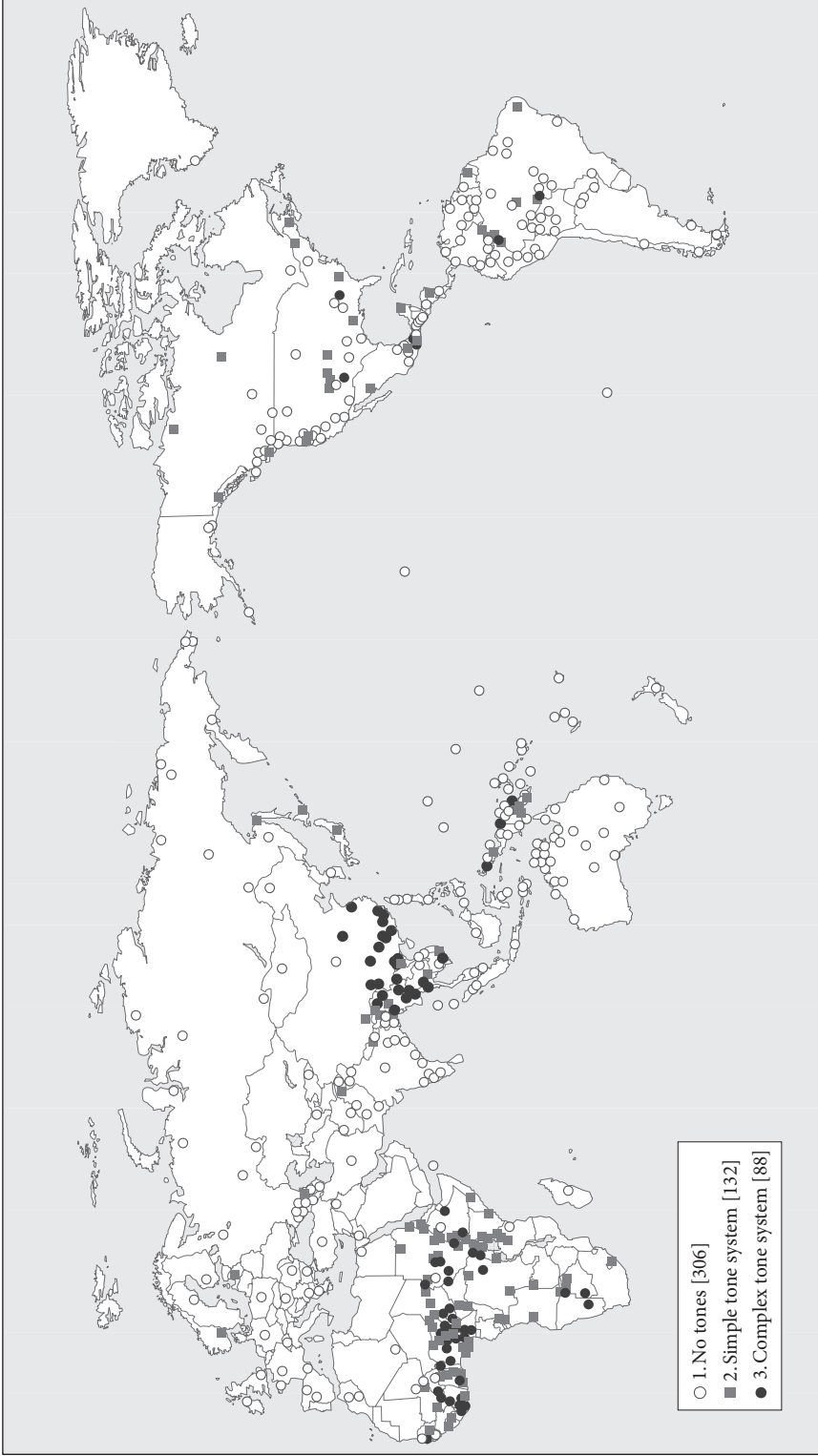


FIGURE 7.1. Map showing the distribution of languages lacking lexical tone (white dots), those with simple binary tone systems (gray squares), and those with complex tone systems involving at least three tones (black dots) according to Maddieson's (2013c) survey

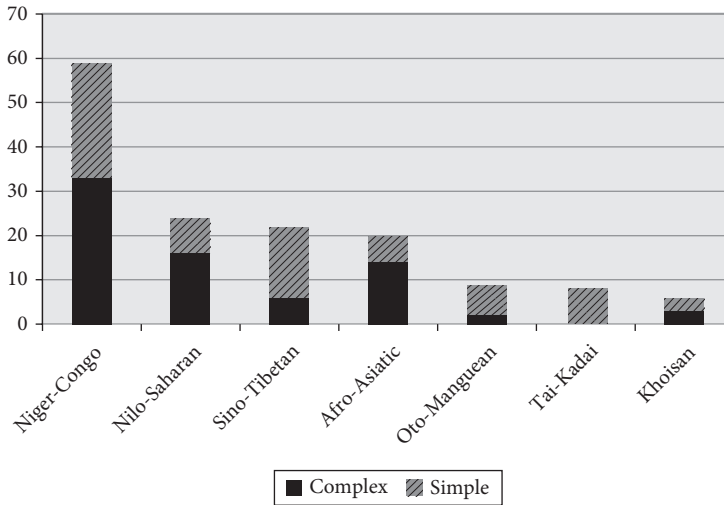


FIGURE 7.2. Map showing the number of languages with simple and complex tone inventories in language families containing at least six languages in Maddieson's (2013c) survey

absent from Australia, although this gap reflects a shared genetic feature. New Guinea displays considerable diversity in its prosodic systems mirroring its genetic diversity; multiple languages belonging to each of three categories in Maddieson's taxonomy are found in New Guinea (see Donohue 1997, Cahill 2011 for an overview). Figure 7.2 plots the number of languages with simple or complex tone systems among the language families in Maddieson's survey with at least six tone languages. The three language families with the greatest percentage of languages possessing complex tone systems are Sino-Tibetan (Asia), Tai-Kadai (Asia), and Oto-Manguean (Meso-America). In contrast, Afro-Asiatic, Nilo-Saharan, and Niger-Congo tend to have relatively simple tone systems. The six surveyed languages in the Khoisan family are split between simple and complex tone inventories (see Yip 2002, which devotes separate chapters and sections to characteristics of tone in different geographic regions and different language families).

Among languages belonging to the complex group in Maddieson's (2013c) survey, most have three contrastive tones, with more complex systems roughly evenly split between those with four, five, or six tones. This distribution is shown in Figure 7.3, which plots the number of contrastive tones (as a proportion of the total number of languages sampled) found in a sample of 207 tone languages presented in Maddieson (1978a) alongside comparable results for the 29 tone languages in the 100-language WALS sample.

Both surveys are similar in showing a sharp decline in frequency of tonal systems that employ more than a ternary tone contrast. However, the surveys diverge in the relative commonness of languages with a simple binary tone distinction relative to those with three tones. In Maddieson's survey, which like

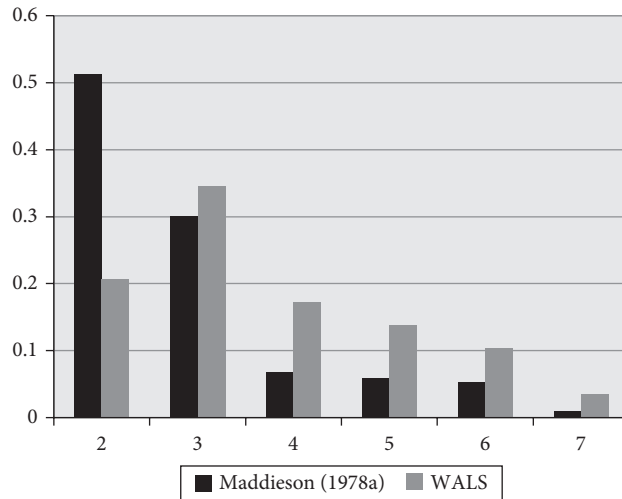


FIGURE 7.3. The number of lexical tones per language expressed as a proportion of the total number of languages in two surveys: the 207-language survey in Maddieson (1978a) and a 29-language survey from WALS

the WALS survey is genetically balanced, binary tone contrasts outnumber ternary tone distinctions, whereas in the considerably smaller survey based on the 100-language WALS sample, ternary distinctions are more common than binary distinctions.

The maximum number of tonal contrasts found in a language is less certain. Two languages in Maddieson's (1978a) survey have seven lexical tones, though there are other languages in the literature reported to have more. At the upper limit of complexity are languages such as the Tai-Kadai language Kam (Tongyin and Edmondson 2008), which distinguishes nine tones, Eastern Chatino (Otomanguean) varieties (Cruz and Woodbury 2006, Villard 2009, Campbell and Woodbury 2010) contrasting as many as 12 tones, and the Niger-Congo language Wobé, which has been claimed to possess as many as 14 tones (Beirth and Link 1980; but see Singler 1984 for reanalysis positing fewer tones).

One complication in evaluating tonal complexity is that tone distinctions, particularly in languages with more elaborate inventories, are often acoustically and perceptually differentiated along other phonetic dimensions in addition to fundamental frequency, such as phonation type or laryngeal features of neighboring consonants (see, for example, Andruski 2006 on Green Hmong, Brunelle 2009 on Vietnamese, Esposito 2012 on White Hmong, and Kuang 2013a, b on Black Miao). The interdependence between tone and other properties (including even duration) often makes it difficult to determine whether certain contrasts are fundamentally tone distinctions or could be distinguished along another phonological dimension (see section 7.8 on the relationship between tone and laryngeal properties).

7.5 Tonal complexity

Another source of divergence between tone languages is in the types of tones that they possess. Tones can be classified into three coarse groups according to their shapes. Level tones consist of basically flat fundamental frequency contours, contour tones have a single cline (either rising or falling), and complex tones have two tonal slopes, either a fall followed by a rise or a rise followed by a fall. It should be noted that this tripartite taxonomy of tone shapes is a phonological one and does not necessarily mirror the phonetic realizations of the tone. For example, a tone that patterns phonologically as a level tone may have a rise or fall phonetically.

There is a general consensus that languages distinguish a maximum of five level tones (Maddieson 1978b, Yip 2002), e.g. in Kam (Edmondson and Gregerson 1992), where those displaying more tone levels are typologically less common than those possessing fewer tone levels (Maddieson 1978b). The presence of contour tones in a language implies the existence of level tones (Maddieson 1978b, Zhang 2002), although in languages with both level and contour tones, the number of contour tones may exceed the number of level tones. The occurrence of complex tones in turn implies the existence of contour tones (Maddieson 1978b, Zhang 2002). The implicational relationship between level, contour, and complex tones becomes transparent if contour and complex tones are viewed compositionally (Woo 1969) within an autosegmental framework (Goldsmith 1976), in which tones link to tone-bearing units (TBU) such as moras or syllables. Adopting this type of representation, contour tones consist of a sequence of a high plus a low tone, where the high precedes the low in a falling tone (1a) and follows it in a rising tone (1b). Complex tones consist of three tones, e.g. high–low–high in the case of a falling–rising tone (1c) and low–high–low in the case of a rising–falling tone (1d).

(1) Phonological representations of contour and complex tones

a. Falling	b. Rising	c. Falling-rising	d. Rising-falling
μ μ	μ μ	μ μ μ	μ μ μ
H L	L H	H L H	L H L

If one adopts this compositional view of tone, the generalization emerges that the occurrence of tones associated with a greater number of tonal targets implies the occurrence of tones associated with a smaller number of tonal targets (Zhang 2002). Thus, a complex tone, which has three tonal targets, implies a contour tone, which has two tonal targets, which in turn implies a level tone with its single tone target.

Zhang (2002, 2004) examines the typology of tone systems possessing contour and/or complex tones. Of the 187 languages in his survey, only two, both Chinese varieties, possess contour tones without level tones. Furthermore, all of the 46 languages that allow complex tones also have contour tones. He also finds that

restrictions on rising tones are stricter than those for falling tones in many languages (37 in his survey). Two such languages possessing falling but not rising tones are the Kiowa-Tanoan languages, Kiowa and Jemez, both of which are discussed in section 7.5.2. In contrast, only three languages in Zhang's survey more sharply restrict falling tones relative to rising tones.

7.5.1 Tonal complexity and language-internal frequency

One might hypothesize that the cross-linguistic preference for certain tones over others is mirrored in language-internal frequency patterns. This question was addressed using frequency data from seven languages with complex tone inventories (>2 tones) differing in their number of lexical tones: three in Hausa and Maninka, four in Mandarin, five each in Thai, Nzadi, and Xochapa Mixtec, and six in Cantonese. Table 7.1 provides information about the languages, including their genetic affiliation, the source from which the counts were collected, the size of the corpus in number of syllables, and the nature of the frequency counts. It may be noted that type and token frequency values were very similar to each other in the four surveyed languages for which both types of frequency data were presented in the consulted source: Cantonese (Leung et al. 2004), Mandarin (Suen 1982), Thai (Munthuli et al. 2013), Maninka (Rovenchak 2011). Following the methodology discussed in Chapter 1, type frequency data are presented here.

Figure 7.4 depicts the relative frequency of the different lexical tones in the seven surveyed languages. Note that Cantonese has two rising tones both of which start at a low level (expressed as 2 along a commonly used numerical scale ranging from 1 to 5 with 1 being lowest and 5 highest) but which differ in their ending level. In the case of Maninka, because the source does not split tone patterns by number of syllables in a word, the totals reflect words in which the only tone(s) are a high, a low, or rising tone, which together comprise approximately 62% of the Maninka corpus.

In interpreting the figure, it should be borne in mind that the results depend in large part on the phonological analysis adopted by the consulted source(s). It is,

TABLE 7.1. Languages sampled for frequency of tones

Language	Family	Type	Size (no. of syll)	Source
Cantonese	Sino-Tibetan	Token	1,923	Leung et al. (2004)
Hausa	Afro-Asiatic	Type	4,439	Randell et al. (1998)
Mandarin	Sino-Tibetan	Type	2,500	Duanmu (2008)
Maninka	Niger-Congo	Token	3,601	Rovenchak (2011)
Mixtec, Xochapa	Oto-Manguean	Type	1,325	Stark et al. (2003)
Nzadi	Niger-Congo	Type	2,592	Crane et al. (2011)
Thai	Tai-Kadai	Type	61,222	Gandour and Gandour (1982)

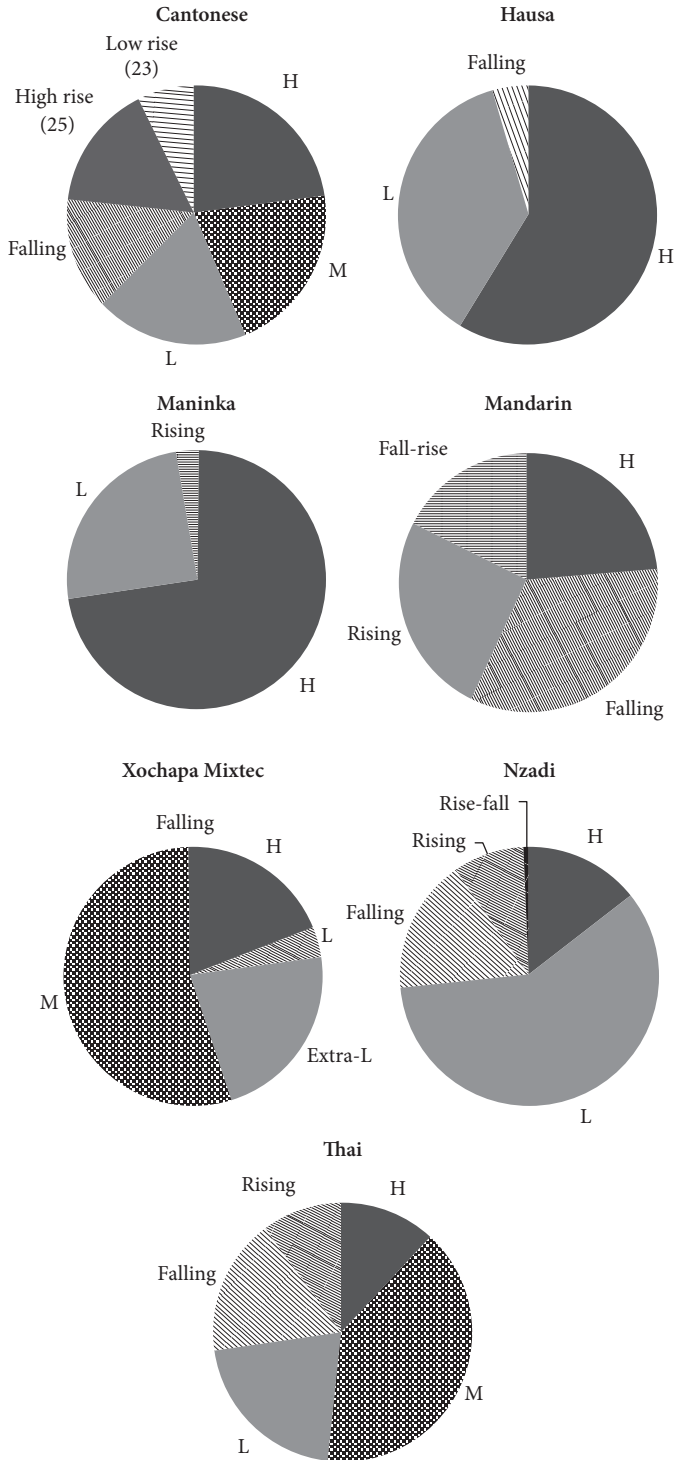


FIGURE 7.4. Type frequency of lexical tones in seven languages

for example, unclear how closely the posited tone categories correspond to their actual phonetic realization, which leaves open the possibility that a tone category could in certain cases be classified differently. For example, a tone categorized as a level tone could have a falling (or rising) *F_o* contour. Furthermore, as mentioned earlier in section 7.4, certain tones might be differentiated along acoustic dimensions other than just tone, e.g. laryngeal properties (see section 7.8 for discussion).

With these limitations in mind, it seems evident that, although there is considerable variation between the seven surveyed languages, many (though not all) of the typological generalizations governing the distribution of tone cross-linguistically are also apparent in the frequency data. Level tones are more prevalent overall in the data in keeping with the typological observation, likely grounded in considerations of articulatory ease (see section 7.5.3), that level tones are more basic than non-level tones. The skewing in favor of level tones is most apparent in the three-toned languages Hausa and Maninka, in both of which the single contour tone (falling in Hausa and rising in Maninka) is quite rare compared to the two level tones. In aggregate the non-level tones are disproportionately rare in all the surveyed languages relative to the proportion of tone categories that they constitute in the inventory.

It is interesting to note, however, that languages vary in which level tone statistically predominates. High tone is the most frequent level tone in Hausa, Maninka, and Mandarin (where it is the only level tone), while mid tone is most common in Thai and Xochapa Mixtec, and low tone is most prevalent in Nzadi. In Cantonese, the high, mid, and low tones are all attested with roughly equal frequency. Given that mid tone is limited to Thai, Xochapa Mixtec, and Cantonese, one can make the generalization that mid tone, when it occurs, is at least as frequent as other tones, presumably owing to its articulatory proximity to the default *F_o* level. On the other hand, the fact that mid tone only occurs in languages with at least two other acoustically more dispersed level tones (high and low) suggests that perceptual distinctiveness plays an important role in the shaping of tone inventories even at the expense of articulatory ease. Further support for the importance of perceptual differentiation comes from the presence of two contour tones and one complex tone compared to only a single level tone in Mandarin.

In the five languages with greater than three lexical tones, four possess at least two contour tones, at least one of which is a rise and one a fall. Xochapa Mixtec is exceptional among the surveyed languages in having four level tones and only a single contour tone (a fall). This contrasts with four-toned Mandarin, which has only a single level tone and three contour and complex tones. The divergence between Xochapa Mixtec and Mandarin in the relative number of level tone and non-level tone categories suggests that the struggle between the conflicting goals of minimizing articulatory effort and maximizing perceptual distinctiveness can have different outcomes on a language-specific basis.

There is also support in the survey for the typological observation that contour tones are more basic than complex tones. Mandarin, Cantonese, and Nzadi all have three non-level tones, where the third contour tone (supplementing the rising and falling tones) is a second rising tone in Cantonese, a complex falling-rising tone in Mandarin, and a complex rising-falling tone in Nzadi. The presence

of a complex tone thus implies the occurrence of a contour tone in the examined languages in keeping with the typological observation that complex tones imply contour tones. Furthermore, the complex tone is the least frequent of all tones in the two languages in which they occur (Mandarin and Nzadi).

Support for the typological observation that falling tones are more fundamental than rising tones finds, however, only mixed support from the survey (as it also does in Maddieson's survey). On the one hand, Hausa and Xochapa Mixtec each have only one contour tone and it is a falling tone. Furthermore, the falling tone is statistically more common than the rising tone in Nzadi and Thai. On the other hand, in Maninka and Mandarin, the only contour tone is a rise and, in Cantonese, there are two rising tones and only one falling tone.

The overall relationship in the survey between the non-level tones and the number of tone contrasts is generally consistent with results from Maddieson's (1978a) survey showing that languages are more likely to exploit non-level tones as the number of contrastive tones increases. The parallel between Maddieson's and the present survey holds, however, only in general terms since certain of the languages examined here are in some ways typologically atypical in their relationship between number and type of tones.

For example, although languages with two or three tones tend to have only level tones cross-linguistically, the two three-toned languages in the survey (Hausa and Maninka) have one contour tone (which admittedly is quite rare in both languages). Furthermore, Mandarin, the lone surveyed language with four tones, is somewhat of a typological outlier in having one level tone and three non-level tones contra the more common pattern for four-toned languages to have either one or zero non-level tones. The five- and six-toned languages in the survey appear to be more representative of cross-linguistic distributions in having (in most cases) either two (Thai) or three (Cantonese and Nzadi) non-level tones. (Xochapa Mixtec appears to be rather unusual in having five tones, four of which are level. It is conceivable that one of the level tones is accompanied by a phonation difference as is common in languages with many level tones (Kuang 2013a, b).) The overall greater likelihood of exploiting non-level tones in languages with many tone categories suggests contour and complex tones provide a useful way to differentiate tones as the tone space becomes saturated in the vertical dimension (Maddieson 1978a) (see discussion of Lindblom and Maddieson (1988) in Chapter 3 for a similar approach to consonant inventories).

7.5.2 Syllable weight and tonal complexity

In addition to observing implicational scales based on tonal complexity, Zhang (2002) also finds that certain contexts are better suited to licensing non-level tones cross-linguistically, where the privileged status of these positions as licensors may be manifested in one of three ways. First, they may be the only positions that permit non-level tones; second, they may license a richer array of non-level tones than other positions; third, they may allow for greater pitch excursions (e.g. a low to high rise involves a larger pitch transition than a low to mid rise). Restrictions

on non-level tones may either be static constraints on the structure of morphemes or they may be manifested through active alternations. Since contour tones are cross-linguistically much more common than complex tones (section 7.5), they serve as the basis for many of the observations about the distribution of non-level tones made in Zhang's (2002) work.

One dimension that Zhang identifies as a predictor of contour tone licensing asymmetries is position in a word. He finds that final syllables preferentially license contour tones over non-final syllables in 45 languages in his survey. For example, the Bantu language Etung (Edmondson and Bender-Samuel 1966) only permits contour tones on the final syllable of phonological words whereas level tones may occur on both final and non-final syllables.

A further property that serves as a preferential licenser of contour tones is stress. Zhang thus identifies 21 languages in which contour tones are limited to stressed syllables. One such language is the Kiowa-Tanoan language Jemez (Bell 1993), in which the only contour tone, a fall, is limited to the first syllable of a word, the stressed syllable.

Yet another factor that Zhang identifies as being relevant for predicting the capacity for supporting contour tones is word length, as defined in terms of number of syllables. He thus finds 19 languages in which shorter words display a greater capacity for realizing contour tones than longer words. Zhang exemplifies this pattern through the Niger-Congo language Mende. Although the Mende tone facts are contentious on some points, Zhang provides a synthesis of the facts that are generally agreed upon and involve sensitivity to word length in addition to syllable type and syllable position (see Zhang 2002 and references cited therein for further discussion). Long vowels can bear a complex tone (rise-fall) in monosyllabic words but not in longer words, in which they may only support level and simple contour tones (fall or rise). Short vowels can be realized with either a falling or rising contour tone in monosyllabic words. In longer words, however, short vowels can carry only a falling tone and only in final position. The Mende tone distribution facts illustrate how multiple factors (tonal complexity, word length, syllable type, and syllable position) can intersect in predicting the distribution of tones in a single language.

Yet another dimension relevant for predicting the capacity for supporting contour tones is rime type, where rimes containing more sonorous sounds are more likely to license contours than other less sonorous rimes (see also Clark 1983, Hyman 1988, Gordon 2001). Syllables preferentially licensed to carry contour tones in a language are often termed "heavy" syllables by analogy with weight-sensitive stress systems (see Chapter 6). Thus, in 38 languages in Zhang's survey of 187 languages, long voweled syllables (CVV, where VV typically stands for both long vowels and diphthongs) preferentially permit contour tones over other syllable types, while in 66 languages, both long vowels and syllables closed by a sonorant coda (CVR) more freely license contour tones than short voweled syllables that are either open or closed by an obstruent.

The Kadu language Krongo (Reh 1985) instantiates the preferential licensing of contour tones (which are both falling and rising, the latter of which is relatively

rare) by CVV. Contour tones are not permitted on syllables containing short vowels, whether they are open or closed. This restriction exists both as a syntagmatic constraint on lexical items but also is manifested through an asymmetric process of tonal spreading triggered by an optional process of vowel deletion applying to word-final vowels in words containing at least three syllables. The process of vowel deletion strands the tone originally associated with the deleted vowel and causes the immediately preceding syllable to become closed. If this syllable contains a long vowel, the stranded tone associates with it, e.g. *àbâ:n* 'strike' (from underlying /àbâ:nà/). If not, the stranded tone is deleted, e.g. *nángùrúf* not **nángùrúf* 'money' (from underlying /nángùrúfí/), *tùkùl* not **tùkùl* 'side (of body)' (from underlying /tùkùlì/).

The Kiowa-Tanoan language Kiowa (Watkins 1984) exemplifies a language in which contour tones are permitted both on long vowels and on short-voweled syllables containing a sonorant coda, e.g. *sô:gù* 'sew' imperfective, *k^hinmɔ́* 'cough' imperfective. Falling tones (the only type of contour tone found in Kiowa) are not permitted on short-vowel syllables that are either open or end in a coda obstruent. A process that shortens long vowels in closed syllables triggers the simplification of underlying contour tones in syllables which come to be closed by an obstruent, e.g. *k^hút* 'pull off' perfective (from underlying *k^hú:l-t*).

Rime-sensitive restrictions on tone are also found in languages with restricted tone systems, including those often regarded as pitch accent languages. For example, in the Indo-European language Lithuanian (Indo-European; Senn 1966, Kenstowicz 1972), a word carries one pitch accent, a high tone, which may fall either on a vowel or on a sonorant coda, but not on an obstruent coda. The location of the pitch accent is thus contrastive for both CVR, where it may fall on either the vowel or the sonorant coda, and for CVV, where it may fall on either half of the long vowel. Thus, CV and CVO contrast only in terms of whether they carry a pitch accent or not, whereas CVV and CVR potentially contrast not only in terms of whether they have a pitch accent or not, but also in the location of the pitch accent.

7.5.3 The phonetic basis of tone restrictions

Zhang (2002) shows that the distribution of contour and complex tones finds a phonetic explanation in terms of the duration and sonority of the sonorant portion of the syllable rime (see also Gordon 2001). As discussed earlier, tone is conveyed through the acoustic property of fundamental frequency as well as through the harmonics, which occur at frequencies that are multiples of the fundamental frequency. For example, a sound with a fundamental frequency of 200 Hertz has harmonics at 400 Hertz, 600 Hertz, 800 Hertz, etc., which aid in the recovery of the tone. The second through fourth harmonics have been shown to be particularly valuable in the perception of tone (Plomp 1967, Ritsma 1967). Because only voiced sounds have a fundamental frequency and harmonics, it follows that only voiced sounds are able to support tonal information. Furthermore, sonorants, i.e. vowels and sonorant consonants, have more intense harmonics than obstruents, even voiced ones. The difference in

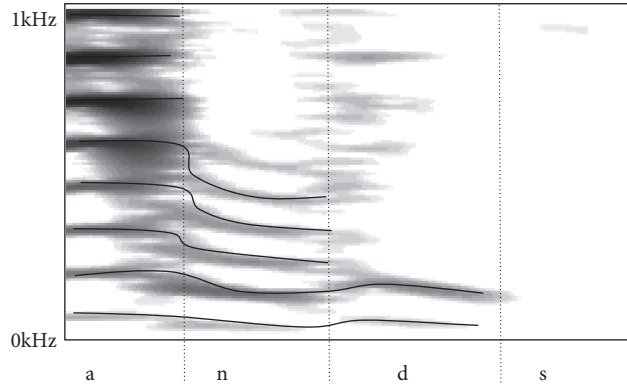


FIGURE 7.5. Narrowband spectrogram of four different segment types illustrating differences in harmonic structure

harmonic properties between vowels, sonorant consonants, and obstruents is illustrated in the narrowband spectrogram in Figure 7.5, where the lines are tracings of the harmonics.

Because a contour tone has multiple tonal targets, one at the beginning and one at the end of the contour, it requires more time to execute than a level tone. It thus follows that many languages, e.g. Kiowa (see above), allow contour tones more freely on syllables containing a long vowel or a sonorant coda than on other syllable types. In these languages, we can say that only one tone may map onto a tone-bearing unit, a mora, and that only sonorants are associated with moras (Zec 1988). Long vowels have two moras by virtue of their phonemic length (2a), and syllables containing a short vowel plus a sonorant coda also have two moras (2b), one for the vowel and one for the coda consonant. Open syllables containing a short vowel and short-voweled syllables closed by an obstruent, on the other hand, are monomoraic (2c). Because a syllable must have two moras to support a contour tone in languages with weight-sensitive tone, only syllables containing a long vowel or a sonorant coda can carry a contour tone in a language like Kiowa.

- (2) Moraic representations in a language allowing contour tones on only CVV, CVR

a. CVV

$$\begin{array}{cc} \mu & \mu \\ | & | \\ T & T \end{array}$$

b. CVR

$$\begin{array}{cc} \mu & \mu \\ | & | \\ T & T \end{array}$$

c. CV(O)

$$\begin{array}{cc} \mu & * \mu \\ | & / \backslash \\ T & T \quad T \end{array}$$

The fact that many languages, e.g. Krongo (see above), more freely permit contour tones on long vowels than on sequences of vowel plus sonorant coda follows from the greater intensity of the harmonics associated with vowels relative to sonorants. In these languages, one can assume that only vowels may be

associated with tone-bearing moras, meaning that only long vowels are bimoraic and thus able to bear a contour tone.

There is another type of restriction on contour tones that is sensitive to syllable type. In a small set of languages, four in Zhang's survey of 187 languages, long vowels and all closed syllables, whether the coda is a sonorant or an obstruent, may support contour tones. For example, CVV and CVC syllables allow contour tones (a falling tone) in Hausa but CV does not, e.g. *jâ:râ:* 'children', *dâ:* 'formerly', *mântâ:* 'forget', *li:mâm* 'imam', *k'attâ:* 'huge (pl.)', *dâbgi:* 'anteater', *kilif* 'paper clip' (Newman 2000: 597), *zôbbâ:* 'rings' (p. 600). This restriction largely acts as a static restriction on roots but is also observed when a suffix with a floating tone attaches to a preceding root. For example, certain suffixes are associated with a floating low tone that links onto the stem resulting in a falling tone. Suffixation of the deverbal nominalizer -`wâ: to the roots *kó:mó:* 'return here' and *kó:jár* 'teach' thus yields *kó:mô wâ:* 'returning here' and *kó:jârwâ:* 'teaching', respectively (Newman 2000: 705). The floating tone does not attach, however, if the stem-final syllable is CV, e.g. /bùlbùlú + -`wâ/ → *bùlbùlúwâ* 'be pourable' not **bùlbùlúwâ*. The capacity of a syllable closed by an obstruent (CVO) to serve as a docking site for a floating tone is demonstrated by a form like *mâtât* consisting of the root *mâtâ:* 'wife' plus the definite suffix -`t (a dialectal version of the standard Hausa suffix -`r) (Russ Schuh p.c.), which triggers shortening of a preceding long vowel in a regular process of long vowel shortening in closed syllables (see Chapter 4 on syllable template restrictions).

Zhang presents phonetic data from Hausa (see also Gordon 2001) showing that a vowel with a falling tone in a syllable closed by an obstruent is lengthened relative to a vowel carrying a level tone. Zhang hypothesizes that this subphonemic lengthening compensates for the impoverished capacity of the obstruent coda to support tonal information. He further hypothesizes that the few languages that allow contour tones on CVO but not on CV resort to strategies to minimize the burden on the obstruent to manifest the tone. These include lengthening the preceding vowel, as in Hausa, or realizing the latter portion of a falling tone as a downstepped tone on the following vowel, as in Luganda (see section 7.7 on downstep).

Even if no languages phonetically realize tonal contrasts on obstruent codas, the existence of languages like Hausa with *underlying* contour tones on CVO but not CV suggests that tones may link to obstruents on a phonological level. A phonetic study of Luganda by Dutcher and Paster (2008) indicates that a vowel can phonetically support a contour tone in a syllable closed by an obstruent, a finding that provides further evidence for the phonological linking of tones to obstruent codas in Luganda. They also show that the contour tone fails to induce any lengthening of the vowel before a voiced obstruent. Their study does not include quantitative data on vowel duration before voiceless obstruent codas: a phonetically driven approach would predict that they would be more likely to lengthen than their counterparts before voiced obstruent codas since a voiceless coda lacks a fundamental frequency and thus cannot itself carry any tonal information.

The other positions identified by Zhang as privileged licensors of contour tones, stressed and final syllables, are characteristically associated with phonetic lengthening, which likely explains their enhanced ability to support contour tones.

The more restrictive licensing requirements for complex tones compared to contour tones in certain languages, e.g. Mende (see above), is consistent with the phonetic requirements imposed by tone. Complex tones have more tonal targets (three or more depending on the complexity of the tone) than contour tones and thus require greater time to execute all else being equal. Furthermore, different types of contour and complex tones vary in their phonetic demands. Greater pitch excursions impose greater temporal demands than smaller pitch excursions; a low-to-high rising tone thus requires longer to implement than a low-to-mid rising tone. Due to anatomical factors, a pitch rise requires longer to implement than a pitch fall of equivalent distance (Ohala 1978, Sundberg 1979), a constraint that accounts for the privileged status of falling tones relative to rising tones (but see Maddieson 1978a and section 7.5.1 for frequency evidence contradicting this generalization).

7.5.4 Weight-sensitive tone and language-internal frequency

The relationship between syllable weight and tonal complexity was explored in three of the languages for which frequency data on tones was presented earlier in section 7.5.1 (Hausa, Cantonese, and Thai). All three languages asymmetrically allow a fuller range of tones on syllable types with higher sonority rimes in keeping with the cross-linguistic patterns described above. As discussed in the previous section, Hausa allows contour tones, i.e. falling tone, on both CVV and CVC but not on CV. In Cantonese, only the three level tones occur with any frequency on syllables closed by an obstruent (Bauer and Benedict 1997). Contour tones are limited to a small set of morphologically derived forms (see Bauer and Benedict 1997 and Yu 2003). In Thai, the five-way tone contrast in open syllables and those closed by a sonorant is reduced to two in syllables closed by an obstruent (a high tone on rimes containing a short vowel and a falling tone on those with a long vowel) including those ending in a glottal stop, which characteristically follows a short vowel (Gandour 1975).

In section 7.5.1, we saw that tones that are more marked cross-linguistically tended to be less frequent than less marked tones in languages that allow tones of varied degrees of complexity. For example, contour tones are considerably less common than level tones in Hausa and Maninka, rising tones are less frequent than falling tones in Thai, and complex tones are more sparsely attested than either contour or level tones in Mandarin. For those languages in which tonal complexity is sensitive to syllable structure, one might ask whether the observed aggregate frequency asymmetries observed earlier hold of all syllable types, even those capable of supporting a full range of tonal contrasts, or whether they are merely an artifact of the statistical predominance of light syllable types, which may only carry a subset of tones. For example, it should be determined whether the rarity of falling tones in Hausa is attributed to an independent rarity of the heavy CVC and CVV syllable types (collapsible as CVX) capable of licensing a contour

tone, relative to CV, which cannot carry a contour tone. This question is addressed in Figure 7.6, which shows the relative frequency for Hausa, Cantonese, and Thai of different tones in syllables able to support all of the attested tones in the language (CVX in Hausa and CVV, CVR in Thai and Cantonese) as opposed to syllables that only support a subset of tone contrasts.

The reduced set of tone contrasts (and, in the case of Cantonese, their extremely limited functional load) found in light syllables (=CV in Hausa and CV(V)O in Thai and Cantonese) is confirmed by the figure. More interestingly, the aggregated frequency patterns shown earlier are largely mirrored in the frequency distributions of tones even in the heavy syllable types able to accommodate the full range of tonal contrasts. Falling tones are thus rare even in CVX syllables (=CVV and CVC) in Hausa, rising tones are uncommon even in CVV and CVR syllables in Thai, and the low rising tone in Cantonese is relatively infrequent in CVV and CVR. This result suggests that even when the necessary sonority is present to support tones that are articulatorily more difficult to execute, these tones are still statistically dispreferred to less marked tones. A competing consideration, however, is the goal of ensuring that tonal contrasts are sufficiently perceptible particularly in syllables where reduced sonority might make distinctions a priori less robust. This factor likely plays a role in the preservation of the high and low level tones in CV(V)O syllables in Thai at the expense of the mid tone, which is more common than either the high or low tone in CVV and CVR syllables.

7.6 Phonological characteristics of tone

An important feature of tone is that it often behaves independent of the segments with which it is lexically associated. We have already seen an example of this independence in the discussion of the migration of a tone from a verbal prefix to the antepenult in the Bantu language Xhosa (section 7.3).

Another manifestation of the autonomy of tones and segments is the possibility of different mapping relations between tones and segments. While tones may map onto tone-bearing units in one-to-one fashion, it is also possible for more than one tone to link to a tone-bearing unit or for a single tone to link to more than one tone-bearing unit. To take an example of multiple tones linking to a single tone-bearing unit, the possessive suffix *-ʔ* in the Na Dene language Tanacross (Holton 2005) contributes a high tone to a preceding root (and also induces voicing in a root-final consonant), thereby yielding a rising tone in a low-toned root, e.g. *tʃʔəx* ‘quill’ vs. *tʃʔəyʔ* ‘his/her quill’.

Tanacross also illustrates the association of a single tone to multiple tone-bearing units: a process of high tone spreading thus spreads a high tone rightward to a following low-toned prefix: *kʔé-el-tsi:* → *kʔéʔéltsi:* ‘It looked like’. Consistent with the Tanacross data, Hyman (2007b) suggests that high tones are more likely to spread than other tones.

The docking of the pre-linking possessive high tone in Tanacross and high tone spreading are illustrated in (3) using the autosegmental notation introduced in the discussion of assimilation in Chapter 5.

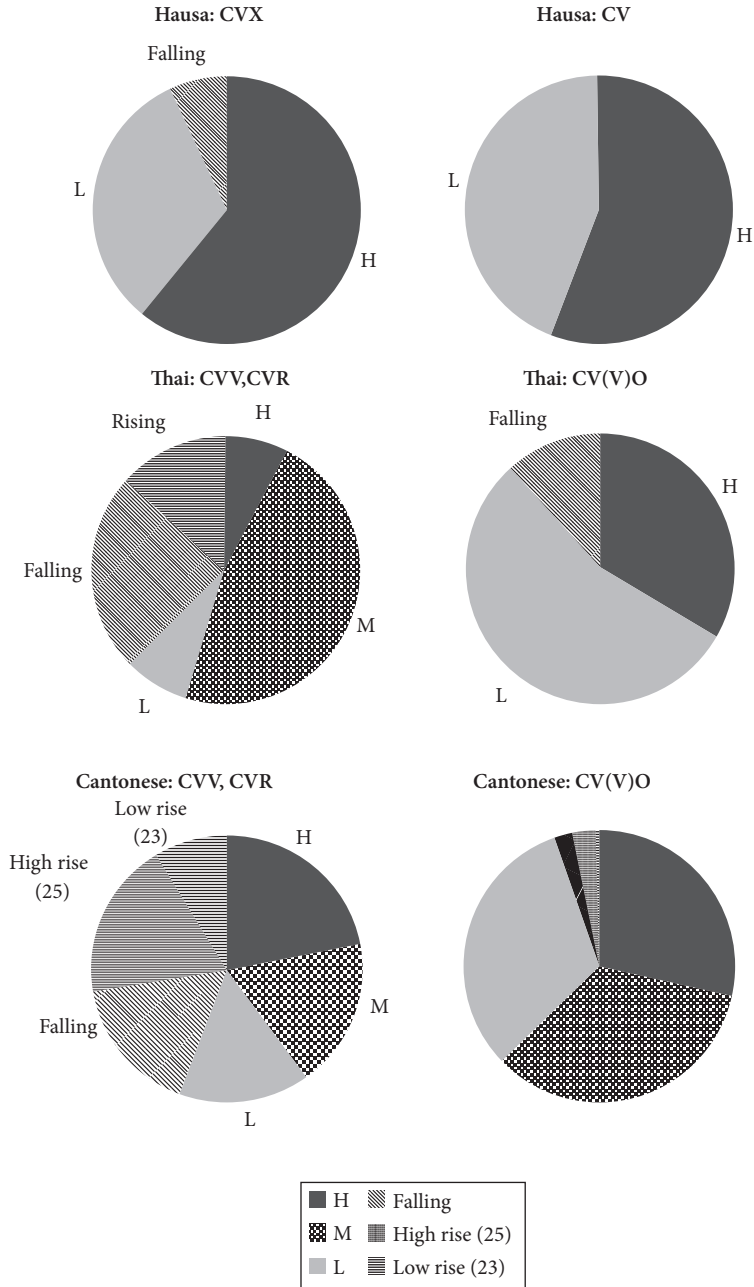
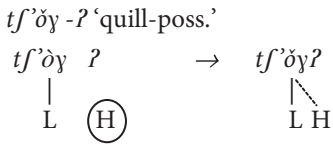


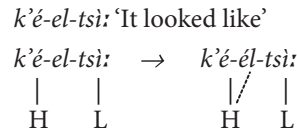
FIGURE 7.6. Frequency of lexical tones in heavy (on left) and light (on right) syllable types in three languages

(3) Leftward high tone association and rightward spreading of high tone in Tanacross

a. High tone association



b. High tone spreading



The Tanacross possessive suffix exemplifies the association of a tone from one morpheme to a different morpheme on the surface. Other examples of this phenomenon were presented in the earlier discussion of Hausa (section 7.5.3), in which the definite article and the deverbal suffixes were associated with low tones that linked to a stem-final heavy syllable. It is also possible for a morpheme to be marked solely through tone. The eventive aspect in Koasati is marked through a low + high tone sequence, where the low is realized on the last sonorant mora of the penultimate rime of the stem and the high is associated with the first sonorant mora of the following syllable. For example, the eventive stem for the root *hopo:ni-* ‘to cook’ is *hopò:ni-*, e.g. compare non-eventive *hopo:nilahō* ‘s/he will cook’ with eventive *hopò:ni-l* ‘I am cooking’.

Tones also may be preserved even when deletion processes eliminate the segmental material with which they were originally associated. Returning to our Koasati eventive aspect example, the final vowel of the stem is lost before certain suffixes, stranding a high tone, which docks on the suffix immediately following the stem, e.g. *hopò:ni-* vs. *hopò:n-híl* ‘we are cooking’. Similarly, in Tanacross, the iterative prefix *nà-* deletes following an open syllable that belongs to a certain class of prefixes (termed “disjunct” prefixes in the Athabaskanist literature), leaving behind its low tone on the preceding syllable, e.g. /*xá-nà-n-εt-t’ax*/ → *xânεtt’ax* ‘It is flying around’ (Holton 2005).

7.7 Tonal processes

Hyman and Schuh (1974) and Hyman (2007b, 2011b) provide an overview of several characteristics of tonal phenomena, which are similar to processes affecting segments in some ways but also different in other respects.

Like segments, tones often undergo contextually governed and phonologically predictable alternations, often referred to (most conspicuously in the literature on Chinese languages) as “tone sandhi”. As in the case of segmental alternations, many of these tonal alternations are assimilatory in nature. Strikingly, though, assimilatory processes pertaining to tone are predominantly perseverative rather than anticipatory in contrast to assimilation affecting segments (see Chapter 5). For example, it is common for the first tone in a sequence of differing tones to spread rightward, i.e. L-H → L-LH or H-L → H-HL (where a hyphen represents a syllable break), while it is relatively rare for the second tone to spread leftward, i.e.

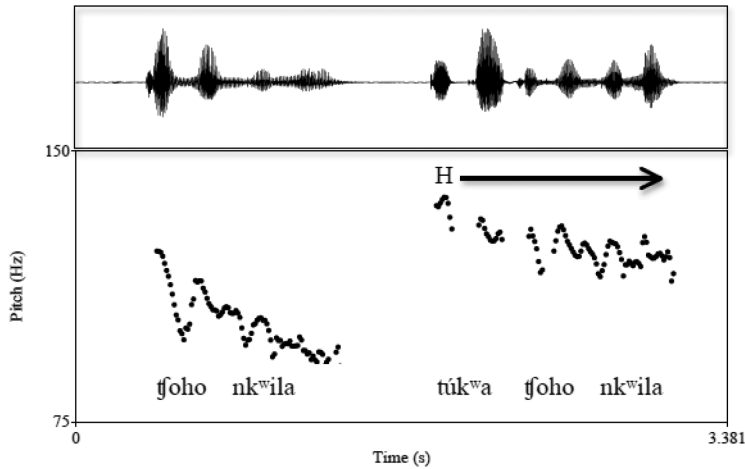


FIGURE 7.7. High tone spreading in the Zenzontepec Chatino phrase: *túk^wa tfoho nk^wila* ‘two chlacayote squashes’ (Campbell 2014: 132)¹

L-H → LH-H or H-L → HL-L. An example of rightward perseverative tonal spreading was given above from Tanacross: *k'é-el-tsi:* → *k'é?éltsi:* ‘it looked like’.

Tone spreading can also apply over larger domains, as in Zenzontepec Chatino (Campbell 2014), in which a high tone spreads rightward to any number of tonally unspecified syllables until either a lexically marked tone or a phrase boundary is reached. For example, when the underlyingly toneless noun *tfoho nk^wila* ‘chlacayote squash’ is preceded by the numeral *túk^wa* ‘two’, the high tone on the first syllable of the numeral spreads rightward through the entire following noun: *túk^wá tfohó nk^wílá* ‘two chlacayote squashes’ (p. 132), as illustrated in Figure 7.7. The unsuffixed toneless noun is shown in isolation on the left and following the numeral on the right. Both forms display an overall tonal declination trend, but the phrase on the right has a much higher overall *F*₀ level, which is attributed to the spreading of the high tone from the first syllable of the numeral through the entire phrase.

As Hyman (2007b) points out, the perseverative nature of tone spreading is consistent with the observation that tonal targets both associated with lexical tones and with intonational tones are often phonetically delayed relative to their phonological location (Kingston 2003). It would thus be natural for a phonological process of perseverative tone spreading to become lexicalized over time from a natural tendency for tones to be realized late. Instances of anticipatory tonal spreading typically involve attraction of a tone by a metrically strong syllable as in the Lamba cases discussed earlier (section 7.3) in which a high tone lexically

¹ Thanks to Eric Campbell for supplying a recording of this form and the form depicted in Figure 7.8.

associated with the root migrates leftward onto an attractor prefix, e.g. /u-{ku-} léemb-a/ ‘to write’ → [u{kú}leemba] ‘to write’.

Another type of assimilation that differs from the above-described tonal spreading processes (termed “horizontal” assimilation by Hyman (2007b)) involves raising or lowering of a tone so that it is more similar (but not identical) to an adjacent tone. In contrast to horizontal tone assimilation which is overwhelmingly perseverative, these cases of “vertical” assimilation may be either perseverative or anticipatory (Hyman 2007b). However, vertical assimilation is subject to a different asymmetry, such that it is common for a tone to move closer in level to a following tone that is higher but not one that is lower, i.e. L-H to M-H but not H-L to M-L. Conversely, a tone is more likely to approximate a preceding tone that is lower but not one that is higher, i.e. L-H to L-M but not H-L to H-M.

The widely attested patterns of vertical assimilation contrast with their sparsely attested counterparts in that they conspire to minimize the pitch excursion in rising tone sequences but not falling tone sequences. The tendency for rising tones to be compressed in the vertical dimension is consistent with the greater time necessary to execute rising tones relative to falling tones, a physiological constraint that as we saw earlier (section 7.5.3) accounts for the predominance of falling over rising tones cross-linguistically.

Strikingly, as Hyman (2007b) points out, tonal sequences consisting of a relatively high tone followed by a relatively low tone actually are subject to processes that *expand* the pitch excursion. Thus, a sequence of a high tone followed by a low tone may undergo either raising of the high tone or lowering of the low tone, an effect that is dissimilatory in nature. This tendency is observed in Mandarin (Xu 1997) and Tianjin Chinese (Zhang and Liu 2011), in which a following low tone exerts a dissimilatory raising effect on a preceding high tone. Rialland (2001) suggests that tonal expansion processes, in particular high tone raising, may have a physiological basis as a mechanism for offsetting the gradual declination in tone that occurs as one moves through an utterance (see below), which potentially diminishes the phonetic distinction between phonological high and low tones.

Not all tone processes may neatly be labeled as assimilatory or dissimilatory. Hyman and Schuh (1974) and Hyman (2007b) describe a common process of “absorption” whereby the second element in a contour tone is absorbed by a following tone that is identical, i.e. LH-H → L H, HL-L → H L. Hyman (2007) observes a directional asymmetry in absorption such that it is rarely triggered by an identical *preceding* tone, i.e. H-HL → H-L, L-LH → L-H. Another process, termed “simplification” by Hyman and Schuh (1974), involves loss of the second component of a contour before a tone that is different, i.e. LH-L → L H, HL-L → H L. As Hyman (2007) suggests, competition between articulatory ease and perceptual distinctness likely accounts for the seemingly paradoxical behavior of adjacent tones as triggers of either absorption or simplification. Absorption is likely driven by perceptual considerations: the end point of a contour is perceptually vulnerable to misidentification as a coarticulatory transition into an immediately following tone that is identical. Simplification plausibly has an articulatory basis: an LHL or an HLH sequence requires

two tonal transitions, which are relatively difficult to execute (see discussion of tonal complexity in section 7.5.3).

There are, however, certain tonal alternations that are not amenable to phonetic explanation synchronically. For example, Beijing Mandarin Chinese has four lexical tones that are canonically realized as follows: a level high tone (traditionally transcribed as 55 on a five-point scale with 5 being highest in pitch and 1 being lowest), a rising tone (transcribed as 35), a complex dipping tone consisting of a slight fall followed by a rise (213), and a falling tone (51). The dipping tone, termed the “third” tone, undergoes two types of tone sandhi shifts, shown in (4), when it precedes another tone within phrases (see Chen 2000, Duanmu 2007 for discussion). Before another third tone, the dipping tone shifts to the rising (35) tone, the so-called “third tone sandhi” (4a). Before any of the other three tones, the third tone truncates to a simple falling (21) tone, the “half-third sandhi” (4b).

(4) Tone sandhi in Beijing Mandarin Chinese (Zhang and Lai 2010: 162)

- | | | |
|-----|--|----------------|
| (a) | $x\alpha u_{213} \text{ t}\check{c}j\text{ou}_{213} \rightarrow x\alpha u_{35} \text{ t}\check{c}j\text{ou}_{213}$ | ‘good wine’ |
| (b) | $x\alpha u_{213} \text{ \xi}u_{55} \rightarrow x\alpha u_{21} \text{ \xi}u_{55}$ | ‘good book’ |
| | $x\alpha u_{213} \text{ ɿ}\check{\text{e}}n_{35} \rightarrow x\alpha u_{21} \text{ ɿ}\check{\text{e}}n_{35}$ | ‘good person’ |
| | $x\alpha u_{213} \text{ k}^h\text{an}_{51} \rightarrow x\alpha u_{21} \text{ k}^h\text{an}_{51}$ | ‘good looking’ |

As Zhang and Lai (2010) discuss, the half-third sandhi has a clearer phonetic motivation than the third tone sandhi. The simplification of a complex tone to a contour tone in half-third sandhi is consistent with the cross-linguistic tendency for non-final syllables to have smaller pitch excursions than final syllables due to the shorter duration of non-final syllables (Zhang 2002; see section 7.5.3). On the other hand, apart from being dissimilatory in a general sense, the shift from a complex tone to a rising tone in third tone sandhi does not have a clear phonetic basis. Rising tones are more difficult to execute than falling tones so the change from 213 to 35 is not ideal from an articulatory perspective. Furthermore, the output of third tone sandhi is phonetically not transparently related to its underlying tone but rather corresponds to a phonetically divergent tone. The half-third and third tone sandhi processes also differ in their sensitivity to syntax: the half-third sandhi is an automatic process that applies to all non-final dipping tones, whereas the third tone sandhi is sensitive to syntactic bracketing. Zhang and Lai (2010) further show in production experiments that the half-third sandhi is more accurately replicated in nonce phrases than the third tone sandhi in keeping with the former’s phonetic transparency.

In the Mandarin tone sandhi system, the tone on the right triggers a change in its neighbor to the left. In certain other tone sandhi systems found in Chinese languages, it is the tone on the left that induces a change in the immediately following tone. For example, in Shanghai Chinese (Zee and Maddieson 1979), the three tones in “unchecked” syllables (those not closed by a stop) are HL, MH, and LH in monosyllabic words in isolation. When followed by another monosyllabic word, the second component of the tonal contour shifts rightward onto the second syllable, displacing the original tone: the result is essentially the same

contour realized over two rather than one syllable. A similar tendency toward rightward expansion is observed in longer strings of syllables, with the complication that a L boundary tone (see section 7.9 on intonation) at the right edge limits the rightward expansion of lexical tone. The L in the HL monosyllabic and disyllabic pattern is also attributed to the boundary tone, which presumably is able to surface even in monosyllables due to their greater phonetic length (see the discussion of Mende tone in section 7.5). The trisyllabic patterns corresponding to HL, MH, and LH are thus HML, MHL, and LHL, respectively where the M on the second syllable in HML reflects the transition between the H-initial and L-final targets (see Chen 2008 for a slightly modified analysis).

Yue-Hashimoto (1997) and Zhang (2007) observe a link between the directionality of sandhi and the nature of the sandhi process. In so-called “right-dominant” systems like the one found in Mandarin, sandhi characteristically involves paradigmatic neutralization of tone contrasts and/or insertion of default tones, whereas “left-dominant” systems, as in Shanghai Chinese, typically display perseverative spreading of tone rightward. Zhang (2007) explains this asymmetry on phonetic grounds appealed to earlier in this chapter to account for weight-sensitive tone (section 7.5.3) and tonal processes (this section). First, tonal transitions are easier to execute over longer durations than shorter durations, a physiological constraint that motivates tone spreading (but itself does not predict any directional asymmetry in spreading). Second, final syllables tend to be phonetically longer than non-final syllables, a durational asymmetry that confers an advantage on shifting tonal transitions rightward onto final syllables but not leftward onto non-final syllables. Finally, tones tend to spread rightward rather than leftward reflecting the general tendency for tone targets to be phonetically delayed. These factors conspire to make left-dominant sandhi more likely than right-dominant sandhi to involve temporal expansion of tonal targets and, conversely, render right-dominant sandhi biased in favor of employing other devices to reduce tonal excursions.

Many tone languages display pitch declination effects in which a tone, typically a high tone, is lowered either following a low tone or another high tone. Two terms associated with these effects, which are most prevalent in (but not limited to) smaller tone inventories, are “downdrift” and “downstep”. The lowering effect of a surface low tone on a following high is commonly characterized as downdrift, while the lowering effect of a high tone in the absence of a preceding low tone on the surface is often referred to as downstep (see Yip 2002, Connell 2011 for overviews and for downstep’s typologically rarer antithesis “upstep”). Downstep canonically arises in a sequence of high tones when the second one is lowered in relation to the first one or when there is a low tone that causes a following high tone to lower without actually surfacing itself.

Although downstep is most commonly associated with African languages, Hyman (2007c: 6) describes a case of downstep in the Sino-Tibetan language Kuki-Thaadow, involving lowering of a high tone following a falling (i.e. HL) sequence, e.g. *kéy* ↓*páa* ↓*úy* ↓*tsóm* ↓*gíet* ↓*kéey* ↓*tôo* ‘my father’s eight short dogs’ feet’, where the downward arrow indicates a high tone that is realized with lower pitch than a preceding high tone. This example from Kuki-Thaadow demonstrates the potentially iterative nature of downstep.

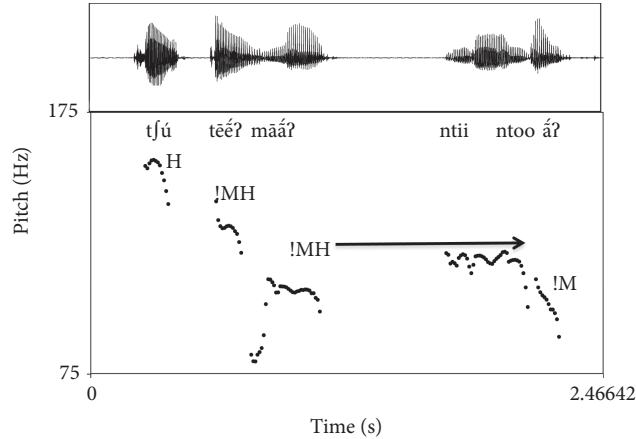


FIGURE 7.8. Iterative downstep (indicated by an arrow) in the Zenzontepec Chatino phrase *tfú tēé? mǎǎ? ntii ntoo ǎ?* ‘My face feels wrinkled, wrinkly, and foul-colored.’ (Campbell 2014: 137)

Figure 7.8 illustrates iterative downstep in conjunction with high tone spreading (see above) in the Otomanguean language Zenzontepec Chatino. In the phrase *tfú tēé? mǎǎ? ntii ntoo ǎ?* ‘my face feels wrinkled, wrinkly, and foul-colored’ (Campbell 2014: 137), the first high on *tfú* ‘wrinkled’ triggers lowering of the phonological MH sequence (which fails to reach its H target due to the short duration of the vowel and the following glottal) on *tēé?* ‘wrinkly’, which in turn further downsteps the MH sequence (also phonetically level) of *mǎǎ?* ‘foul-colored’. The downstepped H on *mǎǎ?* nevertheless spreads rightward until it meets the M on the final vowel, which is also downstepped.

Another common process affecting tones is tone plateauing, whereby a low tone or a tonally unspecified syllable raises to a high tone between intervening high tones. Tone plateauing can potentially encompass large stretches, as in the Creek examples discussed earlier, where a high plateau spans from the first to the last metrically strong syllable, e.g. (*nokó*)(*sótfi*) ‘bear cub’, (*awá*)(*náji*)*ta* ‘to tie to’.

Yet another phenomenon affecting tones is tone polarity, which involves a morpheme, typically an affix or clitic, assuming the opposite tonal value from a neighbor. For example, in the Gur language Dagaare (Bodomo 1997, Anttila and Bodomo 2009), certain classes of nouns display polarity effects whereby the number suffix assumes the opposite tone value (high or low) from the root to which it attaches, e.g. *kù:ri* ‘hoe’ and *kù-é* ‘hoes’ vs. *jí:ri* ‘house’ and *jí-é* ‘houses’.

Another trait of tonal processes is that they are often bounded by domains larger than the word. For example, the rule of high tone spreading in Tanacross discussed earlier applies not only within words but also across words. For example, in the phrase /*ʎóx n-ék-ʔèh*/ (where low tone is the default tone and unmarked in the transcription), the high tone spreads from the first word to the prefix of the second word yielding *ʎóx n-ék-ʔèh* ‘I see the fish hooks’ (Holton 2005). One of the interesting issues in the typology of tonal processes that span word boundaries

is the characterization of the domains bounding the processes. Tonal processes provide one source of evidence for prosodic domains (see the papers on tone languages in the Inkelas and Zec 1990 volume and chapter 5 of Yip 2002 for discussion of the role of prosodic and syntactic constituency in characterizing tonal processes).

7.8 Tonogenesis and interactions between tone and other features

Because tone shares with certain other phonological properties its reliance on the vocal folds to execute, it is not surprising that tone may be influenced by other features, either synchronically or diachronically. One widely recognized influence on tone involves voicing in consonants, where voiced consonants often induce tone lowering while voiceless ones often trigger tone raising. For example in the Niger-Congo language Nupe (George 1970, Hyman and Schuh 1974), a high tone preceded by a low tone in the preceding syllable becomes a rising tone but only if the intervening consonant is voiced. Thus, *bá* ‘sour’ corresponds to prefixed *èbá* ‘be sour’ and *wá* ‘want’ corresponds to *èwá* ‘wants’ but *pá* ‘peel’ corresponds to *èpá* ‘is peeling’. Blocking effects attributed to voiceless consonants are also found in languages with restricted tone (i.e. pitch accent) systems. For example, in the Maasbracht dialect of Limburgian (Hermans and van Oostendorp 2000), there are two pitch accents (falling vs. level high in non-final syllables) that contrast on bimoraic stressed syllables, where long vowels and syllables closed by a sonorant are bimoraic: *é:ɣər* ‘worse’ vs. *é:ɣər* ‘annoy’, *é:dər* ‘every’ vs. *é:dər* ‘earlier’, *pá:tər* ‘father’ vs. *wá:tər* ‘water’. However, in syllables closed by a sonorant followed by a voiceless onset, the falling tone is lost along with any potential contrast: e.g. *bá:lkən* ‘the Balkans’, *há:lp* ‘help’ but **bá:lkən*, **há:lp* (p. 82).

In her survey of consonant–tone interactions, Tang (2008) identifies 29 of 54 languages that display an affinity between low tone and voicing in obstruents and a further 15 that show mutual attraction between high tone and voicelessness. She identifies a single language, Carrier (Athabaskan), in which voiceless obstruents are associated with low tone, but in this language the voicing contrast among stops does not involve voicing but rather aspiration, which is associated with high tone in Carrier.

Hombert et al.’s (1979) overview of the phonetic literature indicates that the lowering effect of voicing and the raising effect of voicelessness on tone is observed synchronically in both tonal and non-tonal languages, indicating that tonogenesis patterns attributed to voicing features have a robust phonetic precursor. At the same time, their comparison of tonal Yoruba with non-tonal English suggests that the pitch perturbations attributed to consonants persist longer into an adjacent vowel in non-tonal languages, presumably because there are no phonemic tones whose perceptibility could be reduced due to microprosodic effects of consonants.

Although Hombert et al. (1979) also observe a tendency for voicing to exert a greater phonetic effect on the tone of a following vowel than a preceding vowel, it is unclear whether this phonetic observation maps onto a meaningful

phonological generalization about the relative frequency of anticipatory vs. perseverative tonogenesis, since languages possessing voicing contrasts in postvocalic consonants are independently far rarer than those with such contrasts prevocalically. Furthermore, postvocalic consonants have in fact been claimed to play a role in certain tonogenesis phenomena. For example, according to Haudricourt (1954), final consonants in Vietnamese historically triggered the development of a three-way tonal contrast between rising tone (before original voiceless stops), falling tone (before original voiceless fricatives), and level tone (in open syllables and before original sonorants). Much later, in Haudricourt's analysis, there was a further split induced by a voicing distinction in initial consonants such that voiced consonants caused lowering of the starting point of a tone whereas voiceless consonants triggered raising of the initial phase of a tone.

One problematic issue in assessing the contribution of consonants to tonogenesis is the potential confound of phonation differences that often accompany consonants with different laryngeal settings. Thurgood (2002) thus argues that phonation differences played an important role in the tonogenesis patterns in Vietnamese described above. Synchronically, many languages, e.g. in the Mon-Khmer family, display a close link between phonation and tone (see Kuang 2013b for a typological overview). For example, certain Western Kammu varieties have a contrast between breathy voiced vowels, which are associated with low tone, and tense or clear voiced vowels, which are realized with high tone. Interestingly, these contrasts based redundantly on both tone and phonation correspond to contrasts in other Western Kammu varieties that rely solely on tone differences and to distinctions in Eastern Kammu that are based on voicing differences in the prevocalic consonant (Svantesson 1989, Suwilai 2003). Cross-dialectal comparison of Kammu thus illustrates the potentially complex relationship between voicing, phonation, and tone.

Tang's (2008) survey suggests that other types of consonant–tone interactions are not as consistent across languages. For example, in her survey, voiced sonorants tend to occur with high tone in three languages but low tone in two others. Likewise aspiration in stops and glottalization pattern differently between languages, sometimes being associated with high tone and sometimes with low tone. Her survey of cross-linguistic phonetic data on consonant–tone interactions confirms the cross-linguistic variability in the effect of consonants on tone (see also Bradshaw 1999, Gordon 2016).

Kingston's (2011) comparative overview of tonogenesis in Athabaskan languages and languages of East and Southeast Asia underscores the potential for considerable variation even between closely related languages in the relationship between consonant type and tone. For example, he shows that voicing in obstruents, which typically is associated with lowering of tone, has actually triggered tone raising in historical tone splits induced by onset consonants in the Tai-Kadai language, Shan.

A particularly striking example of variation in the tonal reflexes of the same historical source is provided by the tonal Northern and Southern Athabaskan languages. Stem-final glottal constriction reconstructed for the proto-language has left high-toned reflexes in some languages in the family but low-toned reflexes in

other languages (Leer 1999, Kingston 2005). In some cases, pairs of geographically and genetically very closely related Northern Athabaskan languages differ in their tonal reflexes of constriction. Kingston (2005, 2011) argues that differences in the laryngeal configurations employed to implement glottal constriction could have yielded the observed variation in the tonal reflexes of constriction in Athabaskan.

7.9 Intonation

Intonation is a universal property referring to the fundamental frequency patterns associated with prosodic units larger than the word. Intonation serves a wide range of grammatical and discourse functions, including the signaling of syntactic boundaries, the marking of semantic properties such as the distinction between questions and statements, the cuing of turn-taking in conversations, the highlighting of novel or interesting information, and the conveying of emotional and expressive states.

Because it is conveyed by the same physical property as tone, intonation is sensitive to many of the same constraints that are relevant for tone. For example, pitch excursions are distributionally constrained in many intonation systems parallel to the confinement of contour tones to more sonorous syllable types in many tone languages. Furthermore, consonants may influence intonation patterns just as consonants potentially impact lexical tone.

Because of its many similarities with tone, intonation is often phonologically analyzed in terms of sequences of discrete high and low tonal targets with surface pitch contours resulting from interpolation between the phonological tones. One of the seminal works adopting this “autosegmental-metrical” analysis of intonation is Pierrehumbert’s (1980) model of English intonation. An important insight of this work is that the tones comprising intonational contours stem from two sources: those associated with prominent, i.e. stressed, syllables and those attributed to the periphery of prosodic domains. Because many important intonational events occur at the end of domains, the study of intonation informs the investigation of prosodic constituency, to which we return in section 7.12.

The tones linked to prominent syllables are typically termed “pitch accents”, where the intonational use of the term “pitch accent” differs from its usage to describe a type of prosodic system between stress and tone. Tones attributed to a prosodic boundary are most common at the end of large intonational constituents, termed “Intonational Phrases” or “Intonation Units”, but also may be found at the beginning of prosodic units and may define constituents smaller than the Intonational Phrase or Intonation Unit. Both pitch accents and phrasal or boundary tones may be composed of more than one tone. To take an extreme example of tone stacking, the right edge of Intonational Phrase boundaries in Korean may be associated with as many as five tones in sequence, e.g. LHLHL, which together conveys a sense of annoyance on the part of the speaker (Jun 2005a).

Relative to tone, the typological study of intonation is in its infancy. Most detailed accounts of intonation systems are based on languages of Europe and widely spoken languages of Asia such as Mandarin, Japanese, and Korean.

Encouragingly, however, there has been a recent explosion of papers devoted to intonation in individual languages, compilations of intonation studies of multiple languages (e.g. Hirst and Di Cristo 1998, Jun 2005b, 2014), and overviews of the current state of intonation research (e.g. Ladd 1996, Gussenhoven 2004). This new wave of research represents a notable advancement from earlier work in that it typically relies on acoustic analysis (if not quantitative, at least qualitative) rather than merely on impressionistic judgments.

7.10 Terminal contours

The intonational feature for which it is easiest to draw typological generalizations based on a broad sample of languages involves terminal pitch contours, which are often described (even if only impressionistically) in overviews of languages. It is most common to find some discussion of pitch contours associated with the end of unmarked declarative statements and certain question types, most reliably yes/no questions but also occasionally wh-questions or echo-questions. Although many of these published descriptions of intonation consist of cursory statements about gross intonational properties and may lack many important details about properties such as pitch height, pitch slope, pre-terminal pitch patterns (e.g. pitch accent type and location), and prosodic constituency, they are still useful for constructing a coarse typology of terminal intonational contours characteristic of major utterance types.

A survey of terminal intonation contours was conducted for the languages in the 100-language WALS sample for which at least impressionistic descriptions of intonation were available in published sources. Descriptions varied considerably in the range of utterance types covered, the level of detail provided (e.g. pre-terminal characteristics, pitch height, etc.), and the extent to which the description was supported by acoustic displays or quantitative study. In order to maximize the breadth and size of the sample, results were compiled for only three utterance types: “neutral” declaratives, wh-questions (information questions), and yes/no questions (polar questions). Of these three utterance types, data on declaratives were available for 51 languages in the survey, on wh-questions for 31 languages, and on yes/no questions for 53 languages.

Figure 7.9 plots the proportion of languages in which the most characteristic terminal contours involve a pitch fall (dark portion of the bar) or a pitch rise (light portion of the bar) in statements, polar questions, and information questions. Tone languages in which the final tone is raised or in which there is a final question particle associated with high tone are included in the class of terminal rise cases. Note that for statement intonation and intonation in polar questions, there was a small set of languages (one in the case of statements and five for polar questions) that could not be reliably assigned to either the terminal fall or rise categories because they were described as having either level or “neutral” pitch.

As the figure shows, falling intonation in declarative utterances is characteristic of the vast majority of sampled languages. The use of terminal pitch falls as the default intonation contour in statements has long been speculated to be a nearly

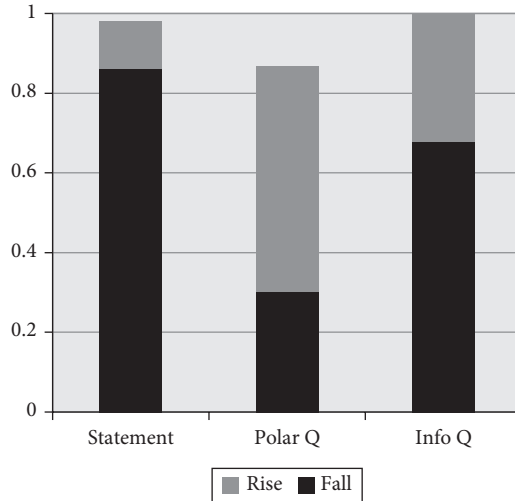


FIGURE 7.9. Proportion of pitch rises and falls associated with the end of default statements, polar questions, and information questions in the 100-language WALS sample

universal pattern (Bolinger 1978), reflecting the natural tendency for pitch to decline throughout an utterance in concert with the declination in subglottal pressure (Gelfer et al. 1983, Gelfer 1987).

There is a slightly less strong bias in favor of terminal pitch falls in information questions. On the other hand, there is a statistical preference for terminal pitch rises in polar questions. It is also interesting to note that all of the languages in the WALS sample reported to have final rises in statements also employ terminal pitch rises in at least polar questions, indicating that the pressure to distinguish questions and statements through intonation does not compel them to be phonologically distinct cross-linguistically. This parallel between statements and questions, however, is not a universal property of intonation systems displaying a final rise in statements. In Chickasaw (Gordon 2005b), the default intonation pattern in statements involves a final rise, whereas questions, both polar and information, are characterized by a terminal fall, a distinction that is depicted in Figure 7.10. It is interesting to note that the Chickasaw pattern is not only cross-linguistically unusual but also diverges from its fellow Muskogean language, Koasati, which typically employs pitch falls at the end of statements but rises in questions (both polar and information).

The results for the WALS sample are largely mirrored by those found in the survey of intonation conducted by Bolinger (1978). Among the non-tonal languages Bolinger (pp. 495–6) cites in a table summarizing intonation patterns, virtually all (39 of 41) languages for which he reports data on terminal contours have declaratives that are characterized by a terminal pitch fall. The bias in favor of final rises in yes/no questions is somewhat greater in Bolinger's survey than in the WALS survey. Of the 36 non-tonal languages for which Bolinger (p. 502) cites patterns in yes/no questions, 32 (88.9%) display terminal rises or final high pitch. However, of the 53 languages (different from the ones reported by Bolinger in his

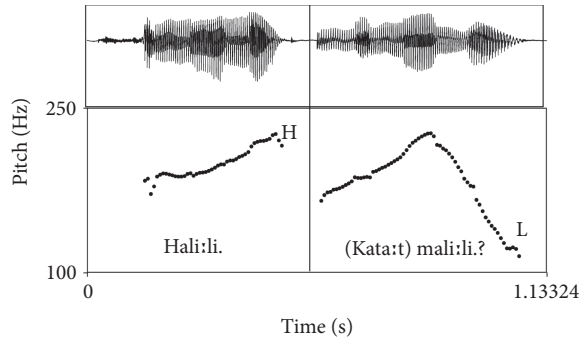


FIGURE 7.10. Terminal pitch rise in the phrase-final word of the statement *Hali:li* 's/he touches it' (on left) and terminal pitch fall in the phrase-final word of the question *(Kata:t) mali:li?* '(who) is running?' (on right) in Chickasaw

study) surveyed by Ultan (1978), 71.7% had terminal rises, a percentage that more closely corresponds to the results for the WALS sample. Of the 20 languages in Hirst and Di Cristo's (1998) survey, 13 (65%) are described as having final rises as the dominant pattern in questions, a figure that also closely approximates the WALS-based survey.

The most striking difference between Bolinger's survey and the WALS sample concerns the relationship between yes/no and wh-questions in their intonation patterns. Of the 13 languages for which Bolinger reports patterns for both yes/no and wh-questions, all but two asymmetrically have terminal pitch rises as the default in yes/no questions but falls in wh-questions. Only one language of the 13, Zuni, has terminal falls in both types of questions, and none asymmetrically have final falls in statements but rises in both types of questions. He reports a single language, Telugu, with an asymmetry between statements and wh-questions whereby the former has a fall as the default and the latter has a rise. Bolinger's results thus suggest that wh-questions tend to parallel statements more often than not whereas the WALS survey suggests that wh-questions behave similarly to yes/no questions with respect to intonation.

The coarse typology of terminal contours presented here for statements and questions obscures many important details of which our current typological knowledge of intonation precludes the formulation of large-scale quantitative distributional statements. For example, describing utterances in terms of their terminal contours fails to acknowledge relevant features that may occur earlier in an utterance. Bolinger's (1978) survey cites many languages (excluded from the figures presented earlier) with an overall declination trend over the course of an utterance that may not necessarily be localized to its end. Although declination constitutes a different dimension from terminal pitch properties, Bolinger's collapsing of declination and terminal contours in a single table potentially obscures the difference between languages in the temporal scope of pitch rises and falls. It is common for languages to initiate a terminal contour with the last pitch-accented syllable. However, it is also possible for a language, e.g. Danish (Grønnum 1998),

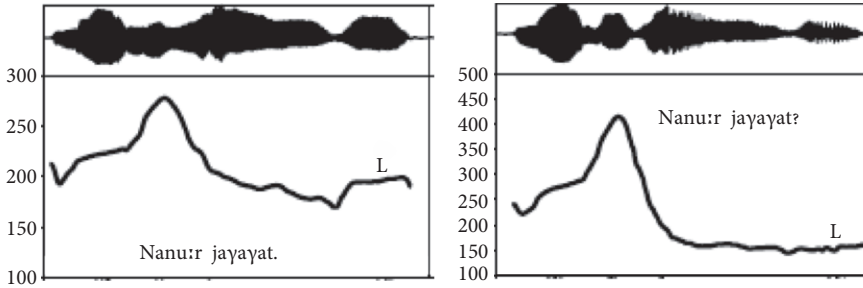


FIGURE 7.11. Intonation in the statement *Nanu:r jayayat* “they made the baby cry” (on left) and the remote past question *Nanu:r jayayat* “did they make the baby cry?” (on right) in Turkish Kabardian (adapted from Applebaum 2010)

to lack a prominent pitch accent from which the terminal contour originates but rather to have a more global pitch contour.

Similarly, two utterance types that may be quite similar in terms of their terminal pitch properties might be distinguished at an earlier point in the utterance. Thus, questions and statements in Finnish both are characterized by falling intonation, but they are nevertheless differentiated at the beginning of an utterance with questions having higher initial pitch than statements and an overall higher pitch range (Hirvonen 1970), a common characteristic of questions cross-linguistically (Hirst and Di Cristo 1998).

Figure 7.11 illustrates the relatively subtle intonational difference between statements and questions in the remote past tense in the Turkish variety of Kabardian (Applebaum 2010). The sentence is *Nanu:r-r* (baby-absolutive) *ja-ya-y-a-t* (they-causative-cry-aspect-remote past) “they made the baby cry/did they make the baby cry?”

As the figure shows, both the statement and the question end in low pitch preceded by a pitch peak, which falls on the final (stressed) syllable of the first word *nanu:r* ‘baby’ (absolutive). However, the question has an expanded pitch range characterized by a steeper drop immediately following the pitch peak to a lowered terminal pitch target (relative to the statement), characteristics shown by Applebaum (2010) to be used by listeners distinguishing otherwise morphologically identical statements and questions.

In many languages, there are potentially different phonological sources of pitch differences distinguishing utterance types, where these differences may only become clearer in utterances of a particular phonological shape. For example, in Hungarian (Ladd 1983), statements and yes/no questions both end in a pitch fall, which can be analyzed as a HL tonal sequence. The two utterance types both have an L% terminal boundary but differ in the source of the H component of the fall. In statements, the H is attributed to a pitch accent falling on the primary stressed syllable (the first syllable in Hungarian words), whereas in questions the H is a phrasal tone associated with the rightmost syllable of the utterance that does not carry primary stress. This difference in phonological association creates a difference between questions and statements in the slope of the terminal fall, which is

steeper in the case of questions. In addition, a question differs from a statement in having a L* pitch accent. The difference between the two utterance types can be seen in the schematic examples in (5) of the segmentally identical statement and question pair *A tanár* ‘The teacher’.

- (5) Statement and question intonation in Hungarian (question from Ladd 1996: 116)

Statement	Question
H* L%	L* HL%
	/
A 'tana:r	A 'tana:r ?

The Kabardian and Hungarian examples underscore how important differences between intonation contours may only emerge in a detailed study of the intonation system of a language potentially eluding more impressionistic description. The issue of the source of a phonological tone is particularly acute in the case of languages described as having final stress, which might be associated with a high pitch accent that could be responsible for the impression of a terminal pitch rise. In the case of final stress, it is thus often difficult in practice to distinguish between a high pitch accent or a high boundary tone as the source of a terminal pitch rise. This issue arises, for example, in the analysis of Chickasaw (Gordon 2005b), in which a high pitch accent is assigned to the rightmost word in an Intonational Phrase. In statements this pitch accent falls on the final syllable but speakers differ in the timing of the accent. For certain speakers, the H* pitch accent is realized at the end of the Intonational Phrase, whereas for others it occurs closer to the middle of the final syllable of the Intonational Phrase. On the basis of tokens in which the pitch accent falls at the right edge, the source of the high pitch is indeterminate: it could be attributed to either an H* pitch accent or an H% boundary tone (or a combination of the two). Tokens in which the pitch accent occurs earlier in the final syllable establish that the high pitch in the final syllable reflects (at least) an H* pitch accent.

7.11 The typology of pitch accents

Another source of cross-linguistic variation in intonation lies in the inventory of pitch accents and their relationship to word-level stress. One dimension along which pitch accents can be classified involves their relationship to word-level stress. In virtually all languages of the world, pitch accents are assigned in “bottom-up” fashion, docking on a syllable that carries primary stress at the word level. For example, in the English sentence *ALLigators deVOUR ANTeaters*, only the first syllable in the words *ALLigators* and *ANTeaters* and the second syllable in *deVOUR* would be eligible to receive a pitch accent, where the choice of word or words that actually receive a pitch accent depends on semantic conditions. Typically, in the default English case, the strongest pitch accent (and potentially the only pitch accent) would fall on the rightmost content word, i.e. on *ANTeaters* in

the sentence above. The strongest pitch accent in a phrase is often referred to as the nuclear pitch accent.

Considerably less common are languages in which pitch accents are assigned based on orthogonal principles to those governing word-level stress with the result that a pitch accent may potentially dock on a syllable that is not necessarily stressed at the word level. The Muskogean language Chickasaw (Gordon 2003) provides an example of this type of “top-down” pitch accent (see Gordon 2014 for further discussion of “bottom-up” vs. “top-down” pitch accent placement). In Chickasaw words without a long-vowel, primary stress (see Chapter 6) falls on the final syllable (and secondary stress docks on non-final CVC) (Gordon 2004a): *isso'ba* ‘horse’, *fa,lak'ki?* ‘Cherokee’, *ok,fok'kol* ‘type of snail’, *ti'fo* ‘helper to a medicine man’. The final syllable in a statement also attracts a pitch accent: *isso'ba* ‘horse’, *fa,lak'ki?* ‘Cherokee’, *ok,fok'kol* ‘type of snail’, *ti'fo* ‘helper to a medicine man’. In questions, however, the final syllable rejects the pitch accent unless it contains a long vowel. This restriction against final pitch accents means that certain word types receive a phrasal pitch accent on a syllable that is unstressed at the word level. For example, the first syllable in a disyllabic word of the shape CVCV(C) has a pitch accent in questions even though it lacks stress at the word level: e.g. *kata:t ti'fo?* ‘who is a helper to a medicine man?’ (cf. phrase-medial *ti'fo pisa* ‘s/he looks at the helper to a medicine man’). The English equivalent to this type of pattern would be exemplified by the highly unnatural rendition of the question *What devours anteaTÉRS?* with a pitch accent on the last syllable of *anteaters*.

Cross-linguistically, pitch accents tend to gravitate toward the right edge of an Intonational Phrase (Ladd 1996) as in the English and Chickasaw examples discussed above, but the sample on which this generalization is based is skewed toward languages of Europe. Languages differ in their density of pitch accents. In Chickasaw, typically only the rightmost word in an Intonational Phrase carries a pitch accent (see Gordon 2005b for exceptions to this generalization). In English, it is possible for one or multiple pitch accents to occur in a single Intonational Phrase. Egyptian Arabic (Hellmuth 2006, 2007) represents an extreme case of pitch accent density in which every content word is associated with a pitch accent.

Languages differ substantially in their inventory of pitch accents and the semantic properties of their pitch accents. Chickasaw instantiates the simplest case of a language with only one type of pitch accent, a high pitch accent (H*), which is found across different utterance types, including both statements and questions. In other languages, however, different utterance types may trigger different pitch accents. One representative language representing this type is Hungarian, which as we have seen has an H* pitch accent in statements but an L* one in questions.

In many languages, pitch accents also differ in whether they consist of a single tone as in the Hungarian, English, and Chickasaw examples we have discussed or consist of a tonal sequence, where one of the tones aligns with the stressed syllable and the other tone either leads or trails this tone. For example, in German (Grice et al. 2005), an H + L* pitch accent consisting of an L* on the stressed syllable and an H on the pretonic syllable is used to convey a soothing or polite request. Boundary tones may consist of even more than two tonal targets. For example, as

mentioned earlier, a terminal rise-fall-rise-fall sequence, analyzable as a LHLHL% string, conveys an intense feeling of annoyance in Korean (Jun 2005a).

7.12 Prosodic constituency

Intonation plays an important role in defining prosodic units larger than words. As we have seen, large prosodic constituents such as the Intonational Phrase can be described in terms of their terminal pitch characteristics and their pitch accents associated with stressed syllables. Many languages present intonational evidence for prosodic units smaller than the Intonational Phrase. An important assumption of Pierrehumbert's seminal work and much other subsequent work on intonation (see, for example, Nespor and Vogel 1986, Beckman and Pierrehumbert 1986, Hayes 1989b) is that prosodic constituency is hierarchical such that smaller prosodic units, e.g. words, group together into progressively larger constituents, where different properties including intonation can be used to diagnose these constituents. For example, in English, a prosodic word consists of a content word and any preceding function word, a Phonological Phrase in turn consists of one or more prosodic words, an Intonational Phrase (or Unit) comprises one or more Phonological Phrases, and a Prosodic Sentence or Utterance is composed of one or more Intonational Phrases. This hierarchical structure is illustrated in Figure 7.12, which provides one possible prosodic parse for the utterance *On Tuesdays, he eats yummy food*.

Units smaller than the Intonational Phrase can be described in terms of intonational tones. One tonally defined unit in certain languages is the Accentual Phrase, which corresponds to the Phonological Phrase in other languages. Intonational Phrases in Korean consist of one or more Accentual Phrases (see Jun 1993, 2005a on Korean intonation), which are canonically associated with the tonal sequence LHLH or HHLH, where the choice between an initial H or initial L is determined by the laryngeal feature of the first consonant of the phrase. An H occurs if the first consonant is aspirated or tense and an L otherwise, an interaction between tone and laryngeal features that parallels effects commonly observed in tone languages (see section 7.8). The first tone is associated with the beginning of an Accentual Phrase and the second one is characteristically associated either with the end of a closed first syllable or with the second syllable if the first syllable is open. The end of the Accentual Phrase ends in another rise

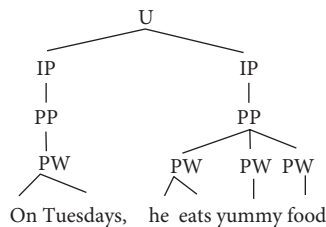


FIGURE 7.12. Hierarchical prosodic structure in English

attributed to the LH terminal sequence, although the H component may be truncated under certain circumstances.

Interestingly, Korean lacks clear evidence for stress apart from the tones comprising Accentual Phrases. In fact, the second tone of the Accentual Phrase, a high tone, is often characterized as stress (see De Jong 2000 for discussion). The Accentual Phrase thus is definitional for a third type of prosodic system in addition to stress and tone (including pitch accent); it corresponds roughly to the Phonological Phrase of languages with unambiguous stress systems. Another language in which stress has been reanalyzed in terms of Accentual Phrase tones is French (Jun and Fougeron 1995), although the case of French is more controversial (see Gussenhoven 2004 for an analysis of French prosody that integrates stress and intonational tones).

The existence of tonally defined phrases such as the Accentual Phrase in a language does not necessarily preclude stress (see Jun 2005b for a typological summary). Chickasaw (Gordon 2005b) displays evidence for an Accentual Phrase associated with a LHHL sequence in addition to stress. This tonal pattern is illustrated in Figure 7.13 for the Accentual Phrase consisting of the Chickasaw word *aba:nompistanompoli?-at* ‘preacher-subj’ (from Gordon 2005b). As the figure shows, there is a lengthy pitch plateau spanning seven syllables from the H on the second syllable to the H on the penult.

Central Alaskan Yup’ik (Woodbury 1989) has an Accentual Phrase that is defined in terms of a combination of pitch accents and a final boundary tone: the first stressed syllable in the phrase is associated with an L* pitch accent and the last stressed syllable with an H* pitch accent while the right edge of a phrase is linked with either an L or an H phrasal tone. Unlike in languages like Korean,

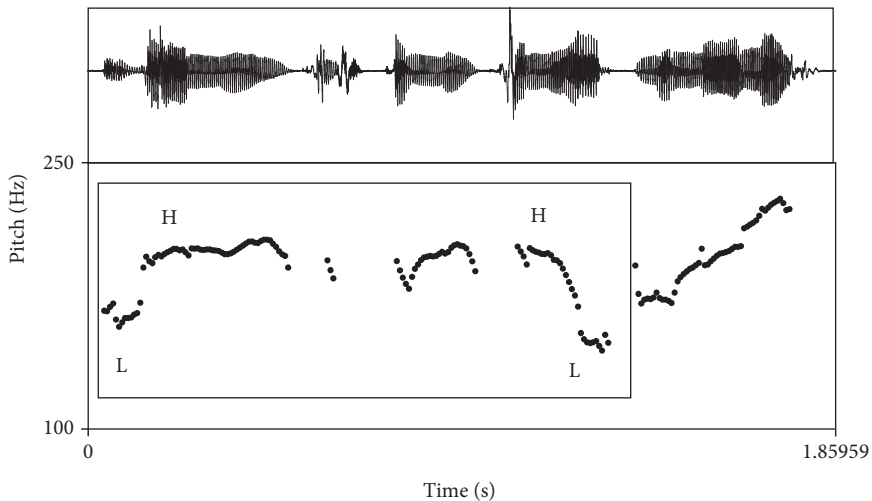


FIGURE 7.13. Accentual Phrases consisting of an LHHL sequence in the word *aba:nompistanompoli?-at* ‘preacher-subject’ in the Chickasaw sentence *Aba:nompistanompoli?at mali’li* ‘the preacher is running’ (from Gordon 2005b)

French, and Chickasaw, the Central Alaskan Yup'ik Accentual Phrase is not characterized by a string of tones defining the intonational properties of the entire phrase. In its realization of the phrasal tone as primarily a right-edge phenomenon, the Central Alaskan Yup'ik Accentual Phrase thus resembles the "intermediate phrase" of many languages including English, German, Greek, and Italian (see Grice et al. 2000 for an overview of evidence for the intermediate phrase). In these languages, the intermediate phrase is defined by a single high or low tone rather than the sequence of tones defining Accentual Phrases in languages like Korean, French, and Chickasaw. As Grice et al. (2000) show, intermediate phrase tones preferentially are aligned with the right edge of a phrase (as in Central Alaskan Yupik), but may under certain circumstances drift leftward to dock on a pre-final syllable.

Intonation does not necessarily provide the only diagnostic for prosodic phrases. Other properties such as final lengthening (or more rarely, final shortening), devoicing, non-modal phonation, and pauses can diagnose prosodic constituents. In addition, segmental alternations spanning word boundaries may be bounded by prosodic units larger than the word. Nespor and Vogel's (1986) seminal work on prosodic constituency describes a number of processes diagnostic of Phonological Phrases in different languages. One of these is the process of Raddoppiamento Sintattico found in central and southern varieties of Italian, according to which a word-initial consonant (but not preconsonantal /s/) geminates following a word that ends in a stressed vowel. For example, in the sentence *La scimmia aveva appena mangiato metà b:anana* 'The monkey had just eaten half a banana', the initial consonant in *banana* is geminated following the word-final stressed vowel in *metá*. Raddoppiamento Sintattico is blocked, however, in certain forms even though the conditions on its application superficially appear to be met. For example, it fails to geminate the first consonant of the word *due* in the sentence *Porterá due tigri fuori dalla gabbia* 'He will take two tigers out of the cage' even though this consonant immediately follows a stressed word-final vowel. Nespor and Vogel (1986) attribute the asymmetric application of Raddoppiamento Sintattico to a requirement that the trigger, the stressed word-final vowel, and the target, the post-tonic word-initial consonant, belong to the same Phonological Phrase. In *La scimmia aveva appena mangiato [metá b:anana]*, the final two words belong to the same phrase, whereas *Porterá* and *due* are separated by a phrase boundary in *[Porterá][due tigri] fuori dalla gabbia*.

In many tone languages, tonal phenomena diagnose phonological phrases. For example, in Kiyaka (Kidima 1990, 1991), a floating high tone associated with a word is realized on a syllable, preferentially an accented one if available, in the following word. Thus, a floating high associated with the word *ndoongo* + H 'needle' docks on the following word in the phrase *ndoongo pé* 'the needle as well' (Kidima 1990: 199). This process, termed "tone donation" by Kidima, fails to apply if the word carrying the floating high is not followed by another word within the same Phonological Phrase. Another example of the Phonological Phrase triggering a tonological process is described below for Kinande. Tone sandhi in Chinese languages (see section 7.7) also is diagnostic for prosodic phrases (Selkirk and Shen 1990, Duanmu 1995).

An open issue concerns the universality of prosodic units. All languages have a large intonational constituent equivalent to the Intonational Phrase that is defined minimally through terminal pitch contours (at least in non-tone languages). Languages, however, appear to superficially differ in terms of the number of units between the word and the Intonational Phrase (see Jun 2005b: 444 for a summary table). Most common is for languages to have one mid-sized unit, an Accentual Phrase or intermediate phrase or a similar type of unit. However, both an Accentual Phrase and an intermediate phrase are posited for Farsi by Mahjani (2003) and Gordon's (2003) analysis of Chickasaw appeals to both a minor phrase and an Accentual Phrase. On the other hand, certain languages, e.g. Serbo-Croatian (Godjevac 2005) and European Portuguese (Frota 2000), have been analyzed without recourse to any units between the word and Intonational Phrase. It has even been proposed that certain languages might lack prosodic words, e.g. Vietnamese (Schiering et al. 2010). It is difficult to determine whether languages truly differ in terms of their number of prosodic constituents, a view that is consistent with Schiering et al.'s (2010) conception of prosodic domains as emergent categories inferred on the basis of language-specific evidence, or whether it is simply the case that the relevant diagnostics for each unit have not yet been identified for all languages (see Vogel 2009 for an overview of the typology of prosodic constituency). A complicating factor is that closer inspection of certain processes claimed to be diagnostic of prosodic units suggests a phonetically gradient and/or probabilistically distributed rather than a categorical and definitively bounded application. For example, the process of *Raddoppiamento Sintattico* described above and another dialectal alternation, *Gorgia Toscana*, advanced as a diagnostic of the Phonological Phrase in Italian by Nespor and Vogel (1986), have been shown to display a more complex distribution than originally described (see, for example, Absalom and Hajek 2006, Dalcher 2008).

It is likely that most if not all languages possess units larger than the Intonational Phrase. These larger units, which have received various monikers in the literature, e.g. Utterance, Prosodic Sentence, Paragraph, Story Unit, also are defined in large part through intonational properties (in addition to temporal characteristics), although evidence suggests that they are often differentiated from the Intonational Phrase through gradient pitch effects rather than discrete phonological differences in tonal specifications. An example of this distinction between the Intonational Phrase and larger units is provided by Lovick and Tuttle's (2012) study of narratives in the Na Dene language Dena'ina. Lovick and Tuttle propose a prosodically defined hierarchy including (from smaller to larger units) the Word, the Intonation Unit, and the Story Unit. The Intonation Unit is most reliably the domain of final lengthening, whereas the Story Unit is associated with final pitch lowering and is often preceded and followed by a pause. However, none of the properties they identify as diagnostics of prosodic structure above the word is uniquely and categorically associated with any single constituent. Lovick and Tuttle also propose an additional larger unit they call the Paragraph, which is defined primarily in terms of discourse properties rather than phonological or phonetic features.

7.13 Prosodic structure and syntax

An important issue in the typology of prosodic constituency is its relationship to syntactic units (see papers in Inkelas and Zec 1990 for case studies of the prosody–syntax mapping as well as Inkelas and Zec 1995, Truckenbrodt 2007, and Selkirk 2011 for overviews of the syntax–prosody interface). Although prosodic units (Accentual Phrases, intermediate phrases, and Intonational Phrases) correspond in many cases to syntactic units, the two are not necessarily isomorphic to each other. Many, but not all (see below) of the apparent mismatches between the two stem from the traditional assumptions of the *Strict Layer Hypothesis* (Selkirk 1981, 1984, 1986, Nespor and Vogel 1986, Hayes 1989b), which presumes that prosodic constituents are non-recursive and strictly layered, such that each unit in the hierarchy is dominated by a unit on the immediately higher level of the hierarchy as in the English example in Figure 7.12. However, an alternative to this view is that prosodic constituency may be recursive just like syntactic constituency (see, for example, Truckenbrodt 1999, Ito and Mester 2007, 2009, and Selkirk 2011). Admitting recursion allows the possibility for phonological processes to reference either minimal or maximal versions of the same prosodic unit (Ito and Mester 2007), a flexibility that resolves certain apparent cases of mismatches between prosodic and syntactic constituency. For example, the Bantu language Chimwiini (Kisseberth and Abasheikh 1974, 2011, Kisseberth 2005) only permits long vowels within a three-syllable window at the right edge of a Phonological Phrase and a high tone falls on the penultimate syllable of a phrase in the default case. The high tone and the long vowel in the penult of the word *chi-búuku* ‘book’ in the phrase *u-zile chi-búuku na méeza* ‘s/he bought a book and a table (=s/he bought + book + and + table)’ indicates that there is a phrase break after *chi-búuku*, even though syntactically *chi-búuku* belongs with the rest of the conjoined object *chi-búuku na méeza*. Selkirk (1986) thus assumes the phrasing is $\phi(u\text{-zile } \phi(\text{chi-búuku})_{\phi} \phi(\text{na méeza})_{\phi})_{\phi}$. However, as Selkirk (2011: 459) shows, it is possible to reanalyze the prosody in terms of nested phrases such that each object noun phrase constitutes a phrase and the conjoined NPs together comprise a larger phrase within the largest phrase bounded by the verb phrase, i.e. $\phi(u\text{-zile } \phi(\phi(\text{chi-búuku})_{\phi} \phi(\text{na méeza})_{\phi})_{\phi})_{\phi}$. Under this analysis, the domain of high tone placement and vowel length is defined by the right-edge boundary of a phrase. Crucially, the data is indeterminate in deciding between the recursive and non-recursive phrasings since only the right edge of a phrase can be diagnosed through the relevant phenomena.

Admitting recursive prosodic structure does not necessarily lead to convergence between prosodic and syntactic constituency in all cases. An important source of the divergence between prosody and syntax lies in the sensitivity of prosodic structure to length in ways that the syntax is typically assumed not to display. Many languages strive for an ideal length for their prosodic phrases where length can be assessed as a function of different properties, including syntactic length as reflected in whether constituents are branching or not, phonological length in terms of number of syllables, and phonetic length in terms of the

duration of a phrase. On the one hand, they should not be too long. For example, in Korean, the Accentual Phrase tends not to be longer than five syllables, where the relevance of phonetic duration, as opposed to purely phonological duration expressed in syllable count, comes into play in that faster speech rate allows for longer strings to constitute a single phrase (Jun 1993). In a comparative study of SVO sentences in Catalan, Iberian Spanish, and European Portuguese, Elordieta et al. (2003) find that the number of branches (zero vs. one vs. two) in a noun phrase as well as the number of syllables in a phrase influence prosodic constituency to varying degrees in the three languages.

The relevance of the branching vs. non-branching distinction between phrases commonly emerges as a complementary bias against prosodic phrases that are too short. Many languages thus group non-branching syntactic constituents together with adjacent material into a single Phonological Phrase but construct an independent prosodic phrase out of a branching constituent. For example, Nespor and Vogel (1986) suggest that *Raddoppiamento Sintattico* may apply to the non-branching object complement to the verb in *Prenderà [k:]ualcosa* [will-take [something]] but may not occur when the object is branching in *Venderà [k]uesto leopardo* [will-sell [this leopard]]. The constraint on prosodic phrase formation in Italian can be interpreted as a requirement (contravened in single word utterances) that phrases consist of minimally two words parallel to similar binarity effects observed at smaller prosodic levels such as the word (see Chapter 8) and foot (see Chapter 6).

Another way in which prosodic phrase construction differs from its syntactic counterpart is its sensitivity to prominence properties, including sentential accent and lexical tone. Many languages, e.g. Japanese (Pierrehumbert and Beckman 1988), Chichewa (Kanerva 1990a, 1990b), Bengali (Hayes and Lahiri 1991), introduce a phrase boundary adjacent to a focused element, which characteristically is associated with a pitch accent. Similarly, a word carrying a lexical pitch accent in Lekeitio Basque (Elordieta 1997, 1998, 2007a, b) is obligatorily followed by a phrase boundary whereas a word lacking a pitch accent is not.

In summary, although typological evidence suggests many instances of non-isomorphism between prosodic and syntactic units, the degree of divergence between the two types of constituency is still an open issue that hinges on assumptions about the properties of both. Another outstanding issue concerns the universality of prosodic constituents. More definitive resolutions to questions about prosodic constituency must await further expansion of our typological database.

7.14 When tones collide: responses to tonal crowding

An important issue in intonational phonology is the interaction between intonational tones of various types and between intonational tones and lexical tones. In our discussion of tone (section 7.5), we saw that tonal crowding plays an important role in explaining the patterning of contour tones. Similar tonal crowding issues arise when a tone contributed by the intonation system is in close proximity

either to another intonational tone or to a lexical tone, a topic to which we now turn.

7.14.1 Tonal crowding in the intonation system

Four basic responses are observed in cases of tonal crowding arising in the intonation system. One strategy for mitigating tonal crowding is to shift the temporal realization of tones such that they are separated from each other. For example, a prenuclear H* pitch accent in English is timed earlier in its syllable when another accented syllable immediately follows (Silverman and Pierrehumbert 1990). In Chickasaw questions, the pitch accent, an H* tone, is repelled from the final syllable preceding an L% boundary tone unless the final syllable contains a long vowel, a situation that parallels the confinement of contour tones to long vowels in many tone languages (section 7.5.3). The pitch accent instead retracts onto the preceding stressed syllable, either the penult or the antepenult. The categorical tonal repulsion effect in Chickasaw is observed on a phonetic level even when the pitch accent falls on a non-final syllable: the actual pitch peak attributed to the accent falls earlier in an accented penult than in an accented antepenult (Gordon 2008).

Another strategy for reducing tonal crowding is to alter the scaling of pitch targets such that high pitch targets are lowered and/or low pitch targets are raised. This type of tonal undershoot is observed in Greek (Arvaniti and Baltazani 2005), where the L* element in a bitonal L* + H pitch accent is often raised (i.e. closer to the trailing H) relative to its canonical realization when not part of a bitonal accent.

A third option for eliminating crowding of tones is to delete one of the crowded tones. This strategy is employed in Chickasaw questions (Gordon 2003) ending in a verb containing a CV root as a response to the combination of two inviolable prohibitions: the aforementioned ban on a tautosyllabic sequence of H* pitch accent followed by an L% boundary tone plus a ban against pitch accents on prefixal syllables. Faced with these constraints, Chickasaw deletes the L% boundary tone leaving only the H* pitch accent if the question-final verb consists of a CV root, e.g. *fí-já* 'Are you?' The result is neutralization with the homophonous statement *fí-já* 'You are.' A similar strategy of tone deletion is employed in Chickasaw's Muskogean relative, Koasati, in which the canonical bitonal HL% boundary tone of imperatives is truncated to a simple H% if there is an insufficiently sonorous backdrop available. Thus, the imperative *afák* 'Follow!' has an H% on the final syllable, which ends in an obstruent, whereas the imperative *intál* 'Build it for him!' has the full HL% sequence on a syllable closed by a sonorant.

Figure 7.14 schematically illustrates different responses to tonal crowding between two tones (labeled T_x and T_y), including temporal shifting of one or both of the tones so that they are further separated (1), scaling of one or both of the tones such that they have more similar pitch targets (2), and deletion of one of the tones (3).

A final way to reduce tonal crowding is to lengthen the segmental material onto which the crowded tones dock. This strategy is employed in Japanese (Venditti

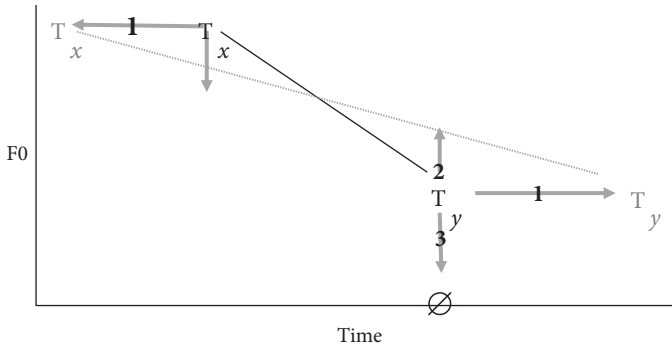


FIGURE 7.14. Strategies for reducing tonal crowding between two tones: temporal shifting (1), rescaling of pitch targets (2), and deletion (3)

2005) and Korean (Jun 2005a), in both of which boundary tones consisting of multiple tonal targets trigger lengthening of the syllable with which they are associated.

7.14.2 Tonal crowding between intonational and lexical tones

Issues of tonal crowding are more acute in languages where lexical tones compete with intonational tones for the same docking sites. One possibility adopted by many tone languages, e.g. Cantonese, Vietnamese, and Hausa (see Yip 2002 for an overview), is to circumvent a potential conflict between the two types of tones by employing discourse particles to convey the semantic content that might be covered by intonation in other languages, much like many (tonal and non-tonal) languages use morphemes, with or without accompanying intonational cues. For example, Cantonese (Law 1990) commonly adds a phrase-final morpheme /a/ on which different intonational contours can be realized with minimal disruption to lexical tone contrasts. Not all semantic functions are conveyed by particles in Cantonese, however, thus necessitating alternative strategies for dealing with crowding between lexical and intonational tones. Yes/no questions in Cantonese are associated with a terminal pitch rise, which dramatically changes the lexical tone of the latter portion of vowels, a permutation that Ma et al. (2006) show detracts from listeners' ability to perceptually recover the lexical tone in question-final instantiations of tones that do not lexically end on high pitch. Ma et al. also find that the terminal rise in questions triggers vowel lengthening, which allows some portion of the vowel to retain lexical tone properties.

Lengthening is also employed as a strategy to accommodate the terminal L% associated with questions in Hausa (Newman and Newman 1981, Newman 2000). When added to a high-toned vowel the result is a falling tone, which potentially is homophonous with an underlying falling tone. However, there is also a global raising of tone in questions, a pattern also found in Mandarin (Yuan et al. 2002), which ensures that statements and questions remain intonationally distinct.

Two other responses to tonal crowding are also observed when lexical tones and boundary tones come into contact with each other. In the Bantu language Kinyambo, a high tone on the final syllable of an Intonational Phrase shifts leftward onto the preceding syllable (Bickmore 1990) in order to accommodate a final low boundary tone, e.g. *émbwa* 'dog' in isolation vs. *embwá zirungi* 'good dogs' (p. 7). Temporal distancing of adjacent tones is observed in the Muskogean language Koasati, which it may be recalled from section 7.2 contrasts different verbal aspects through a distinction in the timing of a rising tone. Thus, the eventive aspectual form *fokò:lil* 'I am getting seated' is associated with a low-high tone sequence that is realized over the penult and final syllable. This low-high sequence is truncated to a simple low (realized as a fall) when the final vowel of an unsuffixed root is lost due to a regular process of apocope, e.g. *fokò:l* 's/he is getting seated'. Unlike statements, questions are associated with an H% boundary tone that triggers a leftward shift of the low tone in order to avoid tonal crowding. In addition, a complementary strategy to facilitate realization of the terminal rise is employed: the process of apocope that applies in statements is suppressed in questions, thereby providing additional space on which to realize the transition from low lexical tone to high boundary tone. Thus, the statement *fokò:l* 's/he is getting seated' with a fall on the final syllable differs from *fokò:lí* 'is s/he getting seated?' with a rise through the long vowel in the penult culminating in a peak on the final vowel.

A striking example of the mobility of boundary tones in tone languages is provided by the Bantu language Luganda (Hyman 1990), which marks questions through a super-high tone. Rather than simply realizing the super-high at the right edge of the question, Luganda links it to the first low-toned mora after the rightmost high tone in the question and assigns low tone to subsequent syllables, e.g. *tú-ba"-gùlililà* 'are we bribing them?', *twáába"làbililà* 'did we look after them?' (Hyman 1990: 122). If there is no high to low drop, the question is marked instead through all low tones, e.g. *àbàgùlililà* 'Is he bribing them?' (p. 122). Statements in Luganda also are intonationally marked in non-local fashion. Atonic forms, i.e. those not lexically marked for an accent, are optionally marked through a high plateau extending from the right edge back to the second mora, e.g. *àgùlililá* 'He bribes' (p. 111). Alternatively, statements are marked through low tone on all syllables, e.g. *àgùlililà*.

Truncation of tonal sequences in crowding contexts is also observed when the offending tones are a lexical tone in combination with an intonational tone. In the Bantu language Kinande, an H% boundary tone associated with the end of an interrogative replaces a lexical high on a final vowel (Hyman and Valinande 1985, Hyman 1990, Mutaka 1994). Thus, a noun that has the underlying tonal pattern HLL is realized as H L H%, e.g. /*ekikoba*/ 'rope' surfaces as *èkíkòbà* at the end of a question (Hyman 1990: 144). The final boundary tone in statements is L%, which does not conflict with any lexical tones when the rightmost lexical tone in a word is a low tone. The statement-final form for 'rope' is thus *è-kí-kòbà* (p. 117).

Interestingly, Kinande also has a Phonological Phrase-final H tone that precedes the Intonational Phrase boundary, but unlike the IP-final boundary tone,

the phrase-final tone only occurs in words lacking a lexical tone on the final vowel. It is thus suppressed in the statement-final form for 'rope' *è-kí-kòbà*. Assuming it is allowed to surface, i.e. when the final vowel is lexically toneless, the phrase-final tone preferentially docks on the penultimate syllable, presumably in order to avoid tonal crowding on the final syllable. Thus, the form /e-ki-rya-tu/ 'shoe', consisting of all toneless vowels, surfaces as *èkiryátú* with a high tone on both the penultimate and final syllables in questions (p. 118) and as *èkiryátù* at the end of a statement (p. 117). A morphological constraint requiring that intonational tones occur on a stem syllable overrides the ban on tonal crowding producing some final HL% sequences. The overall picture that emerges for Kinande is that boundary tones associated with the Intonational Phrase have priority over lexical tones, which in turn are privileged relative to Phonological Phrase boundary tones.

It is not the case that all languages delete the lexical tone in cases of clash with a boundary tone. An example of tonal simplification in favor of the lexical tone is observed in the Na Dene language, Slave (Rice 1987). Slave contrasts high and low tones where the high tone is lexically marked and the low tone is assigned by default. The right edge of statements is associated with an L% boundary tone, which normally overrides a lexical high tone in final position. However, the loss of the lexical high tone does not neutralize any underlying tonal contrasts in these cases, since an independent rule of leftward high tone spreading ensures that the high is still preserved on the penultimate syllable, e.g. *sétthi* 'my head' (cf. *sétthíghá* 'my head hair') (p. 40), *ʔedéhtl'eh* 'paper' (cf. *ʔedéhtl'éh nidjʔa* 'you sg pick up the paper') (p. 42). In cases where there is no possibility of leftward tone spread, e.g. when the final word of the statement is monosyllabic, a different pattern emerges: the final boundary tone rather than the lexical tone deletes, e.g. *tsá* 'beaver' vs. *tsá nécha* 'the beaver is big' (p. 58).

7.14.3 Tonal crowding in intonation systems: a summary

The Slave case represents a compelling case of how lexical tones may be privileged over intonational tones in tonal crowding contexts. This pattern seems intuitive in some sense since the kinds of semantic properties signaled through boundary tones are often accompanied by more global intonational features such as the commonly observed raising of pitch range in questions. In a speculative vein, these ancillary global characteristics may render the boundary tones themselves less crucial and thus more susceptible to loss. However, the preferential preservation of an Intonational Phrase boundary tone over a lexical tone in Kinande indicates that the relative resistance of lexical tone and boundary tones to deletion is subject to cross-linguistic variation. Further research will perhaps shed light on the question of which, if any, features of a language's prosodic system might allow one to predict the strategy employed to resolve tonal crowding between a lexical tone and an intonational boundary tone. It is likely significant that boundary tones in languages like Kinande that preserve them over lexical tones are more fully integrated into the tonal system of the language than in languages like Slave that choose lexical tones over boundary tones in cases of conflict. What seems more consistent across languages is the tendency for boundary tones associated

with larger prosodic domains to be preferentially preserved over those attributed to smaller prosodic domains, as in Kinande.

Among intonational tones, the Chickasaw case of monosyllabic roots (section 7.14.1) in questions and a similar case of boundary tone simplification in Hungarian monosyllabic questions (Ladd 1983) suggest that pitch accents are more likely to be preserved than boundary tones. If both lexical tones and intonational pitch accents have a privileged status relative to boundary tones, one might ask which of the two non-boundary tones is more likely to be preserved when they come into contact with each other. As it turns out, there is relatively little evidence to bear on this issue since pitch accents (of the intonational variety) are typically regarded as a feature of stress languages and detailed descriptions of stress at the phrase level are scant for tone languages. Some relevant data bearing on this issue come from Chickasaw (Gordon 2005b), which, marks aspectual differences in certain verbs through a high tone on the penultimate or antepenultimate syllable. Being a language with stress, Chickasaw also has intonational pitch accents, as we have seen in this chapter. It is possible for a verb with a lexical tone to also have a phonological pitch accent to its right according to the regular rules for assigning pitch accent which are based on syllable weight and morphology (Gordon 2003), e.g. *hójjo?lo-lí:ta* ‘Am I wearing shoes?’, *ʃofánta?ʃí:ta* ‘Will s/he be cleaner?’ However, if phonological conditions would place a pitch accent on a syllable immediately adjacent to a lexical tone, the phonological pitch accent is suppressed, e.g. *ʃofájja?tata* ‘Is s/he really clean?’ not **ʃofájjá?tata*, a pattern that indicates a preference for preserving lexical tone over intonational pitch accent.

7.15 Summary

Although tone and intonation serve different functions from each other, their reliance on the same physical dimension, fundamental frequency (and its perceptual correlate pitch), creates many symmetries between the two properties. Both tone and intonation operate to a large extent orthogonally from the segments on which they are realized, an independence that is captured in autosegmental phonology through the separation of tones and segments on different tiers. In intonation systems, the tones associated with a particular intonation pattern may dock on different morphemes, words, and phrases depending on their position in an utterance and on focus conditions. In tone languages, this separation of tone and segments manifests itself in different ways: deletion processes that target segments but leave tones intact (or vice versa), morphemes that have only a tonal realization, and morphemes that underlyingly carry tones that migrate to different morphemes on the surface. Furthermore, both tone and intonation systems are sensitive to tonal crowding avoidance effects that work against multiple tones realized in close proximity to each other. In tone languages, avoidance of tonal crowding accounts for the cross-linguistic preference for level tones over contour tones (both on categorical and statistical levels) and for the bias in favor of contour tones over complex tones. Tonal crowding constraints also explain the asymmetric capacity for phonetically longer and/or more sonorous syllables (final

syllables, stressed syllables, syllables in shorter words, and syllables containing sonorant coda consonants and/or long vowels) to support more elaborate tonal combinations than their shorter or less sonorous counterparts. Physical constraints on the realization of tone also likely motivate divergences between the typology of tonal and intonational behavior, on the one hand, and the typology of segmental processes, on the other hand. For example, the predominantly perseverative nature of tonal spreading, which contrasts with the bias toward anticipatory assimilation in segmental phonology, is consistent with the tendency for pitch targets to be phonetically delayed in intonational systems. Furthermore, the tendency for vertical assimilation in tone systems to minimize the steepness of rising tones but not falling tones has an analog in a cross-linguistic bias against rising tones, which are articulatorily more difficult to execute than falling tones. Tone plateauing is also observed both in tone systems and in intonational phonology and presumably serves a similar effort-minimizing function to the reduction of rising tone excursions.

In intonation systems, rising pitch is also less common than falling pitch, a tendency that manifests itself as a tendency for the default terminal contour to involve a fall. In the case of intonation, this preference for terminal falls likely is rooted in the physiologically grounded declination effects responsible for the gradual downward trend of subglottal pressure throughout the course of an utterance.

Not all aspects of tone and intonation, however, reflect a movement toward reduced articulatory effort. Tone languages with more than two or three tones tend to introduce contour tones, presumably as an aid in perceptually distinguishing tone contrasts. Furthermore, tonal sequences consisting of a relatively high tone followed by a relative low tone may be subject to processes that *expand* the pitch excursion by raising the first tone or lowering the second one. This a priori unexpected dissimilatory effect plausibly reflects an attempt to counteract the tendency for pitch declination to reduce the perceptual distinction between high and low tones that occurs relatively late in an utterance. The phenomenon of tonal polarity likely has a similar perceptual motivation, as does the widespread occurrence of terminal pitch rises in questions in opposition to the terminal pitch fall characteristic of statements in most languages.

In both tone and intonation systems, tones may stem from different sources. In tone languages, tones may be attributed to different types of morphemes, including roots and affixes. In the case of intonation, an important distinction exists between pitch accents, which dock on metrically prominent syllables, and boundary tones, which are associated with the edges of prosodic constituents. These boundary tones provide much of the evidence (in addition to certain segmental alternations) for prosodic units larger than the word. Although it is typically assumed that these prosodic units are arranged in a hierarchy of progressively larger constituents, there is no consensus about whether there is a single universal prosodic hierarchy holding of all languages. Furthermore, although prosodic constituency is to a large extent predictable from syntactic constituency, the nature of the relationship between prosody and syntax is a matter of ongoing debate.

8

Prosodic morphology

Prosodic morphology refers to a class of phonological phenomena that are sensitive to the prosodic shape of morphemes and were formally linked in an influential research program initiated by McCarthy and Prince (1986/1996). Typological investigation of prosodic morphology is often informed by metrical stress theory, which potentially provides independent means for characterizing the templates relevant in prosodic morphology. The research program exploring the relationship between prosodic morphology and phonological elements such as moras and feet has been especially productive and provides a compelling example of how a theory designed to address one phenomenon, in this case, stress, has spurred hypotheses dealing with other superficially unrelated topics. This chapter considers the typology of two properties that figure prominently in the discussion of prosodic morphology: minimality requirements and templatic morphology, both reduplicative and non-reduplicative.

8.1 Minimality effects

Word minimality effects are a pervasive phenomenon falling under the rubric of prosodic morphology. The Northern Iroquoian language Mohawk (Michelson 1989) exemplifies a minimality constraint. All verbs in Mohawk are minimally disyllabic, a requirement that is enforced through epenthesis of the vowel /i/ before a monosyllabic verb root lacking any other affixes (1).

- (1) Disyllabic minimality in Mohawk verbs (Michelson 1989: 44, 45)
- | Epenthesis in monosyllabic roots | | No epenthesis in disyllabic roots | |
|----------------------------------|---------------|-----------------------------------|--------------|
| /k-jʌ-s/ → | 'ikjʌs | /k-ketskw-as/ | 'kketskwas |
| 1SG.AGT-put-HAB | 'I put it' | 1SG.AGT-raise-HAB | 'I raise it' |
| /k-tat-s/ → | 'iktats | /k-atirut-ha?/ | kati'rutha?/ |
| 1SG.AGT-offer-HAB | 'I offer it' | 1SG.AGT-pull-HAB | 'I pull it' |
| /k-ket-s/ → | 'ikkets | | |
| 1SG.AGT-scrape-HAB | 'I scrape it' | | |

Crucially, minimality requirements hold of prosodic words and not necessarily morphological words although the two types of words often correspond closely. One recurring cross-linguistic source of divergence between morphological and prosodic words arises in function words, which may be viewed as syntactically

independent words but often lack status as full-fledged prosodic words. As a result, they commonly fuse with adjacent content words to form a prosodic word. For example, articles in English prosodically latch onto a following noun, as evidenced by their lack of stress and the resulting vowel reduction to schwa, e.g. [ə]n elephant, th[ə] car (see Chapter 5 on vowel reduction). Unlike function words, content words in English adhere to a minimal word requirement: monosyllabic words contain either a closed syllable or, if they are open, must have a tense, i.e. long, vowel, or diphthong (with a few exceptional words such as *spa*, *bra*, which contain highly sonorous low vowels; see Chapters 3 and 4 on sonority). Words such as *say*, *soy*, *see*, *sue*, *sit*, *soot* are thus attested whereas hypothetical words like **si*, **sʊ* are not.

Minimality constraints may asymmetrically hold of certain morphological classes of words but not others or may differ between morphological classes. For example, Mohawk's linguistic relative Seneca imposes a disyllabic minimum on verbs but a CVC requirement on nouns (Chafe 1996, p.c.). The Australian language Mangarayi (Merlan 1989) does not have a minimality condition for verbs but requires that non-verbs be minimally CVC.

Minimality conditions may also asymmetrically differ between the lexical level and the surface. For example, in Gilbertese (Blevins and Harrison 1999), monosyllabic lexical nouns and verbs are minimally CVC or CVV but additional morphology typically associated with each bulks them up to disyllables. Interestingly, in forms lacking extra morphemes (e.g. imperatives and bare plural nouns), CVC, CVV (when diphthongal), and CVCV roots undergo vowel lengthening: *te bai* 'the/a arm/wing' vs. *bai:* '(the/some) arms/wings', *am on* 'your (sg.) turtle' vs. *o:n* '(the/some) turtles', *au bwata* 'my hut(s)' vs. *bwa:ta* '(the/some) huts'. CV: roots do not lengthen, e.g. *te ni:* vs. *ni:* '(the/some) coconut trees' **ni:*, which Blevins and Harrison (1999) attribute to a restriction against overlong vowels. Crucially, longer roots containing short vowels and diphthongs also fail to lengthen, e.g. *atu:-na* 'his/her/its head' vs. *atu:* '(the/some) heads' **a:tu:*, indicating that lengthening is governed by a minimality requirement.

8.1.1 The typological distribution of minimality constraints

Minimality requirements adhere to a cross-linguistic implicational hierarchy that largely mirrors the one operative for weight-sensitive stress (Chapter 6), whereby CV is lightest (i.e. reflects an absence of a minimality constraint), followed in turn by CVC, CVV, and a disyllabic minimality condition, the most stringent restriction in the continuum (Garrett 1999, Gordon 2006a). Along this hierarchy, which is depicted in Figure 8.1, the presence of prosodic words of a particular size

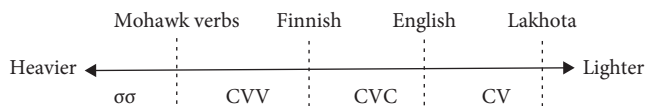


FIGURE 8.1. Hierarchy of minimality templates

implies the occurrence of prosodic words that are heavier on the minimality scale assuming there are no independent restrictions (e.g. a ban on coda consonants, a lack of long vowels) that a priori preclude a particular word shape from occurring.

As we have seen, Mohawk imposes the most stringent type of minimality condition on its verbs, all of which are minimally disyllabic. At the other extreme, many languages do not observe any minimality requirements on their prosodic words. Lakhota, for example, freely permits CV content words, e.g. *p^{hi}* 'liver', *p'o* 'fog', *si* 'foot' (Rood and Taylor 1996). English observes the most lenient minimality requirement (other than lacking one completely) in allowing CVV (where CVV is a tense vowel or diphthong) and CVC monosyllabic content words but not CV ones. Finnish exemplifies a language that draws the cut-off between licit and impermissible prosodic words between CVV and CVC. The smallest prosodic word in Finnish is monosyllabic and contains a long vowel or diphthong, e.g. *suo* 'swamp', *tyø* 'work', *su:* 'mouth', *pæ:* 'head' (Suomi et al. 2008). Monosyllabic content words containing a short vowel, whether in an open or closed syllable, are prohibited.

The disyllabic, CVC, and CVV word minima together constitute the vast majority of minimality conditions cross-linguistically. In a survey of syllable weight in 408 languages, Gordon (2006a) finds that 144 (35%) languages observe a word minimality constraint for at least certain classes of lexical items. Of the 144 languages with a minimality condition, 96 impose a CVC minimum, 22 a disyllabic requirement, and 18 a CVV minimum. The remaining minimality constraints in Gordon's survey are diverse, involving sensitivity to the complexity of the onset (see Hargus and Beavert 2006 on onset-sensitive minimality in Yakima Sahaptin and Topintzi 2010 for other cases), vowel quality (following the same scale relevant for vowel-sensitive stress; see Chapter 6), or, as in Gilbertese (section 8.1), monosyllables of greater weight than CVV, e.g. CVVC and/or CVCC (see section 8.1.2 for discussion of one such case in Estonian).

The distribution of minimal word constraints in the WALS 100-language sample is comparable to that of Gordon's (2006a) survey. The frequency of different minimality conditions expressed as a percentage of the total number of minimality constraints in the WALS sample (which includes 40 languages with a minimality requirement) and in Gordon's larger survey (including 144 languages with a minimality constraint) is depicted graphically in Figure 8.2. As the figure shows, the most common minimal word requirement in both surveys is CVC; CVV and a disyllabic constraint lag behind considerably.

Five languages in the WALS 100-language sample were determined to employ asymmetric minimality conditions for different classes of words. In four of these languages, a CVC minimality requirement obtains for nouns but not verbs, while in one language, verbs are minimally disyllabic but nouns are not constrained by any minimality requirement.

8.1.2 Processes in response to minimality conditions

Minimality requirements may exist as static constraints on the shape of lexemes, i.e. a minimality condition holding of roots, or may be enforced through active

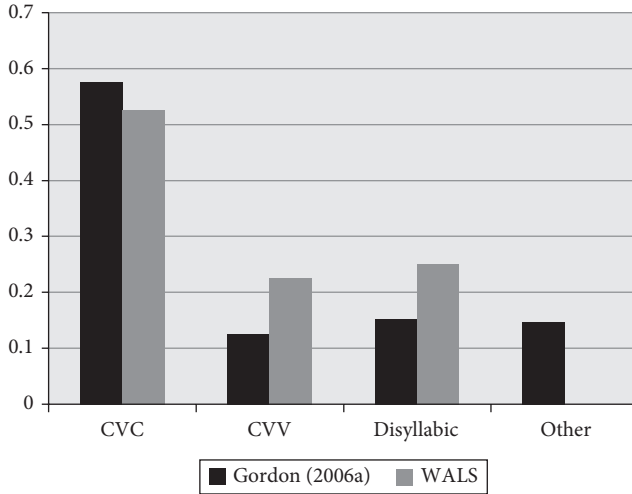


FIGURE 8.2. The distribution of minimality requirements in two surveys

phonological processes that beef up sub-minimal words. One such process commonly invoked to avoid minimality violations is vowel epenthesis, which was exemplified earlier as a means for satisfying a disyllabic minimum holding of verbs in Mohawk. Languages with a CVC minimal word requirement may enlist epenthetic consonants rather than vowels to ensure that a minimality constraint is honored. For example, in the Uto-Aztec language Cupeño (Crowhurst 1994a), a glottal stop is inserted to ensure that underlying CV words surface as CVC (2a). A glottal stop is not inserted after vowel-final roots that are disyllabic (2b).

(2) Glottal stop epenthesis in Cupeño (Crowhurst 1994a: 197)

- (a) /tʃi/ tʃiʔ 'gather'
 /hu/ huʔ 'fart'
 /k^wa/ k^waʔ 'eat'

- (b) /ʔaju/ ʔaju *ʔajuʔ 'want'
 /k^wiʃi/ k^wiʃi *k^wiʃiʔ 'wring out'

Lengthening is another process that satisfies certain minimality conditions. In the Uralic language Northern Sámi (Nielsen 1926), vowel lengthening beefs up monosyllabic CV(C) function words in stressed contexts in order to satisfy a CVV minimality requirement, e.g. /mun/ → *mu:n* 'I', /mu/ → *mu:* 'me (accusative)' (p. 115), a process that bears similarity to the lengthening of the English articles *a* and *the* under focus.

A typologically more unusual means for satisfying minimality is found in the North Caucasian language Kabardian, which employs a process of fusion to prosodically adjoin a CV word to a preceding word within a noun phrase (Gordon and Applebaum 2010b): 'wənw + 'fʷ (house + new) → wənw'fʷ 'new house', fʷə + fʷ (horse + skin) → 'fʷəfʷ 'horse skin'. As these examples show, the

occurrence of a single stress (falling on the penult syllable unless the final is heavy in which case stress is final) for the entire noun phrase provides evidence for prosodic fusion (see Gordon and Applebaum 2010b for other diagnostics of the prosodic word status of the fused elements). Fusion fails to apply to a word that is larger than CV, e.g. *'wənv + 'be:* (house + rich) → *'wənv 'be:*, *'ʔə + 'Bʷər* (man + rich) → *'ʔə 'Bʷur* 'skinny man', *'wənv + 'xʷa:bv* → *'wənv 'xʷa:bv* 'warm house'. Furthermore, certain CV words are blocked from undergoing fusion, either because there is no host within the same noun phrase or because they are verbs and are thus ineligible for fusion. Interestingly, CV words that fail to undergo fusion are exempt from a process of apocope that otherwise targets word-final schwa, including final schwa in CV words that have prosodically fused to a host, e.g. *'fʔə* 'good' vs. *wə'nv-f'* 'good house', *'ʔə* 'man' vs. *ʔv'mv-ʔ'* 'foreigner'. The failure of apocope to target unfused CV suggests a minimality hierarchy in Kabardian, whereby words larger than CV are fully licit, CV is dispreferred but tolerated under certain circumstances, and simple C is absolutely prohibited.

8.1.3 *The source of minimality restrictions: independent constraints and evolution*

Minimal word requirements may emerge as a by-product of independent restrictions or processes. Most trivially, a language may lack word-final consonants, in which case the minimal word could not be CVC. Similarly, a language lacking long vowels or diphthongs could not possess a minimal word requirement of CVV. In the Nilo-Saharan language Lango (Noonan 1992), a process of lengthening targeting stressed word-final vowels ensures that CV content words surface as CVV: *lè:* 'axe', *ɣù:* 'beast of prey', *t̄:* 'to die' (p. 27). Lengthening asymmetrically fails to occur in a stressed closed syllable, e.g. *t̄sɨ* 'spear', *j̄ɔk* 'spirit', *r̄ət̄ɔ* 'stick' (p. 69), an asymmetry that ensures that the minimal content word is CVC in Lango.

Minimal word constraints are susceptible to change over time as independent processes may conspire to either erode or augment existing words, potentially leading to differences between related languages in their minimality requirements. An example of this divergence within a language family is provided by the Balto-Finnic family. As we have seen, the minimal content word in Finnish is CVV. In closely related Veps, however, a diachronic process of vowel shortening has created CV words, e.g. *ma* 'land' (cf. Finnish *ma:*), *su* 'mouth' (cf. Finnish *su:*), *pæ* 'head' (cf. Finnish *pæ:* 'head'), thereby eliminating the minimal word requirement. In Livonian, on the other hand, the long vowels in CVV monosyllables have been preserved but a process of apocope targeting word-final non-low vowels has created a large number of CVC monosyllables out of former CVCV words, e.g. *me^ʔr* 'sea' (cf. Finnish *meri*), *mæ^ʔk* 'hill' (cf. Finnish *mæki*), *su^ʔk* 'relative' (cf. Finnish *suki*). The superscripted glottal stop indicates the *stød* feature, which is associated with creaky voicing and lowered pitch—see Lehiste et al. (2008).

Yet another Balto-Finnic language, Estonian, has gone in the opposite direction from Veps and Livonian and now has a more stringent minimal word restriction

than its relatives. Estonian monosyllabic content words consist of one of the following shapes: a short vowel followed by an overlong single consonant or a cluster containing an overlong consonant (i.e. CVCCC, CV(C)CCC, CVCCC(C)), a long vowel followed by a short or long consonant/cluster (CVVC(C)) or an overlong vowel in an open syllable (CVVV). All of these templates can be analyzed as fulfilling a trimoraic word minimum (Hayes 1989a; see Chapter 6 on moras), e.g. *lin::* 'town' (cf. Finnish *lin:a* 'castle'), *sep::* 'smith' (cf. Finnish *sep:æ*), *ke::l* 'language' (cf. Finnish *kieli*), *mus::t* 'black' (cf. Finnish *musta*).

The trimoraic monosyllabic words in Estonian are traceable to disyllabic words that lost their second vowel. This apocope process was itself constrained by a minimality requirement that the first syllable be either CVV or CVC and failed to apply if the first syllable was CV, e.g. proto Balto-Finnic **mus.ta* 'black' > pre-Estonian **must*, **sep.pæ* 'smith' > pre-Estonian **sep:*, **ku:si* 'six' > pre-Estonian **ku:s*, but **kala* 'fish' > pre-Estonian **kala*. The result of this syncope was a new set of CVCC monosyllables, which underwent compensatory lengthening when the vowel after the initial syllable was lost, thereby creating the minimality restriction holding of closed monosyllables: pre-Estonian **must* > Estonian *mus::t*, pre-Estonian **sep:* > Estonian *sep::*. Overlengthening analogically targeted open monosyllables to yield the typologically rare minimality requirement currently found in Estonian, e.g. *ma::* 'land' (cf. Finnish *ma:*, Veps *ma*), *su::* 'mouth' (cf. Finnish *su:*, Veps *su*).

8.1.4 Minimality as a condition on mora population

Monosyllabic minimality requirements are commonly formalized in terms of constraints on the minimal number of moras in a prosodic word (McCarthy and Prince 1986/1996, Hayes 1995). For example, in a language with a CVC or CVV minimal word requirement, we might assume that words are minimally bimoraic, where coda consonants are mora-bearing in a language with CVC minimality but not in a language with a CVV minimal word requirement. In Estonian (Hayes 1989a) and Gilbertese (Blevins and Harrison 1999), the minimal word may be assumed to be trimoraic. As we have seen in the chapter on stress (Chapter 6), moras also may be invoked to account for the heavy status of certain syllable types in weight-sensitive stress systems. Thus, CVV is universally (or nearly so) heavy because it is bimoraic, whereas CVC is bimoraic in languages in which it too counts as heavy.

Characterizing both weight-sensitive stress and word minimality conditions in terms of moraic structure suggests an intriguing hypothesis: that weight criteria operative for both will coincide, a prevalent assumption since McCarthy and Prince's (1986/1996) seminal work on prosodic morphology (see Garrett 1999, Gordon 2006a for discussion and analysis). Hayes (1995), for example, contains an explicit formulation of this assumed link when he hypothesizes that the smallest possible foot in a word will be equivalent in size to the smallest possible prosodic word and cites several languages that, like Latin, conform to this prediction.

The strongest version of the hypothesized link between foot structure and word minimality consists of two predictions. First, it is predicted that the absence of a

minimality requirement holding of feet in a language will be mirrored by a lack of a minimality constraint at the word level, i.e. tolerance of CV feet implies tolerance of CV words. Maranungku (Tryon 1970) is a language that conforms to this first prediction. It constructs trochaic feet from left to right (see Chapter 6 on foot structure), parsing a final odd-numbered syllable into a foot: (^hɲalti)(_iriti) (_iri) 'tongue'. It also lacks a word minimality constraint, i.e. CV words are permitted.

Second, it is predicted that, in languages with both foot and word minimality constraints, the two types of minimality will be identical, i.e. languages with a CVC minimality requirement at the foot level will also have a CVC word minimality condition and languages with a CVV minimal foot will also display a CVV minimal word constraint. Latin is a language in which minimality criteria converge at the word and foot level. It has a weight-sensitive stress system in which a foot minimally consists of a closed syllable (but can be disyllabic), e.g. (^hsapi)<e:ns> 'wise-nom.sg.', sapi(^hen)<te:s> 'wise-nom.pl.' (where < > surround extrametrical syllables; see Chapter 6) and also has a minimal word requirement of CVC (Mester 1994). Gilbertese (section 8.1) also displays convergence between prosodic minimality and foot construction where both adhere to a trimoraic template (see Blevins and Harrison 1999 for analysis).

The second type of prediction is particularly probative in evaluating moraic uniformity since both foot- and word-level minimality conditions are by default hypothesized to be projected from the same moraic representations. In contrast, an absence of either foot- or word-level minimality constraints (or both) does not allow for diagnosis of moraic structure. A disyllabic minimality condition is also not informative in testing for moraic uniformity since it is captured in terms of syllable rather than mora count.

Garrett (1999) explores the moraic uniformity hypothesis on a broad cross-linguistic basis. He compares foot minimality and word minimality in over fifty languages in order to test the hypothesis that the smallest possible word in a language is equivalent to the smallest possible foot. Garrett's survey fails to unearth broad cross-linguistic evidence of weight consistency between word and foot minimality. He finds eleven languages with a CVC word minimality requirement but which allow only CVV *and not* CVC to constitute a monosyllabic foot, e.g. Cahuilla (Seiler 1957, 1965, 1977; see Chapter 6). In contrast only seven languages have a CVV minimality requirement holding at both the foot and word level. Garrett also finds no tendency for word-minimality requirements to correspond to weight criteria employed in unbounded stress systems, (Chapter 6) in which stress is directly (rather than through foot structure) diagnostic of moraic structure. Three of the four languages in his survey that preferentially stress certain vowel qualities (lower or non-schwa vowels) observe a word-level minimality requirement of CVX rather than one based on vowel quality as predicted by the stress system. Furthermore, all five of the unbounded stress systems not based on vowel quality that have a word minimality constraint are sensitive to a different weight criterion for stress.

Results of Gordon's (2006a) survey of syllable weight dovetail with those of Garrett (1999). Of the 44 languages in Gordon's survey with both weight-sensitive

stress and a minimality condition on words, over half (26 languages = 59%) employ divergent criteria for the two phenomena contra the hypothesis of moraic uniformity.

The overall lack of cross-linguistic support for the moraic uniformity hypothesis raises questions about the significance of languages like Latin that display convergence of weight criteria. Gordon (2006a) concludes that most cases of language-internal uniformity of weight are artifacts of process-specific typological biases in weight criteria. He thus suggests that occasional convergences of the Latin type involving the CVC heavy criterion for both foot and word minimality are bound to occur accidentally given the heavy cross-linguistic skewing in favor of CVC word minimality and the relative frequency of languages that treat CVC as heavy for stress (see Chapter 6).

8.2 Reduplication

In addition to minimality conditions, many types of morpheme-formation processes also are sensitive to prosodic templates. One common form of templatic morphology is reduplication, the construction of novel words by duplicating a morpheme or part of a morpheme. For example, Malagasy (Martin 2005) has a productive process of reduplication targeting nouns, verbs, and adjectives where there are various meanings associated with reduplication depending on the word class, e.g. intensification of adjectives, resemblance of nouns to another noun, intermittent activity in the case of verbs, etc. As the examples in (3) show, reduplication involves copying the primary stressed syllable plus the immediately post-tonic syllable (Martin 2005). Stress in Malagasy (Erwin 1996) falls on the final syllable if it contains a diphthong (there are no long vowels), otherwise on the penultimate syllable in most native words, although it may occur in some lexical items on the antepenult, as in the last example in (3). Secondary stress falls on diphthongs and the first in a sequence of two syllables preceding another stress.

(3) Reduplication in Malagasy (Martin 2005: 289)

₁ mana'dala	₁ mana,dala'dala	'to fool'
₁ mila'lau	₁ mila,lau'lau	'to play'
a'likʲa	a,likʲa'likʲa	'dog'
'namana	₁ nama'namana	'friend'

As Martin shows, the reduplication patterns can be understood as copying of the rightmost foot in the word, which is aligned with the right edge of the word. Feet are trochaic (strong-weak) and bimoraic, consisting of either a single heavy syllable (=CVV) or two light syllables (see Chapter 6 on foot typology): (₁ma^μna^μ) (₁da^μla^μ) ('da^μla^μ), (₁mi^μla^μ) (₁la^μu^μ) ('la^μu^μ).

The data in (3) fail to diagnose the location of the reduplicant (the copy created in reduplication) relative to the base. It is thus possible to analyze the reduplicant as either a suffix, e.g. ₁mana,dala-'dala, or an infix, e.g. ₁mana-,dala-'dala. However,

an interesting twist on the reduplication pattern in loanwords with final stress on a short vowel turns out to be probative in establishing the location of the reduplicant. In words of this shape, the *secondary* stressed syllable plus the immediately following syllable are copied, e.g. ,soko¹la → ,soko,soko¹la ‘chocolate’, ,zavu¹ka → ,zavu ,zavu¹ka ‘avocado’. Martin attributes this pattern to a requirement that the reduplicant consist of a canonical bimoraic foot. Because the rightmost foot in a word with final stress is a non-canonical monomoraic foot, it is skipped in favor of copying the preceding foot: (,so^μko^μ) (,so^μko^μ) (‘la^μ). If one assumes an infixing analysis of reduplication, the location of the reduplicant in both native and loanwords becomes consistent, e.g. ,mana-[,dala]-¹dala and ,soko-[,soko]-¹la, where brackets surround the reduplicant. In contrast, a suffixing analysis is not tenable for the loanword data and a prefixing analysis is not viable for the native word data. The location of the reduplicant relative to the base is discussed further in section 8.2.1.3.

8.2.1 Phonological characteristics of reduplication

Three phonological dimensions along which reduplication can be described are the shape of the reduplicant, its location relative to the base from which it is copied, and the portion of the base that is copied in cases where the reduplicant does not represent a complete copy of the base. We begin discussion with cross-linguistic variation in the shape of the reduplicant.

8.2.1.1 Shape of the reduplicant An important observation about reduplication is that the reduplicant characteristically adheres to a prosodic or morphological template that is independent of the shape of the base providing the material for the reduplicant. It is thus comparatively rare for the reduplicant to shift as a function of the form of the base. For example, there are very few languages that copy the first syllable of the root where the shape of the reduplicant varies in accordance with the shape of the base. In fact, Moravcsik’s (1978) typology of reduplication fails to uncover any cases of copying of prosodic constituents from the base. As it turns out, some languages do display reduplication of a syllable from the base, a pattern to which we return later.

For now, though, we focus on the more typical situation cross-linguistically in which the reduplicant assumes a fixed prosodic shape that does not depend on prosodic constituency in the base. For example, if the reduplicative template is a closed syllable, i.e. (C)VC, the reduplicant may potentially be a subset of the first syllable of the base in some words (e.g. if the first syllable of the base has a coda cluster) or, conversely, may encompass material from the second syllable of the base (e.g. if the first syllable of the base is CV). The forms in (4) from the Chukotko-Kamchatkan language Chukchi (Dunn 1999) illustrate a fixed suffixal (C)VC reduplicative template in the absolutive singular for roots of varying shapes. In case the reduplicant is coextensive with the entire root, i.e. if the root is CVC, the absolutive plural also displays reduplication, although other case forms are formed from the non-reduplicated root.

(4) Reduplication in Chukchi (Dunn 1999: 107–8)

<i>Shape of root</i>	<i>Absol. sg.</i>	<i>Absol. pl.</i>	<i>Gloss</i>
1st $\sigma = (C)V$	e.me- em we.ni- wen	e.me-t we.ni-t	' <i>suxostoj</i> (tree sp.) 'bell'
1st $\sigma = (C)VC$	ir.w- ə-ir	ir.w- ə-t	'something sharp, an edged weapon'
σ root	jil.ʔe- jil	jil.ʔet	'arctic ground squirrel'
1st $\sigma = (C)VCC$	tanŋ- ə-tan	tanŋ- ə-t	'stranger'
(C)VC	wət- wət	wət- wət-te	'leaf'
$\sigma\sigma$ root	nəm- nəm	nəm- nəm-t	'settlement'
	ots- ots	ots- ots-te	'boss, chief'

In Chukchi, reduplication is not employed for nouns smaller than (C)VC so it is not possible to see how the reduplicative template is satisfied when the base provides insufficient material to satisfy the template. Chukchi also lacks phonemic long vowels, so there is no basis for determining whether the reduplicant is truly (C)VC or whether it conforms to a more general template of a heavy (bimoraic) syllable realized as either (C)VC or (C)VV. An unusual feature of Chukchi reduplication is the non-contiguity of base and reduplicant (see section 8.2.3.2).

A bimoraic template is attested in the Austronesian language Mokilese, which displays a process of prefixal reduplication in the progressive of verbs (Harrison 1973, 1976, Blevins 1996). As the forms in (5) illustrate, the shape of the reduplicant shifts between (C)VC and (C)VV according to the shape of the base. If the first syllable of the base is CVV or CVC, the reduplicant is a copy of the first syllable (a). If the first syllable of a polysyllabic base is CV, the onset of the second syllable is copied along with the first syllable to adhere to the reduplicative template (b). Reduplication of a monosyllabic CV root results in a CVV reduplicant in which the base vowel is lengthened to conform to the bimoraic template (c). Similarly, if the first syllable is CV and the second syllable lacks an onset, the vowel in the reduplicant is a lengthened version of the first vowel of the root (d). Finally, for a root beginning with a vowel, reduplication entails copying the first syllable of the root and geminating (if the first syllable is open) or copying (if the first syllable is closed) the onset of the second syllable of the root (e, f). As in Chukchi, if the first syllable of the root contains more material than the reduplicative template allows, copying proceeds from left to right ignoring excess segments (g).

(5) Reduplication in Mokilese (Blevins 1996: 523 unless otherwise indicated)

<i>Shape of root</i>	<i>Root</i>	<i>Progressive</i>	<i>Gloss</i>
(a) CVC...	lɔŋ	lɔ ^h ŋ ^h lɔŋ	'fly/full of flies' (Harrison 1976: 59)
CVV...	sɔ:rɔk	sɔ: ^h ɔ:rɔk	'tear/ing'
(b) CV.C...	pɔdok	pɔ ^h d ^h .pɔdok	'plant/ing'
	nikid	ni ^h k ^h .nikid	'save/ing'

(c) CV#	pa	pa: ^{HH} .pa	‘weave’
(d) CV.V...	di.ar	di: ^{HH} .diar	‘find/ing’
	wi.a	wi: ^{HH} .wia	‘do/ing’
(e) V.C...	alu	a ^H l ^H .lalu	‘walk/ing’
(f) VC.C...	andip	a ^H n ^H .dandip	‘spit/ing’
(g) CVVC.C...	ca:k	ca: ^{HH} .ca:k	‘bend/able to bend’

Despite the variation in the shape of the reduplicant and its relationship to the base, all of these variants have in common that they constitute a single heavy (bimoraic) syllable.

If one assumes that reduplication can be weight-sensitive, as in Mokilese, one might expect there to be languages in which CVV but not CVC fulfills a bimoraic reduplicative template, parallel to other weight-sensitive phenomena that have the option of treating CVV but not CVC as heavy, e.g. stress (Chapter 6) and minimal word requirements (this chapter). In fact, there are relatively few secure examples of CVV reduplicants, where the first vowel of the base is copied with length ignoring any following consonants even a coda. Harrison (1976: 60) notes that speakers of Mokilese, particularly younger ones, optionally employ a CVV reduplicative template instead of a CVX syllable, e.g. *pɔ:^{HH}.pɔdɔk* ‘planting’ instead of *pɔ:^Hd^H.pɔdɔk*.

The Uto-Aztec language Tohono O’odham (Hale 1965, Hill and Zepeda 1992, 1998, Fitzgerald 2012) also employs CVV reduplication in one pattern of plural formation (6), alongside the statistically prevalent CV reduplication. The choice between CV and CVV reduplication is to a large extent predictable on phonological grounds, although semantic factors also play a role (see Hill and Zepeda 1998).

(6) CVV reduplication in Tohono O’odham (Fitzgerald 2012: 454–5)

<i>Base</i>	<i>Reduplication</i>	<i>Gloss</i>
ban	'ba:ban	‘coyote’
maɖ	'ma:maɖ	‘obvious’
ʃjɪɪ	'ʃjɪ:ʃjɪɪ	‘mouth’
moʔos	'mo:moʔos	‘head of bed’
ɲim	'ɲi:ɲim	‘liver’

Another common reduplicative template is a light CV syllable. The Muskogean language Creek (Martin 2011) often employs CV reduplication in intransitive verbs to express distributive meanings (7). The reduplicant is typically a copy of the first consonant + vowel sequence (i.e. the first syllable with an onset) of the root and is placed to the left of the final consonant of the root (7a), a case (like Chukchi) of non-adjacency of the base and reduplicant. Because verbs end in open syllables and the penult is either open or ends in a single coda, this is tantamount to saying that the reduplicant occurs before the onset of the final syllable. Crucially, a long vowel in the first syllable of the root surfaces as short in the reduplicant (7b) and a coda consonant is not copied (7c), indicating that the reduplicative template is a single light CV syllable.

(7) CV reduplication in Creek (Martin 2011: 203–4)

	<i>Base</i>	<i>Gloss</i>	<i>Distributive</i>	<i>Gloss</i>
(a)	likátʃw-i:	‘dirty’	likatʃli ^u w-i:	(two or more)
	hopánk-i:	‘broken’	hopanho ^u k-í:	(two or more)
	falápk-i:	‘split’	falapfa ^u k-í:	(two or more)
	jomotʃk-i:	‘dark’	jomotʃjo ^u k-i:	(as of several rooms)
(b)	apo:k-itá	‘(three or more) to sit, live’	apo:po ^u k-itá	(in several places)
	atʃá:k-i:	‘precious’	atʃa:tʃa ^u k-í:	(two or more)
	a-ló:fk-i:	‘smearred on’	a-lo:flo ^u k-í:	‘smearred on (in more than one place)’
	tó:sk-i:	‘mangy’	to:sto ^u k-í:	(two or more)
(c)	hátk-i:	‘white’	hátha ^u k-í:	(two or more)
	tolk-itá	‘to fall over’	tolto ^u k-íta	(two or more)
	tʃafk-itá	‘to drip’	tʃaftʃa ^u k-íta	‘to drip repeatedly’

It is also possible for a language to display variation between light and heavy syllable reduplication. The Micronesian language Kosraean (Lee 1975, 1976) employs prefixal reduplication to mark the iterative aspect, where the shape of the prefix varies between CV and CVC. The reduplicant is CV before monosyllabic roots (8a) and before disyllabic roots with vowel hiatus or a sequence of vowel–glide–vowel (8b). Otherwise, the prefixal reduplicant is CVC (8c). Kosraean also displays variable weight *suffixal* reduplication to mark the “denotative” (Harrison 1973), where CV is adopted after root-final open syllables (8d) and CVC after root-final closed syllables (8e)

(8) Variable weight prefixal and suffixal reduplication in Kosraean (Lee 1975, 1976)

	<i>Base</i>	<i>Gloss</i>	<i>Reduplication</i>	<i>Gloss</i>
(a)	foʃ	‘smoke’	fofos	‘to emit smoke’
	loŋ	‘to step’	lolon	‘to step repeatedly’
	kæʎ	‘to touch’	kækæʎ	‘to touch repeatedly’
(b)	fo.ul	‘smell’	fofo.ul	‘to emit smell’
	fijɔ	‘to sweat’	fifijɔ	‘sweating’
(c)	tæfoŋ	‘to mistake’	tæftæfoŋ	‘to make lots of mistakes’
	furok	‘to turn’	furfurok	‘to turn little by little’
	kipat	‘to break’	kipkipat	‘breaking’
(d)	nu	‘coconut’	nunu	‘lots of coconuts’
	fijɔ	‘to sweat’	fijɔɔ	‘sweaty’
(e)	læs	‘coral’	læslæs	‘lots of coral’
	ʃanom	‘juice’	ʃanomnom	‘juicy’

Kennedy (2005) offers an analysis of variable weight reduplication in Kosraean that appeals to metrical structure and syllable weight. Crucially, the variation in the shape of the reduplicant in Kosraean differs from true syllable reduplication (see the case of Yaqui below) in being predictable from independent prosodic properties of the

language. Kennedy (2002) develops a similar metrically driven analysis of Kosraean's Micronesian relative Ponapean, which also displays variation between heavy and light syllables in its reduplication patterns (see section 8.2.1.2 for discussion).

Reduplication can also involve copying of single segments, either a consonant or vowel, as illustrated in (9) for three languages: single consonant reduplication in Temiar (Benjamin 1976, Miyakoshi 2006) and Jakaltek (Day 1973) in (9a) and (9b), respectively, and single vowel reduplication in Bella Coola (Nater 1984: 109) in (9c). In the case of Bella Coola, the reduplicant is more accurately described as a single syllabic sound, since a consonant functioning as a syllable nucleus in the base is eligible for copying, as the second example in (9c) shows.

- (9) Single segment reduplication in three languages: consonant in Temiar (Miyakoshi 2006: 45) and Jakaltek (Day 1973: 45) and vowel in Bella Coola (Nater 1984: 109)

	<i>Base</i>	<i>Gloss</i>	<i>Reduplication</i>	<i>Gloss</i>
(a) Temiar	trkɔ:w	'to call'	trkwkɔ:w	'to be calling'
	slɔg	'to lie down'	sglɔg	'to be lying down'
(b) Jakaltek	pits'-a	'squeeze sth gently'	tʃa pits'p-e	'you squeeze s.th. gently several times'
	onom	'noise and/or motion of leaves on shaken trees'	tʃa jukj-e	'you shake s.th.'
(c) Bella Coola	t'ixʔala	'robin'	ʔit'ixʔala-j	(diminutive)
	k'nts	'sperm whale'	ʔnk'nts	(diminutive)

A key feature of these single segment reduplication patterns is the non-contiguity of the base and the reduplicant, which allows the alternations to be diagnosed as reduplication as opposed to gemination or lengthening.

Conversely, reduplicative templates can be larger than a single syllable. Another attested template is a foot, a pattern that was exemplified earlier for Malagasy, in which the reduplicant may consist of either one heavy syllable or two light syllables. In a language with weight-insensitive stress, a foot-sized reduplicant is predicted to be invariantly two syllables long. As it turns out, disyllabic foot templates in virtually all languages are sensitive to the structure of the second of the two syllables such that there is a strong preference cross-linguistically for the second syllable to be CV regardless of whether the second syllable of the base is open or closed or contains a long vowel (McCarthy et al. 2012). In other words, the disyllabic reduplicant is characteristically σCV rather than $\sigma\sigma$. For example, in Ngiyambaa (Donaldson 1980), the reduplicant is a prefixed copy of the first two syllables of the root minus a coda consonant or vowel length that occurs in the second syllable (10). The failure of vowel length or the coda consonant to reduplicate is not attributable to any independent phonotactic constraint in Ngiyambaa, such as a prohibition against word-internal codas or a

ban on long vowels in certain positions, although it plausibly reflects a tendency for reduplicants to display less marked structures than the bases from which they are derived (see section 8.2.1.2 for discussion).

- (10) σ CV reduplication in Ngiyambaa (Donaldson 1980: 70–3)

magu -magu:	‘around one’
guju -gjuŋan	‘more-or-less (one’s) own’
gi:ja -gi:jan	‘pretty green’
gulbi -gulbir	‘more or less than a few’
bunŋu -bunŋu	‘more or less than many’

McCarthy et al. (2012) cite the Australian language Yidiny (Dixon 1977) as the most secure example of true disyllabic reduplication in which the second syllable shifts between CV and CVC to match the second syllable of the base. The examples in (11) consist of nominal reduplication used to signal plurality.

- (11) $\sigma\sigma$ reduplication in Yidiny (Dixon 1977: 156)

<i>Base</i>	<i>Gloss</i>	<i>Reduplication</i>	<i>Gloss</i>
gindalba	‘lizard sp.’	gindalgindalba	‘lizards’
jimuru	‘house’	jimuŋjimuru	‘houses’
ŋalal	‘big’	ŋalalŋalal	‘lots of big (ones)’
mulari	‘initiated man’	mulamulari	‘initiated men’
buŋa	‘woman’	buŋabuŋa	‘women’

Earlier it was suggested that the copied portion of the base in virtually all (if not all) cases of phonologically specified reduplication conforms to a template that is not specified with reference to a constituent in the base. It is thus extremely rare to find syllable reduplication, where the shape of the reduplicant varies as a function of the structure of the copied syllable in the base. One such case of syllable reduplication occurs in the formation of the habitual aspect in the Uto-Aztec language Yaqui (Haugen 2003, 2014). In Hiaki, the shape of the reduplicant varies between CV and CVC to match the shape of the first syllable of the root (12).

- (12) Syllable reduplication in Hiaki (Haugen 2014: 511)

<i>Template</i>	<i>Base</i>	<i>Reduplication</i>	<i>Gloss</i>
CV	vu.sa	vu.vu.sa	‘awaken’
	tʃi.ke	tʃi.tʃi.ke	‘comb one’s hair’
	he.wi.te	he.he.wi.te	‘agree’
CVC	vamse	vam.vam.se	‘hurry’
	hit.ta	hit.hit.ta	‘make a fire’
	?at.b ^w a	?at.?at.b^wa	‘laugh at’
	b ^w al.ko.te	b^wal.b^wal.ko.te	‘soften, smooth’

Thus far we have only discussed cases of reduplication involving a phonologically specified template, e.g. a single segment, a syllable, a light syllable, a heavy syllable, a foot, and a disyllabic string. Yet another type of reduplicant template is

morphologically defined and involves copying of an entire morpheme rather than conforming to any phonologically specified template. Although there are instances of affixes undergoing complete reduplication, it is most common for morpheme copying to involve the root. For this reason, I will henceforth refer to duplication of an entire morpheme as “root” or “whole root” reduplication. The Australian language Martuthunira (Dench 1995) displays root reduplication in both disyllabic (13a) and trisyllabic roots (13b).

(13) Whole root reduplication in Martuthunira (Dench 1995)

(a)	jampa -jampa	‘near to death’
	jiɽi -jiɽi	‘striped’
	wiɽa -wiɽa	‘lost’
	wan̩an -wan̩an	‘overcast’
(b)	wiɽaɽa -wiɽaɽa	‘exhausted’
	wuɽuɽa -wuɽuɽa	‘dirty/dusty’
	piɽɽuɽa -piɽɽuɽa	‘ripples’

Interestingly, Dench (pp. 34–5) suggests that trisyllabic reduplicants in Martuthunira tend to be parsed in a different prosodic word (as evidenced by intonation and lenition) from their base. This is unlike disyllabic reduplicants, which are treated as part of the same phonological word as their base (see section 8.2.3.5 for more on the relationship between reduplication and prosodic word formation).

Many languages display multiple types of reduplication either to cover different semantic functions or for different roots. For example, the language isolate Daga (Murane 1974) spoken in Papua New Guinea employs reduplication of the root to signal plurality (14a), but reduplicates the first σ CV string to mark intensification in non-verbs (14b). A third type of reduplication, characterized by copying of the second CV sequence of the root, is employed in some verb stems to signal “a repetition of the action to or by different groups” (14c). There are additional types of reduplication in Daga (see Murane 1974 for discussion) involving fixed segmentism (see section 8.2.1.2).

(14) Multiple reduplicative templates in Daga (Murane 1974: 72–3)

(a)	oam	‘sun, day’	oam oam	‘always’
	at	‘place’	at at	‘everywhere’
	pa	‘house, village’	pa pa	‘villages’
	ugup	‘different’	ugup ugup	‘many different ones’
(b)	nonon̩ga	‘long’	nonononon̩ga	‘very long’
	bobou	‘short’	bobobobou	‘very short’
	karaua	‘carefully’	karakaraua	‘very carefully’
	togan-a	‘on the hill’	togatogana	‘on the hilly hill’
(c)	baraen	‘he put’	bararaen	‘he put and put until full’
	wadiamopen	‘to teach them’	wadidiamopen	‘to teach several groups’

Some languages may employ two types of reduplication within the same word (see Shaw 2005 for discussion and analysis). The forms in (15) from the Salish language Stát'imcets (van Eijk 1997, Shaw 2005) illustrate the combination of a pluractional (CVC) and a diminutive (CV) reduplicant.

(15) Multiple reduplication in the same word in Stát'imcets (Shaw 2005: 177)

s- ¹ qaxaʔ	Nom-Root	'dog'
s- ¹ qə-qaxaʔ	Nom-DIM-Root	'puppy'
s-qəx ¹ qə-qaxaʔ	Nom-DIST-DIM -Root	'puppies'
s- ¹ jaqtfaʔ	Nom-Root	'woman'
s- ¹ j ² ə-j ² qtfaʔ	Nom-DIM-Root +[CG]	'girl'
s- ¹ jəq-j ² ə-j ² qtfaʔ	Nom-DIST-DIM-Root +[CG]	'girls'

Cases in which the two reduplicants within a single word have the same shape are often referred to as “triplication”. In Mokilese (Harrison 1973), triplication is employed to form the progressive for monosyllabic verbs: *kangkangkang* ‘to eat (progressive)’, *dahdahdaun* ‘to fill (progressive)’, *pwahpwahpwa* ‘to say (progressive)’ (p. 222). Harrison suggests that most cases of triplication arise in order to avoid homophony between derived statives, which are formed through reduplication.

8.2.1.2 Fixed segmentism and reduplicant-base alternations: markedness in reduplication Although reduplication by nature is a matching phenomenon, there are certain types of reduplication featuring material in the reduplicant that is not present in the base. One subtype of “imperfect” copying is consistent with language-specific phonotactic constraints that force a change in one of the copies. For example, in Ponapean (Rehg and Sohl 1981), durative aspect is marked through prefixal reduplication of either a heavy (CVX) or a light (CV) syllable depending on the weight of syllables in the base. The weight-sensitive component driving the choice between the heavy and light template will not be discussed here (see Kennedy 2002 for analysis). Heavy syllable reduplicants assume a CVV or CVC shape depending on the base. If the base is a CV monosyllable, has a long vowel in the first syllable, or begins with a vowel sequence the heavy reduplicant is CVV (16a). Otherwise, the heavy template is fulfilled through prefixation of a CVC reduplicant consisting of the first vowel and the immediately following consonant of the base (16b–d), a pattern that is reminiscent of the Mokilese data discussed in section 8.2.1.1. The final consonant of the CVC reduplicant, however, is subject to constraints on word-medial coda consonants (see Chapter 4 for syllabification constraints) holding more generally of Ponapean: the only word-medial codas are the first half of a sonorant geminate or a nasal that is homorganic to a following stop. The final consonant of a CVC reduplicant remains unchanged if it conforms to coda requirements (16b). Others, however, are adapted to adhere to conditions holding of codas. A consonant that shares the same place as the first consonant of the base changes to the corresponding nasal (16c) and an epenthetic vowel is

inserted immediately after a consonant in the reduplicant that is not homorganic to the initial consonant of the base (16d).

- (16) Reduplicant alternations in Ponapean (Rehg and Sohl 1981: 74–81)
- | | | | |
|-----|--------|--------------------------|---------------------------|
| (a) | pa | pa: pa | ‘to weave’ |
| | du:pek | du: du:pek | ‘starved’ |
| | lia:n | li: lia:n | ‘outgoing’ |
| (b) | dune | du ndune | ‘to attach in a sequence’ |
| | kaŋ | kaŋ kaŋ | ‘to eat’ |
| | pap | pa mpap | ‘to swim’ |
| (c) | dod | do ndon | ‘frequent’ |
| | dilip | di ndilip | ‘to mend thatch’ |
| | sel | se nsel | ‘to be tied’ |
| | kik | kiŋ kik | ‘to kick’ |
| (d) | tep | te pitep | ‘to begin’ |
| | siped | si pisiped | ‘to shake out’ |
| | ped | pe di pe d | ‘to be squeezed’ |

A second subtype of copying displaying a mismatch between base and reduplicant involves a fixed segment that occurs consistently across lexical items within the same reduplication paradigm. The Muskogean language Koasati (Kimball 1991) displays an example of this type of reduplication with “fixed segmentism” in the formation of punctual verb forms signaling that an “action is taking place in repeated, discrete segments” (17). In this reduplicative construction termed “punctual reduplication” by Kimball, the first consonant of the root plus the vowel [o:] is inserted before the final syllable of the root.

- (17) Fixed vowel segmentism in Koasati punctual reduplication (Kimball 1991: 325–6)
- | | | |
|-----------|--------------|-------------------------|
| tahaspin | tahasto:pin | ‘to be light in weight’ |
| lapatkin | lapatlo:kin | ‘to be narrow’ |
| talasban | talasto:ban | ‘to be thin’ |
| ʔimihkon | ʔimihʔo:kin | ‘to be smooth’ |
| ʔfofoknan | ʔfofokʔo:nan | ‘to be angled’ |

In some languages, a consonant is the fixed segment in reduplication. In Khalkha Mongolian (Svantesson et al. 2005), reduplicated forms of nouns (conveying the meaning of ‘X and such things/X and people like him/her’ with a pejorative or indifferent attitude) are constructed by copying the root and adding an [m] to a vowel-initial root (18a), or by changing a root-initial non-palatalized consonant to [m] (18b). In case, however, the root-initial consonant is palatalized (or /j/ before /a/), the fixed segment assimilates the palatalization and surfaces as [m^j] rather than [m] (18c). On the other hand, the fixed segment dissimilates to [ts] if the root-initial consonant is /m/ or /m^j/ (18d).

(18) Fixed consonant segmentism in Khalkha Mongolian reduplication (Svantesson et al. 2005: 60)

(a)	<i>Base</i>	<i>Gloss</i>	<i>Reduplicated form</i>
	ar	'back'	ar-mar
	ontəg	'egg'	ontəg-montəg
(b)	t ^h aɮx	'bread'	t ^h aɮx-maɮx
	gəiməŋ	'noodles'	gəiməŋ-məiməŋ
	jir	'ninety'	jir-mir
	nut	'eye'	nut-mut
(c)	p ^h asɮəg	'cheese'	p ^h asɮəg-m ^h asɮəg
	x ^h a:m	'sausage'	x ^h a:m-m ^h a:m
	jas	'bone'	jas-m ^h as
(d)	maɮ	'cattle'	maɮ-tsaɮ
	miɮxi	'frog'	miɮxi-tsiɮxi
	m ^h agmər	'Tuesday'	m ^h agmər-t ^h agmər

Another common type of reduplication involving only partially faithful copying of sounds involves lexeme-specific substitutions rather than a fixed segment. For example, Thai (Iwasaki and Ingkaphirom 2005: 35–6) has a process of alliterative reduplication in which the copy preserves the same consonants of the base but changes the vowel, where the choice of vowel depends on the particular word (19). The location of the reduplicant relative to the base also shifts between a suffix and a prefix depending on the root.

(19) Vowel substitution in Thai alliterative reduplication (Iwasaki and Ingkaphirom 2005: 35–6)

<i>Base</i>	<i>Gloss</i>	<i>Reduplication</i>	<i>Gloss</i>
ciŋ	'truly'	ciŋ-caŋ	'seriously'
mô:	'pot'	mô:mô:	'pots and things'
ŋɔ:	'be crooked'	ŋɔ:-ŋɛ:	'be fussy, pout like a child'
k ^h rasíp	'whisper'	síp-súp	'whisper'

Fixed segmentism has been argued to instantiate a more general characteristic of reduplicants cross-linguistically: they display less complex (i.e. less marked) structures than the bases from which they are derived (McCarthy and Prince 1994). An example of this markedness reduction is provided by the perfective stem formation in Sanskrit (Janda and Joseph 1986, Steriade 1982, 1988, Kennedy 2011). In this pattern, illustrated in (20), a complex onset in the base is simplified in the reduplicant in favor of the least sonorous member of the cluster. Note that the retroflexion of /s/ in the perfect stem in the first, third, and fifth forms in (20) reflects a general process triggered by a preceding high vowel, /r/ or /k/.

- (20) Syllable simplification in Sanskrit perfective reduplication (Steriade 1988: 313–14)

<i>Stem</i>	<i>Perfect stem</i>	<i>Gloss</i>
sru	su-ṣru	‘to flow’
prac	pa-prac	‘to ask’
snih	si-ṣnih	‘be sticky’
tsar	ta-tsar	‘to approach stealthily’
stu	tu-ṣtu	‘to praise’
spr̥d	pa-spr̥d	‘to contend’

The σ CV reduplicant template, e.g. in Ngiyambaa, also is consistent with a tendency for more basic (or phonetically preferred structures) to emerge in reduplication: the open syllable plausibly reflects a compromise between faithfully duplicating two syllables of the base while also avoiding a marked CVC or CVV syllable.

Fixed segmentism is thus often amenable to an analysis in which the fixed sound reflects a less marked alternative to a sound in the base (Alderete et al. 1999), a principle that also has been claimed to guide the choice of epenthetic segment (see Chapter 5). In the case of vowels, candidates that might be predicted to emerge as fixed elements in the reduplicative template are schwa, /i/, and /a/, the first of which may be treated as a featureless default vowel, and the latter two of which are the vocalic counterparts of relatively unmarked coronal and laryngeal consonants, respectively (see Chapter 5 on epenthesis).

The difficulty with this approach is that there is considerable variation in the fixed segment cross-linguistically and even within languages. For example, Sanskrit has two additional types of reduplication beyond the perfective reduplication illustrated above. The reduplicant in both of these other templates displays fixed segmentism: /a/ in the intensive and a high vowel in the desiderative (see Kennedy 2011 for discussion). The /o:/ in the Koasati plural punctual verb forms described above is also problematic if the fixed segment is predicted to be unmarked, since the rounded vowel [o:] is presumably more marked than /i/, /a/, or even /u/ given the relative rarity of [o:] compared to /i, a, u/ cross-linguistically (see Chapter 3).

In certain cases, there are historical reasons for the fixed segment in reduplication. For example, in Koasati, the fixed /o:/ in punctual reduplication represents a shortened form of an infix *-ho-*, also used to mark punctual events, that is employed instead of reduplication in verbs in which the first consonant of a root is part of a cluster. In such forms, *-ho-* is inserted between the members of the cluster, e.g. *akhoṭatlin* from *akṭatlin* ‘to be oversize’, *okhoṭfakkon* from *okṭfakkon* ‘to be blue’ (Kimball 1991: 326). Although it is not clear how this alternation between infixation of *-ho-* and reduplication should be synchronically modeled (see Martin 1994 for discussion of the history of this plural morpheme in the Muskogean language family), the existence of the alternation provides a reason, at least in this case, for the occurrence of a typologically rare type of fixed segmentism.

Certain instances of fixed segmentism involve choices between different fixed segments that are either dissimilatory or assimilatory in nature. For example, we saw earlier that the fixed initial segment of the reduplicant in Khalkha Mongolian is typically [m], but when the root-initial consonant is palatalized, the [m] is

also palatalized. On the other hand, the bilabial nasal of the reduplicant changes to [ʈ] in case the root begins with a bilabial nasal, whether palatalized or not. The fixed segment in Khalkha Mongolian thus assimilates with respect to palatalization but avoids complete identity with the root-initial consonant.

Avoidance of matching of the base and reduplicant is also found in Turkish (Demircan 1987, Wedel 1999), which employs a CVC prefixal reduplicant to convey intensification of adjectives (21). The first C of the reduplicant is identical to the first consonant of the base, whereas the second C of the reduplicant is chosen from the set of fixed segments [p, m, s, r].

- (21) Dissimilatory fixed segmentism in Turkish reduplication (Wedel 1999: 1)

<i>Stem</i>	<i>Gloss</i>	<i>Emphatic form</i>	<i>Gloss</i>
kara	'dark'	kapkara	'pitch black'
belli	'clear'	besbelli	'obvious'
bejaz	'white'	bembejaz	'bright white'
temiz	'clear'	tertemiz	'spotless'

Although emphatic reduplication no longer provides a productive means to form new words in Turkish, Wedel (1999) finds that speakers readily can create emphatic counterparts to nonce adjectives. This process reveals sensitivity to a number of factors that produce biases, some categorical and others statistical, which mirror to some extent those seen in actual emphatic adjectives in the language. Wedel thus found that the fixed segment cannot be identical to either of the first two consonants of the root. Speakers chose [p] as the default fixed segment but not if the first consonant of the root was a labial. The height of the first vowel acted as a predictor of [m] vs. [s], with [s] being consistently chosen when the first vowel is low and either [s] or [m] being inserted when the first vowel is mid or high. No speakers inserted [r] as the fixed segment although it is found in attested Turkish emphatics. Wedel suggests that the failure of [r] to be chosen by participants in his productivity study is attributed to the rarity of [r] (attested in only four words according to Wedel) as the fixed segment in actual Turkish emphatic adjectives.

8.2.1.3 Location of the reduplicant In addition to the shape of the reduplicative template, another dimension along which reduplication can be described is the location of the reduplicant relative to the base. Typically the base and the reduplicant are contiguous, a property that follows from the mapping of segments from the base to the reduplicant starting from the same edge at which the reduplicant occurs and moving inward (Marantz 1982, McCarthy and Prince 1986). Prefixal reduplicants thus involve the mapping of segments from the base to the reduplicant at the left edge, whereas suffixal reduplicants initiate the mapping at the right edge of the base.

There are cases of reduplication, however, in which the reduplicant and the base are not contiguous. For example, we have seen that suffixal reduplication in Chukchi is associated with separation of the base and reduplicant for roots longer than CVC. Furthermore, infixing reduplication in both Koasati and Creek involves copying of an initial CV string (with a fixed /o:/ in Koasati), which is

placed to the left of the final consonant of the root. In roots longer than two syllables, this means that at least one non-reduplicated syllable intervenes between the base and the reduplicant. The relative rarity of cases of non-contiguity of base and reduplicant has spurred reanalyses (e.g. McCarthy and Prince 1986, Nelson 2003) of apparent cases of non-contiguity of base and reduplicant in terms that maintain the typological generalization that reduplication is local copying (see Riggle 2003 for discussion).

In cases in which reduplicant and base can be distinguished (either because the copying involves fixed segmentism or because the copy is only partial and is non-contiguous with the base), it is possible to diagnose whether the reduplicant is a prefix, suffix, or infix. We have seen examples of the reduplicant surfacing as a suffix (e.g. in Chukchi), as a prefix (e.g. in Tohono O'odham), and as an infix (e.g. in Creek). It is typically assumed that, in the absence of evidence to the contrary, segments that are contiguous in the base form are also contiguous in the reduplicated form and that precedence relations in the base are reflected in the reduplicated form. For example, applying these assumptions to Yidiny (Dixon 1977), the disyllabic reduplicant would be treated as a prefix rather than an infix on the basis of trisyllabic (and longer) forms where only a portion of the root is copied, e.g. *gindal-gindalba* 'lizards' and not **gindal-gindal-ba*, *jimu-jimuru* 'houses' and not **jimu-jimu-ru*. By the same token, in CVC reduplication in Chukchi, the reduplicant is analyzed as a suffix rather than as a prefix with transposition of the initial syllable of the base, e.g. [*jil?e*]-*jil* 'arctic ground squirrel' and not **jil*-[*?ejil*], [*weni*]-*wen* 'bell' and not **wen*-[*iwen*] (where the base appears in []). In the case of clear infixing reduplication, the base and the reduplicant cannot be distinguished if they are identical and contiguous. For example, Malagasy reduplication can be diagnosed as infixing based on the combination of native roots longer than two moras (which rules out prefixation), e.g. *a₁lik^ja^jlik^ja* 'dog', and loanwords with stress on a final light syllable (which precludes a suffixing analysis), e.g. *zavu^jzavu^jka* 'avocado'.

In practice, decisions about the base and reduplicant in cases of indeterminacy are often made based on theory-internal grounds or based on the coherence of the reduplication patterns within a language and their relationship to the broader phonological system of the language. For example, Riggle (2006) pursues an infixal analysis of Tohono O'odham as an alternative to Fitzgerald's account (adopted earlier in section 8.2.1.1), which assumes prefixing reduplication.

8.2.2 *Overapplication and underapplication in reduplication*

The intrinsic nature of reduplication as a copying process is further demonstrated by instances in which reduplicated forms display properties that would not be expected given general phonological processes of the language. For example, in the Jahore variety of the Austronesian language Malay (Onn 1980), a process of rightward spread of nasalization targeting vowels, laryngeals, and glides following a nasal, unexpectedly applies in the first copy of reduplicated roots even to sounds that are only in post-nasal position *in the second copy* of the root (22).

- (22) Overapplication of rightward nasal spreading in Jahore Malay (Raimy 2011)

<i>Base</i>	<i>Gloss</i>	<i>Reduplication</i>	<i>Gloss</i>
hamã	‘germ’	hãmã-hãmã	‘germs’
waŋĩ	‘place’	wãŋĩ-wãŋĩ	‘fragrant (INTENS)’
aŋã	‘reverie’	ãŋã-ãŋã	‘ambition’
aŋĩn	‘wind’	ãŋĩn-ãŋĩn	‘unconfirmed news’

Although this type of overapplication intuitively reflects a matching of the base and the reduplicant, the modeling of this matching presents challenges for phonological theory. One approach to cases like the Jahore Malay one is employed by the theory of correspondence (McCarthy and Prince 1995) within the constraint-based paradigm of Optimality Theory (Prince and Smolensky 1993/2004). In this account, which has conceptual antecedents in a rule-based paradigm (Wilbur 1973), a family of constraints requires identity between properties of the base and the reduplicant. When prioritized above other constraints driving phonological rules, these correspondence constraints have the capacity to capture overapplication (or underapplication) of alternations as an effect of identity preservation between the base and reduplicant. The introduction of a powerful device like correspondence constraints comes at the price of reducing the restrictiveness of the theory, however, raising questions about the typological range of phenomena for which correspondence constraints must be invoked (see Raimy 2011 for discussion).

8.2.3 Cross-linguistic distribution of reduplication patterns

Reduplication is quite common cross-linguistically, though its functional role and productivity vary considerably across languages. In a survey of 368 languages, Rubino (2013) identifies 313 (85%) languages that possess some type of reduplicative patterns employed in a grammatical function. He only includes reduplication patterns that “can be systematically generalized to a set of open class words” and which “can still be applied in the modern form of the language”. Thus, fossilized reduplicated forms that exist in a closed set of lexical items are excluded, e.g. the diminutive enclitic in Caddo *ti?ti?* (Wally Chafe p.c.). He also excludes non-grammatical uses of reduplication in an iconic function, such as the repetition of adjectives or adverbs to emphasize a property, e.g. *tiny tiny*, *big big*, *very very* in English or *vana vana* ‘old old’, *su:r su:r* ‘big big’, *væga væga* in Estonian (Erelt 2008), although the distinction between grammatical and extra-grammatical functions can often be blurry. On the other hand, Rubino treats cases of lengthening of a sound for grammatical purposes as reduplication. Thus, the aspectual use of gemination (along with rising tone) to express a resultative stative in Koasati, e.g. *hallã:tkal* ‘I am holding it’ from *halatka-* ‘grab hold of’, *ƒokkõ:lil* ‘I am seated’ from *ƒoko:li-* ‘sit down’ (Kimball 1991, Martin 2013, Gordon et al. 2015; see Chapter 7) would be considered reduplication in Rubino’s survey. It is not clear how much the inclusion of lengthening as an instance of

reduplication inflates the number of languages analyzed as employing reduplication in Rubino's survey, since many languages with lengthening as a grammatical device also have other types of reduplication. For example, as we have seen, Koasati has two unambiguous reduplicative processes in which the base and the reduplicant are non-contiguous.

In practice, as Stolz et al. (2011) show, there are difficulties involved in quantifying how widespread reduplication is cross-linguistically, particularly in the case of total reduplication. For one, it is often difficult to assess synchronic productivity. It is also very difficult to establish explicit criteria for excluding reduplication patterns that do not constitute a morphological word formation process. For example, the Estonian examples above clearly serve more of a pragmatic than morphological function unlike most of the reduplication patterns discussed in this chapter, e.g. those marking morphological categories such as plural or distributive. Yet, it is often difficult to operationalize the drawing of boundaries between morphological and pragmatic reduplication, particularly when diagnostics of word status suggest that the base and the reduplicant are prosodically separate. On the other hand, if one pursues a more inclusive typology of reduplication, reduplication is then likely underreported since many grammars fail to discuss patterns of total reduplication serving a pragmatic rather than morphological function. Preconceived areal notions, e.g. the view that languages of Europe lack reduplication (see Stolz et al. 2011 for discussion), may further bias the grammar writer against mentioning reduplication. In their comprehensive corpus-based survey of reduplication, Stolz et al. (2011) find that virtually every language of the world (with the possible exception of languages in the Na-Dene and Eskimo-Aleut families) employs total reduplication in some capacity.

Stolz et al.'s (2011) results are consistent with the finding of Moravcsik (1978) and Rubino (2013) that the existence of partial reduplication implies the occurrence of full reduplication in a given language. In Rubino's survey, there is a relatively small set of languages (35) that have only full reduplication compared to those enlisting both partial and full reduplication (278). Stolz et al.'s results indicate, however, that the skewing in favor of total reduplication is actually larger if a broader definition of reduplication not limited to purely morphological instances is employed.

Setting aside unresolved issues about the taxonomy of full reduplication and its relationship to partial reduplication, there are several phonological issues concerning the typology of reduplication that deserve attention. One limitation of Rubino's survey is that it fails to distinguish between the different types of partial reduplication that are attested cross-linguistically. Nor does his survey assess the relative frequency of different sites of the reduplicant relative to the base or the distribution of fixed segmentism in reduplication.

In order to evaluate these properties, a survey of reduplication was conducted for the 100-language WALS sample. The shape and position of the reduplicant were recorded for all the reduplicative patterns that were either deemed to be productive or to be attested in a relatively large number of words. Patterns for which the published description was not explicit about productivity or extensiveness were included in the interest of expanding the database. It may be noted that

the 100-language WALS sample on which the present survey is based also serves as the starting point for the Graz database on reduplication (Hurch 2005), which contains information on both semantic and phonological features of reduplicative patterns, as well as observations about productivity and constraints on usage. Despite its apparent redundancy with the Graz data set (and potentially others), the present study was carried out to address specific research questions related to phonological properties of reduplication not readily extractable from existing databases employing different methods of survey operationalization.

The importance of methodological decisions is particularly relevant in constructing a database on reduplication due to the considerable degree of analytic indeterminacy in establishing the shape and location of the reduplicant relative to its base. It was thus often impossible to diagnose the reduplicative template either due to the limited data presented in the consulted source(s) or due to the fact that the template was coextensive with more than one prosodic domain, often several. For example, if the data included only monosyllabic roots with complete reduplication, the reduplicative template could be interpreted as instantiating one of several types, including a syllable-size, root-size, or even foot-size (assuming that each word constitutes a foot) template. Similarly, copying of a CV string in a language with only CV syllables could be construed as either syllable- or CV reduplication. Determining the location of the reduplicant relative to the base is also similarly problematic due to the inherent nature of reduplication as a copying process (see discussion of Malagasy earlier). Unless the reduplicant displays a fixed segment or undergoes a phonological operation that differentiates it from its base, it is often impossible to determine on purely empirical grounds which copy is the base and which is the reduplicant.

Despite the difficulties inherent in diagnosing phonological features of reduplication, a number of interesting patterns nevertheless emerged in the present survey. We consider these now in sections 8.2.3.1–8.2.3.4.

8.2.3.1 Overall frequency of reduplication Reduplication patterns could be identified from consulted sources for 64 of the 97 (65.9%) languages in the survey with the majority of those (35 of 64) employing at least two types of reduplicative templates and one language (Hausa) described as having five templates, although this includes one pattern that is a frozen one for nouns and two instances of the same CVC template occurring in different positions (infix vs. prefix). Figure 8.3 depicts the number of reduplicative templates found for the surveyed languages. If a single phonological pattern of reduplication, i.e. possessing the same shape of reduplicant and same position relative to the base, was employed in multiple morphosyntactic or semantic functions (e.g. to mark the iterative in verbs and plurals in nouns), it is counted as a single instance in the figure.

As Figure 8.3 shows, there is a steady downward cline in the number of languages as the number of reduplicative templates rises, whereby languages with a single pattern are most common followed in turn by those with two, three, four, and five templates.

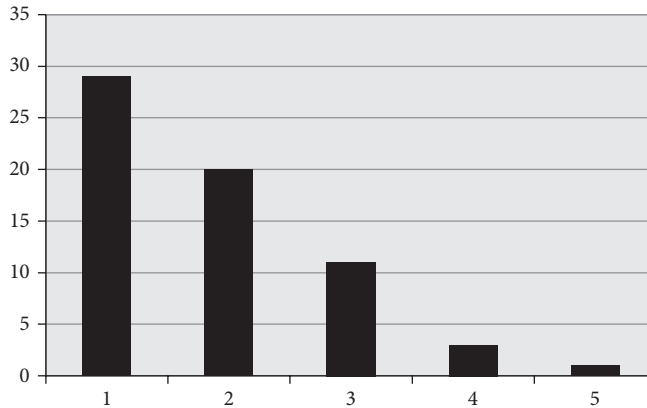


FIGURE 8.3. Number of different reduplicative templates employed in a single language in the 100-language WALS sample

8.2.3.2 Position of the reduplicant In operationalizing the survey of reduplicant location, three criteria were adopted to resolve analytic indeterminacy. First and foremost, the location allowing for a consistent treatment of reduplication in terms of location and shape of reduplicant was assumed (see discussion in section 8.2.1.3). Second, in keeping with the strong cross-linguistic preference for contiguity of base and reduplicant, the reduplicant and base were assumed to be contiguous unless the primary criterion of analytic consistency dictated otherwise. Virtually all instances of reduplication in the survey (115 of 119 cases) are consistent with an analysis in which the base and reduplicant are adjacent to each other. The Koasati and Chukchi cases discussed earlier are thus outliers. One additional case, found in Yoruba, allows for a connective morpheme intervening between the base and the reduplicant, a copy of the root. A final criterion for quantifying results of the survey was the default assumption that the base is continuous, i.e. that reduplication involves prefixation or suffixation of the reduplicant rather than infixation. This criterion was subordinate to the first criterion, that of analytic consistency, as evidenced by the Malagasy case in which only an infixing analysis of reduplication allows for a coherent treatment across the native and loanword vocabulary.

Certain cases were excluded from the tabulation of results. First, those involving lexically governed inconsistency between infixation and suffixation (as in the Thai case with vowel substitution) were omitted. Furthermore, cases in which reduplication involved complete copying of the root (without any segmental substitutions that reveal the location of the base and the reduplicant) were not included in the tallies of reduplicant site since they are not probative in diagnosing the location of the reduplicant.

Figure 8.4 depicts the distribution of sites in which the reduplicant appears in languages in the 100-language WALS sample.

As the figure shows, there is a strong bias in favor of prefixing reduplication. No clear preference between suffixing and infixing reduplication emerged in the

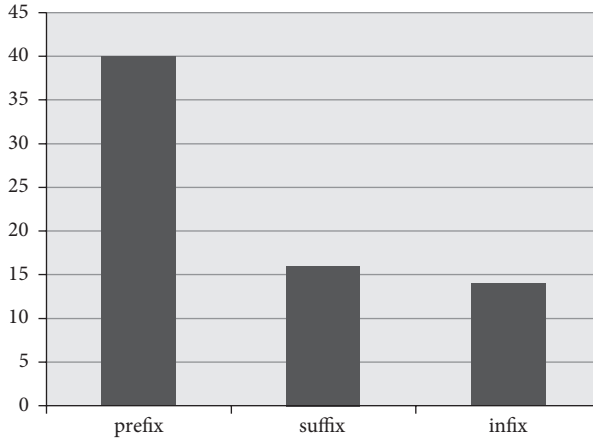


FIGURE 8.4. Location of the reduplicant relative to the base in languages in the 100-language WALS sample

survey. In the cases of infixation, the location of the copy, which was always contiguous to its base (with the exception of Koasati punctual reduplication), varied as a function of distance from a word edge. In all but one case, the copied material came from the right edge of the word, from the penult or the final syllable (or both in the case of a reduplicant longer than a syllable). The outlier instance of copying of a string oriented toward the left edge occurred in Daga, in which CV from the second syllable is copied in one type of reduplication (see section 8.2.1.1). In most but not all (11 of 16) cases of infixing reduplication, the copied string starts with material from either a syllable described as being stressed or that plausibly is stressed based on other alternations that are consistent with stress. For example, iterative reduplication in Koasati (Kimball 1991) involves copying of a CV string from the penult, which is plausibly metrically prominent given its ability to carry lexical tones (see Chapter 7). The choice of post-penultimate position as the infixation site in punctual reduplication is also consistent with penultimate prominence. In one further case, Daga, there is no description of stress in the consulted source to refute (or affirm) the possibility that the choice of reduplicant is predictable from stress.

8.2.3.3 Shape of the reduplicant Nine types of reduplicative templates emerged that could be unambiguously identified in at least one language: C, CV, CVC, CVV, CVX (heavy syllable, i.e. varying between CVV or CVC), foot (i.e. one heavy syllable or two light syllables), syllable (varying as a function of the syllable type in the base), σ CV (disyllabic with the second syllable open), and whole root. These templates differ considerably in the frequency with which they are attested. The single C template is found in only two surveyed languages (Jakaltek and Lezgian). Similarly, the syllable is only attested in two languages (Meithei and Yaqui) and possibly a third (Acoma), though this last case is open to

reinterpretation. The CVX template is observed in Hausa among the surveyed languages and even in Hausa it is found only in fossilized nouns (Newman 2000). Finally, the foot is attested as a reduplicative template only in Malagasy among the surveyed languages. Unattested in the survey but found outside of the survey (see section 8.2.1.1) were V (attested in Bella Coola) and the strict disyllabic template where the second syllable varies between open and closed to match the base (attested in Yidiny). There were also no cases in the survey of variable weight reduplication as in Kosraean (section 8.2.1.1), although Amele (Roberts 1987) displays variation in nominal reduplication between CV and VC reduplication in response to whether the root begins with a vowel or consonant, e.g. *bobos* ‘dust’, *ninihul* ‘wasp species’, *alalag* ‘stagnant water’, *odod* ‘garden path’ (Roberts 1987: 150), a pattern that is reminiscent of the Mokilese reduplication patterns (section 8.2.1.1) and is likely driven by syllabification principles, i.e. an avoidance of vowel hiatus (see Chapter 4 on vowel hiatus).

It should be noted that certain of the sparsely attested templates have counterparts from which they cannot be differentiated in certain languages; depending on how these ambiguous cases are classed, the ranks of the rare patterns could potentially grow. For example, CVV reduplication could be analyzed as the conjunction of a CVX template with an avoidance of closed syllables either in the language as a whole or just in reduplicants (an emergence of the unmarked effect; see section 8.2.1.2). Likewise, CVC reduplication could be interpreted as the combination of CVX reduplication plus an avoidance of long vowels. Similarly, whole root reduplication could be interpreted as $\sigma\sigma$ in languages with no roots longer than two syllables (whether this constraint on root length is reflective of the language or is merely an artifact of the consulted data). Likewise, CV reduplication is amenable to reanalysis as syllable reduplication in languages with only CV syllables or, even in languages with more complex syllable types in roots, as the result of an interaction between a ban on coda consonants and a prohibition against long vowels in reduplicants, both plausibly analyzed as emergence of the unmarked effects.

Crucially, in all of these instances of analytic ambiguity, the template identified as the less common (or absent) one in the survey has fewer *unambiguous* instantiations cross-linguistically. There are thus 13 languages in the survey for which whole root reduplication can be differentiated from disyllabic reduplication on the basis of roots longer than two syllables compared to no languages that unambiguously employ a disyllabic reduplicant. Furthermore, there are ten languages with clear CVC reduplicants and a further four with CVV templates compared to only one language with definitive CVX reduplication. Finally, virtually all of the 22 languages clearly diagnosable as employing CV reduplication (versus only two or three with unambiguous syllable reduplication) have long vowels and/or coda consonants in roots (although as noted above, a relatively abstract analysis could treat all instances of CV reduplication as the interaction between heavy syllable reduplication and avoidance of the typologically marked CVV and CVC structures).

The distinction between commonly and rarely attested reduplicant templates guides the quantitative operationalization of the present survey, in which a

template that ambiguously belonged to either a common type or a rare one was assigned to the more widely attested category. A pattern that could be interpreted as either full or partial reduplication was thus tabulated as an instance of full reduplication. Among partial reduplication templates, a pattern that was consistent given the available data with interpretation as the generic syllable template or a more specific type of syllable (i.e. CV, CVC, CVV) was logged as an instance of the more specific syllable template given the extreme rarity of proven syllable copying in reduplication. For purposes of tabulating tokens of a given reduplicant shape, both cases of faithful copying of material from the base as well as cases of fixed segmentism or substitution (section 8.2.1.2) are included. For example the C + /o:/ template employed in Koasati punctual reduplication (Kimball 1991) belongs to the CVV category and the Thai root reduplication involving vowel substitution counts as an instance of whole root reduplication in considering the relative frequency of different templates (but see section 8.2.3.4 for quantitative results for fixed segmentism).

Figure 8.5 plots the number of reduplication patterns employing different templates among the surveyed languages. Bars are divided according to whether the copy is a faithful duplication of the base (dark bars) or involves one or more segmental substitutions (light bars) either fixed across the template or substituted on a lexeme-specific basis.

As the figure shows, whole root reduplication is more common than any of the other patterns. The statistical dominance of the root as a template pertains to both reduplication involving faithful copying of material from the base as well as reduplication with fixed segmentism or substitutions, which are considerably less common than faithful copying from the base. Ranking second in popularity is CV reduplication followed in turn by disyllabic reduplication with a specified CV second syllable and then CVC. Together, the remaining subtypes (single

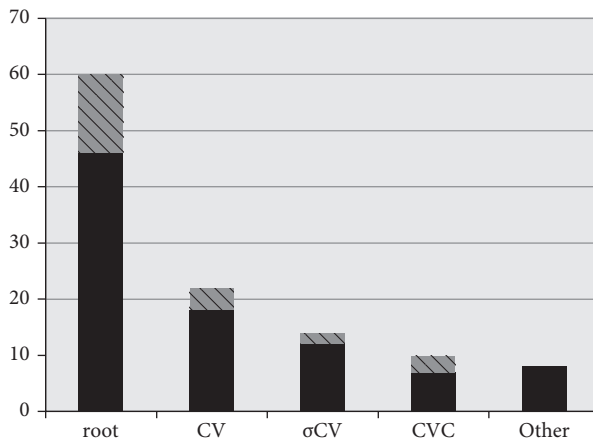


FIGURE 8.5. Frequency of different reduplicative templates in the 100-language WALs sample. Each bar is divided between faithful reduplication (dark bars) and reduplication involving substitutions or fixed segmentism (light bars)

segment, CVV, CVX, syllable, foot) constitute fewer cases than even the fourth most common template, CVC.

There do not appear to be any robust (i.e. evidenced by more than two languages) language-internal implicational statements governing the distribution of reduplication templates. It is thus not the case that the presence of a particular reduplicant in a language implies the occurrence of another shape of reduplicant in languages with multiple types of reduplication. For example, many languages employ whole root reduplication without adopting partial root reduplication, e.g. Martuthunira (Dench 1995), Supyire (Carlson 1994), while others have only partial but not whole root reduplication, e.g. Koasati (Kimball 1991) and Paiwan (Egli 1990). In the current survey, even relatively rare reduplicants may appear to the exclusion of cross-linguistically more common ones. For example, Jakaltek (Day 1973) has only C reduplication and Ngiyambaa (Donaldson 1980) employs only σ CV in reduplication.

The relative independence of full and partial reduplication in the present survey appears to contradict the result of other surveys, including Moravcsik (1978), Stolz et al. (2011), and Rubino (2013), that suggest that partial reduplication implies full reduplication in a language. One possible source (but perhaps not the only one) for the discrepancy between the current survey and (at least) Rubino's survey appears to be a methodological difference in evaluating reduplicative templates. The present survey attempted to unify as many instances of reduplication as possible as instantiations of a single template even if the mapping between base and reduplicant varied as a function of the shape of the words illustrating reduplication in published sources. An alternative procedure, which has the potential to generate an analysis with more patterns, especially full reduplication templates, is to assume separate templates as a function of the particular word shape for a reduplicated form. To illustrate the difference in results produced by the two approaches, consider the following reduplicated forms from Ngiyambaa (Donaldson 1980): *jugu-jugu* 'chook (hen)' (p. 64), *magu-magu*: 'around one' (p. 73), and *gulbi-gulbir* 'more or less than "a few"' (p. 73). On a descriptive level, the first form reflects full reduplication, while the last two involve partial reduplication. The present survey unites both mappings as σ CV reduplication, where the full template can only be diagnosed in disyllabic or longer words with a CVX second syllable. Rubino (2013) analyzes Ngiyambaa as a language with both full and partial reduplication, presumably on the basis of the different surface mappings between the base and reduplicant. Of course, it is also conceivable that there are additional data, of which I am unaware, that cannot be treated as σ CV reduplication and would diagnose full reduplication as a type distinct from σ CV reduplication.

8.2.3.4 Fixed segment(s) No languages in the survey displayed base-reduplicant alternations of the Ponapean type governed by independent phonotactic restrictions. However, a total of 18 reduplicative templates in the WALS sample employed a fixed segment, where some of these patterns involved a choice among a small set of sounds, as in Turkish emphatic reduplication (section

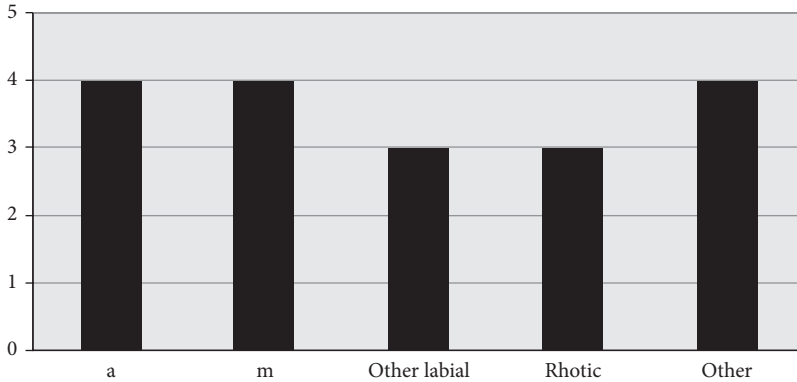


FIGURE 8.6. The distribution of fixed segments in reduplicative patterns identified in the 100-language WALS sample

8.2.1.2). Figure 8.6 shows the distribution of the fixed segments, excluding reduplication patterns involving substitutions not assigned to definable categories by the consulted source(s).

As the figure shows, the two most common fixed segments in reduplication are the vowel /a/ and the consonant /m/. The latter belongs to the class of labials, which the figure shows is the most common place of articulation among fixed segments in reduplication. The only other type of consonant found in more than one reduplicative pattern is the denti-alveolar rhotic.

It is interesting that, despite their prevalence in reduplication, the vowel /a/ and the consonant /m/ (and, more generally, the set of labial consonants) are two of the least preferred epenthetic segments cross-linguistically (Chapter 5). On the other hand, /a/ is the most common vowel and /m/ the third most common consonant cross-linguistically (Chapter 3).

8.2.3.5 Relationship between reduplication and other prosodic properties

One might ask whether the shape of reduplicative templates is predictable from other properties falling under the rubric of prosodic morphology. For example, one might hypothesize that weight-sensitive templates, such as CVV, CVC, or a heavy syllable, are more likely to occur in languages with weight-sensitive stress systems than in languages with weight-insensitive stress. More specifically, extending our earlier discussion of the relationship between minimal word requirements and stress (section 8.1.4), a plausible hypothesis is that syllable types fulfilling a reduplicative template larger than CV also are treated as heavy by other prosodic phenomena such as stress or minimal word requirements. This hypothesized link, encoded in theories that treat (at least) larger reduplicants as full-fledged prosodic words (McCarthy and Prince 1994), follows from the observation that reduplicants often function as independent prosodic units. The status of reduplicants as prosodic words is evidenced by various phonological properties on a language-specific basis, including their ability to carry stress and their adherence to phonotactic restrictions holding of words. For example, in

Paraguayan Guarani (Hamidzadeh 2013), the reduplicant and base each carry a stress on the final syllable, where the stress on the second copy is the primary one for the domain encompassing both copies: *i-kara.pe-kara'pe* (p. 61), *i-ɕuru-ɕai-ɕuru-'ɕai* (p. 63). In Diyari (Austin 1981/2013), coda consonants do not occur at the end of prosodic words, a restriction that also holds of reduplicants, e.g. *tⁱilpa-tⁱilparku* 'bird type', *ɲanka-ɲankan t i* 'catfish' (Austin 1981/2013: 40), a symmetry that is captured if one assumes that the reduplicative morpheme subcategorizes for a prosodic word in Diyari (McCarthy and Prince 1994).

Figure 8.7 shows the breakdown of reduplicative templates as a function of the type of prominence system (weight-sensitive stress, weight-insensitive stress, or tone) for languages in the 100-language WALS sample. Note that languages having lexical tone are assigned to the lexical tone category in the figure even if they belong to the small minority in the survey, e.g. Thai, described as having both tone and stress.

Setting aside the overall very sparsely attested patterns, C, syllable, and foot, the distribution of reduplicative templates does not vary substantially between languages employing different prominence systems. There are, however, some divergences that are potentially significant. First, only three of the 32 reduplication patterns found in languages with weight-sensitive stress systems involve a template that could be construed as a heavy syllable for stress: one CVV, one CVC, and one a foot. One of these is the Malagasy case discussed in section 8.2, in which

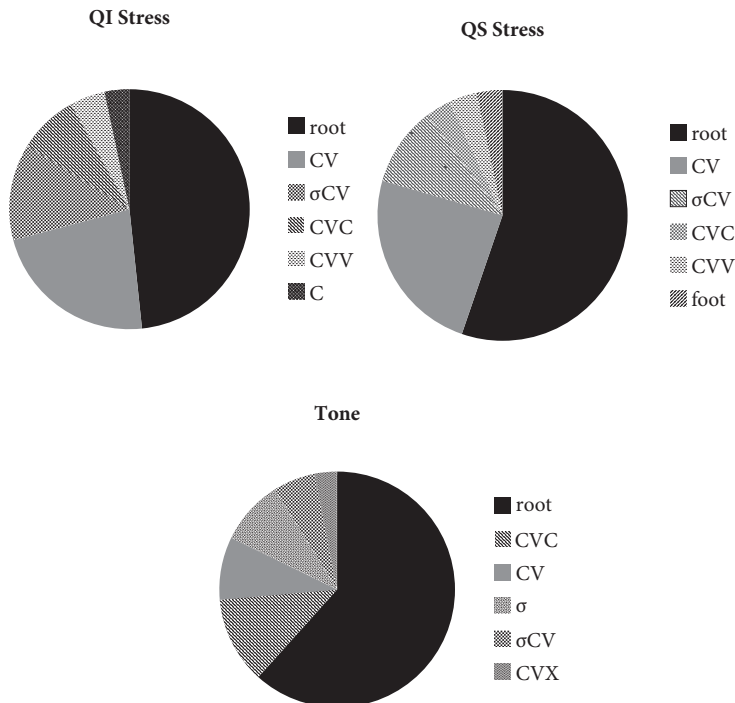


FIGURE 8.7. Distribution of different reduplication templates found in languages with different prosodic systems in the WALS 100-language sample

the foot as diagnosed by the stress system doubles as the reduplicative template. The case of the CVV reduplicant comes from the Austronesian language Rapanui and, in fact, could alternatively be analyzed as a foot template, since the relevant examples in the consulted source (Du Feu 1996) have bases consisting of a single CVV syllable. The CVC case is Hindi, which also treats CVC as heavy in its stress system. However, CVV in Hindi (alternatively analyzed as a syllable containing a tense vowel) is also stress-attracting, even though CVV does not satisfy the reduplicative template. All in all, results of the survey do not suggest a strong link between reduplication and syllable weight for stress.

Another interesting pattern is the particularly strong statistical dominance of the root template in tone languages, which comes largely at the expense of the CV template. The preference for the whole root template is particularly strong in tone languages of Asia with a large percentage of monosyllabic roots, e.g. Vietnamese, Thai, Mandarin, and Burmese.

Another finding that is less apparent in the figure but is evident from closer inspection of individual languages is for σ CV reduplication to be almost exclusively confined to languages with stress. The only non-stress language with σ CV reduplication is Hausa, which limits the type of reduplication to fossilized nouns. The localization of productive σ CV reduplication to stress languages suggests some relationship between metrical prominence and possibly foot structure. It also supports the view (see above) that a disyllabic template like σ CV ensures that a reduplicant be a full-fledged prosodic word. There are different criteria by which a reduplicant could assert itself as a canonical prosodic word. One way would be to contain a stressed syllable, in which case the adoption of a σ CV reduplicant as opposed to a monosyllabic reduplicant would either avoid a stress clash with the root, e.g. if the first syllable of the root were stressed, or possibly avoid a stressed syllable in a position that does not transparently reflect the canonical location of stress in the language, e.g. on the final syllable in a language with regular penultimate stress. There is some evidence that this account might be on the right track, although there is insufficient cross-linguistic data on stress patterns in reduplicated forms to corroborate the hypothesis. Of the 11 languages in the survey with both stress and σ CV reduplication (i.e. excluding Hausa, which lacks stress), eight have either initial or penultimate stress. (Stress is not described in the consulted source on Daga, one of the languages with σ CV reduplication.) Four languages (Gooniyandi, Lavukaleve, Mangarayi, Ngiyambaa [with complications due to syllable weight and morphology]) thus have predominantly initial stress, while another four (Fijian, Luvale, Rapanui, Tukang Besi) have penultimate stress. Five of these languages are also reported to have alternating secondary stress (Gooniyandi, Ngiyambaa, Fijian, Rapanui, Tukang Besi) and the others might, though it was not described in the consulted sources. Sources for two of the languages (Gooniyandi, Rapanui) make explicit reference to disyllabic reduplicants being stressed according to the normal pattern for the language. Assembling these facts, it is conceivable that the σ CV reduplicant corresponds to a trochaic foot in languages with initial or penultimate stress.

Two languages with σ CV reduplication, however, have final stress (Paraguayan Guaraní and Wari'). It is less clear for a language with final stress whether the

disyllabic reduplicant satisfies a metrically defined template. It is possible that σ CV reduplication in languages with final stress is related to a disyllabic minimality condition that precludes a reduplicant smaller than σ CV. However, neither of the two languages with final stress and σ CV reduplication has a minimal word constraint (i.e. they allow CV content words) that would offer support for a link between minimality and reduplication.

One might ask whether there is a general relationship between minimality and reduplication in the 100-language WALS sample, a question addressed in Table 8.1.

One interesting pattern evident in the table is that the majority of the CVC templates in reduplication (six of nine; Chukchi, Cree, and Lakota are exceptions) occur in languages with a CVC minimality condition. This finding offers some support for the hypothesized link between reduplication and prosodic word status. Further evidence for the relationship between the two phenomena comes from the observation (not apparent in Table 8.1) that the four tone languages with largely monosyllabic roots and whole root reduplication (Vietnamese, Thai, Mandarin, and Burmese) likely impose a minimal word requirement of a heavy syllable, satisfied either through a coda consonant or phonetic lengthening of a vowel in an open monosyllable (see Duanmu 1994 on Mandarin)—all four languages lack phonemic vowel length in this context. In these languages, the whole root reduplicative template ensures that the reduplicant is equivalent in size to a prosodic word. On the other hand, evidence fails to unambiguously support the proposed relationship between word minimality and reduplication, since the majority of languages employing σ CV reduplication (7 of 12) lack a minimal word constraint.

In summary, comparison of reduplicative templates with both minimality conditions and metrical patterns provides mild support for the hypothesis that

TABLE 8.1. Number of languages displaying different combinations of minimal word requirements and reduplicative templates

	<i>Minimal Word</i>				Total
	None	CVC	CVV	$\sigma\sigma$	
C	2	0	0	0	2
CV	11	4	2	6	23
CVC	2	6	0	1	9
CVV	1	1	0	2	4
root	29	19	5	4	57
σ	2	0	0	1	3
foot	1	0	0	0	1
σ CV	7	3	1	1	12
Total	55	33	8	15	

reduplicative templates larger than CV are imposed to satisfy a prosodic template independently adopted by another prosodic phenomenon. The prosodic property providing the link to reduplication, however, appears to vary between stress (and possibly metrical structure) and word minimality depending on the shape of the reduplicant.

The fact that tone languages do not employ σ CV reduplication motivates the hypothesis that the σ CV template bears a relationship to stress. As predicted, in languages with stress, there appears to be a relatively robust link between σ CV reduplication and the location of stress such that, if one assumes that reduplicants are stressed, the reduplicant possesses the length necessary both to avoid a stress clash with the root and to adhere to the canonical position of stress. Both of these goals are most efficiently viewed as reflexes of foot structure. In other words, evidence supports the working hypothesis that a σ CV reduplicant is a canonical foot. There is little evidence for the alternative hypothesis that a σ CV reduplicant is a canonical prosodic word since only one of the 12 languages with σ CV reduplicant has a disyllabic word minimum.

CVC reduplication, on the other hand, is not confined to stress languages. Two of the nine surveyed languages with CVC reduplication are tonal (Hausa and Oromo). This suggests that the CVC template is not employed to satisfy metrical well-formedness conditions. Rather there appears to be a closer link between CVC reduplication and word minimality. This link is imperfect, however, as three of the nine languages with CVC reduplication lack independence evidence from either minimality or stress for the special prosodic status of CVC. It is conceivable that in these languages reduplicants simply are subject to a minimality requirement that happens to differ from the one (or lack thereof) governing roots. If reduplicants were subject to a prosodically defined minimality condition, it would not be surprising that it would be CVC, since CVC is the most common minimality requirement holding of prosodic words.

The observation that tone languages with monosyllabic minimal word requirements use whole root reduplication (as opposed to a smaller template) provides support for a link between reduplication and prosodic word minimality. However, given the statistical predominance of whole root reduplication in both tonal and non-tonal languages, the apparent relationship between the two phenomena should be regarded with caution. In fact, the prevalence of whole root reduplication is consistent with the view that reduplication characteristically specifies morphologically defined rather than prosodically defined constituents (Inkelas and Zoll 2005).

Regardless of whether reduplication is viewed as a primarily prosodic operation or not, reduplicants display properties that reflect broader phonological tendencies independently observed in other phenomena. Most notably, there is a bias in favor of open syllables in reduplicants, especially at the right edge, as evidenced by the fact that CV and σ CV are, respectively, the second and third most common (after the whole root) reduplicative templates cross-linguistically. Furthermore, there appears to be a weak preference for typologically more common sounds such as /a/ and /m/ to be employed as fixed segments in reduplication. Finally, the

relative frequency of the σCV template suggests the importance of a constituent that is not readily definable in non-prosodic terms. These typological observations make it clear that a significant phonological component is operative in reduplication. Furthermore, the mere fact that the same language may employ multiple reduplicative patterns also indicates that many considerations are simultaneously at work in reduplication, demonstrating the need for a relatively rich theory of the phenomenon (see Urbanczyk 2007 and Raimy 2011 for overviews of theoretical treatments of reduplication).

8.3 Non-reduplicative templatic morphology

It is also possible for morphological processes other than reduplication to be sensitive to prosodic templates. The Wakashan language Nuuchahnulth (Kim 2003) provides an example of non-reduplicative prosodic morphology. In Nuuchahnulth, suffixes are divided into classes according to how they affect the length of vowels in stems to which they attach (23). One set of suffixes selects for a template consisting of a long vowel followed by, in disyllabic stems, a short vowel (23a). The result is lengthening of an underlying short vowel in the first syllable of the stem and shortening of a long vowel in the second syllable of disyllabic stems. Another class of suffixes requires a long vowel in the first syllable of the stem but does not impose a requirement on the length of the second vowel, which preserves its underlying length (23b). Finally, Kim cites one suffix, $-(q)aq$ ‘very, too’ (where the initial consonant occurs after vowel-final stems), which selects for a stem containing only short vowels, triggering shortening of any underlying long vowels in the stem (23c).

(23) Templatic morphology in Nuuchahnulth (Kim 2003)

<i>Template</i>	<i>Form</i>	<i>Gloss</i>
(a) Long+short	$\text{ʔ}^{\text{a}}\text{a:pats-i:l}$	‘making a canoe’
	canoe-to make	
	cf. $\text{ʔ}^{\text{a}}\text{apats-?i}$	‘the canoe’
	canoe-def	
(b) Long +short/ long	$\text{t}^{\text{u}}\text{:nax-hwa:t}$	‘using a tulle’
	tulle-to use	
	cf. $\text{t}^{\text{u}}\text{una:x-?ata}$	‘to need a tulle’
	tulle-to need	
(c) Long +short/ long	?a:ja-panatʃ	‘many people moving around’
	many-moving around	
	cf. ?aja-qs	‘there are many (people) in a vessel’
	na:?u:k-panatʃ	‘(s.o.) accompanies (s.o.)’
	to accompany-moving	
	cf. na?u:k-?iʃ	‘s/he accompanied John’
	to accompany-3sg/IND	

- (c) Short $\text{ʔ}^{\text{h}}\text{iq}^{\text{h}}\text{-qaq-ʔif naʔa:t}$'s/he is singing a spiritual song
 +short a spiritual song-very-3sg/ very loudly'
 IND loudly
 cf. $\text{ʔ}^{\text{h}}\text{i:qa:ʔif naʔa:t}$'s/he is singing a spiritual
 a spiritual song-3sg/IND song'
 loudly

Kim proposes that the three templates triggered by suffixes in Nuuchahnulth reflect different foot structures. Suffixes that license a long vowel + short vowel sequence select for a foot consisting of a heavy syllable followed by a light syllable, e.g. ($t^{\text{h}}\text{u}^{\text{h}}\text{na}^{\text{h}}\text{x}$)-*hwaʔ*. Suffixes that are associated with a long vowel plus either a short or long vowel impose a requirement that the first syllable of the foot encompassing the stem is heavy, e.g. ($\text{ʔ}^{\text{h}}\text{a}^{\text{h}}\text{j}^{\text{h}}$)-*panaf*, ($\text{na}^{\text{h}}\text{ʔu}^{\text{h}}\text{k}$)-*panaf*. Finally, the suffix that selects for a sequence of two short vowels is associated with a foot comprising two light syllables, e.g. ($\text{ʔ}^{\text{h}}\text{i}^{\text{h}}\text{qa}^{\text{h}}$)-*qaq-ʔif*.

Parallel to reduplication, non-reduplicative templatic morphology can also involve fixed segments. The Afro-Asiatic language Tashlhiyt Berber employs a number of different templates in its morphological system (Dell and Elmedlaoui 1992). To take one example, many deverbal nouns and adjectives are associated with a template of the form *uCCiC* (24). For vowelless roots consisting of three short consonants or a geminate consonant plus a single consonant, the template is satisfied by adding /u/ before the root and /i/ between the last two consonants (24a). If the root consists of a short consonant followed by a geminate, the /i/ splits the geminate (24b). In roots comprising three consonants, one of which is a geminate, the geminate is shortened to satisfy the template (24c). Vowels in a root change to conform to the template (24d). (Note that delabialization of labialized velars observed in some of the forms is a regular dissimilatory process discussed in Chapter 5.)

- (24) Templatic morphology in Tashlhiyt Berber (Dell and Elmedlaoui 1992: 101–2)

	<i>Noun/adjective</i>	<i>Gloss</i>	<i>Verb root</i>	<i>Gloss</i>
(a)	ukris	'trousseau'	krs	'tie in a bundle'
	uxʃin	'ugly person'	x ^w ʃn	'be ugly'
	utlif	'lost soul'	tlf	'be confused'
	uk:im	'a blow'	k ^w :m	'strike'
	ubbiz	'a punch'	b:(i)z	'to punch'
(b)	t-ugmim-t	'mouthful'	g ^w m:	'hold (liquid) in one's mouth'
	u ^ʃ g ^ʃ z ^ʃ i ^ʃ z ^ʃ	'mouthful'	g ^ʃ z ^ʃ :	'crunch'
(c)	uqsif	'squat person'	qs:f	'be narrow'
	uʒniq	'person with a malformation'	ʒn:q	'be malformed'
(d)	umlil	'white'	ml:ul	'be white'
	ulmis	'something bland'	lm:us	'be bland'

8.4 Prosodic truncations

Another type of morphological process relying on prosodically defined templates is truncation: a word formation process involving the creation of a shortened form. Many languages display templatic truncation in vocatives, hypocoristics, and/or compounds. For example, Japanese (Poser 1990) has a hypocoristic suffix *-tean* that is productively added to first names as well as (albeit with less productivity) to kinship terms and certain other items. This suffix can either be attached to the full version of a name or to a truncated version of a name, where the shape of the truncation is predictable from the prosodic shape of the name. If the first two syllables of the name consist of two light (CV) syllables, these two syllables are copied (25a). If the first syllable is heavy, just the first syllable is copied (25b). If the first syllable is light and the second is heavy, the first syllable plus a light version of the second syllable is duplicated (25c).

(25) Hypocoristics in Japanese (Poser 1990)

	<i>Truncated hypocoristic</i>	<i>Full hypocoristic</i>	<i>Name</i>
(a)	megutean	megumitean	megumi
	humitean	humikotean	humiko
	takatean	takatugetean	takatu
(b)	ɕu:tean	ɕu:suketean	ɕu:suke
	jo:tean	jo:kotean	jo:ko
(c)	ta.lo:tean	ta.lo:tean	ta.lo:
	zi.lo:tean	zi.lo:tean	zi.lo:

As Poser shows, the truncated form consistently adheres to a bimoraic template, in the guise of either a single heavy syllable, e.g. *ɕu:ːː-tean*, or two light syllables, e.g. *meːːguːː-tean*.

In a series of works, Alber and Arndt-Lappe (Alber 2010, Arndt-Lappe 2010, Alber and Arndt-Lappe 2012) explore the typology of templatic truncation drawing on a survey of 91 truncation patterns found in 27 languages. They identify a number of recurring patterns. First, they find that the majority of truncations (62.5%) conform to a foot template (either disyllabic or varying, as in Japanese, between a single heavy or two light syllables), while monosyllabic (28.4%) and variable (9%) templates are considerably less common (Alber and Arndt-Lappe 2012).

Alber (2010) and Alber and Arndt-Lappe (2012) discuss the case of Italian, which displays all three templates: the monosyllabic (26a) and disyllabic (foot) (26b) patterns observed in hypocoristics and the variable length template found in Southern Italian vocatives (26c).

(26) Hypocoristics in Italian (Alber and Arndt-Lappe 2012: 298–9)

	<i>Truncation</i>	<i>Base</i>
(a)	Fra	Francésca
	Cri	Cristína
	Lu	Luísa
	Ste	Stefánia

(b) Fráncé	Francésca
Vále	Valentína, Valentíno
Ándre	Andréa
Símo	Simóna
Césca	Francésca
Bérto	Robérto
Méni	Doménico
(c) Bá	Bárbara
Pá	Páola
Francé	Francésca
Carmé	Carméla
Salvató	Salvatóre
Antoné	Antonélla

The monosyllabic and disyllabic patterns illustrate the typologically most commonly preserved material from the base in truncations: the first syllable (50.5% of templates in their survey) and the stressed syllable (16.5%). Thus, the monosyllabic truncations all preserve the first syllable, while the disyllables may either preserve the first two syllables as in *Francé*, *Vále*, *Ándre*, and *Símo*, or the stressed syllable plus the post-tonic syllable as in *Césca*, *Bérto*, and *Méni*. The variable-length truncations in (c) are characterized by preservation of the string spanning from the first syllable through the stressed syllable, a pattern found in 7.7% of the templates in Alber and Arndt-Lappe's survey. Arndt-Lappe (2008) also cites a hybrid pattern found in Spanish hypocoristics in which the first (unstressed) consonant of the base is preserved along with the rime of the stressed syllable plus the posttonic syllable (Lipski 1995), e.g. *Fíko* for *Federíco*, *Fínda* for *Florínda*. Virtually all of the remaining templates are either not specified, unclear, or, in the case of some non-productive patterns, display other mixed preservation patterns. Alber and Arndt-Lappe cite a single case, in Indonesian (Cohn 2005), of a productive truncation pattern characterized by preservation of the last (and unstressed) syllable, e.g. *nak* for *ának* 'child', *Gus* for *Águs*, *Lik* for *Lílik* (Alber and Arndt-Lappe 2012: 300).

Alber (2010) also cites variants of the Italian stress-anchored disyllabic templates involving reduplication. One of these is associated with preservation of the stressed vowel with substitution of its onset consonant with the onset of the post-tonic syllable, e.g. *Píppo* for *Filíppo*, *Gígi* for *Luígi* (Alber 2010: 3). The other is marked by copying of the stressed syllable preceded by a copy of the segments in the stressed syllable of the base but not the stress itself, e.g. *Totó* for *António* or *Salvatóre*, *Sasá* for *Rosário* (p. 4).

8.5 Subtractive morphology

Another type of truncation, "subtractive morphology" (Martin 1988), employs a template for the material that is deleted rather than for the material that is

preserved. Subtractive morphology is illustrated by the Koasati plurals in (27), which are formed by deleting the final rime of the root and adding the suffixes *-ka* or *-li* followed by *-n* (Kimball 1983, 1991, Martin 1988).

- (27) Subtractive morphology in Koasati (Martin 1988: 230–1)

<i>Singular</i>	<i>Plural</i>	<i>Gloss</i>
lataf-kan	lat-kan	'to kick something'
lasap-lin	lap-lin	'to lick something'
misip-lin	mis-lin	'to wink'
tipas-lin	tip-lin	'to pick something off'
ataka:-lin	atak-lin	'to hang something'
albiti:-lin	albit-lin	'to place on top of'
atfoktjana:-kan	atfoktjan-kan	'to quarrel with someone'

As the data show, the deleted rime can consist either of a short vowel + coda consonant or a long vowel.

Another class of verbs in Koasati is characterized by subtractive morphology of a different kind, whereby the coda of the final syllable of the root is lost and triggers compensatory lengthening of the preceding vowel (28) (see Chapter 5 on compensatory lengthening).

- (28) Subtractive morphology with vowel lengthening in Koasati (Martin 1988: 232)

<i>Singular</i>	<i>Plural</i>	<i>Gloss</i>
famot-kan	famo:-kan	'to wave'
labos-lin	labo:-lin	'to extinguish something'
jitfof-kan	jitfo:-kan	'to shrivel'
asikop-lin	asiko:-lin	'to breathe'

8.6 Relationship between non-reduplicative templatic morphology and other weight-sensitive phenomena

Parallel to reduplication and minimal word requirements, other morphological processes employing prosodic templates may be formalized in terms of moraic structure. As we have seen in section 8.3, the different templates imposed on Nuuchahnulth roots by suffixes can be expressed in terms of mora requirements on the first two syllables. Similarly, the template employed in Japanese hypocoristic formation can be analyzed as a bimoraic one.

As it turns out, the moraic structure diagnosed by hypocoristic formation in Japanese finds independent support from other prosodic phenomena in Japanese including mimetic reduplication, which is defined by complete copying of bimoraic words, e.g. *pikapika* 'in flashes', *gatagata* 'rattling', *gungun* 'steadily', *poopoo* 'hooting' (Poser 1990: 94). On the other hand, the Nuuchahnulth root templates triggered by suffixation are not predicted from the moraic configurations diagnosed by the stress system. Stress in Nuuchahnulth falls on the first syllable unless the first is light and the second is heavy, where both long vowels

and syllables closed by a sonorant are heavy (Stonham 1999). The heavy status of syllables closed by a sonorant contradicts their behavior in the suffix-induced templatic morphology, where a short vowel in a syllable closed by a sonorant still undergoes lengthening when followed by a suffix selecting for a long vowel, e.g. *?ink^w-i:t* → *?i:nk^wi:t* ‘making fire’ (cf. *?inkuwit* ‘smoke house’).

The overall evidence for language-internal coherence of weight across different prosodic phenomena is thus mixed. Alongside the compelling but isolated cases of consistency, e.g. Japanese truncations and reduplication, exist other cases involving mismatched weight criteria, e.g. between templatic morphology and stress in Nuuchahnulth.

8.7 Summary

Prosodic morphology covers a wide range of phenomena: minimality requirements on the shape of words and morphemes, reduplication, truncations, and other types of non-concatenative morphology.

Minimality requirements adhere to a cross-linguistic scale of weight with CV syllables occupying the lightest and disyllables the heaviest points on the continuum. Languages draw different cut-off points in the scale separating the boundary between prosodically licit, i.e. bimoraic or larger, and illicit, i.e. smaller than bimoraic, content words, where (barring any independent well-formedness conditions precluding a given syllable type) the occurrence of a word of a given shape implies the existence of words that occupy a heavier position along the scale. Cross-linguistically, the most common minimal word requirement is CVC, occurring even in many languages in which metrical structure does not provide independent evidence for the heavy status of CVC.

Reduplication is a word formation process involving the copying of a morpheme, typically a root, in its entirety or partially. In partial reduplication, a prosodic template smaller than the root is imposed on the duplicated string, which may either represent a faithful copy of the base or a combination of copied material plus fixed or altered material. Whole root duplication is typologically the most common variety of reduplication. CV constitutes the most common partial reduplicant shape with prefixal position being the preferred docking site for reduplicants. There is some evidence for a link between reduplication and either stress or minimality depending on the particular reduplicative template.

The apparent lack of widespread language-internal uniformity in templates adopted by different prosodic phenomena suggests the need for further examination of the motivations underlying the individual phenomena assumed to fall under the rubric of prosodic morphology. One such independent factor is naturalness (and its phonological reflex, markedness), which potentially offers an explanation for at least some type of fixed segmentism in reduplication but also certain cross-linguistic biases in the syllable structure found in reduplicants, e.g. the absence of coda consonants at the right edge of the two most common prosodically governed reduplicative templates: CV and σ CV. Nevertheless, it is

unlikely to be the case that prosodic morphology is fully explicable in purely synchronic terms, as we have seen in the discussion of minimality restrictions in Balto-Finnic languages. Future research will hopefully identify the confluence of synchronic factors and historical changes that conspire to account for the typology of prosodically driven morphological phenomena.

Conclusions

This book has attempted to provide an overview of the cross-linguistic distribution of a number of phonological properties by integrating results from three sources: existing typological surveys in the literature, a survey of various properties in the WALS sample of languages, and tabulations of language-internal frequency data. The primary contribution of this work is not intended to be the advancement of any particular theory of phonology or any particular analysis of the phenomena under consideration but rather to provide a repository of observations, many of them quantitative, about implicational relationships, frequency distributions, and correlations that can provide fodder both to researchers interested in developing and testing theories and to other typologists engaged in the business of discovering meaningful patterns and correlations.

Despite this lofty goal, it is evident that the book has a number of limitations. Perhaps most importantly many of the observed generalizations, whether previously made or novel, are based on relatively small databases and should be corroborated through additional data gleaned from a greater number of languages. This is especially true of the findings related to language-internal frequency. Furthermore, many important phenomena and properties are not covered at all, including, to name just a few, the phonology of clicks, sign language phonology, first language acquisition, loanword phonology, and various interactions between phonology and morphology. (It also goes without saying that many treatments of particular phenomena in the theoretical literature have been given short shrift or none at all.) Also, certain topics that have played a prominent role in the development of phonological theory have not been given adequate attention, e.g. opacity and cyclicity (to name just two), primarily because the book would have become unbearably large had they been discussed but also because many of them appear to be rare or, perhaps more accurately, difficult to draw typological generalizations about using the resources available for conducting broad typological research. In a sense, this work has focused more on uncovering robust generalizations about patterns than on finding the rare outlier or exception to a pattern, although, of course, any comprehensive theory must account for the full range of cross-linguistic variation.

It is hoped, though, that this book will help identify which patterns are common and which ones are rare, since theories are informed by facts about the distribution of patterns, whether this information is directly incorporated into the theory or whether it exerts its influence indirectly by directing attention to patterns that are potentially amenable to reanalysis. Although the tendency might be to view the relationship between typology and theory as a unidirectional one in which the typology informs the theory, it is evident (in fact has become even clearer while writing this book) that the relationship between theory and typology also works in the other direction and that the theoretical literature has played a critical role in shaping the research questions targeted for investigation in this work. Without these guiding questions, the field of typological investigation would be considerably less focused and more impoverished.

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