# Contents

*Preface*  
*Acknowledgements*  

1 Background I: A Phonological Refresher  
1.1 The Basics of Phonology  
1.2 Phonology at and below the Segmental Level  
1.3 Phonology above the Segmental Level  
1.3.1 Syllables  
1.3.2 Stress and Feet  
1.4 Two Conceptual Issues  
1.4.1 Competence vs Performance  
1.4.2 Perception and Production  
1.5 Further Reading  

2 Background II: Infant Speech Acquisition  
2.1 Methodologies: Speech Experiments with Infants  
2.2 Speech Perception in the First Year of Life  
2.2.1 Earliest Perception: Intonation and Prosody  
2.2.2 Perception of Phonemes and Allophones  
2.2.3 Perception of Phonotactics  
2.3 Word Segmentation in the First Year of Life  
2.4 Methodology: Vocabulary Development in the Pre-Phonological Period  
2.5 The Beginnings of Speech Production  
2.6 Further Reading  

3 Early Phonology: The Shapes of Syllables  
3.1 Preliminaries  
3.1.1 When Does Phonology Begin?  
3.1.2 Where Does the Child Get their Inputs?  
3.2 Syllable Shape Inventories  
3.3 Optimizing Syllable Shapes
3.4 More Choices in Optimization  
3.4.1 A Role for Sonority  
3.4.2 Thinking Through the Candidate Set  
3.4.3 Other Cluster Reduction Grammars  
3.4.4 More Competition: Word-Medial Clusters  
3.5 Consequences and Alternatives  
3.5.1 More about the Data  
3.5.2 More about the Theory  
\[3.5.2.1\] More about Representations  
\[3.5.2.2\] More about Constraints  
3.5.3 Comparing Frameworks: Constraints vs. Rules Part 1  
3.6 Methodology: Longitudinal and Cross-Sectional Studies  
3.7 Further Reading  

4 Early Phonology: Word Sizes and Shapes  
4.1 Early Word Shapes  
\[4.1.1\] A First Look at the Data  
\[4.1.2\] A First Analysis of Target Language Stress  
\[4.1.3\] Analysing the Child's One-Trochee Stage  
\[4.1.4\] Adding Faithfulness into the Analysis  
\[4.1.5\] Minimal Word Shapes  
\[4.1.6\] Universals, Tendencies and Early Word Shapes  
4.2 Later Word Shapes  
\[4.2.1\] Bigger Words  
\[4.2.2\] Other Attempts at Bigger Words  
4.3 An Alternative: Perceptual Accounts of Truncation?  
4.4 Methodology: Elicitation Studies  
4.5 Further Reading  

5 Early Phonology: Consonants  
5.1 An Ornithological Introduction to Constraint-Based Featural Phonology  
5.2 Child Consonant Inventories  
5.3 Constraints on Consonant Inventories  
5.4 Child Consonant Repairs  
5.5 Comparing Consonant Repairs in Children and Adults, and their Analysis  
\[5.5.1\] Sonorant Gliding and Liquid/Glide Alternations  
\[5.5.2\] Other Repairs for Nasals  
\[5.5.3\] Fricative Stopping  
\[5.5.4\] Repairs for Individual Fricatives  

Further Reading
5.5.5 Velar Fronting 174
5.5.6 Another Process among Places of Articulation 175
5.6 On Alternative Explanations 181
5.7 Repairs for Rhotics 183
5.8 Methodologies: Phonological Corpora and Acquisition Data 185
5.9 Further Readings 186

6 Early Phonology: More Consonants and Phonotactics 188
6.1 Consonants in Codas 188
   6.1.1 A Case Study of Polish Coda-Onset Acquisition 192
   6.1.2 Geminates 199
   6.1.3 Positional Allophones and Neutralizations, among Children and Adults 201
6.2 Interactions Between Consonants and Vowels 206
6.3 Consonant Harmony 210
   6.3.1 Manner Harmonies 211
   6.3.2 More Divergent Harmonies 214
   6.3.3 Place Interactions in Target Languages 217
   6.3.4 Analysing Consonant Harmony 219
6.4 Another Look at Misperception 222
6.5 Comparing Rules and Constraints Part 2 226
6.6 Finally Tackling Variation in Child Phonology 231
6.7 Further Reading 234

7 Lexical Influences and Interactions in Phonological Learning 237
7.1 What’s in a Word? 237
7.2 Lexical Frequency and Phonological Production 239
   7.2.1 Connecting Input Frequency and Order of Acquisition – Implications for Grammar Use 243
7.3 Lexical Avoidance 244
7.4 Exceptions, Regressions and Fossils 249
7.5 Templates and the Like 258
7.6 Further Readings 262

8 Acquiring Morpho-Phonology 265
8.1 Introduction to the Problem 265
8.2 Methodology and Data: Wug Tests 269
   8.2.1 Plural Wug Testing in Hungarian 270
   8.2.2 Wug Testing in English: Back to Berko 274
<table>
<thead>
<tr>
<th>Section</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>8.2.3 Wug Testing in Dutch: Production, Comprehension and Frequency</td>
<td>278</td>
</tr>
<tr>
<td>8.2.4 Summarizing the Beginnings of Morpho-Phonological Acquisition</td>
<td>281</td>
</tr>
<tr>
<td>8.3 Morphological Paradigms and Phonological Uniformity</td>
<td>282</td>
</tr>
<tr>
<td>8.3.1 The Child Data</td>
<td>282</td>
</tr>
<tr>
<td>8.3.2 The Adult Data</td>
<td>285</td>
</tr>
<tr>
<td>8.3.3 An Analysis of Paradigm Uniformity</td>
<td>287</td>
</tr>
<tr>
<td>8.4 Morphological (Over)regularization and Allomorph Selection</td>
<td>290</td>
</tr>
<tr>
<td>8.4.1 A Tale of Two (Ir)regular Paradigms</td>
<td>291</td>
</tr>
<tr>
<td>8.4.2 Phonology and Analyses of Allomorphy Selection</td>
<td>295</td>
</tr>
<tr>
<td>8.5 On Finding Underlying Forms</td>
<td>298</td>
</tr>
<tr>
<td>8.5.1 The Problems and Methods</td>
<td>298</td>
</tr>
<tr>
<td>8.5.2 Learning Korean Verb-Final Alternations</td>
<td>301</td>
</tr>
<tr>
<td>8.5.3 Learning Korean Noun-Final Alternations</td>
<td>304</td>
</tr>
<tr>
<td>8.6 Further Readings</td>
<td>309</td>
</tr>
<tr>
<td>9 Children’s Bilingual Phonological Acquisition</td>
<td>312</td>
</tr>
<tr>
<td>9.1 Conceptual Issues: Bilingual and Second Language Development</td>
<td>312</td>
</tr>
<tr>
<td>9.2 Early Child Bilingual Phonology</td>
<td>314</td>
</tr>
<tr>
<td>9.2.1 Acquiring Two Phoneme Inventories</td>
<td>314</td>
</tr>
<tr>
<td>9.2.1.1 Bilingual Phonologies and Language Differentiation</td>
<td>318</td>
</tr>
<tr>
<td>9.2.2 Acquisition of Syllable Structure by Bilinguals</td>
<td>319</td>
</tr>
<tr>
<td>9.2.3 Acquisition of Word Shape by Bilinguals</td>
<td>325</td>
</tr>
<tr>
<td>9.2.4 Bilingual Acquisition of Segmental Phonology</td>
<td>329</td>
</tr>
<tr>
<td>9.2.5 A Sidenote on Bilingual Lexical Development</td>
<td>334</td>
</tr>
<tr>
<td>9.3 The Bilingual Learner and an OT Phonological Grammar</td>
<td>335</td>
</tr>
<tr>
<td>9.4 Further Reading</td>
<td>337</td>
</tr>
<tr>
<td>10 Some OT Theories of Phonological Learning</td>
<td>339</td>
</tr>
<tr>
<td>10.1 Framing the OT Learning Problem</td>
<td>339</td>
</tr>
<tr>
<td>10.2 Building an OT Error-driven Learner</td>
<td>345</td>
</tr>
<tr>
<td>10.2.1 The Logic of Re-ranking</td>
<td>345</td>
</tr>
<tr>
<td>10.2.2 Choosing an Initial State</td>
<td>347</td>
</tr>
<tr>
<td>10.2.3 Restrictiveness and the Re-ranking Algorithm</td>
<td>349</td>
</tr>
<tr>
<td>10.3 Learning Gradually</td>
<td>356</td>
</tr>
<tr>
<td>10.3.1 Why Gradual Learning Is Hard so far</td>
<td>356</td>
</tr>
<tr>
<td>10.3.2 Numerical Rankings and Gradual Learning: The GLA</td>
<td>359</td>
</tr>
</tbody>
</table>
10.3.3 Assessing the GLA as a Gradual Learner 361
10.3.4 More on Ordinal Rankings, Biases and Gradual Learning 366
10.4 Learning with Variation 368
10.4.1 Variation with Stochastic OT and the GLA 368
10.4.2 Variation with Ordinal OT, Stored Errors and a Dual Route 373
10.5 Further Reading 376

References 379
Index of Constraints 409
Index of Languages 410
Index of Terms 412
1 Background I:
A Phonological Refresher

1.1 The Basics of Phonology

To begin with: what is phonology? To be more precise, we will usually be talking about the phonology of either a language or a speaker – and our working definition will be that a phonology is a characterization of all the mental representations and unconscious knowledge that speakers have about abstract speech sounds. Studying phonology, then, is studying the nature of this knowledge, and also the characterization of this knowledge.

We will often talk about this abstract knowledge in terms of phonological generalizations. To exemplify: one generalization about Zack's speech from the Preface is that he begins all of his words with only one consonant, and never with two consonants side-by-side. At the same time, a different generalization about English as spoken by the native speaker adults around him is that words begin with two or three consonants in a row all the time! By looking at Zack's own version of English words, we can see that he systematically modifies all words beginning with more than one consonant so that they are consistent with his own pattern – the 'sp' of special comes out as just [p], the 'fl' of fleece as just [f], and so on. The task of a phonological grammar is to capture a speaker or population's generalizations, explicitly enough that an algorithm plugged into some otherwise-dumb computer could approximate the phonological knowledge of a human language speaker.

Most phonological grammars (and all the ones we will use in this text) operate on representations of two kinds: stored forms in the mental lexicon, called underlying representations (URs), and forms that can actually be produced by a speaker or heard by a listener, called surface representations (SRs). This text will also refer to these URs and SRs respectively as inputs and outputs, and the mapping from one to the other is illustrated as /input/ → [output]; note the / / vs [ ] notation. The grammars we will use in this textbook are ones in which you can feed the grammar any input and it will always generate

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1 This property – though certainly not always cached out in this format – is the source of the term generative linguistics, associated as you probably already know with the pioneering work of Noam Chomsky.
a legal output – that is, an output that a native speaker would judge to be a possible surface form in the language. If you give it input /blep/, and it is a phonology of English, it will simply return [blep] again, because that string of sounds is a well-formed possible English word. If you give it /pelb/, though, it will map that input onto some modified form to accord with English phonological generalizations, perhaps as [phɛɫ]. In this way, you might think of a phonological grammar as a language-specific filter. The job of phonologists is to spell out how these filters work: what building blocks they are composed of, how they differ between languages, and what kinds of structures they can rule out or in (and eventually why). When studying acquisition, phonologists take on the further tasks of describing how these filters become language-specific (through learning), and how children use them and refine them in the years before they have acquired a fully-adult grammar.

To build a phonological grammar, we first need to understand the objects that it manipulates: what are these underlying and surface representations made of? The basic phonological building blocks of URs and SRs are segments. Segments are abstractions away from the raw acoustic signal of speech, made into manageable mental chunks that we can manipulate with the grammar. To see the value of this approach consider the two spectrograms below, which together represent much of the raw acoustics of the author saying an English sentence. If you are not familiar with reading spectrograms, these will be rather messy and hard to interpret. The only crucial aspects of the graph are that the x-axis measures time in milliseconds, and the y-axis indicates the strongest resonating frequencies\(^2\) measured in Hertz, and overall intensity of the sound, indicated by the darkness of each bar.

(1a) ‘She borrowed a plastic yellow bin…

\(^2\)Which you may already know are called formants.
Let us just consider the two boxed portions of the sentence, which correspond to the word *yellow* in the (1a) spectrogram and *trock* in (1b). (Yes, *trock* is not a real word of English, on which there will be more in a minute.) It is somewhat hard to process this visual representation, with its continuous time dimension and myriad phonetic dimensions. But from a phonological viewpoint, one basic question is: how many segments does each word contain? If we examine each spectrogram for steady-state periods of sound, expecting some noise during the transitions, then we can perhaps come up with a rough approximation of the words’ segments. Below this has been done for zoomed-in spectrograms of *yellow* and *trock*, where each segment has been transcribed with an IPA symbol.
Segments are thus at least a method of abstracting away from continuous phonetics to more discrete phonology. Phonologists (and others) have also found some compelling evidence that grammars and speakers manipulate their phonologies at the level of the segment, so it is not just a convenient notation. These arguments will be developed as we go. Note also that the fact of *trock not being an English word has caused us no difficulty in segmentation and transcription – and that is precisely the point, that is that phonology is about the legality of speech sound interactions in a language, not just the particular words that happen to occur in your mental dictionary (which we will usually refer to as the mental lexicon). This issue will also be raised many times in the pages that follow.

Exercise 1: Identify all the letters in the English words of (1) which correspond to multiple IPA symbols, and vice versa.

A phonological grammar is a mechanism for regulating phonological segments, their parts and their combinations. The first kind of phonological knowledge we will ascribe to our grammar is phonotactics, by which we will mean the regulations that describe how segments can or can’t be strung together. It is the phonotactics of English that tell you that *trock could be a word, as in our previous example, but for example *tlock could not – English word-initial phonotactics rule out the sequence #[tl]. You also know, via English phonotactics, that *trock’s second segment is a voiceless [ɾ] and that the similar second segment in plastic is a voiceless [l], while borrow and yellow

---

3 The second symbol ‘h’ indicates that the segment [t] was aspirated. If you have forgotten what this term means, read on . . .

4 # is a word boundary sign.
have a voiced [ɹ] and [ɫ] respectively. Note, however, that this knowledge is usually completely unconscious – you almost certainly knew nothing overt about voiced and voiceless versions of ‘r’ and ‘l’ until you encountered them in a linguistics class, but you were already devoicing ‘r’ and ‘l’ whenever appropriate for your dialect without knowing you were doing it.

How does a phonological grammar capture this knowledge? There are many theories, which actually turn out to have rather different consequences. For example, an English grammar could contain a rule that maps word-initial /tl/ onto something else (see 3) – this would mean picking a way of fixing #tl so it conforms to English, for example:

\[(3a) /t/ \rightarrow [k] / \# \_ \_ l \quad \text{(Turn /t/ into [k] when word-initial and followed by l)}\]

\[(3b) /0/ \rightarrow [ə] / \# t \_ \_ l \quad \text{(Epenthesize a schwa between word initial t and l)}\]

Alternatively, the grammar could have a constraint that says ‘No Word-initial [tl]’, which would mean relying on other bits of the grammar to decide what to do about an input /#tl/ should it appear. In this textbook, our first crucial choice will be to use constraints to capture phonological patterns like this, so we will spend some time justifying that choice in later chapters.

One other big job for the phonological grammar is to regulate sound sequences via alternations when they are concatenated by multiple morphemes, that is the meaningful building blocks of words and phrases. An English example of alternation which you have probably seen before comes from our plural morpheme, which has multiple phonological forms. Returning to the nonsense noun trock: whatever a trock is, if you have more than one trock, you have two … [tɹɑks] (trock)s.\(^5\) And if you found another one that needed storage, you would probably want to get more … [bɪnз] (bins). Both words end with a morpheme meaning ‘plural’, but the phonology of English dictates two different surface allomorphs [−z] and [−s] in these two phonological environments. In the grammars that we will build in this textbook, the same kinds of constraints that tell you why *tlock couldn’t be an English word also tell you that trock’s plural is trock[s] and not *trock[z].

### 1.2 Phonology at and below the Segmental Level

While segments are a very useful phonological unit for analysis and study, phonologies also organize their segments according to many different subsegmental properties. To see which of these properties are important for phonological purposes, let us consider one basic way that they are used: defining a language’s phonological categories.

\(^5\)This game of fill in the blank is in fact a common experimental device; see Chapter 8.
One classic example of a property used to categorize phonological segments is *voice onset time* (VOT). In the simple case of a stop followed by a vowel, VOT indicates the number of milliseconds between the burst of air caused by releasing the stop and the beginning of vocal fold vibrations for the vowel. If voicing begins exactly when the stop is released, VOT is zero. If it is negative, voicing had already begun during the stop's closure; if it is positive, then the stop was followed by a period of voiceless *aspiration* before vowel voicing began.

Here are two spectrograms of two English words within that previous phrase, with an arrow indicating the period of aspiration in each case (very little in the first, a fair bit in the second):

(4a) *bin*

(4b) *pin*
For these particular two tokens, the VOT for the initial segment in (4a) was measured at around five milliseconds, while the VOT for the initial segment of (4b) is 50 milliseconds. Whatever the precise difference, the phonological question is whether English speakers treat these two segments as same or different. In this case, the difference in their VOT causes you to perceive two different words: (4a) is *bin* and (b) is *pin*, so these two labial stops belong to two different phonological categories. (We refer to any such useful pair of words like *pin–bin* that highlight the contrast between two categories in a language as a **minimal pair**.)

In comparison, many English dialects distinguish two different lateral ('l'-like) segments: the alveolar, non-velarized [l] of *plastic* and the velarized [ɫ] of *hold*. Unlike the difference in VOT of 5 vs 50 milliseconds, though, the segments in *plastic* and *hold* belong to a single English category; there are no minimal pairs like *hold* vs *ho[l]d* or *plastic* vs *p[l]astic*, and English speakers cannot change the meaning of a word by replacing one lateral with the other. Instead, the English distribution of alveolar vs velarized laterals is *predictable*. Comparing just these two words, you might come up with a prediction as to the contexts in which lateral can be used: for example, before a [d] laterals are velarized (as in *hold*), but after word-initial [p] (as in *plastic*) they are not. Of course, this analysis is only built from two data points, and it is so specific that you should suspect it is missing some broader generalizations (keep reading!).

The traditional terminology is that /p/ and /b/ are different English phonemes, whereas alveolar [l] and velarized [ɫ] are both *allophones* of a single English phoneme /l/. What is crucial in this textbook is the notion of predictability: part of the phonological grammar’s job is to predict which of the allophones from a single category can occur in any specific phonological context. It is also crucial to note that phonemic or allophonic status is language-specific: the question of whether two different segments are part of two different categories (i.e. different phonemes) or a single category (i.e. both allophones of a single phoneme) is answered differently from language to language. As one quick example: nasalizing a vowel in English doesn’t change the vowel’s category – so that the vowels in *lap* [læp] and *lamb* [læm] are allophones of the same phoneme /æ/ – whereas in French nasalized and oral versions of the same vowels are often different phonemes, as shown in minimal pairs like *beau* [bo] ‘beautiful’ and *bon* [bɔ] ‘good’.

The descriptions given so far of a segment’s properties have been fairly grounded in articulatory terms: voice onset time, vowel nasalization and velarization are all measurable phonetic aspects of a sound. In a

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6Which means some raising of the tongue body or *dorsum*: not very detectable on a spectrogram although possibly discernable as movement or ‘pinching’ of F3 relative to F2, and definitely detectible if you happen to have an ultrasound recording.
phonological grammar, however, these articulatory properties do not all have the same status, and it is therefore useful to describe segments and their properties using a formal language of phonological features. Many of these features should not be news to you, but many of them also have definitions that span multiple categories in the IPA chart, so some discussion is necessary.

In the case of the phonetic property of voice onset time, there are a couple of different phonological features that we might need for describing cross-linguistic categories. One feature is aspiration, which distinguishes between the long positive VOT at the beginning of ‘pin’ and the short or nearly-zero VOT at the beginning of ‘bin’, meaning that their true IPA transcriptions might be [pʰɪn] and [bɪn] or [pɪn] respectively. In some environments, aspiration is a predictable feature – meaning that for example in the context [s__ɪn] (as in spin), the English grammar will judge [p] or [b] as grammatical but [pʰ] as ungrammatical. The other most common phonological feature that involves VOT is voicing, which in languages like Spanish and Dutch will distinguish either of these ‘voiceless’ English stops from a truly prevoiced [b], where voicing begins during the closure, resulting in a negative VOT.

A long phonological tradition has argued that features give us insight into how languages arrange their phonemes, allophones, contexts and predictability. Our quick discussion of spin (where aspiration of ‘p’ is banned) vs pin (where ‘p’ aspiration is obligatory) suggested that these aspirated and unaspirated allophones of English /p/ are in complementary distribution, only one appearing in each potential English phonological context. A more interesting point is that other pairs of English segments with similar distributions: stick vs tick; scoff vs cough, where again the s_V context requires an unaspirated allophone [p, t, k] and the #_V contexts requires an aspirated one, [pʰ tʰ kʰ]. Why these three? Not only are {p,t,k} all voiceless stops, they are also the language’s only voiceless stops – in other words, they form the English natural class of voiceless stops. So rather than listing the unrelated behaviours of three phonemes, the English phonology can make broader generalizations like ‘voiceless stops are aspirated word-initially’ (and so on, describing other environments).

Given the wealth and complexity of phonological processes, it is not surprising that several different sets of phonological features have been proposed. This textbook is not designed to provide much insight into choosing between their specifics, and our feature set will lack many necessary bits, but it will

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7 To see this history in its original unfoldings, see: Trubetzkoy (1939); Jakobson (1941); Jakobson, Fant and Halle (1952); Jakobson and Halle (1956); Chomsky and Halle (1968).
make use of a crucial, small set of feature types that most phonologists would recognize. Here we will present them by trying to introduce as little confusing detail as possible. Let’s begin with features describing place of articulation:

(5)

<table>
<thead>
<tr>
<th>Place features</th>
<th>Major/Primary Place</th>
<th>Minor/Secondary Place</th>
</tr>
</thead>
<tbody>
<tr>
<td>labial</td>
<td>+/-labiodental</td>
<td></td>
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</table>
| coronal                          | +/-anterior          | [+ant] = dental, alveolar  
                                        | [-ant] = postalveolar, retroflex  
                                        | note: palatal = [coronal AND dorsal] |
| dorsal                           | +/-low               | [-low] = velar         
                                        | [+low] = uvular               |
| pharyngeal                       |                     |                       |
| glottal                          |                     |                       |

Note that the major place features are monovalent in this table, meaning they are simply attributes that a segment does or does not have – you can be labial or not, those are the only two options. Those minor places features within a major place class, however, are treated as bivalent, so that for example all [coronal] segments can in principle be specified as either [+/-anterior].

Turning to manner features: these are sometimes the hardest for students to get a handle on, so the table in (6) adapts a way of laying them out from Hayes (2009):

(6)

<table>
<thead>
<tr>
<th>Manner features</th>
<th>stops</th>
<th>affricates</th>
<th>fricatives</th>
<th>nasals</th>
<th>liquids</th>
<th>glides</th>
<th>vowels</th>
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<tbody>
<tr>
<td>-sonorant</td>
<td>[+sonorant]</td>
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<td>[-delayed release]</td>
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<tr>
<td>[+/-strident]</td>
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</table>
The first big distinction in manner is [+/-sonorant], distinguishing the obstruents from the sonorants; we will have much more to say about this property of sonority in later chapters. Notice that most other manner features are only defined for a subset of the manners discussed here; note too that the status of nasals as [+continuant] is a rather non-standard assumption here (you will eventually see why in Chapter 5). There are also a few missing features here: two that we will need are [+/-lateral], [+/-tap] (or flap) and [+/-trill]. Finally, we will also use the feature [+/-nasal] which can be used to describe any consonant or vowel.

The laryngeal features we will use include [+/- voice], [+/-aspirated] and [+/-constricted glottis], the last of which describes sounds such as ejectives, ‘tense’ consonants (see Chapter 5), and creaky vowels.

Beyond the manner information above, we will have fairly little to say about vowel features, simply because this text is quite vague about the acquisition of vowels. However, we will use the terms [+/-high], [+/-low], [+/-back] and [+/-round] to describe them, in accordance with their location in the vowel space (see again the IPA vowel chart on page 28). Note also that in Chapter 6.2 we will spend some time discussing how the place features of consonants and vowels line up. In addition, we will need to be able to refer to two prosodic qualities of segments as features: [+/-long], which distinguishes phonemically long vowels and geminate consonants, as well as [+/-stress] (which is not that common a feature, and very possibly for good reason, but is used in e.g. Hayes, 2009). These will appear when necessary.

To re-iterate: this text is not especially committed to the details of any particular featural description, but there are times when we will have evidence from child phonology to prefer one version to another. If this is your first time using phonological features to understand speech patterns, you will want more background, for which see the chapter’s further readings. If you are not sure whether you need more or not, make sure to use the exercises here and at the end of the chapter to evaluate.

**Exercise 2:** Using the features just introduced, how could you describe the English ban on #tl? That is, what features are not allowed in that word-initial sequence?

**Exercise 3:** Now look at this larger set of data, listing possible and impossible word-initial segments in the author’s dialect. Can you give a more general featural account of what features cannot co-occur word-initially? It’s not a completely simple pattern, but you can get started …

---

8Some speakers may also judge *dwin* or *gwin* as bad enough to be impossible, and may judge *bwin* as good enough to be possible. We do have rather few #dw words in English – e.g. *dwarf*, *dwell* and the name *Duane*; #gw is really only found in names like *Gwenneth* so its status may be truly marginal. While we have no native words with #bw, some speakers may be too familiar with Spanish words like *bueno* to keep the English judgments crisp.
This question is designed to show you two things: first, that featural description makes more sense out of a list of facts like (7) than was previously possible, and second, that features are often not well-suited to explaining all the details of a phonological phenomenon, such as the intricacies of place dissimilation among word-initial consonant sequences. Both of these claims will be reinforced throughout our study of child phonology, and we will build a grammar that uses features to describe patterns, but uses other mechanisms to describe the relative importance of each pattern and their individual (principled) exceptions.

**Exercise 4:** Below are examples of alveolar and velarized English laterals, in just four environments. What’s the distribution of the two laterals?

First describe the phonological environment of each column – that is, find a phonological context that includes all the members of each column, without including any members of any other column. Secondly, describe the context for each lateral allophone, and then see if you can describe the two allophone’s contexts each with a single description. If not, how close can you get?

### 1.3 Phonology above the Segmental Level

This section moves on to larger groupings of speech sounds above the segment, called prosodic units, which the phonological grammar can constrain and organize. This textbook will be primarily interested in the acquisition of three prosodic units: *syllables*, *feet* and *words*. 
# Index of Constraints

<table>
<thead>
<tr>
<th>Constraint</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>*[Z], 256</td>
<td></td>
</tr>
<tr>
<td>*[Cor..Dor], 247</td>
<td></td>
</tr>
<tr>
<td>*[-son,+voice], 203</td>
<td></td>
</tr>
<tr>
<td>*[son]-[son]-Coda, 189</td>
<td></td>
</tr>
<tr>
<td>*x[frontV], 289</td>
<td></td>
</tr>
<tr>
<td>*Coda, 57, 60</td>
<td></td>
</tr>
<tr>
<td>*Coda-Manner, 191</td>
<td></td>
</tr>
<tr>
<td>*Coda-Place, 191</td>
<td></td>
</tr>
<tr>
<td>*ComplexCoda, 58</td>
<td></td>
</tr>
<tr>
<td>*ComplexOnset, 57</td>
<td></td>
</tr>
<tr>
<td>*FinalNasal, 229</td>
<td></td>
</tr>
<tr>
<td>*FinalVoicedObstruent, 229</td>
<td></td>
</tr>
<tr>
<td>*FricOnset, 71</td>
<td></td>
</tr>
<tr>
<td>*GlideOnset, 71</td>
<td></td>
</tr>
<tr>
<td>*Interdental fricative, 156</td>
<td></td>
</tr>
<tr>
<td>*Liquid, 165</td>
<td></td>
</tr>
<tr>
<td>*LiquidOnset, 71</td>
<td></td>
</tr>
<tr>
<td>*NasalOnset, 71</td>
<td></td>
</tr>
<tr>
<td>*PalatalFric, 289</td>
<td></td>
</tr>
<tr>
<td>*Pharyngeal, 156</td>
<td></td>
</tr>
<tr>
<td>*RoundV, 252</td>
<td></td>
</tr>
<tr>
<td>*SonorantOnset, 69</td>
<td></td>
</tr>
<tr>
<td>*SonorityRise, 194</td>
<td></td>
</tr>
<tr>
<td>*SyllableContact, 81</td>
<td></td>
</tr>
<tr>
<td>*UnfootedSyllable, 102</td>
<td></td>
</tr>
<tr>
<td>*V[s]V, 288</td>
<td></td>
</tr>
<tr>
<td>*V[-son,-voice]V, 203</td>
<td></td>
</tr>
<tr>
<td>Agree[+/-lateral], 212</td>
<td></td>
</tr>
<tr>
<td>Agree[+/-voice]-obstruent, 277</td>
<td></td>
</tr>
<tr>
<td>Agree[dorsal], 219</td>
<td></td>
</tr>
<tr>
<td>Agree[labial], 220</td>
<td></td>
</tr>
<tr>
<td>Agree-V/C[Place], 208</td>
<td></td>
</tr>
<tr>
<td>Anchor-Left, 142</td>
<td></td>
</tr>
<tr>
<td>Dep, 66</td>
<td></td>
</tr>
<tr>
<td>Dep-Syllable, 136</td>
<td></td>
</tr>
<tr>
<td>FinalFoot, 104</td>
<td></td>
</tr>
<tr>
<td>Final-MainStressFoot, 104</td>
<td></td>
</tr>
<tr>
<td>FootBinarity, 119</td>
<td></td>
</tr>
<tr>
<td>Iamb, 107</td>
<td></td>
</tr>
<tr>
<td>Ident[+/-back], 289</td>
<td></td>
</tr>
<tr>
<td>Ident[+/-back]-derived, 290</td>
<td></td>
</tr>
<tr>
<td>Ident[+/-consonantal], 166</td>
<td></td>
</tr>
<tr>
<td>Ident[+/-continuant]-Recent, 256</td>
<td></td>
</tr>
<tr>
<td>Ident[+/-lateral], 212</td>
<td></td>
</tr>
<tr>
<td>Ident[+/-voice], 288</td>
<td></td>
</tr>
<tr>
<td>Ident[+/-voice]-Derived, 288</td>
<td></td>
</tr>
<tr>
<td>Ident[sonorant], 196</td>
<td></td>
</tr>
<tr>
<td>Ident[continuant], 256</td>
<td></td>
</tr>
<tr>
<td>Ident[coronal], 219</td>
<td></td>
</tr>
<tr>
<td>Ident[labial], 221</td>
<td></td>
</tr>
<tr>
<td>Ident[main stress], 129</td>
<td></td>
</tr>
<tr>
<td>Ident[sonorant], 174</td>
<td></td>
</tr>
<tr>
<td>Ident[stress], 115</td>
<td></td>
</tr>
<tr>
<td>Ident[labial][dorsal]], 180</td>
<td></td>
</tr>
<tr>
<td>Initial-Foot, 101</td>
<td></td>
</tr>
<tr>
<td>Initial-MainStress-Foot, 102</td>
<td></td>
</tr>
<tr>
<td>Integrity, 252</td>
<td></td>
</tr>
<tr>
<td>Integrity-[Lex1], 257</td>
<td></td>
</tr>
<tr>
<td>Linearity, 195</td>
<td></td>
</tr>
<tr>
<td>Linearity-Syllable, 248</td>
<td></td>
</tr>
<tr>
<td>Max, 61</td>
<td></td>
</tr>
<tr>
<td>Max-[labial], 252</td>
<td></td>
</tr>
<tr>
<td>Max-C, 343</td>
<td></td>
</tr>
<tr>
<td>Max-FinalRime, 116</td>
<td></td>
</tr>
<tr>
<td>Max-StressedRime, 114</td>
<td></td>
</tr>
<tr>
<td>M-Parse, 247</td>
<td></td>
</tr>
<tr>
<td>NasalOnly-CodaCond, 194</td>
<td></td>
</tr>
<tr>
<td>Onset, 58</td>
<td></td>
</tr>
<tr>
<td>Trochee, 107</td>
<td></td>
</tr>
<tr>
<td>Uniformity, 178</td>
<td></td>
</tr>
</tbody>
</table>
Index of Languages

Arabic, 154, 159, 162
Berbice Dutch Creole, 119
Bislama, 252
Bukusu, 212
Cantonese, 33, 153, 215, 228, 241
Catalan, 139, 180
Cayuvava, 55
Choctaw, 118–19
Cree, Swampy, 202
Dakota, 20
Dinka, 169
Diola Fogny, 198
Dutch, 57–9, 69, 117, 207, 241, 268, 278–81, 300–1
Estonian, 334–5
Finnish, 200, 206, 255
French, 34, 124, 125, 138, 205, 241–2, 329
French, Acadian, 209–10
French, Quebec, 53, 70, 120–1, 124, 184, 215, 220–1, 245–6, 248, 325–8, 362–4
Garawa, 19, 101
German, 35, 40, 96, 201–2, 246–7, 293–5, 320–1
Greek, 53, 112–13, 161, 171, 216, 240, 284, 289–90
Hawaiian, 15
Hayu, 181
Hebrew, 69, 73, 77–9, 97, 109, 122, 125–6, 233, 244–5, 284
Hindi, 34–5, 37, 324–5
Hixkaryana, 169
Hopi, 21
Hua, 55
Hungarian, 17–18, 101, 270–3, 282
Igbo, 159–62, 223
Ilokano, 99
Indonesian, 178
Italian, 47
Italian, Northern, 286–9
Japanese, 98–9, 135–6, 190, 199, 241–2
Kannada, 134
Kiowa, 175
Kipare, 167
Kolami, 134
Korean, 205, 217–18, 301–9
Lardil, 100
Luo, 82
Luseño, 173
Mandarin, 33, 324–5
Mayan, Quiché, 123
Mohawk, 23, 94, 130
Navajo, 217
Norwegian, 78, A29333
Oriya, 165
Palauan, 300
Pali, 73
Persian, 17–18, 329–30, 333–4
Polish, 15, 20–1, 70, 163, 190, 192–3, 228
Portuguese, Brazilian, 165, 365
Portuguese, European, 53, 65, 84, 112, 322–3
Rotokas, 158
Salish, 169
Samoan, 61
Sidamo, 194
| Spanish, 8, 15, 80–2, 96, 122, 131–2, 153, 241, 314–18, 320–2, 325–6, 330–2 | Warao, 103 |
| Sundanese, 211 | Woleatan, 191 |
| Tahitian, 175 | Xhosa, 163, 184, 210 |
| Telugu, 59 | Yaka, 213 |
| Thai, 33, 34 | Yakuts, 56, 66 |
| Tiriyó, 19 | Yoruba, 223 |
| Tonkawa, 62 | Zuni, 158 |
Index of Terms

allomorph, 5, 266–9, 295–8
allophone, 7, 34–5, 202–4
alternation, 5, 265–7, 301–9
analogy, 270–3
assimilation, of place, 180–1, 217–18
babble, canonical, 44
babble, variegated, 46–7
bilingualism
  global rates of, 312
  early language differentiation, 318
  simultaneous vs. sequential, 313
  and transfer, 319–21, 336–7
bimodal distribution, 35–6
Cancellation/Domination Lemma, 345
candidate, 60, 74–7
category, phonological, 5–7
chain shift, 227–9
CHAT, 186
child-directed speech, see infant directed speech
CHILDES, 186
cluster reduction, see complex onsets, complex codas
coalessence, 177–9
coda clusters, 188–91, 192–9
coda conditions, 191, 194–9
coda, syllable, 12, 191, 194–9, 241
comparative tableau, 344
competence, vs. performance, 24–5
complementary distribution, 8, 34
complex codas, see coda clusters
complex onsets, 14–15, 65–72, 77–9, 322–5, 358
  stressed, 362–6
complex segments, 159, 162–3
comprehension, vs. production, 45, 278–81
consonant harmony, 210–16, 219–22
  child vs. adult grammars, 217–19
  lateral, 211–12
  major place, 214–16, 245–6
  nasal, 213–14
  regressive vs. progressive, 214–16
  triggers and targets, 214
constraint, 5, 63
contextual neutralization, see neutralization
dissimilation, major place, 218–19
dummy syllable, 133–8, 182–3
deletion, segmental, 54, 60–3, 67–8
diary studies, 88
discrimination, 29–31
dissimilation, major place, 218–19
dummy syllable, 133–8, 182–3
early bilingual, see bilinguals, simultaneous vs. sequential
elicitation, 144–5
end state, 339
epenthesis, 65–8, 74, 324–5
epenthesis, in plural marking, 267
error archive, 350, 373–5
error cache, 367, 373–5
error, in learning, 269–71
evidence, positive vs. negative, 340–3
exceptions, lexical, 250, 255–7
extragrammatical factors, 182
faithfulness, 62–6, 74–5, 85, 94, 109, 111–16, 122–3, 129, 156, 166, 173–4, 175–81
familiar words, vs. novel, 237–8
familiarity effect, 31
feature co-occurrence constraints, 156
feature, phonological, 8–10
filler, see dummy syllable
fission, 252
fixed segmentalism, 134–6
foot, 19–21, 97–100
fossilized forms, 253–5
INDEX OF TERMS

frequency
in constraint re-ranking, 363–4, 367, 372
in morpho-phonology, 280–1
lexical, 239–43
type vs. token, 35–6, 239
and typology, 159
of word-final consonants, 242
fricatives
onset, 170
repairs for, 171–4
functional load, 241
fusion, see coalescence
geminates, 199–200, 241
GLA, see Gradual Learning Algorithm
gliding (of sonorants), 162, 164–6
gloss, 134
Gradual Learning Algorithm, 360–6
harmonic bounding, 103, 128
Head Turn Preference procedure, 30
heavy syllable, 22, 99
iamb, 19, 39, 107, 124–6, 244–5
infant directed speech, 33
initial state, 339
input, 1, 51–2, 266–9, 298–301
insertion, see epenthesis
interdentals, late acquisition of, 155
interlanguage phonology, 337
intermediate stages, 361
intervocalic voicing, 202–3
inventories
in bilingual acquisition, 314–18, 330–2
acquisition of, 150–5
and frequency, 240–1
irregular morphology, past tense, 291–3
irregular morphology, plural, 293–5
iterative stress, see rhythmic stress
labial faithfulness, 176–7
laryngeal features, see voicing
late bilingual, see bilinguals, simultaneous
vs. sequential
learnability, 347
learning algorithm, 339
learning bias, 352, 362
lexical avoidance, 244–8
lexical selectivity, see lexical avoidance
lexicon, bilingual, 334–5
lexicon, mental, 4
light syllable, 22
loanword adaptation, 155
longitudinal studies, 88–9
loser, intended, 110, 343–4
main stress, see primary stress
manner of articulation, 9
mapping, 54
maximal word, 94, 98
metathesis, 193
minimal word, 23–4, 117–21
morpheme, 5, 265–9
morphological base, 283–4, 287–90
motherese, see infant directed speech
natural class, 8
neutralization, 201–6
nonce words, 270
novel words, vs. familiar, 237–8
novelty effect, 31
nucleus, syllable, 12–15
obstruent, 9–10, 68–71, 78–9, 157–8, 189, 192–8, 202–5
onset clusters, see complex onsets
onset, syllable, 12
optimal, 55, 60
order of acquisition, 59
order of acquisition, manner, 156–7
order of acquisition, voicing, 157–8, 164
OT, see Optimality Theory
output, 1
over-regularization, 290–5
paradigm uniformity, 284, 281–90
paradigm, morphological, 273, 282–90, 290–5
perception, 25–6, 140–1, 222–5
performance, vs. competence, 24–5
PHON, 186
phoneme, 7, 34–5, 202–4
phonological neighbourhood, 238
phonotactics, 4
place of articulation, 9
plural marking, English, 265–8
Praat, 373
preference, of a constraint, 344
productivity, morphological, 269
progressive idioms, 253
ranking, of constraints, 63
rate of acquisition, bilingual, 319–21, 336–7
reduplication, 62, 99, 138–40
regression, 249–53, 284
regular morphology, 291, 295–8
rendaku, 135–6
repair, phonological, 64, 68
re-ranking algorithm, 349–56
resolving an error, 346
restrictiveness, of a ranking, 350, 362
reverse wug test, 278–81
rhotics, 183–5
rime, syllable, 24, 113, 199–200
rule, phonological, 5
segment, 2
segmentation, word, 38–42
serial vs. parallel grammar, 87–8
sibilants, 174, 217
sonority, 9–10, 13, 68, 70–4, 74–7, 143, 170, 188–9, 194–6
spirantization, stop, 332
Stochastic OT, 368–72
stopping (of fricatives), 149, 169–71
stopping (of nasals), 167–9
stratum, constraint, 351
stress faithfulness, 111–17
stress shift, 114–16
stress shift, bilingual, 329
stress, 16–24
non-iterative, 20
paradigm uniformity and, 285–6
primary, 20, 95
quantity-sensitive, 21–2
rhythmic, 19
secondary, 20
strict domination, 64, 359
structural constraint, 60, 105
sublexicons, 256–7
surface representation, see output
syllabification of underlying forms, 85–6
syllable structure, 12, 52–60, 60–8, 80–3, 241, 319–25
synonyms, bilingual lexicon, 335
tableau, 60
target, 54, 150
targets vs processes, 150
templates, 258–62
transitional probabilities, 41
trochaic bias, 123
trochee, 19, 39, 96, 107, 123, 244–5
truncation, bilingual, 325–8
truncation, syllable, 94,
Tweety Bird, 149–50
ultimate attainment, 313
underlying form/representation, see input
unfaithful mapping, 265
unimodal distribution, 35–6
universals, phonological, 121–6
U-shaped development, see regression
variation, 51, 231–4
variation, in constraint re-ranking, 368–76
velar fronting, 149, 161, 174–5, 181–12
violation, of a constraint, 60, 63
vocabulary, receptive vs productive, 42–4,
voicing, 6–8, 164, 201–4, 316–18
vowel epenthesis, see epenthesis
vowels, xiii, 206–10, 333–4
weight, of syllables, see quantity sensitive
winner, intended, 110, 343–4
wug test, 269, 270–81