

# **The Contrastive Hierarchy in Phonology**

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## Acknowledgements

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## 1. Introduction

‘[D]ans la langue il n’y a que des différences...sans termes positifs.’

[‘In a language there are only differences, and no positive terms.’]

Ferdinand de Saussure, *Cours de linguistique générale* (1972 [1916]:

166)

### 1.1. Approaches to contrast

The notion of contrast has been central to linguistics since Saussure’s famous dictum, cited at the top of this chapter. ‘The sound of a word’, according to Saussure, ‘is not in itself important, but the phonetic contrasts which allow us to distinguish that word from any other.’<sup>1</sup> That is, a phoneme is identified not only by its positive characteristics — for example, the fact that it sounds like [i] — but also by what it is not — that is, by the sounds it contrasts with.

The notion of contrast can be understood at several different levels. At the most basic level, it can refer simply to whether two sounds contrast in a language or not. In English, for example, [i] is different from [ɪ], and these vowel sounds alone are able to differentiate words in the language: *sheep* [ʃip], for instance, is different from *ship* [ʃɪp]. This contrast recurs in many other word pairs, such as *cheap* ~ *chip*, *seat* ~ *sit*, *seen* ~ *sin*, *meal* ~ *mill*, *reed* ~ *rid*, and so on. Compare this

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<sup>1</sup> ‘Ce qui importe dans le mot, ce n’est pas le son lui-même, mais les différences phoniques qui permettent de distinguer ce mot de tous les autres’ (Saussure (1972 [1916]: 163). The English translation is by Harris (Saussure 1986: 116).

situation with that obtaining in Israeli Hebrew, which has a single phoneme in the part of the vowel space where English has two. This phoneme, which can be represented as /i, is pronounced somewhere between English /i/ and /ɪ/ (Chen 1972). In final open syllables it may be pronounced more like [i], in closed syllables it may tend more to [ɪ], but these sounds do not serve to distinguish words; that is, they play no contrastive role in the language. Chen (1972: 216) observes that the vowels in the English loan words *jeep* and *chips* are pronounced the same by many Hebrew speakers; because they fall in between the two English vowel phonemes, English speakers tend to hear them as [ɪ] in *jeep* (as in the first syllable of *gypsy*) and [i] in *chips* (as in *cheap*).

Acquiring the phonological contrasts of a language is one of the more challenging tasks of a language learner, and determining what the contrasts are is a basic aspect of phonological description, and a prerequisite to further analysis. In all the examples that follow I will assume that we know what the contrasts are at this most basic level.<sup>2</sup>

But there is much more to contrast between sounds, and phonologists have traditionally been concerned with further aspects of contrast. One can study the phonetics of contrast to see, for example, how perceptually salient the difference between sounds is. For example, the contrast between [i] and [u] is more perceptible than the contrast between [i] and [ɪ]. It is reasonable to suppose

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<sup>2</sup> This is not to say that it is a trivial matter to determine what the basic phonemes of a language are, or whether certain contrasts are predictable or must be encoded in the lexicon.



that good contrasts will be favoured in inventories over poor ones (Liljencrants and Lindblom 1972, Flemming 2004), and this fact could have synchronic and diachronic consequences. This is an interesting topic, which I will refer to as ‘phonetic contrast’, because it is concerned with the surface phonetics of contrasts between sounds.

However, the study of phonetic contrast has not been the central preoccupation of phonologists or phonological theory since Saussure. On the contrary, an influential current of phonological theory — the main stream, for much of the twentieth century — has held that the phonetics do not determine the way sounds pattern in the phonology of a language. In the very first issue of *Language*, in the seminal paper that popularized the term ‘sound pattern’, Edward Sapir wrote: ‘And yet it is most important to emphasize the fact, strange but indubitable, that a pattern alignment does not need to correspond exactly to the more obvious phonetic one.’ (Sapir 1925).

By ‘pattern alignment’ Sapir meant the arrangement of the phonemes of a language, their place in the phonological system. I will argue that the pattern alignment of a phoneme is a function of its contrastive properties; hence, according to Sapir and many other phonologists, the contrastive status of a phoneme is not determined by its phonetics. What does determine it? This is the topic of this book, what I will call ‘phonological contrast’. Phonological contrast refers to those properties of phonemes that are distinctive in a given

phonological system. In most theories of phonology, this means determining which features are contrastive and which are redundant.<sup>3</sup>

For example, given a language in which there is a contrast between /i/ and /u/, we want to determine, out of the various ways that these sounds differ, which particular dimension is the one most relevant to the phonology of the language. In a theory that posits features like [back] and [round], for example, the question arises whether /i/ and /u/ contrast with respect to one, or the other, or both, of these features.

Jakobson (1962 [1931]) discusses this question with respect to a number of Slavic vowel systems. He cites the observation of B. Hála that, except for a short front vowel *ä* that occurs in dialects of Central Slovak, the simple vowels of Slovak ‘correspond completely both in their production and in the auditive impression they produce to the vowels of Standard Czech’. Jakobson notes (1962: 224) that the presence of *ä* in Slovak, though ‘a mere detail from a phonetic point of view ... determines the phonemic make-up of all the short vowels.’ The ‘phonemic make-up’ of a vowel phoneme, like Sapir’s pattern alignment, can be equated with its contrastive properties. Jakobson diagrams the Czech and Slovak short vowels as in (1.1).<sup>4</sup>

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<sup>3</sup> Some phonological theories do not posit features in the classical sense, but some other set of primitives. Such primitives are also liable to enter into contrastive relations of the type discussed in this book.

<sup>4</sup> I have inverted and reflected Jakobson’s diagrams to the more familiar modern orientation of the vowel space, with high vowels at the top and front vowels to the left.

## (1.1) Czech and Slovak vowel systems (Jakobson 1962: 224)

## a. Standard Czech

i	u
e	o
a	

## b. Standard Slovak

i	u
e	o
ä	a

In Slovak there is a distinction between the low vowels /ä/ and /a/: the former is more front (acute, in terms of Jakobson's features), and the latter is more back (grave). In Czech the low vowel /a/ is not opposed to another low vowel. Therefore, even though the /a/ of Slovak and the /a/ of Czech are phonetically almost identical, in Slovak Jakobson considers it to pattern as a back vowel, whereas in Czech it is neutral with respect to tonality, having no contrastive value except for its height.

The Slovak contrast between the low vowels has consequences also for the status of the non-low vowels, according to Jakobson. Since this contrast does not involve lip rounding (flatness, in Jakobson's features), but only the front-back (acute-grave) dimension, then, presumably by symmetry or feature economy, this distinction may be assumed to hold also of the non-low vowels. That is, Jakobson proposes that the crucial contrast between /i/ ~ /u/, /e/ ~ /o/, as well as /æ/ ~ /ɑ/, is acuteness/graveness; flatness is not a distinctive feature in the Slovak vowel system. In support of this analysis, Jakobson cites the fact that Central Slovak speakers have little trouble learning to pronounce the French and German front rounded vowels *ü* and *ö*. That is, even though Slovak does not have front rounded vowels, the existence of a front/back contrast independently

of lip rounding allows Slovak speakers to combine this dimension with roundness in a new way.

In Czech, tonality is relevant only to the non-low vowels, and Jakobson suggests that the two dimensions of acuteness/gravity and flatness/non-flatness form an ‘indissoluble synthesis’. This analysis accounts for the difficulty Czech speakers have in reproducing the German or French front round vowels.

One might think, from these examples, that it is the shape of the inventories alone that determines the nature of the contrastive features. However, Jakobson’s further remarks on Russian show that this is not correct. For he observes that Standard Russian has five contrasting stressed vowels, phonetically similar to the five short vowels of Czech. But Russian vowels have front and back allophones determined by neighboring consonants. Therefore, he proposes that for the Russian non-low vowels the contrast of flat to non-flat (lip rounding) alone is contrastive. In the independence of the tonality features, Russian is more like Slovak than like Czech. The evidence is that Russian speakers ‘easily’ reproduce the foreign front round vowels *ü* and *ö*.<sup>5</sup>

Jakobson’s analysis of these vowel systems requires making a number of decisions: whether the non-low vowels contrast in backness, or roundness, or whether both features are inseparable; and whether the low vowels participate in these contrasts or not. Such decisions are not self-evident. More surprising, they have seldom been discussed explicitly. But this kind of contrast has been central

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<sup>5</sup> I am grateful to Wayles Browne for bringing Jakobson’s paper to my attention.

to phonological theory for a century, because of an abiding intuition that contrastive features are particularly important to the patterning of sound systems. If contrastive features play a special role in phonology, then we need to be clear about what they are and how to identify them.

Before continuing it may be worth returning to the issue of phonetics and sound patterns. Sapir's view that a pattern alignment may deviate from the phonetics was novel in 1925. Fifty years later it had become linguistic orthodoxy. In recent years the tide has shifted again. Much current work in phonology adopts the hypothesis that phonologies of languages are determined by phonetic principles (see for example, Pierrehumbert, Beckman, and Ladd 2000, and Hayes, Kirchner, and Steriade 2004). I will argue that this hypothesis is wrong. Without denying the contributions that phonetics can make to our understanding of sound systems, I will argue that the influence of phonetics, viewed apart from phonological contrast, has been over-stated.

Therefore, to understand the functioning of phonological systems we need to go beyond phonetics. In particular, I will argue that we need the approach to phonological contrast advocated here.

### *1.2. Two Poles: contrast (negative) vs. substance (positive)*

Linguistic theory has never actually adopted Saussure's position, as expressed in the dictum at the head of this chapter, in its pure form. If a phoneme is indeed to be defined purely in negative terms, as a unit in opposition to the other phonemes in the inventory, then the phonemes of different systems would

become incommensurable. For example, a phoneme /i/ in a three-vowel system /i a u/ would be an entirely different object from an /i/ that is part of a four-vowel system /i e a u/. Even two different three-vowel systems of the form /i a u/ could not be compared, since the contrasts in these systems would presumably not be identical. Thus, comparative and historical linguistics would become impossible, as any change in the nature of the contrasts in a system from one dialect to its neighbour, or from one historical stage to the next, would result in incomparable systems.<sup>6</sup>

Considerations of cross-dialect comparisons aside, it is simply not the case that linguistic units are characterized in purely negative terms. Though granting that what we call the phoneme /i/ in one language may differ in various substantive respects from the /i/ of another language, the symbol /i/ is not a purely abstract symbol devoid of any phonetic correlates. Designating a phoneme as /i/ suggests that it is realized as some sort of front high vowel. Similar observations hold for other linguistic units.

Alongside the view that phonemes are defined in purely negative terms, phonological theory has also contained the opposite tendency, and this, too, from the very beginning of modern synchronic linguistics. Bloomfield (1933) assumed that 'phoneme-features will be present in the sound-waves', and thus launched the search for phonetic 'invariants', the notion that a phoneme is characterized

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<sup>6</sup> Such considerations have been raised as a critique of a purely structuralist dialectology; see Kiparsky (1965) for discussion.

by certain acoustic cues. As was quickly observed, for example by Twaddell (1935), laboratory investigation had not revealed such cues up to then, and there was no reason to suppose they would ever be found. Twaddell then argued for a contrastive approach to defining the phoneme.

Throughout the history of phonological theory, then, there has been a recurring tension between these two views of how members of phonological inventories should be defined. At one pole, phonemes are defined negatively, in terms of how they contrast with other phonemes in an inventory. On this view, the types of oppositions a phoneme enters into are the most important determinants of its phonological behaviour. The other pole of this duality defines phonemes positively, as encoding substantive properties. These properties, on this account, are mainly what govern phonological behaviour, and the makeup of other phonemes in the system is of lesser importance.

The balance between the negative and positive approaches has been set differently at different times and in different schools of linguistics. If the formulations of Saussure and Bloomfield can be taken to represent each pole in a relatively pure form, then the theories of the Prague School represent a position in which they maintain a balance. Jakobson (1941) emphasized the oppositional nature of phonemes; but these oppositions are made in terms of distinctive features that have substantive content. For example, in his theory of how the system of distinctive features develops in the course of acquisition, Jakobson proposes that learners begin with an undifferentiated representation which first splits into a consonant (C) and a vowel (V). This formal opposition has phonetic

content: V represents a sound of greater sonority, and C one of lesser sonority. The first split among the vowels is then likewise one between a vowel of greater sonority (say, /a/) and one of lesser sonority (such as /i/).<sup>7</sup> When these oppositions are maximized, the optimal syllable turns out to be /pa/.

Similarly, Trubetzkoy (1939) appeals to both contrastive and substantive properties in characterizing segmental systems. An example is his discussion of the phoneme /r/ in a variety of languages. German has two liquids, /r/ and /l/, which form, in his terms, an isolated bilateral opposition; that is, they are set apart from all other consonants by being liquids, and the distinction between them is unique to this pair. Trubetzkoy observes (1939: 73) that the ‘phonemic content’ of German /r/ is ‘very poor, actually purely negative: it is not a vowel, not a specific obstruent, not a nasal, nor an *l*. Consequently, it also varies greatly with respect to its realization.’ He notes that some speakers pronounce /r/ as a dental vibrant, some as a uvular vibrant, some as a noiseless guttural spirant, and it varies a great deal in different contexts as well. By contrast, ‘Czech /r/ has a much richer phonemic content, as it stands in a relation not only to *l* but also to a special Czech phoneme *ř*: *r* and *l* are the only liquids, *r* and *ř* are the only two

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<sup>7</sup> The theory of van der Hulst 1993 is similar in spirit, extending the idea of a basic C~V contrast to the entire phonological system. Thus, consonants (C) split into C (obstruents) and V (sonorants), and each of these classes may be further divided into C and V groups. Similar divisions hold in the vowels. At every level V represents a more sonorous or vowel-like sound and C represents its contrasting term. The precise meaning of each C and V contrast depends on its context.



vibrants of Czech. *r* is distinguished from *ř* in that it is not an obstruent but a liquid; from *l* in that it is a vibrant. For this reason, Czech *r* is always, and in all positions, pronounced as a clear and energetically trilled sonorant.’ In Gilyak (1.2c), /*r*/ is opposed to a voiceless spirant, and the two fall into place as the dental members of a series of oppositions between voiced and voiceless spirants, from which it follows that Gilyak /*r*/ is always dental.

(1.2) /*r*/ in different languages (Trubetzkoy 1939)

a. German	b. Czech	c. Gilyak
<i>r</i> - <i>l</i>	<i>ř</i>	<i>v</i> <i>r</i> <i>z</i> <i>ɣ</i> <i>ɣ̣</i>
	<i>r</i> - <i>l</i>	<i>f</i> <i>ř</i> <i>s</i> <i>x</i> <i>x̣</i>

Trubetzkoy concludes that ‘the phonetic realization of *r*, the number of its variants, etc., can be deduced from its phonemic content.’

Trubetzkoy’s ‘phonemic content’, like Sapir’s pattern alignment and Jakobson’s phonemic make-up, can be understood as the sum of a phoneme’s contrastive features. For Trubetzkoy, too, a major concern was to establish what these contrastive features are, though he gives no explicit algorithm for doing so.

Though generative phonology was influenced by the Prague School and by American structuralism in various ways, the emphasis on contrast did not carry over into the developing theory exemplified by Chomsky and Halle’s *Sound pattern of English* (SPE, Chomsky and Halle 1968). Generative phonology has tended to emphasize the substantive aspect of phonological entities, and has downplayed the importance of contrast. More than that, the classic argument of Halle (1959) against the structuralist taxonomic phonemic level can be

understood as an argument against the relevance of the contrastive status of features as well.

Halle (1959) considers the voicing and devoicing of Russian obstruents when preceding another obstruent. Most Russian obstruents come in voiced and voiceless pairs, such as /t/ ~ /d/, /k/ ~ /g/, /s/ ~ /z/, and so on. A few obstruents, including /ts/, /tʃ/, and /x/, have no voiced counterpart. So whereas voicing and devoicing are neutralizing in most cases (in structuralist terms, morphophonemic processes, changing one phoneme into another existing phoneme), in the case of the unpaired obstruents they are allophonic rules, creating voiced sounds [dz], [dʒ], and [ɣ], that belong to no other phoneme. Despite this difference, Halle argues that the same rules of voicing and devoicing apply equally to the unpaired obstruents as well as to the paired ones, and that one would lose a significant generalization if one were to separate these rules into two different components of the grammar, as would be the case in neo-Bloomfieldian structuralist phonology.<sup>8</sup>

One could understand this argument — wrongly, I will contend — as bearing on the relevance of contrast to phonology. If we suppose that paired phonemes have a contrastive value for the feature [voiced], whereas the unpaired phonemes have no such contrastive feature, then it follows that same voicing and devoicing rules apply to and are triggered by contrastive as well as non-contrastive feature values. But the assumption that the unpaired phonemes

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<sup>8</sup> See Chapter 4 and Dresher 2005 for further discussion.

do not have a contrastive voicing feature is not necessarily correct. I will argue, in fact, that the evidence suggests that it is not correct in the case of Russian.

The general antipathy to contrast in generative phonology is exemplified also by Anderson's *Phonology in the twentieth century* (Anderson 1985), still the standard history of the field. The theme of this work is summed up in the subtitle, *Theories of rules and theories of representations*. The history of phonology, in this influential view, is about the tension between rules and representations. In Anderson's analysis, the early emphasis on contrast had, if anything, negative consequences on phonological theory.

Nevertheless, I will argue throughout that contrast is too central to be kept out of phonological theory for long, and I will show that it gradually leaked back into generative phonology in various forms. It is one of the aims of this work to reconnect phonology with its roots in this respect and to establish phonological contrast as a central principle of phonological theory.

### 1.3. *Plan of the book*

In chapter 2 I will look at contrast from a logical point of view. I will show that phonologists have followed two different and incompatible approaches in arriving at what the contrastive features in phonology are in any given case. I will argue on logical grounds that one of these approaches, pairwise comparison, is wrong, and that the other, the contrastive hierarchy, appears to be right.

In chapter 3 I look at how contrast is treated in the pioneering works of modern phonological theory, focusing on the work of Sapir and Trubetzkoy from

the 1920s and 1930s, and looking briefly also at some later work by Martinet, Jakobson and Lotz, and Hockett. I argue that early phonological theory largely adhered to what Hall (2007) calls the Contrastivist Hypothesis, which holds that phonological computation operates only on contrastive features. The method for assigning such features, however, remained unclear. I show that the two approaches identified in chapter 2 are found in the work of these theorists, sometimes coexisting, though often implicitly. A review of the relevant cases leads to the conclusion that pairwise comparison tends to predominate where an analysis is based on abstract theorizing with no real empirical consequences; but when a contrastive analysis is advanced to capture an empirical generalization, it tends to employ the contrastive hierarchy. This is as we might expect, if indeed pairwise comparison is a faulty method and the contrastive hierarchy is the correct way to determine contrasts.

Chapter 4 is devoted to the work of Roman Jakobson and his collaborators in the 1950s. In this work the contrastive hierarchy was proposed to be the only method to assign contrastive features to phonemes (a principle not always followed in practice). However, as the decade progressed, the contrastive hierarchy became disconnected from the Contrastivist Hypothesis, as other rationales came to the fore, and the emphasis changed from the contrastive function of features to the information theoretic roles of underspecification. Deprived of a connection to the empirical workings of the phonology, the contrastive hierarchy became vulnerable to arguments against underspecification in phonology and was soon abandoned.

Chapter 5 reviews the role of contrast in generative phonology. Having rejected underspecification and the Contrastivist Hypothesis, generative phonology required some other mechanisms for capturing the sorts of generalizations captured in earlier theories by the Contrastivist Hypothesis. I review three subtheories that arose to meet this need, markedness theory, underspecification theory, and feature geometry. Each of these subtheories does some of the work of the Contrastivist Hypothesis and contrastive hierarchy, but none serves as an adequate replacement for these.

Chapter 6 looks at contrast within Optimality Theory (OT). I argue, contrary to some claims, that OT is not in itself a theory of contrast; while OT is at home with feature hierarchies, I show that only certain types of hierarchies do the work of the contrastive hierarchy. I show how the contrastive hierarchy can be incorporated in to a serial version of OT.

Chapter 7 presents a series of case studies in support of the contrastive hierarchy and the Contrastivist Hypothesis, drawing on research done mostly at the University of Toronto over the last fifteen years. These studies also show the insufficiency of competing accounts, including purely phonetic approaches and accounts based on other ways of incorporating contrast into phonological theory.



## 2. The Logic of Contrast

[A] phonemic system presupposes a system of oppositions... But opposition is not exclusively a phonological concept, it is a logical one, and the role it plays in phonology is strongly reminiscent of its role in psychology. It is impossible to study phonological oppositions (of which phonemes are only the terms) without analyzing the concept of the opposition from the point of view of psychology and logic.

N. S. Trubetzkoy, 'A theory of phonological oppositions' (2001 [1936]: 15)

### 2.1. *Contrastive specification: an elusive problem*

It is far from obvious how to decide, for a given phoneme in a given language, which of its features are contrastive and which are not. The problem is made even more elusive by the fact that it does not appear to be difficult. In particular situations we may have intuitions about what the answer must be. But our common sense intuitions may lead us astray, in this area as in others. Or we may find that we can follow more than one logical chain of reasoning, each of which may appear to us to be sound, but which lead to different and incompatible conclusions.

To give something of the flavour of this problem, both its seeming obviousness and real difficulty, I would like to begin with a quote from

Anderson (1985: 96–97), a particularly careful writer. Here, he is illustrating Trubetzkoy's (1939) notion of *phonemic content*, intended to be the sum of the contrastive properties of a phoneme:

If we consider [English] /t/, for example, we can see that this segment is phonologically *voiceless* (because it is opposed to /d/), *non-nasal* (because opposed to /n/), *dental* (because opposed to /p/ and /k/), and a *stop* (because opposed to /s/ and to /θ/).

Anderson is not proposing a detailed analysis of English here; he is simply illustrating what some of the contrastive features of English /t/ would be in a Trubetzkoyan analysis, and presumably in any analysis of contrast that used these features. And yet, none of the features listed above are uncontroversially contrastive. Assuming that English /t/ and /d/ differ only in their laryngeal specifications, we could agree that /t/ is contrastively *voiceless*, though other laryngeal features are also possible: thus, /t/ and /d/ differ also in *aspiration* (/t/ is aspirated, /d/ is not), and in *tension* (/t/ has a tenser articulation than /d/), and it is not obvious which of these laryngeal features is contrastive in English. Similarly, we could agree that /t/ differs from /p/ and /k/ with respect to its place of articulation, but it is not obvious that this feature should be designated *dental* as opposed to the more general *coronal*.

The other contrasts are even more problematic. /t/ is opposed to /n/ not only in *nasality* but also in *voicing* (/t/ is voiceless, /n/ is voiced) and *sonority* (/t/ is an obstruent, /n/ is a sonorant): how do we know that nasality is the contrastive feature and not one of the others? And while /t/ differs from the



continuants /s/ and /θ/ in being a stop, it also differs from these phonemes in various other ways. For example, /t/ is *non-strident*, in contrast to /s/, and *apical* in contrast to /θ/. How do we know, then, that the contrastive features of /t/ are those designated by Anderson and not any of the alternatives?

This example is not intended to show that Anderson (1985) was being particularly imprecise; on the contrary, Anderson is more careful than most, and his discussion of the contrastive features of /t/ is entirely typical of what one finds throughout the literature. Anderson's choices are not obviously wrong, but it is not clear that they are right, either. More fundamentally, he provides no procedure for making such distinctions, nor does he discuss how such decisions were made in the history of phonology. Given the centrality of the issue in many phonological theories, this is a striking omission, in my view, and yet again entirely typical of most treatments of the subject. There has been much discussion of the *status* of contrastive representations in phonology; Anderson (1985), for example, is particularly concerned with the question of whether only contrastive features should be included in lexical representations, or all features. This has been a central issue in phonological theory, but it presupposes the answer to a more humble question: how do we decide which features are contrastive in any given segment?

We will see that this more basic question has been answered in different ways. One way proceeds from making pairwise comparisons between the segments of an inventory; the other involves successively dividing up the inventory by an ordered list of features. These approaches are not equivalent,

and typically yield different results. Both have a certain common-sense appeal; but I will argue that one of them cannot be correct.

To illustrate each approach, we will look at a very simple problem: how to specify the features that distinguish the three bilabial stops /p b m/, such as occur, for example, in Standard French. This problem has been treated by numerous authors over the years. To illustrate the two approaches, we will consider the analyses of Martinet (1964) and Jakobson and Lotz (1949). Both of these analyses emerge from the Prague School and share certain general background assumptions. But their approaches to contrastive specification are quite different.

## 2.2. *Contrastive specification by pairwise comparisons*

Martinet (1964: 62–64) considers how to isolate the relevant (i.e., contrastive) features of the Standard French consonants. To simplify the discussion we will focus here only on the bilabial stops /p b m/. Martinet proposes that /p/ is contrastively ‘unvoiced’; /b/ is ‘voiced’ and ‘non-nasal’; and /m/ is ‘nasal’. We can convert these specifications into two binary features, [voiced] and [nasal]: [+voiced] is equal to ‘voiced’, [–voiced] is equal to ‘unvoiced’, [+nasal] is equal to ‘nasal’, and [–nasal] is equal to ‘non-nasal’. In these terms, the specifications proposed by Martinet amount to those in (2.1).

(2.1) Contrastive specifications for French bilabial stops (Martinet 1964: 64)

	p	b	m
[voiced]	–	+	
[nasal]		–	+

How did Martinet arrive at these specifications? He did it by isolating those features that serve to distinguish phonemes that are minimally different in terms of their full feature specifications. To follow his reasoning, let us start with the full (not just the contrastive) specifications of the phonemes /p b m/ for the features [voiced] and [nasal], shown in (2.2).

(2.2) Full specifications for French bilabial stops

	p	b	m
[voiced]	–	+	+
[nasal]	–	–	+

We observe that /p/ and /b/ differ only with respect to the feature [voiced]. Therefore, by any definition, this feature must be contrastive in these segments; if it were absent, we could not distinguish /p/ from /b/. By the same token, /b/ and /m/ are distinguished only by the feature [nasal], which must, too, be designated as contrastive. Let us circle these two undisputedly contrastive features:

## (2.3) Circled features certainly contrastive

	p	b	m
[voiced]	⊖	⊕	+
[nasal]	–	⊖	⊕

What about the features that have not been circled? These are the features Martinet leaves out of his contrastive specifications, so evidently in his view they are not contrastive. He explains (1964: 65) why /m/ is not to be considered as contrastively [+voiced]:

It is likewise to be noted that...the segments /m n ñ/ are not only nasal but also voiced. However, here voice cannot be dissociated from nasality since in this position there are no voiceless nasals. This is why /m n ñ/ do not figure in the class of the ‘voiced’ elements, which are defined as such solely in virtue of their opposition to ‘voiceless’ partners.

By similar reasoning we can see why /p/ is not classed as ‘non-nasal’, even though it is phonetically non-nasal, just like /b/. It is because /p/, unlike /b/, has no nasal ‘partner’; such a partner would have to be otherwise identical to /p/, that is, a voiceless nasal stop /ᵐ/. Since there is no such phoneme in French, /p/ is not contrastively non-nasal.

This method proceeds in terms of pairwise comparisons. It designates as contrastive all and only features that serve to distinguish between pairs of phonemes. An explicit algorithm for extracting contrastive features by this

method was proposed by Archangeli (1988).<sup>1</sup> I will call this the Pairwise Algorithm, given in (2.4).

(2.4) Pairwise Algorithm (Archangeli 1988)

- a. Fully specify all segments.
- b. Isolate all pairs of segments.
- c. Determine which segment pairs differ by a single feature specification.
- d. Designate such feature specifications as ‘contrastive’ on the members of that pair.
- e. Once all pairs have been examined and appropriate feature specifications have been marked ‘contrastive’, delete all unmarked feature specifications on each segment.

Pairwise comparison seems to make sense, and it has been widely used in phonology (though seldom explicitly) as a way to isolate contrastive features. We can see it in the quotation from Anderson (1985: 96–97) above: the phoneme /t/ is opposed in turn to /d/, /n/, /p/ and /k/, and /s/ and /θ/.

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<sup>1</sup> Archangeli (1988) presents this algorithm as part of an argument *against* the sort of contrastive specification proposed by Steriade (1987). Her argument is that the algorithm is faulty, and hence so is contrastive specification. I will show that that while the algorithm, and the general approach it instantiates, are indeed faulty, contrastive specification does not necessarily depend on this approach. A more elaborate algorithm was formulated by van den Broecke (1976); see below for discussion.

### 2.3. *Contrastive specification by feature ordering*

The above analysis of the contrastive features of the Standard French bilabial consonants is not the only one in the literature. An entirely different analysis is given by Jakobson and Lotz (1949). As with the Martinet example above, I will focus only on their analysis of the bilabial consonants, extracting it from their larger analysis of the contrasts in the French consonant system. I will also modify their features to conform with the example we have been using; specifically, I will continue to use [voiced] in place of their *tense* (tense stops are voiceless, non-tense stops are voiced). With these adjustments, their analysis of the contrastive features for the bilabial consonants is as in (2.5).

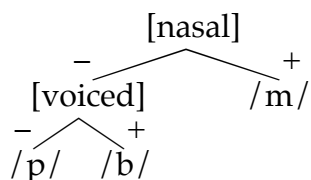
- (2.5) Contrastive specifications for French bilabial stops (Jakobson and Lotz 1949)

	p	b	m
[voiced]	–	+	
[nasal]	–	–	+

Notice that the contrastive specifications in (2.5) differ from Martinet's in (2.1) in that /p/ in (2.5) is specified as [–nasal], a specification omitted in (2.1). Jakobson and Lotz arrived at a different contrastive specification than Martinet because they used a different method. They themselves do not make their method explicit, but we can reconstruct it from later work by Jakobson and his collaborators. Rather than make pairwise comparisons of fully specified segments, they put all the potentially distinctive features into an ordered list, and divide the inventory successively on the basis of this list until every segment has

received a distinct representation. In this case they order [nasal] ahead of [voiced]. We will represent the ordering of feature [F] ahead of feature [G] by the notation '[F] > [G]'. We can represent the result of feature ordering by a tree, as in (2.6).

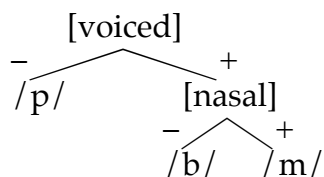
(2.6) Ordering of [nasal] > [voiced] applied to /p b m/



First we divide the inventory into two sets on the basis of the feature [nasal]: those phonemes that are nasal and those that are non-nasal. In the small inventory of bilabial consonants we are concerned with, /m/ is the only nasal consonant, and so is already distinct from the others. There are two non-nasal consonants, however, and they need to be distinguished by the feature [voiced], which is contrastive only in the [-nasal] set. Thus, we obtain the specifications in (2.5).

When we derive contrastive specifications from ordered features, the ordering makes a difference. To see this, consider what we would obtain if we reversed the order of the two features [voiced] and [nasal]. The results are shown in (2.7) in the form of a tree, and in (2.8) as a table of contrastive specifications.

(2.7) Ordering [voiced] > [nasal] applied to /p b m/



(2.8) Contrastive specifications with the ordering [voiced] > [nasal]

	p	b	m
[voiced]	–	+	+
[nasal]		–	+

This time we first divide the inventory on the basis of the feature [voiced]: /p/ is the only voiceless consonant, and so is already distinct from the others. There are two voiced consonants, however, and they need to be distinguished by the feature [nasal], which is now contrastive only in the [+voiced] set.

On this approach, contrastive specifications are determined by splitting the inventory by means of successive divisions, governed by an ordering of features (Jakobson, Fant and Halle 1952, Cherry, Halle and Jakobson 1953, Jakobson and Halle 1956, Halle 1959). An algorithm corresponding to this idea, the Successive Division Algorithm (Dresher 1998b, 2003a, 2003b, based on the work of Jakobson and his collaborators cited above), is given in (2.9):

(2.9) Successive Division Algorithm (SDA)

- a. In the initial state, all tokens in inventory I are assumed to be variants of a single member. Set  $I = S$ , the set of all members.
- b. i) If S is found to have more than one member, proceed to (c).  
 ii) Otherwise, stop. If a member, M, has not been designated contrastive with respect to a feature, G, then G is *redundant* for M.



- c. Select a new  $n$ -ary feature,  $F$ , from the set of distinctive features.<sup>2</sup>  $F$  splits members of the input set,  $S$ , into  $n$  sets,  $F_1 - F_n$ , depending on what value of  $F$  is true of each member of  $S$ .
- d. i) If all but one of  $F_1 - F_n$  is empty, then loop back to (c).<sup>3</sup>  
 ii) Otherwise,  $F$  is *contrastive* for all members of  $S$ .
- e. For each set  $F_i$ , loop back to (b), replacing  $S$  by  $F_i$ .

The algorithm in (2.9) is a very general formulation for defining contrast and redundancy for members of an inventory. It designates feature values as being contrastive or redundant in terms of an ordering of features, which I will call a *contrastive hierarchy*.<sup>4</sup> In this approach, contrast is a matter of *relative scope* or ordering of contrastive features.

#### 2.4. *Contrastive specification as a logical problem*

We have now seen two different approaches to deriving contrastive feature specifications. These are not simply two ways of arriving at the same answer; the fact that they yield different answers shows us that the methods are

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<sup>2</sup> This algorithm does not require any particular set of features. I assume that the set of relevant distinctive features is given by the theory of features, whatever that may turn out to be. By 'new' feature I mean one that has not already been tried. Thus, the value of  $F$  changes every time this step reapplies (I assume some mechanism for keeping track of which features have already been tried, but do not specify it here).

<sup>3</sup> That is, if all members of  $S$  have the same value of  $F$ , then  $F$  is not contrastive in this set.

<sup>4</sup> As far as I know, the earliest appearance of this term in print in this sense is in Walker 1993.

fundamentally different, and inconsistent with each other. In the example of the bilabial stop consonants characterized in terms of the features [voiced] and [nasal], pairwise comparison yields the contrastive representations in (2.1), and feature ordering gives the representations in (2.5). To be more precise, feature ordering can give us more than one answer, depending on how the features are ordered. In the above example, we obtain (2.5) in the ordering [nasal] > [voiced], and (2.8) with the ordering [voiced] > [nasal]. This is another important way in which the two approaches differ: given a phonemic inventory and a fixed set of features, pairwise comparison always gives the same answer (if it gives an answer at all); feature ordering can give different answers.

The flip side of contrast is *redundancy*, which is often equated with *predictability*: if, after we remove a feature, we can predict what it is, based on our knowledge of the inventory and the other features, then it stands to reason that it is redundant; and if it is redundant, it cannot be contrastive, so it would appear. This kind of reasoning, which I will argue is flawed, would appear to support the pairwise method. For both features omitted from the specifications in (2.1) are predictable from the other specifications, and can be filled in by redundancy rules as shown in (2.10).

(2.10) Contrast by pairwise comparison

a. Contrastive specifications

	p	b	m
[voiced]	–	+	
[nasal]		–	+

b. Redundancy rules

- i.  $[-\text{voiced}] \rightarrow [-\text{nasal}]$       ii.  $[+\text{nasal}] \rightarrow [+\text{voiced}]$

Let us define *logical redundancy* as in (2.11).

(2.11) Logical redundancy

If  $\Phi$  is the set of feature specifications of a member, M, of an inventory, then the feature specification [F] is *logically redundant* iff it is predictable from the other specifications in  $\Phi$ .

The omitted features in (2.1), repeated in (2.10a), are logically redundant in the sense of (2.11) because they are predictable from the other features, given this inventory. Thus, because /p/ is the only  $[-\text{voiced}]$  member of the inventory, its feature value  $[-\text{nasal}]$  is predictable by rule (2.10bi) ; similarly, the value  $[+\text{voiced}]$  for /m/ is predictable by rule (2.10bii) because /m/ is the only  $[+\text{nasal}]$  phoneme.

The specifications derived from feature ordering do not omit all logically redundant features. In the ordering  $[\text{nasal}] > [\text{voiced}]$  (2.5), /p/ is contrastively specified as  $[-\text{nasal}]$ , even though this specification is logically redundant, as we have seen. And in the order  $[\text{voiced}] > [\text{nasal}]$ , the value  $[+\text{voiced}]$  for /m/ is not omitted, though it, too, is logically redundant.

The concept of contrast that emerges from feature ordering, then, is not based on logical redundancy as defined in (2.11). Nevertheless, *in any particular feature ordering* some features are defined as redundant (equivalent to those features not designated as contrastive). To avoid confusion, let us call this type of redundancy *system redundancy* and define it as in (2.12).

(2.12) System redundancy

The feature specification [F] is *system redundant* iff it is not contrastive in terms of the method used for determining which features are contrastive in an inventory.

System redundancy is relative to a particular method for designating features as contrastive, whereas logical redundancy is fixed for a given inventory and set of features. Since a specification that is not logically redundant is not predictable under any procedure, it follows that the specifications designated as system redundant in any system of contrastive specification will also be logically redundant. The converse does not necessarily hold: a specification may be logically redundant but not system redundant, as we have seen. Many discussions of redundancy in phonology fail to distinguish the two types of redundancy, and this conflation of two different concepts can lead to considerable confusion.

Which approach to contrastive specification is correct? From the point of view of phonology, the question is ultimately an empirical one: which of these approaches, if any, yields representations that are significant in the phonology? The answer to this question could conceivably be 'neither', if in fact contrastive specifications play no special role in the phonology. I will continue to assume, however, that phonology is sensitive to contrastive specifications and that empirical evidence can be adduced to show that the feature ordering approach is correct. Evidence to this effect will be presented in the subsequent chapters, particularly chapters 3 and 7.

Putting this sort of empirical evidence aside for now, it was already recognized by Trubetzkoy 2001[1936]:15) that the question of contrast (what he called ‘the concept of the opposition’) is also a problem of psychology and logic. In the remainder of this chapter I will consider the logic of contrast. We will see that the pairwise approach suffers from severe logical problems. Feature ordering appears to be impeccable from a logical point of view, though it challenges us to order the features correctly for every language.

## 2.5. *Arguments against the pairwise approach to contrastive specification*

### 2.5.1. *Distinctness*

Let us consider the contrastive specifications in (2.1) a bit more closely. They are repeated here as (2.13) for convenience.

(2.13) Contrastive specifications by the pairwise method

	p	b	m
[voiced]	–	+	
[nasal]		–	+

Recall that these representations were derived by making a pairwise comparison between /p/ and /b/ on one side, and between /b/ and /m/ on the other. Each of these involves a minimal difference in one feature, which must therefore be contrastive. Let us call these *minimal pairs*, defined as in (2.14):

## (2.14) Definition of a minimal pair

Two members of an inventory that are distinguished by a single feature are a minimal pair.<sup>5</sup>

Minimal pairs play a crucial role in the pairwise approach. But let us now observe that there is in fact a third pairwise comparison we can make in (2.13), between /p/ and /m/. Are they properly distinguished in (2.13)? It is not obvious that they are. /p/ is characterized as being [–voiced] and /m/ is characterized as [+nasal]. Thus, they are not in contrast with each other along some common dimension. Where /p/ has a specification /m/ has none, and vice-versa. Their specifications look different, but they are not necessarily distinct. Without applying the redundancy rules, we would not in fact know if /p/ and /m/ are distinct from each other or not. But then we have failed in our attempt to represent all the relevant contrasts in the chart.

The representations in (2.13) would be ruled out by a criterion in the linguistic literature known as the Distinctness Condition, proposed by Halle (1959). He formulates it as in (2.15), and gives the examples in (2.16).

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<sup>5</sup> This kind of *featural* minimal pair differs from the usual sense of ‘minimal pair’ in linguistics, which is a pair of *words* that differ by a single phoneme: for example, *bit* and *pit*, or *cat* and *cap*. Determination of word minimal pairs does not require us to identify in what way one phoneme is crucially distinguished from another.

## (2.15) Distinctness of phonemes (Halle 1959: 32)

Segment-type {A} will be said to be *different from* segment-type {B}, if and only if at least one feature which is phonemic in both, has a different value in {A} than in {B}; i.e., plus in the former and minus in the latter, or vice versa.

## (2.16) Examples of distinctness and non-distinctness (Halle 1959: 32)

- a. {A} is not 'different from' {C}

	{A}	{B}	{C}
Feature 1	+	–	+
Feature 2	0	+	–

- b. All three segment-types are 'different'.

	{A}	{B}	{C}
Feature 1	+	–	–
Feature 2	0	+	–

By the terms of the Distinctness Condition, /p/ and /m/ in (2.13) are not different from each other. Therefore, the pairwise approach fails to contrast these elements of the inventory, and hence fails to provide an adequate set of contrastive specifications, according to the Distinctness Condition.

The Distinctness Condition has not been uncontroversial in linguistic theory, and some readers may question whether it is really necessary. Why *can't* the absence of a specification count as a value distinct from the presence of a value? After all, the system in (2.13) will result in three distinctly specified members once we apply the redundancy rules, so what is the problem?

The problem is that we are abusing the notion of contrast. Consider a language that has bilabial /p/ and /m/, but lacks /b/ (a fairly common situation, as many languages lack phonemic voiced obstruents). If asked to provide a contrastive specification of such an inventory, would anybody choose (2.17)? The relation between /p/ and /m/ in (2.17) is the same as that between /p/ and /m/ in (2.13); but without the middle member /b/ that forms minimal pairs with both of them, the specifications in (2.17) appear bizarre. It does not make sense to assert that one member in a two-member set is contrastively voiceless and the other is contrastively nasal. In contrast with what? If something is contrastively voiceless, it can only mean in contrast to something that is voiced, and the same holds for [nasal]: what is contrastively not nasal must be non-nasal (oral).<sup>6</sup>

(2.17) Contrastive specifications of /p/ and /m/?

	p	m
[voiced]	–	
[nasal]		+

What has gone wrong here? On further reflection, it appears that the chart in (2.13) results from a misconstrual of our original observations about the inventory. When we observed above that ‘/p/ is the only member that is [-voiced]’, what we had in mind was that once we made a contrast between /p/

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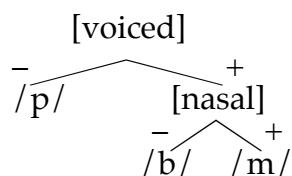
<sup>6</sup> Recall that we are using binary features. In a privative feature system, to be discussed below, the absence of a value acts like a value, and the conclusions drawn above do not hold.



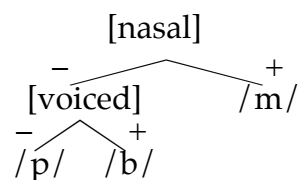
on one side ([−voiced]) and /b/ and /m/ on the other ([+voiced]), there is no need to further specify /p/ for [nasal]. The relevant contrasts can be pictured as in (2.18a). And when we observed that ‘/m/ is the only member that is [+nasal]’, we had in mind a picture such as (2.18b), where once /m/ is specified [+nasal] and /p/ and /b/ [−nasal], there is no need to further specify /m/.

(2.18) Two ways of viewing the contrasts

a. [voiced] > [nasal]



b. [nasal] > [voiced]



Thus, the observations that /p/ is the only voiceless member and /m/ is the only nasal member are correct, but in terms of contrastive force they derive from two different ways of cutting up the inventory, corresponding to the feature ordering approach. The ultra-minimal specification in (2.13) results from trying to put together two observations that derive from incompatible ways of dividing up the inventory. For this reason, it fails to adequately contrast /p/ and /m/.

### 2.5.2. *The problem of too many features*

Whatever one thinks of the Distinctness Condition and the above logical argument, the inventory in (2.17) shows us a fundamental problem with the pairwise approach: in many cases, there are too many logically redundant features. In (2.17), *every* feature specification is redundant given the others: in

/p/, [-voiced] predicts [-nasal] and [-nasal] predicts [-voiced], and in /m/, [+voiced] predicts [+nasal] and [+nasal] predicts [+voiced]. Thus, all four feature specifications are logically redundant, but they can't all be omitted! But this is what the Pairwise Algorithm (2.4) does in such situations: the inventory in (2.17) contains no minimal pairs, as defined above, because the two members differ from each other by two features, not by one. Therefore, no features are designated as contrastive, and all are removed. Clearly, removing all logically redundant features in this inventory does not work, and the Pairwise Algorithm fails in such cases.

The problem of too many features does not arise only in atypical inventories, but is ubiquitous, and affects almost every phonological inventory in some way. For example, it arises in the most common vowel inventories.

Consider first the most commonly attested vowel system, the five-vowel inventory /i e a o u/.<sup>7</sup> If we include only the features [high], [low], [back], and [round], we already have too many features for the pairwise method to function, as shown in (2.19).

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<sup>7</sup> According to the UPSID data base (Maddieson 1984), 68 of the listed languages (21% of the sample) have five-vowel systems, by far the highest number. Of these, 31 have the indicated inventory.

(2.19) Five-vowel system, features [high], [low], [back], [round]

a. Full specifications

	i	e	a	o	u
high	+	–	–	–	+
low	–	–	+	–	–
back	–	–	+	+	+
round	–	–	–	+	+

b. Contrastive specifications according to the pairwise method

	i	e	a	o	u	<i>Minimal pairs</i>
high	+	–		–	+	{i, e}; {o, u}
low						none
back						none
round						none

The only minimal pairs are {i, e} and {o, u}; the features [back] and [round] double each other for every vowel except /a/, making each other logically redundant, but not leaving behind enough features to make a contrast between /i, u/ and /e, o/, and leaving /a/ without any contrastive feature.

The same point applies a fortiori with the simple three-vowel system /i a u/. If we confine ourselves to two features, say [high] and [round], the vowels fall into minimal pairs and the pairwise method can assign them distinct representations.

(2.20) Three-vowel system, features [high], [round]

a. Full specifications

	i	a	u
high	+	–	+
round	–	–	+

b. Specifications according to the pairwise method

	i	a	u	<i>Minimal pairs</i>
high	+	–		{i, a}
round		–	+	{a, u}

Adding one more feature, say [back], wipes out the minimal pairs (2.21), causing the pairwise method to fail to distinguish them.

(2.21) Three-vowel system, features [high], [round], [back]

a. Full specifications

	i	a	u
high	+	–	+
round	–	–	+
back	–	+	+

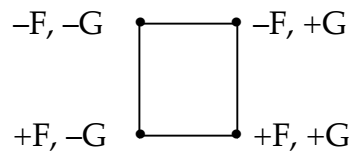
b. Specifications according to the pairwise approach

	i	a	u	<i>Minimal pairs</i>
high				none
round				none
back				none

### 2.5.3. *Minimal pairs and feature space*

We can approach the problem of algorithms that depend on minimal pairs by considering more generally how inventories fill out the available space of feature specifications. Two binary features,  $F$  and  $G$ , define a two-dimensional feature space with nodes at four possible values:  $[-F, -G]$ ,  $[-F, +G]$ ,  $[+F, -G]$ , and  $[+F, +G]$ . This space can be diagrammed as in (2.22).

(2.22) Space defined by 2 features



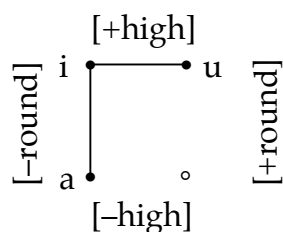
The lines connect nodes that are separated by one feature value. Such nodes, which we will call *neighbours*, are minimal pairs. In (2.22), each node has potentially two neighbours, and hence can form minimal pairs with two other members of the inventory, if they are present.

If an inventory completely fills the feature space, then it is guaranteed that the pairwise method will find sufficient minimal pairs to arrive at a contrastive specification. The pairwise method can tolerate some gaps in the feature space, as long as there are sufficient neighbours. For example, the inventory in (2.20) can be diagrammed as in (2.23), where  $\circ$  indicates an unfilled position.<sup>8</sup>

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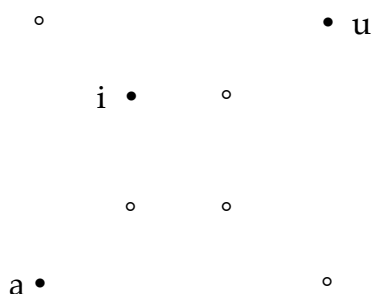
<sup>8</sup> Hall (2004, 2007) discusses in this connection the relevance of the information-theoretic adjacency graphs employed by Shannon (1993 [1956]).

## (2.23) Three-vowel inventory, features [high], [round]



We can observe graphically how adding the feature [back] isolates the members of the inventory in the larger feature space (2.24). The feature space in (2.24) is an expansion of the one in (2.23): the features [high] and [round] remain as before, but now the inside nodes are [–back] and the outside nodes are [+back]. The addition of the feature [back] exiles the [+back] segments /a/ and /u/ to the outer nodes, away from /i/ that had formerly connected them.<sup>9</sup>

## (2.24) Three-vowel inventory, features [high], [round], [back]




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<sup>9</sup> Readers familiar with the learnability literature will be struck by the formal resemblance of the Pairwise Algorithm to the Triggering Learning Algorithm (TLA) of Gibson and Wexler (1994). The TLA is also limited to following paths to immediate neighbours in a parameter space, and fails for much the same reason as the Pairwise Algorithm; see Dresher (1999) for discussion.

It follows, then, that the pairwise approach to contrastive specification fails in the simplest vowel systems, when all features are taken into account. The reason that this simple fact has not disqualified it long ago as a theory of contrast is that many analysts tacitly reduce the feature set to a minimal set. That is, if an inventory is classifiable using a proper subset of the full set of features, then the ‘extra’ features are quietly discarded until the set is minimal, but still able to distinguish every member of the inventory.

In such cases, the analyst chooses which logically redundant features to delete and which to retain. Such a choice implies some notion of a hierarchy, and is in fact a tacit use of the feature ordering approach. Therefore, even an algorithm formulated to remove redundancies from fully specified specifications must be supplemented by some device reminiscent of feature ordering, which orders the redundant specifications so that some take priority over others. That is, some notion of a feature hierarchy is required even in a pairwise approach to contrastive specification. But if a feature hierarchy is independently needed, there is no further rationale for the pairwise method, since the hierarchy can do all the work by itself.

#### 2.5.4. *The problem of too few minimal pairs*

In the type of case discussed above, the pairwise approach can be salvaged (again, ignoring violations of the Distinctness Condition) by removing features (that is, appealing to a feature hierarchy for this limited purpose) until a minimal set of features remains. But this approach fails in more spectacular ways when

faced with inventories that use a minimal set of features whose members do not fill the space of feature values in the right way. In such cases no feature may be removed from the set of relevant features specifying the inventory, but there are still not a sufficient number of minimal pairs to fuel the pairwise algorithm.

Consider again the common five-vowel system in (2.19), this time without the feature [round]. According to the pairwise method, this five-vowel system, fully specified for the features [high], [low], and [back] in (2.25a), would be underspecified as in (2.25b):

(2.25) Five-vowel system, features [high], [low], [back]

a. Full specifications

	i	e	a	o	u	
high	+	−	−	−	+	
low	−	−	+	−	−	
back	−	−		+	+	+

b. Specifications according to the pairwise method

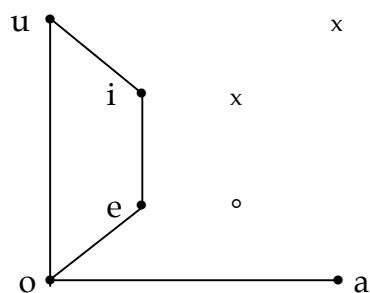
	i	e	a	o	u	<i>Minimal pairs</i>
high	+	–		–	+	{i, e}; {o, u}
low			+	–		{a, o}
back	–	–		+	+	{i, u}; {e, o}

That the pairwise method gives a contrastive specification at all, whether correct or not, is due to the connectedness of the paths through the space of three features being considered here. As before, we can model the space and the minimal pair paths through it with a diagram as in (2.26). The top four nodes are



[+high], the bottom four are [−high]; the four nodes on the left are [−low], the four on the right are [+low]; the inner four nodes are [−back], and the outer four are [+back]. An empty circle represents an unoccupied node, and x represents an impossible combination of [+high, +low].

(2.26) Five-vowel system, features [high], [low], [back]



Archangeli (1988) points out that not every five-vowel system can be assigned a contrastive set of specifications by the Pairwise Algorithm. An example of such an inventory is the vowel system of Maranungku (Tryon 1970). This vowel system is given in (2.27).

(2.27) Maranungku, features [high], [low], [back]

a. Full specifications

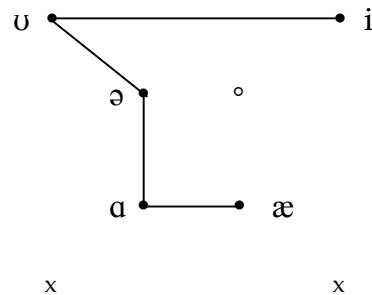
	i	æ	ɑ	ə	u
high	+	−	−	−	+
low	−	+	+	−	−
back	−	−	+	+	+

## b. Specifications according to the pairwise method

	i	æ	ɑ	ə	ʊ	<i>Minimal pairs</i>
high				–	+	{ə, ʊ}
low			+	–		{ɑ, ə}
back	–	–	+		+	{i, ʊ}; {æ, ɑ}

In this vowel system, /i/ and /æ/ have the same contrastive specification because they occupy parallel positions in a [back] contrast, but have no other neighbours that could further differentiate them in terms of the pairwise method. This situation is represented graphically in the diagram in (2.28). The top four nodes are [–low], the bottom four are [+low]; the four on the left are [+back], the four on the right are [–back]; the inside four nodes are [–high], and the outside four are [+high].

(2.28) Maranungku, features [high], [low], [back]



Now, if it were the case that Maranungku represented a relatively rare situation, one could argue that such examples are not serious problems for the pairwise method. One might reason the other way around: if the Pairwise Algorithm is correct, we expect that actual phonological inventories ought have sufficient minimal pairs. However, Hall (2004, 2007) argues that this expectation

is seriously misguided. For actual inventories do not aim for minimal phonetic contrasts, free of all redundant differences. On the contrary, there is much evidence that minimal phonological contrasts are *enhanced* by additional phonetic distinctions, or that members of an inventory are *dispersed* so as to maximize the perceptual salience of contrasts (see Chapter 7 for further discussion and references).

As Hall (2007: 165) demonstrates, the three-vowel inventory /i a u/ diagrammed in (2.24) is problematic for the Pairwise Algorithm because its members differ with respect to too many features. He shows that the algorithm would have no difficulty finding contrastive features for an inventory like /i ə ʊ/; but this type of inventory is non-existent, whereas /i a u/ is the most common three-vowel inventory. It appears that the Pairwise Algorithm rests on exactly the wrong assumption about real phonological inventories, which are designed to thwart an algorithm that relies on phonetic minimal pairs.

#### 2.5.5. *Extending the Pairwise Algorithm*

The pairwise approach as instantiated in the Pairwise Algorithm (2.4) identifies as contrastive only features that distinguish minimal pairs, and finds no contrastive features for members of an inventory that are distinguished by more than a single feature. There is no reason in principle why pairwise comparison must be limited in this way. To deal with situations where members of an inventory are distinguished by more than one feature, there must be a way of selecting one of them as being contrastive. The simplest way to do this is to order

the features, selecting the feature that is highest in the ordering. But this is to adopt feature ordering, and makes pairwise comparison superfluous.

A sophisticated version of pairwise comparison was devised by van den Broecke (1976: 33–34). He wrote a computer program that takes as input a phonological inventory with fully specified feature matrices, with the aim of arriving at a set of contrastive specifications. The first step of this algorithm is equivalent to the Pairwise Algorithm, except that for each pair of phonemes the program records every feature that distinguishes the two. As in the Pairwise Algorithm, features that uniquely distinguish a pair of phonemes are designated as contrastive for that pair.

But whereas the Pairwise Algorithm stops at this point, van den Broecke's program is just getting started. If a pair of phonemes is distinguished by more than one feature, but one of those features has already been marked as contrastive for another pair, then that feature is selected. If none of the distinguishing features has been marked as contrastive elsewhere, then the program creates several columns and in each column marks one of the features as contrastive and the others as redundant. These columns multiply as a function of the number of such choices. For example, for an English inventory of 48 phonemes characterized by 14 distinctive features, van den Broecke reports that the program generated up to 52 columns, with an average number of 10.5 columns per segment.

The next step in van den Broecke's procedure is to assign a relative weighting factor to each candidate contrastive feature based on the number of

columns in which the feature is listed as being obligatory. The feature with the highest weighting is selected as contrastive.

As van den Broecke (1976: 35) points out, the specifications arrived at in this fashion are based only on considerations of economy, and do not take phonological patterning into account. As a result, the specifications tend to be highly counter-intuitive and not the specifications that any phonologist would propose. For example, the major class features [vocalic], [consonantal], and [sonorant] are rarely marked as contrastive by this method, because they are predictable from more specific features, like [strident]. Thus, [sonorant] is marked as contrastive in only a single segment, /ð/, a typically strange result of this method.

Van den Broecke does not advocate this method for arriving at contrastive specifications; on the contrary, he presents it to show that attempts to remove redundant features based only on a notion of feature economy or minimality ( a criterion allied to logical redundancy, as it aims to reduce the set of specifications to a minimum) result in unnatural contrastive specifications that no phonologist would posit. I am unaware of any other attempt to apply an algorithm along these lines.

#### 2.5.6. *Summary*

The preceding sections have argued that the pairwise approach, despite its common-sense appeal, faces serious logical problems. In the cases where it yields a set of contrastive specifications that make all the segments look different, it is

not at all clear that the specifications are properly contrastive. More usually, the analyst must remove certain logically redundant features *before* making the pairwise comparisons, thus tacitly putting the features into a partial order. Finally, there are cases where pairwise comparisons simply fail to distinguish some members of an inventory even when the features are reduced to a minimal set. In short, the pairwise approach to contrastive specification is simply too problematic and too sensitive to the vagaries of the distribution of members of an inventory to serve as a principle for assigning contrastive specifications. While one can imagine ways of trying to extend the pairwise approach, the one extension I am aware of (van den Broecke 1976) results in bizarre specifications and has never actually been used in a phonological analysis.

## 2.6. *Feature ordering*

The feature ordering approach, instantiated by the Successive Division Algorithm, is not subject to these difficulties. As long as the members of an inventory can be distinguished by the full set of relevant distinctive features, the SDA is guaranteed to arrive at properly contrastive specifications. To see this, we will consider the various difficulties faced by pairwise comparison in turn.

First, all members of an inventory assigned contrastive features by the SDA are guaranteed to pass the Distinctness Condition. This was demonstrated by Halle (1959). Since the SDA works by successively splitting an inventory, and does not stop until each segment has been assigned a unique set of features, it is guaranteed that every phoneme will be distinct from every other phoneme in the

sense of the Distinctness Condition. In a sense, every time the SDA splits an inventory on the basis of a feature,  $F$ , it applies the Distinctness Condition with respect to  $F$ : assuming a binary feature, every member of the relevant inventory is assigned either  $[+F]$  or  $[-F]$ . Therefore, every phoneme in one set is distinct from every phoneme in the other set. Phonemes in the same set are not distinct with respect to  $F$  (or with respect to any feature ordered higher than  $F$ ); but since the procedure iterates, it is guaranteed that eventually every set will have just one member.

Second, the SDA does not depend on any particular distribution of the members of an inventory in feature space. No matter how sparse the inventory or how long the list of features, the SDA functions in the same way. It starts by selecting the first feature,  $F_1$ , in the list. If this feature is contrastive within the inventory, then the SDA splits the inventory into two sets (assuming binary features), one contrastively specified  $[+F_1]$ , the other  $[-F_1]$ . It is possible that this feature is not contrastive: it could be that the members of the inventory are all  $[+F_1]$ ; or all members are  $[-F_1]$ ; or  $F_1$  may not be relevant to the members of the inventory (in the case of features defined to apply in limited circumstances). In any of these cases, the SDA will move on to the next feature. As long as the full set of features is capable of characterizing each member of the inventory in a unique way, the SDA is guaranteed to find a unique set of contrastive features. Given a small inventory, the SDA will stop sooner; a larger inventory will require more splits. In every case, the SDA assigns a minimal set of specifications that meet the Distinctness Condition.

Therefore, I conclude that of the two methods for arriving at contrastive specifications, the pairwise method is inadequate on purely logical grounds, whereas feature ordering is logically sound. Of course, it remains to be shown that it has empirical support from the actual functioning of phonological systems.

This approach to contrastive specification imposes a task on language learners and analysts that pairwise comparison does not: it requires that the features be ordered. Although the feature order, or contrastive hierarchy, is crucial to the functioning of the SDA, it is not itself discovered by the SDA. Where does the ordering come from? I will return to this important issue in subsequent chapters.

## 2.7. *Contrast limited by position*

Up to here we have considered contrasts as being defined over the entire inventory: we have considered, for example, the contrastive specifications of phonemes /p b m/ as if these were fixed once and for all for the whole language. In languages, members of an inventory (be they phonemes or morphemes or other systematic units) are arranged into *sequences*. Once we have sequences, we can define *positions*, and we open the possibility that contrasts may be defined relative to certain positions. The sequential axis has been called *syntagmatic*, as opposed to looking at the choices available in a particular position, the *paradigmatic* axis.



Phonotactic restrictions can alter the set of contrasts at particular positions in a language. English, for example, observes the restriction that in an initial sequence of three consonants the first consonant must be *s*: hence, *splash*, *stretch*, *squat*, are well-formed words, but no English word results from substituting another consonant for *s* in these examples. If we evaluate the contrastive status of *s* in this position only, it would suffice to specify it as [+consonantal].

Should we evaluate contrasts globally or by position? And if by position, how do we define the positions? In the above example we singled out a position before two consonants and following a word boundary; clearly, there are many other possible positions of varying degrees of specificity. We could, for example, focus on initial single consonants in monosyllables (*pick*, *tail*, *comb*, *fuse*, etc.), or limit the vowel to [ɪ] (*pick*, *rig*, *win*, *fill*, etc.), or further limit the final consonant to [k] (*pick*, *tick*, *wick*, *sick*, etc.). As in other matters concerning contrast, phonologists have not been consistent in this regard.

A rather extreme example of limiting contrasts to narrowly-defined positions is provided by Twaddell (1935). Twaddell proposed to define phonemes in terms of minimal contrasts, limited to particular positions. The first step is to isolate units that participate in minimal contrasts and characterize them in terms of their articulatory differences (2.29a), such as the series in (2.29b). Within each class, articulatory differences must be distinguished from the similarities (c). Each series defines a set of *micro-phonemes*. Twaddell observes that the micro-phonemes of Class I and Class II, characterized by the differences among terms in each series, are similarly ordered. Factoring out the difference in

aspiration of initial voiced and voiceless stops as being predictable, we can line up the micro-phonemes in Classes I and II as in (d).

‘The sum of all similarly ordered terms (micro-phonemes) of similar minimum phonological differences among forms is called a macro-phoneme’ (Twaddell 1935: 73 in Joos 1957). The common terms of Class I and II show that initial and final stops can be combined into a macro-phoneme, so that initial [p<sup>h</sup>] is part of the same macro-phoneme as final [p-]. However, the same does not hold for stops following /s/. Since a contrast between voiceless and voiced stops is lacking in this position, the three-member list of differences in Class III cannot be aligned with the four-member lists of Classes I and II. According to Twaddell (1935: 75), ‘The stops of ‘spill, spare’, etc. are significantly bilabial and stop, but not significantly voiceless; the stops of ‘pill, nap, tapper’, are significantly bilabial, stop, and voiceless.’ For similar reasons it follows from this procedure that nasals in initial position are different phonemes from those in final position, because the former participate in a two-way contrast, whereas the latter form a three-way contrast.

(2.29) Defining phonemes in terms of minimal contrasts (Twaddell 1935)

a. Articulatory components (partial list)

1. bilabial 2. aspirated 3. voiceless 4. exploded stop 5. alveolar
6. palato-velar 7. voiced 8. unaspirated 9. unexploded stop

## b. Minimal contrasts

<i>Class I</i>		<i>Class II</i>		<i>Class III</i>
<b>pill</b>	1 - 2 - 3 - 4	<b>nap</b>	1 - 8 - 3 - 9	<b>spill</b> 1 - 8 - 4
<b>till</b>	5 - 2 - 3 - 4	<b>gnat</b>	5 - 8 - 3 - 9	<b>still</b> 5 - 8 - 4
<b>kill</b>	6 - 2 - 3 - 4	<b>knack</b>	6 - 8 - 3 - 9	<b>skill</b> 6 - 8 - 4
<b>bill</b>	1 - 8 - 7 - 4	<b>nab</b>	1 - 8 - 7 - 9	(* <b>sbill</b> )

## c. Differences (micro-phonemes) and similarities

<i>Class I</i>		<i>Class II</i>		<i>Class III</i>
<b>pill</b>	(1-2-3) - (4)	<b>nap</b>	(1-3) - (8-9)	<b>spill</b> (1) - (8-4)
<b>till</b>	(5-2-3) - (4)	<b>gnat</b>	(5-3) - (8-9)	<b>still</b> (5) - (8-4)
<b>kill</b>	(6-2-3) - (4)	<b>knack</b>	(6-3) - (8-9)	<b>skill</b> (6) - (8-4)
<b>bill</b>	(1-8-7) - (4)	<b>nab</b>	(1-7) - (8-9)	

## d. Macro-phonemes (partial)

<i>Class I</i>		<i>Class II</i>		<i>Class III</i>
<b>pill</b>	(1-3) - (2)	<b>nap</b>	(1-3)	<b>spill</b> (1)
<b>till</b>	(5-3) - (2)	<b>gnat</b>	(5-3)	<b>still</b> (5)
<b>kill</b>	(6-3) - (2)	<b>knack</b>	(6-3)	<b>skill</b> (6)
<b>bill</b>	(1-7) - (8)	<b>nab</b>	(1-7)	

## e. Initial nasals: {m, n}

map - nap

## Final nasals: {m, n, ŋ}

sum - sun - sung

In this theory, there is no such thing as a phoneme /n/ in English: there is an initial (including medial) /n/, and a final /n/. These may be phonetically very similar, but phonemically they are different.

Twaddell's algorithm is presented only with partial examples. So the series of initial stops is not limited to {p-t-k-b}, but also includes *d*, *g*. But why limit it to stops? Why not include all initial consonants? The procedure is also very sensitive to accidental gaps: it follows, for example, that [p<sup>h</sup>] in *pig* {*pig* - \**tig* - \**kig* - *big*} is not part of the same macro-phoneme as [p<sup>h</sup>] in *pill*, which appears to be an undesirable result. Unless the sets of relevant positions can be somehow limited in reasonable ways, positionally-limited contrastive evaluation can get out of hand.

Therefore, for the most part I will continue to assume that contrasts are defined globally for phonemes in inventories. However, we will return to this topic in Chapter 7, where we will see that there is a place for positionally-defined contrasts in phonology.

## 2.8. *Types of features: equipollent and privative*

We have looked at how to determine which features are contrastive in the members of an inventory, and which features are redundant. In this section we will consider the nature of the features themselves, still keeping to logical aspects of the problem. Up to here I have assumed that all features are binary. It is also possible to have *multi-valued* features, either *discrete* or *continuous*. There have been proposals that multi-valued, even continuous, features play a role in linguistic theory (Broe and Pierrehumbert 2000, Pierrehumbert, Beckman and Ladd 2000). Nevertheless, I will continue to assume that phonological features are discrete and mainly binary.

There are different kinds of binary features. The kind discussed above have two values, one positive and one negative. As long as we do not attribute special status to + or –, the two values of a binary feature have equal status. To borrow the Prague School term (Trubetzkoy 1969), such features are *equipollent*.

The +F ~ –F notation introduces an inherent asymmetry, however: [+voiced] feels psychologically different than [–voiceless], because each names the feature after a different one of its values. It is a small step to suppose that the two values are not equal in status. One could be the *default*, or *unmarked*, value, and the other could be the *marked* value. The terms ‘marked’ and ‘unmarked’ are also borrowed from the Prague School, who took it somewhat literally, as meaning that an unmarked feature value is simply not indicated, whereas a marked value is indicated by a mark. This kind of contrast can be represented as  $\emptyset \sim F$ , where  $\emptyset$  represents the *absence* of a mark and F is the marked value. In Prague School terminology, this kind of binary contrast is called *privative*.

Privative contrasts impose more structure on representations than equipollent ones, and hence require more information. To make an equipollent contrast between nasal and oral, it is enough to write [+nasal] ~ [–nasal], or, equivalently, [–oral] ~ [+oral] (which name we choose has no significance). To make a privative contrast, we have to decide which is the marked feature.

Privative features act differently from equipollent ones with respect to contrast. For the sake of discussion, let us suppose that the marked values for the features [voiced] and [nasal] are the positive values in both cases. The *full* (not

contrastive) specifications of the simple inventory in (2.2) will now look like (2.30).

(2.30) Full specifications: privative features

	p	b	m
[voiced]		✓	✓
[nasal]			✓

In the fullest possible set of specifications, /p/ is completely unmarked, and has no specifications. Looking at the inventory as a whole, the ‘full specifications’ of (2.30) look like very minimal contrastive specifications. However, these are not contrastive specifications in the sense of the previous section.

What effect does contrastive feature ordering have on the specifications in (2.30)? Let us consider again the two ways of ordering the features. If [voiced] is the first feature, we mark /b/ and /m/ for this feature and leave /p/ unmarked. The next feature, [nasal], distinguishes between /b/ and /m/, and marks /m/ as [nasal]. Now we have the specifications in (2.31a), which are the same as in (2.30). That is, the contrastive specifications are the same as the full specifications in this ordering of the features. Proceeding in the other order, we first mark /m/ [nasal] in contrast to /p/ and /b/, which are unmarked; we then draw a contrast between /p/ and /b/ by marking /b/ [voiced], deriving the contrastive values in (2.31b). In this order, one specification is omitted relative to the full specification.



members of a contrast receive a feature value, leaving it unclear which of the phonemes that are unmarked for a feature are in the scope of the contrast and which fall outside it. It follows that if it is important to know the scope of a contrast and which segments it affects in a privative feature system, we will have to keep track of this information with some machinery in addition to the representations themselves.

## 2.9. *Contrast and underspecification*

There is a natural, but by no means necessary, connection between contrast and underspecification. In a theory where contrastive feature specifications are assigned hierarchically by the SDA, it is natural to suppose that contrastive specifications are specified and redundant specifications are unspecified.

Consider again our example of bilabial stops /p b m/, assuming an ordering [nasal] > [voiced]; the contrastive specifications are as in (2.5). It is natural to assume that the contrastive feature values in (2.5) are specified whereas the redundant values (in this case, the feature [+voiced] for /m/) are unspecified. This is not necessarily the case, however. We have seen that it is not necessary for all contrastive values to be specified. In a privative feature system, only *marked* contrastive values are specified, as in (2.31b).

In (2.31), representations are underspecified beyond the requirements of contrast, by omitting also unmarked contrastive specifications. The converse is also theoretically possible: representations may be specified over and above the requirements of contrast. Thus, it is possible to interpret the SDA not as an



algorithm that *assigns* feature values in contrastive fashion, but rather as an algorithm that *designates* which values are contrastive. In such a theory, all possible feature values are always present, but some of them are designated as being contrastive. In this kind of theory, the specifications in (2.5) can be viewed as shorthand for the more complete listing in (2.33); specifications designated  $_C$  are contrastive.

(2.33) All specifications, [nasal] > [voiced], C = contrastive

	p	b	m
[voiced]	$\neg_C$	$+_C$	$+$
[nasal]	$\neg_C$	$\neg_C$	$+_C$

We can take a similar approach to markedness; rather than assume that only marked values are specified, as is the case with privative features, we can designate which values of each feature are marked, as in (2.34). In such a theory, the phonology has the option of targeting all features, or contrastive features, or marked features; this is the approach of Calabrese (2005) and Nevins (2004).

(2.34) All specifications, [nasal] > [voiced], ], C = contrastive, M = marked

	p	b	m
[voiced]	$\neg_C$	$+_{C,M}$	$+_M$
[nasal]	$\neg_C$	$\neg_C$	$+_{C,M}$

## 2.10. Conclusions: one approach to contrast left standing

In this chapter we have looked at how we might determine which features are contrastive in a given phoneme. I have identified two approaches to this

question: the pairwise approach, based on making comparisons of fully specified phonemes with special attention to minimal pairs, and contrastive specification by feature ordering. The pairwise approach identifies as contrastive only specifications that are not logically redundant. While this may seem to be a point in its favour, I have argued that it is actually the source of a number of insurmountable problems.

The feature ordering approach, on the other hand, poses no logical difficulties. This approach is based on the notion that the scope of a contrast depends on where a feature is ordered in the hierarchy: features ordered higher up take wider scope than features ordered lower down. The feature ordering approach is not dependent on any particular distribution of minimal pairs, and separates the notions of logical redundancy and system redundancy.

Another difference between the two approaches is that pairwise comparison always produces the same results, given an inventory and a set of features, whereas feature ordering can give different results depending on the ordering. Again, this property might at first seem to favour pairwise comparison, for it is automatic and imposes less of a burden on the analyst as well as on the learner, who must determine the correct ordering of features in the latter approach. I will argue, however, that the advantage here again is on the side of feature ordering, for there is empirical evidence that similar-looking inventories can indeed have different contrastive specifications.

I conclude, then, that feature ordering must be the basis of any theory of phonological contrast.

Another issue in the determination of contrast involves the syntagmatic dimension, the extent to which contrast is evaluated globally over an inventory or is tied to particular positions. From a logical point of view there is no way to decide this question. I will argue later that there are practical constraints that limit the degree to which contrasts can be tied to particular syntagmatic contexts; but where these constraints do not hold, there is evidence for contrasts limited to certain positions.

An issue orthogonal to the evaluation of contrast is the question of whether features are equipollent or privative. This issue has important implications for the identification of contrasts and the scope of a contrast. Also orthogonal to contrastive specification is whether redundant features are entirely absent from the phonology.

A study of the logical problem of contrast can take us only so far. The important question, from the point of view of phonology, is what role, if any, contrastive specifications actually play in phonological theory, and the extent to which a theory of contrastive specifications helps to illuminate phonological phenomena. In the next chapter we will find some preliminary answers to these questions in the work of some major figures in the formative years of phonological theory.



### 3. Contrast in Structuralist Phonology

‘And yet it is most important to emphasize the fact, strange but indubitable, that a pattern alignment does not need to correspond exactly to the more obvious phonetic one.’

Edward Sapir, ‘Sound patterns in language’ (1925)

#### 3.1. *Introduction*

In the preceding chapter I identified two basic approaches to contrastive specification in phonology, and discussed their status from a logical point of view. I argued that pairwise comparisons based on full specifications has severe logical problems, whereas contrastive specification by feature ordering is logically sound. I showed that Martinet’s (1964) analysis of Standard French bilabial stops can be viewed as an example of the former approach, and that Jakobson and Lotz’s (1949) analysis of the same phonemes exemplifies the latter approach.

In this chapter I will review some work in structuralist phonology that bears on this issue. This chapter has three main aims. First, I wish to show the extent to which contrastive specification was central to the project of phonological theory in its formative years, roughly the period 1925–1950. Though the authors I will survey are central figures in the field whose work has been widely read, I believe that this work has been misconstrued in various ways. There are several reasons for this. First, the authors sometimes use

terminology that is unfamiliar to contemporary readers. Second, they are not always very explicit about how their theory is supposed to work, and in some cases, their writings do not add up to a consistent theory. Third, we tend to read these works through the prism of our own preoccupations, with the result that we do not see what is hiding in plain sight.

The second aim of this chapter is to investigate in detail the narrower question of how these phonologists determined which features of a phoneme are contrastive in a given language; that is, how they arrived at contrastive specifications. One might come away from the previous chapter with the impression that Martinet and Jakobson represented two different theoretical positions (pairwise comparison versus feature ordering), and one might expect to see arguments for and against these positions. However, this impression would be incorrect. I will show on the contrary that explicit procedures for determining contrasts were not formulated, and the authors I survey did not adopt clear-cut or even consistent positions on this issue. Nevertheless, it is possible to see the workings of the two basic approaches to contrast in this work.

This review of early work in phonology proceeds not just from a historical interest. The third and most important aim is to recover fundamental insights into the nature of contrast and its role in phonology that should form a part of contemporary phonological theory. To this end, I will show the existence of what appears to be a recurring pattern: when these theorists were thinking abstractly about contrast, they tended to assume something like pairwise comparison; but when they had empirical reasons for proposing contrastive specifications, they

tended to apply something like feature ordering. This result supports the findings in the previous chapter that feature ordering is the only viable approach to contrastive specification. Moreover, we will see that it is indispensable to accounting for phonological patterning.

### 3.2. *Sapir: phonetics versus phonological patterning*

A central theme in the work of Edward Sapir is the distinction between a phonetic description of the sounds of a language and the way these sounds ‘pattern’ in the phonology (Sapir 1925, 1933). Sapir emphasizes that the phonological patterning, or ‘pattern alignment’, can be different from what we might expect from the phonetics. But what does Sapir mean by ‘sound pattern’? Through the prism of generative phonology, this term is usually understood to be the collective set of rules and representations that make up the phonology of a language. And while this is true in a general sense, it can be argued that the ‘pattern alignment’ of a phoneme refers most narrowly to the set of its contrastive properties.

Sapir (1925) presents interesting examples of how systems that appear to be phonetically similar pattern very differently (languages A and B), and, conversely, how languages that may appear to be phonetically quite different can be very similar in their phonemic patterning (languages C and D). The languages

are constructs of Sapir's, though they are based on cases with which he was familiar. Sapir's languages C and D are shown in (3.1).<sup>1</sup>

(3.1) Different phonetics, similar patterning (Sapir 1925)

a. Pattern of C

a	ε	i	u			
a:	ε:					
h		w	j	l	m	n
p	t		k	q		
b	d		g	G		
f	s		x	χ		

b. Pattern of D

æ	e	i	ü			
æ:	e:					
h		v	ʒ	r	m	ŋ
p <sup>h</sup>	t <sup>h</sup>		k <sup>h</sup>	q <sup>h</sup>		
β	ð		ʏ	ɤ		
f	ʃ		ç	ħ		

Sapir points out that if one were to be guided only by phonetics, one might suppose that [ʒ] in Language D should be listed under [ʃ] as its voiced counterpart, just as [b] is placed under [p] in system C. Similarly, we might

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<sup>1</sup> I have changed some of Sapir's phonetic symbols to accord with current usage. I use V: to indicate a long vowel instead of Sapir's V', and C<sup>h</sup> rather than C' to represent an aspirated consonant. Next to q, Sapir writes '(velar k)', and similarly for all the obstruents in the fourth column. I assume he means uvular rather than velar. I use G for Sapir's g, χ for x, and ø for y. I also use ʒ in place of Sapir's j, ʃ for š, ð for δ, and ç for x. I assume ü is IPA æ.



expect that [v] in D should be placed under [f] as its voiced counterpart. Sapir allows that the ‘natural phonetic arrangement’ of sounds is a useful guide to how they pattern, but he goes on Sapir (1957: 23), ‘[a]nd yet it is most important to emphasize the fact, strange but indubitable, that a pattern alignment does not need to correspond exactly to the more obvious phonetic one.’

It is worth inquiring a bit more closely into the significance of Sapir’s inventory charts. We observe first that he specifies no features or other substantive specifications of the listed sounds (except for the parenthetical comments about the obstruents in the fourth column). Therefore, the basis of the similarities in the patterns of C and D is, in the first place, in the typographical arrangement of the sounds. C and D have isomorphic patterns because each segment in one corresponds to a unique segment in the other, and the relative position of each segment in the pattern is the same as that of its correspondent.

But what is the meaning of these typographical layouts? They surely imply some phonological feature specifications, though these are not listed explicitly. Moreover, by arranging the systems of C and D isomorphically, Sapir is suggesting that the specifications for the two languages are parallel, if not identical. He writes (1957: 234) that the reasons for placing [ʒ] (which he represents as *j*) in D where it is may have to do with the alternations it enters into (it might alternate with /i/ but never with /š/), or the phonotactic combinations it enters into (for instance, that *v*- and *ʒ*- are possible initials, like /r, m, ŋ/, but that /β, ð, ɣ, ɤ/ are not). He continues, ‘In other words, it “feels” like the *y* of

many other languages, and as *y* itself is absent in D, we can go so far as to say that *j* [= [ɟ]] occupies a “place in the pattern” that belongs to *y* elsewhere.<sup>2</sup>

The notion of ‘place in the pattern’ can be interpreted in a number of ways. One interpretation in terms of generative theory is that the corresponding segments in C and D have the same underlying specifications, which, in classical generative phonology, are full, not contrastive, feature specifications. Thus, we could understand Sapir to be suggesting that the lexical (underlying) phonological specifications of the phonemes /v/ and /ɟ/, that appear to be in the wrong place in the pattern of D, are to some extent at odds with their phonetics. In derivational generative terms, we can justify their positions in the pattern of D by assuming that they are specified as sonorants rather than obstruents, just like /w/ and /j/ in C, and assume their phonetic forms by late rules that alter some of their specifications. On this interpretation, /v/ and /ɟ/ in D correspond to /w/ and /j/ in C because they *are* those sounds at an abstract level of analysis.

While such an analysis is tenable in these cases, it does not extend to the rest of the phonemes whose phonetics do not deviate so spectacularly from their positioning in the phonological pattern. According to Sapir, /b/ occupies a place in the pattern of C that corresponds to the place of /β/ in D. In this case we have no reason to suppose that one of these sounds derives from the other. Looking at their fully specified lexical representations would not show us in what way they

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<sup>2</sup> Sapir’s *y* is a front high glide, equal to IPA [j].

can be said to occupy the same position in the pattern of their respective languages. Rather, in this case, we must understand the notion of 'place in the pattern' to refer to the contrastive role of speech sounds. What /b/ in C and /β/ in D have in common is that they are both the only voiced labial obstruents in their respective languages; no further specifications are required to distinguish them from every other phoneme. That /b/ is also a stop whereas /β/ is a fricative is not relevant to their contrastive positioning, in this analysis.

Similarly, /l/ in C corresponds to /r/ in D because each is the only liquid in the language, and /n/ in C corresponds to /ŋ/ in D by being a non-labial nasal consonant.

More generally, both languages C and D can be said to have a series of contrastively voiceless stops (with redundant aspiration in D), a series of contrastively voiced obstruents (which are redundantly stops in C and spirants in D), and a series of contrastively voiceless spirants. Both languages contrast four places of articulation for each obstruent series, roughly, labial, coronal, dorsal, and post-dorsal, with further specification within these broad place categories not being important to the phonological patterning of the system.

Similar considerations hold for the vowels. Both languages have two high vowels, one unrounded and the other rounded; whether the latter is front or back is not significant. Each language also has one mid vowel and one low vowel, the exact tonality of which is not important phonologically. Each language also has a long vowel corresponding to the non-high short vowels.

The contrastive patterning common to these languages is shown in (3.2). In each cell, the first phoneme is from C, and the second is from D. Phonemes that share a cell have the same contrastive specifications.

(3.2) Contrastive patterning of languages C and D

a. Short vowels

unrounded	rounded
i/i	u/ü
ε/e	
ɑ/æ	

b. Long vowels

high

mid

low

ε:/e:
ɑ:/æ:

c. Consonants

			labial	coronal	dorsal	post-dorsal
obstruent	voiceless	stop	p/p <sup>h</sup>	t/t <sup>h</sup>	k/k <sup>h</sup>	q/q <sup>h</sup>
		spirant	f/f	s/ʃ	x/ç	χ/ħ
	voiced		b/β	d/ð	g/ɣ	ɠ/ɢ
sonorant	nasal		m	n/ŋ		
	liquid		l/r			
	glide		w/v	j/ɹ		h/h

Sapir's discussion lacks formal rigour and a system of features, but we can recognize in it some seminal ideas that I would like to build on later. First is the notion that not all properties of a sound are equally important, but that certain ones – the contrastive ones – are particularly relevant to the phonology. Second, the contrastive status of a phoneme may differ from what its phonetics might

lead us to think; that is, the phonetics of a segment is a guide to its distinctive properties, but is not sufficient to indicate what these are, and may sometimes even be at odds with the phonological status. Finally, we determine what the contrastive properties of a phoneme are by the phonetics in combination with its phonological *behaviour*. This behaviour could consist of phonotactic restrictions or the way it alternates, or the effects it has on other phonemes.

### 3.3. *Trubetzkoy: a theory of oppositions*

The phonologist who did the most to develop the principle of contrast as an organizing principle of phonology was N. S. Trubetzkoy. His *Grundzüge der Phonologie*, written in the 1930s, is a major statement of the Prague School approach to phonology. In this work, Trubetzkoy's aim is to present an exhaustive account of the various types of contrastive oppositions that can exist in a phonological system. The influence of Trubetzkoy's approach can be found in many subsequent schools of linguistics. Therefore, Trubetzkoy's approach to contrast is central to our investigation.

Trubetzkoy made major contributions to our understanding of how contrast functions in phonological systems. One of his key insights is that the determination of contrastive features in an inventory is not self-evident but must be established by the analyst on the basis of the patterning of the phonological system. I will also show that the notion of feature hierarchy as a way to depict contrastive relations makes an appearance —perhaps its earliest appearance — in the *Grundzüge*. However, his account of contrastive relations is crucially

incomplete, because it is not explicit with respect to how contrasts are assigned. More than that, I will show that Trubetzkoy (1939) does not follow a consistent approach to contrast, but varies between the pairwise approach and feature ordering. The former predominates in the earlier parts of the book, where the discussion tends to be abstract and mainly theoretical, with no direct empirical consequences. In later sections, where Trubetzkoy has empirical evidence for proposing certain contrastive relations, he uses an approach consistent with feature ordering.<sup>3</sup>

### 3.3.1. *Phonologically relevant features and phonemic content*

Every phoneme of a language enters into an *opposition* with every other phoneme. It is important to bear in mind that an opposition is a relation between a *pair* of phonemes. It is not just the number of oppositions, but their particular characters that give structure to a phonological system.

From the outset, Trubetzkoy distinguishes between *phonologically relevant* and *phonologically irrelevant* features of speech sounds: '[E]very sound contains several acoustic-articulatory properties and is differentiated from every other sound not by all but only by a few of these properties' (p. 35).<sup>4</sup> As an example he adduces the German phonemes *k* (/k/) and *ch* (/x/). The latter has two allophones, [x] (what Trubetzkoy calls the '*ach* sound') and [ç] (the '*ich* sound').

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<sup>3</sup> I am grateful to William Sullivan for reminding me that Trubetzkoy died before he was able to complete his book. This fact may account for some of the inconsistencies noted here.

<sup>4</sup> All quotes drawn from the English translation by Baltaxe, cited as Trubetzkoy 1969.

The sounds that belong to the /k/ phoneme are distinguished in manner of articulation from /x/ by forming a complete closure, whereas /x/ sounds form a stricture; that is, /k/ is distinctively a stop, whereas /x/ is a fricative. As to place of articulation, the fact that the opposition between [x] and [ç] is non-distinctive ‘presents evidence that for *ch* the occurrence of a stricture between dorsum and palate is *phonologically relevant*, while the position of stricture in the back or central dorsal-palatal region is *phonologically irrelevant*’ (p. 36).

From this example we can also see Trubetzkoy’s approach to determining what the distinctive marks of a phoneme are. These are the marks that abstract away from the variation of the surface allophones. Thus, in the case above, variation in the place of articulation of the allophones of German /x/ provides evidence that its place must be specified only as generally dorsal. Similarly, the more radical variation in the place of articulation of German /r/, which is sometimes alveolar and sometimes uvular, reveals that place is a completely irrelevant property of this phoneme.

This diagnostic does not apply in cases of neutralization of underlying distinctive contrasts.<sup>5</sup> For example, in certain positions German voiced obstruents become voiceless, causing /g/ to become [k], which is identical to [k] that derives from phoneme /k/. Since the contrast between /g/ and /k/ is suspended in these positions, it is not possible to define the contrastive features

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<sup>5</sup> As we shall see, neutralization itself is Trubetzkoy’s primary diagnostic for bilateral oppositions, and hence for the structuring of contrasts in an inventory.

of /g/ in such a way that they abstract away from the variation between [g] and [k].<sup>6</sup> Allophonic variation is not a necessary condition for determining the phonologically relevant features of a phoneme. We will see below that Trubetzkoy also appeals to other aspects of a sound's phonological behaviour in discovering its relevant distinctive features.

The phonologically relevant marks of a phoneme make up its *phonemic content*. 'By phonemic content we understand all phonologically distinctive properties of a phoneme, that is, those properties which are common to all variants of a phoneme and which distinguish it from all other phonemes of the same language, especially from those that are most closely related.' (p. 66). Again, this must exclude neutralized variants of phonemes. More important, the phonemic content of a phoneme is a function of the contrastive oppositions it enters into. 'The definition of the content of a phoneme depends on what position this phoneme takes in the given phonemic system, that is, in final

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<sup>6</sup> Trubetzkoy did not deal with the extreme case of absolute neutralization of underlying phonemes, and the existence of such cases remains controversial even today. However, there appear to be well-founded cases, such as Yowlumne (Archangeli 1984, Kuroda 1967, Newman 1944), where the long high vowel /u:/ never appears as such at the surface, but is lowered and merges with /o:/. Clearly, we cannot diagnose the relevant phonemic properties of /u:/ by attending to the range of distribution of its surface variants, which may be [o:] or by shortening, [o]. These are the same variants that characterize /o:/. The difference between the two phonemes is rather in their effect on neighbouring segments: /u:/ causes a following high vowel /i/ to become round, but does not affect non-high /a/, whereas /o:/ rounds a following /a/ but not /i/.



analysis, with which other phonemes it is in opposition ... Each phoneme has a definable phonemic content only because the system of distinctive oppositions shows a definite order or structure' (Trubetzkoy 1969: 67–68).

The above remarks suggest that the phonemic content of a phoneme, that is, the set of its distinctive (contrastive) properties, ought to *derive* from its position in the system of distinctive oppositions. Therefore, we need a way to determine a phoneme's position in the system of oppositions *before* we have determined its distinctive properties. But Trubetzkoy does not explicitly show us how to do this.

Consider, for example, his comments on the German phoneme *r*. Trubetzkoy (1969: 67) observes that the phonemic content of German *r* is 'very poor, actually purely negative: it is not a vowel, not a specific obstruent, not a nasal, nor an l.' How did Trubetzkoy arrive at this conclusion? First, he is assuming a theory of markedness wherein one value of a feature is marked (positive) and the other is unmarked (negative). Based on his remarks, he assumes the markedness values in (3.3); the feature names are not Trubetzkoy's, but I have chosen them so that the marked value is the positive (+) one.

(3.3) Markedness of features of German /r/

<i>Feature</i>	<i>Marked</i>	<i>Unmarked</i>
[obstruent]	obstruents	sonorants
[nasal]	nasals	liquids
[lateral]	laterals	rhotics

Markedness is one ingredient we require to reconstruct Trubetzkoy's analysis, but we need to answer a further question: how did he pick these particular features, and only these, to distinctively characterize German *r*? One way we can arrive at this result is by successively dividing up the German consonantal inventory by features following the order given in (3.3). The phonemes shown in (3.4) are those listed by Trubetzkoy, and the layout of the chart is based on his remarks.

(3.4) German consonantal phonemes

p	pf	t	ts		k
b		d			g
	f		s	š	x
	v		z		h
<hr/>					
m	n				ŋ
<hr/>					
①					
r					

We can distinguish /r/ from every other phoneme by this procedure:

1. First, divide the inventory by the feature [obstruent], which distinguishes between obstruents (above the line in the chart) and sonorants (below the line). Since *r* is a sonorant, this feature distinguishes it from all obstruents, which no longer need be considered with respect to uniquely characterizing *r*.

2. Among the sonorants the feature [nasal] distinguishes the nasal consonants (in the box) from the non-nasal sonorants, leaving *r* in contrast only with *l*.

3. The final feature, [lateral], distinguishes between *l* (circled) and *r*, and leaves them both with a unique set of features.

The above procedure meets the requirement that the phonemic content of a phoneme, that is, the set of its distinctive (contrastive) properties, follows from its position in the system of distinctive oppositions. Moreover, in this procedure, ‘the system of distinctive oppositions shows a definite order or structure.’ The order in question is the order of the features, which gives structure to the inventory.

It follows that feature ordering gives us a way to reconstruct what Trubetzkoy may have meant by the statements cited above. However, it is not possible to state definitively that this is indeed what he intended, for he does not give any explicit procedure for how he arrived at his analysis of German *r*. Moreover, some of the other examples do not appear to work the same way, and other statements are inconsistent with feature ordering.

In the following sections I will first give some examples consistent with the assumption that Trubetzkoy determined contrasts by means of pairwise comparisons. I will then review other examples that are more consistent with contrast through feature ordering.

### 3.3.2. *Some examples that imply the pairwise method*

#### 3.3.2.1. *Bilateral and multilateral oppositions*

In Chapter 3 Trubetzkoy presents what he calls a ‘logical classification’ of distinctive oppositions. He makes clear that he intends the principles presented

in this chapter to be applicable to any systems with contrastive elements made up of features, though his examples are almost all drawn from phonology.

Oppositions are characterized by the properties that distinguish the opposition members, as well as by the properties the members have in common. In developing his logical taxonomy, Trubetzkoy considers the case of any two elements that could be compared, as long as they have some basis for comparison. His example of two items that have no basis for comparison is an inkpot and free will. But in a phonemic system, any two phonemes can be put into opposition with each other, and his aim is to be able to characterize the nature of their opposition.

In a *bilateral* opposition the sum of the properties common to both opposition members is common to them alone. In a *multilateral* opposition, the basis of comparison is not limited exclusively to the two opposition members.

Trubetzkoy gives a non-phonetic example from the Latin alphabet: *E* and *F* form a bilateral opposition because the sum of the features common to them (the three lines of *F*) occurs in no other letter. The opposition of *P* and *R* is multilateral, because the line and loop (as in the *P*) occur also in *B*. In Trubetzkoy's usage it should be kept in mind that opposition is a binary relation. Thus, 'multilateral' refers to the relation between *P* and *R*, or *R* and *B*, or *P* and *B*, not to a relation that refers to all three at the same time.

A question immediately arises: in comparing the opposition members, do we consider *all* their properties, or only their *distinctive* properties?<sup>7</sup> Trubetzkoy's initial answer is decisive (1969: 68): 'Of course, only the phonologically distinctive properties are to be considered.' But he goes on: 'However, some nondistinctive properties may be taken into consideration if, on the basis of these properties, the members of the opposition in question are placed in opposition with other phonemes of the same system.' This latter qualification muddies the waters considerably. In this case, Trubetzkoy presents an example to illustrate why he wants to allow nondistinctive features to play a role.

### 3.3.2.2. *French consonants*

The example is from French; Trubetzkoy writes (1969: 69): '[T]he opposition *d-n* (as in French) is to be considered bilateral because its members are the only voiced dental occlusives. Yet neither voicing nor occlusion is distinctive for *n*, as neither voiceless nor spirantal *n* occur as independent phonemes.'

The above statement rests on pairwise comparisons of minimal pairs. The only way to make sense of Trubetzkoy's remarks is to assume that he adopted the pairwise method here to determine which features are contrastive. In particular, we can make the following pairwise comparisons:

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<sup>7</sup> The alphabet example above does not answer this question, because we have not been given an analysis of the distinctive properties of each letter, so it is not clear whether the properties Trubetzkoy refers to are all distinctive. It is plausible to suppose that they are, since E and F are a minimal pair in the sense defined above, as are P~R, P~B, and R~B.

1. *n-m* are distinguished by [dental] (or another place feature).
2. *n-d* are distinguished by [nasal].
3. These two features suffice to distinguish *n* from every other segment as well, regardless of any other distinctions that may exist.
4. The only way *n* could be contrastively [voiced] in a pairwise procedure is for there to exist a voiceless segment with the same full feature specifications as *n* except for [voice], that is, a voiceless *n*.
5. Similarly, *n* could be contrastively [noncontinuant] if there existed a fricative *n*, identical to *n* in all other features.

To confirm that Trubetzkoy must be (tacitly) following the pairwise method here, it suffices to observe that feature ordering does not give this result. If we used that procedure here, we could, for example, order the feature [voiced] first, distinguishing between voiced (boxed) and voiceless consonants:

(3.5) French consonantal phonemes

p	t	k
b	d	g
f	s	š
v	z	ž
m	n	ɲ
	l	j
		r

Since both *d* and *n* are voiced, following this division we would only have to subsequently distinguish among the voiced consonants. Continuing to use Trubetzkoy's terms, the next feature could be [occlusive], which we apply

(horizontal boxes in (3.6)) to the set of voiced consonants (we are not concerned with voiceless consonants, which are no longer relevant to distinguishing *n* within the inventory). Finally, the feature [dental] (vertical box in (3.6)) narrows the set to just *d* and *n*.

(3.6) French voiced consonantal phonemes

b	d	g	
v		z	ʒ
m	n	ɲ	
		l	r
		j	

Note that under this procedure the features for voicing and occlusion *are* distinctive for *n*; in fact, together with [dental], they are the *only* distinctive features so far assigned to *n*. Since Trubetzkoy does not consider the possibility that these features are contrastive in *n*, it must be that he was not thinking of the feature ordering method in this discussion of French.<sup>8</sup>

### 3.3.2.3. German vowels

Further examples of what appears to be extraction of contrasts based on pairwise comparisons occur in Trubetzkoy's discussion of types of multilateral

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<sup>8</sup> The question that has not been addressed is whether there is evidence that the French *d* ~ *n* opposition is indeed bilateral. Contrary to the statement above that /d/ is occlusive, we will see below that Trubetzkoy argues that occlusion does not play a role in the contrastive features of French. Rather, he argues that stops and fricatives are distinguished by place, not manner.

oppositions. *Homogeneous* oppositions are multilateral oppositions that can be conceived of as the outermost points of a 'chain' of bilateral oppositions, *heterogeneous* oppositions cannot be so construed. For example, in German the opposition  $u - e$  is multilateral, since they share in common only that they are vowels, a property shared by the other vowels in the system.

(3.7) The German vowel system (based on Trubetzkoy 69-70)

i	ü	u
e	ö	o
ä	a	

Trubetzkoy goes on to comment (69-70) that  $u$  and  $e$  'are nevertheless to be conceived of as the outermost points of the chain  $u - o, o - \ddot{o}, \ddot{o} - e$ , consisting entirely of bilateral oppositions: in the German vowel system  $u$  and  $o$  are the only back rounded vowels,  $o$  and  $\ddot{o}$  the only rounded vowels with mid-degree of aperture, and  $\ddot{o}$  and  $e$  the only front vowels with a mid-degree of aperture. The opposition  $u - e$  is therefore homogeneous.'

Trubetzkoy gives a more complete list of bilateral oppositions in his discussion of a further distinction among homogeneous multilateral oppositions. A *linear* opposition can be analyzed into only one chain, a *nonlinear* opposition can be analyzed into several chains. The opposition between the German vowels  $u$  and  $e$  is nonlinear, as there are several paths between them consisting of chains of bilateral oppositions. Trubetzkoy gives the chains in (3.8).



(3.8) Chains connecting German *u* and *e* (Trubetzkoy 70)

- a. *u* – *o* – *ö* – *e*
- b. *u* – *ü* – *ö* – *e*
- c. *u* – *ü* – *i* – *e*
- d. *u* – *o* – *a* – *ä* – *e*

Let us accept for the moment Trubetzkoy's account of the chain in (3.8a), given in the passage quoted above. By similar reasoning, we can suppose that *u* and *ü* are the only rounded vowels with minimum degree of aperture, and that *ü* and *ö* are the only front rounded vowels. This gives us the chain in (3.8b). To make the chain in (3.8c), we need the oppositions *ü* – *i* and *i* – *e* to also be bilateral. The former pair are the only front vowels with minimum degree of aperture, so they can form a bilateral opposition. But what of *i* and *e*? They are front and unrounded, but so is *ä*. Trubetzkoy makes clear elsewhere that he regards aperture to be a gradual relation in this case, increasing from *i* to *e* to *ä*. So it would appear that *i* and *e* are in a multilateral relation. Similar difficulties hold in construing the oppositions *o* – *a* and *ä* – *e* as bilateral, as is required for the chain in (3.8d).

Putting aside the question of how Trubetzkoy analyzed these oppositions as bilateral, we can arrive at the desired result if we reanalyze his multi-valued aperture feature into two height features, [high] and [low]. Armed with these features, the three problematic oppositions can all be construed as bilateral. *i* and *e* are the only front unrounded non-low vowels; *o* and *a* are the only back non-high vowels; and *ä* and *e* are the only front unrounded non-high vowels.

As with the French example above, here Trubetzkoy appears to be assigning contrastive features on the basis of pairwise comparisons of fully specified phonemes. We can represent the full distinctive feature specifications of the German vowels as in (3.9). Here I have interpreted Trubetzkoy's 'back' as [+back]; 'front' as [-back]; 'rounded' as [+round]; and 'unrounded' as [-round].

(3.9) Distinctive features of German vowels

	i	ü	e	ö	ä	a	o	u
back	–	–	–	–	–	+	+	+
round	–	+	–	+	–	–	+	+
low	–	–	–	–	+	+	–	–
high	+	+	–	–	–	–	–	+

The bilateral oppositions can now be read off this chart by finding all oppositions that uniquely share some set of specifications. The list of such pairs is given in (3.10). These are the just the pairs listed in the chains in (3.8).

(3.10) German vowels: Bilateral oppositions

<i>Opposition</i>	<i>Basis of comparison</i>	<i>Difference</i>
a. i – ü	[-back, +high, –low]	[round]
b. ü – u	[+high, +round, –low]	[back]
c. e – ö	[-back, –low, –high]	[round]
d. ö – o	[-low, –high, +round]	[back]
e. ä – a	[+low, –high, –round]	[back]
f. i – e	[-back, –round, –low]	[high]
g. ü – ö	[-back, +round, –low]	[high]

h.	u – o	[+back, +round, –low]	[high]
i.	e – ä	[–back, –round, –high]	[low]
j.	o – a	[+back, –high]	[round]

It is worth noting that Trubetzkoy's assignment of bilateral oppositions for German vowels is based on their full feature specifications, not on their contrastive specifications, by whatever method these may be derived. The specifications in (3.11) are those derived by the pairwise method.

(3.11) Contrastive features of German vowels: Pairwise Algorithm

	i	ü	e	ö	ä	a	o	u
back	–		–	–	+	+	+	
round	–	+	–	+				
low			–		+			
high	+	+	–	–			–	+

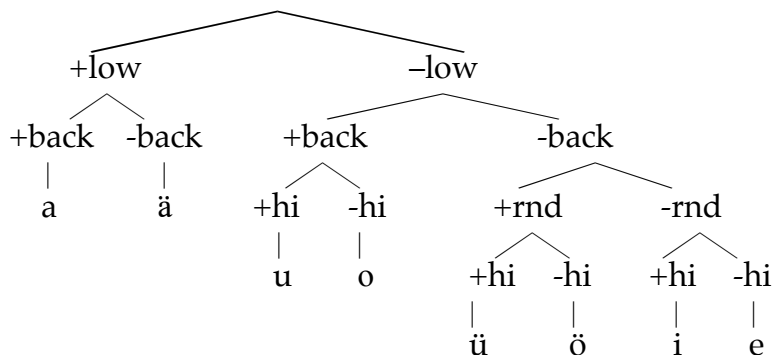
Because of gaps in the inventory, these specifications are not altogether successful. For example, /a/ is specified only as [+back], and /o/ is specified as [+back, –high], specifications that hold also of /a/. This aside, it is clear that the representations in (3.11) could not serve as a basis for assigning the bilateral oppositions in the chains in (3.8).

Nor could these assignments of bilateral oppositions be derived from any ordering of features. For example, suppose we used the feature hierarchy [low] > [back] > [round] > [high]. We would obtain the diagram in (3.12a) which yields the contrastive specifications in (3.12b). The bilateral oppositions so derived are a

subset of those in (3.10). In particular, the oppositions in (3.12c) are now multilateral, for the reasons shown.

(3.12) German vowels: Contrastive divisions

a. low > back > round > high



b. Contrastive features

	i	ü	e	ö	ä	a	o	u
back	–	–	–	–	–	+	+	+
round	–	+	–	+				
low	–	–	–	–	+	+	–	–
high	+	+	–	–			–	+

c. Bilateral oppositions that become multilateral oppositions

	<i>Opposition</i>	<i>Basis of comparison</i>	<i>Others in set</i>
a.	ü – u	[–low, +high]	i
b.	e – ä	[–back]	ü ö i
c.	ö – o	[–low, –high]	e
d.	a – o	[+back]	u

Other feature hierarchies yield different contrastive specifications, but none give all the bilateral oppositions identified by Trubetzkoy. In this example,

then, it is clear that Trubetzkoy does not adhere to the notion that the status of oppositions as bilateral or multilateral should be assigned only (or mainly) on the basis of contrastive features.

### 3.3.3. *Examples of hierarchy in Trubetzkoy*

One might conclude from the above examples that our earlier interpretation of Trubetzkoy's theory of contrast is simply wrong. Additional cases from the early part of the book could be adduced as well. Nevertheless, I do not believe that this position can be consistently maintained. For one thing, the notion of 'relevant contrast' is central to Trubetzkoy's entire exposition. If, as he writes in connection with the  $d \sim n$  opposition, oppositions must normally be established using only contrastive features, the implication is that the contrastive status of a specification is established *before* oppositions are classified as bilateral or multilateral. But such a notion is incompatible with deriving bilateral pairs from full (non-contrastive) specifications.

Second, as we have seen, pairwise comparisons do not always yield a clear result. In comparing two phonemes that differ by *more* than a single feature (the majority of oppositions), we don't know which feature is the contrastive one and which are redundant.

Consider again Trubetzkoy's analysis of German *r* (see (3.4)). Recall that Trubetzkoy assigns German *r* the distinctive (negative) features nonlateral, nonnasal, and nonobstruent. We have seen that *l-r* are distinguished by the feature [lateral]. But except for this pair, the pairwise method yields unclear

results. What feature distinguishes *r* from *ŋ*, for example? It could be [nasal], as in Trubetzkoy's analysis; but it could also be an occlusion feature (nasals are stops, in contrast to *r*), or a place feature. Similarly, *r* may be distinguished from *z* by [obstruent], as in Trubetzkoy's analysis, but this is not the only feature that distinguishes these phonemes; other candidates are [strident], or place of articulation. Such choices arise with respect to almost every opposition.

Third, there are places where Trubetzkoy makes crucial use of the notion that bilateral oppositions are a function of the system of contrasts, and that the same inventory can be viewed in different ways, depending on what contrasts have been established. These examples are all easily reconstructible in terms of a contrastive hierarchy, but not in terms of pairwise comparisons. It is to these cases that we now turn.

### 3.3.3.1. *Consonant systems: place vs. manner and voicing*

Many examples come from Trubetzkoy's discussion of consonant systems. We frequently find two consonants that differ slightly in place of articulation (e.g., bilabial vs. labiodental, or dorsal vs. laryngeal) as well as in another dimension, such as manner (stop vs. fricative) or voicing. It is a recurring question whether the contrast is primarily one of place of articulation, from which the other differences are derived, or whether the other dimension is the determining difference. Trubetzkoy resolves these oppositions differently, depending on how the particular opposition fits into the overall system, in a way that implies some hierarchical organization of the relevant features.

Trubetzkoy recognizes a basic series of place contrasts that includes the gutturals (or dorsals), the apicals (dentals), and the labials. To these he adds the sibilants. Some languages have other basic series. He lists the lateral, labiovelar, palatal, and laryngeal series.<sup>9</sup> The key point is that ‘the phonological concept of series of localization must not be confused with the phonetic one of position of articulation.’ (124).

### *German and Czech h*

Consider, for example, Trubetzkoy’s treatment of German and Czech *h*. According to Trubetzkoy (1969: 69), German *h* does not take part in any bilateral oppositions. In particular, it is not in a bilateral opposition with *x*: *h* is laryngeal and *x* is dorsal, and so there is no set of features that the two share exclusively. Looking at the Czech consonant inventory in (3.13),<sup>10</sup> one might suppose that Czech *h* (more properly, *ɦ*) is similarly isolated.

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<sup>9</sup> In contemporary feature theory the features [sibilant] and [lateral] are not typically considered to be places of articulation.

<sup>10</sup> Trubetzkoy does not provide an explicit account of the Czech phoneme inventory; the charts in (3.13) and (3.14) are based on Hall 2007: 38. There are other differences between the German and Czech arrangements that illustrate the same point as that shown by *h*. For example, Trubetzkoy (1969:125) proposes that the German bilabials *p*, *b*, and *m* form a series distinct from the labiodentals *v*, *f*, and *pf*; he makes no such claim for Czech, where the labial consonants presumably make up a single series, what Trubetzkoy considers the usual situation. See further the discussion of Greek and French labial consonants below.

(3.13) Czech consonant phonemes: *h* in a separate laryngeal series

p	t	c	k	
b	d	ʃ	g	
	ts	tš		
f	s	š	x	
v	z	ž		ɦ
m	n	ɲ		
	r	ř		
	l			
		j		

However, Trubetzkoy (1969:124) proposes that *ɦ* forms a bilateral opposition with *x*. His reason is that the distinction between these phonemes can be neutralized, for they behave phonologically like a voiced-voiceless pair, like the other such pairs in Czech. ‘The *h* in Czech thus does not belong to a special laryngeal series, which does not even exist in that language. It belongs to the guttural series, for which, from the standpoint of the Czech phonological system, only the fact that lips and tip of tongue do not participate is relevant.’ That is, we should diagram the Czech consonants as in (3.14) rather than as in (3.13).

(3.14) Czech consonantal phonemes: *h* part of the guttural series

p	t	c	k
b	d	ʃ	g
	ts	tš	
f	s	š	x
v	z	ž	ɦ
m	n	ɲ	
	r	ř	
	l		
		j	



The difference in the contrastive status of German *h* and Czech *h̥* does not emerge from pairwise comparisons of the phonetic properties of these phonemes with other phonemes in the system. Rather, it is the *phonological behaviour* of these phonemes that is the key to the analysis of their phonological content. Whereas pairwise comparison tells us nothing about the difference between the German *h*-*x* opposition and the Czech *h̥*-*x* opposition, we can use feature ordering to implement Trubetzkoy's analysis and capture this distinction. In German, if the feature [laryngeal] is ordered relatively high in the list, it will distinguish *h* from every other consonant, including *x*; therefore, *h* participates in no bilateral oppositions. In Czech, [laryngeal] would be lower in the order; instead, a feature [guttural] (perhaps characterized negatively as [noncoronal] and [nonlabial]) and the voicing feature are ordered higher. As there are no distinctive place differences between *h̥* and *x*, their opposition is bilateral.

As Trubetzkoy (2001: 20) remarked in his 1936 article addressed to psychologists and philosophers, the correct classification of an opposition 'depends on one's point of view'; but 'it is neither subjective nor arbitrary, for the point of view is implied by the system.' Feature ordering is a way to incorporate 'point of view' into the procedure of determining contrastive properties. Different orders result in different contrastive features, as is the case with German *h* and Czech *h̥*.

#### *Greek and French labials*

In German and Czech, the question is whether the laryngeal consonant makes up a distinct place of articulation, or whether it is to be regarded as part of a more

general guttural series. In Greek and French, a similar question arises with respect to the labial consonants: are bilabials and labiodentals to be classified as a single contrastive place of articulation, or two?

In Greek, labial and apical stops and fricatives differ in place as well as in occlusion: the fricatives /f v/ are labiodental in contrast to the bilabial stop /p/, and fricatives /θ ð/ are interdental in contrast to the stop /t/. The major contrast between these stops and fricatives could thus be based either on place or on occlusion. Trubetzkoy appeals to ‘parallel’ relations between stops and fricatives at different places of articulation. In the sibilant and dorsal series, /ts s z/ and /k x ɣ/, respectively, the contrast is unambiguously one of stop versus fricative, since stops and fricatives occur at exactly the same place of articulation. By parallelism, Trubetzkoy proposes that the same contrast should apply to the ambiguous cases, which leads to the conclusion that the minor place splits are phonologically irrelevant. The Greek consonant contrasts can thus be represented as in (3.15).

(3.15) Greek: major place, voicing, occlusion > minor place<sup>11</sup>

	Labial	Apical	Sibilant	Dorsal
voiceless stops	p	t	ts	k
voiceless fricatives	f	θ	s	x
voiced fricatives	v	ð	z	ɣ

---

<sup>11</sup> I substitute phonetic transcription for Trubetzkoy’s Greek letters.

The criterion employed here by Trubetzkoy can also be viewed in terms of symmetry, or economy. Since the feature [continuant] is required in any case to distinguish between /k/ and /x/, using it also for /p/ ~ /f/ and /t/ ~ /θ/ results in a minimal feature set and a more symmetrical inventory.

In French, however, Trubetzkoy argues for a split labial series. ‘For in the entire French consonant system there is not a single phoneme pair in which the relation spirant : occlusive would occur in its pure form.’ (126). Trubetzkoy argues that place should take priority over occlusion in this type of case. Indeed, he follows this analysis to its logical conclusion (n. 93) and disputes that there is an opposition between occlusives and spirants in French, because degree of occlusion cannot be regarded independently of position of articulation. As Trubetzkoy does not give a chart, I adapt the one in (3.16) from Martinet (1964), whose analysis is clearly influenced by Trubetzkoy.

(3.16) French obstruents (based on Martinet 1964: 65)

	bilabial	labiodental	apical	alveolar	pre-palatal	dorso-velar
voiceless	p	f	t	s	ʃ	k
voiced	b	v	d	z	ʒ	g

We can express the above analyses formally if Greek and French have different orderings of the occlusion feature, which we can call [continuant], relative to the minor place features that distinguish bilabial from labiodental place:

## (3.17) Variable feature ordering

French: minor place features &gt; [continuant]

Greek: [continuant] &gt; minor place

Moreover, Trubetzkoy's discussion of these cases suggests a principle that guides the choice of ordering: minor place features take scope over occlusion (German *h*, French labials) *unless* an occlusion contrast is needed as evidenced by neutralization (Czech *h̃*) or by the principle of parallelism (Greek labials).

## 3.3.3.2. Vowel systems

*Polabian*

In his discussion of the Polabian vowel system, Trubetzkoy explicitly refers to a hierarchy of contrasts (102-103): a 'certain hierarchy existed' whereby the back ~ front contrast is higher than the rounded ~ unrounded one, the latter being a subclassification of the front vowels. Trubetzkoy's analysis suggests that the features are ordered into the (partial) hierarchy: [low] > [back] > [round]; under this analysis, the vowel system is as in (3.18).

## (3.18) Polabian vowel system, based on Trubetzkoy 1969

[−back]		[+back]	
[−round]	[+round]		
i	ü	u	
ê	ö	o	
[−low]	e	α	
[+low]		a	

Trubetzkoy's rationale for this analysis is that in Polabian, palatalization in consonants is neutralized before all front vowels and before 'the maximally open vowel *a* which stood outside the classes of timbre.' (102). Our analysis in (3.18) captures the notion that *a* 'stood outside the classes of timbre' by ordering [low] before [back]: thus, *a* has no contrastive value for [back] or [round]. Trubetzkoy cites, as further evidence, the fact that the oppositions between back and front vowels are constant, but those between rounded and unrounded vowels of the same height are neutralizable after *v* and *j* to the unrounded vowels *i* and *ê*. Because [back] is ordered ahead of [rounded], 'the properties of lip participation were phonologically irrelevant for the back vowels.' That is, they have no contrastive value for [round].

Though Trubetzkoy does not say so explicitly, it is clear that the vowels /*ü*/ and /*u*/ do not form a bilateral opposition in this analysis of Polabian. Since /*u*/ is not contrastively round, the two vowels have in common only the minimum degree of aperture, a feature they share with /*i*/. /*i*/ and /*ü*/, however, do form a bilateral opposition based on the shared features [front] and [minimum aperture].

*Triangular vowel systems with an 'indeterminate vowel'*

In the case of Polabian, Trubetzkoy explicitly refers to a hierarchy of contrasts. In other cases, he makes clear that different bilateral oppositions may be assigned to inventories that look the same. This notion is not compatible with pairwise comparisons, which would yield the same result for such inventories. One such example occurs in his discussion of triangular vowel systems that have an

‘indeterminate vowel’ in between the extreme classes of timbre (i.e., the front/back, or unrounded/rounded vowels). An example of such a system is given in (3.19).

(3.19) Triangular system with schwa

i		u
	ə	
e		o
	a	

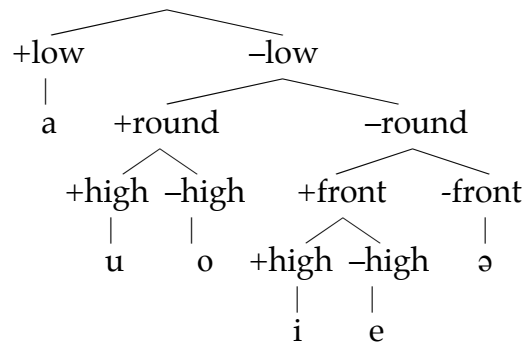
According to Trubetzkoy (113), ‘the ‘indeterminate vowel’ does not stand in a bilateral opposition relation with any other phoneme of the vowel system.’ If we assume that the distinctive features relevant to (3.19) are [low], [high], [round], and [front], then the fully specified specifications of the vowels in (3.19) are as in (3.20).

(3.20) Distinctive features of vowels in (3.19)

	i	e	ə	a	o	u
front	+	+	–	–	–	–
round	–	–	–	–	+	+
low	–	–	–	+	–	–
high	+	–	–	–	–	+

Reading the feature values off the chart in (3.20), we can see that /a/ and /ə/ are a (potential) minimal pair. However, Trubetzkoy states explicitly that /ə/ is not part of a bilateral relation with any other vowel, in the usual case, but is ‘characterized only negatively.’ We can instantiate this idea in terms of a contrastive hierarchy ordered [low] > [round], [front] > [high], as in (3.21).

(3.21) Triangular system with schwa: low > round > front > high

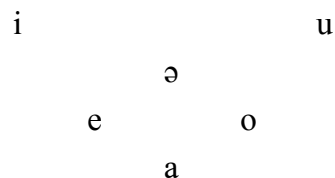


In the contrastive specifications that result from the hierarchy in (3.21), /a/ is specified only as [+low], and so shares no other feature(s) exclusively with /ə/. Therefore, there is no bilateral opposition between /a/ and /ə/.

Though Trubetzkoy considers the above to be the usual analysis for vowel systems like (3.19), he also allows for other analyses. Because the indeterminate /ə/ vowel is 'outside the system of timbre,' it can enter into a relation with the maximally sonorous vowel in a triangular system, which is also outside the timbre system (114). An example of a system where this relation is bilateral and proportional to that between the high and mid vowels of the extreme classes is Bulgarian.

(3.22) Bulgarian (Trubetzkoy p. 114)

a. Stressed syllables



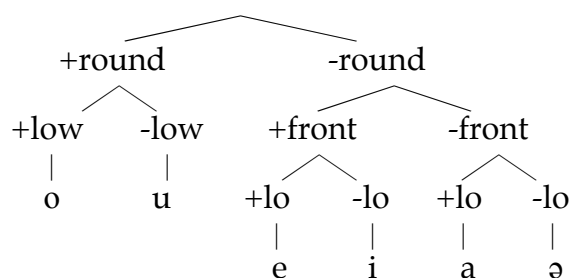
b. Unstressed syllables



An opposition is *proportional* if the relation between its members is identical to the relation between the members of another opposition. Otherwise, it is *isolated*. This classification crosscuts the bilateral ~ multilateral one. In German, the opposition  $p - b$  is bilateral and proportional (with  $t - d$  and  $k - g$ );  $r - l$  is bilateral and isolated;  $p - t$  is multilateral and proportional (with  $b - d$  and  $m - n$ ), and  $p - š$  is multilateral and isolated.

With respect to Bulgarian, Trubetzkoy writes (114), 'It would hardly be possible to assume a pure opposition of timbre between Bulgarian  $\text{ə}$  and  $o$ , or between  $\text{ə}$  and  $e$ . But the proportions  $o:a = u:\text{ə}$ ,  $e:a = i:\text{ə}$ , and the proportion  $u:o = i:e = \text{ə}:a$  deduced therefrom may well be established.' We can interpret these remarks in terms of contrastive divisions by ordering [round] and [front] before any height contrasts. In this way we divide the vowel space into three vertical sets. Now, the lower vowel in each set is assigned [low].<sup>12</sup>

(3.23) Bulgarian: round > front > low > high



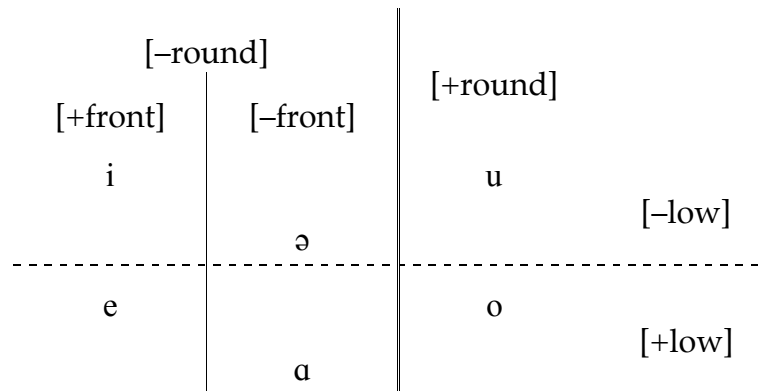

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<sup>12</sup> Alternatively, the higher vowel can be assigned high. However, the neutralization in unstressed syllables suggests that the higher set of vowels is the unmarked one. Whichever is chosen, only one height feature is needed.



This way of cutting up the vowel space can be schematically represented as in (3.24). Trubetzkoy's evidence for this analysis is the pattern of neutralization in unstressed syllables (3.22b), where /u/ and /o/ neutralize to /u/, /i/ and /e/ neutralize to /i/, and /ə/ and /a/ neutralize to /ə/.

(3.24) Bulgarian: round > front > low > high



Now the neutralization in unstressed syllables amounts to delinking of low. It may be the ordering of all place features before height that makes this a 'rare case' for Trubetzkoy.

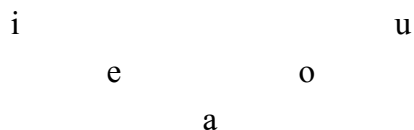
#### *Five-vowel systems*

The above examples are overt examples of Trubetzkoy's appeal to a hierarchical approach to establishing contrasts. More subtle examples are found throughout his book. The examples are more subtle because hierarchy or scope of features is not mentioned; nevertheless, the examples appear to demand such treatment.

Trubetzkoy's treatment of five-vowel systems is a case in point. I will show that he assigns such systems a variety of contrastive relations in a way that can be modeled using a contrastive hierarchy, but not by the pairwise method.

In a typical five-vowel system of the form /i e a o u/, the non-low vowels are opposed in both place and rounding. An example is Latin.

(3.25) Latin



Trubetzkoy proposes that if there is no evidence for assigning primacy to either the place or rounding contrast, then the two properties should not be isolated, but should be treated together in what he calls an *equipollent* opposition.

Equipollent oppositions are oppositions in which both members are logically equivalent. They are neither considered as two degrees of one property (*gradual* oppositions) nor as the absence or presence of a property (*privative oppositions*).<sup>13</sup>

To model this treatment of the non-low vowels with the contrastive hierarchy, we would have to assume that the rounding and place features apply simultaneously. This is logically possible, but note that Trubetzkoy does not actually give positive evidence in support of this view in this case. Positive evidence would be evidence that the features [back] and [round] are both

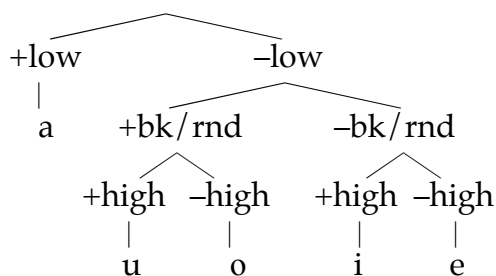
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<sup>13</sup> Compare Jakobson's (1962 [1931]) analysis of Czech discussed in Chapter 1. This approach to the relationship between backness and rounding is echoed in later treatments. For example, Chomsky and Halle (1968) single out the feature [back] in the context of non-low vowels as having no unmarked value, assigning equal markedness to front unrounded and back rounded vowels. Kaye, Lowenstamm, and Vergnaud (1985) propose that the features [back] and [round] are 'fused' in languages like Latin.

phonologically active in the non-low vowels. In the absence of evidence that either one is active, we could just as well pick one of these features, perhaps on the basis of a universal default.

Of particular interest here is Trubetzkoy's claim that the low vowel stands outside the system of oppositions that the other vowels participate in. Although the low vowel in such systems is (typically) phonetically [+back] and [–round], it is not contrastively so, according to Trubetzkoy. That is to say, the low vowel is not in the scope of the features governing backness and roundness, even though these features could in principle be relevant to it. In the contrastive hierarchy of Latin, therefore, the feature [low] must take wider scope than the place and/or rounding features. Once /a/ is specified as [+low], it is already unique in the set, and takes on no further contrastive features.

(3.26) Triangular five-vowel system: low > back/round, high



Trubetzkoy also finds some triangular systems with privative oppositions, which he deduces from the distribution of the allophones or 'from the circumstances surrounding the neutralization of the various oppositions.' (100).

In Artshi, a language of Central Daghestan, certain consonants are divided into a rounded and unrounded variety. This contrast is neutralized before and after the rounded vowels /u/ and /o/. 'As a result, these vowels are placed in opposition with the remaining vowels of the Artshi system, namely, with unrounded *a*, *e*, and *i*. This means that all vowels are divided into rounded and unrounded vowels, while the back or front position of the tongue proves irrelevant...' (100-101).<sup>14</sup>

It appears that Trubetzkoy might have in mind a principle to the effect that, if one set of vowels in a proportional relation exhibits effects while the other does not, this militates in favour of a privative relation, where the vowels exhibiting effects are marked. So Artshi would look like (3.27) in his analysis.

(3.27) Artshi (East Caucasian)

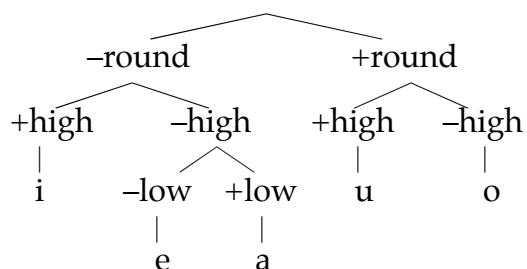
[−round]	[+round]
i  e  a	u  o

Here, the low vowel is contrastively specified for [round]. Such a result follows from ordering [round] over [low] in the contrastive hierarchy for Artshi, as shown in (3.28).

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<sup>14</sup> He finds further support for this view in the fact that *u*, *o*, and *a* are fronted in specific environments.

## (3.28) Artshi vowel system: round &gt; low, high



Trubetzkoy argues that neutralization of the opposition between palatalized and non-palatalized consonants before *i* and *e* in Japanese shows that these vowels are put into opposition with the other vowels /a,o,u/, and that the governing opposition is that between front and back vowels, lip rounding being irrelevant. Because of the phonological activity of the front vowels, they are the marked ones.

## (3.29) Japanese

[+front]	[-front]
i  e	u  o  a

Again the low vowel is included in the scope of the front/back contrast, which would here be modeled by placing the feature [front] (or [coronal]) at the top of the contrastive hierarchy.<sup>15</sup>

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<sup>15</sup> See Hirayama (2003) for an analysis of Japanese vowels. Her proposal agrees with that of Trubetzkoy's to the extent that the vowels /i/ and /e/ must be specified for [+front] ([coronal],

In these examples there appears to be no alternative to a hierarchical analysis: the pairwise method would yield the same results for all the five-vowel systems discussed above.

### 3.3.4. *Summary*

I have argued that Trubetzkoy, despite his many contributions to our understanding of how contrasts work in a phonological system, did not explicitly work out a procedure for determining which features of a phoneme are contrastive and which are redundant. When we try to deduce what he had in mind from the particular analyses presented in the *Grundzüge*, we find that his results sometimes appear to presuppose a procedure involving pairwise comparisons of phonemes. We have seen that this method is not an adequate way to determine contrastive features. It is interesting that Trubetzkoy's most obvious applications of this method occur early in the book when he is discussing oppositions in the abstract. In these cases he brings forward no empirical evidence that the oppositions are in fact the way he proposes. Hence, I conclude that his analyses of these cases, such as French *n*, are incorrect.

Where he wishes to account for actual phonological patterning, however, Trubetzkoy's analyses usually imply a feature ordering approach to determining contrastive specifications. Indeed, in hindsight, one could see Trubetzkoy's work

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in her analysis). While lip rounding ([peripheral], in her analysis) is not contrastive in the underlying representation of /u/, she proposes that it is specified for /o/ (in contrast to /a/). She proposes further that postlexical processes require the specification of additional features.

as the beginning of an effort to develop criteria governing the formulation of contrastive hierarchies for particular languages. However, phonological theory did not develop in this way.

Trubetzkoy's failure to arrive at a consistent point of view concerning how to determine contrasts was to be repeated many times. Particular analyses of Trubetzkoy were discussed and debated in subsequent years – his analysis of French was to give rise to a recurring debate – but little more was said about the criteria he proposed, or about the hierarchies they imply. In fact, the principles governing the selection of relevant contrasts became more obscure in subsequent work, as we shall see in the following sections. Thus, despite its drawbacks, Trubetzkoy's work on contrast attained a level of insight that remained unequaled in the phonological literature.

In the rest of this chapter I will consider three structuralist analyses of the French consonant system: Martinet (1964), Jakobson and Lotz (1949), and Hockett (1955). Each takes a different position on what the relevant contrasts are; each is also crucially incomplete as a theory of contrast. However, we can see in these works the central role that contrast played in phonological theory.

#### 3.4. *Martinet: French contrasts based on place*

Martinet's *Éléments de linguistique générale*, first published in 1960 and translated into English by Elisabeth Palmer (Martinet 1964), follows in the Prague School tradition of phonological analysis, which gives a central role to contrast. 'The aim of phonological analysis is to identify the phonic elements of a language and to

classify them according to their function in that language. Their function is distinctive or oppositional when they contribute to the identification, at one point of the spoken chain, of one sign as opposed to all the other signs which could have figured at that point if the message had been a different one.'

(Martinet 1964: 53).

Martinet begins his analysis of the French consonants by looking at all the consonants 'which appear or may appear before *-ouche*' (1964: 64).<sup>16</sup> Grouping together segments characterized by a relevant feature, Martinet arrives at the sets in (3.30). He puts the names of the features in quotation marks to emphasize that these are not intended as exhaustive phonetic descriptions, but rather as phonological contrastive categories.

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<sup>16</sup> The idea is to ground the contrastive set by an objective criterion, by limiting the comparison set to segments that can occur in this one context. However, the contextual criterion is loosened almost to the point of circularity when it includes not only those consonants which actually appear in a given context but also those that 'may appear,' in the absence of any further criterion as to what may appear in a given context.



(3.30) Contrastive sets of French consonants (Martinet 1964: 64)<sup>17</sup>

‘unvoiced’	/p f t s ʃ k/	‘voiced’	/b v d z ʒ g/
‘non-nasal’	/b d j/	‘nasal’	/m n ɲ/
‘lateral’	/l/	‘uvular’	/r/
‘bilabial’	/p b m/	‘labio-dental’	/f v/
‘apical’	/t d n/		
‘hiss’	/s z/	‘hush’	/ʃ ʒ/
‘palatal’	/j ɲ/	‘dorso-velar’	/k g/

As we observed in Chapter 2 looking only at the nasal consonants, these specifications are consistent with contrastive specifications derived by pairwise comparisons, as follows:

- a. The ‘voiced’ consonants do not include any sonorants, which are also phonetically voiced, but only obstruents that participate in a minimal pair with an ‘unvoiced’ phoneme.
- b. Similarly, ‘non-nasal’ phonemes are only those that have a minimally distinct ‘nasal’ partner.
- c. The other features can be considered as representing nine values of a single place feature. These include values that are not usually thought of as place features, such as ‘lateral’ as well as ‘hiss’ and ‘hush’. However, this interpretation would account for why there is a ‘lateral’ category but no ‘non-lateral’ category.

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<sup>17</sup> ‘Hiss’ is the translator’s rendering of Martinet’s term ‘sifflant,’ and hush translates ‘chuintant.’ I use *j* in place of Martinet’s *ñ*.

Since he does not suggest that there are any internal groupings among these features (unlike Trubetzkoy, who views bilabial and labio-dental as having a special relationship, for example), we will simply treat all these values on a par.

d. The choice of uvular is a bit unexpected, as Martinet asserts elsewhere (54) that /r/ does not always have a uvular pronunciation in French. According to Trubetzkoy's criteria, variation in place of /r/ indicates that [uvular] should not be the defining characteristic of the phoneme.

Though he does not refer to Trubetzkoy's discussion of French consonants, Martinet is clearly following Trubetzkoy in distinguishing stops and fricatives by place of articulation rather than by using continuancy. Thus, the stop/continuant contrast is redundant in Martinet's analysis, though he gives no argument for choosing this approach over one that makes continuancy the relevant contrast, and treating some of the minor place distinctions as redundant. More than that, unlike Trubetzkoy, he does not mention the possibility of this alternative.

Martinet represents some of these features and phonemes in tabular form, shown in (3.31).

## (3.31) French consonants (Martinet 1964: 65)

	'bilabial'	'labiodental'	'apical'	'hiss'	'hush'	'palatal'	'dorso-velar'
'voiceless'	p	f	t	s	š		k
'voiced'	b	v	d	z	ž		g
'nasal'	m		n			ɲ	
						j	

3.5. *Jakobson and Lotz (1949): French contrasts based on continuousness*

A paper on the Standard French phonemic pattern by Jakobson and Lotz was published in a volume in honour of Henri Muller. The phonemes of Standard French are analyzed into six features. Phonemes are assigned one of the following values for each feature: +, if a phoneme has the feature contrastively; –, if a phoneme contrastively lacks a feature; ±, if a phoneme has an intermediate value of the feature; or nothing, if a phoneme lacks a contrastive value for the feature.

In (3.32) I present a chart of the specifications proposed by Jakobson and Lotz.

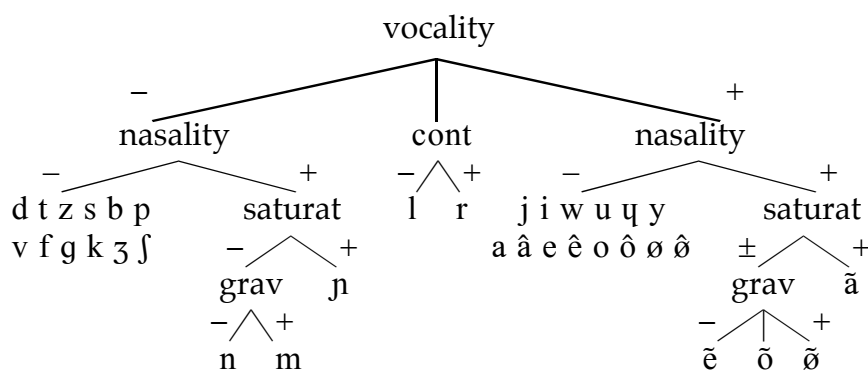


	o	ô	ø	ô	ã	ẽ	õ	õ	ə
Vocality	+	+	+	+	+	+	+	+	#
Nasality	-	-	-	-	+	+	+	+	
Saturation	±	±	±	±	+	±	±	±	
Gravity	+	+	±	±		-	+	±	
Tensity	-	+	-	+					
Continuousness									

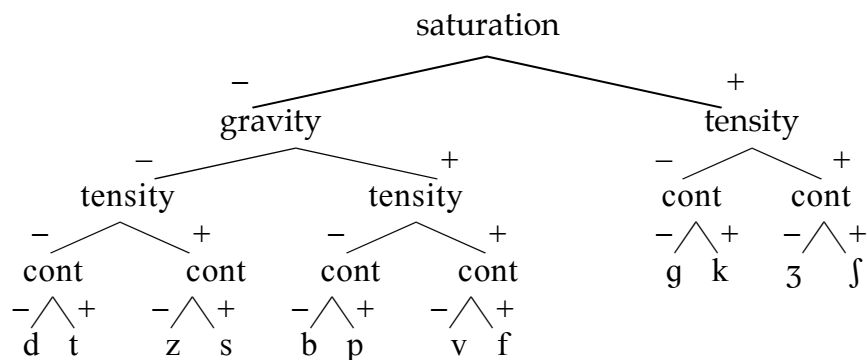
Jakobson and Lotz do not discuss the method whereby they arrive at these specifications. Though they do not explicitly refer to feature ordering, it is clear that the specifications in (3.32) follow from a hierarchical approach to contrastive specification in which the features are ordered as in the chart. That is, the specifications can be converted into a tree as in (3.33).

(3.33) Contrastive hierarchy for Standard French

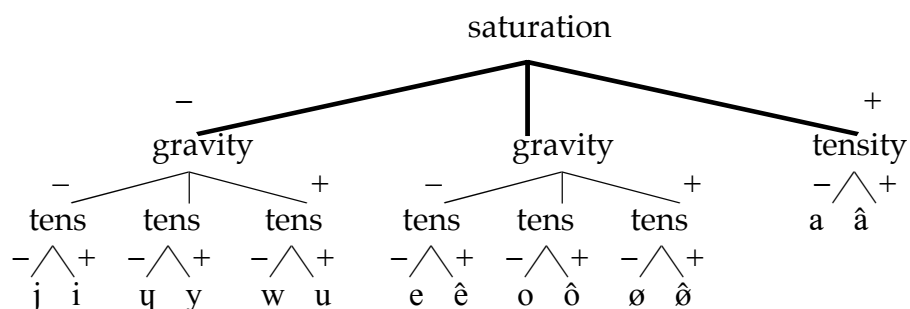
a. Top of the hierarchy: [vocality] > [nasality]



## b. Consonants [–vocality, –nasality]



## c. Vowels [–vocality, –nasality]



The subtree in (3.33a) represents the top two features, [vocality] and [nasality]. Every phoneme receives a value for [vocality]: – for consonants, ± for liquids, – for vowels and glides, and the special value # for the ‘zero phoneme’ /ə/ (not depicted in this tree). As /ə/ is already uniquely specified, it receives no other features. The liquids need only be further distinguished from each other, in this feature system by [continuousness]. All the other phonemes participate in a nasal/oral contrast. The nasal phonemes are completed as shown.

Subtree (3.33b) depicts the contrasts among the consonants specified [-vocality, –nasality] and (3.33c) shows the corresponding vowels.

Just as Martinet decides that place is the main contrastive dimension for French consonants, with occlusion playing no contrastive role at all, Jakobson and Lotz decide that occlusion is the main contrastive dimension, and collapse the place distinctions into four contrastive places, demarcated by the features saturation and gravity. They propose that saturated phonemes have longer duration, higher perceptibility, and greater resistance to distortion than non-saturated (= diluted) phonemes; saturated consonants (palatals and velars) have a widened front resonator and reduced volume of the back resonator in comparison to diluted consonants (labials and dentals). The distinction between grave and non-grave (= acute) consonants is relevant only among consonants that are [–saturation], and opposes labials, with a predominant lower formant, to dentals, with a predominant upper formant.<sup>18</sup>

Jakobson and Lotz present some empirical evidence in favour of their analysis, based on the adaptation of foreign sounds, as well as on language-internal alternations. They observe (153) that ... 'the difference between velar and palatal is irrelevant in French phonemics... These contextual variations do not hinder French speakers from rendering the English velar  $\eta$  through the French palatal  $j$ ... or the German 'ich-Laut' through  $\text{ʃ}$ . The advanced articulation of  $k$   $g$

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<sup>18</sup> The limitation of the grave/acute distinction to diluted consonants is inconsistent with other definitions of gravity, where palatals, which are saturated, are acute, not grave; compare the analysis of Serbo-Croatian by Jakobson 1949 presented in the next chapter.

before *j* or *i*, as well as the existence of *ɲ* instead of *ɲ* before *w*... illustrates the unity of the saturated consonants in French.'

Jakobson and Halle (1956) return to the problem of the structure of the French obstruent system, updating the Jakobson and Lotz feature system, but keeping to the same basic analysis. Instead of saturation they use diffuse/compact. A chart based on their proposal is given in (3.34).

(3.34) French consonants, based on Jakobson and Halle (1956)

	diffuse				compact	
	grave		acute			
oral	tns	lax	tns	lax	tns	lax
discontinuous	p	b	t	d	k	g
continuous	f	v	s	z	ʃ	ʒ
nasal	m		n		ɲ	

Jakobson and Halle also provide arguments for their analysis over one which bases the contrasts on point of articulation. They argue (1956: 46) that this solution is 'the unique solution' on the grounds that it is optimal in terms of the number of binary decisions that have to be made. They state that if point of articulation rather than (dis)continuousness were distinctive, 'then the six French voiceless consonants...would require, for their identification, fifteen distinctions instead of three, according to the elementary mathematical formula cited by



Twaddell (1935)...<sup>19</sup> Second, the narrower differences in point of articulation are ‘minute’ and ‘hardly recognizable’ by themselves. Third, they find that the distinctions between /s ~ /f/ and /t/ ~ /p/ involve the same contrast, as do /k/ ~ /t/ and /ʃ/ ~ /s/.<sup>20</sup>

### 3.6. Hockett: French contrasts and the ‘odor of pure game-playing’

C. F. Hockett’s *A Manual of Phonology* (1955), is an outstanding example of late Bloomfieldian American structuralism. This theory is characterized by an unyielding empiricism with respect to both science and psychology. In terms of science, Hockett writes at the outset (2), ‘It would be well to state explicitly that our view will be empiric: I accept Bloomfield’s assertion that ‘the only useful generalizations about language are inductive generalizations,’ and hence affiliate with the ‘god’s-truth’ school of thought rather than with the ‘hocus-pocus’ school.’ A consequence of this approach, he goes on, is that he has to recognize areas of indeterminacy where the ‘hocus-pocus’ practitioners are freer to make ‘ad hoc decisions arbitrarily.’ Though he grants that Trubetzkoy, for example, usually made analytic decisions in accord with a well formulated set of

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<sup>19</sup> This calculation assumes the worst case, that the narrower points of articulation are not generated by binary features along the lines used in their own solution.

<sup>20</sup> Note that whereas Jakobson and Lotz’s (1949) arguments primarily involve phonological patterning and phonological activity, Jakobson and Halle (1956) focus less on activity and more on arguments of economy, part of a shift in emphasis from phonological activity to economy that will be discussed in the next chapter.

principles, and not arbitrarily, he nevertheless cannot accept Trubetzkoy's methodology because the principles themselves are arbitrary.<sup>21</sup>

With respect to psychology, Hockett inherited Bloomfield's extreme anti-mentalism that rules out any role for the mind in a scientific description. Together, this scientific empiricism and psychological behaviourism keep any theorizing about the grammar confined to rather narrow limits.

### 3.6.1. *Hockett's approach in principle*

A good example of this theoretical stance is its application to the familiar problem of the French obstruent inventory. Hockett observes (173) that it is possible to regard each consonant phoneme as 'a bundle of three coequal ultimate constituents: a voicing-term (voiceless or voiced), an occlusion term (stop or spirant), and one of three positions (say front, central, and back).' We can diagram this arrangement, essentially the analysis of Jakobson and Lotz (1949), as in ( 3.35a). Alternatively, we could adopt the analysis of Trubetzkoy and Martinet, shown in ( 3.35b).

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<sup>21</sup> This objection applies to any approach to linguistic theory that puts no constraints on hypotheses, as long as they are capable of being empirically tested.

## (3.35) Two decompositions of French obstruents (Hockett 1955: 173)

## a. Major places only, stop vs. spirant, voiceless vs. voiced

		'front'	'central'	'back'
'stop'	'voiceless'	p	t	ʃ
	'voiced'	b	d	ʒ
'spirant'	'voiceless'	f	s	k
	'voiced'	v	z	g

## b. Major and minor places, voiceless vs. voiced

	'bilabial'	'labiodental'	'apico-dental'	'apico-dent. rill'	'laminoalveolar'	'dorso-velar'
'voiceless'	p	f	t	s	ʃ	k
'voiced'	b	v	d	z	ʒ	g

After considering the merits of each approach, Hockett notes (173), 'Both of these decompositions of the French obstruents have the odor of pure game-playing, an odor which is seemingly appetizing to some linguists.' He argues that if our sole guide in decomposition is retaining predictability of the omitted features, then far more drastic solutions are available. He notes that any system of sixteen phonemes can be assigned values of four 'determining' (i.e., contrastive) features as in (3.36). All other features are then 'determined' (i.e., redundant).

## (3.36) Assigning 'determining' features to set of sixteen phonemes

	a	b	c	d	e	f	g	h	i	j	k	l	m	n	o	p
A	x	x	x	x	x	x	x	x								
B	x	x	x	x					x	x	x	x				
C	x	x			x	x			x	x			x	x		
D	x		x		x		x		x		x		x		x	

The chart in ( 3.36), which represents an arbitrary binary coding, is for Hockett (174) 'a psychologic reductio ad absurdum ... The opposite of this sort of game-playing is what I mean by 'hugging the phonetic ground closely.'"<sup>22</sup>

Of course, the chart in ( 3.36) assumes that the *only* criterion for assigning contrastive features is minimality of feature specifications, and that there are no testable empirical consequences of any particular feature assignment. Neither of these assumptions is necessary. This train of reasoning, however, leads Hockett (174-5) to reject the possibility of making any distinctions between contrastive and redundant features: 'Furthermore, it turns out that in general we cannot divide the ostensible ultimate phonologic constituents of a system neatly into 'determining' and 'determined,' assigning the latter some secondary status. In the actual complexity of speech, a given feature or difference turns up in some contexts as of primary relevance, in other contexts as subsidiary... Thus, for

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<sup>22</sup> This chart, and the related discussion, may have been inspired by Cherry, Jakobson and Halle (1953). They make it clear, however, that actual phonological systems are not motivated solely by considerations of maximum feature economy; see further the following chapter.

French obstruents, we have no choice but to recognize (1) two voicing terms; (2) two occlusion terms; (3) six combinations of articulator, point of articulation, and contour of articulator – ten features in all.’ The fact that this system could lead one to expect twice as many phonemes as there are — for example, a bilabial spirant or a labio-dental stop — ‘is simply a limitation on privilege of occurrence.’

Hockett observes that the problem of determined and determining features is related, but not identical to, the distinction between primary and secondary features. Primary and secondary refer to the degree to which a feature is present in realizations of a phoneme. A feature that is present only occasionally, or in limited contexts, is secondary; one that is more typically present is primary. His example is a phoneme /u/ that is always round but in some contexts fronted; rounding is the primary feature, the fronting is secondary. Even in this kind of case, Hockett writes that the analyst should not arbitrarily avoid mentioning the secondary feature, which may be perceptually important to a hearer in some contexts.

Against Hockett’s arguments in this section, we observe first that it is incorrect to reduce any example of distinguishing between a contrastive and redundant feature to an arbitrary binary coding. One could have empirical, non-arbitrary reasons for deciding that some features are contrastive. Moreover, contrastive features need not be the mathematically minimal set. Second, Hockett brings no empirical evidence in favour of his own analysis of the French

obstruents. Thus, we have no reason to think it is superior to either of the two analyses he rejects.

### 3.6.2. *Hockett's approach in practice*

Third, and most important, Hockett's conclusion is not consistent with his own practice in the rest of the manual. If we can indeed make no distinctions between 'determining' and 'determined' features, it would be difficult to assign phonemic symbols to a set of allophones, let alone arrange them into neat schematic diagrams. But this Hockett does consistently in his presentation of types of vowel and consonant systems.

For example, he observes (84) that a 2x2 type of vowel system is widespread. He portrays such a system with the diagram in (3.37)

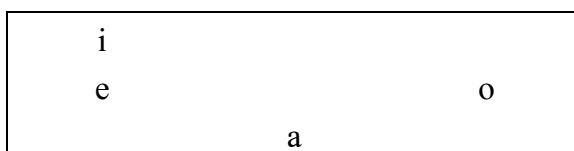
(3.37) A 2x2 vowel system (Hockett 84)

i	o
e	a

As examples, Hockett cites Rutul (Caucasian), in which the high back vowel is sometimes rounded, sometimes not, depending on environment; Fox and Shawnee (Algonquian), where the low back vowel is usually unrounded, though rounded in certain environments; and a number of other languages. It is particularly interesting that the schematic diagram, for which he cites no specific language, has /o/ rather than /u/, and /e/ rather than /æ/. Hockett adds (84), 'we class Fox as a two-by-two system despite the fact that the vowel classed as low back, /a/, is typically lower than that classed as low front, /e/.' Though he

lists no features, thus leaving open whether the relevant contrast is one of roundness, backness, or both, the arrangement in ( 3.37) can only mean that these dimensions, as well as a single height contrast, are the relevant (determining) ones. In particular, it is not relevant that /o/ may be phonetically lower than /i/, and /a/ lower than /e/; indeed, the choice of these symbols suggests that /o/ and /e/ might be at the same height phonetically, though functioning phonemically at different heights, whereas /i o/ and /e a/ show the reverse. If it were not so, we would have to diagram the vowel system as in ( 3.38).

(3.38) A different 2x2 vowel system



Thus, the schematization in ( 3.37) does not ‘hug the phonetic ground’ as closely as it might; on the contrary, it appears to be specifically chosen to show how the contrastive structure of a vowel system can *differ* from its surface phonetic appearance.

It should be noted that Hockett (84) admits that in his survey he may have made some ‘arbitrary’ decisions. Thus, he observes that he has assigned three vowel heights rather than two to systems like /i ü u e a o/ and /i i u e a o/ (3.39), because ‘the /a/ in any such case is typically lower than the /e o/.’

## (3.39) Six-vowel systems: three heights

a. Sixth vowel /*ü*/

i	ü	u
e		o
	a	

b. Sixth vowel /*i*/

i	i	u
e		o
	a	

He goes on, 'Yet such a minor difference in height is not always decisive' as for example in Fox. Though Hockett would no doubt deny it, it appears clear that his decisions here are not arbitrary (though they may be incorrect), but are based on his understanding of how these systems function.

Hockett makes decisions like these throughout his survey of vowel and consonant systems. To take one more example involving vowels, he writes that a 3+1 system 'is reported for Amahuaca' ( 3.40a), 'though the / *i* / may be lower than / *i u* /, placing Amahuaca rather with Ilocano and others' ( 3.40b). He observes that in the Filipino (Austronesian) languages represented by ( 3.40b), /*ə*/ has fronted variants, and also higher central or back unrounded variants.

## (3.40) Vowel systems: 3+1 vs. 2+1+1 (Hockett 84-5)

a. Amahuaca

i	i	u
	a	

b. Ilocano

i		u
	ə	
	a	

It is not important, for the purposes of this discussion, whether Amahuaca (a Panoan language of Peru and Brazil) is as in ( 3.40a) or ( 3.40b). What is important is that Hockett believes it is meaningful to assign it to one or the other.



If there is indeed no way to distinguish between determined and determining, we could not represent Ilocano as in ( 3.40b), since this diagram implies that the determining features of /ə/, for example, are that it is central and mid, even though it has variants that are front and others that are high. Similarly, Amahuaca could not be represented as in ( 3.40a) if /i/ is phonetically lower than /i u/ to any extent, because that means making a decision that its centrality is the determining feature and its lower height is the determined feature.

Hockett's discussion of consonant systems is also at odds with his stated theoretical position. He begins his discussion of classification of consonants by observing (95) that '[i]t does not seem feasible to handle them as wholes for constitutional classification; it seems better to develop some manner of breaking them up into subsystems.' The breaking up into subsystems begins with a binary split, typically dividing the obstruents from the sonorants. To illustrate, he presents the following table of Ossetic (Iranian):

(3.41) Consonant system of Ossetic (Hockett 95)<sup>23</sup>

p	t	c	č	k	?
p <sup>h</sup>	t <sup>h</sup>	c <sup>h</sup>	č <sup>h</sup>	k <sup>h</sup>	
b	d	ʒ	ž	g	
f		s	š	x	
v		z	ž	ɣ	
m	n				
w	y	r	l		

<sup>23</sup> Hockett uses an inverted comma to represent aspiration. I have replaced this with superscript <sup>h</sup>.

As to what counts as an obstruent, Hockett writes (96): ‘We include among the obstruents not only all stops and affricates and most spirants, but also, in some cases, a [y]-like, [w]-like, or [l]-like consonant *if it fits neatly into the scheme*, and if distributional facts do not militate against such a treatment.’ [italics added/BED]

Though the main split in the consonant system is often obstruent – sonorant, ‘In a few cases all the consonants, apart from manner consonants (if any), must be otherwise dichotomized in the first instance, the classification into obstruent and sonorant coming second.’ (96). He illustrates with Lifu (Malayo-Polynesian), in which the voicing contrast ‘is operative throughout the system except for /h/; the latter is a manner consonant and pairs off with the whole set of voiceless obstruents and sonorants.’

(3.42) Consonant system of Lifu (Hockett 96)<sup>24</sup>

p	t		ʈ	č	k	h
f	θ	s		š	x	
m̥	n̥			ɲ̥	ŋ̥	
w̥	l̥					
b	d		ɖ	ž	g	
v	ð	z		ẓ̌	ɣ	
m	n			ɲ	ŋ	
w	l					

Hockett calls the laryngeals in Ossetic and Lifu ‘manner consonants’ because ‘they match one or another of the styles of delivery found for obstruents.’ He also

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<sup>24</sup> Hockett represents voiceless sonorants with capital letters.

considers Russian /y/ (= IPA /j/) a manner consonant, because it ‘matches the whole set of palatal consonants as over against the plain consonants.’

Hockett’s analysis translates easily into a contrastive hierarchy. Indeed, it is exactly a hierarchy of successive binary splits, but not carried out all the way or entirely explicit. Ossetic first splits into obstruent – sonorant sets. Then /ʔ/ splits from the rest of the obstruents. We could interpret Hockett’s designation of ‘manner consonant’ to mean that /ʔ/ is placeless, being characterized only by the fact it is an obstruent. The rest of the obstruents are then split into place and manner categories. The diagram suggests that the coronal sonorants do not have a definite place. In Lifu, the first division is voiceless ~ voiced. Then /h/ splits away from the voiceless set, and can be interpreted along the lines of Ossetic /ʔ/.

Hockett’s grounds for adopting these diagrams are distributional. With respect to Lifu, he notes (6) that ‘[d]istributional classification supports the constitutional grouping indicated above: only voiced consonants (and all of them except /w ɲ ɡ ɣ v/ occur finally.’

Thus, there are empirical grounds, based on phonological patterning, for organizing segment inventories one way rather than another. We see, then, that Hockett’s practice throughout the *Manual* is inconsistent with his discussion of the French obstruents.

One could argue that Hockett viewed his diagrams simply as ways of expressing distributional or other generalizations about inventories, and not as expressing any ‘correct’ analysis of the grammar. Ultimately, it is not really important if Hockett thought of his classifications as having reality in any sense,

or as useful fictions. His philosophy of science, and distinction between ‘god’s truth’ and ‘hocus pocus,’ are not mine. What is important is his practice, which is reminiscent of Trubetzkoy’s in this sense: when he considers the problem of contrast in the abstract, he arrives at conclusions that are not consistent with what he does when he needs to make sense of actual data; in such cases, where there is real empirical evidence for doing things a certain way, he appeals to notions of contrast and redundancy that operate in terms of a language-particular contrastive hierarchy.

### 3.7. *Prolegomenon to a theory of contrastive specification*

In this chapter we have surveyed the work of some leading phonologists from the structuralist period (Jakobson will be discussed further in the next chapter). I have argued that issues of phonological contrast were central to their thinking. Matters are somewhat more obscure when we try to isolate an explicit or consistent approach to a theory of contrastive specification. However, I have argued that when we put together their most insightful and empirically supported analyses we can begin to sketch an outline of a theory of contrastive specification. In this section I will attempt to distil the main principles of such a theory.

Of the various features that characterize a phoneme, we must distinguish between those that are contrastive and those that are redundant. We do so by ordering the features into a contrastive hierarchy, and assigning features to phonemes in order until each phoneme has been uniquely distinguished from

every other one. The sum of contrastive features make up the ‘phonemic content’ of a phoneme. There are in principle different ways of ordering the features for a given set of phonemes, and each ordering corresponds to a potentially different set of contrastive specifications. In this sense, the contrastive structure of a language is a function of ‘point of view’, that is, of a particular way of ordering the features.

This variability gives rise to a fundamental question: how do we know what the particular ordering is in any given case? The work surveyed in this chapter suggest a general answer to this question. We can recognize the phonemic content of a phoneme by its ‘patterning’, that is, by the way it behaves. A common assumption of the authors surveyed above is that the behaviour of a phoneme is a function of its contrastive features. Reviewing the cases discussed above, we can compile a list (3.43) of diagnostics used in this chapter for identifying contrastive features.

(3.43) Diagnostics used in identifying contrastive features

A phoneme  $\varphi$  has contrastive feature F if:

- a.  $\varphi$  enters into an alternation or neutralization that is best explained if F is part of  $\varphi$  (cf. Sapir (3.1), Trubetzkoy Czech /fi/, Polabian front vowels (3.18), Bulgarian vowels (3.24)).
- b.  $\varphi$  causes other phonemes to alternate or neutralize in a way that is best explained if F is part of  $\varphi$  (Trubetzkoy Polabian (3.18), Artshi round vowels (3.27), Japanese front vowels (3.29)).

- c.  $\varphi$  participates in a series with other phonemes,  $\Phi$ , with respect to phonotactic distribution, where F is required to characterize  $\Phi$  in a general way (Sapir (3.1), Trubetzkoy Greek (3.15)).
- d. The set of allophones which make up  $\varphi$  all have F in common (Trubetzkoy, German /x/, /r/ in German, Czech, Gilyak, Hockett Rutul, Fox, Shawnee back vowels (3.37)).
- e. Speakers adapt a sound from another language in a way that can be explained by supposing that they assign F to the foreign sound (Jakobson and Lotz, English /ŋ/ adapted as French /ɲ/, also Jakobson 1962 [1931], Slovak, Russian, and Czech ability to pronounce foreign front rounded vowels).

To the extent they are not present or contradicted, some of these diagnostics can be used conversely to identify redundant features (3.44).

(3.44) Diagnostic used in identifying redundant features

Feature F is system redundant (noncontrastive) in phoneme  $\varphi$  if the set of allophones which make up  $\varphi$  do not have F in common:

- a. Trubetzkoy: dorsal and palatal features not contrastive in German /x/.
- b. Trubetzkoy: place of articulation not contrastive in German /r/.
- c. Hockett: [round] not contrastive in Rutul, Fox, Shawnee back vowels (3.37)).

We have also seen some arguments for ordering features in a given system (3.45)

## (3.45) Diagnostics for ordering features

If a phoneme  $\varphi$  has two features, F and G:

- a. F is ordered above G if F is contrastive in  $\varphi$  and G is redundant in  $\varphi$  (based on general assumption in all authors above that phonologically irrelevant features do not participate in phonemic content).
- b. If a phoneme  $\varphi$  has two contrastive features, F and G, F is ordered above G if G if G is neutralizable and F is not (Trubetzkoy, Polabian (3.18).
- c. F is ordered above G if F applies to a wider range of phonemes than G (Hockett, Ossetic [sonorant] > [voiced] (3.41), Lifu [voiced] > [sonorant] (3.42)).

The above make up a preliminary set of principles that may contribute to a theory of contrastive specification. It is not clear that all of the above diagnostics are valid, or valid in all circumstances, and we will try to refine these principles in later chapters. Much has also been left open. To take one important issue, we have not attempted to clarify the relationship between contrast and specification. A natural assumption is that contrastive features are specified in a phoneme and redundant features are unspecified; but this is not a necessary position to take. As Anderson (1985) and Calabrese (1995) have emphasized, distinguishing between contrastive and redundant features does not necessarily imply that the latter must be absent from representations. In a theory where all features are specified, for example, we can still designate some as contrastive.

Then, everything we have said about phonemic content and so on still holds, but must be understood not as making a distinction between features that are present and those that are entirely absent, but rather as distinguishing between features that are present as contrastive features and those that are not. However, this and other issues must be deferred to later.

To conclude this section, let us first subsume the various diagnostics in (3.43) under a general term, and look at a sample example. We will say that a feature that exhibits one of the characteristics of (3.43) is *phonologically active*. Conversely, a feature that does not have one of these characteristics is *phonologically inert*. Now the various diagnostics for identifying contrastive features follow from the hypothesis in (3.46).

(3.46) Contrast and phonological activity (preliminary hypothesis)

Only contrastive features are active in the phonology. Redundant features are inert.

Hall (2007: 20) calls this idea the *Contrastivist Hypothesis*, which he formulates as in (3.47).

(3.47) Contrastivist Hypothesis:

The phonological component of a language L operates only on those features which are necessary to distinguish the phonemes of L from one another.

Let us consider again the Artshi example (3.27) discussed by Trubetzkoy. The vowels /u/ and /o/ cause the distinction between rounded and unrounded consonants to be neutralized, when they are adjacent to these consonants. Since



the affected feature involves rounding, it is reasonable to suppose that the neutralization is caused by the feature [+round] associated with these vowels. That is, the feature [round] is active in these vowels. By hypothesis (3.46), only contrastive features are active. Therefore, the feature [round] is contrastive in /u/ and /o/. Since there is no evidence that the feature [back] is contrastive in these vowels, we assume that this feature is redundant, because no contrastive hierarchy exists that would assign these vowels the contrastive feature [+back] if they are already assigned [+round].

Note a certain benign circularity here: we hypothesize that only contrastive features are active, and then we decide that the feature [round] is contrastive in /u/ and /o/ because it is active in these vowels. This circularity is ‘benign’ because it is the typical circularity characteristic of scientific explanation. To explain why objects fall to the earth with a certain acceleration, we posit a force of gravity; evidence for this force is the fact that objects fall with a certain acceleration. What is important is that contrast and activity are not defined in terms of each other: activity is not part of the definition of contrast, and contrast is not part of the definition of activity. Activity is not defined in terms of contrast because the various manifestations of activity do not refer to the contrastive status of features. Contrast is not defined in terms of activity because the notions of feature ordering and the Successive Division Algorithm do not refer to activity. Moreover, there are situations where we must designate features as contrastive to differentiate between phonemes in the absence of any evidence of activity.

At a practical level, the hypothesis that only contrastive features are active can be easily falsified. If in Artshi, for example, we found that the features [round] and [back] were both active in /u/ and /o/, and that [+low] was active in /a/, this result would not be consistent with the hypothesis in (3.46). For there is no feature ordering that would make all these features contrastive at the same time. Conversely, this hypothesis is supported to the extent we find cases where the active features are consistent with orderings that make them contrastive.

To sum up, based on the work surveyed in this chapter, we have sketched the beginnings of a theory of phonology that assigns a central role to contrastive feature specifications. So far, this theory has two main tenets: (1) only contrastive feature specifications are active in the phonology (the Contrastivist Hypothesis), and (2) contrastive features are assigned by ordering the features and applying the Successive Division Algorithm.

In the work surveyed above, the Contrastivist Hypothesis was much in evidence, but the contrastive hierarchy was not clearly understood. In the next chapter we will see that the contrastive hierarchy was promoted to a leading place in phonological theory by Roman Jakobson and his colleagues; its connection to phonological activity, however, was loosened and eventually lost, along with the Contrastivist Hypothesis.

#### 4. The Rise and Fall of the Contrastive Hierarchy

‘The dichotomous scale is the pivotal principle of the linguistic structure. The code imposes it upon the sound.’

Jakobson, Fant and Halle (1952: 9)

##### 4.1. *Introduction: Jakobson and his collaborators*

The work of Roman Jakobson and his colleagues merits a separate discussion. Many of the main ideas in Trubetzkoy’s *Gründzüge* were worked out in collaboration with Jakobson. To Jakobson is due the notion of the distinctive feature. Whereas Trubetzkoy allowed features to be gradual (multi-valued), Jakobson eventually proposed that all features were binary. The notion that language and cognition crucially involve binary dichotomies became central to Jakobson’s thinking, and this idea was later taken over into generative phonology.

In the 1950s and early 1960s, Roman Jakobson, Morris Halle, and their colleagues wrote a series of important publications that laid the groundwork for the next phase of distinctive feature theory and what eventually became the theory of generative phonology. Much critical attention, then and afterwards, was directed at various aspects of their theory that struck observers as being the most controversial and innovative, such as the nature of distinctive features, the relation of phonemes to allophones, and the organization of the grammar.

What is of greatest interest for our present purposes is an aspect of their work that attracted relatively less attention. This is their development and utilization of a contrastive hierarchy of distinctive features. We have seen that such a hierarchy is already implicit in much of Trubetzkoy (1939), and it could be that this was one source of the idea. It also fits well with Jakobson's general emphasis on dichotomies as a fundamental aspect of cognition: if the distinctive feature is grounded in a binary discrimination, then it makes sense that an inventory is built up via a succession of such binary splits.

Although Jakobson and his collaborators assumed that feature ordering is the correct way to arrive at contrastive features, the concept remained oddly unfocused. Like Trubetzkoy, Jakobson and Halle continued to oscillate between feature ordering and pairwise comparisons in working out the distinctive features for a language. The notion of feature ordering was never, to my knowledge, the subject of debate and discussion in the way that other aspects of linguistic theory were. When it was used it was used without explicit defense or recognition that there were other methods; similarly, when it was not used, its absence was not commented on.

Most important, for our purposes, is that the earlier association between contrastive specification and phonological activity was not developed in Jakobson's work in the 1950s, but was gradually dropped as a prime motivation for assigning contrastive specifications. As the contrastive hierarchy became detached from the Contrastivist Hypothesis, it was deprived of its most important empirical motivation. This left the notion of feature ordering, and of

contrastive specification more generally, vulnerable to arguments that it plays no useful role in phonological theory.

In this chapter I will trace the rise of the contrastive hierarchy in the early 1950s to ‘the pivotal principle’ of linguistic structure, through its gradual dissociation from the Contrastivist Hypothesis, to its ultimate disappearance from phonological theory in the 1960s.

#### 4.2. *The dichotomous scale*

Jakobson, Fant and Halle (1952) propose that the distinctive features into which the phonological systems of all the world’s languages can be analyzed are drawn from twelve binary oppositions (4.1).

(4.1) Universal set of distinctive features (Jakobson, Fant and Halle 1952)

- |                           |                                |
|---------------------------|--------------------------------|
| 1. vocalic/non-vocalic    | 2. consonantal/non-consonantal |
| 3. interrupted/continuant | 4. checked/unchecked           |
| 5. strident/mellow        | 6. voiced/unvoiced             |
| 7. compact/diffuse        | 8. grave/acute                 |
| 9. flat/plain             | 10. sharp/plain                |
| 11. tense/lax             | 12. nasal/oral                 |

They propose that listeners identify phonemes by distinguishing them from every other phoneme in the system. These distinctions are effected by making a series of binary choices that correspond to the oppositions active in the language. ‘The dichotomous scale is the pivotal principle of the linguistic structure. The code imposes it upon the sound.’ (1952: 9) There is no clear

statement as to whether there is a universal hierarchical ordering of the features, and if so, what it is. But it is possible to infer from their discussion that there are some universal patterns and some tendencies for features to be ordered in a certain way. They write (40–41) that there are ‘laws of implication’ that are ‘universally valid or at least have a high statistical probability: X implies the presence of Y and/or the absence of Z.’ These laws limit the possible variety of phonological systems to ‘a limited set of structural types.’

Jakobson, Fant and Halle (1952: 10) write that the dichotomous scale of distinctive features, in the context of the patterning of the linguistic code, influences perception of speech sounds. ‘Therefore, a monolingual Slovak identifies the rounded front vowel /ø/ of the French word *jeu* as /e/, since the only distinctive opposition in his mother tongue is acute (front) vs. grave (back) and not flat (rounded) vs. plain (unrounded). A monolingual Russian, on the contrary, perceives the same French vowel as /o/ because his native tongue possesses only the one of the two oppositions in question, namely flat vs. plain.’<sup>1</sup> It is clear that reference here is not to phonetic contrasts, but to the contrastive features that are active in the phonologies of these languages.

#### 4.3. *The dichotomous scale as an acquisition sequence*

The contrastive hierarchy is featured prominently in Jakobson and Halle’s influential *Fundamentals of Language* (1956). Jakobson & Halle (1956) refer to this

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<sup>1</sup> The rationale behind this analysis is provided in Jakobson 1962 [1931], discussed in Chapter 1.

hierarchy as the 'dichotomous scale,' and adduce 'several weighty arguments' in support of this hierarchical approach to feature specification.<sup>2</sup> First, they claim (47) that such a system is an 'optimal code' for speech participants who have to encode and decode messages; on this, see further below in the next section.

Their second argument involves language acquisition (cf. Jakobson 1941). They suggest that distinctive features are necessarily binary because of the way they are acquired, through a series of 'binary fissions'. They propose (1956: 41) that the order of these contrastive splits is partially fixed, thereby allowing for certain developmental sequences and ruling out others.

The sequence in (4.2), for example, concerns oral resonance (primary and secondary place) features. The decimals indicate precedence relations: if one decimal sequence is entirely contained in another sequence, then the contrast corresponding to the former must precede the acquisition of the latter contrast. In (4.2), wide (equals compact) vowels are low vowels of high sonority; narrow (equals diffuse) vowels are high vowels of low sonority; palatal vowels are front, and velar vowels are back. Thus, (4.2) predicts that a height contrast between a low and a high vowel must precede the emergence of a contrast between a front and a back vowel, since 0.11 is contained in 0.111. Further, the latter contrast should emerge in the high vowels (0,111) before it can emerge in the low vowels

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<sup>2</sup> These arguments are presented as a reply to Chao (1954), who asked if the dichotomous scale is a principle imposed by the analyst, or inherent in the structure of language.

(0.1111). These precedence relations thus are meant to account for why /i a u/ is a typical vowel inventory, but /i æ ʌ/ is not.

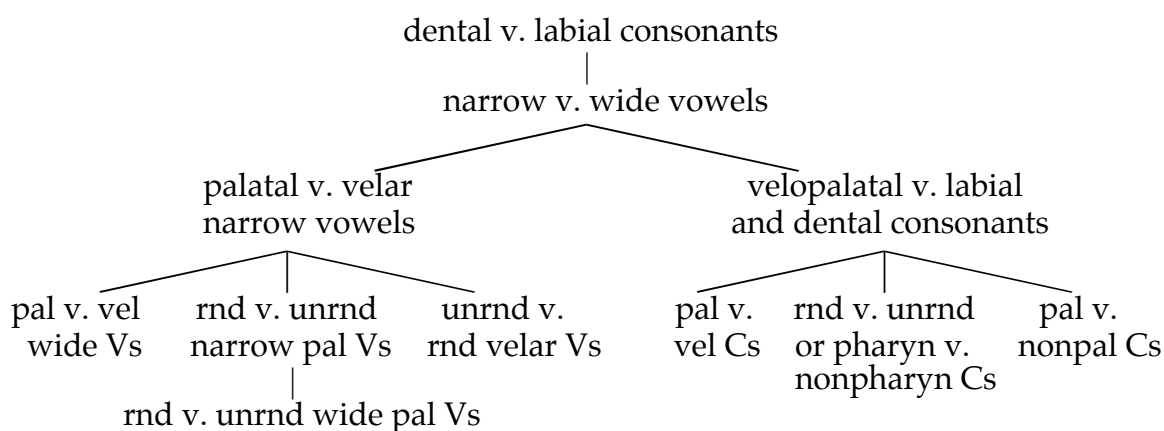
By the same token, the contrast between wide and narrow vowels is predicted to precede the development of a consonantal contrast between velopalatal vs. labial and dental (i.e. /k/ vs. /p/ and /t/), since 0.11 is contained in 0.112. But no implicational relation is predicted to hold between the contrast of palatal vs. velar narrow vowels and velopalatal vs. labial and dental consonants, since 0.111 is not contained in 0.112. There is no significance to the fact that one decimal is a smaller number than the other; thus, the chart in (4.2) is equivalent to a branching tree diagram (4.3), or a partially ordered lattice.

(4.2) Predicted acquisition sequences (Jakobson & Halle, 1956: 41)

Consonants: dental vs. labial	..... 0.1
Vowels: narrow vs. wide	..... 0.11
Narrow vowels: palatal vs. velar	..... 0.111
Wide vowels: palatal vs. velar	..... 0.1111
Narrow palatal vowels: rounded vs. unrounded	..... 0.1112
Wide palatal vowels: rounded vs. unrounded	..... 0.11121
Velar vowels: unrounded vs. rounded	..... 0.1113
Consonants: velopalatal vs. labial and dental	..... 0.112
Consonants: palatal vs. velar	..... 0.1121
Consonants: rounded vs. unrounded or	
pharyngealized vs. non-pharyngealized	..... 0.1122
Consonants: palatalized vs. non-palatalized	..... 0.1123



## (4.3) Predicted acquisition sequences as a tree diagram



The arguments from perception and acquisition discussed above give empirical reasons in support of the contrastive hierarchy.<sup>3</sup> Over time, however, the emphasis began to shift toward considerations of efficient coding and reducing redundancy, and this emphasis eventually led away from the Contrastivist Hypothesis.

#### 4.4. *Feature ordering and efficient coding*

Cherry, Halle, and Jakobson (1953) consider some properties of phonemic structure in terms of mathematical concepts relevant to the then emerging field of statistical communication theory. In their article, they explicitly adopt feature ordering: 'For the purpose of identifying one particular phoneme out of the set employed by the language, the distinctive features may be regarded as questions to be answered yes or no.' (325 in Makkai) They make it clear that these

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<sup>3</sup> I return to the use of the contrastive hierarchy in language acquisition in Chapter 7.

questions must be asked in an order, and explicitly point out that the logic employed is three-valued, yes (+), no (–), and zero, which they take to mean that either answer can be given.

The authors make some observations about the number of feature specifications required to differentiate any number of phonemes. For example, they observe that a set of eight phonemes can be fully distinguished by three binary features without incurring zeros.<sup>4</sup>

(4.4) Logical identification of objects in a set of eight

A	B	C	D	E	F	G	H
–	–	–	–	+	+	+	+
–	–	+	+	–	–	+	+
–	+	–	+	–	+	–	+

In contrast to the hypothetical chart in (4.4), which splits the members of the set into equal groupings so as to produce an optimally efficient coding, Cherry et al. observe that phonemes in real languages are not so evenly divided. The consequence of this is that more than the logical minimum number of features has to be employed, and each phoneme requires more than the

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<sup>4</sup> This diagram and the related discussion may have been the trigger for Hockett's (1955) attack on arbitrary binary coding of phonemes. Cherry et al. make clear, however, that the table in (4.4) is meant only as an illustration of the logic of successive binary choices when dealing with 'objects without linguistic significance.' (326 in Makkai) Their discussion of Russian demonstrates that real phonemes do not typically split up so as to produce an optimally efficient binary coding.

minimum possible number of bits of information. As an example they consider the phonemes of Russian (see further below). In their analysis there are 42 phonemes which require eleven distinctive features, rather than the six features which make up the logical minimum needed to fully distinguish a set of 42 members.

Continuing their earlier attention to the question of the efficiency of the coding obtained by their procedure, Cherry et al. ask if it is possible to remove all or many of the zero signs in their table by reordering the features. They observe that no simple reordering will permit them to remove all the zeros or push them to the end of each phoneme column. They go on to propose that gains can be achieved if one gives up a fixed feature order, and allows the order of the features to vary in different branches of the decision tree. In their focus on the problem of zero specifications, Cherry et al. (1953) foreshadow what was soon to become a major concern in early generative phonology.

#### 4.5. *Inconsistent approaches to contrastive specification*

Though the contrastive hierarchy was well-established in the work of Jakobson and his colleagues from the late 1940s on, it was not always strictly employed in working out phoneme specifications. While many publications incorporate it, some others do not, for reasons that are not made explicit. One can speculate that the authors were somehow not satisfied with the results of feature ordering in particular cases. The reasons are impossible to reconstruct, but it is possible that they had reasons for wanting to specify certain phonemes in ways not

permitted by strict feature ordering. Another possibility is that they were unable to arrive at a universal feature hierarchy that gave satisfactory results for every language they studied.

In this section I will briefly review some case studies where Jakobson et al. deviate from feature ordering. The existence of these analyses illustrates that the concept of the contrastive hierarchy was not in fact as securely rooted as one might have otherwise thought.

#### 4.5.1. *Jakobson 1949: Serbo-Croatian*

Jakobson's (1949) analysis of Serbo-Croatian appeared the same year as the paper by Jakobson and Lotz. We have seen that the specifications in the latter paper are consistent with feature ordering. The same is not the case for Jakobson's analysis of Serbo-Croatian. It can be shown that Jakobson does not use feature ordering. Rather, his results are fairly consistent with what would be given by the pairwise method, which extracts contrasts from full specifications.

Jakobson (1949) observes that Standard Serbo-Croatian has 29 phonemes that are analyzed into eight 'dichotomous properties.' Six of these are qualitative or inherent features, and two are prosodic features (high tone and length). Jakobson gives the values of each phoneme for the inherent features in the chart in (4.5).<sup>5</sup> For some features he allows a ternary choice (not counting a lack of specification): + indicates the presence of a feature; – indicates its 'distinctive

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<sup>5</sup> I retain here Jakobson's use of the Croatian spelling form for the phonemes.

absence' (i.e., not its absence by virtue of redundancy); and  $\pm$  indicates a 'complex combining both opposite terms.'

(4.5) Feature specifications: Serbo-Croatian (Jakobson 1949)

	t	d	c	s	z	p	b	f	v
Vocality									
Nasality		–					–		
Saturation	–	–		–	–	–	–	–	
Gravity	–	–		–	–	+	+	+	+
Continuousness	–	–	$\pm$	+	+	–	–	+	+
Voicing	–	+		–	+	–	+	–	+

	ć	đ	č	ǧ	š	ž	k	g	x
Vocality		–							
Nasality		–							
Saturation	+	+	+	+	+	+	+	+	+
Gravity	–	–			–		+	+	+
Continuousness	–	–	$\pm$	$\pm$	+	+	–		+
Voicing	–	+	–	+	–	+	–	+	

	n	m	ń	r	l	ĺ	i	u	e	o	a
Vocality				$\pm$	$\pm$	$\pm$	+	+	+	+	+
Nasality	+	+	+								
Saturation	–	–	+		–	+	–	–	$\pm$	$\pm$	+
Gravity	–	+					–	+	–	+	
Continuousness				–	+	+					
Voicing											

Simple inspection of the chart shows immediately that feature ordering does not yield the given values. Recall that feature ordering requires that some

feature be at the top of the hierarchy, and that an initial division based on this feature will result in all phonemes receiving a value for that feature.<sup>6</sup> We observe, however, that there is no row in which all phonemes have a value. Certainly, the ordering of the features cannot reflect their ordering in any contrastive hierarchy, since the feature listed first, vocality, is unspecified for all but one of the obstruents, and the following feature, nasality, is specified for only six consonants.<sup>7</sup>

A look at the specifications of the oral and nasal stops for [voicing] and [nasality] shows us that Jakobson must have been working from fully specified minimal pairs. The relevant specifications are shown in (4.6). I have rearranged the rows and columns to better bring out the relevant comparisons.

(4.6) Specifications of oral and nasal stops

	t	d	n	p	b	m	ć	ď	ń	k	g
Voicing	–	+		–	+		–	+		–	+
Nasality		–	+		–	+		–	+		

---

<sup>6</sup> This is not the case for privative features, but it is clear from Jakobson's remarks that he is not using privative features here, because the 'distinctive absence' of a feature is indicated by minus.

<sup>7</sup> It is interesting that the procedure of van den Broecke (1976), discussed in Chapter 2, which is an elaborate version of the pairwise method, also resulted in a single consonant, /ð/, being specified for [sonorant], which plays a similar role to that assumed by [vocalic] in Jakobson's analysis. This is further evidence that Jakobson must have been using some form of pairwise comparison here.

We have seen that this is the characteristic pattern of specifications driven by minimal pairs: in the coronals and labials, the voiced stop receives two specifications because it participates in two minimal pairs, whereas the voiceless stop and the nasal each receive one specification because they participate in one minimal pair with the voiced stop. As there is no velar nasal, the velar stops /k g/ lack specifications for nasality.

To test whether Jakobson was consistently working back from full specifications via minimal pairs, I applied the pairwise method to the full set of Serbo-Croatian phonemes in (4.5). The results are given in (4.11). Any divergence from Jakobson's assignments is shaded.

(4.7) Serbo-Croatian via pairwise method

	t	d	c	s	z	p	b	f	v
Vocality		–			–				–
Nasality		–					–		
Saturation	–	–	–	–	–	–	–	–	
Gravity	–	–		–	–	+	+	+	+
Continuousness	–	–	±	+	+	–	–	+	+
Voicing	–	+		–	+	–	+	–	+

	ć	đ	č	ǧ	š	ž	k	g	x
Vocality		0				–			
Nasality		–							
Saturation	+	+	+	0	+	+	+	+	+
Gravity	–	–			–		+	+	+
Continuousness	–	–	±	±	+	+	–		+
Voicing	–	+	–	+	–	+	–	+	

	n	m	ń	r	l	l'	i	u	e	o	a
Vocality				±	±	±	+	+	0	0	0
Nasality	+	+	+								
Saturation	–	0	+		–	+	–	–	±	±	+
Gravity	–	+					–	+	–	+	
Continuousness				–	+	0					
Voicing											

These results come fairly close to Jakobson's specifications. There are twelve discrepancies in all. Some of them may be due to simple mistakes or typos in Jakobson's article.

(a) There are two pairs of segments where one member is specified and the other unspecified in Jakobson's chart and where my calculation comes out the other way around. In my calculation, /d/, not /ḋ/, is specified [–vocality], because it forms a minimal pair with /r/ on this dimension, assuming /r/ is [–saturation]. Similarly, I find that /c/ must be specified [–saturation] rather than 0 to distinguish it from /č/, with which it forms a minimal pair; but /ǵ/ should be unspecified for this feature, since it lacks a minimal partner. Perhaps these are simple mistakes and the specifications should be switched. This would account for four of the discrepancies.

(b) Another two discrepancies between my application of the pairwise method and Jakobson's specifications involve consonants where Jakobson has a value where I derive a 0. These cases are: /m/ ([saturation]) and /l'/ ([continuousness]). In both cases, the phoneme in question forms a class with two other phonemes: /m n ń/ are the only nasals, and /r l l'/ are the only



liquids. The middle term in each set forms two minimal pairs, the peripheral phonemes each form one (4.8).

(4.8) Nasal and liquid contrasts via minimal pairs

a. Nasals

	m	n	ɲ
Saturation	–	–	+
Gravity	+	–	–

b. Liquids

	r	l	l'
Saturation	–	–	+
Continuousness	–	+	–

These, too, may be simple mistakes in Jakobson's chart.

(c) The remaining discrepancies have to do with [vocality]. From the point of view of the pairwise method, the voiced continuants are underspecified in Jakobson's chart while the vowels are overspecified for this feature.

According to the full feature specifications I have assumed, the voiced continuants /z/, /v/, and /ʒ/ form minimal pairs based on [vocality] with /l/, /u/, and /l'/, respectively. Therefore, according to the pairwise method they must be specified [–vocality].

On the other hand, the vowels /e, o/ need not be specified for [vocality]. The mid vowels are unique in being specified [ $\pm$ saturation], so they need only be distinguished from each other by one more feature.

/a/ is a different case. It forms minimal pairs only with /u/ and /o/, from which it is distinguished by [saturation]. Its lone specification [+saturation] is indeed insufficient to distinguish it from any other segment that is [+saturation], but it is too far from them to form a minimal pair that can be

recognized by the pairwise method. Therefore, the lack of specification of further features in /a/ results from a failure in the mechanical operation of this approach.

Perhaps because of this Jakobson departed from strict minimal pair comparisons to guide the specification of [vocality] in the vowels, which may have resulted in the apparent over- and under-specifications.

#### 4.5.2. *Halle 1954: Standard Literary German*

Though this article refers to the ‘dichotomous scale,’ it does not appear to consistently utilize feature ordering in the one example for which detailed specifications are given, Standard Literary German, shown in (4.9). Neither feature ordering nor pairwise comparisons yield exactly these specifications.

#### (4.9) Feature specifications: Standard Literary German (Halle 1954)<sup>8</sup>

	m	p	b	f	v	pf
Vocalic vs. non-vocalic	–	–	–	–	–	–
Consonantal vs. non-cons.	+	+	+	+	+	+
Compact vs. diffuse	0	–	–	–	–	–
Grave vs. acute	+	+	+	+	+	+
Flat vs. plain	0	0	0	0	0	0
Nasal vs. non-nasal	+	–	–	–	–	–
Continuant vs. interrupted	0	–	–	+	+	–
Strident vs. mellow	0	–	0	0	0	+
Tense vs. lax	0	+	–	+	–	0

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<sup>8</sup> I have replaced Halle’s *ŕ* by *pf*, and *ŝ* by *ts*. Halle notes that he has not indicated vowel length contrasts, and that the distinction between /e/ and /æ/ is not phonemic among short vowels.

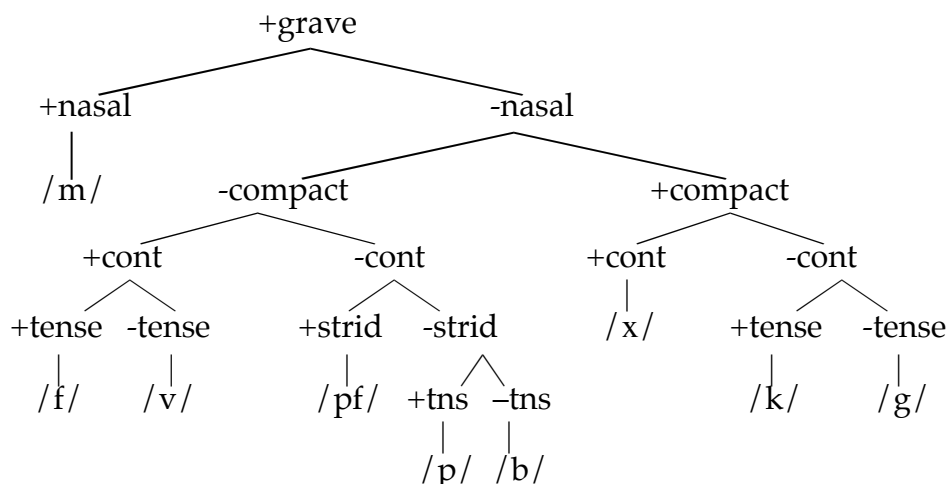
	n	t	d	s	z	ts	k	g	x	ʃ
Vocalic	–	–	–	–	–	–	–	–	–	–
Consonantal	+	+	+	+	+	+	+	+	+	+
Compact	0	–	–	–	–	–	+	+	+	+
Grave	–	–	–	–	–	–	+	+	+	–
Flat	0	0	0	0	0	0	0	0	0	0
Nasal	+	–	–	–	–	–	–	–	–	–
Continuant	0	–	–	+	+	–	–	–	+	0
Strident	0	–	0	0	0	+	0	0	0	0
Tense	0	+	–	+	–	0	+	–	0	0

	r	l	u	o	a	ü	ö	i	e	æ	h
Vocalic	+	+	+	+	+	+	+	+	+	+	–
Consonantal	+	+	–	–	–	–	–	–	–	–	–
Compact	0	0	–	±	+	–	±	–	±	+	0
Grave	0	0	+	+	+	–	–	–	–	–	0
Flat	0	0	+	+	0	+	+	–	–	0	0
Nasal	0	0	0	0	0	0	0	0	0	0	0
Continuant	–	+	0	0	0	0	0	0	0	0	0
Strident	0	0	0	0	0	0	0	0	0	0	0
Tense	0	0	0	0	0	0	0	0	0	0	0

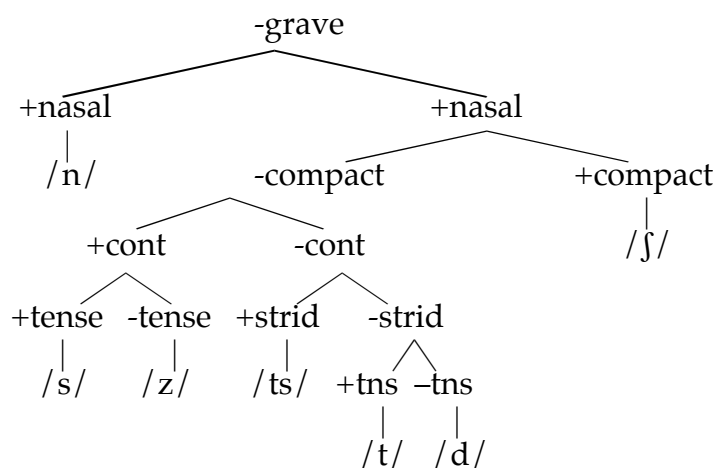
Looking at the consonants, it is possible to derive almost all the specifications via feature ordering if we slightly reorder the features. To come close to the listed specifications we must move [compact] down below [grave] and [nasal] ([flat] is not relevant to consonants here). The order vocalic > consonantal > grave > nasal > compact > continuant > strident > tense is illustrated in (4.10).

## (4.10) Contrastive hierarchy: Standard Literary German consonants

## a. [+grave] consonants



## b. [-grave] consonants



In Halle's chart the segments /b d/ lack specifications for [strident]. In the tree in (4.8) they must both be specified [-strident]. A [strident] specification can be omitted if we reorder the feature [tense] higher than [strident]; but then /pf ts/ would have to receive a specification for [tense]. The possible specifications

of /b p pf/ for the features [strident] and [tense], assuming the other values as listed, are shown in (4.11).

(4.11) Specifications of [-compact, +grave] segments by the SBA

a. strident > tense

	b	p	pf
strident	–	–	+
tense	–	+	0

b. tense > strident

	b	p	pf
tense	–	+	+
strident	0	–	+

I have shaded the specifications that are zeros in Halle's chart. Evidently, Halle has derived these specifications using minimal pairs.

However, it could not be the case that minimal pairs were used to derive most of the specifications. For example, all the [-vocalic, +consonantal] non-nasal phonemes are specified [-nasal], though only /b/ and /d/ are distinguished only by that feature from nasals. Thus, the chart appears to have been basically derived by feature ordering, and then perhaps some adjustments were made to the specifications. The discrepancy between the order of features in the table and the order required to derive the specifications may be due to a wish to maintain the general order used for other languages in tension with an order that appeared to be more appropriate for this particular language.

#### 4.6. *Ordered rules and the contrastive hierarchy*

Halle's *The sound pattern of Russian* (Halle 1959) is a major work in early generative phonology. The book is in two parts: the first part presents a

phonological analysis of Russian, and the second, longer, part is devoted to acoustics. Halle sets out a number of principles that a phonological theory should observe. Prominent among these are that features must be ordered into a hierarchy.

Halle's first argument in support of this principle is based on the need to keep segments properly distinct. To this end he proposes that feature specification must adhere to the Distinctness Condition (see Chapter 2). He argues that specifying phonemes by 'branching diagrams' (what I have been calling the Successive Division Algorithm) is the only way to ensure that phonemes meet this condition.<sup>9</sup>

Halle also requires that the number of specified features be minimal, in keeping with the requirement that they contrast. He argues that this condition requires feature ordering. He writes (1959: 34), 'It can be shown that imposing this condition on a set of fully specified morphonemes is tantamount to requiring that the matrix consisting of the set of fully-specified morphonemes be mappable into a branching diagram in such a way that if to each node a particular feature is assigned and the two branches emanating from each node are made to represent the values plus and minus that the feature can assume, then each path through

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<sup>9</sup> Halle (1959: 34 n. 26) mentions in a footnote that his discussion of specification via branching diagrams 'is based in part on an unpublished paper by N. Chomsky and M. Halle "On the Logic of Phonemic Description," presented at the M.I.T. Conference on Speech Communication, June 16, 1956.' I have found no other mention of this paper. One can only speculate how generative grammar might have developed had this topic been pursued.

the branching diagram beginning at the initial node and ending at the end points of the branching diagram will uniquely define a fully specified morphoneme.'

In the above quotation, the term 'morphoneme' is equivalent to the phoneme of generative grammar. By 'fully specified' Halle means specified as far as required by contrast. Thus, he does not use the term in the sense I have used it throughout, meaning that all distinctive features are specified, whether contrastive or not. Halle discusses some examples of branching diagrams, showing how a different ordering of features can produce different specifications. He observes that it is possible that features could apply in a different order in different parts of the branching diagram, though he writes he does not know if such cases arise in natural languages.<sup>10</sup>

There are limits to the extent to which Halle expects the feature hierarchy to have consequences for the workings of the phonology. He does in places refer to empirical reasons for ordering the features in a particular way. Thus, he observes (37) that intermediate nodes in the tree represent classes of segments (essentially the Prague School archiphonemes), and that these nodes play an important role in the functioning of a language. Again, in discussing the features [vocalic] and [consonantal], he observes (52) that these features 'show a high degree of negative correlation' and one might suppose that they should be replaced by less redundant features. However, he counters that these features

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<sup>10</sup> In fact, he uses different orders in different parts of the tree in his specification of Russian several pages later.

establish the major classes of Russian, and allow for the simple characterization of phonological constraints on the construction of Russian phonemes. Therefore, in these instances he appeals to the patterning of Russian phonology to support a particular feature hierarchy, even at the expense of minimality. Elsewhere, however, minimality plays a more important role. Thus, he chooses to order [strident] ahead of [continuant] because this ordering results in fewer specifications.

Halle 1959 presents one of the first analyses to use synchronic rule ordering to convert underlying lexical forms to surface phonetic forms.<sup>11</sup> In contrast to the prevailing neo-Bloomfieldian theory, Halle does not split the phonology into morphophonemic and phonemic components, where the first converts morphophonemes into phonemes, and the latter accounts for the allophonic realizations of phonemes. Rather, Halle views the conversion of underlying to surface forms as occurring gradually in the course of the derivation. Thus, he makes no fundamental distinction between rules that change a specified feature value into another value (a plus into a minus or vice-versa) and rules that assign a plus or minus to a zero value.

Halle argued that the seamless conversion of underlying to surface representations allowed one to capture generalizations that would be lost in a theory that separates morphophonemic from phonemic rules. However, this same reasoning comes into conflict with the Contrastivist Hypothesis.

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<sup>11</sup> Chomsky (1951) had applied a series of ordered rules in his analysis of Hebrew.



The conflict between a unified phonological derivation and the Contrastivist Hypothesis can be illustrated by the case of Russian voicing assimilation, the subject of Halle's famous argument against what Chomsky later called the taxonomic phoneme. Halle (1959: 45) proposes the specifications in (4.12) for Russian.<sup>12</sup> The features apply in the order indicated.

(4.12) Feature specifications: Russian (Halle 1959)

	t	d	tʲ	dʲ	n	nʲ	ts	s	z	sʲ	zʲ
vocalic	–	–	–	–	–	–	–	–	–	–	–
consonantal	+	+	+	+	+	+	+	+	+	+	+
diffuse	0	0	0	0	0	0	0	0	0	0	0
compact	–	–	–	–	–	–	–	–	–	–	–
low tonality	–	–	–	–	–	–	–	–	–	–	–
strident	–	–	–	–	–	–	+	+	+	+	+
nasal	–	–	–	–	+	+	0	0	0	0	0
continuant	0	0	0	0	0	0	–	+	+	+	+
voiced	–	+	–	+	0	0	0	–	+	–	+
sharped	–	–	+	+	–	+	0	–	–	+	+
accented	0	0	0	0	0	0	0	0	0	0	0

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<sup>12</sup> The specifications are very similar to those proposed by Cherry et al. (1953). As before, the transcription is slightly modified to reflect contemporary usage.



	e	é	o	ó	a	á	i	í	u	ú
vocalic	+	+	+	+	+	+	+	+	+	+
consonantal	–	–	–	–	–	–	–	–	–	–
diffuse	–	–	–	–	–	–	+	+	+	+
compact	–	–	–	–	+	+	0	0	0	0
low tonality	–	–	+	+	0	0	–	–	+	+
strident	0	0	0	0	0	0	0	0	0	0
nasal	0	0	0	0	0	0	0	0	0	0
continuant	0	0	0	0	0	0	0	0	0	0
voiced	0	0	0	0	0	0	0	0	0	0
sharped	0	0	0	0	0	0	0	0	0	0
accented	–	+	–	+	–	+	–	+	–	+

As can be seen from the charts, in Russian, voicing is a contrastive feature that distinguishes pairs of obstruent phonemes; /t/ and /d/ have opposite specifications for the feature [voiced], as do /k/ and /g/, /s/ and /z/, and so on. Of special interest are the Russian obstruents that do not have voiced counterparts, /ts tʃ x/. Halle (1959: 22–23) observes that these phonemes participate in voicing alternations just the way other obstruents do. In particular, there is a rule of regressive voicing assimilation that assimilates all obstruents in a cluster to the voicing of the final obstruent in the cluster.

(4.13) Regressive voicing assimilation (RVA) (Halle 1959: 64)

Rule P 3a. If an obstruent cluster is followed by a [phrase] boundary or by a sonorant, then with regard to voicing the cluster conforms to the last segment...

Halle observes that in the prevailing neo-Bloomfieldian theory the rule of RVA would have to apply twice: once in the morphophonemic component,

where the result is an existing phoneme (4.14a); and again at the phonemic level to create voiced allophones of the unpaired phonemes /ts tʃ x/ (4.14b).

(4.14) Russian regressive voicing assimilation applying twice

a. Morphophonemic voicing

Morphophonemes	/ /mók bi/ /	/ /ʒétʃ bi/ /
RVA	móg bi	---
(Taxonomic) phonemes	/móg bi/	/ʒétʃ bi/

b. Allophonic voicing

(Taxonomic) phonemes	/móg bi/	/ʒétʃ bi/
RVA	---	ʒédʒ bi
Systematic phonetic form	[móg bi]	[ʒédʒ bi]

We find [móg bi] ‘were (he) getting wet’, where *k* voices to *g* before voiced obstruent *b* (compare [mók lʲi] ‘was (he) getting wet?’, with a *k* preceding the sonorant *l*). The rule that changes *k* to *g* changes one phoneme to another, and so it must be a morphophonemic rule (4.14a). This result is forced in any phonemic theory that observes the constraint that allophones of different phonemes may not overlap: in this case, [k] may not be an allophone of both /k/ and /g/. But the very same process produces [ʒédʒ bi] ‘were one to burn’, where *dʒ* is the voiced counterpart of *tʃ* (compare [ʒétʃ lʲi] ‘should one burn?’, with voiceless *tʃ* before *lʲ*). Because [dʒ] is not a phoneme in its own right, but exists only as an allophone of /tʃ/, this application of voicing is an allophonic rule, and must be assigned to the component that maps phonemic forms into phonetic forms (4.14b).

Since the alternations between [k] ~ [g] and [tʃ] ~ [dʒ] occur under the exact same conditions, the analysis in (4.14) must state the same generalization twice. By giving up the condition on non-overlapping, and hence giving up a level of taxonomic phonemes that observes this and other such conditions, the rule of RVA can be stated once for both types of cases.

The unpaired phonemes /ts tʃ x/ function as regular obstruents not only as targets of regressive voicing assimilation: when they are in the position to trigger the rule (when they are final in an obstruent cluster), they function as ordinary voiceless consonants, not as consonants with no specification for voicing. To capture this result, Halle (1959: 63) proposes the rule in (4.15), which applies before RVA.

(4.15) Specification of unpaired segments (Halle 1959: 63)<sup>13</sup>

Rule P 1b. Unless followed by an obstruent, /ts/, /tʃ/ and /x/ are voiceless.

Halle's derivation of the voicing alternations discussed above is presented in (4.16). The phoneme /tʃ/, unspecified for [voiced] at the underlying level, is converted to [–voiced] early in the derivation, making it equivalent to underlying specified phonemes such as /k/ with respect to all further voicing rules.

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<sup>13</sup> As throughout, I have replaced Halle's symbols by the IPA symbols, and changed his {} to slant brackets, as per current practice.

## (4.16) Derivation of Russian voicing

a. Systematic phonemes	/mók bi/	/ʒétʃ bi/
[voiced]	0 – +	+ 0 +
b. Rule P 1b (specify <i>t</i> )		–
c. Rule P 3a (RVA)	+	+
d. Other rules	[móg bi]	[ʒédʒ bi]

Though it is unclear to what extent any of the spirit of the Contrastivist Hypothesis still animated thinking about phonology, one can see that the introduction of a seamless set of ordered rules is a major blow against it. Recall that the Contrastivist Hypothesis posits a major distinction between contrastive and redundant features: only the former are computed by phonological operations. But if unspecified values can be freely changed to specified ones in the course of a derivation, then the distinction becomes unimportant: a redundant feature that is filled in acts just like a contrastive feature with respect to all subsequent rules.

The easy transition of an unspecified value to a specified one may be a reason that the following question was not asked: is the voicing feature really noncontrastive for the unpaired phonemes? If contrast is based on minimal pairs, the answer is obvious: the lack of voiced counterparts of the unpaired phonemes, identical to them with respect to every feature except [voiced], means that voicing is not contrastive in these segments. But if contrast is based on feature ordering, whether the feature is contrastive or not depends on the ordering.

In the specifications proposed by Halle, these phonemes have no specification for [voiced], just like the sonorants. This result follows from the ordering, which puts place features above manner features. A different result would follow if the feature [voiced] were placed higher in the order. This issue is important with respect to the hypothesis that only contrastive features are active: the fact that /tʃ/ triggers devoicing, like all the other voiceless obstruents, suggests that the voicing feature is active, hence by hypothesis contrastive, in this segment. Halle (1959), however, did not assume this kind of connection between contrast and activity; by an early rule (P 1b) the feature [voiced] became *as if* contrastive in /tʃ/ with respect to the rule of RVA (rule P 3a). Therefore, there was no compelling reason to question or revise the feature hierarchy on these grounds. Rather, minimality of specification became the most compelling criterion for ordering features.

Minimality also dictated that feature specifications made predictable by sequential (contextual) constraints should also be removed from underlying forms, and this, too, led to a blurring of the specifications derived by feature ordering. To account for specifications made predictable in this way, Halle proposed a set of Morpheme Structure rules. For example, if a Russian word begins with a glide (G), the following segment must be a vowel (V), as there are no initial clusters GC where a consonant (C) follows a glide. Therefore, to satisfy minimality, Halle proposed that the predictable specifications for [vocalic] and [consonantal] could be omitted from a vowel that follows an initial glide.

Contextual underspecification greatly complicates the nature of underlying representations. Now, it is not just feature ordering that governs specification, but a large array of Morpheme Structure rules that refer to sequences. As with paradigmatic underspecification, there are many ways of arriving at contextual underspecification, for there are many possible contexts one can consider.

#### 4.7. *Summary: the contrastive hierarchy on the edge*

The developments sketched above show that, by the 1960s, the contrastive hierarchy had begun to lose its *raison d'être*. In the earlier work of Jakobson, the main motivation for contrastive specification was the patterning of phonological systems, assuming some version of the Contrastivist Hypothesis. The contrastive hierarchy as a method for arriving at contrastive specifications remained an obscure principle until the early 1950s, when 'branching diagrams' were viewed as 'the pivotal principle' of linguistic structure by Jakobson, Fant, and Halle (1952). All the ingredients existed, at that moment, for the development of a theory in which the Contrastivist Hypothesis and the contrastive hierarchy played central roles.

Phonological theory, however, did not advance in this direction. Rather, considerations of efficient coding and minimality came to the fore. Failure to find a universal feature order may have led to a certain loss of faith in the utility of feature ordering. Finally, the advent of a single gradual derivation from lexical to phonetic representations blurred the distinction between contrastive and



redundant specifications, resulting in the total eclipse of the Contrastivist Hypothesis. Lacking this empirical motivation, the stage was set for the contrastive hierarchy to be ushered out of phonological theory when underspecification itself came under attack.

#### 4.8. *Stanley (1967) and the end of zeros in generative phonology*

Stanley's famous article, 'Redundancy Rules in Phonology' (Stanley 1967), is well known in the phonological literature for its attack on the potential for misuse of zero values in binary feature matrices. This article convinced phonologists that the phonological component should be limited to working with fully specified matrices. In place of filling in empty values by redundancy rules, Stanley proposed the adoption of morpheme structure constraints. The main proposals of this article were adopted by Chomsky and Halle 1968 (*SPE*) and other influential works and effectively put an end to underspecification in phonology for the next fifteen years.

Stanley's general arguments against underspecification would have sufficed to put an end to any sort of underspecification. However, he also made some arguments explicitly against the 'branching diagrams,' that is, the contrastive hierarchy, as used by Halle 1959. We will see that the main arguments against contrastive specification rest on the assumption that (contrastive) underspecification of a feature is merely a matter of notation and should have *no* empirical consequences for how the phonology works.

#### 4.8.1. Zeros and ternary power

Stanley (1967: 413) points out that the presence of unspecified feature values in the phonology raises formal questions about how rules apply in such situations.<sup>14</sup> He shows that, whatever the definition, there is the danger that binary features will be used in a ternary manner, whereby 0 contrasts with both + and –.

Consider first the initial matrices in (4.17a).

(4.17) Rule application: Sub-matrix interpretation (Stanley 1967: 413)

##### a. Initial matrices

A	B	C
$\begin{bmatrix} \\ \vdots \end{bmatrix}$	$\begin{bmatrix} +f \\ \vdots \end{bmatrix}$	$\begin{bmatrix} -f \\ \vdots \end{bmatrix}$

##### b. Phonological rules

- |   |                             |
|---|-----------------------------|
| i. $\begin{bmatrix} \\ \vdots \end{bmatrix} \rightarrow [-g]$ | ii. $[+f] \rightarrow [+g]$ |
| iii. $[-f] \rightarrow [+g]$                                  | iv. $[-g] \rightarrow [+f]$ |

##### c. Derived matrices

A	B	C
$\begin{bmatrix} +f \\ -g \\ \vdots \end{bmatrix}$	$\begin{bmatrix} +f \\ +g \\ \vdots \end{bmatrix}$	$\begin{bmatrix} -f \\ +g \\ \vdots \end{bmatrix}$

Phoneme A has no specification for feature *f*, B is [+*f*], and C is [–*f*]. In the view of redundancy rules commonly held at the time, the omission of a feature value in A is simply supposed to be a way of reducing the information content of a segment, as indicated by the number of symbols that need to be specified for it.

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<sup>14</sup> Stanley remarks that this problem was first stated by Lightner (1963).

Since *f* is a binary feature, it should only be able to make a binary distinction.

Thus, *A* has either the specification [+*f*] or [-*f*], but this specification is omitted in underlying representation because it is redundant in this segment.

Consider now the ordered phonological rules in (4.17b). Rule (4.17bi) states that a segment unspecified for *f* is specified [-*g*]. The next two rules apply to segments that are specified [+*f*] and [-*f*], respectively. The formal question that arises is whether a segment that is unspecified for *f* should undergo these rules or not. On the sub-matrix interpretation of rule application, a segment is subject to a rule only if the rule is a sub-matrix of the feature matrix of the segment. On this interpretation, segment *A* does not undergo rules (ii) and (iii). But, then, if we add a redundancy rule like (4.17biv), all three segments *A*, *B*, and *C* will end up being distinct, though they started out distinguished only by the feature *f*.

Stanley shows that similar results can be obtained if we adopt a different convention of rule application. On the distinctness interpretation of rule application, a rule applies to a matrix if the matrix is non-distinct from the feature matrix of the segment. In that case, a segment unspecified for *f* will undergo any rule that mentions either [+*f*] or [-*f*], and segments specified for *f* undergo rules that do not mention *f*, if their matrices are otherwise non-distinct from the structural description of the rule.

## (4.18) Rule application: Distinctness interpretation (Stanley 1967: 413)

## a. Initial matrices

$$\begin{array}{ccc} \text{A} & \text{B} & \text{C} \\ \begin{bmatrix} \phantom{+f} \\ \vdots \end{bmatrix} & \begin{bmatrix} +f \\ \vdots \end{bmatrix} & \begin{bmatrix} -f \\ \vdots \end{bmatrix} \end{array}$$

## b. Phonological rules

- i.  $[\phantom{+f}] \rightarrow [-g, -h]$
- ii.  $[+f] \rightarrow [+g]$
- iii.  $[-f] \rightarrow [+h]$
- iv. Default:  $[\phantom{+f}] \rightarrow [+f]$

## c. Derived matrices

$$\begin{array}{ccc} \text{A} & \text{B} & \text{C} \\ \begin{bmatrix} +f \\ -g \\ -h \\ \vdots \end{bmatrix} & \begin{bmatrix} +f \\ +g \\ -h \\ \vdots \end{bmatrix} & \begin{bmatrix} -f \\ -g \\ +h \\ \vdots \end{bmatrix} \end{array}$$

No matter what the default or redundant value of *f* turns out to be, all three segments end up distinct in their values for features *g* and *h*, and again a binary feature has functioned in ternary fashion. Stanley (414) argues that this is an ‘improper use of blanks’ that gives ternary power to a binary system.

On logical grounds, Stanley’s argument is perfectly correct. However, it rests on the empirical assumption that distinctive features must function in a strictly binary way. Although this assumption was adopted by almost all generative phonologists in the subsequent decade, it is actually inconsistent with the logic of contrastive specification. For a segment can be contrastive with respect to a feature, *f*, in which case it is either  $[+f]$  or  $[-f]$ , or it is noncontrastive with respect to that feature, in which case it receives no contrastive specification

(or equivalently, [0f]).<sup>15</sup> Even if the theory requires that all non-contrastive values be filled in, it remains an open question at what point this occurs.<sup>16</sup> If the application of the redundancy rules is very late – say, in a phonetic component that follows all phonological rules – then the phonology will indeed be operating with three values, +, –, and 0.

One could argue that a genuinely binary feature system is more constrained than a ternary one, but this argument has no force if empirical evidence suggests that the phonology does make ternary distinctions. In Autosegmental Phonology, or any other theory that posits semi-autonomous tiers, the ability to exploit ternary distinctions of this kind is what gives the theory much of its interest. Thus, in a tone language with one phonological contrast between a high (H) and low (L) tone, we often find morphemes that are

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<sup>15</sup> The distinction between contrastive and redundant features does not necessarily require that redundant specifications are absent, though that is a natural interpretation of how the grammar marks this distinction. I will assume this interpretation of redundant features for purposes of this discussion, on the grounds that a segment that is only redundantly [+f] or [–f] does not have the same status as a segment that is contrastively [+f] or [–f], whether or not the redundant value is present somehow or not.

<sup>16</sup> I have assumed this to be the case throughout, but the matter is not so straightforward. This assumption requires that all features be defined for all phonemes. Many recent theories of feature representation include features that are defined only for subsets of the inventory. For example, [anterior] can be limited to apply within the coronal region. Or some theories posit that certain segments are inherently unspecified for certain features. In these theories, it is not the case that all unspecified feature values are filled in.

always high-toned, some that are always low-toned, and some that alternate, depending on context. An elegant analysis is to view high and low tone as two values of a single feature, say H. Then, the first group of morphemes are associated with [+H], the second group with [-H], and the third group have no associated specification, but receive tone from the context, either by spreading of a nearby tone or by default.

Stanley (416) considers the case of a language where all [-consonantal] segments are [+voiced]. By redundancy (and by feature ordering, assuming [consonantal] is ordered higher than [voiced]), we would therefore not specify such segments as [+voiced]. Suppose now that the language also has a rule that applies to the class of voiced obstruents, [+consonantal, +voiced]. Stanley observes that a phonological rule could just mention [+voiced], taking advantage of the fact that [-consonantal] segments are not specified at the point in the phonology where this rule applies.<sup>17</sup> He writes (416) that ‘this is a specious simplification, an improper use of blanks.’

What Stanley considered specious was later considered a result! The insight underlying Structure Preservation and various versions of underspecification theory is precisely that certain redundant specifications are indeed absent (or, in another interpretation, not visible to the relevant rule). Thus, it has been proposed in a number of cases that rules spreading obstruent voicing values do not affect sonorants, and are not triggered by sonorants,

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<sup>17</sup> Stanley assumes here the sub-matrix interpretation of rule application.

because the latter indeed lack specifications for [voiced], and are barred (at least in a certain component of the grammar) from taking any on.

Thus, later developments of phonological theory routinely exploit the ternary distinction between [+f], [-f], and [0f]. This does not mean that the theory needs to exploit the full ternary power that is available. Dresher 1985 argues that the sort of cases imagined by Stanley, whereby the ternary distinction in a feature *f* is used to affect other features *g* and *h*, in fact do not arise. Almost all cases of ternary distinctions are rather confined to a single feature. Thus, one feature value is typically the *active* value, and the opposite value is *inert* or *opaque*, serving to block the spreading of the active value to unspecified segments.

To take another type of case, it is possible to misuse underspecification to make distinctions that are not clearly warranted. For example, suppose a rule palatalizes /k/ before /i/. To account for the fact that certain sequences of /ki/ escape this rule, we might write the rule to apply to a [+high] consonant. Then, /k/ that undergoes the rule is specified [+high] underlyingly, but /k/ that does not undergo the rule could be specified some other way, say as a voiceless dorsal stop, with [+high] being filled in later. What makes this case more suspicious than the usual kind of underspecification is that the descriptions of the two types of /k/ are non-distinct and non-contrastive. This is not a case of neutralization of two distinct phonemes into surface /k/, but rather a single underlying /k/ that is being described in two different ways. This type of analysis would not be

permitted by feature ordering, which would not permit any feature to treat two identical segments as different.<sup>18</sup>

Therefore, we may still want to rule out some of the situations Stanley wished to bar, not by banishing blanks from the phonology, but through other means, by limiting the power of phonological operations (see Drescher 1985 for further discussion).

#### 4.8.2. *Arguments against 'branching diagrams'*

Stanley (1967: 407) opens his discussion of the 'branching diagrams' (contrastive hierarchy) of Halle (1959) by recalling Halle's observation that 'not all ways of choosing the non-redundant feature values leave open the possibility of constructing a branching diagram (Halle 1959: 35). A branching diagram can only be constructed if there is a feature  $f_1$  which is non-redundant in every segment; if there is a feature  $f_2$  which is non-redundant in all  $+f_1$  segments and a feature  $f_3$  which is non-redundant in all  $-f_1$  segments; if there are features  $f_4, f_5, f_6$ , and  $f_7$  which are non-redundant in all  $+f_2, -f_2, +f_3$ , and  $-f_3$  segments respectively,

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<sup>18</sup> This theory does not, however, rule out the absolute neutralization of genuine underlying contrasts, even contrasts that are somewhat abstract with respect to phonetic reality. For example, we could distinguish between a dorsal /k/ and a placeless consonant, call it /K/, that surfaces as [k], if the theory allows consonants to be placeless. However, one would need to see evidence for the existence of such a contrast; cf. Ghini 2001a for an analysis that argues for the existence of placeless consonants in Miogliola, supported by synchronic and diachronic evidence. Whether one agrees with his analysis or not, the issue here is not the use of ternary features, but the existence of a genuine underlying contrast between segments that have identical surface forms.



etc.’ Stanley remarks that this distribution of non-redundant features is not always found.

Stanley’s remark appears to assume that branching trees are constructed working back from feature specifications, rather than looking at it the other way round — that specifications are the consequence of the branching tree. Before arguing against branching trees, Stanley notes that generative grammars have been chosen that have a branching diagram of this kind, and summarizes the reasons why it was regarded as important to have such a diagram. I quote his passage in full (408):

‘(1) Giving segments in a branching diagram appears to be the most direct means, involving the fewest feature specifications, which will guarantee that each pair of segments is DISTINCT in the sense that for any pair of different segments there is at least one feature *f* such that one member of the pair is specified *+f* and the other *–f*. (2) The branching diagram gives a hierarchy of features which can be interpreted as meaning that the features at high nodes (such as Consonantal) are in some sense more basic than the features at low nodes (such as Voiced). (3) The branching diagram gives a way of formalizing the notion of the archiphoneme.’

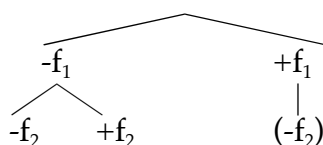
Stanley proceeds to take issue with each of these assumptions. He argues that the Distinctness Condition is both too strong and too weak. It is too weak because it does not prevent specious simplifications of rules obtained by improper use of blanks. This is of course part of Stanley’s general argument

against blanks in the phonology, and I addressed that above in connection with that argument. The Distinctness Condition is too strong, in Stanley's view, because it prevents leaving out redundant features when feature values of a higher-order feature is predictable from the values of lower-order features (i.e., what we can call 'underspecification from below').

For example, suppose we have a feature hierarchy as in (4.19a). If a segment is  $[+f_1]$ , then it must be  $[-f_2]$ ; since this specification is not contrastive, it would be omitted. For clarity, I indicate it here in parentheses. This value of  $f_2$  can be filled in by the redundancy rule (4.19bi). However, it is now also true that if a segment is  $[+f_2]$  then it must also be  $[-f_1]$ ; Stanley argues that this fact, expressed by rule (4.19bii), should allow us to underspecify two segments that contrast with respect to  $f_1$  as in (4.19c).

(4.19) Distinctness Condition and redundancies from below

a.  $f_1 > f_2$



b. Redundancy rules

i.  $[+f_1] \rightarrow [-f_2]$

ii.  $[+f_2] \rightarrow [-f_1]$

c. Lexical entries

	A	B
$f_1$	+	
$f_2$		+

d. Full specification

	A	B
$f_1$	+	-
$f_2$	-	+

Such situations occur frequently in languages. A typical case is a language where all sonorants are voiced; since [+sonorant] implies [+voiced], it follows that a specification [–voiced] necessarily implies [–sonorant]. Stanley argues that the lexical entries in (c) should be permitted, because the redundancy rules in (b) are legal and lead to the two segments being completely distinguished (d).

Stanley's argument would go through if it were indeed a requirement of the theory that all logical redundancies be expressed by blank specifications. But we have seen before that it is neither necessary nor possible for a theory to express all logical redundancies. If we take specification by feature ordering as the fundamental way to express contrasts in a system, then a certain amount of underspecification follows from the contrastive hierarchy, if we interpret redundant features as unspecified. However, underspecification, on this view, is a consequence of establishing contrasts, not an end in itself. We would thus rule out specification from below as in the rule (4.19bii): lower-order features cannot supply values for higher-order features.

Stanley observes correctly that the sequential MS rules of Halle (1959) lead to violations of the Distinctness Condition. The MS rules in (4.20a) can only be applied if hypothetical morphemes like [ijv] and [jiv] are underspecified as in (4.20b). But the two feature matrices are not distinct.

## (4.20) MS rules in Russian and redundancies from below (Halle 1959)

## a. MS rules

- i. A morpheme-initial glide must be followed by a vowel

$$+ \begin{bmatrix} -\text{consonantal} \\ -\text{vocalic} \end{bmatrix} \left[ \quad \right] \rightarrow \begin{bmatrix} -\text{consonantal} \\ -\text{vocalic} \end{bmatrix} \begin{bmatrix} -\text{consonantal} \\ +\text{vocalic} \end{bmatrix}$$

- ii. A morpheme-final glide-consonant cluster must be preceded by a vowel

$$\left[ \quad \right] \begin{bmatrix} -\text{cons} \\ -\text{voc} \end{bmatrix} \begin{bmatrix} +\text{cons} \\ -\text{voc} \end{bmatrix} \rightarrow \begin{bmatrix} -\text{cons} \\ +\text{voc} \end{bmatrix} \begin{bmatrix} -\text{cons} \\ -\text{voc} \end{bmatrix} \begin{bmatrix} +\text{cons} \\ -\text{voc} \end{bmatrix}$$

## b. Lexical entries

[ijv]	i	j	v
consonantal		–	+
vocalic		–	–

[jiv]	j	i	v
consonantal	–		+
vocalic	–		–

It is correct that the Distinctness Condition is not compatible with allowing both underspecification by the contrastive hierarchy as well as sequential underspecification. But rather than throwing out the contrastive hierarchy and the Distinctness Condition, as Stanley proposed, we can choose to keep them and do away with sequential underspecification.<sup>19</sup>

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<sup>19</sup> Sequential underspecification can be made consistent with the contrastive hierarchy if the positions subject to sequential underspecification are viewed as independent domains within which contrasts are evaluated.

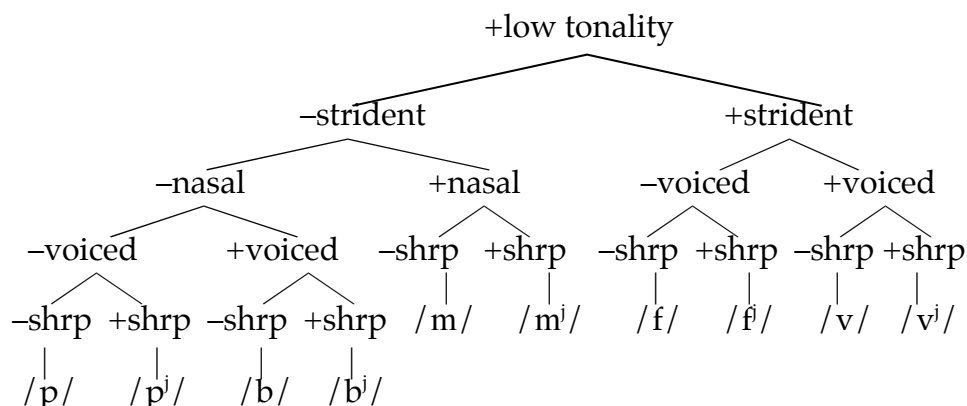
Stanley's second argument against feature ordering is that it is 'somewhat strange' to capture the feature hierarchy in a branching diagram because many different such diagrams can be constructed for a given set of phonemes. Any such hierarchy must represent more than 'a vague set of intuitions' as to which features are more basic than others, which is a danger in the absence of evidence that a certain hierarchy is required by the facts of a particular language. And even if one can establish a particular hierarchy, he wonders why one cannot simply state it separately, 'since it has nothing essential to do with the branching diagram.'

Stanley is correct that one must have evidence to support the proposed hierarchies. He even suggests (408) where such evidence could possibly be found, 'perhaps...in terms of the different ways in which different features behave in the P[honological] rules or the MS rules.' At the time he did not think he had such evidence, and indeed it was not (and is still not!) entirely clear what would constitute such evidence. However, we have seen that from the beginnings of distinctive feature theory phonologists, whether in theory or in practice, have found reasons to assign at least partial feature hierarchies.

Further, it is not correct that the feature hierarchy has no necessary connection to the branching diagram. For it is the hierarchy, implemented by the branching diagram that determines which features are contrastive and which are redundant. And this distinction arguably plays an important role in phonological patterning.

The third argument is that branching diagrams do not adequately formalize the notion of the archiphoneme. By ‘archiphoneme’ Stanley means a representation of the neutralization of a contrast, or a number of contrasts. For example, in Halle 1959, the feature [sharped] is at the bottom of the hierarchy for consonants. Thus, pairs of plain and sharpened consonants are sisters at the bottom of the branching tree. A part of the tree showing the labial consonants is given in (4.21).

(4.21) Contrastive hierarchy for Russian labial consonants (Halle 1959)



Suspending these final branches results in ‘archiphonemes’ that represent consonants without regard to the value of the feature [sharped], but with all other contrastive features expressed. Here we have the archiphonemes /p pʲ/, /b bʲ/, /m mʲ/, /f fʲ/, and /v vʲ/. More extended archiphonemes can be represented by stopping the tree at higher nodes. For example, the feature [voiced] can be neutralized as well as [sharped], resulting in archiphonemes /p pʲ b bʲ/, /m mʲ/, and /f fʲ v vʲ/.

Stanley observes that not all archiphonemes that we may want to represent can be read off the tree. Thus, we may want to represent consonants without regard for their value for [voiced], but still retaining their values of [sharped], neutralizing the contrast between /p b/, /p<sup>j</sup> b<sup>j</sup>/, /f v/, and /f<sup>j</sup> v<sup>j</sup>/, for example. Yet these neutralizations cannot be read off the same tree; we would require a different tree in which [sharped] is higher in the contrastive hierarchy than [voiced]. Therefore, Stanley argues, the branching tree incorrectly limits the possible archiphonemes (neutralizations) that can be represented, and thus fails to capture the relevant notion of archiphoneme.

Stanley is correct if we look only at the tree structure without considering the representations derived from the trees. We can distinguish here between *strong minimal pairs* and *weak minimal pairs*. A strong minimal pair is a pair of members of an inventory that differ in all but one of their features and which are terminal sisters in a branching tree. Weak minimal pairs differ in all but one feature, without also having to be sisters in a tree. The contrastive hierarchy of which the tree in (4.21) is a part yields the representations in (4.22).

## (4.22) Feature specifications: Russian labial consonants (Halle 1959)

	p	b	p <sup>j</sup>	b <sup>j</sup>	m	m <sup>j</sup>	f	v	f <sup>j</sup>	v <sup>j</sup>
vocalic	–	–	–	–	–	–	–	–	–	–
consonantal	+	+	+	+	+	+	+	+	+	+
compact	–	–	–	–	–	–	–	–	–	–
low tonality	+	+	+	+	+	+	+	+	+	+
strident	–	–	–	–	–	–	+	+	+	+
nasal	–	–	–	–	+	+	0	0	0	0
continuant	0	0	0	0	0	0	0	0	0	0
voiced	–	+	–	+	0	0	–	+	–	+
sharped	–	–	+	+	–	+	–	–	+	+

Reading off the table, we see that voiced and voiceless counterparts are indeed (weak) minimal pairs, since they are distinguished only by the feature [voiced]. Therefore, to the extent that representations are important apart from the contrastive hierarchy that generates them, then the branching tree does not limit possible neutralizations as much as Stanley claimed they do.

Of course, any choice of a contrastive hierarchy does limit possible neutralizations beyond what we can obtain with full specification. For example, the representations in (4.22) do not allow us to group /m/ with /b/ against /p/, since /m/ has no value for [voiced]. But this limitation is bad only if there is evidence in the language that /b m/ act together as being [+voiced]. In Russian, however, sonorants do not participate in rules of voicing or devoicing, so the representations in (4.22) are supported in this respect.

To take one more example, in a full specification of the features in (4.22) /p/ and /f/ would differ in two features, [strident] and [continuant].



Neutralizing these features, however, would still not bring them together, because /p/ is specified [-nasal] and /f/ has no value for [nasal]. However, a phonological process could still pick them out by referring to the set [-low tonality, -voiced, -sharp].

Therefore, a judgement as to whether generating specifications with a feature hierarchy results in appropriate or inappropriate representations will rest on a number of empirical and theoretical considerations. These include the nature of the objects that play a role in the phonology — to what extent weak and strong representations play a role, as well as the nature of phonological rules or constraints, and what sort of feature combinations they can refer to.

In sum, Stanley's arguments against the branching trees, and hence against the contrastive hierarchy, rest mainly on logical, not empirical, criteria. The logical points are correct as far as they go, however his main empirical assumptions have become less relevant as phonological theory developed. Nevertheless, his arguments carried the day, and branching trees disappeared from mainstream generative phonology for the rest of the century.

Still, the intuition that, as Stanley put it (408), 'there is obviously some kind of hierarchical relationship among the features which must somehow be captured in the theory', continued to haunt generative phonological theory, and took a number of different forms. Three of them coexisted uneasily at the same time at the heart of mainstream generative phonology: markedness theory, underspecification theory, and feature geometry. All bear interesting, though

seldom discussed, affinities with the contrastive hierarchy, and these form the subject matter of the next chapter.

## 5. Generative Phonology: Contrast Goes Underground

‘[T]here is obviously some kind of hierarchical relationship among the features which must somehow be captured in the theory.’

Richard Stanley (1967: 408)

### 5.1. Chomsky and Halle’s revolution in phonology

Chomsky and Halle’s approach to phonological theory, as represented in their major work *The Sound Pattern of English* (Chomsky and Halle 1968, henceforth *SPE*), represented a sharp break with the main currents of American linguistics that immediately preceded them. Nevertheless, some elements of the Jakobson-Halle approach to phonology were continued in generative phonology. In his review of Jakobson and Halle’s *Fundamentals of Language* (Jakobson and Halle 1956), Chomsky (1957) finds that ‘much can be said’ for Jakobson and Halle’s approach to phonology. In particular, he approved of the hypothesis that the sound systems of all languages could be characterized in terms of a limited number of universal distinctive features. Second, he preferred their approach to identifying phonemes over others then current. They assigned two segments to the same phoneme if they have the same feature specifications. Most other approaches to phonemic analysis prevailing at the time assigned sounds to phonemes if they are in complementary distribution (or in free variation) and phonetically similar, appealing to a notion of similarity that is difficult to define. Finally, Chomsky seconds the authors’ emphasis (advanced over the years by

Jakobson) on the importance of extending phonological theory to account for language acquisition, disorders, and other aspects of linguistic behaviour.

On the other side, Chomsky observes that many of Jakobson and Halle's proposals need to be made more explicit and precise before they can be empirically tested. He further proposes an amendment to their conception of how phonemes are related to speech. He found their requirement that the distinctive features assigned to phonemes be present in their correct sequence in the phonetics too strict. He proposes that distinctive feature specifications form instead an 'abstract underlying system of classification related, perhaps indirectly, to the physical facts of speech.' Finally, Chomsky proposes that general criteria of simplicity play an important role in the evaluation of particular phonological analyses.

Thus, Chomsky and Halle's theory of generative phonology was a synthesis of Jakobson and Halle's theory of distinctive features and phonemic analysis, revised in the light of Chomsky's emphasis on formal explicitness, simplicity, and abstractness and autonomy of mental representations.

One aspect of Jakobson and Halle (1956) that did not make it into *SPE* was the contrastive hierarchy, consigned to the scrap heap of history by Stanley (1967). As discussed in the previous chapter, the atmosphere was not in any case conducive to assigning a special role to contrastive specifications. One of the major points of difference between the older structuralist approach and generative phonology was in the status of the 'taxonomic phoneme' (Chomsky 1964). Classical generative phonology posits only two significant levels in the

phonology: the underlying lexical, or ‘systematic phonemic’ level (known as the morphophonemic level in structuralist theory), and the surface phonetic level (a level that was not recognized as a systematic level in structuralist phonology, following the arguments of Bloomfield 1933). Instead of a phonetic level, the neo-Bloomfieldians posited what Chomsky called the ‘taxonomic phonemic’ level, a level defined largely in terms of surface-oriented criteria designed to simplify the acquisition problem (see Dresher 2005 for discussion). Chomsky and Halle argued that this level was superfluous, causing a loss of generalizations by requiring certain phonological rules such as Russian voicing assimilation to be split across two components, as demonstrated in the previous chapter.

As I observed there, the Russian example does not necessarily show that the contrastive status of a phoneme is irrelevant to the functioning of the voicing assimilation rule. However, it may have seemed so at the time. More generally, an emphasis on a single seamless derivation from lexical to phonetic representations is not compatible with dividing up the phonology into a component that is concerned with contrastive representations and a component that allows for redundant features as well; such a proposal would have looked like a move to reestablish the taxonomic phoneme.<sup>1</sup>

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<sup>1</sup> In fact, we need to break up the phonology into at least two components to distinguish between phonological rules, that compute only contrastive features, and ‘low-level’ phonetic rules, that introduce allophones that require noncontrastive features. Such a distinction was reintroduced to

Therefore, the basic theory of *SPE* grants no special role to contrastive feature specifications, and in this respect amounts to a complete rejection of the Contrastivist Hypothesis implicit in much early phonological theory. However, generative phonology found over time that it could not get along without something like the Contrastivist Hypothesis and a contrastive feature hierarchy, and several subtheories arose within generative phonology to fill this gap. In this chapter I focus on the treatment of contrast within ‘classical’ generative phonology, beginning with the first attempt, in *SPE* itself, to remedy some shortcomings brought about, in part, by its rejection of the Contrastivist Hypothesis.

## 5.2. *Markedness*

### 5.2.1. *Chapter 9 of SPE*

Chapter 9 of *SPE* opens with a dramatic statement (Chomsky and Halle 1968: 400): ‘The entire discussion of phonology in this book suffers from a fundamental theoretical inadequacy.’ This inadequacy consists of *SPE*’s ‘overly formal’ approach to features, which does not take into account their intrinsic content. If all segments are fully specified in terms of the same features, and the evaluation measure counts only the number of symbols, then there is no basis for evaluating

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generative phonology in the form of the theory of Lexical Phonology and Morphology (LPM) (Pesetsky 1979, Kiparsky 1982, 1985, Mohanan 1986).

any segment as being more or less costly, or complex, than any other. As a result, the *SPE* theory as presented in the previous eight chapters cannot account for why certain segments are more common than others, or why certain segmental inventories are common and others are not.

In addition, Chomsky and Halle observe that the problem is not limited to inventories, but has implications for the functioning of phonological rules. They present a number of examples, some of which are reproduced in (5.1), of pairs of rules to which a purely formal evaluation measure would assign incorrect relative costs.

(5.1) Pairs of rules (Chomsky and Halle 1968: 401)

- |  |  |
|--|--|
| a. i. $i \rightarrow u$  | ii. $i \rightarrow i$  |
| b. i. $t \rightarrow s$  | ii. $t \rightarrow \emptyset$  |
| c. i. $k \rightarrow tʃ / \text{ — } \begin{bmatrix} - \text{ cons} \\ - \text{ back} \end{bmatrix}$ | ii. $tʃ \rightarrow k / \text{ — } \begin{bmatrix} - \text{ cons} \\ + \text{ back} \end{bmatrix}$ |

In (5.1a), rule (i) is formally more complex than (ii) because it changes an extra feature, [round], in addition to a change in [back]: *i* is [–back, –round], among other features not in play here, *i* is [+back, –round], and *u* is [+back, +round]. Nevertheless, rule (i) is much more common than rule (ii). This is presumably because [u] is a more common segment than [i], a fact not recognized by the *SPE* theory, which only counts the number of symbols in a rule, and does not evaluate their content. In this case the cost of the extra feature in rule (i) is outweighed by the more natural result. Or, rather, the cost of the extra feature is only apparent.

The case of (5.1b) is similar. Of the features relevant to this rule, *t* is [-continuant, -strident], *θ* is [+continuant, -strident], and *s* is [+continuant, +strident]. Rule (5.1bii) appears to be the cheaper rule because it changes only [continuant], in the *SPE* feature system, whereas rule (i) also changes [strident]. Again, the formally simpler rule is less common than the more complex one, because [s] is a more common segment than [θ].

The example in (5.1c) looks a bit different, but ultimately falls under the same heading in Chomsky and Halle's analysis. They point to an asymmetry in the direction of a rule: whereas the change of /k/ to [tʃ] before a front vowel is quite common,<sup>2</sup> the converse change of /tʃ/ to [k] before a back vowel is not. Since the two rules are formally very similar, once again the formal simplicity criterion fails to distinguish the common rule from the rare one.

Contrast by itself does not account for why [u] and [s] are more common than [i] and [θ], respectively; but contrast is relevant to the observations in (5.1). Thus, rule (i) in (5.1a) is more common than rule (ii) only in vowel systems that lack a three-way contrast between /i i u/. In inventories with all three vowels, the result of simply backing /i/ would indeed be *ɨ*; to arrive at *u*, it would be necessary to change not just [back], but also [round]. In such inventories, in other words, the formal simplicity measure gives the right answer. Similar

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<sup>2</sup> Actually, the fronting of /k/ to [tʃ] most usually occurs before /i/ and sometimes also /e/, but rarely before the low front vowel /æ/.



considerations hold for the change of /t/ to [s]: rule (i) in (5.1b) is only more common than rule (ii) in inventories that lack a phoneme /θ/.

The *SPE* markedness theory classifies segments as either unmarked (u) or marked (m) for particular features. A set of *marking conventions* convert markedness values into +/– values before the phonology proper begins. Markedness conventions can nevertheless interact with the phonology via the concept of *linking*. I will first briefly review some of the marking conventions, and then look at how linking works. I will show that these devices do some of the work of specification by a contrastive hierarchy, but run into problems because they do not take account of language-particular contrasts.

### 5.2.2. SPE *marking conventions and feature hierarchy*

Chomsky and Halle (1968: 404–407) present a ‘tentative statement’ of the marking conventions. To illustrate the form of these statements I reproduce the conventions for vowels in (5.2).

(5.2) Some markedness conventions for vowels (*SPE*: 405)

- a. (V)  $\begin{bmatrix} +\text{voc} \\ \pm \text{cons} \end{bmatrix} \rightarrow \begin{bmatrix} \pm \text{ant} \\ \pm \text{strid} \\ +\text{cont} \\ +\text{voice} \\ \pm \text{lateral} \\ \text{etc.} \end{bmatrix}$
- b. (VI)  $[\text{u low}] \rightarrow \left\{ \begin{array}{l} [+low] / \left[ \begin{array}{c} \overline{\text{u back}} \\ \text{u round} \end{array} \right] \\ [-low] \end{array} \right\} \quad \begin{array}{l} \text{(i)} \\ \text{(ii)} \end{array}$
- c. (VII)  $[+low] \rightarrow [-high]$
- d. (VIII)  $[\text{u high}] \rightarrow [+high]$

- e. (IX)      [+high]      →      [–low]
- f. (X)      [u back]      →      [+back] /  $\left[ \begin{array}{c} \text{---} \\ +\text{low} \end{array} \right]$
- g. (XI)      [u round]      →       $\left\{ \begin{array}{l} [\alpha \text{ round}] / \left[ \begin{array}{c} \text{---} \\ \alpha \text{ back} \\ -\text{low} \end{array} \right] \\ [-\text{round}] / \left[ \begin{array}{c} \text{---} \\ +\text{low} \end{array} \right] \end{array} \right\}$       (i)
- h. (XII)      [u tense]      →      [+tense]

The marking conventions are rather heterogeneous. Some take as their inputs an unmarked feature value, [u F], whereas others have +/– values as their input. These latter are statements of necessary universal implications, such as that [+low] vowels are necessarily [–high] (VII), or that [+high] vowels are necessarily [–low] (IX). Most rules converting u values to +/– values have contexts specified only with +/– values, or variables ranging over these values (VIII, X, XI), but some conventions also contain u/m values in their contexts (only (VI) in the conventions shown, but the full set of markedness conventions contains further examples).

Not all features are governed by markedness conventions in all contexts. For example, convention (X) states that the unmarked value of [back] is + in the context [+low] (low vowels are preferably back: /a/ is preferred to /æ/), but there is no corresponding convention for [back] in the context [–low]. Therefore, non-low vowels have no u/m value for [back], but only a +/– value.

No marking conventions convert a marked feature into +/– values. If for some feature, F, a rule converts [u F] into [ $\alpha$  F] in some context C, it follows logically that a segment specified [m F] in the same context must receive the



The recursive manner of application is limited to the conventions for these features. Chomsky and Halle propose (1968: 408) that the remaining conventions apply only once and in order. We will investigate the relationship between this order and feature ordering with respect to the markedness conventions for the vowels.

The conventions for the main vowel features [low], [high], [back], and [round], apply in this order, which might at first suggest that this is their order in the hierarchy. The conventions depart from a branching tree in that the convention for [low] (VI) mentions [u back] and [u round]; in particular, the unmarked value of [low] is + for a vowel that is unmarked for [back] and [round]. This statement is inconsistent with a contrastive hierarchy, in that a higher-order feature refers to one ordered later. Nevertheless, the vowel conventions (V)-(XII) correspond most closely to a hierarchy in which [low] is higher than [back] and [round]. The convention for [back] (X) presupposes specification of [+low], and the convention for [round] (XI) presupposes +/– values of both [low] and [back]. The relationship between [low] and [high] also departs from a consistent hierarchy: [+low] leads to the specification of [–high] (VII), presupposing that [low] is specified first, but (IX) states that [+high] implies [–low], presupposing the opposite.

Chomsky and Halle perceive a hierarchy among the features, though they modify the markedness theory for vowels somewhat to achieve it. The immediate reason for modifying the results of the markedness conventions is their dissatisfaction with the predicted vowel inventories that emerge from these

conventions. Assigning a cost of 0 to a *u* and 1 to *m*, +, or −, with the total cost of each segment being its *complexity*, the theory assigns the lexical representations of some typical vowels the complexity measure shown in (5.4).

(5.4) Markedness matrices for vowels (*SPE*: 409)

	a	i	u	æ	ɔ	e	o	ü	ɪ	œ	ö	ʌ
low	u	u	u	m	m	u	u	u	u	m	u	u
high	u	u	u	u	u	m	m	u	u	u	m	m
back	u	−	+	m	u	−	+	−	+	m	−	+
round	u	u	u	u	m	u	u	m	m	m	m	m
Complexity	0	1	1	2	2	2	2	2	2	3	3	3

The conventions predict, correctly, that the simplest possible three-vowel system is /a i u/. However, for five-vowel systems, the theory assigns the same complexity score to every system containing /a i u/ and any two of /æ ɔ e o ü ɪ/. For example, the commonly found and presumably optimal five-vowel system /a i u e o/ receives the same complexity score as the unlikely /a i u ü ɪ/.

Rather than modify the markedness conventions, Chomsky and Halle (1968: 410) propose to add two general conditions on lexical representations, as in (5.5).

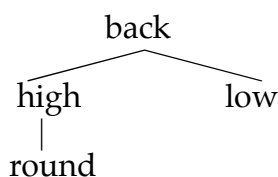
(5.5) Conditions on lexical representations (*SPE*: 410)

- a. No vowel segment can be marked for the feature ‘round’ unless some vowel segment in the system is marked for the feature ‘high.’

- b. Other things being equal, a system in which more features have only the specification *u* is preferable to a system in which fewer features have only the specification *u*.

Chomsky and Halle (410) observe that condition (5.5a) 'establishes a hierarchy in the availability of features for marking vowels in the lexicon. There are doubtless other conditions of this sort. Thus one would expect a hierarchy in which the feature 'segment' is above 'consonantal' and 'vocalic,' and the latter two are above the features listed in [(5.4)].' They go on to say that (5.5a) should be extended so that features [high] and [low] would be available for marking only after [back] has been marked, resulting in the hierarchical structure in (5.6).

(5.6) Extended hierarchy of vowel features (*SPE*: 410, ex. (11))



The hierarchy in (5.6) refers to marked values, and is not equivalent to a developmental path specified by a contrastive hierarchy. Thus, (5.6) does not require that the first contrast in a vowel system be between [+back] and [–back] (a position that would contradict the view of Jakobson and Halle 1956). The maximally unmarked vowel remains /a/, and the unmarked three-vowel system

remains /a i u/. The vowels /i u/ are considered to be marked for [back],<sup>4</sup> so other vowels in the inventory could be marked for [high] or [low]. Of the other vowels in (5.4) that have complexity 2, /ɔ ü i/ are marked for [round], so cannot be added to an inventory containing /a i u/, as none of these vowels are marked for [high].

This still leaves vowels /æ e o/ which have complexity 2. Now the vowel system /a i u e o/ is preferred to /a i u æ o/ by (5.5b) because in the former only the features [high] and [back] are marked, whereas in the latter [high], [back], and [low] are all marked. Thus, condition (5.5b) builds in a symmetry requirement, since symmetrical systems will tend to have marked values restricted to fewer segments than unsymmetrical ones. In this case, symmetrical /e o/ are both marked for [back] and [high], whereas in unsymmetrical /e æ/, /e/ is marked for [back] and [high] and /æ/ is marked for [back] and [low].

Thus, it is clear that Chomsky and Halle were moving in the direction of imposing a consistent feature hierarchy on the markedness statements of *SPE*, though this goal remains unachieved in *SPE* itself. A revision that completed this change was undertaken a few years later by Mary-Louise Kean.

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<sup>4</sup> Recall that /i u/ are specified [+back] and [-back], respectively in (5.4), rather than by *u* or *m*. These specifications count as marking, since they contribute to a segment's complexity score.

### 5.2.3. Kean's (1980) revision of the marking conventions

Kean's 1975 MIT dissertation, published as Kean (1980), is a revision of the *SPE* theory of markedness. Kean proposes that markedness statements are restricted in format, so that for every feature, *F*, there is a *markedness convention* of the form (5.7) that specifies a + or – value of the unmarked specification of *F*, [u *F*].

(5.7) Markedness convention (Kean 1980: 11)

$$[u F] \rightarrow [\alpha F] / X \quad \text{where } X \text{ is } \begin{bmatrix} \overline{\phantom{\beta_1 G_1}} \\ \beta_1 G_1 \\ \vdots \\ \beta_n G_n \end{bmatrix}$$

*F*, *G*<sub>1</sub>, ..., *G*<sub>*n*</sub> are features, and  $\alpha, \beta_1, \dots, \beta_n$  are + or –.

For example, Kean proposes the markedness conventions in (5.8) for the main vowel features [back], [low], [lab], and [high].<sup>5</sup>

(5.8) Some markedness conventions (Kean 1980: 23-25)

- a. V     [u back]  $\rightarrow$  [+back] /  $\begin{bmatrix} \overline{\phantom{-ant}} \\ -ant \end{bmatrix}$
- b. VI    [u low]    $\rightarrow$  [+low] /  $\begin{bmatrix} \overline{\phantom{-cons}} \\ -cons \\ +back \end{bmatrix}$

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<sup>5</sup> Kean employs a unified set of features that apply to vowels as well as consonants. For illustrative purposes, I have extracted the features that are most relevant to vowels. [lab] is the same as [round] when applied to vowels. The Roman numeral indicates the ordering of the convention with respect to the entire list.



- c. VII [u lab]  $\rightarrow$  [+lab] /  $\left[ \begin{array}{c} \text{---} \\ -\text{cons} \\ +\text{back} \\ -\text{low} \end{array} \right]$
- d. XI [u high]  $\rightarrow$  [-high] /  $\left[ \begin{array}{c} \text{---} \\ \alpha \text{ cons} \\ \alpha \text{ ant} \\ \beta \text{ cor} \\ -\beta \text{ lab} \\ -\beta \text{ spr} \end{array} \right]$

Kean proposes that every markedness convention of the form in (5.7) projects a set of *markedness rules* according to the *Complement Convention* (5.9). In (5.9), [m F] is the marked value of feature F, X is the context as in (5.7), and  $\bar{X}$  is the set of environments that make up the complement of X.

(5.9) The Complement Convention (Kean 1980: 11)

- a. [u F]  $\rightarrow$  [ $\alpha$  F] / X
- b. [m F]  $\rightarrow$  [ $-\alpha$  F] / X
- c. [u F]  $\rightarrow$  [ $-\alpha$  F] /  $\bar{X}$
- d. [m F]  $\rightarrow$  [ $\alpha$  F] /  $\bar{X}$

To illustrate, the markedness convention (5.8a) generates the markedness rules in (5.10). All vowels are [-anterior], so according to (5.8a) (= (5.10a)) it is unmarked for a vowel to be [+back], and thus it follows (5.10b) that it is marked for a vowel to be [-back]. Consonants that are [-anterior] (palatals, velars, and other back consonants) are likewise unmarked if [+back] (velars) and marked if [-back] (palatals). [+anterior] consonants (labials and prepalatal coronals) are the other way around, following (5.10c, d): their unmarked value is [-back], and marked value (if it can exist at all) is [+back].

(5.10) Markedness rules for [back] (Kean 1980: 23-25)

- a. [u back]  $\rightarrow$  [+back] /  $\left[ \begin{array}{c} \text{---} \\ -\text{ant} \end{array} \right]$
- b. [m back]  $\rightarrow$  [-back] /  $\left[ \begin{array}{c} \text{---} \\ -\text{ant} \end{array} \right]$
- c. [u back]  $\rightarrow$  [-back] /  $\left[ \begin{array}{c} \text{---} \\ +\text{ant} \end{array} \right]$
- d. [m back]  $\rightarrow$  [+back] /  $\left[ \begin{array}{c} \text{---} \\ +\text{ant} \end{array} \right]$

In this case the context of the markedness convention is simple, consisting only of a single feature, so the complement of the context is also simple. When the context is more complex, the complement rules multiply. For example, the complement of the environment [-cons, +back] consists of the three contexts [+cons, +back], [+cons, -back], and [-cons, -back].

The limitation on markedness conventions to a single context sometimes results in odd specifications. For example, it is unmarked for all vowels to be [+high], because vowels occur in the complement of the context of the markedness convention for [high] (5.8d). However, this results in the vowel /a/ receiving the specification [m high], though its unmarked value is [+low]. As Kean (1980: 28) points out, no vowel could be simultaneously [+low, +high]; once a vowel is specified [+low], it has no choice but to be [-high]. As there is no choice in the matter, [-high] cannot be a marked value, for that would imply that it is possible for the unmarked counterpart to exist. Rather than complicate the markedness conventions, Kean proposes to have a set of implications that

capture co-occurrence restrictions on feature specifications. Some examples of such rules are listed in (5.11).

(5.11) Implicational co-occurrence restrictions (Kean 1980: 29-30)

- a.  $[-\text{cons}] \supset [+ \text{son}]$
- b.  $[-\text{cons}] \supset [-\text{ant}]$
- c.  $[+ \text{low}] \supset [-\text{high}]$
- d.  $[+ \text{lat}] \supset [+ \text{cor}]$

Kean (1980: 30) proposes the principle in (5.12) to be part of the procedure for specifying feature values.

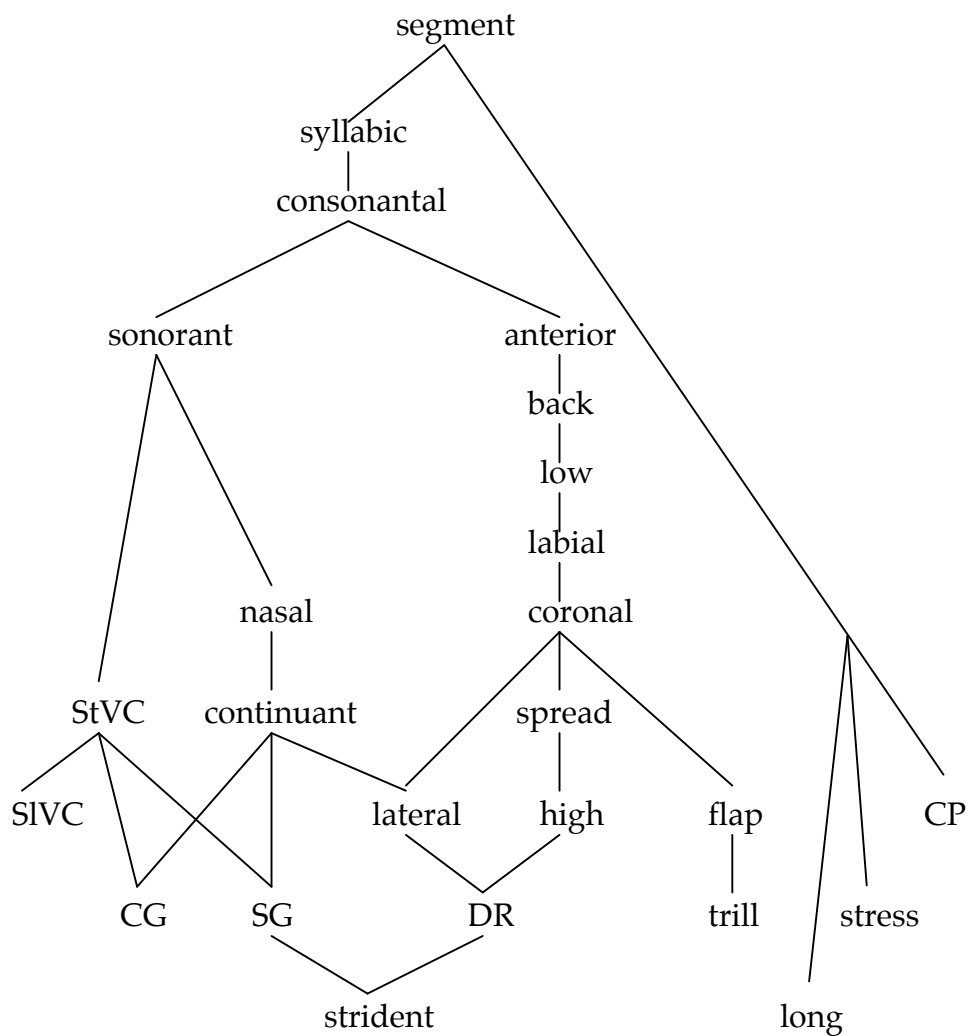
(5.12) Specification of co-occurrence restrictions (Kean 1980: 30)

Whenever a segment is specified to be  $[\alpha F]$ , where  $F$  is a feature and  $\alpha$  is  $+$  or  $-$ , all implications whose antecedents are satisfied apply to that segment.

#### 5.2.4. *Markedness and feature hierarchy*

It is evident even from the few examples in (5.8) that the markedness conventions are intrinsically ordered. The rule for [back] presupposes a value for [anterior]; the rule for [low] presupposes [back] and [consonantal], [labial] presupposes these two and [low], and [high] presupposes [labial], among others. Kean has devised the markedness conventions so the features fall into a partially ordered hierarchy, which she presents as in (5.13). In the diagram, StVC = stiff vocal cords; SlVC = slack vocal cords; CG = constricted glottis; CP = constricted pharynx; SG = spread glottis; and DR = delayed release.

## (5.13) Feature hierarchy (Kean 1980:26)



The markedness conventions thus presuppose a feature hierarchy. This hierarchy, however, functions quite differently from the contrastive hierarchy because it is not driven by language-particular contrasts, and does not

distinguish between contrastive and redundant feature specifications in particular languages.<sup>6</sup>

Consider, for example, the markedness matrices for vowels that emerge from the markedness conventions and implicational restrictions proposed by Kean, shown in (5.14). I omit features for which all vowels have the same specifications.

(5.14) Markedness matrices for vowels (Kean 1980: 31)

	i	e	æ	ü	ö	œ	ɪ	ə	a	u	o	ɔ
back	m	m	m	m	m	m	u	u	u	u	u	u
low	u	u	m	u	u	m	m	m	u	m	m	u
lab	u	u	u	m	m	m	m	m	u	u	u	m
high	u	m	u	u	m	u	u	m	u	u	m	u
Complexity	1	2	2	2	3	3	2	3	0	1	2	1

If we assume that languages favour segments with low complexity values, it would follow from (5.14) that the least marked three-vowel inventory should contain /a/, the least marked vowel (with 0 marked specifications), and two of

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<sup>6</sup> One generative approach to markedness that did incorporate a contrastive hierarchy is the Markedness Theory of Syllable Structure (MTSS) proposed by Cairns (1988). This theory combines markedness, underspecification, and a contrastive hierarchy, which Cairns calls a ‘coding tree’, to arrive at feature specifications. The MTSS determines contrasts narrowly by position, rather than over the language as a whole.

/i/, /u/, and /ɔ/. The latter would be an unexpected choice, since the most common three-vowel inventory is /i a u/, not /i a ɔ/ or even less probably, /a ɔ u/. Whichever vowels we choose, there is no notion that some feature values are contrastive whereas others are not.

One disadvantage of this kind of approach to markedness is that it appears that markedness is relative to a particular inventory. As we will see in Chapter 7, a vowel like /i/ is more marked than /i/ in the sense that the latter occurs more frequently in vowel inventories; but when both /i/ and /i/ occur in the same inventory, it is /i/ that functions like the less marked vowel. This kind of fact cannot be captured by a markedness scale like that in (5.14).

#### 5.2.5. *Linking to the phonology*

In the *SPE*-Kean approach to markedness, the markedness statements are largely insulated from the phonology proper. Recall that the motivation for this was to enable the phonology to operate with fully specified +/– feature values, and to avoid bringing into the phonology any underspecified feature values, or features specified in terms of the *u/m* notation of markedness theory. The disadvantage of this strategy, however, is that the phonology cannot refer to either markedness or underspecification in cases where such reference would be useful in capturing generalizations about phonological processes. In effect, a theory in which the active phonological component is entirely insulated from the markedness component embodies the claim that markedness is relevant only to underlying

phonological inventories and phonotactics, but ceases to play any role in the phonology proper.

For example, recall the pairs of rules in (5.1a, b). These are listed by Chomsky and Halle as being examples where the rule in (i) of each pair is formally more complex than (ii), though more natural and more expected. The markedness theory they propose has the effect of making the derived segment in the rule in (i) less marked than the one in (ii). But the rule component manipulates only  $+/-$  values, not  $m/u$  values. It remains to show how markedness can influence the operation of phonological rules.

Chomsky and Halle accomplish this by means of the device of *linking*. Essentially, when a phonological rule changes the value of a feature, any markedness conventions that mention this feature value are ‘linked’ to the rule, meaning that these markedness conventions can be brought into play. By linking the markedness conventions to phonological rules, they allow the phonology to refer to markedness in a limited way.

Chomsky and Halle state the linking convention formally as in (5.15).

(5.15) Linking convention (Chomsky and Halle 1968: 420)

Suppose the phonology contains the rule (i) and that there exists markedness convention (ii), where  $\alpha, \beta = +$  or  $-$ ,  $Y, Z, Q, W$  may be null, and the feature  $G$  is distinct from  $F$ .

- $$\begin{array}{ll} \text{i.} & X \rightarrow [\alpha F] / Y \left[ \begin{array}{c} \text{---} \\ Q \end{array} \right] Z \\ \text{ii.} & [u G] \rightarrow [\beta G] / \left[ \begin{array}{c} \text{---} \\ \alpha F \\ W \end{array} \right] \end{array}$$

If the segment to which (i) has applied meets the condition W of (ii), then the feature specification [ $\beta$ G] is automatically assigned to that segment.

For example, consider again the rules in (5.1a), whereby /i/ becomes [+back]. *SPE* would fully specify /i/ as in (5.16a).<sup>7</sup> Let us write the rule in question generally as in (5.16b). Changing the specification of [back] leads to (5.16c), which, if left undisturbed, would yield [i], not [u]. However, there exists a markedness convention that mentions the specification [+back] and whose other specifications are also met by (5.16c), namely vowel convention XI, listed above as (5.2gi) and repeated here as (5.16d). Linking this convention to the rule means in effect that the value of the feature [round] in the segment produced by the backing rule must revert to its unmarked value, which is [+round] in the context of [+back, –low], yielding (5.16e), which is [u], not [i].

(5.16) Linking in the change of /i/ to [+back]

- a. Specification of /i/: [–low, +high, –back, –round]
- b. Backing rule:  $V \rightarrow [+back] / \left[ \begin{array}{c} \text{---} \\ -low \end{array} \right]$
- c. Change by rule (b): [–low, +high, +back, –round]

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<sup>7</sup> Full specification is a relative matter, since there are further features that could apply here ([ATR], [tense], [nasal], etc.). Additional features will not affect the basic point.



d. Linked markedness convention (5.2gi):

$$(XI) \ [u \text{ round}] \rightarrow [\alpha \text{ round}] \ / \left[ \begin{array}{c} \hline \alpha \text{ back} \\ -\text{low} \end{array} \right]$$

e. Change by linking:  $[-\text{low}, +\text{high}, +\text{back}, +\text{round}]$

Linking crucially depends on the feature hierarchy inherent in the marking conventions, for the only feature values that can be affected by linking are those that are ordered after the feature directly changed by the rule. This result would be expected given specification governed by the contrastive hierarchy. If a potentially contrastive feature, like [round] in the above example, is not in fact contrastive in a segment, it must be that some other contrastive feature that draws a related contrast, in this case [back], is ordered above it in the hierarchy. The non-contrastive features are left unspecified and take on their default values, given the specified (contrastive) features.

Moreover, Chomsky and Halle (423) observe that for the phonology to fully benefit from linking, it must allow the successive application of all markedness conventions that apply to a given rule as well as to any markedness convention that links to that rule. That is, if a rule, R, changes a feature value to  $[\alpha F]$ , and a marking convention, C1, assigns  $[uG]$  to  $[\beta G]$  in the context of  $[\alpha F]$ , then C1 links to R. But then so, too, does marking convention, C2, that assigns  $[uH]$  to  $[\gamma H]$  in the context of  $[\beta G]$  and other relevant features, and so on.

In other words, when a rule changes a feature value, all features ordered below it revert to their unmarked values, *as if* they had never been specified. In this way, linking effects a temporary despecification of subordinate features.

Moreover, in the usual case these features are also noncontrastive in the relevant domain. In this way, the linking convention mimics contrastive specification via a contrastive hierarchy. As mentioned, however, the *SPE*-Kean approach to markedness does not really do the same work, because it does not take account of language-particular contrasts. We will return to the subject of markedness in Chapter 7, where we will see why the ‘complexity’ of a segment is not fixed universally, but varies with the particular contrasts in play in an inventory.

### 5.3. *Contrast and underspecification*

By the early 1980s, the original arguments against underspecification began to lose their force, and underspecification was reintroduced to the theory. However, it did not come back in the form of a contrastive hierarchy. I will argue in what follows that, like the pre-generative phonologists before them, underspecification theorists associated with one of the two main theories of underspecification, Radical Underspecification, did not pay sufficient attention to the notion of contrast. This was a point also made by advocates of the other prominent approach to underspecification, Contrastive Specification; I will argue that the latter, however, did not pay sufficient attention to how contrasts are established. The lack of an adequate theory of contrast hindered the subsequent development of underspecification theory and left it vulnerable to critiques that underspecification has no principled basis and is empirically flawed.

### 5.3.1. *Radical Underspecification*

Kiparsky (1982) proposed that only unpredictable features are included in underlying representations. Assuming binary features, therefore, in any given context only one feature need be specified. This approach, which came to be called Radical Underspecification (RU), was taken up by Archangeli (1984) and Pulleyblank (1986), and exemplified in a number of further publications.<sup>8</sup>

Radical Underspecification allows for two main types of rules. *Default rules* capture universal restrictions on feature co-occurrence, and are context dependent. We continue with an example that came up earlier, voicing on sonorants. Because voicing on sonorants is completely predictable in most languages, the feature [voiced] need not be included in their underlying representation, but is instead introduced by a default rule of the form in (5.17):

(5.17) Default rule for sonorants

[+sonorant] → [+voiced]

The second rule type proposed in RU, *complement rules*, are context-free rules that introduce the opposite feature value on a language-specific basis if a default rule is not available to supply the feature value. Suppose, for instance, that there are two series of stops in a language, voiced stops and voiceless stops. Voicing is clearly distinctive in this language. In RU, it is proposed that only a

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<sup>8</sup> See also Archangeli 1988, Abaglo and Archangeli 1989, and Archangeli and Pulleyblank 1989. Archangeli and Pulleyblank 1994 renounce RU in favour of what they call Combinatorial Specification.

single value of a distinctive feature need be marked. Two possible markings are possible for any single feature, as in (5.18).

(5.18) Possible specifications for [voiced] in RU

	a.	p	t	k	b	d		b.	p	t	k	b	d	g
voiced					+	+	+					—	—	—

Either the plus value of the feature is marked, as in (a), or the minus value of the feature is marked, as in (b), but not both. It is suggested that one of the markings (in this case (a)) will be preferred by universal grammar but that language-particular considerations can override this, yielding (b) as a second possibility.

#### 5.3.1.1. *Radical Underspecification and the Contrastivist Hypothesis*

RU has one characteristic that accords with the Contrastivist Hypothesis, as I have characterized it, as opposed to the *SPE*-Kean markedness theory. RU relies to some extent on phonological activity in arriving at the choice of underlying specifications. Because patterns of activity differ across languages, RU therefore posits that languages can differ in their choice of underlying specifications. As evidence in establishing underlying specifications for vowel systems, Archangeli (1984) is guided by the identity of the epenthetic vowel, on the assumption that it is the least specified vowel. For example, Spanish, Japanese, and Telugu all have five-vowel systems that can be represented by the phonemes /i e a o u/. In Spanish the epenthetic vowel is /e/, in Japanese it is /i/, and in Telugu it is /u/. To account for these different patterns, Archangeli (1984) proposes that the underlying representations of the vowels differ in each language.

RU does not fully adopt the Contrastivist Hypothesis, for it places severe limits on the extent to which aspects of phonological activity besides epenthesis are considered evidence for underlying specifications. In RU, the notion of contrast is not explicitly mentioned in the characterization of either default or complement rules, nor is there explicitly a contrastive hierarchy. Most central to the Contrastivist perspective, it can be shown that RU does not systematically distinguish between contrastive and redundant feature values.

Consider, for example, the vowel system of Spanish, which has the feature specifications shown in (5.19a). In Spanish the epenthetic vowel is /e/. One way of guaranteeing that /e/ is completely unspecified is to disallow specification of any values that /e/ has in its full specification. In this case, these values are all [–F] for every feature, F, in (5.19). A consequence is that these values cannot be specified on any other vowel, either. The result of removing these values is (5.19b). Each removal requires the formation of a complement rule (5.19c).<sup>9</sup>

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<sup>9</sup> The complement rules in (5.19c) are all context free. There are other ways to ensure that /e/ is unspecified. One could, for example, adopt context-sensitive complement rules that more closely resemble the markedness rules discussed in the previous chapter (see further Mohanan 1991).

(5.19) Spanish: /e/ is unspecified (Archangeli 1984)

a. Full specifications

i	e	a	o	u	
+	–	–	–	+	high
–	–	+	–	–	low
–	–	+	+	+	back
–	–	–	+	+	round

b. Removing values of /e/

i	e	a	o	u	
+				+	
		+			
		+	+	+	
			+	+	

c. Complement rules

i. [ ]  $\rightarrow$  [–high]

ii. [ ]  $\rightarrow$  [–low]

iii. [ ]  $\rightarrow$  [–back]

iv. [ ]  $\rightarrow$  [–round]

Since underlying representations consist essentially of privative features, the Distinctness Condition is not in effect. Once it has been decided that /e/ is the unspecified vowel and its features have been removed, the main principle governing the specification of the rest of the phonemes is minimality of specification. Looking at (5.19b), we see that the features [high] and [low] divide the vowels into three sets: /i u/, /e o/, and /a/. It remains to make a further division in each of /i u/ and /e o/. Either feature [back] or [round] will suffice to do this. Archangeli chooses to dispense with [back], presumably because /a/, which requires no specifications beyond [+low], has a specification for [back] but not for [round]; therefore, [round] results in fewer specifications, respecting

minimality. This leaves us with the representations in (5.20a), the complement rules in (5.20b), and the default rules in (5.20c).<sup>10</sup>

(5.20) Spanish vowels: RU underlying features (Archangeli 1984: 58-9)

a. Underlying specifications

	i	e	a	o	u
high	+				+
low			+		
back					
round				+	+

b. Complement rules

- i. [ ]  $\rightarrow$  [-high]                      ii. [ ]  $\rightarrow$  [-low]
- iii. [ ]  $\rightarrow$  [-round]

c. Default rules

DR1 [ ]  $\rightarrow$  [+back, -round] / [\_\_\_\_, +low]

DR2 [ ]  $\rightarrow$  [ $\alpha$  back] / [\_\_\_\_, -low,  $\alpha$  round]

It can be shown that the complement rules do not distinguish between contrastive and redundant values. Complement rules always fill in *all* values [- $\alpha$  F] of a feature for which [ $\alpha$  F] is specified in underlying representation. By any definition of contrast, some of these complement values are contrastive, and

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<sup>10</sup> Since both values of [back] are removed from underlying representations, Archangeli dispenses with the complement rule for [back] (5.19ciii), and uses instead the default rules in (5.20c).

some are redundant. Consider the complement rule that introduces the feature [–low]. To gauge whether particular values are contrastive, let us look at how the SDA would treat this feature. Since feature ordering makes a difference to the SDA, consider the two orderings in (5.21): in (5.21a), the complement value [–low] is contrastive for all of /i e o u/; in (5.21b), it is contrastive only for /e/, and redundant for /i o u/.

(5.21) Spanish vowels: contrastive features by the SDA

a. Ordering: [low] > [round] > [high] > [back]

	i	e	a	o	u
high	+	–		–	+
low	–	–	+	–	–
back					
round	–	–		+	+

b. Ordering: [high] > [round] > [low] > [back]

	i	e	a	o	u
high	+	–	–	–	+
low		–	+		
back					
round	–	–	–	+	+



Similar results can be shown to be true of the other complement rules.<sup>11</sup> If the distinction between contrastive and redundant is important in phonology, then the complement rules of RU fail to capture it.

With respect to phonological activity, there is no rationale for assigning a privileged status to epenthesis as an indication of the underlying unspecified vowel. In the case of Japanese, for example, Archangeli (1984) supposes that the epenthetic vowel is /i/, and therefore assigns this vowel no underlying specifications. By RU hypothesis, [–high], [+low], and [+back] must be specified in Japanese, as shown in (5.22).

(5.22) Japanese underlying specifications (Archangeli 1984: 59–60)

	i	e	a	o	u
high		–		–	
low			+		
back				+	+

We observed in Chapter 3, however, that there are reasons, based on the way vowels affect consonants, to suppose that Japanese /i/ is specified [+front] (equivalently, [–back]), contrary to (5.22). Also contrary to (5.22), Hirayama (2003) argues that /o/ must be contrastively specified for a feature indicating lip

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<sup>11</sup> The default rules in (5.20c) also do not distinguish contrastive from redundant values. DR2 assigns values of the feature [back], which are all redundant by any definition of contrast applicable to Archangeli's analysis. But DR1 also fills in [–round] on /a/; as is evident in (5.21), this specification may be contrastive (b) or redundant (a).

rounding. Moreover, Hirayama (2003: 117–119) observes that *u* and *o*, as well as *i*, can appear as epenthetic vowels in Japanese; she argues that *u* is the default epenthetic vowel, with *o* and *i* occurring only in specific environments. By looking at a range of phenomena that attest to phonological activity, we can arrive at a better picture of how phonemes pattern than by limiting the relevant evidence to epenthesis.

#### 5.3.1.2. *The Redundancy-Rule Ordering Constraint*

The underlying representations posited by RU are quite minimal, and so we might imagine that they represent strong claims about the phonology of a given language. This would be the case if unspecified features could not be filled in in the course of the phonology, or could only be filled in in circumscribed situations. If the phonology could be properly characterized with only a minimal set of feature markings, that would constitute strong empirical support for the analysis.

However, RU allows both + and – values to be filled in freely throughout the phonology. Although the preference is for unspecified features to be filled in as late as possible, they may be inserted whenever needed, in accord with the Redundancy-Rule Ordering Constraint (RROC) (Archangeli 1984: 85).

#### (5.23) The Redundancy-Rule Ordering Constraint (Archangeli 1984: 85)

A redundancy rule assigning ' $\alpha$ ' to F, where ' $\alpha$ ' is '+' or '–'. is automatically ordered prior to the first rule referring to [ $\alpha$  F] in structural description.

The RROC guarantees that there will be no empirical evidence that can potentially disconfirm the choice of underlying feature specifications. Consider, for example, the underlying vowel system of Yowlumne Yokuts (formerly Yawelmani: Kuroda 1967, Newman 1944), a Penutian language of California. The underlying vowels can be represented as /i u a o/, and their phonological patterning suggests that they are characterized in terms of the features [round] and [high], as in (5.24).

(5.24) Yowlumne vowels

-round	+round	
i	u	+high
a	o	-high

Because the epenthetic vowel is /i/, Archangeli (1984: 75) chooses to specify [-high] and [+round] underlyingly, as in (5.25).

(5.25) Yowlumne vowels (Archangeli 1984: 75–76)

a. Underlying specifications

	i	a	o	u
high		–	–	
round			+	+

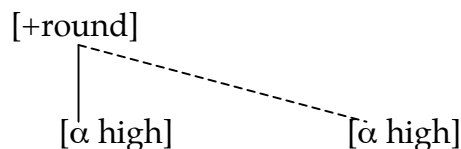
b. Complement rules

- i. [ ]  $\rightarrow$  [+high]
- ii. [ ]  $\rightarrow$  [-round]

The representations in (5.25) limit the underlying vowel feature specifications to [-high] and [+round]. We might expect that these are the only active features and that some empirical consequences flow from this limitation. Yowlumne has a rule of rounding harmony whereby an *i* changes to *u* when a *u* stands in the preceding syllable, and *a* changes to *o* following a preceding *o*. That

is, the rule of rounding harmony is limited to affect vowels in the same height class. Archangeli formulates it as a spreading rule as shown in (5.26).

(5.26) Yowlumne Rounding harmony (Archangeli 1984: 79)



The rule makes reference to the feature  $[\alpha \text{ high}]$ . According to the RROC, the reference to  $[\alpha \text{ high}]$  triggers all rules that fill in both values of  $[\text{high}]$ , if they have not yet applied, before the spread of  $[\text{round}]$  can occur. Since rounding harmony is a fairly early rule, there are no empirical consequences of the decision to specify only  $[-\text{high}]$  in underlying forms. As far as the phonology is concerned, both values of  $[\text{high}]$  may as well have been specified.

#### 5.3.1.3. *Summary*

Although Radical Underspecification takes phonological activity into account to the extent that it bases the choice of underlying specifications on the identity of the epenthetic vowel, this is the only aspect of phonological activity it looks at. Considerations of minimality trump any other criteria, and the RROC systematically removes phonological activity as a possible determinant of feature specification by insulating the theory from any possible negative consequences of underspecification. As Hall (2007: 24–26) puts in, Radical Underspecification predicts that features may be absent only if they are redundant, whereas the Contrastivist Hypothesis says that they may be present only if they are contrastive.

### 5.3.2. *Contrastive Specification*

Steriade (1987) proposes an alternative to Radical Underspecification called Contrastive Specification (CS) (see also Clements 1987 and Christdas 1988).

Steriade argues that we must distinguish between two rule types. First, there are redundancy, or R-rules. These are similar to the default rules of RU, introducing a redundant value within a class for which that value is fully predictable. The familiar voicing on sonorants provides the prototypical example of an R-value introduced by an R-rule: the feature [voiced] is introduced on sonorants by a redundancy rule, as in (5.17). Sonorants are thus underlyingly unmarked for voicing.

The second class of rules, D-rules, introduce D-values, which are contrastive feature values which distinguish between segments. In a language with voicing contrasts among obstruents, the feature [voiced] is distinctive in the obstruent inventory, and so is a D-value for the obstruents. Steriade proposes that only R-values are underspecified in the sense of RU; contrary to RU, she proposes that both D-values (+ and –) are specified underlyingly. Thus, in a language with both voiced and voiceless stops, the voiced stops are specified as [+voiced] and the voiceless stops as [-voiced].

#### 5.3.2.1. *Contrastive Specification and the contrastive hierarchy*

Steriade's proposal puts the notion of contrast at the centre of underspecification theory, by making a basic distinction between contrastive and redundant values. According a special role to contrastive features is a large step in the direction of the Contrastivist Hypothesis. It thus becomes absolutely crucial to know whether

a feature value is redundant or contrastive in any particular instance. Steriade does not supply an explicit mechanism for determining contrasts, but rather provides evidence for particular analyses that can be viewed as consistent with an asymmetry between the patterning of redundant and contrastive features. For example, in her analysis of the Pasiego dialect of Montañes Spanish, a language with a five-vowel system, Steriade (1987: 343) argues that /a/, which neither triggers nor blocks a rule of height harmony, has no marking for the feature [high]. This is because ‘the impossibility of simultaneous [+high, +low] specifications establishes that the height of low vowels is a R-value’ (342). This analysis appears to be unproblematic, especially when the vowel system is diagrammed as in (5.27), where /a/ is the obvious odd man out with respect to the feature [high]:

(5.27) Pasiego (Steriade 1987)

i	u	+high	
e	o	–high	D-class of [high]
<hr/>			
a			R-class of [high]

As demonstrated earlier, however, these cases are deceptively simple looking: the basis according to which D-values are determined is not self-evident. The value [–high] is logically redundant for /a/, as it is indeed retrievable from [+low]; however we have seen that logical redundancy is not an adequate basis for establishing contrastive specifications. From the point of view of feature ordering, the values in (5.27) correspond to (5.28a), and require [low] >

[high]. If [high] > [low], as in (5.28b), [high] would be a D-value for /a/. Notice also that in the former case, the high vowels are specified [-low].

(5.28) Pasiego Spanish vowels: Possible orderings of [high] and [low]

	a. low > high					b. high > low				
	i	e	a	o	u	i	e	a	o	u
high	+	-		-	+	+	-	-	-	+
low	-	-	+	-	-		-	+	-	

Similarly, Steriade (1987) argues that the low vowel /a/ is unspecified for [back] in triangular five-vowel systems such as those of Ainu and Tamil. Again, though she does not state this explicitly, the analysis relies either on logical redundancy or on a contrastive feature hierarchy whereby [low] > [back].

Although Steriade (1987) makes no mention of the contrastive hierarchy as a general principle for determining if feature values are contrastive or redundant, she does propose a hypothesis that translates into a constraint on possible hierarchies. Dividing features into *stricture features* (essentially manner features for consonants and height features for vowels) and *content features* (place features for consonants and timbre features for vowels), she proposes that in a redundancy rule  $[\alpha F] \rightarrow [\beta G]$ , F may be a stricture feature and G may be a content feature, but not vice-versa. Thus, we may have a redundancy rule [+low]  $\rightarrow$  [+back], but not [+round]  $\rightarrow$  [+high]. This is tantamount to claiming that stricture features must always have wider contrastive scope than content features; that is, they are ordered higher in the contrastive hierarchy.

#### 5.3.2.2. *Pairwise Algorithm for Contrastive Specification*

Given that the distinction between R-values and D-values is central to the theory of CS, it is noteworthy that neither Steriade (1987) nor any other advocate of CS proposed an algorithm to determine which values are R-values and which are D-values. Lacking an algorithm for CS by its proponents, one was suggested by an opponent of the theory.

Archangeli (1988) proposes an algorithm for determining contrasting classes, namely the Pairwise Algorithm discussed in Chapter 2. As we have seen, the Pairwise Algorithm instantiates a particular approach to picking out contrastive specifications and cannot be identified with contrastive specification itself. Nevertheless, the Pairwise Algorithm became identified with CS theory, to its detriment. For then the many shortcomings of the Pairwise Algorithm became shortcomings of CS.

#### 5.3.3. *Backlash against theories of underspecification*

The lack of an adequate mechanism for deciding which features to omit ultimately led to a backlash against theories of underspecification. Critics such as Mohanan (1991) and Steriade (1995) pointed out various inconsistencies and apparently insoluble conundrums in the practice of underspecification theorists. Mohanan (1991: 306–307) argues that if the goal of underspecification theories is to remove all predictable information from underlying representations, then this goal is unachievable because of the existence of mutual dependencies.



This is essentially the argument I made in Chapter 2 against any procedure that is designed to remove all logical redundancies from specifications. Underspecification that results from contrastive specification by the SDA is not susceptible to this argument, because it is not intended to remove all logical redundancies, nor does it equate system redundancy with predictability.

Sterade (1995: 118–119) observes that a constraint \*[+sonorant, –voice] ‘renders predictable not only the voicing of sonorants but also the sonority of voiceless segments. Must we then leave the [–sonorant] value of *p, t, k* out of the underlying representations? There seems to be little evidence for such a move and we need to ask why, especially as there exists substantial evidence for leaving the sonorants unspecified for [voice] (Kiparsky 1985; Itô and Mester 1986).’ Similarly, she observes that either [back] or [round], but not both, can be omitted from the specifications of the non-low vowels in triangular systems such as /i e a o u/; the choice of which to omit thus appears to her to be arbitrary.

As we have seen, this type of problem is solved by the contrastive hierarchy in conjunction with the Contrastivist Hypothesis. The feature [sonorant] is a major class feature that is typically higher in the hierarchy than [voiced]; in the typical case where all sonorants are voiced, [voiced] is not contrastive in the [+sonorant] set, but is in the [–sonorant] set. The fact that [–voiced] segments are predictably [–sonorant] plays no role in their specification. To have a situation where [sonorant] is omitted from voiceless consonants, we would need a feature hierarchy with [voiced] > [sonorant]. Such

a hierarchy is relatively rare.<sup>12</sup> Similarly, we have seen numerous cases where the choice of [back] or [round] is not arbitrary, but dictated by considerations of phonological patterning and activity.<sup>13</sup>

#### 5.4. *Theories of feature organization*

In addition to markedness theory and underspecification theory, generative phonology produced a third family of subtheories that crucially involve hierarchical relations between distinctive features. These theories posit that features are organized into various kinds of structures. This idea was developed in a number of quite different ways, giving rise to distinct theories of phonological representation. Some examples include what has come to be known as feature geometry (Clements 1985, Sagey 1986, McCarthy 1988, Clements and Hume 1995, Halle 1995), Government Phonology (Kaye, Lowenstamm and Vergnaud 1985), Dependency Phonology (Anderson and Ewen 1987), and Radical CV Phonology (van der Hulst 1996). It is not possible to discuss these all

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<sup>12</sup> It may be premature to rule out such systems, however; compare Hockett's analysis of Lifu discussed in Chapter 3. It is noteworthy that Lifu has voiceless sonorants, in his analysis. There also appear to be languages where the feature [sonorant] does not play a major role at all; compare the dialect of Inuktitut discussed in Chapter 7.

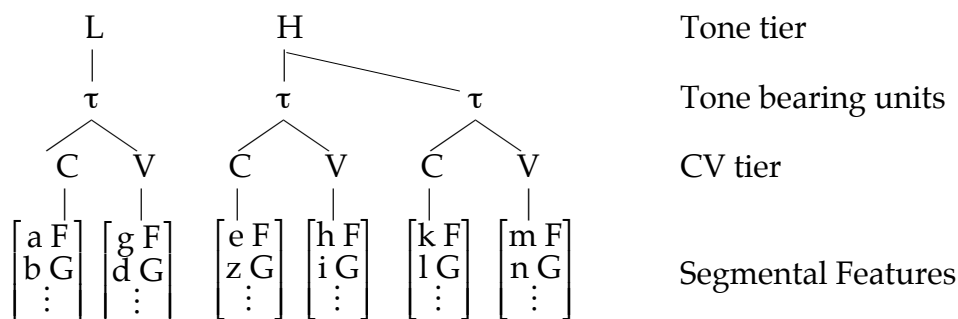
<sup>13</sup> As in other areas of linguistic theory, there may be situations in which the feature order is not clear, for lack of decisive evidence pointing to one or another ordering. But such indeterminacy arises for empirical reasons, not because the theory lacks coherence or is inherently arbitrary.

these theories here. Rather, I will focus on how a theory of feature organization might be related to markedness, underspecification, and ultimately to the contrastive hierarchy.

#### 5.4.1. Feature geometry

What has come to be known as ‘feature geometry’ developed as an extension and generalization of the theory of Autosegmental Phonology (Goldsmith 1976). Autosegmental Phonology starts with the observation that certain features, notably tone, are relatively autonomous of the other segmental features. For example, tone sequences can exhibit stability, remaining unperturbed even though their associated segments may be deleted or modified. Thus, a ‘tone melody’ can be stretched or compressed, resulting in some tones being associated with more than one segment and some segments being associated with multiple tones. Early work in Autosegmental Phonology posited that tones should be represented on a tone tier independent of the other features, which remained bundled together in *SPE*-style matrices, as in (5.29).

#### (5.29) Autosegmental Representation



In their review and synthesis of a number of approaches to feature geometry, Clements and Hume (1995: 245–6) write, ‘Earlier theoreticians tended to think of phonemes as unstructured sets of features, or ‘feature bundles’ in Bloomfield’s well-known characterization. In accordance with this view, later work in the Jakobsonian and generative traditions treated segments as feature columns with no internal structure.’

As we have seen, this summary is not entirely correct. Jakobson and early generative phonology did experiment with a hierarchical approach to features in terms of the contrastive hierarchy.

Feature geometry in generative grammar is motivated by several considerations. Our interest here will be to compare it with the contrastive hierarchy, to see to what extent the two perform similar functions and in what ways they differ.

One obvious similarity between the two approaches is that they both encode hierarchical relations between features. In (5.30) I present the geometry proposed by Clements and Hume (1995: 292).<sup>14</sup> These trees contain two kinds of nodes. Terminal nodes in square brackets, such as [nasal], [continuant], and [labial], are features. The other nodes, such as laryngeal, oral cavity, and C-place, are class labels that function as organizing nodes, grouping together the features

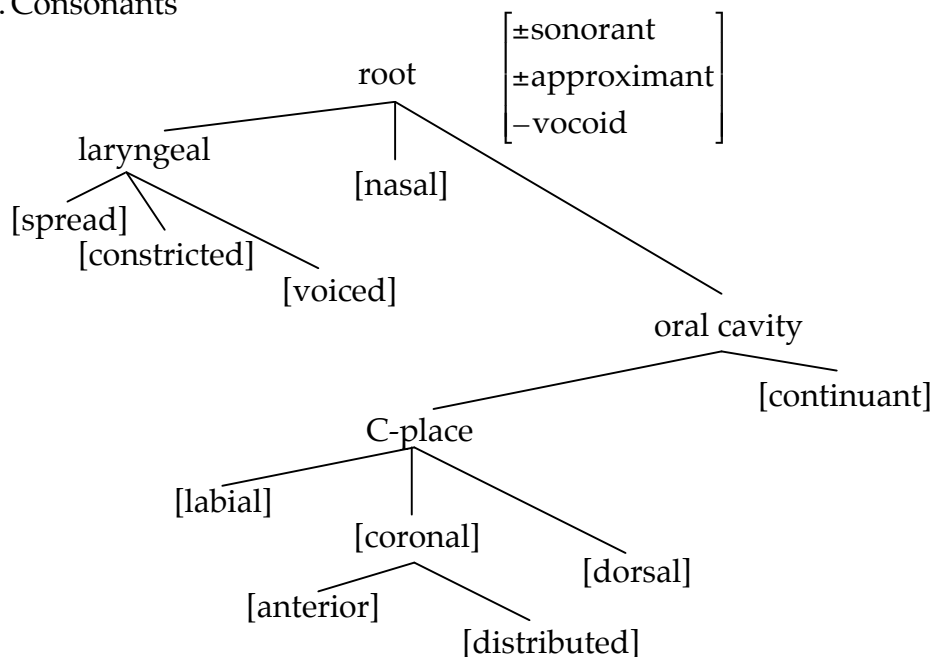
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<sup>14</sup> the feature [vocoid] is the converse of [consonantal], and the class of vocoids includes vowels and glides.

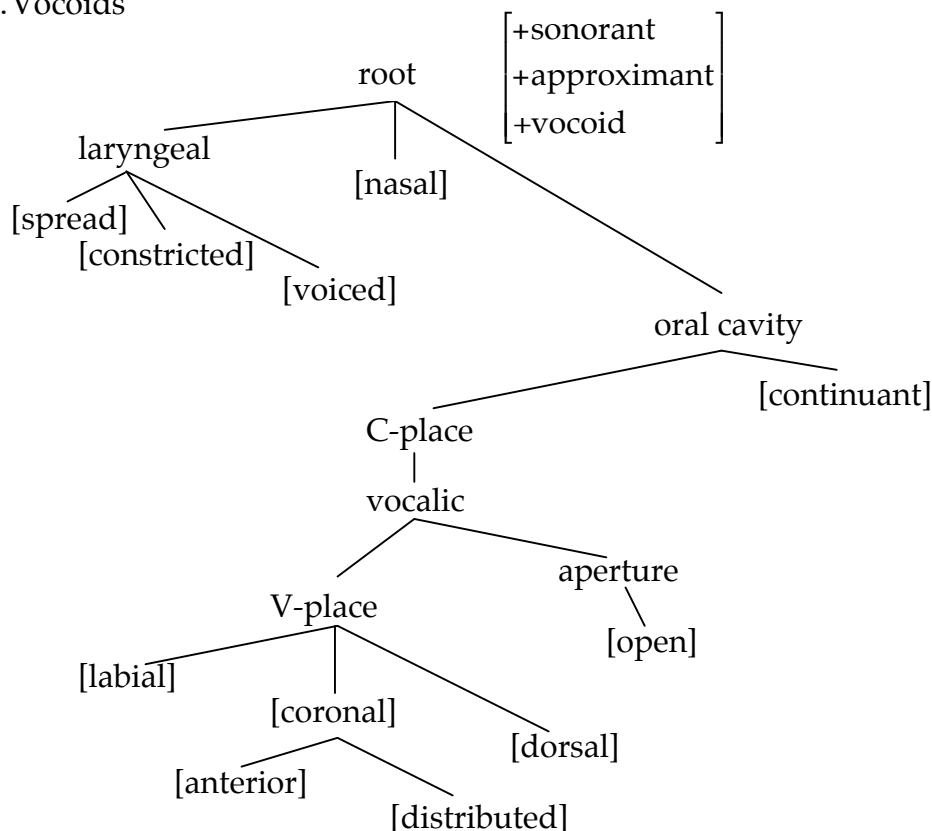
below them. The root node receives special treatment, as it is considered to be not just an organizing node, but also bears the major class features [sonorant], [approximant], and [vocoid].

(5.30) Feature geometry (Clements and Hume 1995: 292)

a. Consonants



## b. Vocoids



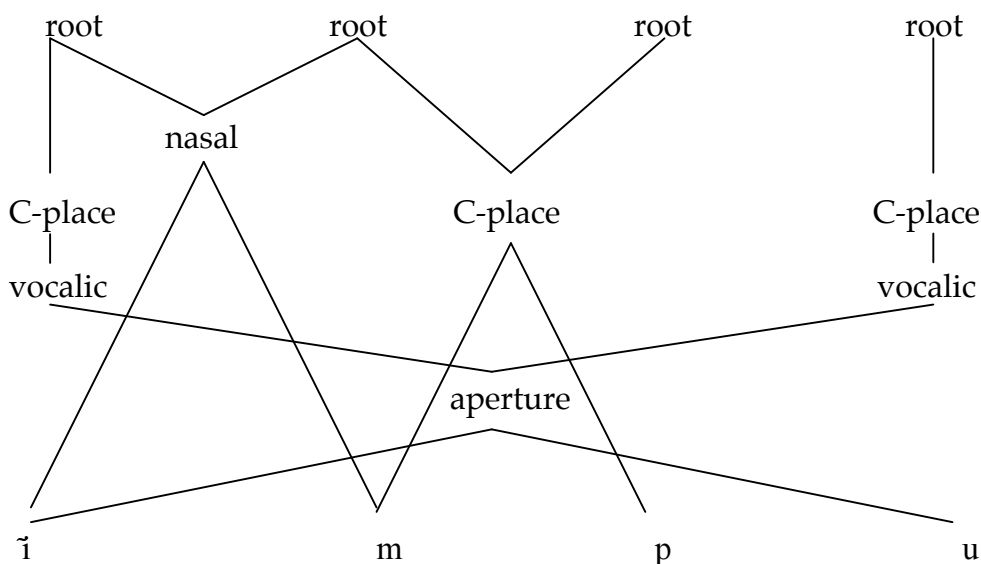
There are a number of differences between the trees in (5.30) and contrastive branching trees. Most obvious is the presence of class nodes in addition to feature nodes. The motivation for the class nodes is to group together features that function together in the phonology of particular languages. For example, many languages have rules assimilating the place of articulation of neighboring consonants. In standard binary feature systems, such assimilation can be expressed only by a conjunction of all the features that characterize place of articulation (labial, coronal, anterior, etc.), or else by an ad hoc notation such as  $[\alpha \text{ place of articulation}]$ . This notation is given substance by positing a class node that dominates place of articulation (C-place, in (5.30)). Similarly, the

laryngeal node groups together the laryngeal features that govern processes such as voicing, aspiration, glottalization, and so on, which can pattern together in some languages.

In standard versions of nonlinear phonology, of which feature geometry is a part, class nodes serve not just as abstract superordinate sets, but as real nodes that can spread and be delinked from skeletal positions. In (5.30), each node is on a separate line, which represents the fact that each node defines its own independent tier.

For example, assimilation in nonlinear phonology is viewed as spreading of a node from a trigger segment (or position) to one or more target segments. Features may be linked to more than one segmental position, either through spreading, or underlyingly. The result is that different nodes may be associated with different stretches of segmental material, as in (5.31) (not all nodes are shown).

(5.31) Nodes variously associated with segmental positions



#### 5.4.2. *Feature Geometry and the Contrastive Hierarchy*

We will return to the class nodes below. Here I will focus on the treatment of the terminal features. We observe that there are a number of ways in which their treatment departs from a contrastive hierarchy. However, these characteristics for the most part represent empirical assumptions about feature organization that can be easily modified so as to bring about a rapprochement between feature geometry and a contrastive hierarchy.

First, the major class features tied to the root node, [sonorant], [approximant], and [vocoid] (the converse of [consonantal]), are treated as a bundle, and not hierarchically. These features, however, can be unpacked to reveal internal hierarchical structure. Conversely, the contrastive hierarchy could reflect the organization in (5.30) by allowing these features to cross-classify at the top of the feature hierarchy.<sup>15</sup>

Second, the tree in (5.30) is not strictly binary, since the laryngeal and the place nodes have three branches each. We have observed that there is no logical requirement that the contrastive hierarchy be binary. Therefore, the contrastive hierarchy can mirror  $n$ -ary splits by treating the daughter nodes as different values of a single  $n$ -ary feature. Conversely, the ternary branchings in (5.30) can be converted to a series of binary splits.

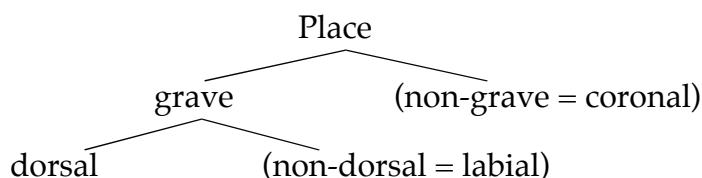
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<sup>15</sup> Cross-classification is equivalent to treating each feature as if it had wide scope independently of the feature(s) it cross-classifies.



Avery and Rice (1989), for example, propose to revive the Jakobsonian feature [grave], which groups together labial and dorsal sounds (also sometimes called [peripheral]). Thus, the Place node for consonantal place expands in binary fashion as in (5.32).

(5.32) Binary expansion of Place node (Avery and Rice 1989)



Avery and Rice assume in addition that features are single-valued, reflecting markedness relations. Thus, dorsal consonants, the most marked on this view, are specified [Place, grave, dorsal]; labials are [Place, grave], reflecting the assumption that they are unmarked among the grave consonants], and coronals, as the least marked consonants with Place, are marked only [Place]. Avery and Rice support this hierarchy of [grave] markedness by pointing to assimilation patterns in Korean, where the labials /m/ and /p/ can assimilate to a following dorsal consonant, but dorsals do not assimilate to labials.<sup>16</sup>

A third difference between the feature geometry in (5.30) and the contrastive hierarchy is that the former is intended to be universal, and does not allow for language-particular variation. But this difference also can be easily

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<sup>16</sup> In subsequent work Avery and Rice do not hold that these markedness relations are necessarily universal; see Avery and Rice 2004, Rice 2007, forthcoming, and Chapter 7.

bridged. Feature geometry can be made to allow for language-particular variation (cf. Piggott 1992), just as the contrastive hierarchy can be constrained to require universal ordering, to whatever degree is required in either direction.

A fourth difference is that the various nodes of the feature geometry, in some accounts, are assumed to be fixed and independent of considerations of contrast. This point is non-negotiable from the point of view of contrastive hierarchy theory. A hierarchy that does not encode contrasts is no longer a contrastive hierarchy. However, there is no reason that feature geometry cannot adopt contrast as a requirement for expanding nodes. Indeed, Clements (1985) in his seminal paper on feature geometry assumes that only contrastive features are specified in feature-geometric lexical representations. Avery and Rice tie feature geometry to contrast (Avery and Rice 1989, Rice 1993, Rice and Avery 1993, Avery 1996). Such an approach is taken implicitly by feature geometry theorists who simply ignore aspects of the feature geometry that do not pertain to the language they are working on.

This leaves the class nodes as the major difference between feature geometry and the contrastive hierarchy. To the extent that class node theory is a true empirical property of feature organization, then it must be incorporated into the contrastive hierarchy, and this has been done by Avery and Rice. Incorporating class nodes, or indeed any inherent feature dependencies, leads to certain complications in the procedure of contrastive specification.

In its simplest version, the contrastive hierarchy contains a feature if and only if it is contrastive. When built-in dependencies are added in, this relation

between specification and contrast no longer holds. In particular, suppose that a feature, *F*, is a dependent of a class node, *C*. This means that *F* cannot exist without *C*. Now it could be the case that *C* is not contrastive, but *F* is. In that case, *F* must be specified, a specification that in turn requires specification of the noncontrastive *C*.

This situation arises commonly. One recurring example concerns the feature [coronal]. In (5.30), as well as many other versions of feature geometry, [coronal] functions both as a feature and as a class node, as it has dependents, [anterior] and [distributed] in (5.30). An example is Sanskrit, which has a contrast between plain and retroflex coronals. Assuming the latter have some marked feature that is a dependent of [coronal], say [–anterior], their representation must include [coronal], as in (5.33a).

(5.33) Representation of coronal contrasts

a. Retroflex	b. Plain (minimal)	c. Plain (NAC)
Place	Place	Place
[coronal]		[coronal]
[–anterior]		

But how should the plain coronal consonants be represented? As we have been assuming that [coronal] is the unmarked place for consonants, there is no need to specify [coronal] for such consonants, and they could be represented like coronal consonants in languages without internal coronal contrasts, as simply having a Place node, as in (5.33b).

Taking (5.33b) together with (5.33a), however, it appears that there are more differences between plain and retroflex consonants than there are. Intuitively, the two segments differ only with respect to coronal-internal specifications; but now they appear to differ also with respect to specification for [coronal] itself. In effect, a single contrastive difference — [–anterior] vs. no specification for anterior — has turned into two differences. Moreover, there is no actual contrast between the two segments as regards their coronality, so it is odd that one should be specified for [coronal] while the other is not.

Avery and Rice (1989) address this issue, and propose the Node Activation Condition (NAC) for such situations. The NAC, given in (5.34), requires that Sanskrit plain coronals be represented with a coronal node, as in (5.33c).

(5.34) Node Activation Condition (NAC) (Avery and Rice 1989)

If a secondary content node is the sole distinguishing feature between two segments, then the primary feature is activated for the segments distinguished. Active nodes must be present in underlying representation.

Though the NAC reduces the difference between plain and retroflex consonants to the minimal feature by which they contrast, it does so at the cost of introducing noncontrastive features and nodes into otherwise contrastive representations. In this way feature geometry introduces ‘contrast from below’: a feature (or node) is introduced not for contrastive purposes (contrast from above), but ‘retroactively’ so to speak, to serve dependent nodes that require its

presence. Whether the NAC is required is ultimately an empirical question. The Contrastivist Hypothesis can accommodate such ‘extra’ specifications if they are warranted. But developments in feature geometry may make devices like the NAC unnecessary.

#### 5.4.3. *Spreading of Class Nodes?*

Our comparison of feature geometry and the contrastive hierarchy reveals that, for the most part, the two either encode similar relations or else can be reconciled so that they do so. This raises the prospect that the two can be identified; put differently, that we can dispense with feature geometry as an independent theoretical entity in favour of the contrastive hierarchy. The major obstacle in the way of doing this is the participation of class nodes in phonological rules. If a class node is targeted by phonological processes, then it cannot be dispensed with, at the risk of losing the ability to formulate phonological rules that express significant generalizations.

It is thus interesting that some recent approaches to feature geometry no longer allow class nodes to spread. For example, the Revised Articulator Theory (RAT) (Halle 1995, Halle, Vaux and Wolfe 2000) requires that terminal features spread separately. Further, designated articulators are indicated by features, not by nodes in the geometry. Similarly, Padgett (2002) proposes that feature classes like Place, Color, Laryngeal, etc., are not nodes in a structure, but features of features, or sets of features. Phonological processes or constraints can mention these classes, but apply directly to the features that make them up. Though the

theories diverge in other respects, Padgett agrees with RAT with respect to terminal spreading and partial spreading of classes. Padgett argues that this approach preserves the advantages feature geometry was supposed to have in being able to refer to certain groups of features, while escaping some of the negative consequences of feature geometry.

If class nodes are not required to participate in phonological operations, then there are no compelling reasons why they are required in phonological representations beyond the needs of contrast. If this is correct, then we can do away with ‘specification from below’ (the insertion of a non-contrastive class node because it is required to support a dependent contrastive feature) and stick to features that are motivated only by contrast.

It remains an empirical question whether feature geometry may indeed be subsumed into the contrastive hierarchy, or whether certain dependencies between features must be represented independently of requirements of contrast. In what follows I will assume the former; that is, I will assume that the only hierarchical relations among features that need to be represented are those dictated by the contrastive hierarchy.

## 6. Contrast in Optimality Theory

‘The OCP...defines a marked configuration that grammars tend to avoid though they do not necessarily always succeed in doing so. Identifying such configurations, circumscribing the ways in which they are respected, and finding the proper formalism to express the phenomenon has emerged as one of the critical challenges facing contemporary phonological theory.’

Michael Kenstowicz, *Phonology in generative grammar* (1994: 534)

### 6.1. Introduction

Optimality Theory (OT; Prince and Smolensky 2004) is a radical departure from the derivational model of previous versions of generative phonology. Since my own approach remains based in derivational phonology, this chapter might appear to be something of a digression from the main path. Nevertheless, OT is highly relevant to the subject of contrast in phonology in several ways. Any new theory puts old questions into a new light, and it may be illuminating to explore the relationship between OT and the Contrastivist Hypothesis. I will show that the contrastive hierarchy, being a static set of conditions, lends itself very easily to formulation in terms of a set of constraints, and hence to OT. At the same time, I will argue that OT is itself not a theory of contrast, but is capable of instantiating a wide range of such theories.

The relationship between OT and the Contrastivist Hypothesis is more complex. It appears that the insights of a contrastivist approach can best be captured in a serial (derivational) model of OT in which some of the restrictions of the main parallel versions are relaxed. This may not be a bad thing, given the advantages of serialism in accounting for rule opacity.

I will begin by presenting some background to the rise of OT, in the course of which I set out what I think are the advantages and disadvantages of the theory. Then I will turn to the relation between OT and contrast. After that I will consider how the contrastive hierarchy might be incorporated into OT.<sup>1</sup>

## 6.2. *Background to Optimality Theory*

### 6.2.1. *Derivations*

Generative Phonology as developed by Chomsky and Halle (1968) is based on the notion of a *derivation* from underlying to surface representations. A derivation is a kind of assembly line where an underlying form passes in turn through a set of rules of the form (6.1a). These rules can be decomposed into a *structural description* (SD) (6.1b), which is the *input* to the rule, and a *structural change* (SC) (6.1c), which is the *output* of the rule .

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<sup>1</sup> Aspects of this issue are discussed in more detail by Hall 2007: Chapter 5.



(6.1) Rule format (Chomsky and Halle 1968)

- |                                |                                       |
|--------------------------------|---------------------------------------|
| a. Rule                        | A $\rightarrow$ B / C $\rightarrow$ D |
| b. Structural description (SD) | CAD                                   |
| c. Structural change (SC)      | CBD                                   |

A form that matches the SD of a rule is changed as specified by the rule, and then moves on to the next rule. In addition to the underlying representation, UR, there are as many distinct stages in the derivation of a form as there are rules that effect a change in that form. The number of stages can be increased if the form has more than one cyclic domain of rule application. In that case, all the rules are checked in order on the innermost cycle, and then again on each successive cycle.

In his MA thesis (Chomsky 1951), Chomsky discovered that he could capture synchronic generalizations about Hebrew by means of such derivations, which mimicked in some ways stages of historical changes. The power of this approach is seen most strikingly in cases where a form appears to be affected by a rule that applies not to the underlying representation, but to an intermediate one.

An example involves Biblical Hebrew spirantization, whereby a nonemphatic stop becomes a fricative following a vowel. Consider the form *lixθōv* ‘to write’, derived from the underlying prefix /li-/ ‘to’ and the stem /ktob/ ‘write’. Underlying /k/ and /b/ are spirantized [x] and [v], respectively, because of the vowels that precede them; but why is the /t/ spirantized to [θ]?

There is no vowel there at the surface. Neither is there one there in the UR. A derivation is given in (6.2).

(6.2) Biblical Hebrew spirantization (Dresher 1983, Idsardi 1998)

a. Underlying form (UR)	[li [ktob]]
b. Inner cycle	[ktob]
Epenthesis	[kVtob]
Spirantization	[kVθov]
c. Outer cycle	[li + kVθov]
Vowel deletion	[li + kθov]
Spirantization	[li + xθov]
d. Phonetic form (PR)	[lixθóv]

Assuming a cycle on /ktob/ (Dresher 1983), we see that a vowel arises in the course of the derivation. In Biblical Hebrew syllables do not begin or end with a consonant cluster, so *ktob* is not a proper syllable in Biblical Hebrew. Vowel epenthesis changes the form to *.kV.tob* (where *V* represents a vowel of unspecified character, effectively schwa, and dots represent syllable boundaries). Spirantization then applies to /t/ and /b/ yielding *.kV.θov*.

On the outer cycle, the prefix /li-/ is added, yielding *.li.kV.θov*. Now the epenthesized vowel is subject to a rule deleting a short vowel in an open syllable preceded by an open syllable (Prince 1975, Malone 1993). The /k/ is spirantized by its preceding vowel, and other rules apply deriving the phonetic form [lixθóv]. The interest of this case is that the conditioning context of the spirantization of /t/ is present neither at the underlying nor at the surface

representations, but at some hypothesized intermediate stage (see further Idsardi 1997, 1998). This kind of *rule opacity* (Kiparsky 1973), where the context of a rule is obscured at the surface, is an expected consequence of a derivational phonology in which rules are routinely added to the grammar over time.

### 6.2.2. *Output conditions*

As research in generative phonology progressed, suggestions were made from time to time that derivations are sensitive not just to input conditions (structural descriptions), but also to outputs. Another example from Hebrew can illustrate this.

(6.3) Biblical Hebrew vowel deletion (Prince 1975, Kenstowicz and Kisseberth 1979)

a. Vowel deletion applies

/šamar+u/ ---> [šāmrŭ] ‘they watched’

b. Vowel deletion is blocked

/parnes+u/ ---> [parnəsŭ] (\*[parnsŭ]) ‘they supported’

/šamar/ ---> [šāmár] (\*[šmár]) ‘he watched’

Underlying /šamar+u/ becomes [šāmrŭ] by vowel deletion. The rule is blocked in /parnes+u/, as well as in /šamar/. It is of course possible to write a rule that would apply in the right cases:  $V \rightarrow \emptyset / VC\_CV$ . However, it is suspicious that the context has the effect of blocking the rule in cases where it would lead to an ill-formed syllable, as in \**par.n.sŭ* or \**š.már*. It is as if vowel deletion can ‘look ahead’ to see if its outcome is syllabifiable. Such conditions are

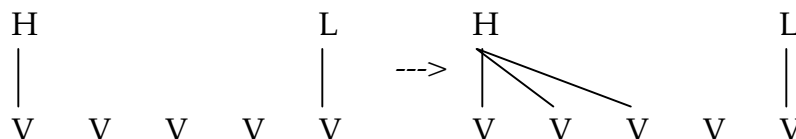
hard to understand in a serial derivation, where rules are expected to apply if their SD is met.

Not only do some individual rules appear to be concerned with outputs, but there appear to be cases where a group of rules ‘conspire’ to achieve a certain surface pattern (Kenstowicz and Kisseberth 1977). For example, a language might have a number of ways of breaking up a medial three-consonant cluster, CCC, or an initial cluster #CC, or a final cluster CC#: this could be achieved by by epenthesis of a vowel, or deletion of a consonant, or by vocalization of a glide (e.g., /CVCj/ to [CVCi]). From a formal point of view, these rules appear to have nothing in common; but functionally, they all repair bad syllable structures, and create a limited set of well-formed ones.

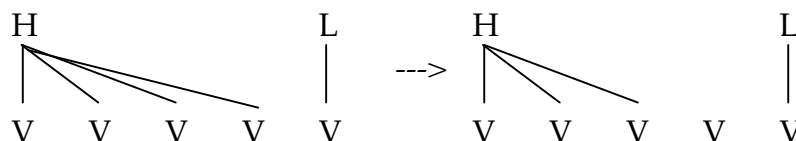
Another example occurs in Shona tonal phonology (Myers 1997). One rule spreads a high (H) tone to the right, but stops one syllable short of a low tone (L) (6.4a). Another rule delinks a multiply-linked H from a vowel adjacent to L (6.4b); a H linked to a single vowel next to a L remains, however (6.4c).

(6.4) Shona high tone (Kenstowicz and Kisseberth 1977, Myers 1997)

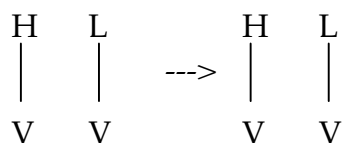
a. High tone (H) spreads to the right



b. Delinking of a high (H) tone from a vowel adjacent to a low (L)



- c. H linked to a single vowel remains adjacent to L



Formally, the rules in (a) and (b) are again completely unrelated, yet from the point of view of the output they both contribute to preventing a H tone from being to the immediate left of a L.

Another characteristic of this Shona constraint against adjacent H L sequences is that it is *violable*. Though Shona avoids sequences of H L when the H is linked to more than one vowel, the restriction is not absolute; when preventing a sequence of H L would involve the complete deletion of H, the violation remains. One could say that maintaining an underlying H tone takes precedence over eliminating a sequence of adjacent H L.

### 6.2.3. *Nonlinear phonology and constraints on representations*

The development of nonlinear phonology and richer representations was accompanied by the rise of well-formedness conditions, such as the Obligatory Contour Principle (OCP), which rules out adjacent like features, or Structure Preservation (SP), which blocks the creation of non-structure preserving segments. Such persistent conditions do not fit well with a serial derivation model.

Richer representations also permit nonderivational alternatives to analyses that had required sequential rule-ordering explanations. For example, in Seri (Marlett 1981), a Hokan language spoken in Mexico, there are words that

begin with a consonant (C), and words that begin with a vowel (V), and these words undergo different rules. There are also words that begin with vowels but act, with respect to all the relevant rules, as if they begin with consonants. In linear phonology, we would need to express this generalization in terms of a derivation (6.5a): at early stages of the derivation, these words are of the form CVX; at some point, the initial C is deleted, and the forms surface as VX. In nonlinear phonology, there is the possibility of accounting for these facts on one representational level that uses two tiers, a feature tier and a skeletal (or CV) tier giving CV structure: on the CV tier the representation is CVX; on the feature tier, the first C is unassociated (6.5b). Thus we can replace a derivational account with a representational account in terms of static constraints.<sup>2</sup>

(6.5) Seri ‘anomalous’ stems (Marlett and Stemberger 1983)

a. Derivational solution		b. Tiered solution		
UR	/Cax/	CV tier	C	V C
Phonological rules				<div style="display: flex; justify-content: space-around;"> <div style="text-align: center;"> <div style="width: 1px; height: 50px; background-color: black;"></div> </div> <div style="text-align: center;"> <div style="width: 1px; height: 50px; background-color: black;"></div> </div> </div>
C-Deletion	ax			
PR	[ax]	Feature tier		<div style="display: flex; justify-content: space-around;"> <div style="text-align: center;">a</div> <div style="text-align: center;">x</div> </div>

The same is true of ‘conspiracies’ involving syllable structure. Biblical Hebrew has underlying stems of the form /CVCC/ such as /malk/ ‘king’. As observed above, Biblical Hebrew does not allow coda clusters; hence, a vowel [e],

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<sup>2</sup> See Drescher 1996 for discussion of the learnability implications of cases like these.

known in Hebrew as *seghol*, is epenthesized between the final two consonants, resulting eventually in the surface form [mélex] (6.6). Words with final geminates do not undergo segholation, but degemination: /ʕamm/ becomes [ʕám], not \*[ʕémem]. In linear phonology, we need to order the rules of epenthesis and degemination in the right way: /ʕamm/ ---> [ʕám], blocking epenthesis; otherwise, /ʕamm/ > \*[ʕámem], blocking degemination and deriving the wrong result.

(6.6) Biblical Hebrew segholates (Prince 1975: 39–40)

Underlying representation	/malk/ 'king'	/ʕamm/ 'people'
Degemination	---	ʕam
Epenthesis	malek	---
Phonetic representation	[mélex]	[ʕám]

Looking at it another way, both epenthesis and degemination can be seen as conspiring to filter out ill-formed syllables; they are alternative ways of disposing of an unsyllabifiable final C position. Moreover, they can be viewed as constraints that apply simultaneously, reducing the derivational distance from lexical to phonetic representations.

Not all cases are so easily transformed into nonderivational accounts: Hebrew spirantization, for example, remains a sticky case. Another type of difficult case is the following. A segholate with a final guttural, like /dašʔ/, surfaces as [déše] 'grass'. This outcome can be easily understood in terms of

ordered rules (6.7a) : epenthesis applies before a rule of  $\varnothing$ -deletion, which deletes a guttural consonant in a coda.<sup>3</sup>

(6.7) Biblical Hebrew segholates with final guttural (McCarthy 1999, Idsardi 2000)

a. Derivational phonology: epenthesis > guttural deletion

Underlying representation	/malk/	/dašʔ/
Epenthesis	malek	dašeʔ
$\varnothing$ -deletion	---	daše
Phonetic representation	[mélex]	[déše]

b. Rules apply minimally only to ensure wellformedness

Underlying representation	/malk/	/dašʔ/
Epenthesis	malek	---
$\varnothing$ -deletion	---	daš
Phonetic representation	[mélex]	*[dáš]

The outcome is harder to understand if we are concerned mainly with the output. Assuming that rules such as epenthesis and deletion do not apply unnecessarily, that is, when not provoked by well-formedness considerations, the output form [déše] appears less than optimal: epenthesis applies to break up a cluster that would have been resolved by  $\varnothing$ -deletion. Since the final consonant is deleted anyway, why is the optimal result not \*[dáš], parallel to [ʕám] (6.7b)?

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<sup>3</sup> Simultaneous application of the two rules to the UR results in the same output in this case.



This type of case has provoked an extensive literature, but in my view a derivational account remains the simplest and most explanatory.<sup>4</sup>

#### 6.2.4. *Constraint-based phonology*

There were various attempts to recast phonological theory entirely in terms of well-formedness conditions, or constraints. Piggott and Singh 1985, Singh 1987, and Paradis 1988 proposed that the purpose of phonology is to repair violations of phonotactic constraints caused by morphology: hence, theories of constraints and repair strategies. For example, Semitic morphology puts together roots of the form CVCC; as CVCC is unsyllabifiable, the phonology has to adjust it in various ways.

One problem with constraint-based theories, however, is the fact that many constraints appear to be violated in specific contexts. For example, the Shona rule that H may not abut L is violated in simple forms HL where H is not multiply linked; the Hebrew syncope rule is blocked not only when it would

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<sup>4</sup> See Idsardi 2000 and McCarthy 2007 for reviews and different perspectives on this problem with respect to OT. Sometimes problems that appear to involve opacity can be resolved by reanalyzing the processes involved. Balcaen and Hall (1999) raise the possibility that the underlying glottal stop in /dašʔ/ is vocalized to a vowel that appears on the surface as [e]. Thus, the surface form [déše] is not the result of an opaque interaction between vowel epenthesis and guttural deletion. Whether this is the correct approach or not in this case, it is unlikely that all cases of opacity can be reanalyzed in this manner.

leave behind a stranded C, as in /parnesu/, but also when it would create a derived geminate: hence, deletion of the /e/ is blocked in *hitpalelū* 'they prayed', not \**hitpallū*. If we say that there is a constraint in Biblical Hebrew to avoid a sequence of open syllables, here is a case where the constraint is violated. In this example, we might attribute the retention of the vowel to the blocking action of the OCP, preventing the formation of a geminate that is not doubly linked to a single set of features. But the OCP is itself a constraint that does not always hold at the surface, for it is violated in various other situations. In a system with many interacting constraints, it is only to be expected that constraints might conflict, with the result that only a few constraints will actually appear to be obeyed all the time in any given language. The other constraints will have the appearance of stronger or weaker tendencies. The existence of violations to most constraints was a major stumbling block to creating a theory of phonology based on constraints.<sup>5</sup>

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<sup>5</sup> Similar are examples of preferences in various domains: for example, it has been claimed that some syllable contacts are better than others, though nonoptimal contacts exist (Murray and Vennemann 1983). Similarly, Prince (1990) has argued for a hierarchy of metrical foot types, in which [l h] is an optimal iamb, and [h] and [l l] are less optimal, though permissible, iambs (where *l* represents a light syllable, and *h* a heavy syllable).

### 6.2.5. *Optimality Theory (OT)*

Optimality Theory (Prince and Smolensky 2004, first published 1993) is a theory of constraint interaction that posits violable ordered constraints. For example, to account for the universal preference of syllables to have onsets and to avoid codas, Prince and Smolensky posit the constraints in (6.8).

#### (6.8) Syllable preference (markedness) constraints

- a. ONSET            A syllable must have an onset.
- b. NOCODA        A syllable must not have a coda.

The constraints in (6.8) can be broadly called markedness constraints, for they jointly amount to a markedness scale for syllable types: CV is the least marked syllable, in that it obeys both constraints; CVC and V each violate one of the constraints; and VC is most marked because it violates both constraints.

An underlying syllable CVC (say, /bak/) violates NOCODA; therefore, it is possible that it will be ‘repaired’ so as to conform to the constraint. Whether or not this happens, and the nature of the repair, depend on the ranking of the constraints. If NOCODA is ranked relatively high, it will have to be satisfied, meaning that underlying /bak/ will not be permitted to surface as [bak]. The nature of the repair depends on the ranking of other constraints, two of which are shown in (6.9).


#### (6.9) ‘Faithfulness’ constraints

- a. MAX C    Preserve an input consonant.
- b. DEP V    A vowel in the output must be present in the input.

The constraints in (6.8) belong to the class of ‘faithfulness’ constraints because they regulate the relation between input and output forms. Constraints of the MAX type require that input material be preserved in the output; DEP constraints penalize the insertion (epenthesis) of material not in the input.

Rather than applying constraints in sequence to an underlying form, as in classical generative phonology, OT posits that the optimal output form corresponding to a given input form is selected by an evaluation of competing candidates. The optimal candidate is the one that best satisfies the set of ranked constraints. An example is given in (6.10).

(6.10) Constraint evaluation tableau

/bak/	ONSET	NoCODA	MAX C	DEP V
a. bak		*!		
b.  bake				*
c. ba			*!	
d. ak	*!	*	*	


The tableau in (6.10) represents a grammar in which the constraints are ranked in the order ONSET >> NoCODA >> MAX C >> DEP V. The input (underlying) form is /bak/, and the forms in rows (a) – (d) are candidate output forms. Candidate (a) is the ‘faithful’ candidate, matching the input form most closely. However, it violates NoCODA; as there are two other candidates that do not violate this, or any higher-ranking constraint, this violation is fatal, indicated by !. Candidates (b) and (c) represent two different repair strategies: in (b) a vowel is inserted to

convert the coda into an onset, and in (c) the coda consonant is deleted. In the grammar in (6.10), MAX C is ranked above DEP V; therefore, this grammar prefers the preservation of the underlying consonant to its deletion, and candidate (b) is optimal, indicated by the pointing hand. Candidate (d) is eliminated immediately because it violates the highest ranking constraint.

In OT, there is no cumulative calculation of violations: if a candidate violates the highest ranking constraint and other candidates do not, it is a loser even if it does better with respect to all the remaining constraints.<sup>6</sup>

Different constraint rankings yield different optimal outputs. In (6.11), the faithfulness constraints are in reverse order from (6.10), and sandwiched between the markedness constraints, also in reverse order from the previous example.

(6.11) Constraint evaluation tableau

/bak/	NoCODA	DEP V	MAX C	ONSET
a. bak	*!			
b. bake		*!		
c.  ba			*	
d. ak	*!		*	*

---

<sup>6</sup> Nothing prevents OT from adopting other forms of constraint evaluation, including stochastic rankings, or weighted constraints that are added cumulatively, and so on. These issues are largely orthogonal to the general relation between OT and contrast.

The optimal candidate in this grammar is (c). Candidate (a) will become optimal in a grammar that ranks the faithfulness constraints over the two markedness constraints. No ranking of these constraints will make (d) a winner, because it violates a superset of the constraints violated by each of candidates (a) and (c).<sup>7</sup> OT picks the candidate that best satisfies a particular set of ranked constraints, not a perfect candidate.

### 6.3. *Treatment of contrast in OT*

#### 6.3.1. *Licensing and underspecification (Itô, Mester and Padgett 1995)*

Itô, Mester and Padgett (1995) propose that the inertness of redundant features can be accounted for in OT by deriving underspecification not as an input property, but as an output property. Building on a proposal of Padgett (1991: 56-58), they link redundancy to underspecification via a theory of licensing. For every feature F, there is a constraint of the form (6.12).

(6.12) Licensing (Itô, Mester and Padgett 1995)

License (F): 'The phonological feature F must be licensed.'

Features can be licensed by other features. However, there is an important restriction on licensing, called Licensing Cancellation (6.13).

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<sup>7</sup> Candidate (c) can be a winner, of course, if new constraints are added.

## (6.13) Licensing Cancellation (Itô, Mester and Padgett 1995)

Licensing Cancellation: If  $F \supset G$ , then  $\neg(F \wedge G)$ . 'If the specification [F] implies the specification [G], then it is not the case that [F] licenses [G].'

In Itô, Mester and Padgett's example, the features [sonorant] and [nasal] each imply [voiced]; that is, [voiced] is redundant in a sonorant segment and in a nasal segment.

## (6.14) Some redundancy rules

- a. SONVOI: [sonorant]  $\supset$  [voiced]
- b. NASVOI: [nasal]  $\supset$  [voiced]

It follows that [voiced] is not licensed by [sonorant]. Other things being equal, this implies that a sonorant will be unspecified for [voiced] at the surface.

Itô, Mester and Padgett's approach implies a hierarchy of features in which [sonorant] and [nasal] are higher than [voiced]. Without such a hierarchy, the theory runs into the problems with logical redundancy that we discussed earlier. Thus, it is also true in most languages that a nasal is predictably sonorant. Does this mean that feature cancellation requires that nasal segments not be specified for [sonorant]? Presumably not, but one would have to explain why. In a contrastive hierarchy approach, it is because [sonorant] generally has wider contrastive scope than [nasal]; thus, nasal segments are a subtype of sonorants, whereas sonorants are not a subtype of nasals. Similarly, we need to know why we do not cancel the license of Russian affricates to be marked for voice because coronal affricate implies voicelessness. So we still need a theory to tell us when a

crucial redundancy exists, just to make licensing cancellation well defined. The contrastive hierarchy is one such theory.

Let us now turn to the relation between contrast and phonological activity. Itô, Mester and Padgett write (1995: 608) that the ranking of licensing constraints and redundancy rules like SONVOI with respect to each other tips the scales in favour either of specification or underspecification. That is, if we rank Licensing above Redundancy, then a sonorant (in this case /m/) will be unspecified for voice (6.15a). If we rank the other way, with SONVOI above Licensing, then a sonorant will be forced to have a voice specification (6.15b).

(6.15) Ranking and underspecification

a. License >> Redundancy

Candidate	License	SONVOI
m   v	*!	
☞ m		*

b. Redundancy >> License

Candidate	SONVOI	License
☞ m   v		*
m	*!	



While this is no doubt true, the conclusion is that this theory makes no predictions about whether a redundant feature will or will not be specified in any given case. Like Radical Underspecification, it predicts only that a feature may be absent if it is redundant. If underspecification is indeed essentially arbitrary, then this is the best we can do. But we could have done the same in a derivational theory as well: we can simply stipulate the underlying specifications of each phoneme, allowing some to be more fully specified and others to be underspecified as required.

### 6.3.2. *Contrast as an emergent*

Kirchner (1997: 84) diagrams a standard representational model of contrastive specification as in (6.16).

#### (6.16) Representational contrastive specification (Kirchner 1997:84)

Underlying representation	<i>(ideally) pure representation of contrast</i>
Phonological component	<i>non-contrastive properties may be filled in, particularly if contrastive in other languages</i>
Phonetic component	<i>remaining non-contrastive phonetic properties, including gradient values, filled in</i>
Phonetic representation	<i>representation of all speaker-controlled phonetic properties of the utterance</i>

I note that this model is weaker than the strong Contrastivist Hypothesis, in allowing some noncontrastive features to be filled in the phonological component; it remains an empirical question whether the strong version of this hypothesis has to be weakened to allow something like (6.16). Be that as it may, Kirchner (1997: 83-84) cites Steriade (1995) as observing that ‘the assumptions of this model have often been disregarded in practice’ because phonologists have not been consistent in which redundant features they choose to remove. We have already discussed this objection to underspecification theory in the previous chapter. As we have seen, the objection applies to theories based on logical redundancy, but not to the contrastive hierarchy approach to contrastive specification.

Like Itô, Mester and Padgett (1995), Kirchner (1997) considers it an advantage of OT that it can model varying degrees of contrastive specification. If required, the constraint hierarchy can simulate the specification of only contrastive features, or of all features, or of features that are contrastive only in some contexts, and so on.

As has been stressed throughout, the degree of underspecification of phonological representations is an empirical matter. While it is true that various degrees of (under)specification can ‘emerge’ from different types of constraint rankings, allowing arbitrary orderings is tantamount to adopting the null hypothesis about contrastive specification: namely, that the degree of specification is arbitrary, and free to vary without limit from language to language.

Nothing compels OT to adopt this, or any other, position on contrastive specification. In the following section I will consider how the contrastive hierarchy can be represented in OT.

#### 6.4. *The contrastive hierarchy in OT*

##### 6.4.1. *Outputs and inputs*

Since OT requires a set of interacting constraints that mediate between an input and an output, we must make some decisions concerning what the input and output are when it comes to modelling the contrastive hierarchy.

Let us consider first the output. I will continue to assume that the contrastive hierarchy specifies only features that are contrastive (at least in some part of the inventory), and does not specify redundant features. For example, given a three-vowel inventory /i a u/ and the ordered binary features [high] > [round], the SDA first divides the inventory into [–high] and [+high] sets. The [–high] set consists only of /a/, so the assignment of features to this phoneme stops at this point. The specification of further phonetic features that characterize /a/, such as [–round], [+back], [+low], and so on, is left to a later component. The [+high] set, consisting of /i u/, requires one further division, effected by [round] in this hierarchy, and other specifications are left for later. That is, the output of the SDA for the inventory /i a u/ consists of the contrastive specifications in (6.17).

(6.17) Output specifications of the SDA for /i a u/, [high] > [round]

$$/i/ = \begin{bmatrix} +\text{high} \\ -\text{round} \end{bmatrix} \quad /a/ = [-\text{high}] \quad /u/ = \begin{bmatrix} +\text{high} \\ +\text{round} \end{bmatrix}$$

The standard theory of OT posits a single parallel mapping from lexical representation to surface phonetic form. Such a mapping would not mirror the effect of the Successive Division Algorithm, but would include also redundant features. There are other reasons for not trying to model the contrastive hierarchy in a single mapping. First, there are the problems with opacity we observed above. These arise immediately in the contrastive hierarchy. For example, we will see in Chapter 7 that the Classical Manchu vowel /u/ is phonetically [round] but does not bear a [round] feature phonologically. Moreover, in many contexts surface [u] represents two different underlying vowels: [ATR] /u/, and non-ATR /ʊ/. The same is true of Nez Perce surface /i/, which represents the merger of two different underlying phonemes.

Thus, there are a number of different sources that lead to a differentiation between the output of the SDA and the surface phonetic form. Therefore, the SDA fits best into a multi-stratal or serial version of OT (cf. Kiparsky 2000, 2002, to appear; Rubach 2000, 2003; and Bermúdez-Otero 2003).<sup>8</sup>

What should be the input to the OT constraint system? The SDA specifies the set of well formed contrastive representations for a given inventory.

Therefore, the input to an OT implementation of the algorithm should be able to

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<sup>8</sup> The claim that OT posits a single mapping from lexical to phonetic representations is often disregarded in practice. We have seen, for example, that Itô, Mester and Padgett (1995) posit outputs that may have a certain amount of underspecification. Presumably, these are intermediate representations that are subject to a further round of specification.

take fully-specified representations as input, and output the corresponding contrastive specifications. Thus, the constraint system acts as a *filter*, sifting fully-specified representations and allowing only the contrastive specifications to pass through.

OT theorists have proposed that the constraint evaluation system should be able to give an output for *any* input (cf. Prince and Smolensky's (2004) notion of 'richness of the base'). In our case, there are two types of potential additional inputs that could be distinguished. First, there are *illicit* combinations of features, corresponding to phonemes that are not in the inventory. Presenting the grammar with such an input is tantamount to asking what a speaker will do when presented with a segment from another language, or what learners do with phonemes they have not yet acquired. For example, how does the grammar corresponding to (6.17) treat an input /o/, that is, a set of features that includes the specifications [–high, +round]? We will consider this issue in §6.5.

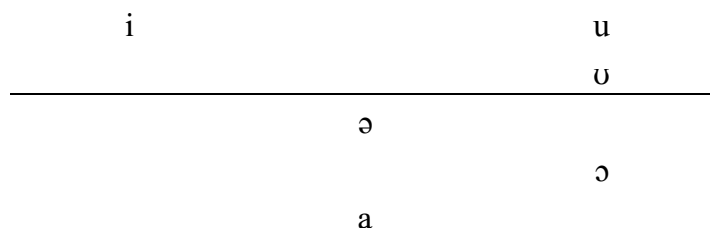
A second type of additional input consists of inputs that are *underspecified* relative to the representations licensed by the contrastive hierarchy. For example, in (6.17), any segment specified for [round] must also be specified [+high]. What should the OT translation of the contrastive hierarchy do with an input that consists only of the feature [–round]? I will consider this type of case in §6.6.

In the first instance, however, we will limit inputs to fully specified but legal phonemes; that is, we will first limit the OT constraint evaluation system to the filtering function. It will take fully specified phonemes as input and produce contrastive specifications as output.

#### 6.4.2. *An OT version of the Successive Division Algorithm*

For the sake of this discussion, let us take as an example the Classical Manchu vowel system, shown in (6.18). The line divides vowels into two height classes.

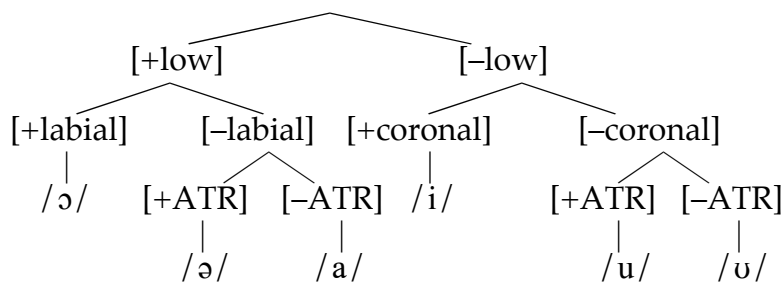
(6.18) Classical Manchu (Zhang 1996)



Zhang (1996) proposes that the contrastive feature hierarchy for Classical Manchu consists of the features [low] > [coronal] > [labial] > [ATR]. The SDA using this hierarchy creates the tree shown in (6.19a), and the resulting specifications are listed in (6.19b).<sup>9</sup>

(6.19) Contrastive hierarchy for Classical Manchu (Zhang 1996)

a. SDA: [low] > [coronal] > [labial] > [ATR]



<sup>9</sup> For expositional reasons I use binary features for this example, in place of the privative features used by Zhang (1996). This example and the rationale for the analysis are discussed in Chapter 7.

## b. Output specifications

$$\begin{array}{lll}
 /i/ = \begin{bmatrix} -\text{low} \\ +\text{coronal} \end{bmatrix} & /u/ = \begin{bmatrix} -\text{low} \\ -\text{coronal} \\ +\text{ATR} \end{bmatrix} & /ʊ/ = \begin{bmatrix} -\text{low} \\ -\text{coronal} \\ -\text{ATR} \end{bmatrix} \\
 /a/ = \begin{bmatrix} +\text{low} \\ -\text{labial} \\ -\text{ATR} \end{bmatrix} & /ə/ = \begin{bmatrix} +\text{low} \\ -\text{labial} \\ +\text{ATR} \end{bmatrix} & /ɔ/ = \begin{bmatrix} +\text{low} \\ +\text{labial} \end{bmatrix}
 \end{array}$$

Starting at the top of the hierarchy, the feature [low] makes the first dichotomy in the inventory: all segments must be specified for this feature. I will use the constraint MAX [F] to require that any specification of F (+ or –) must be preserved. On the assumption that only fully specified inputs are provided to the grammar, ranking MAX [low] highest will ensure that any underlying value of [low] is preserved in the output.

The next feature in the Manchu hierarchy is [coronal]. If we rank MAX [coronal] next, then any underlying value of this feature will be preserved in the output. However, a segment that is [+low] may not be specified for [coronal]. Therefore, we must exclude the feature combination [coronal, +low] for any value of [coronal]. Therefore, ranked higher than MAX [coronal], but lower than MAX [low], we require a co-occurrence constraint ruling out this combination of features.

The next feature is [labial]. We repeat the above procedure, specifying a co-occurrence constraint \*[labial, –low,] ranked above the constraint MAX [labial].

The fourth and final feature is [ATR]. Here there are two co-occurrence restrictions, one for each branch of the tree descending from [low]. One is \*[ATR,

+labial, +low], the other is \*[ATR, +coronal, –low]. Since [labial] has already been excluded in the domain of [–low] and [coronal] is excluded with [+low], the specifications of [low] in the [ATR] exclusions are redundant here. Following these restrictions we add, as before, MAX [ATR], which requires the preservation of [ATR] wherever it is not excluded.

As the contrastive hierarchy ends at this point, every other feature specification is simply excluded: \*[F].

Summing up, we require the constraint types in (6.20).

(6.20) Two basic constraint types

- a. MAX F: Preserve the feature value of F (either + or –).
- b. \*[F, Φ], where F is the feature to be excluded, and Φ is the set of feature values (of features with wider scope than F) forming the context of F.

The constraint hierarchy for Classical Manchu is given in (6.21), and the general procedure for converting any contrastive hierarchy into an OT constraint hierarchy is summarized in (6.22).

(6.21) Classical Manchu constraint hierarchy: MAX [low] >> \*[coronal,

+low] >> MAX [coronal] >> \*[labial, –low] >> MAX [labial] >>

\*[ATR, +coronal], \*[ATR, +labial] >> MAX [ATR] >> \*[F]

- a. MAX [low].                      Ordered highest.
- b. \*[coronal, +low]      If [+low], cannot specify a value for [coronal].
- c. MAX [coronal]              Must be ordered after (b).



- d. \*[labial, -low]      After (c), not crucially here, because  
[coronal] > [labial].
- e. MAX [labial]      Must be ordered after (d).
- f. \*[ATR, +coronal]      After (e) because [labial] > [ATR].
- g. \*[ATR, +labial]      After (e), in the same stratum as (f).
- h. MAX [ATR]      After (f) and (g).
- i. \*[F]      For F = any feature.<sup>10</sup> After (h).

(6.22) Converting a contrastive hierarchy to a constraint hierarchy

Given an ordering of features:

- a. Go the next contrastive feature in the list,  $F_i$ . If there are no more contrastive features, go to (e).
- b. In the next stratum of constraints, place any co-occurrence constraints of the form  $*[F_i, \Phi]$ , where  $\Phi$  consists of feature values of features ordered higher than  $F_i$ .
- c. In the next stratum, place the constraint MAX  $[F_i]$ .

---

<sup>10</sup> There is no need to specify that [F] here is different than the contrastive features. If [F] is any feature, then every candidate will incur a violation for each feature it specifies. In the case of contrastive features, this violation will be harmless, because any candidates that lack a required feature will have been already ruled out by a higher constraint. In the illustrative tableaux, however, I will record a \* under \*[F] only for violations of features that are not in the contrastive hierarchy, so as not to clutter up the tableaux with marks that play no role in deciding the outcome.

- d. Go to (a).
- e. In the next constraint stratum, place the constraint \*[F], and end.

A sample constraint tableau is given in (6.23).

[PUT (6.23) ABOUT HERE]

In this example the input is overspecified with respect to the contrastive specifications allowed by this contrastive hierarchy. The feature specifications of the input vowel correctly characterize the phonetics of Manchu /i/, but in the analysis in (6.19) the only contrastive features are [–low, +coronal]; the feature values [–labial] and [+ATR] are present phonetically but not phonologically. Candidates (a) and (b) maintain both or one of these noncontrastive features and both are losers because they violate the co-occurrence constraint against having [labial] together with [–low]. Candidate (c) is the winning output: it dispenses with the features [labial] and [ATR], but retains [low] and [coronal], as required by the contrastive hierarchy. Candidate (d) also retains two features of the input, [low] and [labial], but loses because MAX [coronal] is ranked higher than MAX [labial]. Candidate (e) retains three features in a licit configuration by changing the input [+low] to [–low], but is immediately ruled out because this change violates MAX [low]. Candidate (f) retains only [+coronal]. Though through logical redundancy this would uniquely identify the phoneme /i/, it is ruled out as a representation because it, too, violates MAX [low] (i.e., no underspecification ‘from below’ is permitted). Finally, candidate (g) retains the correct specifications from the input but adds a redundant feature, [–back]. It thus incurs an extra violation of \*[F] and so loses to (c).

#### 6.4.3. *Constraint hierarchies not corresponding to a contrastive hierarchy*

The procedure in (6.22) can convert any legal contrastive hierarchy into a constraint hierarchy. The converse is not the case, however. We have seen that a number of commentators have observed that OT is capable of simulating a wide spectrum of grammars, ranging from those with highly underspecified representations to those with fully specification, as well as grammars intermediate between these. If all of these grammars are indeed attested, then this degree of expressive power is warranted. If however, there are constraints on the degree of specification allowed in grammars, then it is undesirable to allow constraint hierarchies that produce impossible grammars.

The assumption here, following from the Contrastivist Hypothesis, is that the contrastive hierarchy sets the limits on specification in phonology, at least to a first approximation. If that is the correct position, then we wish to constrain OT to be limited to hierarchies that simulate legal contrastive hierarchies. That is, we could require that OT grammars contain only constraint hierarchies that adhere to (6.22). In the absence of such a constraint, OT grammars can indeed mimic all manners of specification and underspecification. This can be illustrated with the same Classical Manchu vowel system we considered above.

Let us begin with full specification. Full specification of the features of an inventory can be required simply by promoting all MAX [F] constraints to the top of the constraint hierarchy. A tableau of this type is given in (6.24). It is clear that

only a fully specified output can be a winner, given a fully specified input, since all features must be preserved.<sup>11</sup>

[PUT (6.24) ABOUT HERE]<sup>12</sup>

We can limit the phonology to full specification of ‘relevant’ features (i.e., features that are contrastive somewhere in the phonology) by promoting only the MAX constraints for contrastive features, as in (6.25). Features that are redundant everywhere are filtered out, but all segments must be specified for all contrastive features, even if they are not contrastive in any given contrastive hierarchy.

[PUT (6.25) ABOUT HERE]<sup>13</sup>

We can mimic the effect of the Pairwise Algorithm, giving a type of underspecification. A set of feature specifications for Classical Manchu consistent with those generated by the Pairwise Algorithm is given in (6.26).<sup>14</sup>

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<sup>11</sup> Recall that we are limiting inputs to be fully specified, for now. MAX constraints apply only to features present in the input. As we shall see when we consider underspecified inputs, this fact allows unconstrained OT constraint systems to create unusual grammars in which underspecified inputs are required to be underspecified, while fully specified inputs must remain so in the output.

<sup>12</sup> The various co-occurrence restrictions are all abbreviated as  $*[F, \Phi]$  in this tableau, since they have no effect on the outcome.  $*\dots$  represents an indefinite number of violations.

<sup>13</sup> The various co-occurrence restrictions are again abbreviated as  $*[F, \Phi]$ . MAX  $[G]$  refers to all the redundant features that play no contrastive role anywhere in the inventory.

<sup>14</sup> The feature [coronal] is omitted because the Pairwise Algorithm would fail if it were included.

## (6.26) Pairwise Algorithm specifications for Classical Manchu

Vowel	/i/	/ə/	/a/	/ɔ/	/u/	/ʊ/
[low]	–	+		+		–
[labial]	–		–	+	+	
[ATR]		+	–		+	–

These specifications can be obtained by placing a series of pairwise restrictions ordered in a block above a set of MAX constraints, also in a block. Since the Pairwise Algorithm does not incorporate any kind of ordering of features, it follows that the constraints of the same type also do not have to be ordered. Sample tableaux with two different inputs are given in (6.27) and (6.28).

[PUT (6.27) ABOUT HERE]

[PUT (6.28) ABOUT HERE]

An OT constraint hierarchy can be made to simulate the theory of Radical Underspecification (RU) (Archangeli 1984, Pulleyblank 1986). In this theory, one value of each feature, the marked value, is specified on every segment. RU also assumes that a minimal number of features is used. A possible RU analysis of Classical Manchu is given in (6.29).<sup>15</sup>

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<sup>15</sup> [coronal] is again omitted here to keep to a minimal feature set.

## (6.29) Radical Underspecification for Classical Manchu

Vowel	/i/	/ə/	/a/	/ɔ/	/u/	/ʊ/
[low]		+	+	+		
[labial]				+	+	+
[ATR]	+	+			+	

This type of underspecification is easily modelled in OT by positing a set of constraints of the form MAX [m F], where [m F] is the marked value of F.<sup>16</sup> These constraints can be ordered in a single stratum above \*[F]. A sample tableau is shown in (6.30).

[PUT (6.30) ABOUT HERE]

We have seen, then, that OT is capable of simulating the effects of any theory of specification or underspecification. This is to be expected, since OT is primarily a theory of constraint interaction, not a theory of specification. If we are to have a theory of specification, OT must be constrained so as to produce the desired representations and exclude the others. To the extent that phonologies adhere to contrastive specifications of the sort that can be produced by the SDA, OT must be constrained, for example along the lines of (6.22).

More fundamentally, such constraints on the theory are required if OT is to instantiate some version of the Contrastivist Hypothesis. The reason for

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<sup>16</sup> It is not so straightforward to model the derivational aspect of RU — the fact that feature values can be inserted in the course of a derivation. Also, we continue to restrict inputs to fully specified, or overspecified, forms.

limiting specifications to those that are contrastive is to capture the relationship between contrast and phonological activity.

#### 6.5. *Inputs containing illicit feature combinations*

Up to here we have considered only inputs that are as specified or more specified than the contrastively specified outputs. For example, the Manchu vowel /i/, contrastively specified as [–low, +coronal], can be input as such, or with additional redundant features, for example [–low, +coronal, –labial, –ATR, –back]. The constraint system filters out the redundant features and outputs the contrastive representations we have proposed above.

Many OT theorists require the constraint system to do more than filter redundancies from fully specified representations. According to the notion of the ‘richness of the base’ (Prince and Smolensky 2004), we might expect the constraint system to be able to convert *any* arbitrary input into a licit output. For purposes of this discussion, it is useful to recognize two additional types of inputs: fully specified inputs that contain combinations of features that are not permitted in the given inventory (i.e., input segments that are not part of the inventory); and underspecified inputs (i.e., inputs lacking certain required features). Let us first consider cases of the former kind.

Continuing with our Manchu example, we can ask what the constraint hierarchy in (6.23) would do with an input [+low, +coronal, –labial, –ATR, –back, –high, etc.], that is a front low vowel such as /æ/ or /ε/. Such a vowel does not

exist in Classical Manchu. A tableau showing the results given by the hierarchy in (6.23) is given in (6.31).

[PUT (6.31) ABOUT HERE]

The constraint system gives a unique optimal output, [+low, –labial, –ATR], namely /a/. The high ranking of MAX [low] ensures that the underlying specification [+low] is maintained, and the next highest-ranking constraint, \*[coronal, +low], rules out any output that contains a coronal feature specification. All the other features must be preserved insofar as they are not excluded. Thus, the competition between the conflicting [+low] and [+coronal] input specifications is resolved in favour of the feature that is higher in the hierarchy.

This situation is tantamount to asking the question: what would speakers of Classical Manchu do when presented with a vowel outside of their inventory? This, of course, is part of a larger question: how are foreign (L2) sounds integrated into one's native (L1) phonology? This is an empirical question, and a considerable literature has arisen to address it. Here I will briefly look at the role of the contrastive hierarchy in the treatment of L2 sounds that fall outside the native L1 inventory. I will return to this topic in Chapter 7, where I will present an empirical study that makes crucial use of the contrastive hierarchy in accounting for patterns of loanword adaptation. Here, I will consider the matter more abstractly.

One possible approach is the one we took above: in any clash of features, the feature higher on the hierarchy takes precedence over the one lower down,



and the rest of the features are retained or not to the extent that they fit into the native contrastive system. To take another example involving Classical Manchu, an input vowel /o/, which we will assume is specified [+low, –coronal, +labial, +ATR] (i.e., the [+ATR] counterpart of /ɔ/), will first of all retain its [+low] specification. Since [coronal] is excluded in the [+low] domain, that feature will be filtered out. In this case, the exclusion of [coronal] has no perceptible effect, since the vowel will in any case be phonetically [–coronal]. Continuing down the hierarchy, [+low] vowels are all specified for [labial], so the [+labial] specification is retained. Vowels specified [+low, +labial] admit of no further specification in Classical Manchu, so the [+ATR] specification is filtered out. The prediction of this approach is that an input /o/ will be converted to its (redundantly) non-ATR counterpart, /ɔ/.

This is the result we obtain by following down the contrastive tree in (6.19). If L2 words are borrowed following this approach, foreign sounds are assigned to native categories by preserving the feature specifications with widest scope at the expense of those with narrower scope. This is a purely hierarchical approach to loan phonology. It is possible that L2 phonology works this way; however, it is not necessary to apply the contrastive hierarchy to foreign sounds in just this way. Other factors may intercede to lead to different results.

Consider again, for example, the three-vowel system in (6.17), where [high] > [round]. Suppose we were to present the grammar with an input vowel /o/, that is, a vowel specified [–high, +round]. Following a purely hierarchical approach, we would require [–high] to be preserved above any other

consideration. Once the vowel is designated [–high], any specification for [round] must be filtered out, and the result would be [–high], that is, /a/.

Again, this is perhaps the right outcome. But one can imagine a different outcome, whereby the [+round] specification is perceived by L1 speakers as being more *salient* than the height feature. If the priority is to retain this [+round] specification, then necessarily the height feature will have to be adjusted, giving the output [+high, +round], that is, /u/.

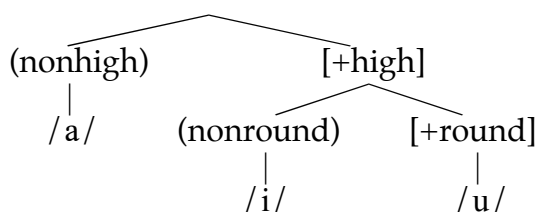
This scenario raises the question of the relation between salience and the contrastive hierarchy. On the approach taken here, saliency is closely tied up with the contrastive hierarchy. Now it could be that salience is to some extent free of language-particular hierarchies. In that case, the contrastive hierarchy and salience would be two coexisting dimensions that each contribute in different degrees to various aspects of the phonology. To the extent that salience would also have to be organized into a hierarchy (to sort out what happens when two features are both salient but conflicting), it would of course be more desirable, from a theoretical point of view, if the contrastive and salience hierarchies could be conflated, or at least related to one another. The matter is, however, empirical, and will ultimately be decided on the evidence.

Before leaving this topic, it is worth pointing to a third position, one which relates salience to the contrastive hierarchy, but which also assigns a role to markedness.

Let us suppose that for each binary feature, one value is unmarked (default) and the other is marked. A more radical implementation of this idea is

adopt privative features, where only the marked value is specified at all, leaving the unmarked value to be literally unmarked. Suppose that in the three-vowel system in (6.17) the values [+high] and [+round] were marked, and the minus values unmarked (or even absent). Assigning labels only to marked values, the tree in (6.17) would appear as in (6.32).

(6.32) Contrastive hierarchy for /i a u/, [high] > [round]



If marked features were to take priority over unmarked features, then an input /o/ would have the marked feature [+round]. Preserving this feature would result in the output [+high, +round], that is, /u/.

This result can be obtained from the constraint system in (6.31) if the MAX [F] constraints were understood as applying only to marked features. Suppose, for sake of this discussion, that in Classical Manchu the marked features were [–low], [+coronal], [+labial], and [+ATR]. To keep the marked values identified with plus values, we will for the rest of this example substitute [high] for [low].<sup>17</sup> Then the input /æ/, [–high, +coronal, –labial, –ATR] would

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<sup>17</sup> I adopt the assumption that [–low] or [+high] is the marked feature in Classical Manchu only for purposes of this example, so as to create a mismatch between the highest feature, [high], and

have the marked value [coronal]. As shown in (6.33), the predicted outcome is now /i/, that is, [high, coronal]. In (6.33) only marked values are shown. A constraint like \*[coronal, –high] must be reformulated, assuming there is no value [–high]. We still want to exclude the specification [coronal] in the absence of [high]. We can recast the constraint in terms of licensing (cf. Itô, Mester and Padgett 1995) as [coronal]  $\subset$  [high] ('[coronal] must be licensed by [high]'), or as a co-occurrence constraint \*[coronal,  $\neq$  high] ('[coronal] may not be specified if [high] is unspecified').

[PUT (6.33) ABOUT HERE]

This brief discussion shows that the contrastive hierarchy by itself does not dictate a particular approach to the question of how foreign sounds are incorporated into a phonology. In conjunction with other concepts, such as markedness, it does make available a range of empirical hypotheses.

Privative feature systems necessarily involve underspecification, as seen in (6.33). Such underspecification is not particularly problematic in this context, since it is permanent. Thus, the presence vs. absence of a feature forms a binary opposition, parallel to that between a plus and minus value of a feature. In binary feature systems, however, underspecification takes on a different status,

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the highest marked feature, [coronal]. Elsewhere, however, I continue to assume that [+low] (or [low] is the marked feature value in Classical Manchu.

creating in effect a ternary opposition between plus, minus, and zero. In the next section we consider the effect of underspecified inputs in a binary feature system.

#### 6.6. *Underspecified inputs*

The notion of ‘richness of the base’ can be extended to include not just illicit combinations of fully specified features, but also underspecified inputs; by ‘underspecified’ I mean here underspecified relative to the representations derived by the contrastive hierarchy. Whereas inputs consisting of illicit combinations of features can be interpreted as foreign sounds being presented to a speaker, it is less obvious in what actual or hypothetical situations a speaker will be presented with an underspecified input. Since it is not possible to isolate individual features in any percept that a speaker can actually be exposed to, it is hard to imagine under what circumstances speakers — let us say of Classical Manchu, to continue with our example — might interpret a vowel that sounds something like [a] as consisting only of the feature [+low], rather than, as required by the contrastive hierarchy, [+low, –labial, –ATR].

Nevertheless, richness of the base has been a basic part of the conceptual system of OT, so let us see what the consequences are of allowing such inputs. In (6.34), an underspecified input consisting only of [+low] is provided as an input to the constraint system we have been using for Classical Manchu.

[PUT (6.34) ABOUT HERE]

The constraint system developed so far does not adequately deal with underspecified representations, as is revealed by (6.34). The constraint hierarchy

in (6.34) does not produce a unique solution. The high ranking of MAX [low] ensures that the underlying specification [+low] is maintained, and the next highest-ranking constraint, \*[coronal, +low], rules out any output that contains a coronal feature specification. Beyond these requirements, however, the constraint system does not distinguish between the candidate consisting of just [+low] and any candidate containing this specification in combination with any other contrastive specifications that can occur with [+low]: [+low, -labial], [+low, +labial], [+low, -labial, -ATR], and [+low, -labial, +ATR].

The problem is that constraints of type MAX [F] require only that an input specification of [F] must be preserved. They have no jurisdiction over a feature that is absent from the input. If we consider a contrastive tree such as in (6.19), we understand that it not only prohibits certain feature combinations, it also *requires* some features to be present. MAX constraints do not do this, nor do the co-occurrence constraints. For while a constraint of the form \*[coronal, +low] prohibits certain combinations of features, it does not require any combinations. Candidates that lack some or all of the features mentioned in such a constraint simply evade its effects.

To enforce the presence of required contrastive features we need to add a third type of constraint, requiring the presence of a feature in the context of other features. One way is by an implicational feature of the form in (6.35).

(6.35) Implicational constraint

[ $\Phi$ ]  $\supset$  [F]: The set of feature specifications [ $\Phi$ ] requires the presence of feature [F].

When a value of [F] is specified in the input, MAX [F] will ensure it is maintained. When no value is specified, the implicational rule will penalize any candidate that lacks [F].

In Classical Manchu, a set of implicational constraints that mirrors the contrastive tree in (6.19) is given in (6.36).

(6.36) Implicational constraints for Classical Manchu

- a. [low]                      The feature [low] must always be specified.
- b. [+low]  $\supset$  [labial]
- c. [-low]  $\supset$  [coronal]
- d. [-labial]  $\supset$  [ATR]
- e. [-coronal]  $\supset$  [ATR]

We now observe a redundancy between the constraints that penalize a feature in a context and those requiring it: the contexts in which these apply are bound to be complementary. Therefore, we can simplify the implicational constraints to simply require the presence of a feature, as long as these are ordered after the constraints forbidding the feature. This type of constraint can take the form shown in (6.37).

(6.37) Specification Constraint

- SPEC [F]                      [F] must be specified.

If we add such constraints en bloc after the constraints we have been using to here, they will filter out candidates that lack required features. For example, in (6.38) the underspecified candidates [+low], [+low, -labial], and [+low, +labial] are eliminated because they lack features that are required in the context of

[+low]. On the other hand, the overspecified [+low, –coronal, –labial, –ATR] does not benefit from its lack of violations of these constraints because it is already excluded by the higher ranking constraint excluding [coronal] in the context of [+low].

[PUT (6.38) ABOUT HERE]<sup>18</sup>

The addition of the SPEC [F] constraints narrows the field down, but does not suffice to decide which value of [ATR] should be supplied.<sup>19</sup> Presumably, we want to supply the least marked values. Thus, we have to add a set of markedness constraints that penalize the marked value of each feature.

(6.39) Markedness constraints (contextual)

\*[*m* F, Φ]: Value *m* of [F] is penalized in the context of [Φ].

If markedness does not vary by context, then this type of constraint can be reduced simply to (6.40).

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<sup>18</sup> The constraint column MAX & \*[F, αG] is simply shorthand for all the MAX and \*[F, αG] constraints as they are ranked in (6.34).

<sup>19</sup> The same might be said of the feature [labial]. In the tableau (6.38), the candidate [+low, +labial] loses because it lacks a feature, [ATR], even though the combination [ATR, +labial] is excluded in Classical Manchu. Thus, ordering all the SPEC [F] constraints before the markedness constraints favours candidates that maximize the number of specified features. This may not be the correct answer. If, for example, [+labial] were unmarked, one might expect that the optimal way to fill out an input consisting only of [+low] would be [+low, +labial], rather than filling in [–labial] and a value of [ATR]. This result can be obtained by interleaving the markedness constraints with the SPEC [F] constraints.



(6.40) Markedness constraints (noncontextual)

\*[*m* F]: Value *m* of [F] is penalized.

In (6.38), these constraints are added at the bottom of the constraint hierarchy. As observed in the previous note, different rankings of the markedness constraints yield somewhat different results.

### 6.7. *Summary*

In this chapter I have argued that OT is not itself a theory of contrast in competition with the Contrastivist Hypothesis or the contrastive hierarchy. Rather, OT can incorporate various theories of contrast. Though it is true that some approach to contrast will inevitably ‘emerge’ from any OT constraint hierarchy, the empirical question is what theories of contrast are allowed to occur in phonology. If, for example, the Contrastivist Hypothesis as implemented by the Successive Division Algorithm operating on a contrastive feature hierarchy is the correct theory, then OT should be constrained to implement that theory.

I have shown how OT with different strata (serial, or derivational OT) can incorporate the contrastive hierarchy by modelling the Successive Division Algorithm. In OT with multiple strata, the constraints corresponding to the SDA can be segregated from the rest of the phonology; the output of these constraints create well-formed contrastive specifications that serve as the input to the phonology proper.

Whether the Contrastivist Hypothesis can be incorporated into a monostratal version of OT is a more difficult question. Such a grammar does not

make available a level at which only contrastive feature specifications are visible, and constraints implementing the SDA cannot be kept separate from the other constraints. Moreover, there are problems with requiring that phonemes be underspecified in various ways. I cannot pursue these issues here, but they are considered in some detail by Hall (2007: Chapter 5). Hall concludes that there are real difficulties in incorporating the Contrastivist Hypothesis into a standard monostratal OT. This result is not too upsetting since, for reasons mentioned earlier in this chapter, I believe that a derivational phonology of some sort is required on independent grounds.

We will return to some of the issues discussed here in the following chapter, where I take up a series of case studies that provide evidence for the contrastive hierarchy and the Contrastivist Hypothesis.


## (6.23) Constraint hierarchy corresponding to Classical Manchu contrastive hierarchy

Input: [-low, +coronal, -labial, +ATR] (overspecified /i/)

Candidates	MAX [low]	*[cor, +low]	MAX [cor]	*[lab, -low]	MAX [lab]	*[ATR, +cor]	*[ATR, +lab]	MAX [ATR]	*[F]
a. [-low, +cor, -lab, +ATR]				*!		*			
b. [-low, +cor, -lab]				*!				*	
c. ☞ [-low, +cor]					*			*	
d. [-low, -lab]			*!	*				*	
e. [+low, -lab, +ATR]	*!		*						
f. [+cor]	*!				*			*	
g. [-low, +cor, -back]					*			*	*!


(6.24) Full specification of all features: all MAX constraints promoted to the top

Input: [-low, +coronal, -labial, +ATR, -back, +high, -nasal] (fully specified /i/)

Candidates	MAX [low]	MAX [cor]	MAX [lab]	MAX [ATR]	MAX [bck]	MAX [hi]	MAX [nas]	*[F, Φ]
a.  [-low, +cor, -lab, +ATR, -bck, +hi, -nas]								*...
b. [-low, +cor, -lab, +ATR, -bck, +hi]							*!	*...
c. [-low, +cor, -lab, +ATR]				*!	*	*	*	*...
d. [-low, +cor]			*!	*	*	*	*	*...

(6.25) Full specification of 'relevant' features: some MAX constraints promoted to the top

Input: [-low, +coronal, -labial, +ATR, -back, +high, -nasal] (fully specified /i/)

Candidates	MAX [low]	MAX [cor]	MAX [lab]	MAX [ATR]	*[F, Φ]	*[F]	MAX [G]
a. [-low, +cor, -lab, +ATR, -bck, +hi, -nas]					*...	*!*	
b. [-low, +cor, -lab, +ATR, -bck, +hi]					*...	*!*	
c.  [-low, +cor, -lab, +ATR]					*...		*...
d. [-low, +cor]			*!	*			*...

## (6.27) Underspecification by means of the Pairwise Algorithm

Input: [-low, -labial, +ATR, +coronal] (overspecified /i/)

Candidates	*[+low, -lab] *[-low, +lab]	*[-low, +ATR] *[+low, -ATR]	*[-lab, +ATR] *[+lab, -ATR]	MAX [low]	MAX [lab]	MAX [ATR]	*[F]
a. [-low, -lab, +ATR, +cor]		*!	*				*
b. [-low, -lab, +ATR]		*!	*				
c. [-low, +cor]					*!	*	
d. ☞ [-low, -lab]						*	
e. [-lab, +ATR]			*!	*			
f. [+cor]				*!	*	*	*

## (6.28) Underspecification by means of the Pairwise Algorithm

Input: [+low, -labial, -ATR] (overspecified /a/)

Candidates	*[+low, -lab] *[-low, +lab]	*[-low, +ATR] *[+low, -ATR]	*[-lab, +ATR] *[+lab, -ATR]	MAX [low]	MAX [lab]	MAX [ATR]	*[F]
a. [+low, -lab, -ATR]	*!	*					
b. [+low, -lab, +ATR]	*!		*			*	
c. [-low, -lab]				*		*!	
e. ☞ [-lab, -ATR]				*			
f. [+low, +ATR]				*	*!	*	

## (6.30) Radical Underspecification

Input: [-low, -labial, +ATR, +coronal, +high] (overspecified /i/)

Candidates	MAX [+low]	MAX [+lab]	MAX [+ATR]	*[F]
a. [-low, -lab, +ATR, +cor, +hi]				*!***
b. [-low, -lab, +ATR]				*!*
c. $\emptyset$ [+ATR]				
d. $\emptyset$			*!	
e. [+low, +ATR]				*!

## (6.31) Illicit fully specified input (segment outside the inventory)

Input: [+low, +coronal, -labial, -ATR, -back, -high, etc.] (/æ/)

Candidates	MAX [low]	*[cor, +low]	MAX [cor]	*[lab, -low]	MAX [lab]	*[ATR, +cor]	*[ATR, +lab]	MAX [ATR]	*[F]
a. [+low, +cor, -lab, -ATR, -bk, -hi]		*!				*			**
b. [+low, +cor, -lab, +ATR]		*!				*			
c. [+low, +cor, -lab]		*!						*	
d. [+low]			*		*!			*	
e. [+low, -lab]			*					*!	
f. ☞ [+low, -lab, -ATR]			*						
g. [-low, +cor]	*!				*			*	
h. [-low, +cor, -lab, -ATR]	*!			*		*			



(6.33) Marked (privative) features: illicit input (segment outside the inventory)

Input: [coronal] (/æ/)

Candidates	MAX [hi]	*[cor, u hi]	MAX [cor]	*[lab, hi]	MAX [lab]	*[ATR, cor]	*[ATR, lab]	MAX [ATR]	*[F]
a. [cor]		*!							
b. [cor, ATR]		*!				*			
c. [Ø]			*!						
d. <del>☞</del> [hi, cor]									
e. [hi, cor, ATR]						*!			

## (6.34) Underspecified input

Input: [+low]

Candidates	MAX [low]	*[cor, +low]	MAX [cor]	*[lab, -low]	MAX [lab]	*[ATR, +cor]	*[ATR, +lab]	MAX [ATR]	*[F]
a. ☞ [+low]									
b. ☞ [+low, -lab]									
c. ☞ [+low, +lab]									
d. ☞ [+low, -lab, +ATR]									
e. ☞ [+low, -lab, -ATR]									
f. [+low, -cor]		*!							
g. [-low]	*!								
h. [Ø]	*!								

(6.38) Underspecified input, adding SPEC [F], where [F] is one of the contrastive features

Input: [+low]

Candidates	MAX & *[F, $\alpha$ G]	SPEC [low]	SPEC [lab]	SPEC [cor]	SPEC [ATR]	*[ $m$ F]
a. [+low]			*!	*	*	*
b. [+low, -lab]				*	*!	*
c. [+low, +lab]				*	*!	**
d. [+low, -lab, +ATR]				*		**!
e. ☞ [+low, -lab, -ATR]				*		*
f. [+low, -cor, -lab, -ATR]	*!					*
g. [-low]	*!					
h. [Ø]	*!					



## 7. Evidence for the Contrastive Hierarchy in Phonology

‘Any structure of any kind of complexity presupposes some form of hierarchy.’

Morris Halle, ‘On markedness’ (1970).

### 7.1. *Modified Contrastive Specification*

In this chapter I will provide further evidence for the Contrastivist Hypothesis and the contrastive hierarchy. The cases surveyed below draw mainly on research done at the University of Toronto over the last fifteen years in the context of the project on Markedness and the Contrastive Hierarchy in Phonology (Dresher and Rice 2002). This approach to segment structure has come to be known as Modified Contrastive Specification (MCS). In this section I will sketch some of the key properties of MCS, which will be illustrated in the subsequent sections.

#### 7.1.1. *Complexity, markedness, and contrast*

This research began with a focus on complexity in phonology (Avery and Rice 1989, Dresher, Piggott and Rice 1994, Dresher and Rice 1993, Dresher and van der Hulst 1998), and evolved to concentrate on markedness and contrast. In this model, complexity in representations is driven by both contrast and markedness. Looking first at markedness, we begin with the common assumption that each feature has a marked and unmarked value. If we suppose that only marked

features count toward complexity, then segments with fewer marked features will be less complex than those with more marked features.<sup>1</sup>

We suppose further that contrasts are determined by the Successive Division Algorithm (SDA) operating on a hierarchy of features. In a three-vowel system, for example, we have seen that only two features can be contrastive, whereas in a five-vowel system at least three contrastive features are required. Since a more complex representation is permitted only if needed to establish a contrast with a less complex one, the theory of MCS leads us to expect a relation between the amount of segmental complexity (i.e., markedness) a system allows and the number and nature of contrasts it has.

Since the contrastive hierarchy is not universal, it is essential to have ways of determining what it is in a given language. The concept of phonological activity is crucial here. We adopt the Contrastivist Hypothesis, our working assumption being that *only contrastive features are active in the lexical phonology* (postlexical phonology, in the sense of being the component where phonetic detail is added to account for allophony, necessarily requires non-contrastive features). This hypothesis suggests a heuristic method of establishing which features are contrastive: namely, if a feature can be shown to be active in the phonology, it must, by hypothesis, be contrastive. Similarly, phonological

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<sup>1</sup> There are many conceptions of markedness in the contemporary literature. As with contrast, the MCS notion of markedness also has roots in the work of Trubetzkoy, particularly in his distinction between *logical*(structural) and *natural* (phonetic) markedness (cf. Rice 2007).

activity also informs us about markedness, on the assumption that phonologically active features are marked and inactive features are unmarked.

The assumption that markedness and complexity are related is inconsistent with the view that markedness scales are universally fixed (Chomsky and Halle 1968, Cairns 1969, Kean 1980, Beckman 1997, Lombardi 2002, Prince and Smolensky 2004, de Lacy 2006; see Rice 2007 for discussion). For example, in a vowel inventory with a front and back vowel, say /i a u/, either /i/ or /u/ may pattern as marked with respect to phonological activity, because only one contrast is required to distinguish front unrounded from back rounded vowels (say, [labial] or [coronal], but not both).<sup>2</sup> However if a central vowel such as /ɪ/ or /ə/ is added, both the front and back vowels pattern as marked with respect to the central vowel, because now both [labial] and [coronal] are required (Rose 1993, Walker 1993, Rice 1995). On the assumption that there is no feature [central], it follows that the central vowel must be unmarked.

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<sup>2</sup> I will continue the practice of the previous chapters of using the feature names used in my sources. In MCS we have been using vowel features [coronal] and [labial], and sometimes [peripheral] (see Rice 1994, 2002). However I take no stand here on whether vowel features are identical to consonant features or distinct from them (see Clements and Hume 1995 and Halle, Vaux and Wolfe 2000 for different views). For practical purposes, for purposes of this book, [coronal] is interchangeable with [front] and [labial] with [round].

An illustration of this principle can be found in developments in the Yupik and Inuit/Inupiaq dialects of Eskimo-Aleut.<sup>3</sup> These dialects descend from a proto-language that had four vowels, as shown in (7.1).

(7.1) Proto-Eskimo vowels (Fortescue et al. 1994)

i	u
ə	
a	

A plausible set of contrastive features for this inventory is given in (7.2). Because of the symmetry of the vowel system, the ordering of the features is not crucial: the division lines in (7.2) depict an ordering in which [low] is the first feature. Only marked feature values are shown.

(7.2) Contrastive features for dialects distinguishing 4 vowels

[coronal]		[labial]
i		u
	ə	
<hr/>		
	a	[low]

Yupik dialects and the Diomedé subdialect of Bering Strait Inupiaq retain this four-vowel system. However, schwa does not have the same status as the other vowels: according to Kaplan (1990: 147), it ‘cannot occur long or in a cluster with another vowel’. The latter phenomenon is characteristic of unmarked

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<sup>3</sup> ‘Inuit’ is the name used in Canada for this language family, ‘Inupiak’ is the name used in Alaska. I would like to thank Richard Compton for discussion of this example.



elements: they tend to be targets of phonological processes, and they are not triggers (Rice 2007). In this case, schwa assimilates to neighboring vowels, and does not cause assimilation in other vowels.

The influence of contrast and markedness can be seen in Inuit dialects that have palatalization of consonants. On the assumption that palatalization of a consonant by a vowel is triggered by a contrastive [coronal] feature, /i/ in (7.1) could trigger palatalization, but /ə/ could not.<sup>4</sup> In most Inuit dialects the vowel represented as \*/ə/ has merged at the surface with \*/i/. Some contemporary dialects, however, distinguish between two kinds of *i*: ‘strong’ *i*, which descends from \*/i/, and ‘weak’ *i*, from \*/ə/. In North Alaskan Inupiaq, strong *i* triggers palatalization of alveolar consonants, but weak *i* does not. Some examples from the Barrow dialect are given in (7.3): the suffixes in (a) have alveolar-initial consonants following a stem ending in *u*; the suffixes in (b) show palatalization of the suffix-initial consonant following strong *i*; and the forms in (c) show that palatalization does not occur after weak *i*.<sup>5</sup>

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<sup>4</sup> How palatalization works is the subject of some debate; see Kenstowicz 1994 and Hall (2007) for a review and references. All that is important here is that /i/ bears some contrastive feature that triggers palatalization.

<sup>5</sup> The palatalization of /t/ results in *s*.

(7.3) Barrow Inupiaq palatalization after strong *i* (Kaplan 1981: 82)

	<i>Stem</i>	<i>Gloss</i>	<i>'and a N'</i>	<i>'N plural'</i>	<i>'like a N'</i>
a.	iglu	'house'	iglulu	iglunik	iglutun
b.	iki	'wound'	ikiɬu	ikɪnik	ikisun
c.	ini	'place'	inilu	ininik	initun

Further, weak *i* undergoes a variety of assimilation and deletion processes that do not affect strong *i* or the other vowels *u* and *a*. For example, weak *i* changes to *a* before another vowel (7.4a), but strong *i* does not (7.4b).

(7.4) Barrow Inupiaq weak and strong *i* before a vowel (Kaplan 1981: 82)

a.	aṇuti	+	-u-	+	-tuq	-->	aṇutauruq
	'man'		COPULA		3SG.		'it is a man'
b.	iki	+	-u-	+	-tuq	-->	ikiuruq
	'wound'		COPULA		3SG.		'it is a wound'

Following Underhill (1976) and Kaplan (1981), I suppose that dialects that distinguish between strong and weak *i* retain four underlying vowels, as in the proto-language, with the same contrastive features as in (7.2). Though this analysis is 'abstract' with respect to the surface phonetics, the analysis is committed to specify the fourth vowel phoneme only as being not low, not labial, and not coronal (i.e., some non-low unrounded central vowel).

These contrastive marked values account for the fact that /i/ can trigger palatalization, as it has a relevant contrastive feature. The fourth vowel is the least marked, literally, and therefore cannot trigger palatalization, and is more susceptible to receive features from the context; according to Kaplan (1981),

weak *i* alternates with *a* in various contexts, in some restricted contexts with *u*, and alternates with zero (syncopates) in other contexts.<sup>6</sup>

Similar distinctions between strong and weak *i* are found in other Inuit dialects that make a contrast between two types of *i*. In 10 of 16 Inuit dialects, there is no longer any distinction between two kinds of *i*: in all these dialects, etymological \*/i/ and etymological \*/ə/ have merged completely to *i*. It is noteworthy that none of these dialects has consonant palatalization triggered by /i/. Presumably, [low] and [labial] are ordered ahead of [coronal] in the contrastive hierarchy of the Inuit language family; with only three vowels in the inventory, only the former two features can be contrastive, as shown in (7.5).

(7.5) Contrastive features for dialects distinguishing 3 vowels

			[labial]
i		u	
<hr/>			
	a		[low]

Many other examples of contrast-driven markedness asymmetries have been adduced. Studies in the general MCS framework include, among others: Avery and Rice 1989, Rice and Avery 1993, Avery 1996, Rice 1996a, and Radišić 2007 on asymmetries in the markedness of consonants; and Rice and Avery 1993,

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<sup>6</sup> See Archangeli and Pulleyblank (1994: 73–84) for an analysis that is similar in spirit, but proceeding from different theoretical assumptions.

Rose 1993, Causley 1999, Frigeni 2003, forthcoming, Rice 2002, 2003, D'Arcy 2003a, and Rohany Rahbar 2006 on vowel systems.<sup>7</sup>

### 7.1.2. *Contrast and phonetic enhancement*

A consequence of this approach is that phonology is necessarily underspecified with respect to phonetics: the number and nature of contrasts that a segment enters into influence, but do not determine, its phonetic realization. Therefore, the contrastive specifications assigned by the phonological component must be supplemented by further principles to derive the detailed phonetic specification of a speech sound.

In the four-vowel system in (7.1), for example, the vowel /a/ is phonologically specified as being contrastively [low]. The fact that it is realized phonetically as [a] and not [æ] or [ɑ] or [ɒ] is due to other principles. The vowel designated as /i/ in (7.2) is fundamentally different from /i/ in (7.5). The former is contrastively [coronal]; this [coronal] feature is also part of its phonetic realization as [i]. The /i/ in (7.5) does not have a contrastive [coronal] feature: its

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<sup>7</sup> For a concise review of this issue, see Rice 2007. Not all activity-based diagnostics that have been proposed in the literature are equally reliable. See Rice 2003, 2007, forthcoming, for further discussion of markedness: here I focus on contrast. Rice argues that asymmetries in assimilation provide the most revealing test of markedness. If we found, for example, that /t/ assimilates to /k/ but /k/ does not assimilate to /t/, that would be evidence that the velar is marked relative to the coronal.

contrastive characterization is purely negative, as Trubetzkoy would put it. It is not [low] and it is not [labial]. Phonologically, then, the vowel in (7.2) that most closely corresponds to /i/ in (7.5) is /ə/, not /i/. Why, then, does this vowel surface as [i] and not as [ə] or [ɪ]? The answer to this question is related to the fact that a vowel system *i a u* is far more common than *ə a u*. or *ɪ a u*.

Stevens, Keyser and Kawasaki (1986) and Stevens and Keyser (1989) propose that phonological contrasts can be *enhanced* by phonetic specification of noncontrastive features. These enhancements serve either to increase the perceptual salience of the contrastive feature, or to increase the perceptual salience of a contrast. The notion of enhancement was reworked in MCS (Avery and Rice 1989, Rice 1993, 1996a, Dyck 1995, Causley 1999, Wu 1994). In the three-vowel system in (7.3), the contrastively non-low vowels are enhanced by the feature [+high], the contrastively [labial] vowel is enhanced by [round], and the non-labial non-low vowel is enhanced by the place feature [coronal]. As Hall (2007: 169) points out, this approach to enhancement achieves similar results to Dispersion Theory (Liljencrants and Lindblom 1972, Flemming 2002, 2004, Padgett 2003), but does not require ‘any sort of global comparison or evaluation of phonetic distance applied to the inventory as a whole, unlike the dispersion-theoretic approaches’.<sup>8</sup>

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<sup>8</sup> See also Hall (1999, 2007) for an extended discussion and critique of the basis of Liljencrants and Lindblom’s (1972) dispersion model, and Kingston (2007) for a critical review of the issue.

### 7.1.3. *Phonetics in phonology versus phonological minimalism*

MCS was developed in the context of works that argue that the phonology is underspecified with respect to phonetics; in addition to the papers on enhancement mentioned above, these include Keating 1988, Cohn 1993, and Lahiri and Reetz 2002. Kingston and Diehl 1994 also argue that an elaborate phonetic component is required to complement the phonology.

These were followed by proposals that aim to diminish or eliminate the distance between phonetics and phonology by arguing that noncontrastive phonetic features play a role in phonology (e.g., Steriade 1997, Boersma 1998, Kirchner 1997, 1998, Flemming 2001, 2002), and that much that goes on in phonology is sensitive to detailed phonetic information (Pierrehumbert, Beckman and Ladd 2000, Hayes, Kirchner and Steriade 2004). It should be emphasized that the Contrastivist Hypothesis does not require that lexical representations must be free of redundancy. As argued in Chapter 2, the aim of the Successive Division Algorithm is not to eliminate logical redundancy, but to identify contrastive specifications. Nor is anything in the theory based on an assumption that the brain has limited storage capacity. The hypothesis that the phonological component assigns a special role to contrastive specifications is an empirical hypothesis formulated in order to account for phonological patterning. It is not a question of what memories may be stored in the brain, but of how the phonology is organized.

MCS is not the only theory to assume a basic distinction between phonetics and phonology. Reacting to the proliferation of phonetic detail in the

phonology, some phonologists have been exploring a minimalist approach to phonological representations (Hyman 2001, 2002, 2003, Morén 2003, 2006). Clements 2001, 2003, 2004 has been exploring the role of feature economy in accounting for phonological inventories (see Hall 2007 for discussion). Avery and Idsardi (2001) argue for representational economy and underspecification drawing on evidence from laryngeal systems. Versions of phonological minimalism can be found in other phonological traditions as well, such as Dependency Phonology (Anderson and Ewen 1987, Anderson 2005), and Radical CV Phonology (van der Hulst 1996).

#### 7.1.4. *Variation in the contrastive hierarchy*

Against the view that the feature hierarchy is universally fixed, analyses of many languages in MCS suggest rather a certain amount of variation. Such studies include work on vowel systems (Aka: Balcaen 1998; Japanese: Hirayama 2003; Manchu-Tungusic: Zhang 1996; Mandarin: Zhou 1999; Miogliola: Ghini 2001a, b; Persian: Rohany Rahbar 2006; Québécois: Mercado 2002; Sumerian: Smith 2006; Yokuts: D'Arcy 2003a) and consonant systems (Czech: Hall 1998, 2007, in press; Inuktitut: Compton 2008; Japanese: Rice 2005; Latvian: Vilks 2002; Mandarin: Wu 1994; Old English: Moulton 2003; Vietnamese: Pham 1997, 1998). Variations are observed in the feature hierarchy for place of articulation (Rice 1996a), stop vs. continuant consonants, and height vs. place for vowels. Avery 1996 found evidence for variation in voicing systems. In tone systems, high tones are unmarked in some languages and low tones in others (Rice 1999, 2003, Rice and

Hargus 2005). It remains to determine the limits of this variation. It may be, for example, that some of the cross-linguistic variation is related to differences in the structure of inventories (Béjar 1998, Casali 2003, Herd 2005).

## 7.2. *Ubiquitous feature hierarchies*

Before proceeding with case studies showing the contrastive hierarchy in action, I would like to answer a question that was recently asked in response to a paper on the contrastive hierarchy. The question was, roughly, the following: ‘We’ve gone along well all these years without the contrastive hierarchy, so why do we need it now?’ Given that the contrastive hierarchy is also somewhat abstract, in that it is not immediately discoverable from the acoustic signal, one might well wonder if we can just do without it. As I have tried to show throughout this book, the question is based on a false premise: phonology has *not* been getting along well without the contrastive hierarchy. In some ways the hierarchy has been here all along; to the extent it has been absent, or misconceived, phonology has missed it. In this section I will briefly review how ubiquitous the contrastive hierarchy is, both in phonological theory and in description, and how inescapable considerations of feature ordering are in almost any phonological analysis.

### 7.2.1. *Feature hierarchies in phonological theory*

The ordering of features into hierarchies is surprisingly pervasive in phonology, even where it is not acknowledged explicitly, and even where one might not be



aware of it. I have shown that hierarchies, often implicit, were central to structuralist phonology. In generative phonology, we have seen that feature hierarchies are embedded into markedness theory, underspecification theory, and feature geometry. Even theories that have not adopted some version of the Contrastivist Hypothesis have required feature hierarchies.

Feature hierarchies are pervasive in Optimality Theory, in the ranking of faithfulness constraints. For example, the tableau in (7.6) represents a portion of the OT grammar proposed by Baković (2000) for Nez Perce, which will be discussed in §7.3. In this grammar it is more important to preserve underlying values of [low] than [back]; similarly, [back] is ranked over [ATR].

(7.6) OT grammar with a feature hierarchy: [low] > [back] > [ATR]

/-lo, -bk, -ATR/ = ε	IDENT [lo]	*[-bk, -ATR]	IDENT [bk]	*[-lo, -ATR]	IDENT [ATR]
a. [+lo, -bk, +ATR] = æ	*!				*
b. [-lo, -bk, -ATR] = ε		*!		*	
c. [-lo, +bk, +ATR] = u			*!		*
d. [-lo, -bk, +ATR] = i					*

In this example, an input segment /-low, -back, -ATR/ (say, the vowel /ε/) surfaces as [i]: an input low vowel must retain its feature [-low] (hence candidate (a) is excluded); the ‘faithful’ output [ε] is excluded because there is a

constraint against being [–back] and [–ATR] at the same time; and candidate (c) does not preserve the underlying [–back] feature, hence loses to (d).<sup>9</sup> The point is that any ranking of faithfulness constraints implies a feature ordering.

### 7.2.2. *Implicit feature hierarchies in practice*

Feature hierarchies are often implicit in at least a partial way in the descriptive practice of phonologists. Consider, for example, the way segment inventories are presented in charts in descriptive grammars. Compare the inventory tables of Siglitun (Dorais 2003: 62),<sup>10</sup> an Inuit (Eskimo-Aleut) language spoken in the Canadian Arctic, and Kolokuma Ijọ (Williamson 1965),<sup>11</sup> an Ijoid (Niger-Congo) language spoken in Nigeria, given in (7.7) and (7.8), respectively. I present them as they are given in the sources (with some changes to the phonetic symbols but not to the arrangement).

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<sup>9</sup> For the sake of concision I have omitted reference to the feature [high] from this example, and the constraints that rule out [e] in Nez Perce.

<sup>10</sup> I have simplified Dorais's *j/dj* and *s/ch* to *j* and *s*, respectively. As he makes clear, these are variants of single phonemes. Dorais does not usually indicate variants in his charts, and in related dialects in which /j/ has similar variants he lists only *j*. Therefore, I keep to the usual practice of representing a phoneme by one symbol.

<sup>11</sup> I substitute *j* for Williamson's *y*. Williamson notes that Back = palatal, velar or glottal, Vl. = voiceless, and Vd. = voiced. Williamson mentions that some speakers have a marginal phoneme /ɣ/, but she omits it from the table. I have added it because it appears to be no less marginal than /h/, which is included.

## (7.7) Siglitun consonants (Dorais 1990: 62)

	Bilabial	Apical		Velar	Uvular
Stops	p	t		k	q
Voiced fricatives	v	l	j	ɣ	ʀ
Voiceless fricatives		ɬ	s		
Nasals	m	n		ŋ	

## (7.8) Consonant phonemes of Kolokuma Ijò (Williamson 1965)

	Plosive		Continuant				
			Fricative		Sonorant		
	VL.	Vd.	VL.	Vd.	Non-lateral		Lateral
					Oral	Nasal	
Labial	p	b	f	v	w	m	
Alveolar	t	d	s	z	r	n	l
Back	k	g	(h)	(ɣ)	j	ŋ	
Labio-velar	kp	gb					

Note in particular the different placements of /l/ and /j/ in these charts. The Siglitun chart is not as overtly hierarchical as the one for Ijò, but it is clear that the feature [lateral], which presumably characterizes /l/ and /ɬ/, has very narrow scope, confined to making distinctions among apicals, whereas [nasal] is higher in the hierarchy. Thus, in the Siglitun chart /l/ and /j/ are ‘partners’, as are /ɬ/ and /s/. Apart from the nasals, the other sonorants are not set apart in

Siglitun, suggesting that the feature [sonorant] is lower in the hierarchy than in Ijɔ.

The chart for Ijɔ expresses a hierarchy in which the feature [continuant] has wider scope than such features as [sonorant] and [voiced], and [lateral] has wider scope than [nasal]. Now /j/ and /ɲ/ are ‘partners’, and /l/ stands apart. The Ijɔ chart groups all post-alveolar consonants, including /j/, together under the general place ‘back’, whereas the Siglitun chart distinguishes between velar and uvular places, and groups /j/ with the coronals.

These sort of examples can be multiplied indefinitely. Descriptive phonologists display phoneme inventories in ways that illuminate their phonological patterning, and these patterns attest to different hierarchical relations among features. This is not to say that any feature hierarchy is equally likely, or even permitted. It is possible to create rather unnatural-looking phoneme inventories by ordering the features in unusual ways. For example, the chart in (7.9) is wrong as a description of the Siglitun inventory, and probably wrong for any language. What is unusual are the relative scopes of place features and manner features.

## (7.9) Siglitun consonants: unusual feature hierarchy

	Labial	Coronal	Velar	Uvular
Oral stops	p	t	k	q
Nasal stops	m	n	ŋ	
Fricatives	v	ɣ		ʀ
Stridents	s			
Voiced laterals	l			
Voiceless laterals	ɬ			
Glides	j			

Such examples show that there are limits to the extent that the feature hierarchy can vary cross linguistically, though it is not clear what these limits are.

7.2.3. *Feature scope ambiguities*

Finally, it is impossible to escape having to make decisions about the scope of a feature. Such decisions are not always thought of as involving feature ordering, but they do, because the relative scope of features can be expressed in terms of ordering. Deciding on the scope of a feature is particularly important when there are asymmetries in a phoneme inventory.

Eastern and Valencian Catalan, for example, have seven stressed vowels /i e ε a ɔ o u/. Most analysts agree that /i u/ are high and /a/ is low; assuming that the main contrast between the mid vowels is [ATR], it must be decided whether this feature is confined to the mid vowels, or if it extends to include the high and low vowels as well. One can find both kinds of analysis: Crosswhite

(2001) assumes that [ATR] is confined to the mid vowels (7.10a), whereas Walker (2005) and Lloret (2008) assign all the vowels values of [ATR] (7.10b).<sup>12</sup>

(7.10) Two analyses of Catalan vowels

a. Eastern Catalan (Crosswhite 2001)

	[+front]	[−front]
[+high]	i	u
[+ATR]	e	o
[−ATR]	ɛ	ɔ
[+low]	a	

b. Valencian Catalan (Walker 2005, Lloret 2008)

	[front]	[back]						
[+ATR]	<table> <tr> <th>[high]</th><td>i</td><td>u</td></tr> <tr> <th></th><td>e</td><td>o</td></tr> </table>	[high]	i	u		e	o	
[high]	i	u						
	e	o						
[−ATR]	<table> <tr> <th></th><td>ɛ</td><td>ɔ</td></tr> <tr> <th>[low]</th><td colspan="2">a</td></tr> </table>		ɛ	ɔ	[low]	a		
	ɛ	ɔ						
[low]	a							

It is an empirical question whether [ATR], or whatever feature is used to distinguish between the mid vowels, is limited to the mid vowels or extends

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<sup>12</sup> Not all authors use a binary [ATR] feature to characterize this system. Jiménez (1998) uses [RTR] instead of [−ATR]. Wheeler (2005: 56) characterizes /e/ as [+close] and /ɛ/ as [−close]. Whatever feature is chosen, questions of scope arise (unless it is limited by definition to certain types of phonemes; if, for example, [close] is defined to be applicable only to mid vowels).

beyond them to contrastively characterize also the high vowels, or the low vowel, or all the vowels. In the Catalan case we may simply be dealing with one system whose analysis is in dispute; but there are cases where there is evidence that different dialects with identical-looking inventories actually differ in their feature ordering, and hence in the relative scopes of contrastive features.

Both Anywa (Reh 1996) and Luo (Tucker 1994), related Nilotic languages, have a dental/ alveolar contrast in the coronal stops; in both languages, the alveolar nasal /n/ has no dental nasal partner. Should /n/ be considered contrastively alveolar (in contrast to the coronal dental stops in general), or is it outside the dental/ alveolar contrast, being only redundantly alveolar? Mackenzie (2005, forthcoming) argues that the two languages adopt different solutions to this question: in Anywa /n/ acts as if it is contrastively alveolar, in Luo it acts neutrally with respect to the contrast.<sup>13</sup>

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<sup>13</sup> See Mackenzie 2005, forthcoming, for further details and the reasons for adopting this analysis. Mackenzie observes that the two consonantal inventories are not in fact identical: Luo has a set of prenasalized stops that also participate in the dental/ alveolar contrast. It is possible that the slightly different compositions of these segmental inventories contribute to an explanation of why the contrastive hierarchies in these languages are different (cf. Béjar 1998, and Hall 2007: 152–153 for discussion).

## (7.11) Nilotic dental/alveolar contrast (Mackenzie 2005)

a. Anywa

Dental	Alveolar	
t̪	t	voiceless stops
d̪	d	voiced stops
	n	nasals

b. Luo

Dental	Alveolar
t̪	t
d̪	d
n	

## 7.2.4. Feature hierarchies and phonological patterning

Given that feature hierarchies have always been a part of phonology and are here to stay, it is worth reflecting on their significance. Notice that in all the examples reviewed in this section, the issue is not the *phonetic* description of the phonemes. I assume that Siglitun and Ijọ *l, j*, etc. are phonetically similar enough that they can be depicted with the same symbols */l/*, */j/*, and so on. Any further phonetic detail that may distinguish them are not in any case provided in the phoneme charts, and it is unlikely that phonetic details are what account for their different placements in the charts. The same is true of the Catalan vowels and Nilotic dental and alveolar consonants. No one disputes that Catalan *i* and *u* are phonetically [ATR], or that Nilotic *n* is phonetically alveolar; the question in each case is whether they function *phonologically* as though they are specified for these features. It follows from the Contrastivist Hypothesis that this amounts to asking whether they are *contrastively* specified for the features in question.



### 7.3. *Vowel harmony*

An important diagnostic of phonological activity is the spreading of a feature from a segment bearing that feature to neighboring segments. In this sense, vowel harmony is a fairly reliable indicator of the presence of an active feature or features. The Contrastivist Hypothesis states that phonologically active features are contrastive; the corollary of this principle in the domain of vowel harmony is that harmony triggers should be contrastive features.<sup>14</sup>

In this section I will review the analysis of Classical Manchu by Zhang (1996), and show that this principle applies in the case of both ATR harmony and labial harmony. The analysis is strikingly supported by diachronic developments in Manchu, showing how changes in the contrastive status of vowels leads to new patterns of phonological activity, as predicted. The analysis of labial harmony is further supported by typological surveys of labial harmony: in all cases, the vowel triggering the harmony can be shown to be contrastive.

I then consider some alternatives to the contrastivist account. Kaun (1995) argues that labial harmony triggers can be accounted for on perceptual-

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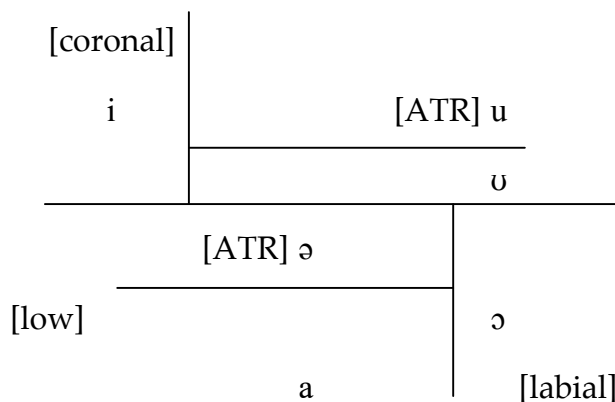
<sup>14</sup> The situation is less clear with targets and other non-triggers, such as transparent and opaque segments. In Manchu the vowel /i/ lacks a contrastive feature for [ATR] and is transparent to ATR harmony, as we might expect. But there are various reasons why segments may block harmony, not all derived from their contrastive status. Similarly, targets may be restricted for reasons beyond their contrastive status; see van der Hulst and van de Weijer 1995 and Archangeli and Pulleyblank 2007 for surveys. Here I will focus on harmony triggers.

functional grounds; however, I show that contrast remains the explanatory property, even in her account. Finally, I review an OT analysis of Nez Perce harmony by Baković 2000 which appears to suggest that the spreading [ATR] feature is not contrastive. This analysis, however, has no empirical support, and I present as an alternative the analysis of Mackenzie (2002), in which [ATR] is clearly contrastive.

### 7.3.1. *Classical Manchu* (Zhang 1996)<sup>15</sup>

The vowel system of Classical Manchu as analyzed by Zhang (1996) was briefly discussed in the last chapter. The vowel system is shown again in (7.12).

(7.12) Classical Manchu vowel system (Zhang 1996)




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<sup>15</sup> The data and analysis of Manchu and related languages in this and the following sections are based on Zhang 1996; see Zhang 1996: 32 for discussion of the transcriptions and phonetic values. See also Zhang and Dresher 1996, Dresher and Zhang 2004, Zhang and Dresher 2004, and Dresher and Zhang 2005 for more details.

As discussed in the previous chapter, Zhang (1996) proposes that contrastive specifications are assigned by the feature hierarchy: [low] > [coronal] > [labial] > [ATR]. The resulting specifications are shown in Chapter 6. Here I will focus on the empirical consequences of this analysis.

The first contrast applies to all the vowels and divides them into a [low] (/a ə ɔ/) and non-low (/i u ʊ/) set. Splitting the inventory in this manner has the effect of allowing for different contrasts in each set.

The next feature, [coronal] (= [–back]), applies only to /i/. This has a number of important empirical consequences. First, it means that /i/ will receive no further contrastive specifications; notably, it does not receive a specification for [ATR], despite the fact that it is phonetically ATR. Second, because the non-low vowels have already been split from the low vowels, no further features are required to draw a contrast between /i/ on one side and /u/ and /ʊ/ on the other. In particular, these latter vowels have no contrastive specification for [labial] (= [round]), despite the fact that they are phonetically rounded vowels.

There are no low vowels eligible to receive a [coronal] specification. Therefore [coronal] has no contrastive effect on the low vowels. Hence, a feature is needed to distinguish between /ɔ/ on one side and /a/ and /ə/ on the other. This contrast is made by the next feature on the list, which is [labial]. The consequence of this is that /ɔ/ is the only one contrastively [labial] vowel in the inventory.

The next feature is [ATR] (= Advanced Tongue Root). It distinguishes /u/ from /ʊ/ and /ə/ from /a/. This feature also accounts for the height differences

in these pairs of vowels, as [ATR] vowels tend to be higher than their non-ATR counterparts. /i/ and /ɔ/ are not contrastive for this feature, in this ordering.

The evidence for these contrastive specifications can be summed up as in (7.13).

(7.13) Summary of evidence for contrastive specifications of Classical Manchu vowels.

- a. /i/ lacks contrastive [ATR]: /u/ and /ə/ trigger ATR harmony, but /i/ does not, though /i/ is phonetically [ATR].
- b. /u/ and /ʊ/ lack contrastive [labial]: /ɔ/ triggers labial harmony, but /u/ and /ʊ/ do not, though they are phonetically [labial].
- c. /i/ is contrastively [coronal]: /i/ triggers palatalization of consonants, suggesting it has some relevant contrastive feature.
- d. All vowels contrastively assigned to one of two height classes: alternations /ə/~/a/~/ɔ/ and /u/~/ʊ/ are limited to a height class. We need one height feature, which we call [low].

A more detailed discussion of the harmony facts follows.

All vowels in a word apart from /i/ must agree with respect to [ATR], as shown in (7.14).

(7.14) ATR harmony in Classical Manchu

- a. /ə/ alternates with /a/

xəxə	‘woman’	xəxə-ŋgə	‘female’
aGa	‘rain’	aGa-ŋGa	‘of rain’

- b. /u/ alternates with /ʊ/

xərə-	‘ladle out’	xərə-ku	‘ladle’
paqt’a-	‘contain’	paqt’a-qu	‘internal organs’

The alternation between /u/ and /ʊ/ is apparent only after back (velar and uvular) consonants (which also alternate, depending on the following vowel). In other contexts, /u/ and /ʊ/ merge at the surface into [u], except for a few sporadic examples. Zhang (1996) assumes that this is a late phonetic rule, since it does not affect the behaviour of /ʊ/ with respect to ATR harmony, as shown in (7.15).

(7.15) Merger of /ʊ/ to [u] except after back consonants

- a. Underlying /u/: ATR harmony

susə	‘coarse’	susə-tə-	‘make coarsely’
xət’u	‘stocky’	xət’u-kən	‘somewhat stocky’

- b. Underlying /ʊ/ not after velar/uvular consonants

tulpa	‘careless’	tulpa-ta-	‘act carelessly’
tat’şun	‘sharp’	tat’şu-qan	‘somewhat sharp’

In each word in (7.15b) the vowel that surfaces as [u] patterns with non-ATR vowels; compare the forms in (7.15a). I suppose, following Zhang (1996), that [u] in (7.15b) derives from /ʊ/, which merges with /u/ as [u] in these environments.

The vowel /i/ is neutral, as shown in (7.16). It can co-occur in roots with both ATR and non-ATR vowels and with both ATR and non-ATR suffixes (7.16a,

b), and it can itself appear in a suffix following either ATR or non-ATR vowels (7.16c).

(7.16) ATR harmony in Classical Manchu: /i/ is neutral

a. /ə/ ~ /a/ suffix

pəki      'firm'

pəki-lə      'make firm'

paqts'in 'opponent'

paqtɬ'i-la- 'oppose'

b. /u/ ~ /ʊ/ suffix

sitərə-      'hobble'

sitərə-sxun ‘hobbled/lame’

panjin      'appearance'

panji-sχun 'having money'

c. /i/ suffix

əmt'ə      'one each'

əmt'ə-li      'alone; sole'

taxa-	'follow'
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taxa-li	'the second'
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Surprisingly, when /i/ is in a position to trigger harmony, it occurs only with non-ATR vowels, as in (7.17).

(7.17) Stems with only /i/: Suffixes with non-ATR vowels

a. /a/ in suffix, not /ə/

fili 'solid'

fili-qan 'somewhat solid'

ili- 'stand'

ili-χa      'stood'

b. /u/ in suffix, not /u/

sifi- 'stick in the hair'

sifi-qu      'hairpin'

tʂʰili-      ‘to choke’

tɕʰili-qu 'choking'

Despite the fact that it is phonetically an ATR vowel, /i/ does not trigger ATR harmony. This fact is explained if we suppose the contrastive specifications in

(7.12), together with the hypothesis that only contrastive values of [ATR] trigger harmony.

The failure of /i/ to trigger ATR harmony is particularly striking given the observation that front high vowels tend to be associated with [ATR] because the gestures required to make a high front vowel are compatible with an advanced tongue root and antagonistic to a retracted tongue root (see Archangeli and Pulleyblank 1994 for discussion and references). While this tendency can account for why /i/ lacks an [RTR] partner, we would expect that /i/, as the ATR vowel par excellence, should trigger ATR harmony if any vowel does. The fact that it does not strengthens the argument that its contrastive status is the key to its neutrality.

Another vowel harmony process in Classical Manchu is labial harmony. A suffix vowel /a/ becomes /ɔ/ if preceded by two successive /ɔ/ vowels (7.18a), but labial harmony is not triggered by a single short or long /ɔ/ (7.18b).<sup>16</sup> Nor is labial harmony triggered by the high round vowels (7.18c, d).

(7.18) Labial harmony in Classical Manchu

a.	pɔtʂ'ɔ	'colour'	pɔtʂ'ɔ-ŋGɔ	'coloured'
	fɔχɔlɔn	'short'	fɔχɔlɔ-qɔn	'somewhat short'
b.	tɔ-	'alight (birds)'	tɔ-na-	'alight in swarm'
	tɔɔ-	'cross (river)'	tɔɔ-na-	'go to cross'

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<sup>16</sup> On this condition see Zhang and Drescher 1996 and Walker 2001.

c.	gulu	‘plain’	gulu-kən	‘somewhat plain’
	kumun	‘music’	kumu-ŋgə	‘noisy’
d.	χotun	‘fast’	χotu-qan	‘somewhat fast’
	tursun	‘form’	tursu-ŋGa	‘having form’

As with ATR harmony, only a contrastive feature can serve as a harmony trigger. In this case, only /ɔ/, but not /u/ or /ʊ/, have a contrastive [labial] feature.

### 7.3.2. *Evolution of Spoken Manchu and Xibe*

This analysis of Classical Manchu is strikingly supported by subsequent developments in the modern Manchu languages. The vowels /ə/ and /u/ undergo changes in their contrastive status, leading to new patterns of phonological activity.

We observed that in Classical Manchu the contrast between /u/ and /ʊ/ is already neutralized phonetically to [u] in most contexts, with surface [ʊ] surviving only after uvular consonants and sporadically in other contexts in a few words. It is no surprise, therefore, to see this neutralization continue to completion in Spoken Manchu, a modern Manchu language descended from an ancestor similar to Classical Manchu. In Spoken Manchu, /u/ and /ʊ/ have merged completely to [u], and the phoneme /ʊ/ has been completely lost.

In a contrast-driven approach to vowel systems, the loss of a contrast in one part of the system could have wider effects. In the Classical Manchu system, the contrast between /u/ and /ʊ/ involves the feature [ATR], just like the



contrast between /ə/ and /a/. As long as the ATR contrast between /ə/ and /a/ is paralleled by a similar contrast between /u/ and /ʊ/, it cannot be mistakenly regarded as a height contrast. But with the loss of /ʊ/, the position of [ATR] in the system becomes much more tenuous. For now the entire burden of the [ATR] contrast would fall on the contrast between /ə/ and /a/. Many languages, however, have these vowels in their inventories without the contrast being due to [ATR]. The contrast between these vowels could more straightforwardly be attributed to a difference in height. Indeed, the feature [low], which is required independently, can serve to distinguish /ə/ from /a/.

Therefore, without assuming that the phoneme /ə/ changed phonetically, the loss of /ʊ/ could have indirectly led to a change in the phonological status of /ə/, from [low] to nonlow. This reclassification, in turn, could have influenced the phonetic realizations of /ə/, because in Spoken Manchu it is definitely a nonlow vowel. Zhao (1989) characterizes it as a mid-high back unrounded vowel, with an allophone [ɤ]; according to Ji et al. (1989), [ə] is in free variation with a high back unrounded vowel [u]. It is reasonable to suppose that there is a mutual influence between phonology and phonetics in such cases. The phonetics of a vowel obviously influence its phonological representation; but this influence is not simply one way, and the phonological representation can in turn affect the phonetics, by defining the space within which the vowel can range (short of neutralization).

The change in status of /ə/ in turn has consequences for the specification of /u/. Recall that in Classical Manchu there is evidence that the vowel /i/ is

actively [coronal], but no evidence that the vowels /u/ and /ʊ/ are actively [labial], though they clearly are phonetically round. The elevation of /ə/ to a nonlow vowel, joining /i/ and /u/, changes the situation. Assuming, as before, that [coronal] takes precedence, /i/ is again specified [coronal], distinguishing it from /ə/ and /u/. But now we must still distinguish the latter two vowels from each other. The most straightforward distinction is to extend the feature [labial], already in the system for /ɔ/, to /u/, as diagrammed in (7.19).

(7.19) Spoken Manchu after loss of /ʊ/

[coronal]		[labial]
i	ə	u
a		ɔ [low]

This analysis thus predicts that the reclassification of /ə/ as a nonlow vowel should cause /u/ to become contrastively [labial]. This prediction is borne out in Spoken Manchu, as evidenced by the development of a new phoneme /y/, a front rounded vowel that originated as a positional allophone of /i/ followed by /u/, as well as /u/ followed by /i/ (Zhang 1996). The front feature [coronal] is contributed by /i/, but the round feature [labial] must be contributed by /u/.

Further evidence can be found in the related modern Manchu language Xibe. Unlike Spoken Manchu, Xibe retains a labial harmony rule in which /ə/

alternates with /u/ in suffixes: /u/ occurs if the stem-final vowel is round (7.20b, c), /ə/ occurs otherwise (7.20a).

(7.20) Labial harmony in Xibe (Li and Zhong 1986)

	<i>Classical Manchu</i>	<i>Xibe</i>	<i>Gloss</i>
a.	gət'ə-xə	gət'ə-xə	'awoke'
	gətʂ'i-χa	gətʂi-χə-	'cherished'
	ərtə-kən	ərtə-kən	'somewhat early'
	χantʂi-qan	χantʂi-qən	'somewhat near'
b.	pətə-χə	pətu-χu	'thought'
	fəχəlo-qən	fəχulu-qun	'somewhat short'
c.	pu-xə	pu-xu	'gave'
	duʂuxu-kən	dzyɛxu-kun	'somewhat sour'
	xət'u-kən	xət'u-kun	'somewhat stocky'
	farχu-qan	farχu-qun	'somewhat dark'

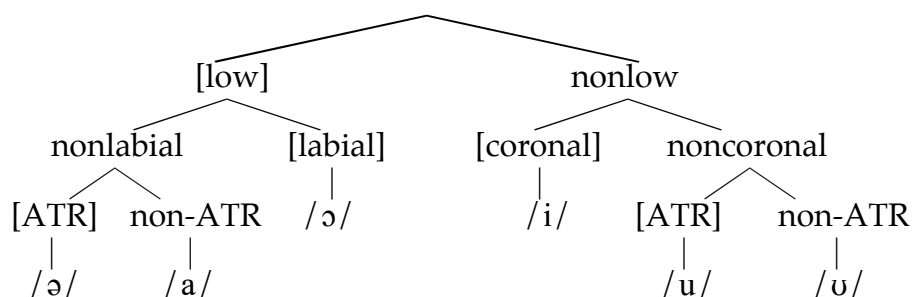
Recall that in Classical Manchu, labial harmony is restricted to the low vowels, and creates an alternation between /a/ and /ə/. In Xibe, noninitial vowels tended to be raised – almost always in suffixes, frequently in stem vowels – so an original sequence of the form /a/ - /a/ would become /a/ - /ə/ or /ə/ - /ə/, and a sequence of the form /ə/ - /ə/ would become /ə/ - /u/ or /u/ - /u/. The labial harmony observed in Xibe is not merely a holdover of Classical Manchu labial harmony, however, for in Xibe harmony is triggered not only by /u/ derived from older /ə/ (7.20b), but also by original /u/ (7.20c). The fact that

/u/ triggers and undergoes labial harmony further supports the hypothesis that it has a [labial] specification in Xibe.

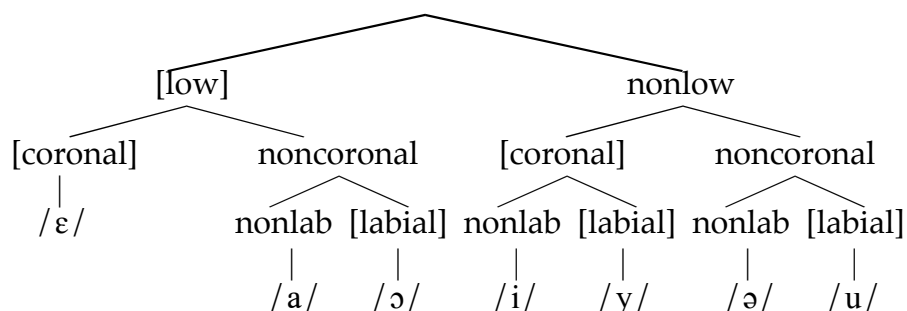
The contrastive hierarchies of the three Manchu languages discussed above are given in (7.21).

(7.21) Contrastive hierarchies of Manchu languages

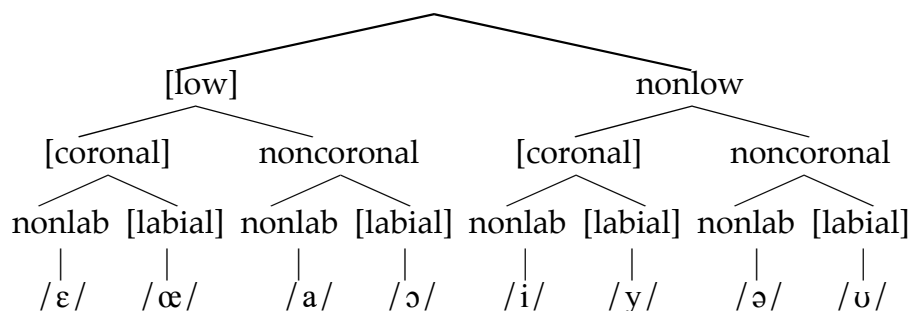
- a. Classical Manchu: [low] > [coronal] > [labial] > [ATR]



- b. Spoken Manchu: [low] > [coronal] > [labial]



- c. Xibe: [low] > [coronal] > [labial]



Spoken Manchu and Xibe make do with only three contrastive features. They have more vowel phonemes than Classical Manchu because they exploit the possibilities of the three features more fully.

### 7.3.3. *Typological surveys of labial harmony*

Typological surveys of labial harmony in Manchu-Tungusic, Mongolian, and Turkic languages support the hypothesis that only contrastive features trigger harmony. Zhang (1996: Chapter 6) surveys a number of Manchu and Tungusic languages in China and Russia. We have seen that labial harmony in Classical Manchu is limited to the low vowels. On this account, only the low vowel /ɔ/ is contrastively [labial] in this inventory. The same holds for most Manchu-Tungusic languages, which have similar vowel inventories. A Tungusic example is Oroqen (Zhang 1996), whose inventory is given in (7.22); again, only low vowels are triggers and targets of harmony.

(7.22) Oroqen vowel system (Zhang 1996)

[coronal]		[labial]	
i	ii	u	uu
		ʊ	ʊʊ
e	ə əə	o	oo
ɛ	a aa	ɔ ɔɔ	[low]

Eastern Mongolian languages have a similar type of labial harmony triggered by and affecting low vowels. An example is Khalkha Mongolian (Svantesson 1985, Kaun 1995), shown in (7.23). Assuming a similar contrastive

hierarchy as for Manchu-Tungusic, again [labial] is contrastive only in the low vowels.

(7.23) Khalkha Mongolian vowel system (Svantesson 1985, Kaun 1995)<sup>17</sup>

[coronal]		[labial]	
i		u	
		ʊ	
		ə	
		o	
		a	
		ɔ	
		[low]	

Turkic languages tend to have symmetrical vowel inventories. They are typically analyzed with three features: one height feature and two place features. A typical example is Turkish, shown in (7.24).

(7.24) Turkish vowel system

coronal				non-coronal			
		nonlabial	labial			nonlabial	labial
high	i		y		ɨ		u
low	e		ø		a		o

Assuming three features, [high], [coronal], and [labial] (or their equivalents), the Turkish vowels exhaust the space of possible values. Therefore, all feature values

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<sup>17</sup> See Dresher and Zhang (2005) for further discussion of the phonemic values of the Khalkha Mongolian vowels.

are contrastive; in particular, [labial] is necessarily contrastive in all vowels that are rounded on the surface.

The theory predicts, therefore, that all round vowels could potentially be triggers of labial harmony in such languages. This prediction is correct, though harmony observes limitations that are not due to contrast, but to other factors. That is, having a contrastive feature is a necessary but not sufficient condition for triggering harmony. We find a variety of labial harmony patterns, where high vowels are favoured as triggers and targets, for reasons unrelated to contrast (Korn 1969, Kaun 1995).

In Turkish, for example, harmony triggers can be high or low, but targets are typically limited to high vowels. In Kachin Khakass (Korn 1969), with the same vowel inventory, both triggers and targets of labial harmony must be high, the opposite of the Manchu-Tungus-Eastern Mongolian pattern.

#### 7.3.4. *A perceptual-functional alternative?*

Kaun (1995) proposes what appears to be an alternative to a contrastive account of labial harmony systems. Closer inspection reveals, however, that her account presupposes a contrastive analysis such as the one presented here.

According to Kaun (1995), labial harmony is governed by a number of constraints. The main ones relevant to the present discussion are given in (7.25).

#### (7.25) Constraints responsible for labial harmony (Kaun 1995)

- a. EXTEND[RD]: The autosegment [+round] must be associated to all available vocalic positions within a word.

- b. EXTEND[RD]If[–Hi]: The autosegment [+round] must be associated to all available vocalic positions within a word when simultaneously associated with [–high].

Constraint (7.25a) provokes labial harmony triggered by both high and low round vowels, as occurs (potentially) in Turkic languages; (7.25b) is meant to account for the Manchu-Tungusic-Mongolian type of labial harmony, which is triggered only by low vowels.

If grammars are permitted to freely rank these constraints, we would have no explanation of the correlation between inventories and type of labial harmony. It remains to be explained why Manchu-Tungusic-Mongolian languages typically use EXTEND[RD]If[–Hi], whereas Turkic languages use EXTEND[RD]. To account for this correlation, Kaun proposes that EXTEND[RD]If[–Hi] is dominant only if there is greater perceptual crowding in the nonhigh vowels than in the high vowels. To implement this notion in her formal theory, she adopts the convention that EXTEND constraints may operate only on *contrastive* feature values. However, Kaun 1995 proposes no theory for identifying which values are contrastive.

The intuitive approach to contrast and the appeal to crowding create unnecessary problems. Yowlumne Yokuts (Newman 1944, Kuroda 1967) has height-bounded labial harmony in both high and non-high vowels, though the high vowel space is not crowded; on the contrary, it has optimal separation (7.26).



## (7.26) Yowlumne Yokuts underlying vowel inventory

i: i	u: u
<hr/>	
a: a	o: o

Kaun (1995: 159) cannot explain why both /u(:)/ and /o(:)/ trigger labial harmony, since, as she assumes, [labial] is not contrastive in the high vowels. But there is no basis for this assumption. It appears that in Yowlumne the feature hierarchy has [labial] ordered above [coronal]. Yowlumne /i/ is quite different from the /i/ in Manchu-Tungusic and many Mongolian languages. Thus, /i/ is the epenthetic vowel, and does not appear to cause palatalization or other modifications in neighboring segments. For these reasons, Archangeli (1984) proposes that /i/ is the unspecified vowel in Yowlumne. Only two features can be contrastive in this inventory, and they are [labial] and [high]. Since [labial] is a contrastive feature on both /u(:)/ and /o(:)/, it is a potential harmony trigger; crowding is not required.<sup>18</sup>

It follows, then, that if we interpret ‘perceptual crowding’ literally, the hypothesis that crowding drives harmony is false. The hypothesis can be saved if we interpret crowding relative to the contrastive hierarchy, so that a feature is

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<sup>18</sup> Yowlumne vowel phonology poses another problem to any approach that posits that only contrastive feature values are active. The result of vowel lowering of /i:/ is [e:], which is not an underlying vowel. Since the only contrastive features are [high] and [labial], a further feature is required to distinguish [e] from [a]. See Hall 2007 for discussion and proposals for how to account for such facts. I will return to this problem at the end of this chapter.

crowded iff it is contrastive; but then crowding plays no role in the explanation. I conclude that Kaun 1995 does not present an alternative to an account in terms of a hierarchical theory of contrast, but rather implicitly presupposes just such a theory.

### 7.3.5. *Nez Perce*<sup>19</sup>

Nez Perce, a Penutian language of the Pacific Northwest in the United States, is another language that displays ATR harmony, though of a different character than the Manchu type. The differences (directional harmony in Manchu versus a dominant harmony in Nez Perce) do not change our expectation that [ATR] should be a contrastive feature. An analysis by Baković 2000 seems to put this assumption in doubt. It is interesting, therefore, that this analysis does not appear to be as empirically adequate as an alternative in which [ATR] is a contrastive feature.

#### 7.3.5.1. *The Nez Perce vowel system*

The surface vowels of Nez Perce are shown in (7.27) (Aoki 1966, 1970):

(7.27) Nez Perce surface vowels

i	u
	ɔ
æ	ɑ

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<sup>19</sup> This section is based on Mackenzie 2002 and Mackenzie and Dresher 2004.

Nez Perce has dominant-recessive ATR harmony (Hall and Hall 1980). All vowels in a word apart from /i/ must agree with respect to [ATR], and the value [–ATR] is dominant. /æ/ alternates with /ɑ/ (7.28) and /u/ alternates with /ɔ/ (7.29).

(7.28) ATR harmony: /æ/ alternates with /ɑ/

<i>Underlying</i>	<i>Surface</i>	<i>Gloss</i>
a. /næʔ-mæq/	næʔmæχ	‘my paternal uncle’
b. /næʔ-tɔt/	nɑʔtɔt	‘my father’
c. /mæq-æʔ/	mæqæʔ	‘uncle VOC’
d. /tɔt-æʔ/	tɔ:tɑʔ	‘father VOC’
e. /cæqæt/	cæ:qæt	‘raspberry’
f. /cæqæt-ɑyn/	caqɑ:tayn	‘for a raspberry’

(7.29) ATR harmony: /u/ alternates with /ɔ/

<i>Underlying</i>	<i>Surface</i>	<i>Gloss</i>
a. /tæwæ:-pu:/	tæwæ:pu:	‘the people of Orofino, Idaho’
b. /sɔ:ya:-pu:/	sɔ:ya:pɔ:	‘the white people’
c. /tuʔuynu/	tuʔuynu	‘tail’
d. /tuʔuynu-ʔɑyn/	tɔʔɔynɔʔayn	‘for the tail, crupper’

As illustrated in (7.30), the vowel /i/ sometimes patterns with [–ATR] vowels (7.30a,b), and other times with [+ATR] vowels (7.30c,d), though it is phonetically [+ATR].

## (7.30) Dual patterning of /i/

<i>Underlying</i>	<i>Surface</i>	<i>Gloss</i>
a. /næʔci:c/	naʔci:c	‘my paternal aunt’
b. /ci:c-æʔ/	ci:caʔ	‘paternal aunt VOC’
c. /næʔ-i:c/	næʔi:c	‘my mother’
d. /ʔi:c-æʔ/	ʔi:cæʔ	‘mother VOC’

Following Jacobsen (1968), Rigsby and Silverstein (1969), Zwicky (1971), and Hall and Hall (1980), Mackenzie (2002) assumes that surface [i] represents a merger of /i/ and a [−ATR] vowel that can be represented as /ε/. In (7.30a, b) the underlying vowel is /ε/ and in (7.30c, d) the vowel is [+ATR] /i/.<sup>20</sup> Thus, every vowel has a counterpart that contrasts with it in the feature [ATR].

## (7.31) Nez Perce underlying vowels

i	u	[+ATR]
ε	ɔ	[−ATR]
æ		[+ATR]
	ɑ	[−ATR]

By any definition, [ATR] would appear to be a contrastive feature in the underlying vowel system of Nez Perce. What are the other contrastive features?

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<sup>20</sup> In its dual behaviour, Nez Perce /i/ is quite different from Classical Manchu /i/. It is more like Classical Manchu /u/, which represents the surface merger of two underlying vowels when not following a velar or uvular consonant.

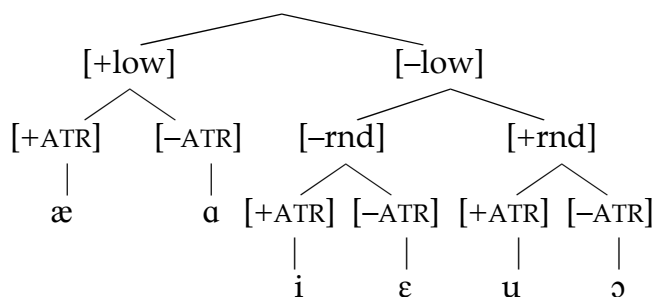
Abstracting away from [ATR], we have a classic three-vowel system, which we can designate /I A U/. In such systems it is usual to have a height feature, either [low] or [high], and a place feature, either [back] or [round].<sup>21</sup> [low] is a better choice than [high] because the surface nonlow [ATR] pair is not strictly [+high], whereas the low pair are both [+low]. Following Jakobson and Halle's (1956) assumption that a contrast between high and low sonority is, preferably, ordered before one based on place (but see Ghini 2001b for a different view), let us order [low] as the first feature. For the second feature, either [round] or [back] are possible; for concreteness, we will pick [round]. This contrast is relevant only among the nonlow vowels.<sup>22</sup> Because of the symmetry of the system, it does not matter very much where [ATR] is ordered. For concreteness, we will assume it is ordered third. We thus arrive at the contrastive hierarchy illustrated in (7.32).

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<sup>21</sup> The feature names are chosen to facilitate comparison with Baković's analysis; [coronal] or [labial] would do as well.

<sup>22</sup> If one knew nothing about the phonological patterning of Nez Perce and looked only at the underlying vowel system as pictured in (7.31), one might think it could be analyzed the way Jakobson (1962 [1931]) analyzed Standard Slovak (see Chapter 1), as three pairs of vowels arrayed into three height classes where each pair is distinguished on the front/back dimension. Such an analysis for Nez Perce totally fails as a basis for capturing the facts of vowel harmony.

(7.32) Nez Perce: [low] > [round] > [ATR] (Mackenzie 2002)



#### 7.3.5.2. *The analysis of Baković 2000*

An OT analysis of the Nez Perce vowel system is given in Baković 2000. His analysis has some properties in common with Mackenzie's. He also needs a hierarchy of featural faithfulness constraints, and constraints to exclude certain combinations of features. However, he arrives at quite different results. Baković arrives at the ranking shown in (7.33). He proposes that these faithfulness constraints and cooccurrence restrictions are sufficient to exclude nonexistent vowels and to ensure that vowels present in the inventory will surface faithfully.

(7.33) Constraint ranking for Nez Perce (Baković 2000)

\*[+back, +ATR] & IO-ID [ATR], IO-ID [low], \*[-back, -ATR] >> IO-ID [bk] >> \*[-high, +ATR], \*[+high, -ATR] >> IO-ID [high] >> \*[+back, +ATR] >> \*[-low, -ATR] >> IO-ID [ATR]

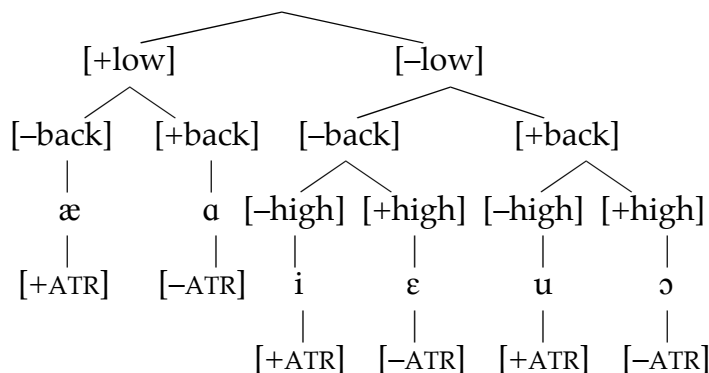
Looking only at the faithfulness constraints, we find the hierarchy in (7.34).

(7.34) Ranking of faithfulness constraints (Baković 2000)

IO-ID [low] >> IO-ID [back] >> IO-ID [high] >> IO-ID [ATR]

This constraint hierarchy translates into an ill-formed contrastive hierarchy (7.35).


(7.35) Contrastive hierarchy based on (7.34)



The feature [ATR] is redundant in this hierarchy, though it is the active feature in vowel harmony. It is redundant because of the presence of [high], which does not appear in the contrastive hierarchy we arrived at earlier. How did Baković (2000) arrive at this feature ranking?

Starting from the assumption that inputs are not restricted to language-specific inventories (richness of the base, Prince and Smolensky 2004), Baković introduces constraints to derive the surface inventory. Thus, Nez Perce has no vowel [o], that is, a vowel with the features [–low, –high, +round, +back, +ATR]. Baković (2000: 245) proposes that an input vowel with these features will surface as [ɔ] rather than [u]. To ensure this result, a high ranking of faithfulness to [high] is required, as shown in (7.36).

## (7.36) Role of IO-IDENT[hi] (Baković 2000:245 (273))

Input /o/	*[-high, +ATR]	IO-IDENT [high]	IO-IDENT [ATR]
a. o	*!		
b. u		*!	
c.  o			*

However, no evidence is adduced that an input /o/ *does* in fact surface as [ɔ] and not, say, as [u]. Therefore, the relatively high ranking of this constraint has no real motivation. Mackenzie's analysis also excludes illicit vowels, though with different results than those proposed by Baković. The contrastive feature hierarchy in (7.32) translates into the constraint ranking in (7.37).


## (7.37) Nez Perce constraint hierarchy based on (7.32)

IO-IDENT [low] >> \* [+low, round] >> IO-IDENT [round] >> IO-IDENT [ATR] >> \* [F]

This ranking also prevents an input /o/ from surfacing, as shown in (7.38). In this case, an /o/ has the same contrastive features as /u/; no other features may be specified. That is, the vowel contrastively specified as [-low, +round, +ATR] surfaces as [u] rather than [o], presumably as a result of enhancement. In this case, there are two sources that both favour a high vowel: in addition to the usual preference for /I A U/ over /E A O/, [+ATR] favours [+high], as discussed in connection with Manchu /i/.




## (7.38) Evaluation of /o/ with low-ranking IO-IDENT[hi]


Input /o/	IO-IDENT [low]	*[+low, round]	IO-IDENT [round]	IO-IDENT [ATR]	*[F]
a. o					*! [hi]
b.  u					
c. ɔ				*!	
d. i			*!		

Similarly, Baković (2000: 246) wishes to ensure that input /e/ surfaces as [i]. In his analysis, faithfulness to [back] plays a prominent role in preventing /e/ from surfacing as \*[ɔ] (7.39). Again, are many other ways of excluding this vowel, and we have no empirical evidence to favour one over another. Another way is shown in (7.40).

## (7.39) Role of IO-IDENT[back] (adapted from Baković 2000: 246 (279))

Input /e/	IO-ID [low]	*[-bk, -ATR]	IO-ID [back]	*[-hi, +ATR]	IO-ID [high]	IO-ID [ATR]
a. e				*!		
b.  i					*	
c. ɛ		*!				*
d. ɔ			*!		*	*
e. æ	*!			*	*	

## (7.40) Evaluation of /e/ without IO-IDENT[bk]

Input /e/	IO-IDENT [low]	*[+low, round]	IO-IDENT [round]	IO-IDENT [ATR]	*[F]
a. e					*! [hi]
b.  i					
c. ε				*!	
d. ɔ			*!	*	
e. æ	*!				*

Of course, it is ultimately an empirical question what would happen to hypothetical input vowels /o/ or /e/ in Nez Perce. One could seek to find various kinds of evidence that would bear on this question. For example, we could investigate the fate of loan words with such vowels when adapted into Nez Perce, or devise perception tests to see how speakers label such vowels, and so on. But in the absence of any such evidence, it is impossible to favour any particular result. Therefore, in making predictions about the fate of illicit vowels we must be guided by our analysis to the extent that it is based on actual empirical evidence.

To conclude, the analysis in Baković 2000 appears to require a ranking of faithfulness constraints that is incompatible with any contrastive hierarchy for Nez Perce. Moreover, this analysis does not draw any connection between contrast and phonological activity in Nez Perce. Given its low ranking, the feature [ATR] appears to be redundant, though it is the active feature in vowel harmony. If such an analysis were supported by evidence, it would be a counterexample to the Contrastivist Hypothesis. It is interesting, therefore, that

this ranking is unmotivated by any empirical facts and relies primarily on unsupported assumptions about what nonexistent vowels should map to.

Moreover, an alternative analysis exists that conforms to the theory being advocated here. In this analysis, the active feature [ATR], together with [low] and [round], is contrastive in the Nez Perce vowel system; there is no evidence that any other vowel features are active in this language.

#### 7.4. *Metaphony and contrast limited by domain*

In Chapter 2 we considered the possibility that contrastive features are not assigned globally to phonemes over the whole language, but may be limited by position. In such a procedure contrasts would be evaluated separately for each distinguished position, or domain. We have not seen this kind of domain-limited contrastive evaluation yet, and in principle a number of conditions must be fulfilled for a language to allow separate contrastive domains.

First, the phonemes that occur in one domain must not have alternants in the other domain. For example, in many languages the same underlying consonant may appear in both coda and onset position. An example is the stem-final consonant in English *write*, which appears in word-final position in the uninflected form, and between vowels when a vowel-initial suffix is added, as in *writing* or *writer*. Presumably, there is a single underlying representation of the morpheme *write*, so it would be contradictory, in English, to assign different

contrastive features to the stem-final /t/ when it is word final and when it is word medial.<sup>23</sup>

A second condition that could be plausibly put on a contrastive domain is that it should correspond to a category that has independent existence in the grammar. This condition would rule out arbitrary domains such as, for English, the set of consonants that could precede the sequence \_\_\_*et* (*pet, vet, Tet, debt, set, net, yet, get* etc.) within a word.

The conditions for having separate contrastive domains for evaluating vowels are met in Romance languages that distinguish between *stem* vowels and *desinential* vowels. Desinential vowels occur in a closed class of suffixes and do not alternate with stem vowels. Moreover, stems and desinences constitute important grammatical distinction in such languages. Dyck (1995) and Frigeni (2003) argue that contrastive specifications must be assigned separately to

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<sup>23</sup> The assumption that morphemes have a unique lexical form is not universally held. In theories that permit multiple lexical representations the concept of a phonological inventory would have to be rethought along with what constitutes a permissible contrastive domain. Children at early stages of acquisition may not yet relate different forms of morphemes, so they may have different lexical representations for stem-final consonant in *write* and in *writer* (since *writer* may not be decomposed into separate morphemes it is not accurate to label the *t* as 'stem final' for their grammar). So child grammar may have separate sub-inventories for different positions in the word.

desinential vowels in dialects of Spanish and Italian (Dyck) and in Campidanian Sardinian (Frigeni).

The evidence in both cases comes from *metaphony*, a type of vowel harmony in which some high desinential vowels trigger raising of some stressed vowels. It is argued that the best account of metaphony triggers in these dialects requires that we distinguish between contrastive and redundant feature specifications. More particularly, the contrasts must be assigned separately to desinential vowels. As in the cases of harmony discussed above, a vowel can only trigger metaphony if it has the appropriate contrastive feature.

#### 7.4.1. *Metaphony in Iberian Spanish and Italian*

The following are examples of metaphony in Pasiego (Spanish), as given by Dyck (1995), adapted from Penny (1969). Centralization/laxing of unstressed vowels is not shown. Desinential /u/ triggers raising of stressed /é/ to [í] and stressed /ó/ to [ú]:

(7.41) Pasiego metaphony of /é/ and /ó/ triggered by /u/

<i>Unmetaphonized Gloss</i>		<i>Metaphonized Gloss</i>	
afilit[é]ros	‘needle-cases’	afilit[í]ru	‘needle-case’
g[ó]rdo	‘fat (neuter)’	g[ú]rdu	‘fat (masculine)’
ab[jé]rtos	‘open (plural)’	ab[jí]rtu	‘open (plural)’
k[wé]rpos	‘bodies’	k[wí]rpu	‘body’

Stressed /í/, /ú/, and /á/ are not affected:

(7.42) Pasiego: metaphony does not affect /í/, /ú/, and /á/

<i>Unmetaphonized</i>	<i>Gloss</i>	<i>Neutral</i>	<i>Gloss</i>
luz m[í]yos	‘mine (plural)’	il m[í]yu	‘mine (singular)’
bj[ú]da	‘widow’	bj[ú]du	‘widower’
br[á]θos	‘arms’	br[á]θu	‘arm’

#### 7.4.1.1. Dyck’s Generalization

Dyck (1995), modifying an earlier observation by Penny (1970), formulates the following generalization about metaphony (raising) triggered by desinential vowels:

(7.43) Generalization about metaphony triggers (Dyck 1995)

Desinential high vowels can trigger metaphony only if they contrast with a mid vowel in the same place.

Note that we are referring here to contrasts *only among the desinential vowels*. In every dialect high vowels contrast with mid vowels in stressed syllables; but dialects have different inventories of desinential vowels, ranging from three to five. Because the phonetics of these vowels can vary, I will henceforth represent them schematically as /I~E A U~O/ for three-vowel desinential inventories, /I~E A O U/ for four-vowel desinential inventories with a contrast between a high and mid back/ labial vowel, and so on.

Dyck’s Generalization makes correct predictions about which dialects may exhibit metaphony, and what the possible desinential triggers of metaphony may be in these dialects. First, we expect no raising in dialects with only three desinential vowels /I~E A U~O/, because there is no contrast between /I/ and

/E/ or /U/ and /O/. For example, no raising is reported in Leonese dialects, where desinences are phonetically [i,a,u] or [e,a,u], depending on the dialect.

In dialects with four desinential vowels /I~E A O U/, the prediction is that raising can be triggered by /U/, not by /I/; in dialects with four desinential vowels /I E A O~U/, we predict that raising can be triggered by /I/, not by /U/. Examples of the former type are Central Asturias, North Central Asturias, and Santander (Montañese dialects), where /u/ contrasts with /o/, but there is only a marginal, archaic contrast between /i/ and /e/. As expected, raising is triggered by [u], not by [i].

In dialects with five desinential vowels, Dyck's generalization predicts that both /I/ and /U/ can trigger raising. No Spanish dialects are of this type, but there are Italian dialects, such as Servigliano, that have five desinential vowels and raising triggered by both [i] and [u].

#### 7.4.1.2. *Accounting for Dyck's Generalization*

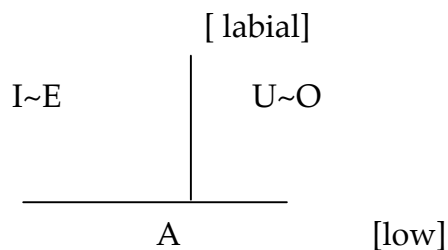
In order to account for Dyck's generalization we must make several assumptions. First, for purposes of evaluating contrasts vowel inventories are divided into stem inventories and desinential inventories. Contrasts in each inventory are assessed separately.

Second, we must assume that features in these dialects are ordered: [low] > [labial] > [high]. If the first feature is [low], then [high] is not needed in the three-vowel system shown in (7.44a). The non-low vowels have no contrastive [high] feature to trigger raising, even if they are pronounced as [i] or [u]. In the inventory in (7.44b) the feature [high] is needed to distinguish between /U/ and

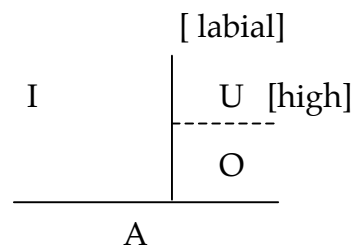
/O /, but its scope is limited to the [labial] vowels. Therefore, only /U/ can trigger metaphony, not /I/.

(7.44) Contrastive features in desinential vowels

a. Three desinential vowels



b. Four desinential vowels



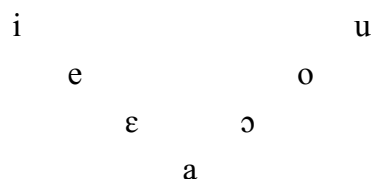
7.4.2. *Metaphony in Campidanian Sardinian*

Frigeni (2003) argues for a domain split in the assignment of contrastive features to vowels in Campidanian Sardinian along the lines of Dyck's analysis. She goes one step further, arguing that the contrastive hierarchy for desinential vowels differs from the one that applies to stem vowels, not just in the number of contrastive features, but also in their ordering.

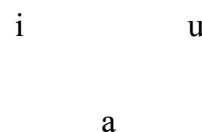
The surface inventories of stem and desinential vowels are shown in (7.45).

(7.45) Surface vowels in Campidanian Sardinian

a. Stem vowels



b. Desinential vowels



Frigeni argues that at the lexical level, there are two fewer stem vowels than in (7.45a), and two more desinential vowels than in (7.45b) (cf. Bolognesi 1998:



20–21). Frigeni argues that the stem vowels [e] and [o] are derived from /ε/ and /ɔ/, respectively, by metaphony.

(7.46) Campidanian Sardinian metaphony

a. No metaphony before /-a/		b. Metaphony before /-i -u/	
pót:a	‘door F. SG.’	pót:u	‘harbour M. SG.’
(a)r:óza	‘rose F. SG.’	drómi	‘sleep INF.’
sér:a	‘hill F. SG.’	zék:u	‘sky M. SG.’
fěʃta	‘party F. SG.’	tés:i	‘weave INF.’

Since the surface stem vowels *e* and *o* are derivable by metaphony from the corresponding lax vowels, there is no evidence that they are underlying.

In the preceding section we saw that Spanish and Italian dialects with three desinential vowels do not cause metaphony. The reason, according to Dyck’s analysis, is that metaphony is caused by a contrastive feature [high] which is only present if there is a contrast between a high and mid vowel at the same place. The Sardinian system in (7.45b) appears to contradict this generalization, but the contradiction is only apparent. Frigeni (2003) shows that the surface desinential vowels *i* and *u* each represent the merger of two vowels, one which causes metaphony, and one which does not. She argues that the vowels which do not cause metaphony derive from underlying /e/ and /o/, which merge with /i/ and /u/, respectively. Therefore, the underlying stem and desinential vowel systems are as in (7.47). Capital letters indicate that we are not committing to any particular features beyond a minimal contrastive set.

## (7.47) Underlying vowels in Campidanian Sardinian (Frigeni 2003)

## a. Stem vowels

I	U
E	O
A	

## b. Desinential vowels

I	U
E	O
A	

Though the two inventories now look identical, Frigeni argues that their contrastive specifications differ. If we continue to assume that the metaphony trigger is a contrastive feature [high], as in the cases in the previous section, we would expect the mid vowels to raise to high vowels *i* and *u*. Second, metaphony here introduces a new contrast between mid vowels, and it is not clear how spreading [high] to a mid vowel unspecified for any other height feature could lead to this result.

To account for the change undergone by the stem vowels, Frigeni (2003) proposes that the spreading feature in Campidanian Sardinian metaphony is [ATR], not [high]. Hence, the contrastive feature distinguishing desinential /I U/ from /E O/ is [ATR], not [high]. But she demonstrates also that the stem vowels could not be characterized in the same way, or else again we should expect metaphonized vowels to surface as *i* and *u*. She proposes therefore that the two domains have different contrastive features, as shown in (7.48). The stem vowels correspond to a contrastive hierarchy [low] > [labial], [high], and desinential vowels have the contrastive hierarchy [low] > [labial], [ATR].

## (7.48) Underlying contrasts in Campidanian Sardinian (Frigeni 2003)

a. Stem vowels			b. Desinential vowels		
I		U [high]	I		U [ATR]
E	O		E	O	
	A	[low]		A	[low]

7.4.3. *Summary*

The generalizations that govern Romance metaphony support the Contrastivist Hypothesis in striking fashion. As predicted, only contrastive features can trigger metaphony. The phonetic realization of a desinential vowel does not predict whether it can be a metaphony trigger.

We might expect that in a three-vowel desinential system /I~E A U~O/, the non-low vowels, lacking a height contrast, have a more room to move around, and so might not have pronunciations that are as high as high vowels in systems where they are in contrast with mid vowels. Dyck (1995), relying on detailed phonetic descriptions, shows that this is true of some three-vowel desinential inventories but not all. In some dialects the non-low vowels are consistently pronounced as high vowels; nevertheless, they do not trigger metaphony. Moreover, it is not surprising that non-low vowels in small inventories should tend to be high. This is a common phenomenon in vowel reduction, the subject of the next section.

### 7.5. *Patterns of vowel reduction*

The desinential vowels in the languages discussed above form a closed set; contrasts in these reduced vowels are evaluated separately. In many languages, there are differences between what vowels may occur in stressed and unstressed syllables, where the same lexical vowel has different phonetic realizations, depending on whether it is stressed or unstressed (e.g., the alternation in both stem vowels in *átom* ~ *atómic*). In some cases contrasts between certain stressed vowels are neutralized in unstressed positions, resulting in a smaller set of vowels in unstressed positions, a phenomenon known as vowel reduction.

Various accounts have been given of the phonetic motivations of vowel reduction; see Kingston (2007) for a review. My interest here is in the paths that neutralizations take. Since these affect the contrasts in the system, they are relevant to our main theme. I will review a study by Crosswhite (2001), who shows that the neutralization patterns in vowel reduction are not predictable from the phonetics of the vowels, but from language-specific ranking of faithfulness constraints. Her analysis goes some way towards a contrastivist account, and I will argue that a fully contrastivist account can account in a more principled way for certain results that are stipulated in her analysis.

#### 7.5.1. *The OT account of Crosswhite (2001, 2004)*

Crosswhite (2001, 2004) proposes an OT account of cross-linguistic vowel reduction patterns. She proposes that there are two distinct types of reduction: reduction based on contrast enhancement, and reduction based on prominence.

When reduction is based on contrast enhancement, unstressed mid vowels are eliminated in favour of the corner vowels /i a u/. Crosswhite proposes this is because corner vowels are less perceptually challenging, and maximize contrast within the vowel space. She formulates the constraint as in (7.49).

(7.49) License-Nonperipheral /Stress

Nonperipheral vowels are licensed only in stressed positions.

Crosswhite proposes that reduction based on prominence reduction is motivated by a ban on more prominent (i.e., sonorous), vowels in favour of vowels that are less prominent. She posits the following vocalic prominence scale:

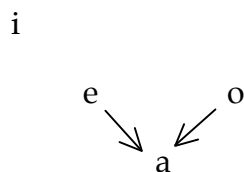
(7.50) Vocalic Prominence Scale

$a > \varepsilon, \text{ɔ} > e, o > i, u > \text{ə}$

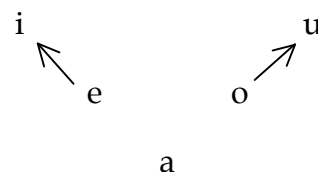
The main goal of Crosswhite's 2001 study is to account for the particular paths that vowels take in achieving the reduced inventories. Compare, for example, the reduction patterns in Belarusian (Slavic) and Luiseño (Uto-Aztecan, Southern California). In stressed syllables, Belarusian has five vowels /i e a o u/. In unstressed syllables, the mid vowels reduce to *a*, resulting in the three vowels [i u a]. Luiseño also has five vowels in stressed syllables, also representable as /i e a o u/. In unstressed syllables, the mid vowels reduce to the corresponding high vowels, again resulting in the three unstressed vowels [i, u, a], but via a different route.

## (7.51) Vowel reduction in Belarusian and Luiseño

a. Belarusian



b. Luiseño



What accounts for these different patterns of reduction? One might suppose that they, too, are phonetically motivated. It could be, for example, that the phonetic distributions of Belarusian /e o/ are closer to /a/ than to /i u/; and that /e o/ are closer to [i u] than to /a/ in Luiseño. Crosswhite (2001: Chapter 4) investigates this hypothesis, which she calls ‘phonetic determinism’. She compared two pairs of languages that have similar stressed vowel inventories but different neutralization patterns under reduction: Eastern Catalan and Brazilian Portuguese, and Bulgarian and Russian. She looked at vowel plots and average formant frequency values of stressed vowels in these languages. In both cases, she concludes that the hypothesis that vowel neutralization patterns are phonetically determined by phonetic similarity is disconfirmed.

If phonetics does not account for the neutralization patterns in these languages, what does? Crosswhite (2001) argues that “the method for avoiding a dispreferred vowel is determined by the relative ranking of the reduction constraint and featural faithfulness constraints.” For example, in Luiseño it is important to retain the place features of the non-low vowels, at the expense of their [–high] feature. In Belarusian, the feature [–high] is ranked higher than the place features.

The ranking of featural faithfulness constraints is the OT counterpart to feature ordering. Can we, then, account for vowel reduction patterns in terms of the same contrastive feature hierarchies that govern the basic inventory? The issue is complex, because factors other than feature ordering are involved in reduction; see Dyck (1995) for an account that appeals crucially to phonetic enhancement. If our basic hypothesis about contrast and phonological activity is correct, however, it should follow that the features that must be preserved in reduction must be contrastive features, which are determined to begin with by ordering. Moreover, an analysis in terms of contrastive features would have certain advantages over Crosswhite's (2001) account.

The feature chart in (7.52) is based on the one given by Crosswhite (2001: 18), modified to be consistent with her actual practice. It has some properties of a contrastive specification, but not consistently so. Thus, [ATR] is limited to the mid vowels; since [ATR] is not universally limited to mid vowels, this restriction would seem to follow from contrastive considerations. Similarly, /a/ has no value for [front], again suggesting some sort of contrastive analysis. But the specifications of /ɔ/, /o/, and /u/ for both [front] and [round] are not consistent with such an analysis. These two features do exactly the same contrastive work in these vowels, and no contrastive analysis would specify both of them. Nor is there any contrastive analysis that could specify /a/ as both [–high] and [+low] while also specifying /i/ and /u/ for both those features; if high vowels are not redundantly [–low], then low vowels must be redundantly [–high]; or vice-versa. In fact, Crosswhite (2001: 121) writes that '/a/ is not specified for the feature

[front]. This is because an earlier factorial typology with /a/ specified as [-front] produced erroneous results...’ This is refreshingly candid, but feature specifications ought to be based on some principled approach.

(7.52) Assumed Feature Specifications (Crosswhite 2001:18)

	i	e	ɛ	a	ɔ	o	u	ə
high	+	–	–	–	–	–	+	Ø
front	+	+	+	Ø	–	–	–	Ø
low	–	–	–	+	–	–	–	Ø
round					√	√	√	
ATR	Ø	+	–	Ø	–	+	Ø	Ø

The SDA provides a principled approach to contrastive specification. We have seen that in many triangular vowel systems, the feature [low] takes precedence over [front] and [round], resulting in /a/ being outside the scope of these contrasts, deriving Crosswhite’s result that /a/ works best if not specified for these features. It is thus worthwhile investigating whether the contrastive hierarchy can shed light on vowel reduction neutralization patterns. Here I can only touch on this problem and sketch the form a contrastivist analysis could take, looking at Belarusian and Luiseño as illustrative examples.

7.5.2. *Neutralization in Vowel Reduction via the Contrastive Hierarchy*

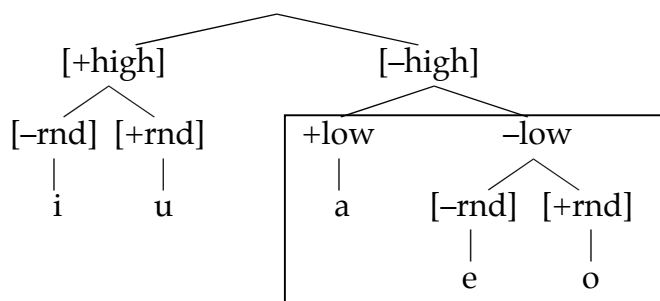
If the reduction patterns follow the contrastive hierarchy, they suggest that the full Belarusian vowel inventory can be analyzed with the contrastive features [high] > [low] > [round]. A tree corresponding to these contrastive features is



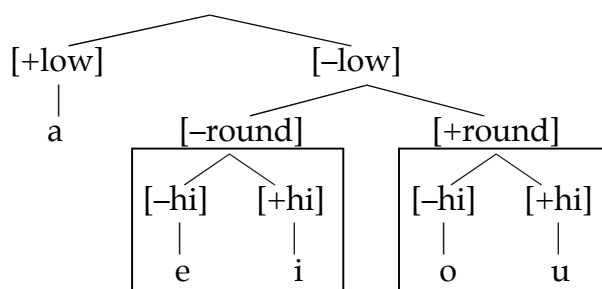
shown in (7.53). Vowel reduction, whereby in unstressed syllables non-high vowels neutralize to *a*, amounts to the suspension of contrasts under  $[-\text{high}]$ : all  $[-\text{high}]$  vowels must be  $[+\text{low}]$ .

Similarly, the full vowel inventory of Luiseño can be analyzed with the contrastive features  $[\text{low}] > [\text{round}] > [\text{high}]$ , as shown in (7.54). In unstressed syllables, no contrasts under  $[\text{round}]$  are permitted, leading to the merger of /*e*/ with /*i*/ and /*o*/ with /*u*/.

(7.53) Belarusian:  $[\text{high}] > [\text{low}] > [\text{round}]$  in stressed syllables



(7.54) Luiseño:  $[\text{low}] > [\text{round}] > [\text{high}]$  in stressed syllables



## 7.6. Consonant co-occurrence restrictions (Mackenzie 2005)

Mackenzie (2005, forthcoming) argues that the best analysis of many consonant harmony systems requires specifying certain features as contrastive in terms of a

contrastive hierarchy. For then a simple generalization emerges: consonant harmony applies to segments contrastively specified for the harmonic feature.

In Bumo Izon (an Ijoid language, Nigeria), labial and alveolar implosive and plosive stops may not co-occur in a morpheme (Efere 2001). Thus, implosive /ɓ ɗ/ may not co-occur with plosive /b d/, though the plosives may freely occur with each other, as may the implosives (10.9).

(7.55) Bumo Izon labial and alveolar plosives and implosives (Efere 2001)

	<i>Plosives</i>	<i>Implosives</i>
<i>Labials</i>	búbú 'rub (powder in face)'	ɓúɓaɪ 'yesterday'
<i>Alveolars</i>		ɗóɗó 'cold'
<i>Mixed</i>	bídé 'cloth'	ɗáɓá 'swamp'

The velar plosive /g/ and the labiovelar implosive /ɕɓ/, however, may freely occur with members of both the plosive and implosive series, as shown in (7.56).

(7.56) Bumo Izon velar plosive and labiovelar implosive (Efere 2001)

	<i>Velar plosive /g/</i>	<i>Labiovelar implosive /ɕɓ/</i>
<i>With same</i>	igódó 'padlock'	ɕɓáɓu 'crack (of a stick breaking)'
<i>With different</i>	ɗúgó 'to pursue'	ɕɓóɗaɕɓóɗa 'rain (hard)'
	ɓúgí 'to wring (hand)'	

Why are /g/ and /ɕɓ/ exempt from harmony? Consider the inventory of oral stops in this language, shown in (7.57).

(7.57) Bumo Izon oral stops (Mackenzie 2005: 174, based on Efere 2001)

		labial	alveolar	palatal	velar	glottal	labio- velar
plosive	voiceless	p	t		k		kp
	voiced	b	d		g		
implosive		ɓ	ɗ				ɡɓ

Intuitively, the labial and alveolar voiced plosive stops each have an implosive ‘partner’, whereas the velar and labio-velar voiced stops have no counterparts. Hansson (2001) discusses this case and observes that contrast seems to play an important role, though he does not discuss any particular theory of contrast. Mackenzie (2005, forthcoming) presents an analysis in terms of the contrastive hierarchy.

Assuming that the relevant laryngeal feature is [glottalic], Mackenzie (2005) proposes that the contrastive hierarchy for Bumo Izon is: place features > [voiced] > [glottalic]. That is, the consonants are first distinguished by place, in terms of the place categories shown in (7.57). Within each place, they are then distinguished by [voiced]. Now [glottalic] is needed only to distinguish the labials and alveolars. The contrastive features assigned to the voiced stops are shown in (7.58). The phonemes that participate in implosive harmony are exactly the ones that are contrastively specified for the harmonizing feature, [glottalic].

(7.58) Bumo Izon voiced stops: contrastive features (Mackenzie 2005)

	b	ḃ	d	ḏ	g	ḡḃ
place	lab	lab	alv	alv	vel	lb-vel
voiced	+	+	+	+	+	+
glottalic	–	+	–	+		

Cases like these are of interest, because it has been claimed that consonant co-occurrence restrictions like these are rooted in some notion of perceptual similarity: co-occurrence restrictions target consonants that are the most similar to each other. On such approach will be discussed in more detail below. For now it suffices to say that the analysis in (7.58) gives one answer to the question of why /ḏ/ is more similar to /b/ than it is to /g/, or why /g/ and /ḡḃ/ are not sufficiently similar to avoid each other in morphemes. The answer is that /ḏ/ and /b/ bear contrastive specifications of the relevant feature but /g/ does not. /ḡḃ/ also lacks the relevant contrastive feature, so does not avoid /g/ no matter how similar they may be on other dimensions.

We will see below that other definitions of similarity do not fare as well in accounting for the Bumo Izon restrictions.

## 7.7. *Loanword adaptation*

### 7.7.1. *Loanword adaptation as evidence of phonological organization*

We have seen that Jakobson (1962 [1931]) and Jakobson and Lotz (1949) appealed to how native speakers adapt foreign sounds as evidence that the native

language uses a particular set of contrastive features. Jakobson (1962 [1931]) cites the alleged relative ease with which native Slovak and Russian speakers adapt front rounded vowels from French or German, in comparison with the greater difficulty Czech speakers have with such sounds, as evidence that the backness and rounding features are dissociated in the former two languages but not in Czech. Presumably, the independence of these features in Slovak and Russian phonology facilitates their combination in novel ways.

Jakobson and Lotz (1949) argue that the difference between velar and palatal place is irrelevant in French; in their analysis, the palatals /ʃ ʒ/ and velars /k g/ both have the place feature [+saturation]. In support of this proposal they cite the frequent adaptation of the English velar nasal /ŋ/ as the palatal /ɲ/ in French. On this view, foreign sounds are filtered through the contrastive features of the native language. Though Jakobson and Lotz do not elaborate on how this might work, we can adapt the ‘decision tree’ model proposed by Jakobson, Fant and Halle (1952) for identifying phonemes in one’s native language as one way of instantiating this idea. Thus, a French speaker hearing or attempting to produce English [ŋ] could proceed down through the French contrastive feature hierarchy, (3.33) in the proposal of Jakobson and Lotz, making a series of binary decisions: going top down, [ŋ] is [–vocalic], [+nasal],

and [+saturated]. At this point there are no further contrastive features to be assigned, and the English sound [ŋ] is identified with the French phoneme /ɲ/.<sup>24</sup>

Hyman (1970a, b, 1973) took up the idea that loan words can shed light on phonological organization, recast in terms of generative phonology. Hyman (1970b) proposes a principle of borrowing that foreign sounds identical to native underlying forms are lexicalized as such and undergo the phonological rules of the borrowing language. He argues that the adaptation of Yoruba words into Nupe is an instance of this principle, and supports his analysis of the Nupe vowel system.

Nupe, a Niger-Congo language spoken in Nigeria, has five contrastive surface vowels at the surface, as in (7.59a). Hyman argues that the low vowel /a/ actually represents the surface absolute neutralization of three underlying vowels: /ɛ/, /ɔ/, and /a/.

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<sup>24</sup> In this case, we could question the strength of the argument by asking what other French phoneme English [ŋ] could be identified with. In the analysis of Martinet (1964), /ɲ/ is assigned a [palatal] place, and the velars /k g/ are [dorso-velar]. The combination of [dorso-velar, +nasal] does not exist in native Standard French, and Martinet's analysis does not suggest what strategy would be employed by a French speaker in realizing this sound. If the place feature were considered to be contrastively more important, we might expect it to override the nasal feature, incorrectly yielding /g/ as the substitute for [ŋ]. But it is not clear Martinet's analysis would be committed to this approach.



they were the corresponding Nupe underlying vowels, and subjected to the same derivation as the native words in (7.60).

(7.61) Yoruba words borrowed into Nupe (Hyman 1970b)

<i>Yoruba</i>	<i>Nupe</i>	<i>Gloss</i>
kèkè	k <sup>j</sup> àk <sup>j</sup> á	'bicycle'
kóbò	k <sup>w</sup> áb <sup>w</sup> à	'penny'

#### 7.7.2. *Loanword phonology and social factors*

Kiparsky (1973 §3.2) discusses the relevance of loan phonology as evidence for particular aspects of phonological organization. Elaborating on a proposal by Steinitz (1964), he argues that we must distinguish between two situations: *casual contact*, in which the language from which words are borrowed is not known to most speakers of the borrowing language, and *extensive bilingualism*, in which it is known. Kiparsky suggests that in the casual contact situation loanwords are assimilated on the basis of phonetic approximation. In extensive bilingualism, borrowers in addition wish to preserve phonological contrasts in the lending language. In order to do this, they may sometimes adopt correspondences that are not phonetically the closest.

Kiparsky suggests that since Yoruba and Nupe have been in close contact and many Nupe speakers are familiar with Yoruba, Yoruba borrowings into Nupe fall under the second type of borrowing situation. Kiparsky proposes that the Nupe adaptations of Yoruba words with /ε/ and /ɔ/ allow words with these vowels to receive distinct representations in Nupe (7.62), preventing large-



scale mergers of lexical items that are distinct in Yoruba. Kiparsky argues that a similar strategy applies in cases where there is no possibility that the underlying phonemes of the borrowing language are the same as those of the lending language; therefore, the adaptations of Yoruba words do not necessarily support positing underlying / $\epsilon$ / and / $\circ$ / in Nupe.

(7.62) Yoruba-Nupe consonant-vowel (CV) correspondences

<i>Yoruba</i>	Ci	Ce	C $\epsilon$	Ca	C $\circ$	Co	Cu
<i>Nupe</i>	Ci	Ce	C <sup>j</sup> a	Ca	C <sup>w</sup> a	Co	Cu

Heffernan (2005, 2007) provides an illustration of the effects of social setting on loan phonology in connection with the adaptation of Chinese nasal consonants into Japanese. Japanese allows only a single nasal consonant in syllable codas, a placeless moraic nasal consonant designated [N]. Chinese allowed three coda nasal consonants up to circa 1850, /m/, /n/, and / $\eta$ /, and two subsequently, /n/ and / $\eta$ /. Heffernan shows that in periods where contact between Japan and China was not close, Japanese adapted the Chinese velar nasal as either [gu] or, more usually, as the coda nasal [N]. Heffernan argues that these adaptations follow from phonetic similarity: lacking a velar nasal, Japanese either maintains the velar place, at the cost of giving up nasality and having to epenthesize a vowel (as [g] cannot stand alone in coda); or it keeps the nasality, at the cost of giving up the velar place and also not keeping the Chinese velar coda nasal distinct from the coronal coda nasal /n/.

In the Nara and early Heian periods (c. 700–1000), however, Chinese was well known and had great prestige in Japan (Loveday 1996); Heffernan (2005:

119) writes that '[m]uch of the upper echelon of Japanese society spoke Chinese, as it was used almost every aspect of aristocratic life...' In this period only, the Chinese velar nasal was adapted as a nasalized high vowel  $\tilde{u}$  or  $\tilde{i}$ , whose backness was harmonic with a preceding vowel. Heffernan argues that no plausible measurement of phonetic similarity could yield this particular adaptation as optimal. Rather, he proposes that the preservation of the Chinese contrasts between the coda nasals took precedence over purely phonetic or phonological considerations.<sup>25</sup>

Heffernan observes that the different conditions of Chinese loan adaptation into Japanese correspond to two different hypothesis about the input to loan phonology. Some hold that the input to loan phonology is analyzed in terms of the phonemes of the lending language (LaCharité and Paradis 1997, Paradis 1988, Paradis and Prunet 2000, Jacobs and Gussenhoven 2000). Paradis and her collaborators, for example, assume that speakers responsible for borrowing are bilingual, and familiar with the grammar of the lending language. Extensive bilingualism is one borrowing situation identified by Kiparsky, and

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<sup>25</sup> An account in terms of phonetic similarity here is consistent also with an account in terms of the contrastive hierarchy. Thus, whereas one can imagine that the result of filtering the Chinese velar nasal through the Japanese contrastive hierarchy could be either [N] (if [nasal] takes precedence) or [gu] (if velar place is most salient), there is no plausible contrastive hierarchy that would yield  $[\tilde{u}]$  as a rendition of  $\eta$ .

characterizes the Nara and early Heian periods. Others have assumed that the input to loan phonology is phonetic (Silverman 1992, Yip 1993, Steriade 2001, Kenstowicz 2003), and Heffernan proposes that this approach holds of the other periods.

With respect to our main theme, it is clear from the above that contrast enters into loan phonology in a number of ways. There is much evidence that the sound structure of one's native language affects one's perception of foreign sounds (Hancin-Bhatt 1994, Best 1995, Flege 1995, Dupoux et al. 1999, Brown 2000). In recent years, some studies have argued that noncontrastive features play an important role in the adaptation of sounds (Brannen 2002, Pater 2003; see Kang 2007 for discussion of this and related issues). However, as with other aspects of phonology, much discussion of contrastive and redundant features in loanword phonology suffers from the lack of a satisfactory account of which features actually are contrastive.

### 7.7.3. *Loanword adaptation and the contrastive hierarchy (Herd 2005)*

Herd (2005) studies patterns of adaptation of English words into a number of Polynesian languages. These languages have impoverished consonantal inventories, so many substitutions can be observed. Herd argues that the patterns provide evidence for the influence of the contrastive hierarchies of the borrowing languages (à la Jakobson and Lotz; see also Chapter 6). Pure phonetic similarity, assuming we had a reliable measure of it, is not sufficient to account for these patterns. Of the many cases he discusses, I will briefly review the

adaptation of coronal fricatives into two Eastern Polynesian languages, Hawaiian and New Zealand Māori.

### 7.7.3.1. *Hawaiian*

Hawaiian has a famously small consonantal inventory (7.63).

#### (7.63) Hawaiian Consonantal Inventory

p	k	ʔ
		h
m	n	
	w	l

All English coronal segments are borrowed into Hawaiian as /k/, including [s], [z], and [ʃ]. Note that these segments are not adapted as /h/, another plausible candidate.

#### (7.64) Hawaiian adaptation of English coronal fricatives (Herd 2005)

- a. [s] → /k/      lettuce → /lekuke/      soap → /kope/
- b. [z] → /k/      dozen → /kaakini/
- c. [ʃ] → /k/      brush → /palaki/      machine → /mikini/

### 7.7.3.2. *NZ Māori*

NZ Māori has both /k/ and /h/, as well as /t/, though it lacks a phonemic glottal stop (7.65). In this language, English [s], [z], and [ʃ] are borrowed as /h/, as shown in (7.66). This is surprising, given that /k/ is available, as in Hawaiian.

#### (7.65) NZ Māori Consonantal Inventory

p	t	k
	f	h
m	n	ŋ
	w	r

## (7.66) NZ Māori adaptation of English coronal fricatives (Herd 2005)

- a. [s] → /h/          glass → /karaahe/          sardine → /haarini/
- b. [z] → /h/          weasel → /wiihara/          rose → /roohi/
- c. [ʃ] → /h/          brush → /paraihe/          sheep → /hipi/

If substitutions are made on the basis of similarity, these facts are hard to explain. As Herd (2005) points out, if coronal fricatives are more similar to /k/ than to /h/ in Hawaiian, why are they more similar to /h/ than to /k/ in NZ Māori? The relevant notion of similarity must be somehow influenced by the different inventories of these languages. Herd proposes that different contrastive specifications are operative in each language.

7.7.3.3. *Contrastive specifications of Hawaiian and NZ Māori consonants*

Herd (2005) proposes that the contrastive status of /h/ is different in the two languages. In Hawaiian, /h/ contrasts with /ʔ/. Following Avery and Idsardi (2001), the existence of this contrast activates a laryngeal dimension they call *Glottal Width*. Glottal Width has two values, [constricted] for /ʔ/, and [spread] for /h/.

Herd proposes the feature ordering for Hawaiian (only features relevant to the current discussion are mentioned) shown in (7.67).

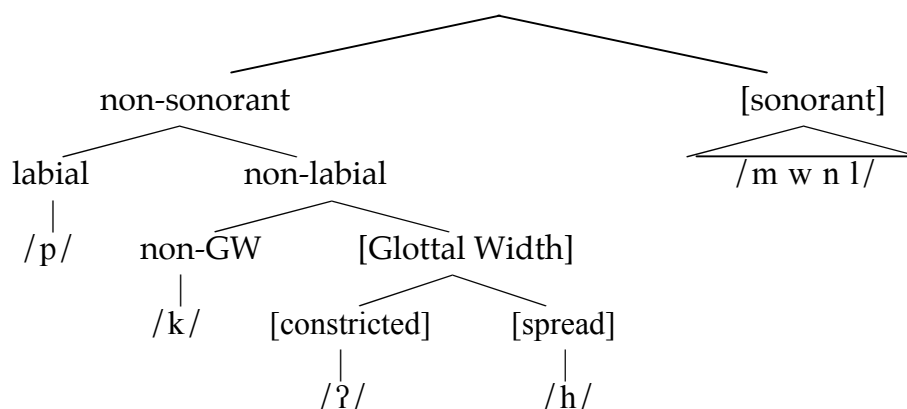
## (7.67) Contrastive hierarchy for Hawaiian (Herd 2005)

[sonorant] > [labial] > glottal width ([spread / constricted])

First, [sonorant] distinguishes /m n w l/ from /p k ʔ h/. Next, [labial] splits off /p m w/ from the rest. Then laryngeal glottal width applies to /ʔ h/. The result is that /h/ is specified for [spread], /ʔ/ is specified [constricted], and

/k/ is the default obstruent (7.68). Therefore, anything that is not sonorant or labial or laryngeal is adapted to /k/. In particular, [s z ʃ] → /k/.

(7.68) Hawaiian contrastive specifications (Herd 2005)



Unlike Hawaiian, NZ Māori has no /ʔ/, so there is no contrast within Glottal Width. Herd (2005) proposes that, lacking such a contrast, [spread] is not accessible as a contrastive feature. This, and the other differences in the inventories of the two languages, results in a different contrastive hierarchy for NZ Māori (7.69).

(7.69) Contrastive hierarchy for NZ Māori (Herd 2005)

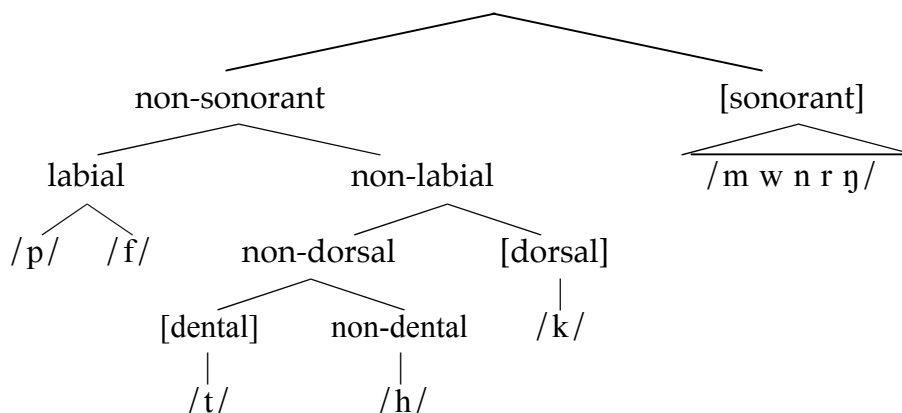
[sonorant] > [labial] > [dorsal] > [dental]

As in Hawaiian, [sonorant] goes first, splitting off /m n ŋ w r/, and [labial] follows, applying to /p f m w/. Unlike Hawaiian, [dorsal] is also required, to distinguish /k ŋ/ from /t n/. It remains to distinguish /t/ from /h/. Herd proposes to use the feature [dental] to characterize the contrastive property of /t/. This feature accounts for why the interdental fricatives [θ] and [ð] become /t/, not /h/. Thus, in Māori /h/ plays the role of default obstruent,

not /k/: /h/ is not sonorant, not labial, not dorsal, and not dental (7.70).

Therefore, [s z ʃ] → /h/.

(7.70) NZ Māori contrastive specifications (Herd 2005)



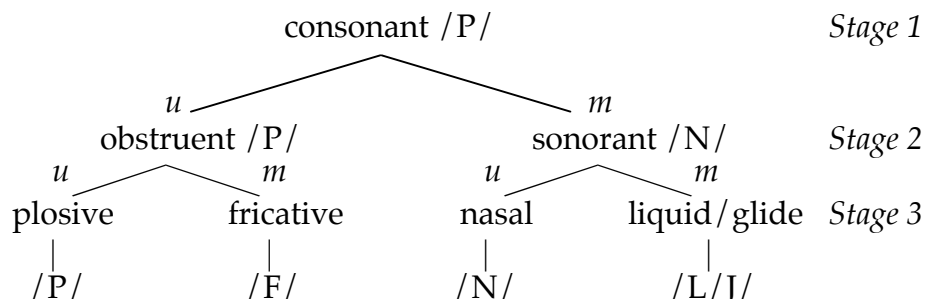
The different contrastive roles played by /h/ in these languages suggests that they have different ‘pattern alignments’, despite their very similar phonetic realizations. The differing status of /h/, as well as the presence of /t/ in NZ Māori but not in Hawaiian, also account for the very different contrastive status of /k/ in each language: general default consonant in Hawaiian, and dorsal obstruent in NZ Māori.

### 7.8. *The acquisition of distinctive features and contrasts*

Following the pioneering work of Jakobson (1941) and Jakobson and Halle (1956) discussed in Chapter 4, the notion of a contrastive hierarchy has been fruitfully applied in acquisition studies, where it is a natural way of describing developing phonological inventories (Pye, Ingram and List 1987, Ingram 1988, 1989, Levelt 1989, Dinnsen et al. 1990, Dinnsen 1992, 1996). For example, Fikkert (1994)

describes the development of segment types in onset position in Dutch as in (7.71).

(7.71) Development of Dutch onset consonants (Fikkert 1994)



In Stage 1 there are no contrasts. The value of the consonant defaults to the least marked onset, namely an obstruent plosive, designated here as /P/. The first contrast (Stage 2) is between obstruent and sonorant. The former remains the unmarked option (*u*); the sonorant defaults to nasal, /N/. At this point children differ. Some expand the obstruent branch first (Stage 3a), bringing in marked fricatives, /F/, in contrast with plosives. Others (Stage 3b) expand the sonorant branch, introducing marked sonorants, which may be either liquids, /L/, or glides, /J/. Continuing in this way we will eventually have a tree that gives all and only the contrasting features in the language.

While the contrastive hierarchy has been useful in depicting developing inventories as they appear in children's production, experiments on child and infant perception of phonetic contrasts have appeared to support a different view of phonological acquisition. Beginning with Eimas et al. (1971), it has been shown that infants can discriminate fine phonetic distinctions in speech sounds, including sounds that are not discriminated in the ambient language (Trehub



1976, Werker et al. 1981, Weker and Tees 1984). Thus, whereas adults have difficulty discriminating certain distinctions not used in their native language, infant perception appears to be 'universal'.<sup>26</sup> A series of studies showed that infants 'tune' their phonetic perceptions in accordance with the distribution of sounds in the language they are acquiring, thus eventually losing the ability to discriminate foreign sounds (Werker and Tees 1984, Kuhl et al. 1992).

This tuning occurs in the first year, before the learners have acquired a lexicon. These results have led some to conclude that learners acquire the phonemes of their language before they can produce or understand words. For example, Pinker (1994: 264–5) describes the process as follows:

By six months, [babies] are beginning to lump together the distinct sounds that their language collapses into a single *phoneme*, while continuing to discriminate equivalently distinct ones that their language keeps separate. By ten months...they do not distinguish Czech or Inslekampx *phonemes* unless they are Czech or Inslekampx babies. Babies make this transition before they produce or understand words... They must be sorting the sounds directly, somehow tuning their speech analysis module to deliver the *phonemes* used in their language. The module can then serve as the

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<sup>26</sup> There are also studies showing that certain phonetic contrasts are not as well discriminated by infants as by native speaker adults (Aslin et al. 1981, Polka, Colantonio and Sundara 2001); see Weiss and Maye in press).

front end of the system that learns words and grammar.” [*emphasis added*]

On the face of it, it is hard to see how infants can acquire phonemes without knowing if two utterances are the ‘same’ or ‘different’ (Bloomfield 1933). It has been argued that learners are particularly attentive to the distribution of sounds, and can draw certain conclusions about whether a cluster of sounds are to be assigned to one category or to more than one, even in the absence of vocabulary or meaning (Maye 2000, Maye, Werker and Gerken 2002, Weiss and Maye in press). However, distribution can only take one so far. In fact, there is no evidence that infants have acquired phonemes by the age of one. The source for Pinker’s claims is the following passage by Kuhl et al. (1992: 608):

‘Infants demonstrate a capacity to learn simply by being exposed to language during the first half year of life, before the time that they have uttered meaningful words. By 6 months of age, linguistic experience has resulted in language-specific *phonetic prototypes* that assist infants in organizing speech sounds into *categories*. They are in place when infants begin to acquire word meanings toward the end of the first year. *Phonetic prototypes* would thus appear to be fundamental perceptual-cognitive building blocks rather than by-products of language acquisition.’ [*emphasis added*]

What Kuhl et al. call ‘phonetic prototypes’ are not equivalent to phonemes; they are *phones*, phonetic variants of phonemes. Infants become sensitive to the phonetic range and distribution of the sounds of their language,

so they can tell, for example, that the pronunciation of a Swedish [i] inserted into an English utterance is somehow anomalous. But this is not the same as learning which phones cluster together to form phonemes.

Nevertheless, the fact that infants are able to make fine phonetic discriminations has sometimes been taken as evidence that children's initial phonological representations are accurate and essentially adult-like. If that is correct, then it must be the case that the appearance that learners are gradually acquiring phonological contrasts is not a reflection of their linguistic competence, but only of production. This theory is bolstered by anecdotes that children are aware of phonemic contrasts that they are unable to produce themselves; a famous example is Neil Smith's son Amahl protesting when his father said *sip* instead of *ship*, even though Amahl himself pronounced both as *sip* (Smith 1973).

If learners' phonological representations were adult-like from the beginning, we would no longer have evidence that the system of contrasts is learned gradually, nor would we have evidence for a contrastive hierarchy in acquisition. In fact, we would not even have evidence that contrast is important in acquisition, beyond the distribution of surface allophones. However, there is evidence that we cannot draw these conclusions from the above studies.

In sharp contrast to the excellent performance of young children on phonetic discrimination tasks is their inability to utilize fine phonetic differences in word recognition tasks (Stager and Werker 1997, Werker et al. 2002, Pater, Stager and Werker 2004). For example, the 14 month-old children studied by Stager and Werker could not distinguish minimally different nonce words that

they had been taught, such as *bin* and *din*, in a word recognition task (when the ‘words’ were associated with objects), though they could distinguish them in a pure discrimination task. It follows that purely phonetic perception does not translate immediately into phonological representation. The results are consistent with the view that phonological representations do not contain all the details available to phonetic perception (Werker et al. 2002, Pater, Stager and Werker 2004, Pater 2004). Fikkert and Levelt (in press) argue that phonological representations are underspecified to begin with, and argue in support of the ‘constructionist’ or ‘emergentist’ view of acquisition inspired by production studies. Fikkert (2007) argues that there is evidence from perception in support of this picture, providing support for the constructionist interpretation of the production studies.

Putting everything together, we have a picture of a learner going in two directions simultaneously. At the phonetic perceptual level, learners begin by attending to many potential sources of contrasts, and are more able than adults to discriminate sounds not used in the ambient language (Eimas et al. 1987, Werker et al. 1981). Acquisition of the native language requires that they ‘tune’ their perceptual system to the contrasts used in their language, while learning to disregard contrasts that are not used (Werker and Tees 1984, Kuhl et al. 1992). Meanwhile, phonological representations are impoverished to begin with (Fikkert 2007). Infants’ rich perception of phonetic contrast does not translate into a system of phonological representations (Stager and Werker 1997). Phonological representations are built into systems of increasing complexity (Rice and Avery

1995), based on the input from phonetic perception together with evidence from the grammar, which itself becomes more complex and removed from the initial percepts (Dresher 1999).

### 7.9. *Other approaches to contrast in phonology*

In this section I will consider a number of other approaches to phonological contrast that have been advanced in the recent phonological literature.

Structured Specification theory (Broe 1993, Frisch 1996, Frisch, Pierrehumbert and Broe 2004) takes into account the membership of a phonological inventory, and hence indirectly is sensitive to the contrasts in an inventory; however, it makes no explicit distinction between 'contrastive' and 'redundant' features. Rather, it computes the similarity of pairs of phonemes as a function of how many natural classes they share and do not share. I will show that this similarity metric simply does not make the right predictions with respect to the phonological processes discussed in the course of this chapter.

Clements 2001, 2004, proposes a feature hierarchy that governs segmental specification, as well as a theory of markedness. His theory differs from the one advocated here in assuming that these are universally fixed and independent of phonological activity. The theory of Calabrese 1994, 1995, 2005 also incorporates contrasts and hierarchy, and pays attention to feature activity, but with a different set of assumptions about how contrasts are achieved and what markedness is. I will argue that phonological activity is an essential source of

evidence bearing on the contrastive feature hierarchy, and that the evidence from activity shows that the hierarchy is not universal.

There are other interesting contemporary approaches to contrast that I am not able to discuss here. A number of approaches in OT (Padgett 2003a, b, Lubowicz 2003) evaluate contrast directly in the grammar by taking sets of words as candidates. These proposals are often allied to phonetically-based accounts of contrast (Flemming 2001, 2002) that account for inventory structure by Dispersion Theory (Liljencrants and Lindblom 1972 and work in that tradition). MCS views such phenomena as distinct from the phonological contrasts that are central to this study.

#### 7.9.1. *Structured Specification Theory and contrast via natural classes*

Structured Specification, or natural classes, theory (Broe 1993, Frisch 1996, Frisch, Pierrehumbert and Broe 2004) derives a similarity metric from the natural classes created by the phonemes of an inventory. The method of computing similarity weights features differently depending on how much they contribute to creating distinct natural classes. Features that uniquely distinguish members of the inventory will contribute more to the similarity metric than logically redundant features; in this way, the computation indirectly take language-particular contrasts into account.

The natural classes theory measures similarity by computing the feature classes shared by two phonemes, and dividing by the number of shared plus unshared classes. This method takes contrast into account because the

distribution of the contrasting phonemes in an inventory determines the classes. But it does not recognize contrastive or redundant features, and arrives at the same computation for every similar inventory.

For example, suppose we have a vowel system /i e a o u/. Let us assume the features in (7.72).<sup>27</sup>

(7.72) Features for a five-vowel system

- a. [syllabic]    /i e u o a/
- b. [high]    /i u/      c. [low]    /a/      d. [open]    /e o/
- e. [front]    /i e/      f. [round]    /o u/      g. [back]    /a o u/

There are seven features here. The number of *potential* classes (i.e., mathematically possible classes, not necessarily existing or even phonologically possible) consists of the power set of the set of features minus the empty set: that is, all the sets that can be formed from combinations of these features. These sets include one set consisting of all seven features (not possible, since some features are antagonistic), seven sets consisting of six features (leaving out one of the seven features in each one), and so on. The number of such classes for  $n$  features is  $2^n - 1$ ; for  $n = 7$ , this comes to 127 classes. Of these we can eliminate phonologically impossible classes (e.g., those with [high] and [low], or [front]

---

<sup>27</sup> For purposes of this demonstration I adopt monovalent features capable of expressing all natural classes, as required by Frisch 1996.

and [back], and so on). Of the possible potential classes, only those with distinct members make up a natural class.

In our example, there are 11 natural classes (7.73).

(7.73) Natural classes derived from (7.72)

- |                              |             |                        |       |
|------------------------------|-------------|------------------------|-------|
| a. [syll, open, round, back] | /o/         | b. [syll, open, front] | /e/   |
| c. [syll, high, round, back] | /u/         | d. [syll, high, front] | /i/   |
| e. [syll, low, back]         | /a/         |                        |       |
| f. [syll, round, back]       | /o u/       | g. [syll, front]       | /i e/ |
| h. [syll, open]              | /e o/       | i. [syll, high]        | /i u/ |
| j. [syll, back]              | /a o u/     |                        |       |
| k. [syll]                    | /i e a o u/ |                        |       |

To see how the inventory influences the number of natural classes, consider /a/, which is characterized as [syllabic, low, back]. Now /a/ is the only [low] vowel in the inventory, so it is also true that /a/ is [low], or [syllabic, low], or [low, back]. But because all these classes have the same membership, they only count as one natural class, represented by the most fully specified description.

The similarity measure for each pair of phonemes is shown in (7.74).



(7.74) Similarity measures (S = shared classes, U = unshared classes)

	<i>Pair</i>	<i>S</i>	<i>U</i>	<i>S/S+U</i>		<i>Pair</i>	<i>S</i>	<i>U</i>	<i>S/S+U</i>
a.	/u o/	3	4	0.43	b.	/i e/	2	4	0.33
c.	/o a/	2	4	0.33	d.	/u a/	2	4	0.33
e.	/e o/	2	5	0.29	f.	/i u/	2	5	0.29
g.	/i a/	1	5	0.17	h.	/e a/	1	5	0.17
i.	/i o/	1	7	0.13	j.	/u e/	1	7	0.13

Why is /u/ more similar to /o/ than /i/ is to /e/? They would appear to be in parallel relations. The parallelism is disturbed by the fact that /u o/ are both [back] as well as [round], whereas /i e/ share only [front]. The classes [syllabic, round, back] and [syllabic, back] are distinct because /a/ is a member of the latter, but not the former. In the case of unshared classes, the features [round] and [back] function together, because /a/ is neither [high] nor [open], in this system of features, so [syllabic, high/open, round, back] = [syllabic, high/open, round] = [syllabic, high/open, back]. The shared and unshared classes for /u o/ and /i e/ are shown in (7.75).

(7.75) Shared and unshared classes for /u o/ and /i e/

a. Shared classes

i.	/u o/:	3	[syll, round, back]	[syll, back]	[syll]
ii.	/i e/:	2	— — —	[syll, front]	[syll]

b. Unshared classes for /u o/: 4

i.	/u/:	2	[syll, high, round, back]	[syll, high]
ii.	/o/:	2	[syll, open, round, back]	[syll, open]

c. Unshared classes for /i e/: 4

- |     |      |   |                     |              |
|-----|------|---|---------------------|--------------|
| i.  | /i/: | 2 | [syll, high, front] | [syll, high] |
| ii. | /e/: | 2 | [syll, open, front] | [syll, open] |

The features [back] and [round] do similar contrastive work in most classes; therefore, the weight they are accorded by the similarity measures is reduced, somewhat capturing the notion that these features make each other logically redundant in most cases, without actually designating one as contrastive and the other as redundant. Though their weight is reduced, they are not entirely disregarded: thus, /u o/ are computed to be more similar to each other than /i e/.

Note that this procedure is very sensitive to the choice of features: different choices of features can change the results quite substantially. The choice of a feature [open], defined as applying only to mid vowels, is responsible for the somewhat counterintuitive result that /i/ and /e/ are equally similar to /a/, and so, too, /u/ and /o/. But since the feature set is presumably universal, whatever set is chosen will give the same results to every inventory with these phonemes.

Frisch, Pierrehumbert and Broe (2004) propose that similarity as computed using natural classes is successful in accounting for the co-occurrence restrictions on consonantal roots in Arabic. This is so, they argue, because all features contribute in some measure to these restrictions. However, the most basic fact about the Arabic (and Semitic, more generally) constraints is inconsistent with Structured Specification theory. As they write (Frisch,

Pierrehumbert and Broe 2004: 198), '[s]ince OCP effects in Arabic only apply to consonants that share major place of articulation features, we stipulate that the natural classes used in the similarity computations are only those natural classes containing a place of articulation feature. Thus, nonhomorganic consonant pairs will have similarity 0...' This type of stipulation contradicts the basic assumption that the restrictions are sensitive to overall similarity as computed by natural classes; rather, it is more naturally accounted for in a theory where place features are hierarchically superior to other features. That is, certain features count more than others with respect to specific phonological processes and constraints.

In the following subsections I apply Structured Specification theory to examples of vowel harmony, consonant co-occurrence, and loan phonology discussed above. I will show that the similarity metric makes the wrong predictions in each case.

#### 7.9.1.1. *Vowel harmony*

We observed that the vowels that trigger ATR and labial harmony in Classical Manchu are just those that are contrastively specified for the [ATR] and [labial] features, respectively. Specifically, the vowels /u/ and /ɔ/ are specified for a contrastive [ATR] feature, and may not co-occur with /ʊ/ and /a/, which are contrastively non-ATR. The vowel /i/ is not contrastively specified for [ATR], and may co-occur with any of the above vowels. The feature [labial] contrastively distinguishes between /ɔ/ and /a/, and these are the only vowels that participate in labial harmony in Classical Manchu.

On the assumption that ATR harmony targets vowels that are highly similar to each other, we expect that /u/, /ə/, /ʊ/, and /a/ should all be more similar to each other than any of them are to /i/. Of course we expect /u/ to be very similar to /ʊ/, and /ə/ to be very similar to /a/, since these vowels are distinguished only by the feature [ATR]; any feature-based theory would derive this result. The test of the theory is whether /u/ and /ʊ/ are also similar to /ə/ and /a/.

To test this prediction, I computed similarity measures for the vowels of Classical Manchu, using the features in (7.76), which mirror the features used by Zhang (1996). Following the usual practice in Structured Specification theory (Broe 1993, Frisch 1996), I have given each marked feature an unmarked counterpart, so that all classes of vowels can be picked out. The similarity measures are shown in (7.77).

(7.76) Vowel features for Classical Manchu

- |               |               |               |         |
|---------------|---------------|---------------|---------|
| a. [syllabic] | /i ə a ɔ u ʊ/ |               |         |
| b. [back]     | /ə a ɔ u ʊ/   | c. [front]    | /i/     |
| d. [low]      | /ə a ɔ/       | e. [nonlow]   | /i u ʊ/ |
| f. [round]    | /ɔ u ʊ/       | g. [nonround] | /i ə a/ |
| h. [ATR]      | /i ə u/       | i. [non-ATR]  | /a ɔ ʊ/ |

## (7.77) Similarity measures for Classical Manchu

<i>Phonemes</i>	<i>Similarity</i>	<i>Harmony</i>	<i>Phonemes</i>	<i>Similarity</i>	<i>Harmony</i>
a. /ɔ ʊ/	0.45	None	b. /a ɔ/	0.45	Labial
c. /u ʊ/	0.42	ATR	d. /ə a/	0.42	ATR
e. /i ʊ/	0.33	None	f. /i ə/	0.33	None
g. /ə ʊ/	0.29	ATR	h. /a ʊ/	0.23	ATR
i. /ɔ ʊ/	0.21	None	j. /ə ɔ/	0.21	Labial
k. /i ʊ/	0.15	None	l. /i a/	0.15	None
m. /ə ʊ/	0.13	ATR	n. /a ʊ/	0.13	ATR
o. /i ɔ/	0.07	None			

It is evident from the results in (7.77) that the similarity between two phonemes as computed by this metric has no bearing on whether or not these segments may co-occur in a word. We can set no threshold above which harmony is required. To explain why certain vowels participate in harmony, we require a theory that picks out which features are contrastive.

7.9.1.2. *Consonant co-occurrence*

It has been proposed (Hansson 2001, Rose and Walker 2004) that consonant harmony and other restrictions on the co-occurrence of consonants depend on similarity, as computed by Structured Specification theory. Mackenzie (2005, forthcoming) argues, however, that this theory rather consistently fails to account for common types of consonant harmony and co-occurrence. Here I will review one such case.

Let us consider again Bumo Izon, in which labial and alveolar voiced stops must all be pulmonic or all implosive in a word; the velar pulmonic voiced stop and the labiovelar implosive consonant do not participate in this restriction. We saw that the phonemes that participate in implosive harmony are exactly the ones that are contrastively specified for the harmonizing feature, [glottalic] (Mackenzie 2005). Hansson (2001) observes that the Structured Specification/natural classes approach will not work for this case. The following demonstration of why this is so is based on the discussion in Mackenzie (2005).

For purposes of computing natural classes, let us assume the features in (7.78).<sup>28</sup>

(7.78) Features for Bumo Izon stops

- |               |                         |                           |
|---------------|-------------------------|---------------------------|
| a. [stop]     | /p b ɓ t d ɗ k g kp ɠɓ/ |                           |
| b. [labial]   | /p b ɓ/                 | c. [coronal] /t d ɗ/      |
| d. [velar]    | /k g/                   | e. [labiovelar] /kp ɠɓ/   |
| f. [pulmonic] | /p b t d k g kp/        | g. [glottalic] /ɓ ɗ ɠɓ/   |
| h. [voiced]   | /b ɓ d ɗ g ɠɓ/          | i. [voiceless] /p t k kp/ |

---

<sup>28</sup> I observed above that the similarity metric is very sensitive to the choice of features, and different numbers are obtained if we make different decisions about what the features are. For example, the labiovelars can be considered to be combinations of [labial] and [velar] rather than as [labiovelar]. I have run the computations with various combinations of features, and though the specific numbers are different, the crucial result holds under every selection of features I have tried.

Similarity computations for this inventory are shown in (7.79).

(7.79) Similarity measures for Bumo Izon

<i>Phonemes</i>	<i>Similarity</i>	<i>Harmony</i>	<i>Phonemes</i>	<i>Similarity</i>	<i>Harmony</i>
a. /d d/	0.4	Yes	b. /ɓ b/	0.4	Yes
c. /ɗ ɗ/	0.22	No			
d. /d g/	0.2	No	e. /ɓ g/	0.2	No
f. /ɗ ɗ/	0.18	No	g. /ɗ b/	0.18	No
h. /d b/	0.17	Yes	i. /ɓ d/	0.17	Yes

As already pointed out by Hansson (2001), the similarity metric of Structured Specification theory makes the wrong predictions in these cases. For example, it rates /g/ as more similar to implosive /ɓ/ than /d/ is, and more similar to implosive /d/ than /b/ is. It thus incorrectly predicts that /g/ and /ɗ/ should be the most likely of all the voiced stops to participate in implosive harmony with stops at different places of articulation.

As with vowel harmony, the simplest account appeals to contrastive features as derived by the contrastive hierarchy. No better alternatives have been proposed, to my knowledge.

#### 7.9.1.3. *Loanword adaptation*

We observed above that English /s/ is borrowed into Hawaiian as /k/, but into NZ Māori as /h/. In Herd's (2005) analysis, these adaptations follow from the contrastive hierarchies of these languages. If these adaptations are based on perceived similarity, then /s/ is more similar to /k/ than to /h/ in Hawaiian,

but more similar to /h/ than to /k/ in NZ Māori. Do the different inventories of these languages yield these results in Structured Specification theory?

To test these predictions, I assumed the features in (7.80) for Hawaiian, with /s/ added to the inventory for purposes of comparison. The results are shown in (7.81). The similarity metric rates /s/ as most similar to /h/ or to /l/; the expected winner, /k/, ranks third.

(7.80) Features for Hawaiian consonants + /s/

- |               |                     |                  |               |
|---------------|---------------------|------------------|---------------|
| a. [nonsyll]  | /p m w n l k ʔ h s/ | b. [consonantal] | /p m n l k s/ |
| c. [sonorant] | /m w n l/           | d. [obstruent]   | /p k ʔ h s/   |
| e. [labial]   | /p m w/             | f. [coronal]     | /n l s/       |
| g. [dental]   | /n/                 | h. [nondental]   | /l s/         |
| i. [dorsal]   | /k/                 | j. [laryngeal]   | /ʔ h/         |
| k. [stop]     | /p m n k ʔ/         | l. [continuant]  | /w l h s/     |
| m. [spread]   | /h/                 | n. [constricted] | /ʔ/           |
| o. [lateral]  | /l/                 | p. [liquid]      | /l/           |
| q. [nasal]    | /m n/               |                  |               |



## (7.81) Similarity measures for Hawaiian consonants and /s/

<i>Phonemes</i>	<i>Similarity</i>	<i>Phonemes</i>	<i>Similarity</i>
a. /s h/	0.36	b. /s l/	0.36
c. /s k/	0.29	d. /s p/	0.25
e. /s n/	0.19	f. /s ʔ/	0.15
g. /s w/	0.14	h. /s m/	0.11

Assuming the feature specifications in (7.82), the results for NZ Māori are even worse (7.83). As in Hawaiian, the similarity metric rates /s/ as more similar to /h/ than to /k/. In NZ Māori this is a good result, because English words with /s/ are adapted as /h/; the problem is that /h/ is ranked as only the fourth most similar phoneme to /s/, behind /f/, /t/, and /r/.

## (7.82) Features for NZ Māori consonants + /s/

a. [nonsyll] /p f m w t n r k ŋ h s/	b. [cons] /p f m t n r k ŋ s/
c. [sonorant] /m w n r ŋ/	d. [obstruent] /p f t k h s/
e. [labial] /p f m w/	f. [coronal] /t n r s/
g. [dental] /t n/	h. [nondental] /r s/
i. [dorsal] /k ŋ/	j. [laryngeal] /h/
k. [stop] /p m t n k ŋ/	l. [continuant] /w f r h s/
m. [spread] /h/	n. [nonlateral] /r/
o. [liquid] /r/	p. [nasal] /m n ŋ/

## (7.83) Similarity measures for NZ Māori consonants and /s/

<i>Phonemes</i>	<i>Similarity</i>	<i>Phonemes</i>	<i>Similarity</i>
a. /s f/	0.47	b. /s t/	0.38
c. /s r/	0.35	d. /s h/	0.31
e. /s k/	0.25	f. /s p/	0.21
g. /s n/	0.16	h. /s ŋ/	0.11
i. /s w/	0.11	j. /s m/	0.1

7.9.1.4. *Summary*

Although Structured Specification theory and the natural classes method of computing similarity are interesting proposals for taking into account contrast in inventories without designating features as contrastive, the results surveyed above suggest that typical phonological processes are not sensitive to similarity as computed in this way. In every case, the Contrastivist Hypothesis, implemented by the contrastive hierarchy, provides simple successful accounts of the phonological patterns, suggesting that phonology is particularly sensitive to contrastive feature specifications.

7.9.2. *Clements's approach to contrastive specification*

Clements (2001, 2003, 2004) has been developing an approach to contrastive feature specification that has some affinities with MCS, as well as some important differences. Like MCS, Clements (2001) proposes that only *active features* are specified in the phonology, where his notion of 'active feature' is essentially the same as the one assumed here. However, Clements does not tie

activity to contrast, as supposed in the strong version of the Contrastivist Hypothesis. Clements (2001: 77–78) proposes three conditions for feature specification, corresponding to the lexical, phonological, and phonetic levels, respectively (7.84).

(7.84) Conditions for feature specification (Clements 2001: 77–78)

a. Lexical level: distinctiveness

A feature or feature value is present in the lexicon if and only if it is distinctive (in a sense to be defined).

b. Phonological level: feature activity

A feature or feature value is present at a given phonological level if it is required for the statement of phonological patterns (phonotactic patterns, alternations) at that level.

c. Phonetic level: pronounceability

Feature values are present in the phonetics if required to account for relevant aspects of phonetic realization.

Condition (a) requires that only contrastive features are specified in the lexicon; the method of determining what these are is discussed below. Condition (b) allows for the specification of features if required in the phonology, that is, if they are active. This condition represents a severe weakening of the Contrastivist Hypothesis. The latter starts with the assumption that only contrastive features are active in the phonology, which would require that the features specified to satisfy condition (a) should be the same as the active features required by condition (b). Of course, it is an empirical question if this hypothesis can be

maintained; Clements (2001) believes that this condition is too strong. There is indeed evidence that the strongest version of the Contrastivist Hypothesis cannot be maintained (see the next section). However, the theory in (7.84) represents an extreme retreat from the strongest version, essentially abandoning the Contrastivist Hypothesis, for it allows redundant features to be added freely in the phonology, with no restrictions. It is possible that this is the correct approach, but there are several ways of relaxing the strong Contrastivist Hypothesis before arriving at this position.

Like MCS, Clements (2001) assumes that contrastive specifications at the lexical level are introduced by means of a feature hierarchy, called an *accessibility hierarchy* in Clements 2001; it is slightly revised and called a *robustness scale* in Clements (2004). This scale is presented in (7.85).

(7.85) Robustness Scale for consonant features (Clements 2004: 31)

- a. [ $\pm$ sonorant]
  - [labial]
  - [coronal]
  - [dorsal]
- b. [ $\pm$ continuant]
  - [ $\pm$ posterior]
- c. [ $\pm$ voiced]
  - [ $\pm$ nasal]
- d. [glottal]
- e. others

Unlike the assumption pursued here that the contrastive hierarchy may vary cross-linguistically, Clements assumes that the robustness scale is universal. The empirical import of this claim is substantially weakened by condition (b) in (7.84), however: since phonological activity is not evidence bearing on which features are contrastive, it is difficult to prove or disprove any proposed set of contrastive features for a particular language.

Clements argues that the robustness scale is supported in a general sense by the distribution of phonological inventories and the order of appearance of contrasts in the course of acquisition. Cross-linguistic evidence can certainly be useful in establishing general tendencies and perhaps even some default feature orderings. However, in the absence of any language-particular criteria for identifying contrastive features, one cannot tell if a particular language follows the general ordering or not. Second, the cross-linguistic evidence itself could be compromised, as Hall (2007: 187–188) points out. The robustness scale is at the same time a hypothesis about what phonological inventories are universally preferred, as well as a guide to which features in a particular inventory are contrastive. For example, according to the scale in (7.85), a contrast between /t/ and /s/ involves the feature [continuant] rather than [strident], because the former feature is higher in the scale. But then, as Hall observes, we cannot take

this analysis as evidence that [continuant] is universally preferred over [strident].<sup>29</sup>

To sum up, Clements makes stronger claims about the universality of the feature hierarchy than I am willing to make, but weaker claims about the connection between contrast and phonological activity. The two positions are closely linked: it is easier to argue for a universal feature hierarchy if one does not take into account phonological activity; conversely, it is easier to argue that active features are contrastive if one is not bound to a universal feature hierarchy. It is reasonable to consider the robustness scale in (7.85) as a hypothesis about the default universal feature hierarchy, but one that is subject to variations under language-particular conditions.

Herd (2005) takes this approach, adopting the hierarchy proposed in Clements 2001 as an initial hypothesis for the contrastive hierarchies of the Polynesian languages in the study discussed above. As a result of loanword evidence, he proposes that variation may be introduced into the hierarchy under specific conditions. For instance, in the hierarchy of Clements (2001), [spread] is ranked higher than [continuant], with the consequence that the contrast between /h/ and a stop should involve [spread], not [continuant]. As we have seen, [spread] distinguishes /h/ from other phonemes in Hawaiian, but the loanword

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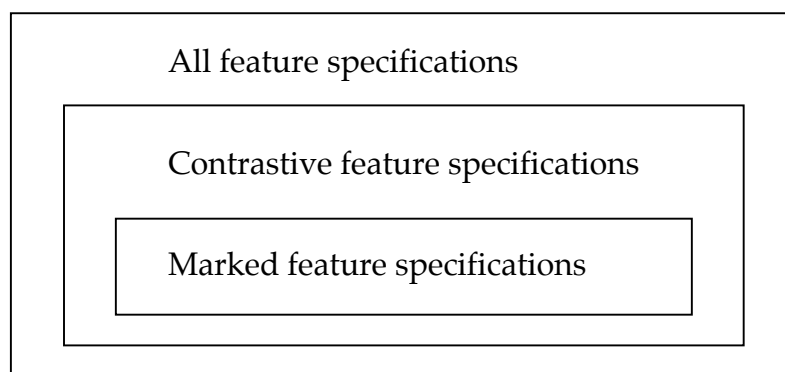
<sup>29</sup> Hall (2007: 188) also points to valid typological evidence that Clements (2004) draws on to support the robustness scale; see Hall (2007) for an extended discussion of feature economy from a contrastivist point of view.

evidence suggests that [continuant] is the contrastive feature in NZ Māori. Herd proposes to keep the general ordering of [spread] > [continuant], but to allow [spread] to be accessible only if it contrasts with another glottal segment.<sup>30</sup>

### 7.9.3. Calabrese (2005): *Visibility Theory*

Calabrese (2005: 68–69) proposes a theory of markedness and of contrast. Like MCS, he proposes that some rules target only *contrastive* feature specifications. Other rules target only *marked* contrastive specifications, a position that is also consistent with MCS practice. However, he also freely allows rules to target *all* feature specifications, a major weakening of the Contrastivist Hypothesis. The three classes of rules are diagrammed in (7.86). Calabrese calls this Visibility Theory, an approach taken also by Halle 1995, Halle, Vaux and Wolfe 2000, Vaux 2000, and Nevins 2004, 2005.

(7.86) Visibility Theory: accessible features (Calabrese 2005: 68)



<sup>30</sup> In the revised robustness scale (7.85), [continuant] has been moved above [spread glottis], so a slightly different modification of the scale would be required to promote the latter feature over [continuant] in the presence of a laryngeal contrast.

In addition to allowing phonological rules to freely access noncontrastive features, Calabrese's approach to markedness and contrast are different from what is assumed here.

#### 7.9.3.1. *Calabrese: markedness filters*

Calabrese (1988, 1994, 1995) proposes that markedness is encoded in a series of universal markedness statements, or filters, of the form in (7.87).

(7.87) Format for marking statements (Calabrese 1988, 1994)

$*[\alpha F, \beta \underline{G}] / [ \text{____}, X]$

means that  $[\beta G]$  is not permitted in the context of a segment bearing  $[\alpha F]$  and  $X$ , where  $F, G$ , are features;  $\alpha, \beta$ , are + or –; and  $X$  is a set of feature specifications.

For example,  $*[+back, \underline{-round}] / [ \text{____}, -low]$  means that  $[-round]$  is not permitted on a segment specified  $[-low, +back]$ . These statements can be overridden in particular grammars, resulting in marked segments. The markedness statements (implicitly) encode a hierarchy of features against which contrast is assessed, in that feature  $G$  has a marked value in the context of  $F$  and  $X$ . Such a statement presupposes, in our terms, that  $F$  and the features that constitute  $X$  are ranked higher than  $G$ ; in this example,  $[low], [back] > [round]$ . Calabrese (2005: 126) proposes that the ordering of most of the features can be derived from the robustness scale proposed by Clements (2004). Calabrese observes that, to the extent that the features are ordered by independent



principles, it is not necessary to designate feature G as the dependent feature by means of an underscore; the notation can thus be simplified to  $*[\alpha F, \beta G]/...$

Calabrese's approach to markedness statements is not only hierarchical, but also has a binary aspect, evident in the format adopted for marking statements. According to Calabrese (1994: 42), 'by restricting the focus of the statement to only two features, we capture the intuition that the basic relationships between feature specifications involve pairings of features, as observed by Stevens, Keyser & Kawasaki (1986). For example, there is a special acoustic relationship between [+back] and [−round] which is not shared by [−low]...' In this way, his version of markedness theory has connections with enhancement in MCS.

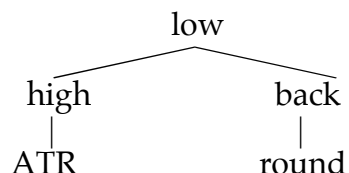
Calabrese (2005) proposes the marking statements in (7.88) for vowels.

(7.88) Marking statements for vowels (Calabrese 2005: 439)

- a.  $*[-low, -high]$
- b.  $*[-high, +ATR]$
- c.  $*[+low, -back]$
- d.  $*[-back, +round]$
- e.  $*[+high, -ATR]$
- f.  $*[+back, -round] / [ \_\_\_\_\_\_, -low]$
- g.  $*[+low, +round]$
- h.  $*[+low, +ATR]$
- i. Prohibition:  $*[+high, +low]$

Features in the context are ordered above features in the focus of a marking statement (so that  $X > F > G$  in (7.87)); the statements in (7.88) are consistent with a single partial ordering of features, as shown in (7.89).

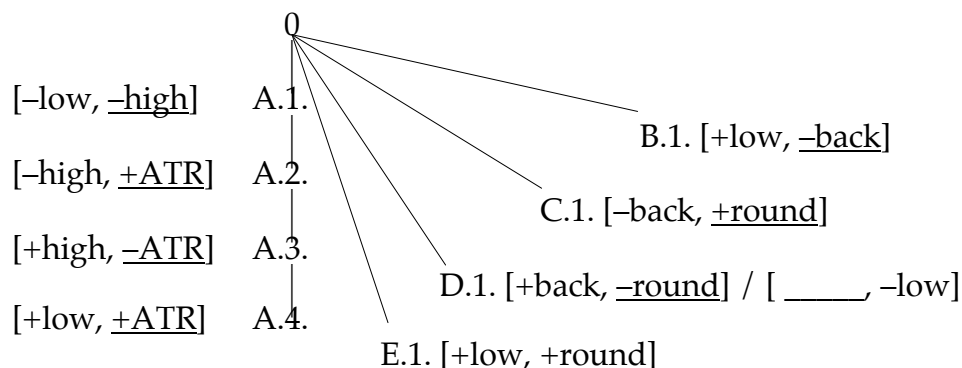
(7.89) Partial feature ordering presupposed by (7.88)



Calabrese (1994) proposes that marked segments can be assigned a Degree of Complexity, indicating how marked they are. In the case of vowels, there are no marking statements ruling out a [+low] vowel that is [+back, –round, –ATR], namely /a/. Similarly, there is no statement restricting high vowels that are [–back, –round, +ATR] or [+back, +round, +ATR], namely /i/ and /u/, respectively. Thus, these vowels have Degree of Complexity 0, and the prediction is that vowel systems consisting of /i a u/ should be very common.

With respect to the marking statements themselves, Calabrese proposes that they are arranged according to the scale shown in (7.90).

(7.90) Degree of Complexity scale (Calabrese 1994:45)



In the branch designated A, a marking statement may not be deactivated until the one above it is. Thus, deactivating A.1 enables a vowel to be specified [–low, –high], adding the vowels /ε ɔ/ to the basic /i a u/. These vowels have Degree of Complexity 1. Statement A.2 prohibits vowels that are [–high, +ATR]. Since [+low, +ATR] is ruled out by A.4, deactivating A.2 permits vowels that are [–low, –high, +ATR], namely /e o/. The ordering of A.1 before A.2 is intrinsic, because the specification [–low, –high] is properly contained within [–low, –high, +ATR]. In this case the greater complexity of the latter can be derived from the marking statements themselves.

The same does not hold of statement A.3, however. Given that we have a vowel that is [+high, +ATR] that has Degree of Complexity 0, one would think that adding [+high, –ATR] would add one further degree of complexity, rather than two. Moreover, this expansion is in no formal sense a further step on the path marked out by A.1 and A.2, which expands a path beginning with [–low], and successively adds [–high] and then [+ATR]. A.3 is on a path from [–low, +high]. Calabrese's stated motivation for making A.3 subordinate to A.2 is to capture the empirical generalization that languages that have [+high, –ATR] vowels, /ɪ ʊ/, also have all the vowels permitted by A.1 and A.2.<sup>31</sup> Similarly, A.4

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<sup>31</sup> This generalization may hold of typical African languages with ATR or RTR vowel contrasts, but it does not appear to be true of Manchu-Tungus languages, which typically have two height classes, each of which may have ATR or RTR contrasts. In these languages, there is no

is on an independent path relative to the other statements in A, being an expansion of [+low]. The motivation for putting it where it is is again empirical, following the assumption that a low [+ATR] vowel can only arise in systems that have the other vowels permitted by the other statements in A.

If we consider the other paths marked B-E, we again find that they do not follow in any systematic way from the nature of the marking statements themselves. B.1 has Degree of Complexity 1; with just this addition to the basic three-vowel set, we obtain the vowel system /i æ a u/. E.1, which adds the vowel /ɒ/ to the basic set, is formally similar to B.1, and its presence on an independent path indicates that the presence of /ɒ/ does not presuppose /æ/ or any of the vowels permitted by C and D. Nevertheless, Calabrese wishes to indicate that /ɒ/ is more complex than /æ/, and he does this graphically by putting E further from the root of the tree than B. Thus, B, C, D, E represent steps of increasing complexity, though none presupposes any of the others.

While the intuitions behind these relative degrees of complexity may have some merit, it is not clear how the graphic display follows from anything else in the markedness theory. While in some cases relative degree of complexity follows from the marking statements, in the majority of cases both the dependencies and the relative degree of complexity are stipulated.

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phonological class of [-low, -high] vowels, though there are vowels that are [+high, -ATR]. See Zhang (1996) for discussion of such systems.

Of most interest to our theme is the connection between the markedness statements and Calabrese's approach to contrast.

#### 7.9.3.2. *Calabrese's approach to contrast*

In addition to markedness, Visibility Theory makes reference to contrastive feature specifications. Therefore, a procedure for selecting contrastive specifications is required. Calabrese (2005) proposes a procedure that looks very complicated, but which is, in essence, a combination of the pairwise method bolstered by a feature hierarchy that was described in Chapter 2: contrastive specifications are those that are not logically redundant; where two features make each other logically redundant, priority is given to the feature that is higher in the robustness scale. Calabrese's own definition is given in (7.91).

(7.91) Formal definition of contrast (Calabrese 2005: 438)

- i. Given an active constraint  $*[\alpha F, \beta G]$  in a system  $S$ ,  $[-\beta G]$  is noncontrastive in the context of  $[\alpha F]$ , and  $[-\alpha F]$  is noncontrastive in the context of  $[\beta G]$ ;
- ii. if  $*[\alpha F, \beta G]$  and  $[-\alpha F, -\beta G]$  are active in  $S$ ,  $[-\beta G]$  is noncontrastive in the context of  $[\alpha F]$ , and  $[\beta G]$  is noncontrastive in the context of  $[-\alpha F]$  where  $[G]$  is marked with respect to  $[F]$ .

Clause (i) defines as noncontrastive those feature specifications that are logically redundant in pairs of features. For example, given a constraint  $*[+low, +round]$ , it is predictable that a low vowel must be  $[-round]$ ; by the same token, any vowel that is  $[+round]$  must be  $[-low]$ . If we assume that  $[low] > [round]$ , then the first conclusion is consistent with the contrastive hierarchy:  $[round]$  is

not contrastive in the domain of [low]. The second conclusion allows the lower feature to make the higher one noncontrastive.

The danger of the procedure in clause (i) is that features can make each other noncontrastive, resulting in the designation of both as noncontrastive, thereby failing to distinguish between phonemes. For such cases, clause (ii) stipulates that one chooses the feature that is higher in the hierarchy as contrastive.

Consider how this procedure will apply to the three-vowel inventory /i a u/. We begin with the full feature specifications (7.92a).

(7.92) Assigning contrastive specifications (Calabrese 2005: 438–440)

a. Begin with full specifications

	i	u	a
low	–	–	+
high	+	+	–
back	–	+	+
round	–	+	–
ATR	+	+	–

- b. Features that make each other logically redundant
- i. [low] and [high]                      [low] > [high]
  - ii. [back] and [round]                      [back] > [round]
  - iii. [low] or [high] and [ATR]              [low], [high] > [ATR]
- c. Reduced feature set                      d. Contrastive specifications
- |      | i | u | a |  | i | u | a |
|------|---|---|---|--|---|---|---|
| low  | – | – | + |  |   | – | + |
| back | – | + | + |  | – | + |   |

All the markedness statements in (7.88) are active in this inventory; thus, many features make each other logically redundant (7.92b), a problem for the pure Pairwise Algorithm. In Calabrese's procedure, such feature pairs fall under clause (ii) of (7.91). In each case, the feature higher in the hierarchy renders the lower one noncontrastive. In this way, we effectively dispatch the features [high], [round], and [ATR], reducing the set of potentially contrastive features to two (7.92c). Now clause (i) of (7.91) enacts the Pairwise Algorithm, resulting in the familiar pairwise contrastive pattern of (7.92d), where /u/ is the middle phoneme that forms a minimal pair with each of the others.

This procedure for contrastive specification is open to many of the objections raised in Chapter 2 against versions of the pairwise method: it fails the Distinctness Condition, and it uses both feature ordering and pairwise comparison when the former alone is sufficient. The most important objection, however, is empirical: this theory does not allow for variation in the feature

hierarchy, and so will arrive at the same contrastive relations for every similar-looking inventory. We have seen throughout that this is an undesirable result.

Curiously, Calabrese (2005: 430–433) levels the same objection against the theory in Drescher 2002, the same as the one being advocated here. Calabrese first mischaracterizes it as being identical to the approach taken by Clements (2001), which he considers to be a simpler reformulation of Drescher 2002. We have seen that a crucial difference between Clements's approach and the one taken here is that Clements assumes a universal feature ordering (the robustness scale) that does not take phonological activity into account, whereas I assume that the feature order is variable, and that the chief source of evidence for what the hierarchy is in a language derives from the pattern of phonological activity in that language.

Calabrese observes, correctly, that if we suppose that [back] is universally ordered above [round], then the SDA will assign the contrastive feature [–back] to both *i* and *y* in a system like /i y u/ (looking only at high vowels, for ease of exposition). He observes, also correctly, that this is the wrong result for languages like Finnish and Hungarian which have palatal (front/back) harmony, in which the front unrounded vowel /i/ is neutral. The correct analysis is one in which the front unrounded vowels are not contrastively specified for the harmonizing feature, which requires the ordering [round] > [back]. This may be a problem for Clements, but since I do not assume a universal ordering, the ordering [round] > [back] is possible (see D'Arcy 2003b for a contrastive analysis using other features).



Calabrese's argument actually cuts the other way. If Trubetzkoy is to be believed about Polabian (see Chapter 3), in that language the three vowels /i y u/ have different contrastive relations than they do in Finnish and Hungarian; in Polabian, /i/ and /y/ are both contrastively [–back] against [+back] /u/. That is, whereas in Finnish and Hungarian /y/ and /u/ are partners with respect to [back] while /i/ is neutral, in Polabian /i/ and /y/ are partners with respect to [round] while /u/ is neutral. These different relations correspond to different contrastive hierarchies. It is Calabrese's theory that cannot capture this variability.

Similar arguments can be made for other inventories where we have seen variation in the system of contrasts. To take just one more example, consider again the four-vowel /i a o u/ system of Yowlumne. We have seen that the phonological patterning of this language is best accounted for by assuming that [labial] (or [round]) is contrastive and [coronal] (or [front]/[back]) is not, because the language is characterized by height-bounded rounding harmony. Yowlumne vowels can be assigned the specifications in (7.93).<sup>32</sup>

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<sup>32</sup> The vowel usually transcribed as *o* is here given as a low vowel *ɔ*, following Newman (1944: 19); see also Hall (2007: 115) and the next section.

## (7.93) Yowlumne vowels: full specifications

	i	u	a	ɔ
low	–	–	+	+
high	+	+	–	–
back	–	+	+	+
round	–	+	–	+
ATR	+	+	–	–

Following Calabrese's procedure, we observe that [low] and [high] make each other mutually logically redundant, so we dispense with [high]. [ATR] is also fully predictable given [low], and vice-versa; since [ATR] ranks lower, it can be removed as being entirely noncontrastive. Since /a/ and /ɔ/ are a minimal pair based on [round], those feature values must be marked as contrastive. But even though /i/ and /u/ make a parallel pair distinguished by [round], [round] in this case is trumped by [back]: in the non-low vowels they predict each other, but [back] ranks higher in the universal scale. Therefore, we arrive at the contrastive representations in (7.94). This set of contrastive representations does not at all reflect the patterning in the language, and contradicts the intuition, shared by every analysis of this language I have seen, that Yowlumne vowels are divided on the basis of rounding, not backness.<sup>33</sup>

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<sup>33</sup> Calabrese could still capture rounding harmony, but he would have to characterize it as targeting all features, not just contrastive features.

(7.94) Yowlumne contrastive specifications by (7.91)

	i	u	a	ɔ
low	–	–	+	+
back	–	+		
round			–	+

### 7.9.3.3. *Systematic and accidental gaps*

Another example where Calabrese's adherence to contrasts based on minimal pairs leads to an undesirable result is with respect to Russian voicing assimilation. We have seen that voicing is not contrastive among the sonorants, and so they do not participate in voicing assimilation. The problem is that the obstruents /f, x, ts, tʃ/ pattern with the other contrastively voiceless obstruents, though they have no voiced (minimal) counterparts. Calabrese proposes that, unlike sonorants, there is no universal marking statement making fricatives and affricates voiceless. Thus, the absence of their voiced counterparts is an 'accidental' gap, not a systematic one. He proposes that the accidental absence of segments from a phonological inventory does not determine the underlying specifications of the segments of that inventory. Therefore, the unpaired fricatives and affricates can be treated as contrastively voiceless.

Besides being a very complicated way of arriving at this result, this procedure seems to contradict the intuitive notion of what it means to be contrastive in a system. The theory proposed here has a much simpler way of

arriving at the same result while limiting the evaluation of contrast to contrasts actually observed within the system in question.

Hall (2007: 65–66) presents a contrastivist analysis of Russian voicing assimilation. Following Avery (1996), he proposes that Russian is for the most part a ‘Laryngeal Voice’ (LV) language, where voiceless obstruents have a bare Laryngeal node, and voiced obstruents have a Laryngeal node with a dependent feature [voiced].<sup>34</sup> Sonorant consonants have a sonorant voicing [SV] node.<sup>35</sup>

Using the Successive Division Algorithm, we can appeal to the hierarchy of features to explain both the non-contrastive nature of voicing among sonorants, and its contrastive status even among the unmatched obstruents. As is common, we assume that the feature [sonorant] (in this analysis, [SV]), is high in the hierarchy and divides the sonorants from the obstruents. Since the sonorants are not contrastive for [Laryngeal], they do not participate in voicing assimilation. All non-sonorant consonants (other than /v/) receive the [Laryngeal] feature. All that is required for the unpaired obstruents to be

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<sup>34</sup> Avery (1996) has elements of feature geometry together with a contrastive hierarchy. In keeping with the discussion in Chapter 5, we can think of [Laryngeal] as simply a feature, and [voiced] is another feature that is contrastive in the domain of [Laryngeal]. Hall (2007) follows Avery in regarding [voice] as a dependent of [Laryngeal].

<sup>35</sup> Russian also has a consonant /v/ which is a target of voicing assimilation but does not trigger it. Hall (2007) analyzes /v/ as belonging to a distinct voicing class which has neither a [Laryngeal] nor [SV] feature. I will not discuss this segment here.

contrastively voiceless is for the voicing feature to be higher in the order than the features that distinguish the unpaired consonants from all the other consonants.

(7.95) Partial contrastive feature hierarchy for Russian

[SV], [Laryngeal] > [voiced] > other features

Thus, Calabrese's distinction between systematic and accidental gaps in an inventory can be modeled in terms of the contrastive hierarchy. The difference between gaps that are perceived as systematic as opposed to those that are perceived as accidental is a function of where in the hierarchy the gap occurs. Thus, the lack of voiced sonorants looks systematic when the [sonorant] feature is ordered above [voice], for then no sonorant consonant has a specification for [voice]. The same gap would look more accidental if [voice] were ordered ahead of [sonorant]. This conclusion is presented formally in (7.96).

(7.96) 'Gaps' in the light of the Successive Division Algorithm

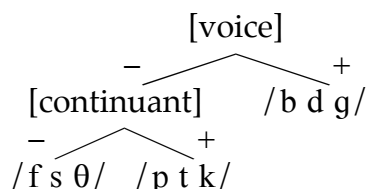
If  $\tau$  is a segment with feature  $[\alpha G]$ , and if  $\Phi$  is the minimal set of ordered features that distinguishes  $\tau$  from all the segments that have  $[-\alpha G]$ , then the absence of a segment  $\sigma$  that differs minimally from  $\tau$  by the feature  $G$  is 'accidental' iff  $G >$  at least one of  $\Phi$  ( $\tau$  is contrastively  $[\alpha G]$ ), and is 'systematic' if all of  $\Phi > G$  ( $\tau$  is redundantly  $[\alpha G]$ ).

An interesting example is provided by Moulton (2003), in an analysis of Old English fricatives. The Old English fricatives /f s θ/ do not contrast lexically with respect to voicing, but, like the Russian unpaired fricatives and affricates, they enter into voicing alternations, and have voiced allophones. Moulton

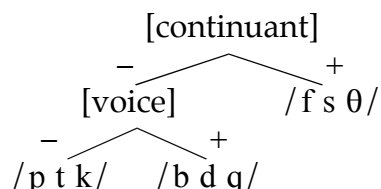
proposes that they are contrastively [–voice], a specification that follows from the contrastive hierarchy in (7.97a).

(7.97) Old English fricatives (Moulton 2003: 161)

a. Moulton's analysis



b. An incorrect analysis



Divided up as in (7.97a), the lack of voiced continuants could be called ‘accidental’: the feature [continuant] occurs in the domain of [–voice], but there happen not to be any continuants under [+voice]. Another way of dividing up the inventory (7.97b) makes the gap appear to be more ‘systematic’: voicing contrasts are permitted in the domain of [–continuant], but not in the domain of [+continuant]. On this analysis the fricatives have no contrastive specification for [voice], a result that is contradicted by their behaviour with respect to voicing alternations. It follows that whether a gap is considered systematic or accidental is to some extent a matter of the point of view of the analyst.

### 7.10. *Refining the Contrastivist Hypothesis*

Throughout this study I have been assuming the form of the Contrastivist Hypothesis as stated in Chapter 3: ‘the phonological component of a language L operates only on those features which are necessary to distinguish the phonemes of L from one another’ (Hall (2007: 20). This formulation captures the intuitive idea that the ‘phonemic content’ or ‘pattern alignment’ of a phoneme is made up

of its contrastive feature specifications. In this section I would like to consider the empirical adequacy of the Contrastivist Hypothesis. I will conclude that the Contrastivist Hypothesis in its strong form cannot be maintained, but that less drastic weakenings are possible than are assumed in the other approaches to contrast survey above.

#### 7.10.1. *Is the Contrastivist Hypothesis too weak?*

Before considering if the Contrastivist Hypothesis is too strong, I would like to briefly consider whether it might also be too weak. Saying that a theory is too weak means that it is not sufficiently constrained, and thus is hard, in the limit, impossible, to falsify.

I addressed this question at the end of Chapter 3, where I showed that the Contrastivist Hypothesis is easily falsifiable. It is enough to find examples of more features being phonologically active than are permitted to be contrastive. As our review of the approaches of Clements and Calabrese has shown, these theorists assume that such cases are common, enough that they allow noncontrastive features to freely figure in the phonology. I conclude, then, that the Contrastivist is all too falsifiable, and therefore not too weak in this regard.

#### 7.10.2. *Is the Contrastivist Hypothesis too strong?*

The real question to be addressed is whether the Contrastivist Hypothesis is too strong, and if so, in what ways? When considering counterexamples, it is important to distinguish between apparent counterexamples and real ones.

The world is full of apparent counterexamples to the Contrastivist Hypothesis that turn out not to be real counterexamples to the theory presented here. One reason for this is that many studies make different — I would say incorrect — assumptions about which features are contrastive. Many phonologists arrive at contrastive specifications by something like pairwise comparison. This approach, we have seen, takes logical redundancy as its basic criterion for deciding if a feature specification is contrastive or not. Such theories typically designate too few feature specifications as being contrastive. That is, there will typically be features that the SDA in a certain ordering designates as contrastive that pairwise comparison designates as redundant. If such a feature is active, then we have an apparent violation of the Contrastivist Hypothesis, but one which dissolves when we recognize the feature in question to be contrastive.

For example, the famous unpaired fricatives and affricates of Russian are active in voicing assimilation. If pairwise comparison is the procedure for assigning contrastive features, the [–voice] specifications of these phonemes will be designated as redundant, with the result that a redundant feature triggers assimilation, in violation of the Contrastivist Hypothesis. Adopting the contrastive hierarchy as the procedure for assigning contrasts results in a different conclusion: the features in question are contrastive, and there is no violation of the Contrastivist Hypothesis.

To take another example, Yowlumne labial harmony is triggered by both /o/ and /u/. A number of theories find that the [labial] (or [+round]) specification on /u/ is redundant; this could be because [back] must take



precedence over [round], or because /u/ is not sufficiently ‘crowded’, or because [labial] is not the sole feature that distinguishes /u/ from any other phoneme, and so on. In any such theory the crucial harmonic feature is noncontrastive. But in the approach taken here [labial] is contrastive on both /u/ and /o/, and there is no violation of the Contrastivist Hypothesis.

It is only to be expected that there will be many such cases, given the widespread use of pairwise comparison in determinations of which features are contrastive. Therefore, many apparent violations of the Contrastivist Hypothesis can be resolved with a different – I would say correct — assignment of contrastive feature specifications.

Another source of uncertainty concerns the dividing point between the phonological component, in which only contrastive features are computed, and the postlexical or phonetic components where this limitation does not obtain. If a post-phonological rule that refers to redundant features is incorrectly assigned to the phonological component, we will create an apparent counterexample to the Contrastivist Hypothesis that will disappear once the rule is reassigned to its correct component.

That said, not all counterexamples to the Contrastivist Hypothesis can be resolved in these ways, and we are left with real counterexamples that have to be accounted for. Hall (2007) presents one class of cases of this kind, and proposes in response a slight modification of the Contrastivist Hypothesis.

### 7.10.3. 'Prophylactic' features (Hall 2007)

Yowlumne Yokuts provides a real counterexample to the Contrastivist Hypothesis. We have seen that the underlying vowel system of Yowlumne is specified by two contrastive features, repeated here in more detail as (7.98).

(7.98) Yowlumne underlying vowels

-round	+round	
i i:	u u:	+high
a a:	o o:	-high

In lexical (underlying) forms, Yowlumne has a symmetrical vowel system where each short vowel has a long counterpart. Underlying long high vowels, however, are not pronounced as such, but are lowered. /u:/ lowers to /o:/, as expected, but lowered /i:/ comes out as [e:], not as [a:]. Inspection of the features in (7.98) reveals that the allophone /e:/ cannot be accommodated with the two features [high] and [round]. A third feature is required to keep *e:* distinct from *a:*, and whatever this feature is, it cannot be contrastive. Since the lowering rule feeds further phonological rules, such as shortening (see Kenstowicz and Kisseberth 1977 for a detailed exposition), it is unlikely that it is simply a late phonetic rule. This, then, is a case where a noncontrastive feature is needed in the phonology.

Hall (2007, in press) proposes that the noncontrastive feature [+low] must be attributed to /a a:/.<sup>36</sup> When /i:/ lowers, it loses its specification [+high], but does not take on [+low]. Thus, it remains distinct from /a:/. Hall observes that the function of the redundant feature [low] is purely passive: it serves only to distinguish segments that would otherwise be neutralized. He calls such features *prophylactic*, defined as in (7.99).

(7.99) Prophylactic features (Hall 2007: 87–88)

A prophylactic feature is a redundant feature that is crucially present in the representation of a segment before the phonological computation begins, but which is invisible to all phonological rules.

Hall discusses several such examples. To cite one more, Czech /t/ and /ř/ (IPA ɽ) are distinguished only by the feature [Laryngeal], in the analysis of Hall (2007). Devoicing, on this account, is effected by the addition of [Laryngeal]. However, when /ř/ devoices it does not merge with /t/, but appears as voiceless [ɽ̥], an allophone that does not exist as a distinct phoneme in Czech. To prevent the merger, Hall proposes that /ř/ bears the prophylactic feature [Vibrant]. Like Yawlumne [low], this feature does not figure in the phonological

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<sup>36</sup> Hall (2007, in press) adopts privative features [high], [low], and [peripheral] (for [round]). For ease of exposition I will continue to use binary features. Hall observes that the presence of [low] on /a/ predicts that it should remain a low vowel when it is rounded to /o/. He argues that this is indeed the case, and that the vowel /o/ is transcribed by Newman (1944: 19) as ɔ, ‘as in German *voll* and English *law*’.

computation: it does not trigger rules, and it is not referred to by rules. However, its presence prevents the merger of two phonemes.

Positing prophylactic features represents a minimal retreat from the Contrastivist Hypothesis. It remains to specify under what conditions such features typically arise, and whether other types of counterexamples must be recognized. In the meantime, the range of cases where the Contrastivist Hypothesis is upheld and contributes to illuminating analyses suggests that it is well worth maintaining and refining as a basic principle of phonological patterning.

## 8. Conclusion

‘The stone that the builders rejected has become the chief  
cornerstone.’

*Psalms* 118: 22.

This book has been about the contrastive hierarchy in phonology. In one sense, ‘phonology’ refers to phonological theory as it has been understood and practised from the 1920s until today. I have tried to trace the history of the notion of a contrastive feature hierarchy, and its various guises as it has appeared and disappeared in different versions of phonological theory. In another sense, ‘phonology’ can be understood as a component of the language faculty whose properties phonologists are trying to discover. In this sense, I have looked for evidence of the role that the contrastive hierarchy plays in contributing to an understanding of this cognitive domain.

In both aspects of this study the fate of the contrastive hierarchy has been closely connected to another central concept, the Contrastivist Hypothesis. The Contrastivist Hypothesis states that only contrastive features are active in the phonology. To properly test whether this hypothesis is correct, we need to have reliable ways of identifying the ‘contrastive features’. We also need to know what it means for a feature to be ‘active’, and what place ‘in the phonology’ refers to; but my main concern here has been contrast. I have argued that the contrastive hierarchy is crucial to the Contrastivist Hypothesis, because it

provides the proper way to identify contrastive features. Conversely, the Contrastivist Hypothesis is crucial to the contrastive hierarchy because the former supplies the main empirical reasons for being interested in the latter, at least as far as phonology is concerned.

These two concepts have not always been linked in phonological theory. On the contrary, they have more usually been dissociated, with sometimes one, sometimes the other coming to the fore. At the risk of simplifying a complex history, the story can be summed up as follows. Something like the Contrastivist Hypothesis was adopted by the principal phonological theorists in the first half of the twentieth century, but the notion of a contrastive hierarchy remained inchoate. Though it played an implicit role in the most interesting Structuralist contrastivist analyses, it remained unformulated, and competed with a pairwise approach to contrast that relied on logical redundancy and minimal pairs.

The 1950s were a turning point. For the first time the contrastive hierarchy was explicitly proposed as governing feature specifications. At the same time, however, the Contrastivist Hypothesis began to be deemphasized. The contrastive hierarchy came to be viewed mainly as a way of minimizing redundancies in phonological specifications, not as a way of capturing phonological generalizations. The Contrastivist Hypothesis was abandoned in early generative phonology, and when redundant feature values were shown to cause technical and empirical problems, the contrastive hierarchy also disappeared from phonological theory.

But not entirely. In Chapters 5 and 6 I traced the influence of these concepts in generative phonology and in Optimality Theory. As in earlier incarnations of phonological theory, sometimes the Contrastivist Hypothesis was adopted without the contrastive hierarchy, and sometimes feature hierarchies were proposed, but without a connection to contrastive specification.

In the final chapter the focus is on empirical evidence for the Contrastivist Hypothesis and the contrastive hierarchy. I outlined the main tenets of the theory of Modified Contrastive Specification (MCS), in which the Contrastivist Hypothesis is united with the contrastive hierarchy, and reviewed a number of case studies that adopt this framework. I also briefly looked at some other contemporary approaches to contrast, arguing that the MCS approach accounts better for the data.

This study has only touched on a few aspects of a multifaceted topic. I hope to have shown that the contrastive hierarchy merits its former designation as a 'pivotal principle, even if not *the* pivotal principle, of linguistic structure.





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