# Frontiers of Phonology: Atoms, Structures, Derivations

Jacques Durand
and Francis Katamba

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# Frontiers of Phonology: Atoms, Structures, Derivations

Edited by Jacques Durand and Francis Katamba

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AND FRANCIS KATAMBA

# Contributors

**Lee Bickmore** is Assistant Professor of Linguistics and Cognitive Science at the University of Albany, State University of New York. His contributions to the field include descriptions and analyses of some lesser-known Bantu languages on which he has collected the primary data. His work addresses various factors which influence the application of tone rules, especially those which are syntactic or metrical in nature.

**Wiebke Brockhaus** is Lecturer in German at the University of Huddersfield. She has worked mainly on aspects of the phonology of German, especially on final devoicing, about which she is now writing a book (based on her 1992 University of London PhD thesis). Having participated in a Government Phonology-based automatic speech recognition project at the School of Oriental and African Studies (University of London) in the past, she is currently involved in a similar undertaking at the University of Huddersfield.

**John Coleman** is Director of the Phonetics Laboratory at the University of Oxford. He has written many papers on declarative phonology, and has a special interest in developing computational implementations of non-segmental phonology and phonetics in speech synthesis. He is co-author (with J. P. Olive and A. Greenwood) of *Acoustics of American English Speech* (1993).

**Jacques Durand** is Professor of French and Linguistics at the University of Salford (Greater Manchester). His research work has mainly been in the areas of Machine Translation and Phonology (both general and applied to French) where he has published widely. His publications include *Generative and Non-Linear Phonology* (1990) and as editor or co-editor *Dependency and Non-Linear Phonology* (1986), *Explorations in Dependency Phonology* (1987), *Essays in Grammatical Theory and Universal Grammar* (1989). He was the Chairman of the Department of Modern Languages at Salford between 1992 and 1994, and in 1993 he became the Director of its European Studies Research Institute.

**John Harris**, Reader in Linguistics at University College London, writes on phonological theory, language change and the history of English. He is the author of *Phonological variation and change* (1985, Cambridge University Press) and *English sound structure* (1994, Blackwell).

**Harry van der Hulst** is Associate Professor in the department of general linguistics and the Holland Institute of Generative Linguistics (HIL) of the Leiden University (in the Netherlands). His publications deal mainly with issues in non-linear phonology, and in particular with stress, segmental structure and phonological aspects of sign language. He has edited over ten books on phonology and is currently Editor-in-chief of the international linguistic journal 'The Linguistic Review' (since 1990) and series editor of 'Linguistic Models' (Mouton de Gruyter).

**Francis Katamba** is Lecturer in linguistics at Lancaster University. He is the author of *An Introduction to Phonology* (1989), *Morphology* (1993) and *English Words* (1994). He has also written on the implications of Bantu for phonological and morphological theory. His edited books include *Bantu Phonology and Morphology* (1995).

**Jonathan Kaye** is Professor of General Linguistics at the School of Oriental and African Studies (University of London). The author of many books and papers on various aspects of phonological theory, notably *Phonology: A cognitive view* (1989), '*Coda*' *Licensing* (1990) and *Constituent structure and government in phonology* (1990, with Jean Lowenstamm and Jean-Roger Vergnaud). Along with the two last mentioned linguists, he is one of the originators of the theory of Government Phonology.

**Geoff Lindsey** is Lecturer in Linguistics in the University of Edinburgh's Linguistics Department. He has directed the Department's Laboratory, and has published in phonetics and phonology. He is also known for work on the semantics of intonation.

**Douglas Pulleyblank** is Associate Professor at the University of British Columbia. His research has centred on autosegmental representations, with a focus on West African languages. He is the author of *Tone in Lexical Phonology* (1986) and *Grounded Phonology* (with Diana Archangeli, 1994).

**Draga Zec** is Assistant Professor of Linguistics at Cornell University. Her contributions to phonological theory fall into three general areas: prosodic structure, lexical phonology, and the phonology–syntax interface. She is a co-editor of *The Phonology–Syntax Connection*, and her dissertation recently appeared in the 'Garland' series.

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# Introduction

*Jacques Durand and Francis Katamba*

*Frontiers of Phonology: Atoms, Structures, Derivations* is a collection of essays that present a selective overview of recent trends in the linguistic analysis of sound structure. During the 1970s and the 1980s a fairly radical reconfiguration of the field of phonology took place, largely against the backdrop of Chomsky and Halle's *The Sound Pattern of English* (1968), hereafter abbreviated as SPE. The need to move away from the spartan approach to phonological representations advocated in SPE is now universally accepted but the range of solutions provided within current frameworks can be quite confusing for the non-specialist. Our aim is not to attempt to provide an exhaustive, panoramic coverage of the entire field, but rather to explore theoretical issues in three core areas of phonological theory from a number of different perspectives. The questions fall into three broad categories:

1. The nature and representation of phonological features (Are they unary or binary? What is the architecture of featural representations? Is underspecification justified?).
2. The role and structure of the skeletal tier and syllable structure.
3. The competing claims of derivational and declarative approaches to phonology.

All these issues are controversial. A major objective of this book is to provide a forum for the discussion of important theoretical topics from the standpoint of frameworks such as Autosegmental and Multidimensional Phonology, Moraic Phonology, Dependency Phonology, Government Phonology and Declarative Phonology.

Not surprisingly, no one approach has found all the answers to all the questions. So, in phonology, as in many other fields of inquiry, much is to be gained from constructive criticism, debate and dialogue with those who adopt a stance different from one's own.

Further, we hope that the light thrown on these matters by dialogue will facilitate the task of judging the relative merits of the competing post-SPE models. This should be a welcome result for anyone who is sometimes left bewildered by the claims made by adherents of phonological models which are in some respects radically different and in other ways quite similar – in spite of what their proponents might say.

This book is intended for a variety of readers: advanced linguistics students and professional linguists, psychologists, speech scientists and scholars in related fields who are interested in finding out what modern phonologists are up to today. While we expect the reader to have more than a nodding acquaintance with post-SPE generative phonology, a serious effort has been undertaken to provide essays which are self-standing and do not presuppose a specialist knowledge of the issues under discussion. Readers who feel that their background is not sufficient for coming to grips with the issues discussed in this book are referred to Durand (1990a) or Katamba (1989).

Part 1 of the book deals with the atoms of phonological representation. In SPE it is assumed that segments are made up of unordered sets of phonological features and that these features are binary. Both these assumptions have been challenged within a variety of frameworks but the dust has not yet settled on these debates. In Douglas Pulleyblank's 'Feature geometry and underspecification' (Chapter 1), it is first of all argued that to account properly for assimilatory processes one needs to move radically away from the SPE model. But it is not enough to organize features in different tiers or planes as is done in Autosegmental Phonology. The best account of assimilation processes requires a geometric organization of features, i.e. that features should be intrinsically organized into a hierarchical set of a universally defined nature. Pulleyblank's Chapter then turns to the degree of specification of phonological features. While in SPE all features are fully specified as + or −, evidence is given that underspecified representations (which allow for only one feature-value to be present) can be advantageous from the point of view both of phonology and of phonetic implementation. This does not mean, however, that only unary (or monovalent) features should be countenanced. While the class nodes of geometric representations are inherently monovalent, Pulleyblank argues that the terminal features which hang from class nodes are binary in nature. Both values (+ or −) of features such as [ATR] or [voice], define a natural class and both can be manipulated by phonological processes.

In marked contrast with Pulleyblank's Chapter, John Harris and Geoff Lindsey in Chapter 2, 'The elements of phonological representation' claim that phonological primes are inherently unary. It should not be assumed, however, that the atoms of phonology (which they call 'elements') are the standard distinctive features minus the assumption of binarity. Harris and Lindsey put forward the idea that the elements are different from classical features in being independently interpretable – a hypothesis most vigorously defended within Government Phonology but also associated with Dependency Phonology and Particle Phonology. They then exemplify the theory of elements and show how phenomena assumed to require binary features can be appropriately handled with unary elements within a Government Phonology framework. The paper is also challenging in criticizing underspecification, and in tackling the question of the cognitive basis of phonological primes. In the wake of Jakobson, Harris and Lindsey argue strongly in favour of primes which are mappable in the first instance not onto articulations, but onto sound patterns. As part of the discussion, the authors offer a description of the elemental acoustic patterns which characterize a few of the primitives.

In 'Radical CV Phonology: the categorial gesture', Harry van der Hulst offers a discussion of phonological primitives from the standpoint of a revised version of Dependency Phonology. The symbols C and V in his title do not refer to the skeletal units in the sense of Clements and Keyser (1983), as used in Bickmore's article here, but to two phonological features which play a central role in his account. As in classical Dependency Phonology, van der Hulst assumes that phonological primes are grouped in hierarchical sets, called gestures, but unlike standard accounts of feature geometry (see Pulleyblank this volume) the dependency relation is seen as central to the internal structure of segments. For reasons of space, this article concentrates on the 'categorial' gesture. It includes an outline of classical Dependency Phonology proposals concerning this gesture (see Anderson and Ewen, 1987) which provides a clear point of departure for van der Hulst's own radical proposals.

Part 2 of the book is devoted to the skeletal tier and its relation to aspects of suprasegmental structure (in particular, the syllable). During the 1970s and 1980s, a lot of effort was devoted to the reintroduction of the syllable, and other units of the prosodic hierarchy, within phonological theory. It became accepted that phonological representations should be multidimensional and that the various planes should be organized around a set of timing or weight units (Cs and Vs, Xs or morae according to the framework), often referred to as the skeleton or the skeletal tier.

Lee Bickmore's Chapter 4, 'Accounting for compensatory lengthening in the CV and moraic frameworks' begins with a survey of the developments in skeletal phonology that led to the rise of moraic theory. Bickmore then goes on to present a detailed analysis of compensatory lengthening of vowels in current moraic theory. The thesis offered in this chapter is that moraic theory presents a more adequate account of compensatory lengthening phenomena than skeletal accounts formulated in terms of either Cs and Vs or Xs. In Chapter 5, 'The role of moraic structure in the distribution of segments within syllables', Draga Zec defends the idea that the mora is the unit in terms of which segments are regulated and syllable structure is projected. She advances this thesis through an explanatory account of complex nasal interactions in Pali. This chapter is also interesting in presenting an account of phonological structure in terms of Prince and Smolenski's Optimality Theory (1993). This approach is based on constraints and constraint-interactions and claims that constraints (unlike classical phonological rules) do not impose absolute requirements but vary in degrees of strength and can be ranked accordingly. Next, in Chapter 6, is Wiebke Brockhaus's committed, but not uncritical, review of Government Phonology, with special emphasis on the representation of skeletal and syllabic structures. A major claim made by Brockhaus in 'Skeletal and suprasegmental structure within Government Phonology' is that in Government Phonology, neither the mora nor the syllable is needed as a unit of phonological structure, contrary to the claims of moraic phonology and other contemporary theories of syllable structure: licensing is the motor that drives phonology. In the last chapter in this section, Chapter 7, 'Skeleta and the prosodic circumscription of morphological domains', Francis Katamba takes a different standpoint. He sees virtue in moraic phonology. However, unlike the first two moraic phonology chapters by Bickmore and Zec, Katamba's concern is not structure below the syllable, but rather the place of skeletal structures in the circumscription of phonological structures to which morphological processes apply.

In Part 3, the nature of phonological derivations is reexamined. Jacques Durand in his 'Universalism in phonology: atoms, structures and derivations' (Chapter 8) argues that a strong universalist position in phonology is the best methodological stance. After examining universalism with respect to atoms and structures, he focuses on the derivational issue. Should the theory of phonology allow for rules with transformational power as assumed in SPE and reaffirmed by Bromberger and Halle (1989) or, on the contrary, should it be structured like other components of linguistic description which in many current theories do not allow such operations? Durand argues strongly against a 'transformational' approach to phonology and surveys a number of arguments in favour of 'mirroring' between the various modules making up the language faculty.

The issue of derivation is again taken up in Chapter 9 by Jonathan Kaye's 'Derivations and interfaces'. This chapter is devoted to the notion of derivation within Government Phonology. The author discusses the lexical representation of lexical strings and their relationship to speech signals, hence the emphasis on interfaces. One of the major claims made by Kaye here is that there is no significant level of phonology as distinct from phonetics. A consequence of this claim is that, as in the other two contributors to Part 3, a derivational/transformational approach characteristic of the mainstream SPE tradition is found wanting. However, unlike Coleman who closes Part 3, the author argues that claims made in favour of notational systems such as that of *declarative phonology* do not provide the answer to the question at issue.

The final contribution to this volume is John Coleman's 'Declarative Lexical Phonology' (Chapter 10). In this chapter, Coleman criticizes the standard derivational/transformational approach to phonology and argues that many current descriptions formulated in a 'Principles and Parameters' notation (such as Government Phonology) are also close to the SPE paradigm if examined from a formal point of view. He outlines a linguistic formalism derived from unification-based grammars (cf. Shieber 1986) which does not use transformational or context-sensitive rewrite rules and yet allows for a truly restrictive, principle-based theory of sound structure. This essay is particularly interesting in offering a precise, formal description of aspects of phonological theory, a detailed critique of widely held assumptions concerning the nature of phonological derivations and a reanalysis of aspects of the phonology of English in a unification-based format.

As will be obvious from our summary of the contents of this volume, the essays offered here are wide-ranging and challenging. Many assumptions made by phonologists in their daily practice are reexamined by the contributors and debated from a variety of standpoints. We hope that the readers will gain insight into issues which are at the cutting edge of current research and, perhaps, that they will be prodded by these chapters into contributing to this debate themselves.

Lancaster–Salford, 1995

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The Publishers are grateful to the following for permission to use copyright material: Edinburgh University Press for our Figure 8.1 being Figure 52 in *Fundamental Problems in Phonetics* by J. C. Catford (1977) and Elsevier Science for our Figures 8.2 and 8.3 from page 88 of 'Structural Analogy and Case Grammar, *Lingua 70* by J. M. Anderson (1986).

# List of Abbreviations

| | |
|---|---|
| A&E | Anderson and Ewen |
| ATR | Advanced tongue root |
| B&H | Bromberger and Halle |
| BP | Brazilian Portuguese |
| CFG | Context-Free Grammar |
| CL | Compensatory Lengthening |
| CP | Class prefix |
| CS | Context sensitive |
| CSG | Context-Sensitive Grammar |
| DN | Deverbal nominal marker |
| DP | Dependency Phonology |
| ECP | Empty Category Principle |
| FS | Finite state |
| GP | Government Phonology |
| H&M | Halle and Mohanan |
| KLV | Kaye, Lowenstamm and Vergnaud |
| N | Nucleus |
| O | Onset |
| OCP | Obligatory Contour Principle |
| R | Rhyme (rime) |
| RCVP | Radical CV Phonology |
| RE | Recursively enumerable |
| RTR | Retracted tongue root |
| SPE | *The Sound Pattern of English* |
| UR | Underlying representation |

# PART 1

# ATOMS

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## Chapter 1

# Feature geometry and underspecification

*Douglas Pulleyblank*

## 1 Introduction

Phonological processes affect particular *classes* of sounds, and are triggered by other *classes*, sometimes null. A significant task for a theory of phonology is to delineate such classes, the characterization of which derives in primitive terms from a small set of subsegmental *distinctive features* (Jakobson et al. 1952, Chomsky and Halle 1968, henceforth SPE, etc.).

This chapter examines three basic properties involving such featural representations. First, features constitute a hierarchically organized set. The classes of features established by the hierarchy reflect phonetically motivated properties, and define the range of set behaviour possible in the phonological patterns attested in natural language.

Second, the phonological representation of oppositions is examined. A superficial distinction between two phonetic properties, $\alpha$ and $\beta$, may be most appropriately represented phonologically by assigning one member of the pair, $\alpha$, some non-null phonological feature $F$ which is not present on the second member of the pair, $\beta$. That is, representations are in many instances *underspecified.* Not only is this true of phonological representations, but such underspecification may persist right into the level of phonetic implementation.

Third, aspects of the formal relation between the feature hierarchy and underspecification are examined. On the one hand, it has been proposed that underspecification derives directly from the nature of featural primitives: if features are *unary*, or *monovalent*, then it follows from the basic structure of feature theory that phonological contrasts involve the assignment of some unary feature *F* to one member of a contrasting pair (α) and the absence of *F* on the second member of the pair (*β*). On the other hand, it has been suggested elsewhere that underspecification derives not from some basic property of feature theory, but from the way in which *binary* features formally combine. This apparent conflict is resolved by distinguishing between two types of features, one type appropriately characterized as unary, the second as binary. For the unary type, 'underspecified' representations are formally the only alternative and observed properties reflect this; for the binary class, representations vary in a manner that is derived from the different possibilities for feature combination. The distinction between the two sets corresponds to the distinction between class nodes and necessarily terminal nodes of the feature hierarchy.

## 2 Feature geometry

Non-linear approaches to feature content such as SPE viewed segments as composed of unordered sets of binary distinctive features, as seen in (1).

(1) *Linear models*

$$\begin{bmatrix} \alpha F \\ -\beta G \\ \gamma H \\ \delta I \\ \vdots \end{bmatrix} \quad \begin{bmatrix} -\alpha F \\ \beta G \\ -\gamma H \\ \delta I \\ \vdots \end{bmatrix} \quad \begin{bmatrix} \alpha F \\ \beta G \\ -\gamma H \\ \delta I \\ \vdots \end{bmatrix}$$

Such a linear model of segmental structure fails in numerous regards. We consider a single example here, involving *assimilation*. An assimilatory process is one whereby some segment comes to share some feature or features with some other segment. For example, a vowel may nasalize adjacent to a nasal consonant, a consonant may come to share place features with an adjacent consonant, voicing may come to be shared by the members of a cluster, and so on. Within a linear segmental model, such assimilatory processes are formally derived by changing feature values in the appropriate segmental matrices.

As a concrete example, consider the data in (2) showing the application of place assimilation to the nasal marker of the 'progressive' in Yoruba, a Niger-Congo language spoken primarily in Nigeria.[1]

(2) *Yoruba nasal assimilation*

| *Simple form* | *Progressive form* | |
|---|---|---|
| (a) *Labial* | | |
| bá | ḿbá | 'overtake' |
| ba | ḿba | 'hide' |
| bà | ḿbà | 'perch' |
| fɔ̃́ | ɱ́fɔ̃́ | 'break' |
| (b) *Alveolar* | | |
| tà | ńtà | 'sell' |
| tɛ́ | ńtɛ́ | 'spread' |
| dũ̀ | ńdũ̀ | 'pain' |
| lɔ | ńlɔ | 'go' |
| sũ | ńsũ | 'sleep' |
| (c) *Palatal* | | |
| jó | ɲ̄́jó | 'dance' |
| jɛ | ɲ̄́jɛ | 'eat' |
| (d) *Velar* | | |
| kɔ | ŋ́kɔ | 'write' |
| kú | ŋ́kú | 'die' |
| gũ̀ | ŋ́gũ̀ | 'climb' |
| wí | ŋ́wí | 'say' |
| (e) *Labial-velar* | | |
| gbɔ́ | ŋ́mgbɔ́ | 'hear; understand' |
| kpa | ŋ́mkpa | 'kill' |
| kpĩ́ | ŋ́mkpĩ́ | 'divide' |

In binary terms, these five places of articulation can be represented as in (3).

(3)

| | *Labial* | *Alveolar* | *Palatal* | *Velar* | *Labial-velar* |
|---|---|---|---|---|---|
| [coronal] | − | + | + | − | − |
| [anterior] | + | + | − | − | − |
| [labial] | + | − | − | − | + |

Place assimilation is achieved by causing the nasal of the progressive morpheme to acquire the values of [coronal], [anterior] and [labial] that are found on the immediately following consonant, as seen in (4).

(4) *Linear place assimilation*

$$\begin{bmatrix} +\text{consonantal} \\ +\text{nasal} \end{bmatrix} \longrightarrow \begin{bmatrix} \alpha \text{ coronal} \\ \beta \text{ anterior} \\ \gamma \text{ labial} \end{bmatrix} \; / \; \underline{\qquad} \begin{bmatrix} \alpha \text{ coronal} \\ \beta \text{ anterior} \\ \gamma \text{ labial} \end{bmatrix}$$

Such a theory of assimilation has serious drawbacks, however (see, for example, McCarthy 1988). Nothing intrinsically restricts the use of variables so as to produce assimilation rather than dissimilation – both are equally valued formally, although assimilation appears to be much more common cross-linguistically. In addition, the variable notation required in (4) can be used to produce completely unattested patterns. The rule in (5), for example, would cause a nasal to be palatal before a labial consonant ([ñ + b]) and labial before a palatal consonant ([m + j]), velar before a labial-velar consonant ([ŋ + gb]) but labial-velar before a velar consonant ([ŋm + g]), and before an alveolar consonant, the nasal would be a labialized alveolar ([ŋ$^{w}$ + d]).

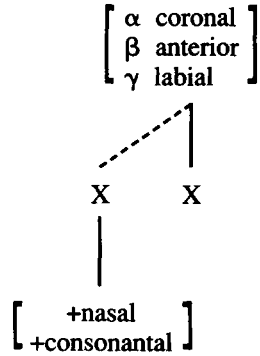
(5) *Impossible place assimilation pattern*

$$\begin{bmatrix} +\text{consonantal} \\ +\text{nasal} \end{bmatrix} \longrightarrow \begin{bmatrix} \beta \text{ coronal} \\ \alpha \text{ anterior} \\ -\gamma \text{ labial} \end{bmatrix} \; / \; \underline{\qquad} \begin{bmatrix} \alpha \text{ coronal} \\ \beta \text{ anterior} \\ \gamma \text{ labial} \end{bmatrix}$$

Not only is such a pattern not the one found in Yoruba, but such a pattern does not occur in any known natural language. The linear model fails, therefore, to adequately account for the range of assimilatory processes actually observed in human language.

To solve these (and other) problems, the theory of autosegmental phonology developed a very different account of assimilatory processes (Goldsmith 1976, Hayes 1986, etc.). By assigning the assimilating features to a separate autosegmental tier of representation, assimilation can be represented without the use of interdependent variables. The appropriate set of features simply extends its domain to include the elements that undergo the assimilatory process. In a case such as that of the Yoruba progressive marker, the place features would appear on a separate tier and then spread as a unit, as shown in (6).[2]

(6) *Autosegmental place assimilation*

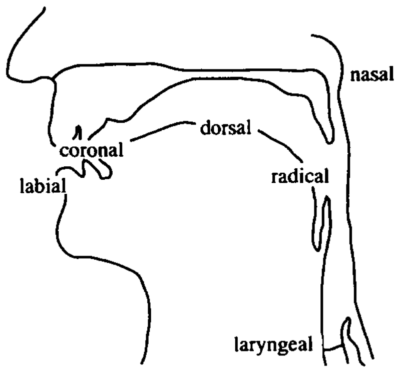



Without interdependent variables, autosegmental theory does not provide a mechanism for deriving the unattested type of process illustrated in the linear rule of (5), a welcome result. In other respects, however, autosegmental theory fails in a manner entirely comparable to a purely linear theory.

Consider the class of assimilation rules. Cross-linguistically, it is observed that some feature classes exhibit assimilatory behaviour, while others do not. The set of assimilatory classes appears not only to be finite, but also to be extremely small. Assimilation may take place with respect to individual features, to the coronal features, to the laryngeal features, to the place features, and so on. Arbitrary combinations of features, however, are not permitted. Compare the treatments of this issue within both linear and standard autosegmental theories. Within a linear theory, there are no restrictions on the classes of features that may undergo feature-changing rules of the type seen in (4). Segments are explicitly analysed as unordered, unstructured sets of binary features; any subset of this feature set can form the focus of a particular rule. As such, linear theory makes the incorrect formal claim that a cross-linguistic survey of assimilation processes should demonstrate any and every possible combination of features as a legitimate assimilation process. Standard autosegmental theory makes exactly the same (incorrect) claim. There are no inherent restrictions on the set of features that can be assigned to a particular autosegmental tier. In (6), for example, the features [±coronal], [±anterior] and [±labial] are assigned to an independent tier. Nothing prevents, however, the assignment of sets such as {[±coronal], [±anterior], [±voiced]}, or {[±labial], [±strident]}, or {H-tone (whatever the appropriate feature specification), [±nasal]}. The basic problem that both linear theory and standard autosegmental theory fail to address is that there are principled reasons for restricting assimilation rules to those involving narrowly delimited classes of feature sets.

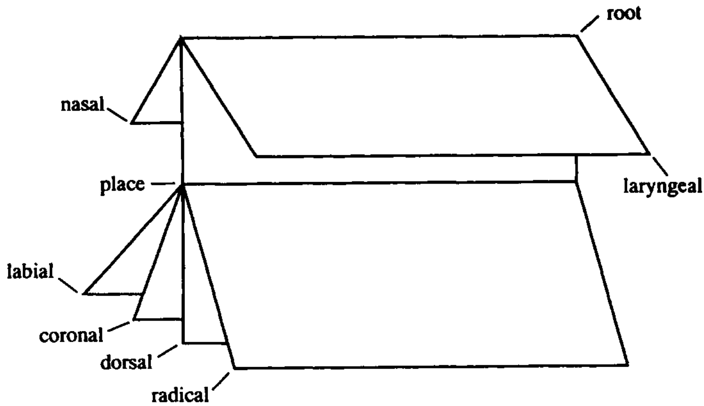
To address this problem as well as others, much recent work has proposed that features are intrinsically organized into a hierarchical set structure of a universally defined nature (see Lass 1976, 1984, Mascaró 1983, Mohanan 1983, Clements 1985a, Ewen 1986, Anderson and Ewen 1987, etc.): individual features may spread, and those features defined as sets by the feature geometry may spread. In a particular elaboration of this idea, Sagey (1986), Ladefoged and Halle (1988) and Ladefoged (1989) argue that the features that define and play a role in phonological processes bear a direct relation to physiological properties of the vocal tract and to acoustic properties of the speech signal. Considered from an articulatory point of view, there must be features defining movements in areas such as those indicated in (7).

(7) *Articulatory features*



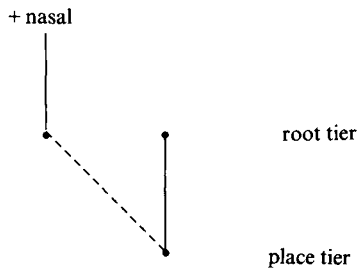

Following proposals made in Sagey (1986), the role of such articulators is directly encoded in the way features are hierarchically organized, as sketched in (8). Reference to the *root* tier involves the set of *all features*; reference to the *laryngeal* tier and the *place* tier involve *all laryngeal* and *all place* features respectively, while reference to individual articulator tiers (*labial*, *coronal*, *dorsal* and *radical*) involves all features defined for each of the individual articulators.

(8) *Place geometry*




In this framework, the Yoruba rule of nasal assimilation, formulated in (9), is characterized as involving the spreading of the *place* node.

(9) *Hierarchical place assimilation*




Neither of the shortcomings of linear and standard autosegmental theories arise. The actual process of assimilation results from the simple extension of the domain of the place features; no variables or feature-changing rules are involved. As for the characterization of the features that spread, this is determined by the impoverished set of possibilities made available by the universally determined make-up of the hierarchical feature structure. Note in this regard that place assimilation can be formally accomplished by the rule in (9) regardless of the specific place features appropriate for a particular language. Inventories of place specifications may vary, whether there are multiple *coronal* specifications, whether double articulations are permitted, and so on, but whatever the inventory permitted by a language, the entire set may be spread by a rule such as (9).

## 3 Degree of specification

For the remainder of this chapter, a particular issue is discussed that arises from the shift from linear to non-linear representations. Within the standard linear theory of SPE, every feature was specified for either a '+' or a '−' value. Features were fully specified. With the shift to non-linear models, this issue became the focus of considerable attention. In work such as Goldsmith (1976), early levels of representation did not require that segments be specified for all features; on the contrary, the prototypical autosegmental configuration involved representations where segments initially unspecified for a particular feature came to acquire it as a result of derivational processes of association and spreading. It was assumed, nevertheless, that by the time a phonological representation was fully derived, it was also fully specified. This was ensured by the first clause of the highly influential Well-Formedness Condition (10) (Goldsmith 1976: 27).

(10) *All vowels are associated with at least one tone.*

Views of the precise nature of underlying representations varied, as did the precise mechanisms by which underspecified representations received autosegmental values (see Pulleyblank 1986a), but it was typically assumed that representations were fully specified by the time they entered the level of phonetic implementation. Since representations were ultimately fully specified, a standard research strategy was to consider underlying representations as 'retreating' from a fully specified state, hence the notion of 'underspecified' representations.

The assumption of fully specified outputs, however, has been attacked on two very different grounds. First, it has been argued that a variety of features are intrinsically monovalent. They are either present or not present; they are not characterized by two values. As such, even at the level of phonetic implementation, only one value of an opposition is formally represented. Second, it has been argued that representations that constitute appropriate input to the phonetic component do not include specifications for all phonological features, regardless of whether features are binary or unary.

In the following discussion, we review certain issues raised in this debate. First, we consider implications of assuming hierarchical feature structure as regards establishing the degree of phonological specification. Class nodes are inherently monovalent, and their combinatorial properties, it is suggested, define the prototypical fashion in which distinct features cooccur. The phonetic interpretation of phonological representations is then considered, focusing on the type of evidence that has been presented in favour of positing underspecified representations at the level of the phonetics. The phonological source of such underspecification is subsequently examined.

On the one hand, phonetic underspecification could be solely due to intrinsic underspecification: if all features were intrinsically unary, then one value involved in any given surface contrast would involve an absence of specification. This approach is shown to be defective for two reasons. First, independent of intrinsic unary values, formal underspecification is necessary as a device. It is not eliminated by the adoption of unary features. Second, features are distributed between two classes with different clusters of properties, and it will be suggested that identification of the two classes falls out straightforwardly from the nature of the feature hierarchy. One of the classes is plausibly characterized by unarity, the set of hierarchical class nodes, the second by binarity, the necessarily terminal features. The discussion concludes with a brief discussion of combinatorial specification (Archangeli and Pulleyblank 1994). It is suggested that once full specification is abandoned as an output condition, phonology should focus on the features that are necessary for inclusion in a phonological representation, rather than the features that may be underspecified, or 'excluded'.

## 4 Unary features

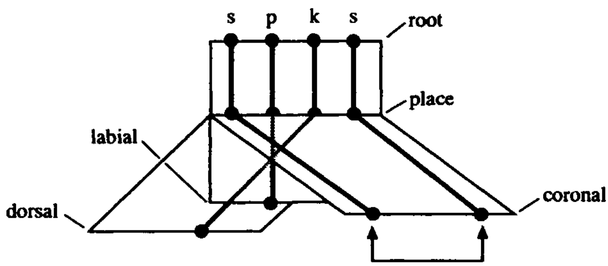
Consider again the approach to *place* features laid out above. Phonologically specifying a segment for *place* involves the determination of which of four semi-independent articulators are involved in the production of a particular speech sound.[3] Consider again the figure in (7). In broad terms, the configuration found at each of the six indicated areas is independent of the configuration found at the other five. Such freedom of phonetic cooccurrence is reflected phonologically by the assignment of each articulator to an independent autosegmental tier. That is, with the formal structure of (8), the expectation is that values for difference *place* features, as well as other features such as those dominated by the *laryngeal* node, will freely combine.

As illustration, consider the cooccurrence of the *dorsal* articulator with the three other articulators. In combination with the *labial* articulator, consonants such as labialized velars [kʷ, gʷ, etc.] and labial-velars [kp, gb, etc.] are derived, as well as rounded vowels such as [u] and [o]. Combining the *dorsal* articulator with the *coronal* articulator can be argued to derive palatal and palatalized consonants, as well as front vowels (see Pulleyblank 1989); such a combination also derives velarized coronals such as the 'dark l' of English. Combining the *dorsal* articulator with the *radical* articulator derives uvulars (see Cole 1987), emphatic consonants such as the relevant series in Arabic (see McCarthy 1991) as well as vowels with a specified tongue root value.

Consider the same representations from a slightly different perspective. If we know that a segment is *dorsal*, this does not imply particular values for *labial*, *coronal*, and so on. Similarly, if we know that a segment is *not dorsal*, this implies no particular values for other features.[4] This relation of independence is reflected in the tier structure of (8). Note as well that *coronality*, *dorsality*, etc. are active properties that may interact and function in particular ways. There is no phonologically relevant property of *not-being-coronal*, or *not-being-dorsal*. The complement class to the *coronal* class, or to the *dorsal* class is not a natural class of segments observed to trigger or undergo phonological processes.

Combinatorial properties in conjunction with cross-linguistic patterns of natural classes, therefore, suggest that the types of class nodes constituted by articulator features are best analysed as unary nodes. A welcome result obtained through the adoption of such a hypothesis concerns the interaction of segments specified by different articulator nodes. In a sequence of segments involving, for example, coronal, labial and velar segments, coronals can be adjacent on their tier of representation even if consonants with different places of articulation intervene. Consider the schematic representation in (11).

(11) *Articulator node transparency*




Since labials and velars are intrinsically unspecified for a *coronal* node, there is no non-null material intervening between the two coronal consonants in a representation such as (11). As a result, processes of a local type may take place between coronal segments which, on the surface, are non-adjacent. For example, in Tahltan (Shaw 1991), a process of coronal harmony affects the realization of /s/, as in the first person singular subject marker (underlined in the data in (12)).[5] Before dental consonants such as [θ] and [tθ'], /s/ is realized as [θ]; before alveopalatal obstruents such as [tš] and [dž], /s/ is realized as [š]:

(12) *Tahltan coronal harmony*

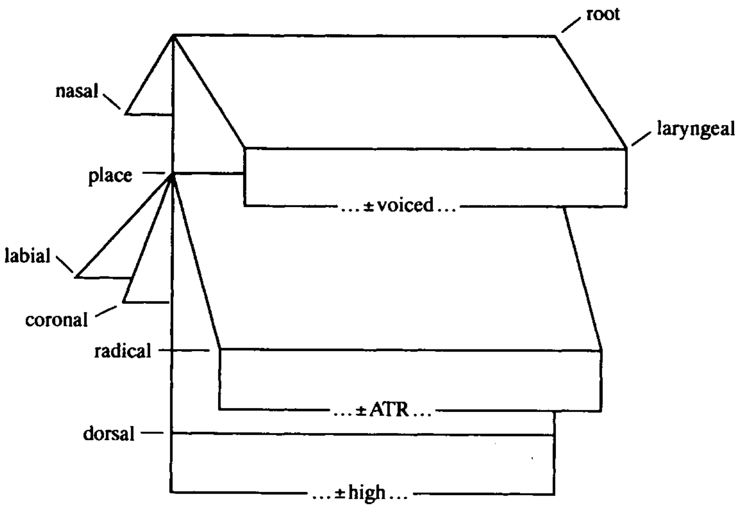
| | | |
|---|---|---|
| (a) /s/ | | |
| | εsk'a: | 'I'm gutting fish' |
| | εsdan | 'I'm drinking' |
| (b) /θ/ | | |
| | mεθεθεθ | 'I'm wearing on feet' |
| | naθtθ'εt | 'I fell off (horse)' |
| | dεθ$k^w$ʊθ | 'I cough' |
| (c) /š/ | | |
| | hudištša | 'I love them' |
| | εšdžɪni | 'I'm singing' |

The harmony process is unaffected by non-coronal consonants that intervene between the trigger and target of harmony, as seen in the last example of (12b).[6]

The widely held conclusion is that features are organized in a hierarchical fashion, and that the organizing nodes are single-valued. Subject to substantive conditions on how particular nodes cooccur, such featural nodes are characterized by freedom of combination. Moreover, the locality effects defined by the intrinsic underspecification of such monovalent nodes plays a role in the phonologies of numerous languages.

Compare, however, such monovalent behaviour with that of a feature such as [±ATR]. In vowel systems employing the ATR (advanced tongue root) feature (see below), all vowels are either advanced or retracted; not having one value automatically implies having the other value. It is universally impossible to combine a [+ATR] value with a [−ATR] value.[7] Such properties describe the types of features dominated by the monovalent class nodes seen in (8); for example, the feature [±voiced] is shown in (13) as dominated by the *laryngeal* tier and the feature [±high] as dominated by the *dorsal* tier.

(13) *The geometry of terminal features*



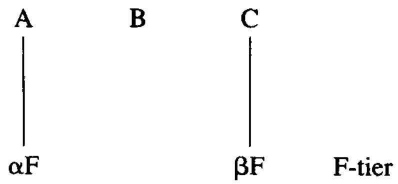

In each case, natural classes are defined by both values of the features, but the two values may not cooccur. In contrast to the representation of articulator features on independent tiers, this conjunction of properties is formally represented by assigning both values to a single tier, dominated by the appropriate monovalent class tier.

Before examining arguments for such binary features, however, we turn first to a consideration of the nature of the representations that constitute the output of the phonological component and the input to the implementational rules of the phonetics.

## 5 Underspecification in the phonetics

Arguments for not specifying a particular feature can be of various types: transparency effects, phonological inertness, distributional asymmetries, and so on (see Mohanan 1991, Archangeli and Pulleyblank in press, and references therein). One compelling argument has involved phonological transparency (see discussion of Tahltan above). Consider the configuration in (14):

(14) *Transparency*




Segments A and C are specified for values of feature F; segment B is not. It has been argued (see Keating 1988, Pierrehumbert and Beckman 1988, etc.) that such representations appropriately characterize the input to processes of phonetic interpolation and coarticulation. For example, Keating (1988) discusses cases where vowel-to-vowel coarticulation effects take place over a consonant, the consonant having no apparent effect at all on the transition. Formants appropriate for the vowel 'A' move gradually into those appropriate for 'C' without regard for an intervening consonant 'B'.

Such phonetic facts receive a straightforward explanation in a theory incorporating underspecification. Since 'B' is unspecified for feature F in the output of the phonological component, there is nothing to interfere with the phonetic coarticulation of 'αF' and 'βF'. Compare this picture with a linear, SPE mode of representation such as in (15). Since all segments are specified phonologically for all features, phonetic transparency is not expected to occur. Whatever the precise values of 'αF' and 'βF', the intervening segment 'B' is expected to have some value for 'F' itself.

(15) *Lack of transparency in linear models*

$$\underset{A}{\begin{bmatrix} \alpha F \\ \vdots \\ -\beta G \\ \gamma H \\ \delta I \\ \vdots \end{bmatrix}} \quad \underset{B}{\begin{bmatrix} \gamma F \\ \vdots \\ \beta G \\ -\gamma H \\ \delta I \\ \vdots \end{bmatrix}} \quad \underset{C}{\begin{bmatrix} \beta F \\ \vdots \\ \beta G \\ -\gamma H \\ \delta I \\ \vdots \end{bmatrix}} \cdots$$

The value for 'F' on 'B' will be expected to create a local transition between 'B' and 'A' to its left, and 'C' to its right; coarticulation between 'A' and 'C' is not expected.

The conclusion of such phonetic investigation is that the output of the phonological component, the representation which constitutes the input to quantitative phonetic implementation, must not be fully specified. Facts of interpolation and coarticulation can only be explained if the appropriate representations are selectively assigned feature values. In the terminology of Harris and Lindsey (this volume), the *realizational autonomy* hypothesis must be correct whether features are unary or binary in nature.

Several issues arise at this juncture. For example, do phonetic arguments for underspecification correlate with phonological arguments? Are underspecified feature values the same across languages? Is it always the case that one value of an opposition exhibits the properties expected of an underspecified representation? Is it possible to predict when a representation will be underspecified? The list can easily be extended. In the following discussion, phonological arguments will be examined that bear on two related questions concerning underspecification. Is it always the same value in a feature opposition that is underspecified? Can underspecification derive from the intrinsic nature of such a representation?

## 6 The representation of oppositions

Conceptually, there are six basic ways of phonologically representing an opposition between two sounds, as illustrated schematically in (16).

(16) *Primary representations of an opposition*

| *Binary* | *Unary* |
|---|---|
| +F vs. -F | G vs. H |
| +F vs. ∅ | G vs. ∅ |
| ∅ vs. -F | ∅ vs. H |

Assuming that each phonetic value of the opposition represents one value of a binary feature, the opposition may be represented by having both values present, [+F] and [−F] represented, or by having one value present and the second absent, [+F] only represented or [−F] only represented. An alternative is to assume that the feature in question is *unary*, that is, that it is single-valued. Under such an approach, there are again three primary ways of representing such an opposition (although see below). Two unary features could be posited, each corresponding to one value of the opposition (G vs. H), or one feature could be posited, corresponding either to the binary representation of [+F] ('G') or to [−F] ('H').

The choice between this range of alternatives is largely an empirical one. There are a variety of types of considerations. On the one hand, phonetic evidence such as the work on coarticulation effects bears directly on this question. Although this type of evidence will not be pursued here, it is worth noting Keating's conclusion (given in (17)) concerning the analysis of transparency and lack of transparency in Russian VCV sequences of the type given schematically in (14) above (Keating 1988, 289–90):

(17)

> in Russian both members of the contrasting pairs of consonants are specified for [back], since all contrasting consonants seem to block vowel-to-vowel coarticulation. However, other data on secondary articulations also suggest the opposite: that in some languages, only half of the contrasting consonants are specified for [back].

The implications of these conclusions, albeit rather preliminary in terms of the amount of phonetic research in these questions that has been conducted to date, are important. Phonetic effects vary from language to language. In cases of a phonological opposition, the phonetic manifestation of the opposition is unary in some cases, binary in others. These conclusions are, it will be suggested below, supported in the literature on phonological representations.

To consider the manner most appropriate for the representation of an opposition, consider a concrete example. In Yoruba, the agentive prefix is realized as [o] when the first vowel of the following verb stem is [i, e, o, u] (18a) and realized as [ɔ] when the first vowel of the verbal base is [ɛ, a, ɔ] (18b) (Archangeli and Pulleyblank 1989).[8]

(18) *Agentive prefix*

| | | | | | | |
|---|---|---|---|---|---|---|
| (a) | [o] | òjìyà | [òjìyà] | 'victim' | jìyà | 'to be punished' |
| | | òṣèwé | [òšèwě] | 'publisher' | ṣèwé | 'publish a book' |
| | | ògbójú | [ògbǒjú] | 'brave person' | gbójú | 'be brave' |
| | | òkú | [òkǔ] | 'corpse of person' | kú | 'die' |
| (b) | [ɔ] | ọ̀lẹ | [ɔ̀lɛ] | 'lazy person' | lẹ | 'be lazy' |
| | | ọ̀làjú | [ɔ̀làjǔ] | 'civilized person' | lajú | 'become civilized' |
| | | ọ̀tọpinpin | [ɔ̀tɔkpĩkpĩ] | 'careful scrutinizer' | tọpinpin | 'investigate fully' |

Such alternations demonstrate that the advanced vowel [o] is in opposition to the retracted vowel [ɔ]. When the agentive prefix occurs with a vowel for which the tongue root is advanced ([i, e, o, u]), the agentive prefix is also advanced ([o]); when the agentive prefix occurs with a vowel for which the tongue root is retracted ([ɛ, a, ɔ]), the agentive prefix is also retracted ([ɔ]). The representation of this opposition is the topic of the following discussion.

### 6.1 Two unary features

One approach can be ruled out largely for conceptual reasons, namely the possibility of positing two unary features, one for advancement ('ATR') and one for retraction ('RTR').[9] The guiding rationale for adopting unary features (see van der Hulst 1989) is to develop a theory that is more restrictive than a theory whose features are binary. The argument is essentially the following. If features are binary, and if underspecification is possible, then there are three logically possible ways of representing an opposition in a binary theory (as seen in (16)). In contrast, if features are unary, *and if a single feature is available for any given contrast*, then there is a single way of representing an opposition within a unary theory. It should be stressed that the restrictiveness argument depends crucially on both formal and substantive factors (see Harris and Lindsey this volume).

Formally, the range of combinatorial possibilities allowed is crucial in evaluating restrictiveness. For example, it is assumed within a binary framework such as SPE that two binary features define a maximum of four contrasting outputs: (i) [+F, −G], (ii) [+F, +G], (iii) [−F, −G], (iv) [−F, +G]. Two monovalent features F and G can similarly define four possible representations: (i) F, (ii) F, G, (iii) ∅, (iv) G. Supplementing these possibilities with formal notions such as headedness or dependency derives additional contrasts. For example, four forms can be doubled to eight by building in a notion of headedness (indicated by underlining) and by allowing null heads: (i) $\underline{F}$; (ii) $\underline{\emptyset}$, F; (iii) $\underline{F}$, G; (iv) F, $\underline{G}$; (v) $\underline{\emptyset}$, F, G; (vi) $\underline{\emptyset}$; (vii) $\underline{G}$; (viii) $\underline{\emptyset}$, G (see, for example, Lass 1984, Durand 1986, Anderson and Ewen 1987, Harris and Lindsey this volume). A general determination of formal restrictiveness, therefore, can be determined only by an evaluation of the full range of formal possibilities, not just whether features themselves have one or two values.

In terms of substantive considerations, the complete inventory of features must be established. If two unary features are assumed in the case of an opposition, the range of logical possibilities becomes greater than if a single feature is posited in a binary theory. Recall that the paradigm combinatorial possibility for unary features is free combination. Positing two unary features G and H would therefore predict the possibility of assigning both G and H to a single segment. As such, the possibilities of representing an opposition in some language as G vs. H, in another as G vs. ∅, and in a third as H vs. ∅ (as seen in (16)), would be supplemented by the logical possibilities of representing oppositions in appropriate languages by having one segment class specified for both G and H, with an opposing class specified as G, as H, or as devoid of specifications (see (19)).

(19) *Additional representations of an opposition*

*Unary*

| |
|---|
| G/H vs. G |
| G/H vs. H |
| G/H vs. ∅ |

Restrictiveness, therefore, balances formal and substantive simplicity and complexity. Formally, issues of binarity/unarity interact with issues of how such features combine. Substantively, restrictiveness depends on positing a highly impoverished set of featural primitives.

### 6.2 A single unary feature: retraction

Returning to the case of tongue root behaviour, no substantive properties appear to warrant combinations of putative unary ATR ('advancement') with a unary RTR ('retraction'). Conceptual reasons therefore argue against the positing of two such unary features. A unary analysis of data such as that seen for Yoruba in (18) must therefore either select the advanced value as phonologically active, 'ATR', or the retracted value as phonologically active 'RTR'. Moreover, to eliminate the possibility of combining two tongue root features in the analysis of any language, the choice for Yoruba must correspond to the choice made universally.

For Yoruba, Archangeli and Pulleyblank (1989, 1994) argue at some length that the phonologically active value must be tongue root retraction, that is, '[ − ATR]' or 'RTR'. Consider the behaviour of non-mid vowels in harmonic contexts. Unlike the mid vowel prefixes that alternate according to the tongue root value of the stem, high vowel and low vowel prefixes are unaffected by the quality of a following vowel, as shown in (20) and (21) respectively.

(20) *Abstract nominalizing prefix*

| | | | | | | |
|---|---|---|---|---|---|---|
| (a) | [i] | ìbínú | [ìbǐnű̂] | 'anger' | bínú | 'become angry' |
| | | ìgbédè | [ìgbědê] | 'binding' | gbédè | 'bind' |
| | | ìṣòro | [ìsòro] | 'difficulty' | ṣòro | 'be difficult' |
| | | ìdúró | [ìdǔró] | 'standing' | dúró | 'stand' |

| | | | | | | |
|---|---|---|---|---|---|---|
| (b) | [i] | ìbẹ̀rẹ̀ | [ìbɛ̀rɛ̀] | 'beginning' | bẹ̀rẹ̀ | 'begin' |
| | | ìpàdé | [ìkpàdě] | 'meeting' | pàdé | 'meet' |
| | | ìrọ́jú | [ìrɔ̌jú] | 'endurance' | rọ́jú | 'carry on under strain' |

(21) *Factive nominalizing prefix*

| | | | | | | |
|---|---|---|---|---|---|---|
| (a) | [a] | àjíkí | [àjǐkí] | 'waking up to greet' | jí kí | 'wake up to greet' |
| | | àṣefún | [àšefṹ] | 'doing for' | ṣe fún | 'to do for' |
| | | àbósè | [àbǒsê] | 'peeling and cooking' | bó sè | 'peel and cook' |
| | | àjùlọ | [àjùlɔ] | 'exceeding' | jù lọ | 'exceed' |
| (b) | [a] | àbẹ̀rẹ̀wọ̀ | [àbɛ̀rɛ̀wɔ̀] | 'stooping to enter' | bẹ̀rẹ̀ wọ̀ | 'stoop to enter' |
| | | àbálọ | [àbǎlɔ] | 'going on behalf of' | bá lọ | 'go on behalf of' |
| | | àjọbí | [àjɔbí] | 'consanguinity of persons' | jọ bí | 'be a joint progenitor' |

In each case, the tongue root value is redundant, derivable from the non-mid vowel's height. For high vowels, the tongue is redundantly advanced; for low vowels, the tongue is redundantly retracted. Thus if ATR is phonologically active, it could appear on high vowels, as in (22a); if RTR is phonologically active, it could appear on low vowels, as in (22b).

(22) *Possible redundant harmonic values in Yoruba*

```
(a)  HI    LO        (b)  HI    LO
     |                           |
     |                           |
     ATR                         RTR
```

To test the appropriateness of one or the other modes of representation, one must look for evidence that high vowels or low vowels affect the value of an adjacent mid vowel, mid vowels being the class of vowels exhibiting alternants determined by an adjacent tongue root value. As noted in Archangeli and Pulleyblank (1989), high vowels have no effect on the tongue root value of an adjacent mid vowel. Advanced mid vowels may both follow and precede high vowels (23a); retracted mid vowels may both follow and precede high vowels (23b).

(23) *Inertness of high vowels*

| | | | | | | |
|---|---|---|---|---|---|---|
| (a) | ilé | [ilé] | 'house' | ìgò | [ìgò] | 'bottle' |
| | ebi | [ebi] | 'hunger' | orí | [orí] | 'head' |
| (b) | ilẹ̀ | [ilɛ̀] | 'land' | itọ́ | [itɔ́] | 'saliva' |
| | ẹ̀bi | [ɛ̀bi] | 'guilt' | ọ̀kín | [ɔ̀kĩ́] | 'egret' |

With respect to vowels to their right, low vowels are comparable to high vowels in that they have no effect: when a mid vowel follows a low vowel, it may be either advanced or retracted (24a). Such inertness is in marked contrast to the active effect of the redundant retracted value when a low vowel is preceded by a mid vowel. In such a configuration, the mid vowel must be retracted (24b).

(24) *Active effect of low vowels*

| | | | | | | |
|---|---|---|---|---|---|---|
| (a) | ate | [ate] | 'hat' | àwo | [àwo] | 'plate' |
| | àjẹ̀ | [àjɛ̀] | 'paddle' | aṣọ | [ašɔ] | 'cloth' |
| (b) | ẹ̀pà | [ɛ̀kpà] | 'groundnut' | ọjà | [ɔjà] | 'market' |
| | | *[eCa] | | | *[oCa] | |

The observed patterns in Yoruba are straightforwardly derived if [ − ATR]/RTR is posited as the phonologically active feature.[10] If [ + ATR]/ATR were the selected feature, the patterns would be anomalous.

Let us return to the general issue of feature specification. A theory with unary features should posit no more than a single feature per opposition. In the case of the advanced/retracted opposition, Yoruba must therefore be interpreted as providing evidence that the appropriate value for the phonological instantiation of the opposition is *retraction*, that is, 'RTR' or '[ − ATR]'.

### 6.3 A single unary feature: advancement

The problem with the hypothesis that the tongue root feature is a monovalent 'RTR' is that this contradicts the actual proposals that have been made for a unary tongue root feature. In work such as Kaye et al. (1985) and van der Hulst (1989) it has been proposed that there should indeed be a single tongue root feature, but that its value should be *advancement*, 'ATR'. One type of argument that has been presented in favour of the feature ATR is based on its appearance in *dominant harmony systems*.

A large number of harmony systems are intrinsically asymmetric, exhibiting a pattern with the following basic properties. Roots and affixes may be either *dominant* or *recessive*. A word composed entirely of recessive morphemes surfaces with one harmonic value; a word containing one or more dominant morphemes surfaces with the opposite harmonic value. Crucially, a single dominant morpheme, whether a root morpheme or an affix morpheme, is sufficient to cause the entire word to surface with the dominant value.

The following examples from Kalenjin, a Nilotic language spoken in Kenya, illustrate this pattern (Antell et al. 1973). When all morphemes are recessive (25), surface vowels are retracted (ɪ, ɛ, a, ɔ, ʊ = retracted).

(25) *Words composed entirely of recessive morphemes*

(a) kɪ-a-bar-ɪn 'I killed you (sg.)'
(b) kɪ-a-gɛr 'I shut it'

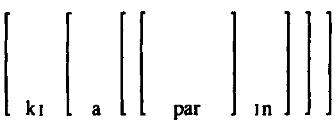
When a dominant morpheme occurs either as root or affix, then all vowels surface as advanced (i, e, a̙, o, u = advanced).[11] To illustrate the dominant pattern, the dominant root /ke:r/'see' in (26a) appears with the same affixes as the root/par/'kill' in (25a);[12] as a result, *all* vowels are advanced. Similarly, the addition in (26b) of the dominant suffix /e/'non-completive' to the form in (25b) causes all vowels to surface in their advanced form.

(26) *Words including a dominant morpheme*

(a) ki-a̙-ge:r-in 'I saw you (sg.)'
(b) ki-a̙-ger-e 'I was shutting it'

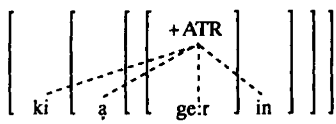
As proposed by Halle and Vergnaud (1981) and illustrated in (27), an autosegmental account of such dominant harmony is straightforward. Dominant morphemes are consistently advanced, hence analysed as containing an autosegmental [+ ATR] specification as part of their lexical specification; recessive morphemes are variable, analysed as containing no such specification. The [+ ATR] value links and spreads to all vowels within its domain; vowels left unspecified surface as retracted.

(27) *Dominant* [+ *ATR*] *harmony in Kalenjin*



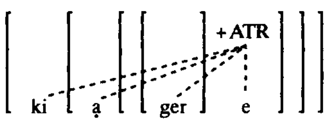
'I killed you (sg.)'

(a)



'I saw you (sg.)'

(b)



'I was shutting it'

(c)

The dilemma for a theory positing strictly unary features is that the opposition between advanced and retracted vowels requires a retracted value to be active in a language like Yoruba, but an advanced value to be active in a language like Kalenjin. The dilemma is compounded by the fact that patterns of dominant harmony are not restricted to languages with an advanced active value.

### 6.4 Dominant harmony: retraction

In languages like Nez Perce (Hall and Hall 1980, Song 1990) and Chukchee (Bogoras 1922, Archangeli and Pulleyblank 1994, etc.), dominant harmony systems exist where the dominant value is [−ATR] and the recessive value if [+ATR]. The phonological behaviour of such systems is entirely comparable to that seen above for Kalenjin, except that the dominant tongue root value is inverted.

Illustrating with Nez Perce, roots such as in (28) are recessive, surfacing with advanced vowels.

(28) *Recessive roots*

| | | |
|---|---|---|
| (a) | mæq | 'paternal uncle' |
| (b) | cæqæ:t | 'raspberry' |

In combination with recessive affixes such as *næ?* 'first person possessive' and *æ?* 'vocative', the resulting words continue to exhibit uniformly advanced vowels, as seen in (29).

(29) *Recessive affixes*

| | | |
|---|---|---|
| (a) | næ?-mæx | 'my paternal uncle' |
| (b) | mæq-æ? | 'paternal uncle!' |

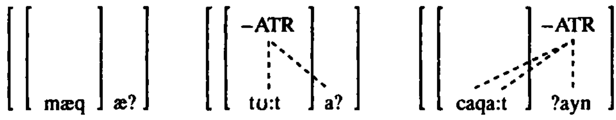
In combination with a dominant morpheme like *tʊ:t* 'father', however, recessive affixes surface with retracted variants (30a, b); similarly, with a dominant affix like *?ayn* 'for', a recessive root surfaces as retracted (30c):[13]

(30) *Dominant morphemes*

| | | |
|---|---|---|
| (a) | na?-tʊ:t | 'my father' |
| (b) | tʊ:t-a$^?$ | 'father!' |
| (c) | caqa:t-$^?$ayn | 'for a raspberry' |

Just as the Kalenjin pattern of harmony is accounted for by positing dominant, morpheme-level [+ATR] specifications that link and spread, so is the Nez Perce pattern accounted for by a comparable analysis involving [−ATR], as shown in (31).

(31) *Dominant [−ATR] harmony in Nez Perce*




'paternal uncle!' 'father' 'for a raspberry'

(a) (b) (c)

## 6.5 Two values in one language

Languages such as Kalenjin argue for postulating an active phonological feature of tongue root advancement; languages like Yoruba and Nez Perce argue for postulating an active phonological feature of tongue root retraction. The clear prediction in a theory allowing both such values is that a third language type could exist, one employing the two values actively. One example of such a language type is Lango, a Nilotic language of Uganda (Woock and Noonan 1979, Archangeli and Pulleyblank 1994).

Although a detailed discussion of Lango harmony goes beyond the scope of this chapter (see Archangeli and Pulleyblank 1994), two sub-patterns of the overall harmonic system illustrate the importance of positing both [+ATR] and [−ATR] values. Lango has a basic five-vowel system [I, E, A, O, U] crosscut by ATR. This gives ten surface vowels, as seen in the stem column of (32).

(32) *Advancement harmony*

| | *Stem* | | *Stem + suffix* | |
|---|---|---|---|---|
| [i] | píg | 'soup, juice' | píggí | 'your juice' |
| [e] | ém | 'thigh' | émí | 'your thigh' |
| [ə] | ñə̀ŋ | 'crocodile' | ñə̀ŋŋí | 'your crocodile' |
| [o] | dòk | 'cattle' | dòkkí | 'your cattle' |
| [u] | búk | 'book' | búkkí | 'your book' |
| | | | | |
| [ɪ] | yíb | 'tail' | yíbí | 'your tail' |
| [ɛ] | dɛ̀k | 'stew' | dèkkí | 'your stew' |
| [a] | màc | 'fire' | mə̀ccí | 'your fire' |
| [ɔ] | kɔ̀m | 'chair' | kòmmí | 'your chair' |
| [ʊ] | lʊ̀t | 'stick' | lùttí | 'your stick' |

The second person suffix seen in the stem + suffix column of (32) is underlyingly advanced. As can be seen by its interaction with the set of underlyingly retracted vowels, the second group of five in (32), the [+ATR] value of the suffix spreads regressively back onto the stem vowel. Such regressive harmony takes place only from high vowels. Compare, for example, the absence of regressive advancement harmony in the cases in (33) involving an advanced mid-vowel suffix:

(33) *Absence of regressive harmony from a non-high argument*

| | | |
|---|---|---|
| [i] | riŋŋo | 'to run' |
| [e] | ketto | 'to put' |
| [ə] | (no example in Woock and Noonan) | |
| [o] | pwoddo | 'to beat' |
| | | |
| [u] | rucco | 'to entangle' |
| [ɪ] | lɪmmo | 'to visit' |
| [ɛ] | nɛnno | 'to see' |
| [a] | wayo | 'to pull' |
| [ɔ] | lwɔkkɔ | 'to wash' |
| [ʊ] | lʊbbɔ | 'to follow' |

That the mid vowel of the suffix is advanced is clear from the three examples *lɪmmo* 'to visit', *nɛnno* 'to see' and *wayo* 'to pull'. Since the root is retracted in these cases, there is no source for the suffixal [+ATR] value other than the suffix itself. But with this in mind, the last two examples need to be considered: *lwɔkkɔ* 'to wash' and *lʊbbɔ* 'to follow'. In these cases, the back vowel of the root triggers the spreading of [−ATR] from left to right onto the suffix vowel.

We observe, therefore, that the focus of the regressive assimilatory process seen in (32) is [+ATR], while the focus of the progressive assimilatory process seen in (33) is [−ATR]. Such behaviour is consistent with the hypothesis of a binary feature governing tongue root oppositions, [±ATR], but is inconsistent with positing either a unary ATR or a unary RTR to the exclusion of the second feature value.

Empirical considerations are therefore inconsistent with the view that all oppositions are to be characterized by the positing of unary features. The opposition between advanced and retracted tongue root requires the postulation of phonological values for both advancement and for retraction. It would of course be possible to posit two unary features to express the two poles of the tongue root opposition, but this would have the result of weakening, not strengthening, the theory for the reasons discussed in section 6.1.

## 7 Voicing oppositions: another binary contrast

One might ask, of course, whether the binary behaviour of the feature governing the tongue root is special in some way. Is it the only feature whose properties are binary? There appear, in fact, to be numerous binary features governing oppositions. Still considering vowels, cases have been made for both values of features like [±high] and [±back] (see Archangeli and Pulleyblank 1994). For consonants, LaCharité (1993) argues that both values of [±continuant] are required; both values of [±anterior] have been used for the description of various consonant harmony systems (see Poser 1982, Shaw 1991). Theories of *contrastive underspecification* (see Clements 1987, Steriade 1987) have argued for the analysis of numerous phonological patterns in terms of binarily represented oppositions. In this section, one additional case of a binary feature is briefly addressed, a case that is of some interest since it has been proposed recently that the feature is actually unary.

Many languages exhibit an opposition between voiced and voiceless consonants. In binary terms, this contrast is standardly represented in terms of the feature [±voiced] (see Chomsky and Halle 1968). Recently, however, it has been suggested that the feature should be considered to be unary, its phonologically marked value being [+voiced] (Mester and Itô 1989, Rice and Avery 1990).

Evidence for the phonologically active status of [+voiced] is uncontroversial; consider, for example, the case of Russian voicing assimilation (Hayes 1984, Kiparsky 1985, etc.). Cases involving assimilation to voicelessness also exist, for example English *loose/lost*, but it has been suggested that these cases, like the widespread phenomena of syllable-final and word-final devoicing, actually involve the delinking of a phonologically specified [+voiced] specification (Mester and Itô 1989).

Other patterns, however, are not straightforwardly amenable to such manipulations of a [+voiced] feature. In a recent paper, Peng (1991) discusses one such case from Kikuyu. Dahl's Law affects velar consonants in a large number of related Bantu languages (Davy and Nurse 1982). The rule voices velar stops (which subsequently and independently spirantize) when they are morpheme-initial and followed in the next syllable by a voiceless obstruent. In the examples in (34), Dahl's Law applies to voice the initial velar stop of *ko* because the initial consonant in the syllable following the prefix is voiceless.

(34) *Voiceless obstruents*

| | | |
|---|---|---|
| (a) | go-tɛm-a | 'to cut' |
| (b) | go-ku-a | 'to die' |
| (c) | go-θɛk-a | 'to laugh' |
| (d) | go-cuuk-a | 'to slander' |

In (35) and (36), on the other hand, Dahl's Law does not cause voicing of the prefixal [k] because the root-initial consonant is voiced.

(35) *Voiced obstruents*

(a) ko-gat-a 'to cut'
(b) ko-*β*a*β*at-a 'to pinch'
(c) ko-gor-a 'to buy'

(36) (*Voiced*) *sonorants*

(a) ko-rug-a 'to cook'
(b) ko-mɛñ-a 'to know'
(c) ko-niin-a 'to finish'

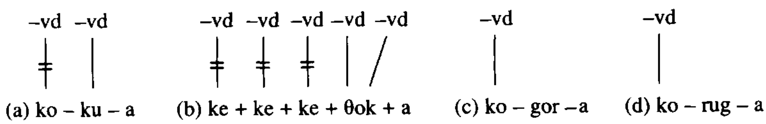
Strings of velar stops undergo the rule, as illustrated by examples such as in (37).

(37) *Sequences of velars*

(a) ge-ge-ge-θok-a 'and thus it was spoiled'
(b) a-ge-go-tɛng-a 'he met you'
(c) ga-ge-gaa-ge-go-θɛk-a 'before it goes and laughs at you'

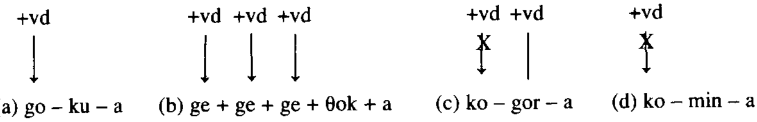
The analysis of this pattern depends crucially on basic assumptions about the phonological representation of voicing. If the theory allows for the active specification of [ – voiced], the analysis is straightforward: a [ – voiced] specification is lost from a velar consonant when the following syllable begins with a [ – voiced] segment (see (38) below). Considered in these terms, Dahl's Law is formally a dissimilation process, as it has been traditionally characterized.

(38) *Dahl's Law in Kikuyu – Delinking* [ – voiced]




An analysis is not so straightforward if phonological theory allows only for the specification of [ + voiced]. Within such a theory, two basic analyses are possible, depending on assumptions about the underlying representation of the k / g segment. If prefixes exhibiting the k / g alternation are analysed as underlying unspecified for voicing, then Dahl's Law must insert a [ + voiced] specification, as in (39). The problem for such an analysis is how to characterize the class of environments that conditions such insertion.

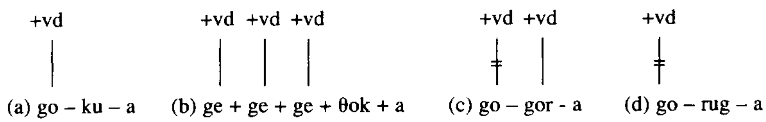
(39) *Dahl's Law in Kikuyu – Inserting* [+ voiced]




Insertion of [+ voiced] must take place with the prefix of (39a), as with the series of prefixes in (39b); insertion must be blocked with (39c) and with (39d). While blocking of [+ voiced] insertion in (39c) could be attributed to the [+ voiced] specification of the root-initial voiced obstruent, there is no explanation for the absence of insertion in (39d): since the voicing of sonorants is completely redundant (see Kiparsky 1982b, Pulleyblank 1986a, Archangeli 1984, Clements 1987, Steriade 1987, etc.), sonorants would not be expected to bear a voicing specification, hence would not be expected to block the insertion of a [+ voiced] specification. Note in this regard that Dahl's Law applies at the very earliest level of Kikuyu phonology, applying as a Morpheme Structure Condition (Pulleyblank 1986b). Moreover, even if one were to allow the presence of [+ voiced] on sonorants, there would be no plausible account for the absence of blocking in the series of velars in (39b). If Dahl's Law is blocked by the presence of a [+ voiced] value on a root-initial consonant (39c), then it should be similarly blocked by the presence of a [+ voiced] value on a prefix-initial consonant (39b) – but such is not the case.

An analysis of the alternating prefixes as underlyingly [+ voiced] is similarly problematical (40). Under such an account, it would be necessary to have a root-initial [+ voiced] specification trigger delinking (40c), while an affix-initial [+ voiced] specification would not (40b). As with the other account involving [+ voiced], sonorants would be required to trigger the process in spite of a complete absence of motivation for a [+ voiced] specification on such a class of segments.

(40) *Dahl's Law in Kikuyu – Delinking [+ voiced]*




As a final point concerning Dahl's Law, Peng (1991) argues that the feature involved in the process is indeed [voiced], not some other feature such as [spread glottis], citing phonetic evidence that the voiceless stops of Kikuyu are unaspirated; note also relevant discussion of the 'lenis' fricative [*θ*] in Davy and Nurse (1982). The conclusion is that reference must be made to the feature value [−voiced]. A theory that makes it impossible to refer to this value forces complications in the formulation of rules like Dahl's Law as a direct result.

## 8 Binary features and underspecification

One might ask whether binarity implies full specification at any level of phonological representation. Clearly such is not the case. The dominant harmony systems considered above, for example, depend crucially on positing a single harmonic value, whichever of the two binary possibilities such a value corresponds to. Similarly, for asymmetries of the type exhibited by Yoruba, it is important that only one value of the binary feature [±ATR] be specified phonologically (see Pulleyblank 1988).

Like unary features, binary features *when underspecified* may participate in long-distance processes. For example, the Japanese forms in (41) illustrate a process referred to as Rendaku whereby the initial consonant of the second member of certain compounds is voiced (Itô and Mester 1986).

(41) *Rendaku*

| | | |
|---|---|---|
| (a) iro + kami | [irogami] | 'coloured paper' |
| (b) mizu + seme | [mizuzeme] | 'water torture' |
| (c) yama + tera | [yamadera] | 'mountain temple' |

Of interest, application of Rendaku is blocked by the presence of a voiced obstruent anywhere in the member of the compound undergoing the rule (Lyman's Law). The initial consonant therefore remains voiceless in examples like (42).

(42) *Lyman's Law*

| | | | |
|---|---|---|---|
| (a) kami + kaze | [kamikaze] | (*kamigaze) | 'divine wind' |
| (b) siro + tabi | [sirotabi] | (*sirodabi) | 'white tabi' |
| (c) onna + kotoba | [onnakotoba] | (*onnagotoba) | 'feminine speech' |

As noted by Itô and Mester (1986), to account for Lyman's Law, it is crucial that voiceless obstruents be underspecified for voicing since if only [+voiced] specifications are present (43a), Lyman's Law can be attributed to a constraint prohibiting the insertion of

[+voiced] adjacent to an existing [+voiced] specification: * [+voiced] [+voiced]. If [−voiced] were specified (42b), there would be no violation of such a constraint in cases like **onnagotoba* (42c) and Rendaku would erroneously be expected to apply.

(43) *Lyman's Law in Japanese*


(a) (b)

In a later paper, Mester and Itô (1989) note that the required underspecification could be due to the intrinsic unarity of a monovalent [+voiced] feature. If, as argued by Peng (1991) however, voicing is necessarily binary, then cases such as Rendaku clearly argue for the possibility of underspecifying a binary feature. Moreover, in the absence of positive evidence to the contrary, such underspecified representations are perfectly adequate to serve as input to the quantitative implementation of the phonetic component.

## 9 Conclusion

To recapitulate, it was first demonstrated that features do not constitute an unordered set. On the contrary, features group together in a highly restricted fashion to determine the attested range of classes that function in phonological processes of natural language. It was demonstrated that oppositions may be phonologically characterized in two ways. Monovalent class nodes establish unary representations of oppositions: the presence of such a node contrasts with its absence. Such unary specifications are characterized by their relative freedom of combination: the presence of one feature does not imply the absence of the other. It is precisely the range of combinatorial possibilities that establishes the basic diversity of phonological systems. It can be noted as well that different class nodes appear on distinct phonological tiers, the formal expression of their ability to function independently in phonological processes. Finally, it should be noted that the complement class of a set defined by a monovalent class node is not a natural class. For example, in a system that includes labials, coronals, velars and pharyngeals, while *dorsal* defines the natural class of velars, this does not mean that the complement class, labials, coronals and pharyngeals, constitutes a similarly natural class.

In marked contrast to the above range of properties, unary class nodes dominate terminal features that are binary in nature.[14] The opposing values of binary features like [±ATR] and [±voiced] may not cooccur; their combinatorial possibilities are governed by the types of constraints that govern combination of their dominating nodes. With binary features, the presence of one value implies the absence of the other value. Both values of such features, in contrast with class nodes, appear on the same phonological tier. Finally, and importantly, both members of a binary opposition constitute natural classes, and both define classes of elements manipulated and referred to in phonological processes.

Both unary and binary feature types exhibit properties of underspecification. For class nodes this is a necessary property, inherent to the theory of feature structure itself. For binary features, languages vary as to the feature value that is phonologically active, variously exhibiting properties characteristic of underspecified representations and properties of representations that are more fully specified. This might appear to be an unfortunate result: while underspecification is an intrinsic part of a theory of unary features, it must be stipulated for binary features.

In fact, however, such a negative evaluation is inappropriate for at least two reasons. First, even the active value of a unary feature can be underspecified, hence underspecification as a formal property is independent of such intrinsic underspecification. For example, sonorants are clearly unspecified for [+voiced] in Japanese since they do not invoke the blocking characteristic of Lyman's Law: /hara + kuro/'stomach + black' → [haraguro], *[harakuro] 'wicked'. Nevertheless, in a language like Zoque (Kenstowicz and Kisseberth 1979, Sagey 1986), stops voice after nasals; that is, the [+voiced] value spreads from nasals: *tatah* 'father' vs. *ndatah* 'my father'. At the relevant stages, therefore, Japanese and Zoque differ in that Japanese is underspecified for even a hypothetically monovalent [+voiced] specification, while Zoque nasals are redundantly assigned a voicing specification by the time the rule takes place. Whether features are unary or binary, it is therefore necessary to include underspecification as a property of phonological theory.

As a second point, it should again be noted that to 'underspecify' implies a research strategy of beginning with full specification and retreating from that position to the extent that there is evidence for such a retreat (a strategy that reflects the history of generative work on the topic since SPE). But since phonetic work suggests that the goal of full specification is ill-founded, the research strategy based on such retreat must also be reconsidered. An alternative research strategy is to posit only those feature specifications required to establish the oppositions attested in a particular language, filling out such representations with redundant specifications to the extent that there is positive evidence for such (see Archangeli and Pulleyblank 1994). The expectation of such a strategy is that the specification of all features, whether unary or binary, will be relatively sparse, at least at initial stages of representation. In the case of unary features, some class nodes are more commonly involved in establishing oppositions than others; for example, the tongue root is less commonly employed than the tongue dorsum, laryngeal oppositions are common but not universal, and so on. The same is true of values for binary features; invoking values like [+back], [+voiced], [+high] is very common, while invoking a feature value like [+ATR] is much less so. Both values of a binary feature would not normally be invoked in a single language to establish an opposition since one value is sufficient to establish the opposition. Where motivated by patterns of distribution or alternation, adding a second value establishes redundancy, not opposition.

## Notes and Acknowledgements

Thanks to Jacques Durand and Pat Shaw for discussion of this article. This work was supported by a Social Sciences and Humanities Research Council of Canada grant, No. 410-91-0204.

1. In the following transcriptions, [ɟ] represents a palatal stop, [ɱ] represents a labio-dental nasal, and tone-marked nasals are syllabic.
2. Note that the variables in (6) are completely different from those in (4) and (5). In (6), the variables simply mean, 'spread *whatever values* of [coronal], [anterior] and [labial] are found after a nasal consonant.' In (4) and (5), the variables indicate interdependency; one matrix is assigned a particular value of a feature in a manner that is sensitive to the value of a feature in some other matrix.
3. Characterizing the nodes dominated by PLACE as purely articulator nodes may be an over-simplification (see Gorecka 1989, McCarthy 1991).
4. In a specific case, for example in a language where there are no labialized velars, no palatals and so on, one might be able to make predictions on the basis of the presence vs. absence of a DORSAL specification. This, however, cannot be true in general.
5. For a detailed discussion of Tahltan as well as for discussion of consonant harmony systems in general, see Shaw (1991).
6. Note that a small class of coronal consonants may also intervene without interrupting harmony. For discussion, see Shaw (1991).
7. Setswana and Sotho may constitute counter-examples to this claim; see Khabanyane (1991), Dichabe (in preparation).
8. In Yoruba orthography, 'ẹ' represents [ɛ] and 'ọ' represents [ɔ]; 'ṣ' represents [š], while 'p' represents [kp]; a 'Vn' sequence indicates a

nasalized vowel. The symbol/letter 'j' represents a palatal stop in both orthography and transcription.

9. For a contrary view, however, note Anderson and Ewen (1987).
10. See Archangeli and Pulleyblank (1989, in press) for detailed arguments to this effect.
11. Not discussed here are three opaque morphemes that interrupt the harmonic domain. See Antell et al. (1973), Halle and Vergnaud (1981) and Archangeli and Pulleyblank (in press) for discussion.
12. Obstruents are underlyingly voiceless in Kalenjin, becoming voiced between sonorants.
13. In Hall and Hall (1980), the retracted back vowel [ᴜ] is transcribed as [o]. Nez Perce exhibits a three-vowel system [I, A, U] crosscut by the ATR distinction. The vowel in question is the retracted counterpart of /U/, transcribed as [ᴜ] here so as to avoid the suggestion that it is an advanced mid vowel rather than a retracted high vowel. For relevant discussion of problems in the transcription of ATR systems, see Archangeli and Pulleyblank (1994).
14. *Terminal* here means *necessarily terminal.* Class nodes may or may not be terminal while binary features like [±ATR] and [±voiced] must be terminal.

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