

THE THEORY OF MARKEDNESS IN GENERATIVE GRAMMAR

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ABSTRACT

The theory of markedness is a theory of the distinctive features which characterize the segments of languages at all levels of phonological representation. Following Jakobson, it is assumed that there is a relatively small set of features with binary specifications which are sufficient for the representation of the segments of all languages. It is further held that the same class of segmental representations which are required for the characterization of 'surface' phonological representations is the class which is required for the characterization of underlying representations. There is no segmental representation which is found only at the surface. A set of universal rules is postulated which characterize the 'optimal' (most likely) conjunctions of specified features within segments. It is proposed that based on these rules certain substantive universal properties of the underlying and surface segmental inventories of languages can be captured. Furthermore, it is claimed that these universal rules play an overt role in the mapping of underlying representations onto surface representations. That is, the theory proposed here is a theory of the universal properties of sound systems at all levels of representation.

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Preface

Every natural (human) language has a sound system; the existence of a segmental system is an essential part of a language. The members of the segmental system of any language are not an arbitrary set of segments. For example, there is no language in which all the segments are nonsyllabic. The question this thesis addresses is what are the necessary conditions a phonological system must meet in order to be potentially the phonological system of a language.

It is assumed here that there is a relatively small set of distinctive features with binary specifications in terms of which all the members of every segmental system can be characterized at every stage of phonological representation. The postulation of such a set of features makes a substantive claim as to the class of possible elements in phonological systems.

Of the set of possible segments characterized by the distinctive features, it is evident that some are present in nearly every language, with others only occasionally

occurring. For example, the segments t and a are nearly ubiquitous in segmental systems; they are found at all stages of phonological representation in an overwhelming majority of languages, but the segments k^h and u only occasionally enjoy a place in segmental systems. The simple postulation of a set of features cannot account for such facts. It is argued here that some conjunctions of specified features are more likely to occur than others; if a segment is characterized by a likely set of specified features then that segment is likely to occur in many languages. As a first approximation, the theory of markedness can be said to be a theory of the most likely intrasegmental conjunctions of specified features. A likely specification of a feature in a segment is termed an unmarked specification; an unlikely one is termed a marked specification.

It follows from basic assumptions of linguistic theory that those segments which are most likely at one level of phonological representation are the most likely at every other. The phonological component of a generative grammar consists of a set of ordered rules which map lexical (underlying) formatives represented in terms of specified features onto utterances (surface representations). The set of phonological rules of any given language is the most highly valued set of statements which provide a means for deriving utterances from underlying representations. Within the framework

of generative grammar the most highly valued such set is taken to be that which requires the least number of symbols to state under notational conventions that express significant generalizations. Given such a theory it is to be expected that those segments which are most likely at some level of representation are most likely at every level of representation. The theory of markedness is therefore concerned with all levels of phonological representation.

The segmental representation $\begin{bmatrix} \alpha_i & F_i \\ \vdots & \vdots \\ \alpha_n & F_n \end{bmatrix}$, where $\alpha_i, \dots,$

α_n are + or - and F_i, \dots, F_n are distinctive features, is said to characterize a 'natural' (though not necessarily likely) class of segments. The natural class so represented is that class of segments for which it is true that every segment is specified $[\alpha_i F_i], \dots,$ and $[\alpha_n F_n]$. The members of a natural class are not all equally likely. For example, consider the class of segments which are [- syl], the class of consonants and glides. Given the two features syllabic and consonantal where the former is specified -, the most likely (the unmarked) specification of the latter is +. That is, nonsyllabic segments are typically consonants. Therefore, in the class of [- syl] segments some segments are more likely than others.

A second type of natural class is introduced by the theory of markedness. This type of natural (though, again, not necessarily likely) class is the class of all segments

which have the same markedness specifications for each of the features F_1, \dots, F_n . Consider the features consonantal and sonorant. It is typical for [+ cons] segments to be [- son] and for [- cons] segments to be [+ son]. Thus, the class of segments which are unmarked for sonorant is the class of 'true' consonants, vowels, and glides. The class of segments which are marked for sonorance, the class of nasals and laterals, is made up of segments which are [+ cons] and [+ son].

In every segmental system at each level of representation there is at least one nasal or one lateral. Within the standard framework of phonology this fact would be captured by stipulating that one such segment must occur in the segmental system of every language. Consider now the feature anterior. In consonant systems it is generally the case that there is a strong bias in favor of front consonants; therefore, the specification [+ ant] is unmarked in consonants, and the specification [- ant] is marked. In every language there are consonants which are [- ant]. The standard theory must again stipulate that such a consonant must occur in every language. Within the framework of markedness, however, it can be said that in every language there must be a segment which is marked for sonorant and a segment which is marked for anterior.

There exist conditions on the structure of segmental systems requiring that there be a certain variety of segments.

In the standard theory of phonology this can only be captured by listing the natural classes of segments (in the first sense) which must occur. The theory of markedness attempts to give a principled and general statement of such conditions. In the theory of markedness it is possible to capture such conditions by the postulation of a class of features such that for each feature in that class there must be some segment in the segmental system of every language which is marked. It is therefore concerned with 'unlikely' feature specifications as well as likely ones.

It is the most typical case for consonants to be voiceless. No language is without voiceless consonants though there are languages without voiced consonants. It follows that voicelessness is unmarked in consonants, and that unlike anterior and sonorant it is not the case that in every language there are segments which are marked for voicing. In every language with fricatives there are strident segments, while in some languages there are no nonstrident fricatives. Thus, stridency is unmarked in fricatives and it is not the case that every language has some segment which is marked for this feature. Here again, in the absence of the theory of markedness the only way of capturing such facts is simply by listing them. Within the theory of markedness it can be said there exists a set of features which need not be marked at any level of representation.

High back consonants are generally [- lab]; that is their unmarked specification. If a language has a labialized velar then it also has a nonlabialized one. Thus, it can be said that a marked specification of labial in some segment implies the existence of a segment that is unmarked for labial, and which shares all other feature specifications. Observe now, that since all languages have voiceless stops but not all have voiced ones, the existence of a marked specification for voicing implies the existence of an unmarked specification; the same is true of strident. While all languages have at least one lateral or nasal, it is also the case that all languages have nonsonorant consonants. The generalization can therefore be made that the existence of a marked specification of a feature (for at least a class of features) in a language implies the existence of the unmarked one, but not conversely. A theory of phonology which only uses + and - specifications for features must list these facts; it is not the case that [+ F] for any feature F implies [- F] in every language, or conversely that [- F] for any feature implies [+ F]. There are regularities in the structure of the sound systems of languages and it is the goal of the theory of markedness to provide a principled account of these. Thus, a generalization such as that given just above would be such a principle if the class of features for which it held true were not an ad hoc class, for instance if it were true of the

class consisting of all the distinctive features.

At every stage in phonological derivation from underlying representation to surface representation segments are characterized by distinctive features. So far only the extreme levels of phonological representation have been considered. If the general assumptions of generative phonology are accepted, then conditions on the structure of segmental representations must hold at the intermediate levels of representation as well as at the extremes. That is, the claim is made that the only classifications of features (hence of segments) are those which hold of underlying and surface representation; there are no classifications of features (hence of segments) which are introduced in derivations.

The theory of markedness introduces two types of feature specifications, +/- specifications and markedness specifications. That these two types of specifications are distinct can be seen from the following example. The class of [+ cons] segments is the class of segments which are articulated with a radical obstruction in the vocal tract; there is a clear phonetic correlate to the single specification [+ cons]. From the specification of a set of segments as unmarked for consonantal, in the absence of other information, it is impossible to tell whether a segment in that class is produced with a radical obstruction; there is no clear phonetic correlate to that specification of a class--the class of

segments so specified is the class of true consonants and vowels. That markedness specifications are not necessarily directly translatable into phonetic properties does not make them any the less real. Markedness specifications characterize the nonphonetic linguistically significant properties of segmental systems.

The postulation of two distinct types of binary feature specifications enriches the theory of segmental systems. That this is somewhat more complicated than the standard phonological theory is not an argument against the validity of the claim. The legitimacy of any theory rests not on how easy it is to use and understand but rather the work it does within the context of well defined goals. The value of a theory can only be judged on the basis of its success in satisfying the goals that are set out for it.

The goal of general linguistics is taken here as being the characterization of the essential, universal properties of natural languages. If conjunctions of specified distinctive features characterize the segmental systems of all languages at all levels of phonological representation, and there are universal properties of phonological systems beyond the property that the elements of such systems are drawn from a finite set of segments, then these properties must be captured in linguistic theory. There are such properties; therefore the theory of markedness is a necessary part of general linguistic theory.

The capacity for language is a species specific property of human beings; a property shared by virtually all men. On the basis of limited and often contradictory data, the child constructs a complex and abstract grammar in a very short time. Language could not be learned were a strategy for grammar construction not part of the child's cognitive capacity. The essential universals of language must therefore reflect an aspect of the cognitive capacity of the species. Linguistic theory is therefore a biological model. It follows that the theory of markedness is itself a model of part of the cognitive domain.

The question is then not whether there is a theory of markedness, but rather what is the internal structure of such a theory. It is this question to which this thesis is addressed. The thesis is divided into two major parts. In the first part (Chapter 1, §§1-7) the phonological alphabets of languages are considered. Based on the universal properties of segmental inventories some necessary conditions on the sound systems of languages are proposed. These conditions form the core of the theory of markedness to be outlined. In the second part (§§8-17 in Chapter 2) the effect of phonological rules on segments is considered, and it is argued that each of the distinctions among classes of features which follow from the conditions proposed in Chapter 1 has a unique function in the application of phonological rules. In §18 there is a summary of the technical details of the theory.

Chapter 1

On the Structure of Segmental Systems

Within the standard theory of generative phonology (that developed in The Sound Pattern of English (SPE), chapters 1-8) there is no way to capture the fact that some segmental systems, at the systematic phonemic level, are quite probable for natural (human) languages while other segmental systems are quite improbable. In this chapter a theory will be proposed to distinguish the probable segmental systems from the improbable ones.

1. It is proposed that there exists a set of universal conventions which express the most natural (probable) intrasegmental relations which hold among the classificatory features which characterize segments.¹ If the specification, + or -, of a feature in a segment is the most likely specification of that feature in such a segment, that specification will be called an unmarked specification of that feature. If, on the other hand, the specification, + or -, of a feature in

a segment is not the most likely specification for that feature in such a segment, it will be called a marked specification of that feature.²

1.1 For example, consonants are characteristically [- lab], therefore:

- (i) the specification [- lab] is unmarked in [+ cons] segments.

Among $\begin{bmatrix} - & \text{cons} \\ - & \text{back} \end{bmatrix}$ segments the characteristic specification of labial is [- lab]; that is, /i/ is a more likely vowel than /ü/, therefore:

- (ii) the specification [- lab] is unmarked in $\begin{bmatrix} - & \text{cons} \\ - & \text{back} \end{bmatrix}$ segments.

Since /a/ enjoys far wider currency in segmental systems than does /ɔ/, the most likely specification of labial in a segment which is $\begin{bmatrix} - & \text{cons} \\ + & \text{back} \\ + & \text{low} \end{bmatrix}$ is [- lab], therefore:

- (iii) the specification [- lab] is unmarked in $\begin{bmatrix} - & \text{cons} \\ + & \text{back} \\ + & \text{low} \end{bmatrix}$ segments.

The most common specification of labial in $\begin{bmatrix} - & \text{cons} \\ + & \text{back} \\ - & \text{low} \end{bmatrix}$ segments is [+ lab]; at the underlying level /u/ and /o/ are more probable than /ɨ/ and /ə/, therefore:

- (iv) the specification [+ lab] is unmarked in $\begin{bmatrix} - & \text{cons} \\ + & \text{back} \\ - & \text{low} \end{bmatrix}$ segments.

We can formalize (iv) as (1).

$$(1) \quad [u \text{ lab}] \longrightarrow [+ \text{ lab}] / \begin{bmatrix} - \text{cons} \\ + \text{back} \\ - \text{low} \end{bmatrix} \quad (= (iv))$$

We will interpret (1) as: the specification u, 'unmarked', for the feature labial is rewritten as the specification + for the feature labial in a segment which is $\begin{bmatrix} - \text{cons} \\ + \text{back} \\ - \text{low} \end{bmatrix}$. Using the notation of (1), we can formalize (i)-(iii) as (2)-(4), respectively.

$$(2) \quad [u \text{ lab}] \longrightarrow [- \text{ lab}] / \begin{bmatrix} + \text{cons} \end{bmatrix} \quad (= (i))$$

$$(3) \quad [u \text{ lab}] \longrightarrow [- \text{ lab}] / \begin{bmatrix} - \text{cons} \\ - \text{back} \end{bmatrix} \quad (= (ii))$$

$$(4) \quad [u \text{ lab}] \longrightarrow [- \text{ lab}] / \begin{bmatrix} - \text{cons} \\ + \text{back} \\ + \text{low} \end{bmatrix} \quad (= (iii))$$

There is an obvious relation between (1) and (2)-(4). Consider first (2). The environment of (2) is [+ cons] while the environment of (1) is [- cons]; the unmarked value of labial is [- lab] in (2) while it is [+ lab] in (1); in (2) the specification of the feature in the environment is the reverse of the specification of that feature in the environment of (1), and the unmarked specification of labial in (2) is the reverse of that in (1).

The specification of the feature back in the environment of (3) is the opposite of that for back in the environment

of (1), and the unmarked specification of labial in (3) is the opposite of that in (1). Finally, in (4) the specification of the feature low is the contrary of that in (1), and the unmarked specification of labial in (4) is the contrary of that in (1).

Based on these observations we can make the generalization that for any segment which does not satisfy the environment of (1) the unmarked specification of labial is the opposite of that assigned by (1). The formal relation between (1) and (2)-(4) can be characterized as the relation between (5a) and (5b).

$$(5) \text{ a} \quad [u \ F] \longrightarrow [\alpha \ F] / X$$

$$\text{b} \quad [u \ F] \longrightarrow [-\alpha \ F] / \bar{X}$$

$$\text{where } X \text{ is } \begin{bmatrix} \beta_1 \overline{G_1} \\ \vdots \\ \beta_n \overline{G_n} \end{bmatrix},$$

F, G_1, \dots, G_n are features, and

$\alpha, \beta_1, \dots, \beta_n$ are + or -

(5a) states that the unmarked specification of some feature F is α , where α is + or -, in a segment characterized by the specification(s) of X . (5b) states that the unmarked specification of that feature F is $-\alpha$ in the complement of the set of segments characterized by X .

Given the features consonantal, back, and low, and the possible specifications + and -, eight classes of

segments can be characterized.

$$\begin{array}{l}
 (6) \text{ a } \begin{bmatrix} - \text{ cons} \\ + \text{ back} \\ - \text{ low} \end{bmatrix} \\
 \\
 \text{b } \text{i} \begin{bmatrix} + \text{ cons} \\ + \text{ back} \\ - \text{ low} \end{bmatrix} \quad \text{ii} \begin{bmatrix} + \text{ cons} \\ + \text{ back} \\ + \text{ low} \end{bmatrix} \quad \text{iii} \begin{bmatrix} + \text{ cons} \\ - \text{ back} \\ - \text{ low} \end{bmatrix} \quad \text{iv} \begin{bmatrix} + \text{ cons} \\ - \text{ back} \\ + \text{ low} \end{bmatrix} \\
 \\
 \text{c } \text{i} \begin{bmatrix} - \text{ cons} \\ - \text{ back} \\ - \text{ low} \end{bmatrix} \quad \text{ii} \begin{bmatrix} - \text{ cons} \\ - \text{ back} \\ + \text{ low} \end{bmatrix} \\
 \\
 \text{d } \begin{bmatrix} - \text{ cons} \\ + \text{ back} \\ + \text{ low} \end{bmatrix}
 \end{array}$$

(6a) characterizes the set of segments which are subject to (1); (6b) characterizes the segments which are subject to (2); (6c) characterizes the segments which are subject to (3); and (6d) characterizes the segments which are subject to (4). The set of segments (6b,c,d) is derivable from (6a) if we take the specified features in (6a) to define a set and then characterize the complement of that set.

It is claimed here that for every feature defined on a single segment, there exists a statement of the form (5a) and, derivatively, a set of statements conforming to (5b) which exhaustively characterize the unmarked specifications, + and -, of every such feature.

If [+ lab] is the most likely, hence unmarked, specification of labial in nonlow back vowels, then, in accordance with the terminology given above,

- (v) the specification [- lab] is marked in
 $\begin{bmatrix} - \text{cons} \\ + \text{back} \\ - \text{low} \end{bmatrix}$ segments.

Similarly,

- (vi) the specification [+ lab] is marked in
 [+ cons] segments;

- (vii) the specification [+ lab] is marked in
 $\begin{bmatrix} - \text{cons} \\ - \text{back} \end{bmatrix}$ segments;

- (viii) the specification [+ lab] is marked in
 $\begin{bmatrix} - \text{cons} \\ + \text{back} \\ + \text{low} \end{bmatrix}$ segments.

Using the notation developed in (1), and the specification m to mean 'marked', (v)-(viii) can be stated as (7)-(10), respectively.

$$(7) \quad [m \text{ lab}] \longrightarrow [- \text{lab}] / \begin{bmatrix} - \text{cons} \\ + \text{back} \\ - \text{low} \end{bmatrix} \quad (= (v))$$

$$(8) \quad [m \text{ lab}] \longrightarrow [+ \text{lab}] / \begin{bmatrix} + \text{cons} \end{bmatrix} \quad (= (vi))$$

$$(9) \quad [m \text{ lab}] \longrightarrow [+ \text{lab}] / \begin{bmatrix} - \text{cons} \\ - \text{back} \end{bmatrix} \quad (= (vii))$$

$$(10) \quad [m \text{ lab}] \longrightarrow [+ \text{lab}] / \begin{bmatrix} - \text{cons} \\ + \text{back} \\ + \text{low} \end{bmatrix} \quad (= (viii))$$

The relation between (7) and (8)-(10) is analogous to the relation between (1) and (2)-(4). Using the same

notation as in (5), we can characterize this relation as being that which holds between (11a) and (11b).

$$(11) \quad \begin{array}{l} \text{a} \quad [m \ F] \longrightarrow [-\alpha \ F] / X \\ \text{b} \quad [m \ F] \longrightarrow [\alpha \ F] / \bar{X} \end{array}$$

The claim is made here that for each feature defined on a single segment, the set of statements consistent with (11a,b), which are derivable from (5a), exhaustively characterize the marked specifications for each such feature.

1.2 The primitives of the system outlined above are:

- (12) a The set of distinctive features defined on single segments
 b The specifications: u, m, +, -
 c \longrightarrow (rewrite as)
 d Conjunction of specified features
 e Complementation

It is proposed that associated with every feature in (12a) there exists a statement of the form (13)--call it a markedness convention.

$$(13) \quad [u \ F] \longrightarrow [\alpha \ F] / X$$

where X is $\left[\begin{array}{c} \beta_1 \ G_1 \\ \vdots \\ \beta_n \ G_n \end{array} \right],$

F, G_1, \dots, G_n are features, and
 $\alpha, \beta_1, \dots, \beta_n$ are + or -

Furthermore, it is proposed that for every feature in (12a) there exists a set of markedness rules which are projected from (13) in accordance with (14), and which exhaustively characterize the markedness specifications of each feature in (12a).³

(14) The Complement Convention

- a [u F] → [α F] / X
- b [m F] → [-α F] / X
- c [u F] → [-α F] / \bar{X}
- d [m F] → [α F] / \bar{X}

Within such a theory of phonology, a segment can be characterized for the features (12a) solely in terms of u and m specifications. It will be argued here that the probability of some arbitrary segment having a place in the sound pattern of some language L depends on the array of marks in the segment in the context of the marks of the other segments of L.

The rest of this chapter is organized as follows. A set of markedness conventions is proposed. Not all combinations of feature specifications are possible, e.g., there can be no $\left[\begin{array}{l} + \text{ high} \\ + \text{ low} \end{array} \right]$ segment; a set of co-occurrence restrictions on possible combinations of feature specifications within segments is then proposed to account for these restrictions. It will be argued that there is a set of features for which there must be marked specifications in the underlying segmental system of any natural human language.

2.1 Segments which are [- syl] are characteristically [+ cons] (that is, consonants are more common than glides), and segments which are [+ syl] are generally [- cons] (vowels are more common than syllabic laterals and nasal consonants). (15) is proposed as the appropriate markedness convention for the feature consonantal.

$$(15) \text{ III} \quad [u \text{ cons}] \longrightarrow [+ \text{ cons}] / \left[\begin{array}{c} \text{---} \\ - \text{ syl} \end{array} \right]$$

2.2 Among consonants the most common specification for the feature anterior is [+ ant]; labials and coronals are [+ ant], while, in the most typical case, only the velars are [- ant]. Vowels and glides are almost invariably [- ant]. (16) is proposed to account for this distribution in specifications.

$$(16) \text{ IV} \quad [u \text{ ant}] \longrightarrow [+ \text{ ant}] / \left[\begin{array}{c} \text{---} \\ + \text{ cons} \end{array} \right]$$

2.3 Nonanterior segments are usually [+ back]. In the stop series of a language it is generally the case that if there is a /č/ then there is also a /k/. It has frequently been observed that /a/ is a member of almost every vowel system. It appears to be the case that in most vowel systems there is some bias toward the specification [+ back]. (17) is posited as the markedness convention for back.

$$(17) \text{ V} \quad [u \text{ back}] \longrightarrow [+ \text{ back}] / \left[\begin{array}{c} \text{---} \\ - \text{ ant} \end{array} \right]$$

2.4 Consonants are characteristically nonlow. The front vowels /i/ and /e/ enjoy wider currency than does the front low vowel /æ/; therefore, it is unmarked for front vowels to be [- low]. /a/ is a member of virtually every segmental system. /u/, though quite common, is not nearly so ubiquitous. Of the three common back glides, /h/, /w/, and /?/, both /h/ and /?/ are [+ low]. Based on these observations, (18) is proposed as the convention for low.

$$(18) \text{ VI} \quad [u \text{ low}] \longrightarrow [+ \text{ low}] / \left[\begin{array}{c} - \text{cons} \\ + \text{back} \end{array} \right]$$

Convention (18) is projected as the markedness rules (19).

$$(19) \text{ a} \quad [u \text{ low}] \longrightarrow [+ \text{ low}] / \left[\begin{array}{c} - \text{cons} \\ + \text{back} \end{array} \right]$$

$$\text{b} \quad [m \text{ low}] \longrightarrow [- \text{ low}] / \left[\begin{array}{c} - \text{cons} \\ + \text{back} \end{array} \right]$$

$$\text{c} \quad \text{i} \quad [u \text{ low}] \longrightarrow [- \text{ low}] / \left[\begin{array}{c} + \text{cons} \\ + \text{back} \end{array} \right]$$

$$\text{ii} \quad [u \text{ low}] \longrightarrow [- \text{ low}] / \left[\begin{array}{c} + \text{cons} \\ - \text{back} \end{array} \right]$$

$$\text{iii} \quad [u \text{ low}] \longrightarrow [- \text{ low}] / \left[\begin{array}{c} - \text{cons} \\ - \text{back} \end{array} \right]$$

$$\text{d} \quad \text{i} \quad [m \text{ low}] \longrightarrow [+ \text{ low}] / \left[\begin{array}{c} + \text{cons} \\ + \text{back} \end{array} \right]$$

$$\text{ii} \quad [m \text{ low}] \longrightarrow [+ \text{ low}] / \left[\begin{array}{c} + \text{cons} \\ - \text{back} \end{array} \right]$$

$$(19) \text{ d iii } [m \text{ low}] \longrightarrow [+ \text{ low}] / \left[\begin{array}{c} - \text{ cons} \\ - \text{ back} \end{array} \right]$$

It follows from (19a) that a is unmarked for low. By (19b) u, o, ɪ, and ə are marked for low. By (19c-i,ii) all nonlow consonants are unmarked for low. The vowels i, e, ü, and ö are unmarked for low by (19c-iii). ɥ is [m low] by (19d-i). The role of (19d-ii) is left open. (19d-iii) requires that ɤ and œ be [m low].

2.5 The convention for labial, given above, is repeated here for continuity.

$$(20) \text{ VII } [u \text{ lab}] \longrightarrow [+ \text{ lab}] / \left[\begin{array}{c} - \text{ cons} \\ + \text{ back} \\ - \text{ low} \end{array} \right]$$

2.6 Consonants are usually not sonorants; [- cons] segments are always [+ son].

$$(21) \text{ VIII } [u \text{ son}] \longrightarrow [- \text{ son}] / \left[+ \text{ cons} \right]$$

2.7 The specification [+ cor] is typically associated with consonants and glides which are neither back nor labial.

$$(22) \text{ IX } [u \text{ cor}] \longrightarrow [+ \text{ cor}] / \left[\begin{array}{c} - \text{ syl} \\ - \text{ back} \\ - \text{ lab} \end{array} \right]$$

2.8 Vowels are characteristically [- spr]. Glides and consonants which are $\left[\begin{array}{c} + \text{ back} \\ + \text{ lab} \end{array} \right]$ are generally [- spr], as are $\left[\begin{array}{c} + \text{ lab} \\ + \text{ cor} \end{array} \right]$ glides and consonants. Consonants and glides which

are labial but neither coronal nor back are [+ spr].

$$(23) \text{ X} \quad [u \text{ spr}] \longrightarrow [+ \text{ spr}] / \begin{bmatrix} - \overline{\text{syl}} \\ - \text{cor} \\ - \text{back} \\ + \text{lab} \end{bmatrix}$$

2.9 The specification [- high] is usually associated with anterior consonants and with glides that are coronal or labial and spread.

$$(24) \text{ XI} \quad [u \text{ high}] \longrightarrow [- \text{ high}] / \begin{bmatrix} \alpha \overline{\text{cons}} \\ \alpha \text{ant} \\ \beta \text{cor} \\ -\beta \text{lab} \\ -\beta \text{spr} \end{bmatrix}$$

In (24) a variable, α , is used in the environment of the convention. This variable is being used here as it is used in phonological rules. α ranges over + and - and once fixed at + or - in one instance all other instances of α are fixed in agreement. The introduction of variable specifications increases the descriptive power of possible markedness conventions.

By the Complement Convention (24) is expanded as the set of markedness rules in (25).

$$(25) \text{ a} \quad [u \text{ high}] \longrightarrow [- \text{ high}] / \begin{bmatrix} - \overline{\text{cons}} \\ - \text{ant} \\ + \text{cor} \\ - \text{lab} \\ - \text{spr} \end{bmatrix}$$

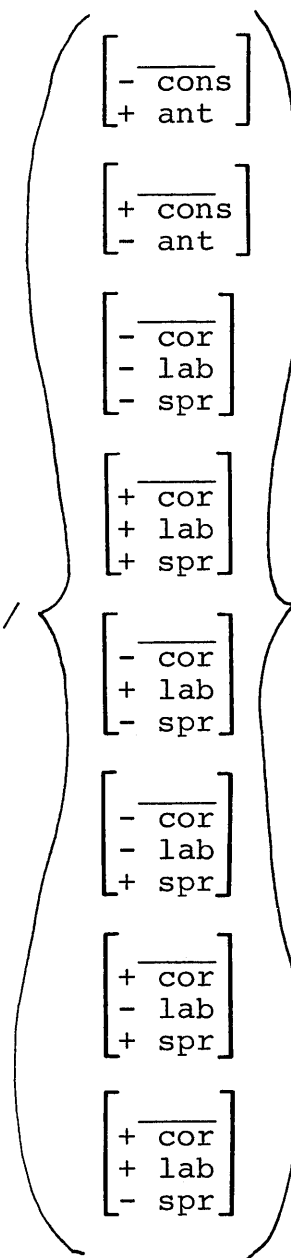
$$[u \text{ high}] \longrightarrow [- \text{ high}] / \begin{bmatrix} - \overline{\text{cons}} \\ - \text{ant} \\ - \text{cor} \\ + \text{lab} \\ + \text{spr} \end{bmatrix}$$

(25) a continued

	[u high]	[- high] /	$\begin{bmatrix} + \text{cons} \\ + \text{ant} \\ + \text{cor} \\ - \text{lab} \\ - \text{spr} \end{bmatrix}$
	[u high]	→ [- high] /	$\begin{bmatrix} + \text{cons} \\ + \text{ant} \\ - \text{cor} \\ + \text{lab} \\ + \text{spr} \end{bmatrix}$
b	[m high]	→ [+ high] /	$\begin{bmatrix} - \text{cons} \\ - \text{ant} \\ + \text{cor} \\ - \text{lab} \\ - \text{spr} \end{bmatrix}$
	[m high]	→ [+ high] /	$\begin{bmatrix} - \text{cons} \\ - \text{ant} \\ - \text{cor} \\ + \text{lab} \\ + \text{spr} \end{bmatrix}$
	[m high]	→ [+ high] /	$\begin{bmatrix} + \text{cons} \\ + \text{ant} \\ + \text{cor} \\ - \text{lab} \\ - \text{spr} \end{bmatrix}$
	[m high]	→ [+ high] /	$\begin{bmatrix} + \text{cons} \\ + \text{ant} \\ - \text{cor} \\ + \text{lab} \\ + \text{spr} \end{bmatrix}$

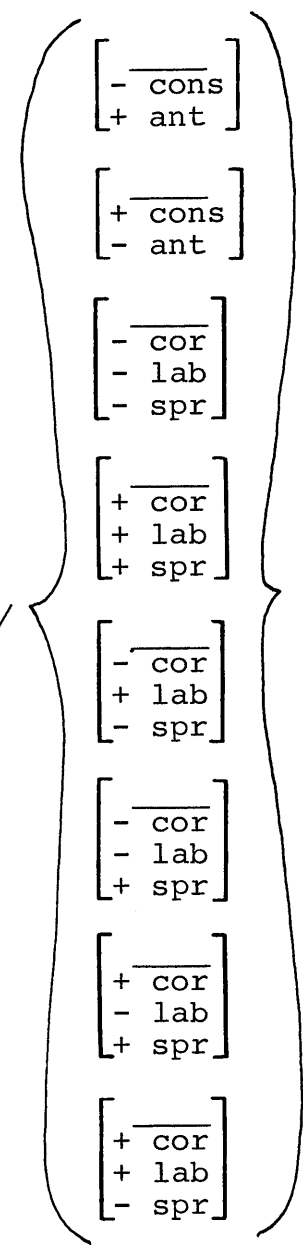
(25) c

[u high] → [+ high] /



(25) d

[m high] → [- high] /



2.10 The most common sonorant consonants are nasals. Vowels and obstruents are generally not nasalized.

$$(26) \text{ XII} \quad [u \text{ nas}] \longrightarrow [- \text{ nas}] / \left[\begin{array}{c} \alpha \overline{\text{cons}} \\ -\alpha \text{son} \end{array} \right]$$

2.11 Nonnasal sonorants are almost always [+ cont]. In obstruent systems the stop series is generally more elaborated than the fricative series; in no language can there be only one stop but several fricatives while in a not insignificant number of languages there is but one fricative and a stop series of several members.

$$(27) \text{ XIII} \quad [u \text{ cont}] \longrightarrow [+ \text{ cont}] / \left[\begin{array}{c} + \overline{\text{son}} \\ - \text{nas} \end{array} \right]$$

2.12 Halle and Stevens (1971) suggest that instead of the feature voice there should be two features, stiff vocal cords and slack vocal cords. Within their system voiceless

obstruents are [+ StVC] while voiced obstruents, [- StVC] obstruents may be either [- SlVC] or as [+ SlVC], the determination of the specification being contingent to some extent at least on the phonological environment. There are no segments which are both [+ StVC] and [+ SlVC].

Normal vowels, liquids, and nasals are [- StVC] and [- SlVC]. Vowels with high tone are [+ StVC] while vowels with low tone are [+SlVC]. Using these features it is possible to relate voice and tone.

To account for the distribution of the specification for stiff vocal cords the markedness convention (28) is proposed.

$$(28) \text{ XIV} \quad [u \text{ StVC}] - [- \text{ StVC}] / \left[\begin{array}{c} \text{son} \\ + \end{array} \right]$$

By the rules expanded from (28) it must be the case that voiceless obstruents are unmarked for stiff vocal cords and that voiced obstruents are marked for this feature. Given that all languages have voiceless obstruents and that some languages only have voiceless obstruents (for example, according to Hockett (1955), p. 108 ff., Hawaiian, Trukese, Fox, Tunica, etc., are such languages), this markedness specification for stiff vocal cords in obstruents is supported.

Since obstruents which are [- StVC] are generally [+ SlVC], (29) is posited.

$$(29) \text{ XV} \quad [u \text{ SlVC}] \rightarrow [+ \text{ SlVC}] / \left[\begin{array}{c} \text{son} \\ - \\ - \text{ StVC} \end{array} \right]$$

2.13 The table in (30) gives the distribution of the features spread glottis and constricted glottis.

(30)	liquids nasals vowels glides	h breathy vowels aspirates	? creaky vowels glottalized segments
Constricted glottis	-	-	+
Spread glottis	-	+	-

Breathy vowels, creaky vowels, aspirated segments, and glottalized segments are of far more limited occurrence in underlying and surface systems than are segments which are $\begin{bmatrix} - & \text{CG} \\ - & \text{SG} \end{bmatrix}$. The only segment which is characteristically [+ SG] is h. Convention (31) is proposed as the appropriate convention for this feature.

$$(31) \text{ XVI} \quad [u \text{ SG}] \longrightarrow [+ \text{ SG}] / \begin{bmatrix} - & \overline{\text{syl}} \\ - & \text{cons} \\ + & \text{cont} \\ + & \text{StVC} \end{bmatrix}$$

Glottalized segments and implosives are [+ CG]. Given the relative rarity of such segments it must be assumed that they are marked. ? is the only segment which is characteristically [+ CG]. Convention (32) is tentatively proposed.

$$(32) \text{ XVII} \quad [u \text{ CG}] \longrightarrow [+ \text{ CG}] / \begin{bmatrix} - & \overline{\text{syl}} \\ - & \text{cons} \\ + & \text{StVC} \\ - & \text{cont} \end{bmatrix}$$

2.14 Segments which are $\begin{bmatrix} + \text{ cons} \\ + \text{ son} \\ + \text{ cont} \\ + \text{ cor} \end{bmatrix}$ are characteristically [+ lat].

$$(33) \text{ XVIII} \quad [u \text{ lat}] \rightarrow [+ \text{ lat}] / \begin{bmatrix} + \text{ cons} \\ + \text{ son} \\ + \text{ cont} \\ + \text{ cor} \end{bmatrix}$$

2.15 The specification [+ DR] is associated with affricates. The most common affricate appears to be /č/. A non-continuant consonant which is $\begin{bmatrix} + \text{ cor} \\ + \text{ high} \\ - \text{ back} \end{bmatrix}$ is usually an affricate. Noncontinuant laterals are realized as lateral affricates. These facts lead to the postulation of (34).

$$(34) \text{ XIX} \quad [u \text{ DR}] \rightarrow [+ \text{ DR}] / \begin{bmatrix} - \text{ son} \\ - \text{ cont} \\ + \text{ cor} \\ \alpha \text{ high} \\ -\alpha \text{ lat} \\ - \text{ back} \end{bmatrix}$$

2.16 Nonvelar fricatives which are [- SG] are generally strident, as are affricates. Fricatives which are [+ SG] are typically nonstrident. Vowels and glides are always nonstrident. Lateral affricates are nonstrident.

$$(35) \text{ XX} \quad [u \text{ stri}] \rightarrow [+ \text{ stri}] / \begin{bmatrix} - \text{ son} \\ \alpha \text{ cont} \\ -\alpha \text{ DR} \\ - \text{ back} \\ - \text{ SG} \\ - \text{ lat} \end{bmatrix}$$

2.17 Segments which are $\begin{bmatrix} - & \text{cons} \\ - & \text{syl} \\ + & \text{cor} \end{bmatrix}$ are characteristically r's.

$$(36) \text{ XXI} \quad [u \text{ flap}] \longrightarrow [+ \text{ flap}] / \begin{bmatrix} - & \overline{\text{syl}} \\ - & \text{cons} \\ + & \text{cor} \end{bmatrix}$$

2.18 Segments which are $\begin{bmatrix} - & \text{syl} \\ - & \text{cons} \\ + & \text{cor} \\ - & \text{flap} \end{bmatrix}$ are characteristically trilled.

$$(37) \text{ XXII} \quad [u \text{ trill}] \longrightarrow [+ \text{ trill}] / \begin{bmatrix} - & \overline{\text{syl}} \\ - & \text{cons} \\ + & \text{cor} \\ - & \text{flap} \end{bmatrix}$$

2.19 There are several features whose unmarked specification is constant across all classes of segments. These features are long, stress, and constricted pharynx. All segments are characteristically not long, unstressed, and nonpharyngealized.

$$(38) \text{ XXIII} \quad [u \text{ long}] \longrightarrow [- \text{ long}] / \begin{bmatrix} + & \overline{\text{seg}} \end{bmatrix}$$

$$(39) \text{ XXIV} \quad [u \text{ stress}] \quad [- \text{ stress}] / \begin{bmatrix} + & \overline{\text{seg}} \end{bmatrix}$$

$$(40) \text{ XXV} \quad [u \text{ CP}] \longrightarrow [- \text{ CP}] / \begin{bmatrix} + & \overline{\text{seg}} \end{bmatrix}$$

The convention for each of these features has a null complement.

2.20 The features segment and syllabic differ from the features discussed so far in two major ways. One obvious difference is that neither of these features has an articulatory definition. A second difference is that whether or not a unit

is marked for either of these features depends on the place of that unit in a string and not solely on the other features of that unit.

A phonological representation consists minimally of a string of segments bounded on the right and on the left by a nonsegmental unit. Since it is characteristic for a morpheme to contain a vowel (41) is proposed.⁴

$$(41) I' \quad [u \text{ seg}] \longrightarrow [- \text{ seg}] / \\ ([- \text{ seg}] \times [+ \text{ syll}]) \left[\underline{\text{Unit}} \right]$$

By (41) it is claimed that short morphemes are less marked than long morphemes; in particular, that monosyllabic morphemes are less marked than polysyllabic morphemes. Whether or not this is true, is of course an empirical question. If it were to be proved that disyllabic morphemes were the unmarked morphemes, then (41) would have to be reformulated as (42).

$$(42) I'' \quad [u \text{ seg}] \longrightarrow [- \text{ seg}] / \\ ([- \text{ seg}] \times [+ \text{ syll}] [- \text{ syll}]_0 [+ \text{ syll}]) \left[\underline{\text{Unit}} \right]$$

Both (41) and (42) incorporate the claim that open syllables are less marked than closed syllables. Here again we are dealing with a question of fact, and it is not clear at this time whether or not open syllables should be considered unmarked. Were it shown that closed syllables are the unmarked syllables (41) would have to be reformulated as (43).

$$(43) \text{ I'' } [u \text{ seg}] \longrightarrow [- \text{ seg}] / \\ ([- \text{ seg}] \text{ X } [+ \text{ syl}] [- \text{ syl}]) \left[\overline{\text{Unit}} \right]$$

The questions of morpheme length and open syllables are left open here.

It is almost universally true that every language admits the sequence +CV. It has only rarely been suggested that a language excludes this sequence. To capture this (near) universal, (44) is proposed.

$$(44) \text{ II } [u \text{ syl}] \longrightarrow [- \text{ syl}] / \\ [- \text{ seg}] \text{ (X } [+ \text{ syl}]) \left[\overline{+ \text{ seg}} \right]$$

(41)-(44) differ from the other conventions proposed in that their environments are not single segments and they do not conform to (13). This is not surprising since they are features defined on strings; in fact what would be surprising is for their environments not to be strings. The features segment and syllabic will be designated 'major features'.

(45) For each major feature there exists a statement of the form

$$[u \text{ F}] \longrightarrow [\alpha \text{ F}] / \text{ X}$$

where F is the major feature,

α is + or -, and

X is a string of units.

It is further proposed that statements of the form

(48) are projected as markedness rules in accordance with the Complement Convention (14). In (46) the expansion of (41) is given, and in (47) the expansion of (44) is given.

(46)

- a [u seg] → [- seg] / ([- seg] X [+ syl]) $\left[\overline{\text{Unit}} \right]$
- b [m seg] → [+ seg] / ([- seg] X [+ syl]) $\left[\overline{\text{Unit}} \right]$
- c [u seg] → [+ seg] / [- seg] X [- syl] $\left[\overline{\text{Unit}} \right]$
- [u seg] → [+ seg] / [- seg] $\left[\overline{\text{Unit}} \right]$
- d [m seg] → [- seg] / [- seg] X [- syl] $\left[\overline{\text{Unit}} \right]$
- [m seg] → [- seg] / [- seg] $\left[\overline{\text{Unit}} \right]$

(47)

- a [u syl] → [- syl] / [- seg] (X [+ syl]) $\left[+ \overline{\text{seg}} \right]$
- b [m syl] → [+ syl] / [- seg] (X [+ syl]) $\left[+ \overline{\text{seg}} \right]$
- c [u syl] → [+ syl] / [- seg] X [+ syl] $\left[+ \overline{\text{seg}} \right]$
- d [m syl] → [- syl] / [- seg] X [+ syl] $\left[+ \overline{\text{seg}} \right]$

3.1 The markedness conventions given in §2 are, intrinsically, a partially ordered set. For the purposes of this discussion, assume that underlying representations are in terms of markedness matrices, rather than +/- matrices. Under this assumption, the markedness conventions must apply in their intrinsic order in order to specify the features of a segment or sequence of segments with +/- values. For example, consider a segment whose features have been partially specified in terms of + and - values, and which is at a stage in derivation where it is [+ cons] and $\begin{bmatrix} \text{u ant} \\ \text{u back} \end{bmatrix}$. No markedness rule for the feature back can apply to the segment at this stage in derivation since the back rules crucially require that the feature anterior be specified + or -. The appropriate anterior markedness rule must apply prior to the application of any markedness rule for back.⁵ The markedness conventions are listed in (48a), and in (48b) the partial ordering of the markedness conventions--and hence markedness rules--is schematized.

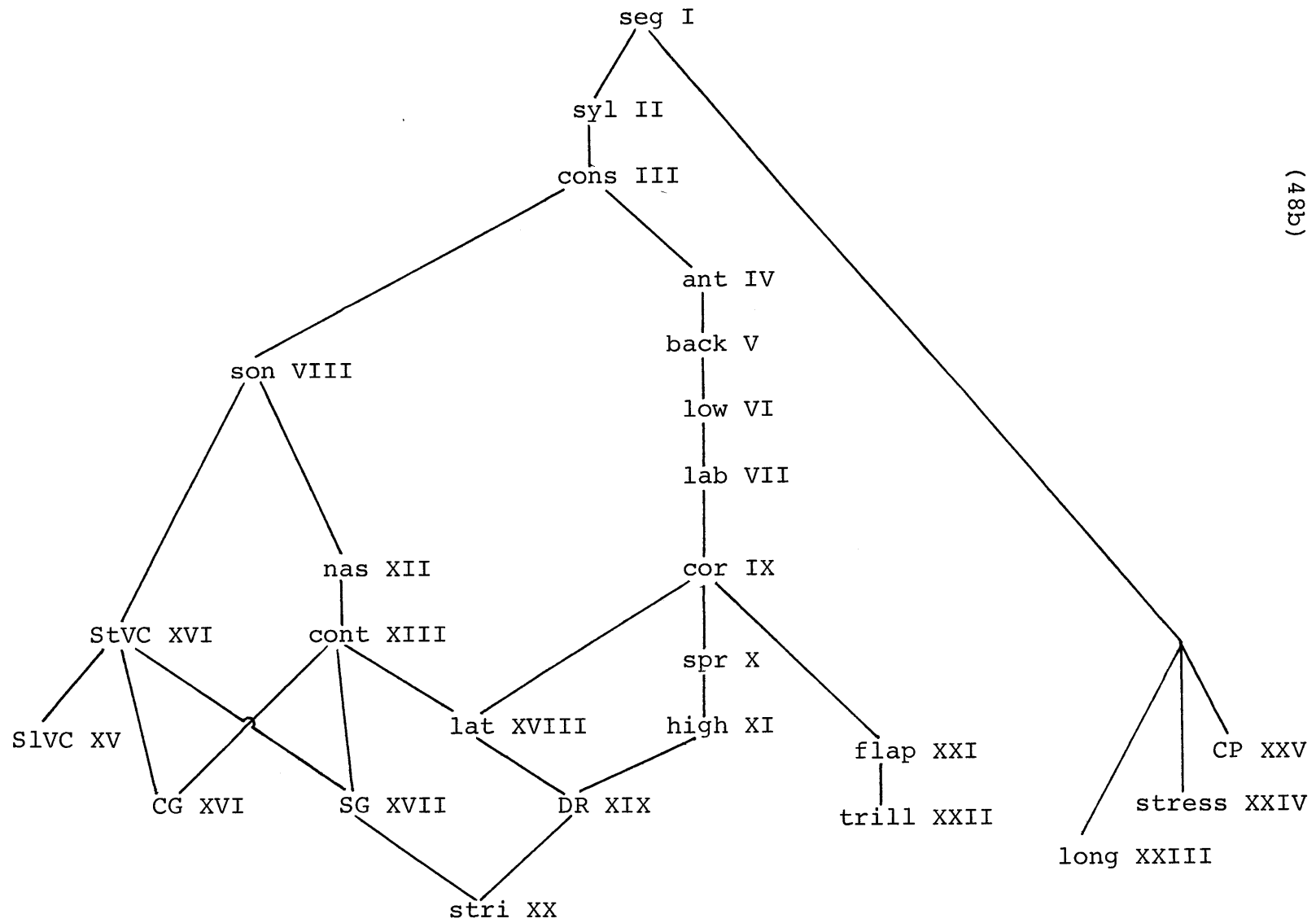
- (48a) I' [u seg] \longrightarrow [- seg] /
 ([- seg] X [+ syl]) $\left[\overline{\text{Unit}} \right]$
- II [u syl] \longrightarrow [- syl] /
 [- seg] (X [+ syl]) $\left[\overline{+ \text{seg}} \right]$
- III [u cons] \longrightarrow [+ cons] / $\left[\overline{- \text{sy1}} \right]$
- IV [u ant] \longrightarrow [+ ant] / $\left[\overline{+ \text{cons}} \right]$

(48a) continued

V	[u back] → [+ back] /	$\left[\begin{array}{c} \overline{\text{ant}} \\ - \end{array} \right]$
VI	[u low] → [+ low] /	$\left[\begin{array}{c} \overline{\text{cons}} \\ + \text{back} \end{array} \right]$
VII	[u lab] → [+ lab] /	$\left[\begin{array}{c} \overline{\text{cons}} \\ + \text{back} \\ - \text{low} \end{array} \right]$
VIII	[u son] → [- son] /	$\left[\begin{array}{c} \overline{\text{cons}} \\ + \end{array} \right]$
IX	[u cor] → [+ cor] /	$\left[\begin{array}{c} \overline{\text{syl}} \\ - \text{back} \\ - \text{lab} \end{array} \right]$
X	[u spr] → [+ spr] /	$\left[\begin{array}{c} \overline{\text{syl}} \\ - \text{cor} \\ - \text{back} \\ + \text{lab} \end{array} \right]$
XI	[u high] → [- high] /	$\left[\begin{array}{c} \overline{\alpha \text{ cons}} \\ \alpha \text{ ant} \\ \beta \text{ cor} \\ -\beta \text{ lab} \\ -\beta \text{ spr} \end{array} \right]$
XII	[u nas] → [- nas] /	$\left[\begin{array}{c} \overline{\alpha \text{ cons}} \\ -\alpha \text{ son} \end{array} \right]$
XIII	[u cont] → [+ cont] /	$\left[\begin{array}{c} \overline{\text{son}} \\ - \text{nas} \end{array} \right]$
XIV	[u StVC] → [- StVC] /	$\left[\begin{array}{c} \overline{\text{son}} \\ + \end{array} \right]$
XV	[u SlVC] → [+ SlVC] /	$\left[\begin{array}{c} \overline{\text{son}} \\ - \text{StVC} \end{array} \right]$
XVI	[u SG] → [+ SG] /	$\left[\begin{array}{c} \overline{\text{cons}} \\ - \text{syl} \\ + \text{cont} \\ + \text{StVC} \end{array} \right]$

(48a) continued

- XVII [u CG] → [+ CG] / $\left[\begin{array}{l} - \overline{\text{cons}} \\ - \text{syl} \\ - \text{cont} \\ + \text{StVC} \end{array} \right]$
- XVIII [u lat] → [+ lat] / $\left[\begin{array}{l} + \overline{\text{cons}} \\ + \text{cont} \\ - \text{nas} \\ + \text{cor} \end{array} \right]$
- XIX [u DR] → [+ DR] / $\left[\begin{array}{l} - \overline{\text{son}} \\ - \text{cont} \\ + \text{cor} \\ \alpha \text{ high} \\ -\alpha \text{ lat} \\ - \text{back} \end{array} \right]$
- XX [u stri] → [+ stri] / $\left[\begin{array}{l} - \overline{\text{son}} \\ \alpha \text{ cont} \\ -\alpha \text{ DR} \\ - \text{back} \\ - \text{SG} \\ - \text{lat} \end{array} \right]$
- XXI [u flap] → [+ flap] / $\left[\begin{array}{l} - \overline{\text{cons}} \\ - \text{syl} \\ + \text{cor} \end{array} \right]$
- XXII [u trill] → [+ trill] / $\left[\begin{array}{l} - \overline{\text{cons}} \\ - \text{syl} \\ + \text{cor} \\ - \text{flap} \end{array} \right]$
- XXIII [u long] → [- long] / $\left[\begin{array}{l} + \overline{\text{seg}} \end{array} \right]$
- XXIV [u stress] → [- stress] / $\left[\begin{array}{l} + \overline{\text{seg}} \end{array} \right]$
- XXV [u CP] → [- CP] / $\left[\begin{array}{l} + \overline{\text{seg}} \end{array} \right]$



(48b)

3.2 Assuming that underlying representations are stated in terms of markedness matrices, consider how the string (49a) is to be interpreted by the markedness rules projected from I' and II. The markedness rules must apply from left to right, first specifying the leftmost unit for all of its features, then the next leftmost for all of its features, etc. This is necessitated by the fact that the markedness rules for the feature segment make crucial reference to the syllabicity specification of a segment to the left.

(49) a		U ₁	U ₂	U ₃	U ₄
	segment	u	u	u	u
	syllabic		u	u	
b	segment	-			
c	segment		+		
	syllabic		-		
d	segment			+	
	syllabic			-	
e	segment				-
f	output	+	C	V	+

The application of the rules proceeds as follows. U₁ is specified [- seg] by (46a); U₂ is specified [+ seg] by (46c) and [- syl] by (47a); U₃ is specified [+ seg] by (46c) and [+ syl] by (47c); U₄ is specified [- seg] by (46a).

4.1 Consider now the matrix (50).

(50)	i	e	æ	ü	ö	æ	ɨ	ə	a	u	o	ɔ
syl	+	+	+	+	+	+	+	+	+	+	+	+
cons	u	u	u	u	u	u	u	u	u	u	u	u
ant	u	u	u	u	u	u	u	u	u	u	u	u
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
cor	u	u	u	u	u	u	u	u	u	u	u	u
son	u	u	u	u	u	u	u	u	u	u	u	u
lab	u	u	u	m	m	m	m	m	u	u	u	m
spr	u	u	u	u	u	u	u	u	u	u	u	u
high	u	m	m	u	m	m	u	m	m	u	m	m
nas	u	u	u	u	u	u	u	u	u	u	u	u
cont	u	u	u	u	u	u	u	u	u	u	u	u
StVC	u	u	u	u	u	u	u	u	u	u	u	u
SlVC	u	u	u	u	u	u	u	u	u	u	u	u
SG	u	u	u	u	u	u	u	u	u	u	u	u
CG	u	u	u	u	u	u	u	u	u	u	u	u
lat	u	u	u	u	u	u	u	u	u	u	u	u
DR	u	u	u	u	u	u	u	u	u	u	u	u
stri	u	u	u	u	u	u	u	u	u	u	u	u
flap	u	u	u	u	u	u	u	u	u	u	u	u
trill	u	u	u	u	u	u	u	u	u	u	u	u
Complexity	1	2	3	2	3	4	2	3	1	1	2	2

By the rules of markedness for high it is unmarked for all vowels to be [+ high]. As a consequence, the vowels /a/, /æ/, /æ/, and /ɔ/ are all marked for high. The markedness rules for low are ordered before those for high. Thus, /a/, /æ/, /æ/, and /ɔ/ must be marked for high in order to prevent

the derivation of the contradictory feature specification
 $\begin{bmatrix} + \text{ low} \\ + \text{ high} \end{bmatrix}$. There is something seriously wrong with a theory
 that does not predict that [+ low] segments will be [- high].

4.2 In addition to $\begin{bmatrix} + \text{ high} \\ + \text{ low} \end{bmatrix}$, there are many other
 specifications of features which cannot cooccur at the sur-
 face, e.g. $\begin{bmatrix} - \text{ cons} \\ - \text{ son} \end{bmatrix}$, $\begin{bmatrix} + \text{ StVC} \\ + \text{ SlVC} \end{bmatrix}$, $\begin{bmatrix} + \text{ cont} \\ + \text{ DR} \end{bmatrix}$, $\begin{bmatrix} + \text{ son} \\ + \text{ stri} \end{bmatrix}$. By allow-
 ing a segment such as /a/ to be [m high] it is suggested that
 there could be a segment like /a/ in all respects except that
 it is [u high]. To permit such segments to occur in under-
 lying representations would vitiate the basic assumption
 behind the theory of distinctive features, to wit: the same
 features and feature specification arrays serve not only to
 characterize all possible representations at the output of
 the phonology but also all possible representations under-
 lyingly. To block the occurrence of matrices whose specifi-
 cations are contradictory a set of implications is proposed
 which capture the cooccurrence restrictions on feature
 specifications (a short arrow, \rightarrow , means 'implies').⁶

- (51) a [- cons] \rightarrow [+ son]
 b [- cons] \rightarrow [- ant]
 c [+ son] \rightarrow [- DR]
 d [+ son] \rightarrow [- stri]
 e [+ low] \rightarrow [- high]
 f [+ StVC] \rightarrow [- SlVC]

(51) g	[+ SG]	→	[- CG]
h	[+ cont]	→	[- DR]
i	[+ trill]	→	[+ cont]
j	[+ flap]	→	[- trill]
k	[+ flap]	→	[+ cor]
l	[+ lat]	→	[+ cor]
m	$\begin{bmatrix} - \text{cont} \\ - \text{DR} \end{bmatrix}$	→	[- stri]
n	$\begin{bmatrix} - \text{son} \\ + \text{cont} \\ - \text{stri} \end{bmatrix}$	→	[+ SG]
o	$\begin{bmatrix} - \text{son} \\ + \text{lat} \end{bmatrix}$	→	[- cont]
p	$\begin{bmatrix} + \text{nas} \\ - \text{cont} \end{bmatrix}$	→	[+ son]
q	$\begin{bmatrix} + \text{cons} \\ - \text{cor} \\ - \text{back} \\ + \text{lab} \end{bmatrix}$	→	[+ ant]
r	$\begin{bmatrix} - \text{syl} \\ - \text{cons} \\ + \text{StVC} \\ \alpha \text{ SG} \\ -\alpha \text{ CG} \end{bmatrix}$	→	$\begin{bmatrix} + \text{back} \\ + \text{low} \\ - \text{cor} \\ - \text{spr} \end{bmatrix}$
s	$\begin{bmatrix} - \text{cont} \\ - \text{CG} \end{bmatrix}$	→	[+ cons]

By contraposition it follows that the complement of the consequent of any statement in (51) implies the complement of the antecedent; e.g.,

(52) a	[- son]	→	[+ cons]	from (51a)
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- (52) b [+ stri] → [- son] from (51d)
 c [+ stri] → $\left\{ \begin{array}{l} [+ \text{ cont}] \\ [+ \text{ DR}] \end{array} \right\}$ from (51m)

In order to obviate the necessity of having to specify a segment such as /a/ as [m high], (53) is proposed.⁷

- (53) Whenever a segment is specified to be [α F], where F is a feature and α is + or -, all implications whose antecedents are satisfied apply to that segment.

Given (53) there can be no matrix such as (50) for /a/, /æ/, /œ/, or /ɔ/. These segments are specified [+ low] by the markedness rules for low, and the implication (51e) immediately applies to specify them [- high]. The markedness rules for high take as their input segments which are specified either [u high] or [m high]; therefore, no segment which is specified [+ low] can ever be subject to the markedness rules for high since at the time those rules apply all low segments will be specified [- high]. It follows then that every [+ low] segment is unmarked for high.

By the adoption of (53) the markedness matrices for the vowels in (50) must be those in (54). In (55a,b,c) markedness matrices are given for voiceless and voiced stops and nasal consonants. Markedness matrices for fricatives are given in (56a,b). The markedness matrices for laterals are given in (57), and for glides in (58).

(54)	i	e	æ	ü	ö	œ	ɨ	ə	a	u	o	ɔ
syl	+	+	+	+	+	+	+	+	+	+	+	+
cons	u	u	u	u	u	u	u	u	u	u	u	u
ant	u	u	u	u	u	u	u	u	u	u	u	u
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
cor	u	u	u	u	u	u	u	u	u	u	u	u
son	u	u	u	u	u	u	u	u	u	u	u	u
lab	u	u	u	m	m	m	m	m	u	u	u	m
spr	u	u	u	u	u	u	u	u	u	u	u	u
high	u	m	u	u	m	u	u	m	u	u	m	u
nas	u	u	u	u	u	u	u	u	u	u	u	u
cont	u	u	u	u	u	u	u	u	u	u	u	u
StVC	u	u	u	u	u	u	u	u	u	u	u	u
SlVC	u	u	u	u	u	u	u	u	u	u	u	u
SG	u	u	u	u	u	u	u	u	u	u	u	u
CG	u	u	u	u	u	u	u	u	u	u	u	u
lat	u	u	u	u	u	u	u	u	u	u	u	u
DR	u	u	u	u	u	u	u	u	u	u	u	u
stri	u	u	u	u	u	u	u	u	u	u	u	u
flap	u	u	u	u	u	u	u	u	u	u	u	u
trill	u	u	u	u	u	u	u	u	u	u	u	u
Complexity	1	2	2	2	3	3	2	3	0	1	2	1

(55a)	p	t	t ^y	č	ty	k, k	k ^w	q	
	-	-	-	-	-	-	-	-	
syl	-	-	-	-	-	-	-	-	
cons	u	u	u	u	u	u	u	u	
ant	u	u	u	m	m	m	m	m	
back	u	u	u	m	m	m	u	u	u
low	u	u	u	u	u	u	u	u	m
lab	m	u	u	u	u	u	u	m	u
son	u	u	u	u	u	u	u	u	u
cor	u	u	u	u	u	m	u	u	u
spr	u	u	u	u	u	u	u	u	u
high	u	u	m	u	u	u	u	u	u
nas	u	u	u	u	u	u	u	u	u
cont	u	u	u	u	u	u	u	u	u
StVC	u	u	u	u	u	u	u	u	u
SlVC	u	u	u	u	u	u	u	u	u
SG	u	u	u	u	u	u	u	u	u
CG	u	u	u	u	u	u	u	u	u
lat	u	u	u	u	u	u	u	u	u
DR	u	u	m	u	m	u	u	u	u
stri	u	u	u	u	u	u	u	u	u
flap	u	u	u	u	u	u	u	u	u
trill	u	u	u	u	u	u	u	u	u
Complexity	1	0	2	2	3	3	1	2	2

(55b)	b	d	d ^y	ǰ	dy	g, g	g ^w	g	
	Exactly like (55a) except:								
StVC	m	m	m	m	m	m	m	m	m
Complexity	2	1	3	3	4	4	2	3	3

(55c)	m	n	ñ	ŋ		ŋ, ŋ		ŋ	
	Exactly like (55a) except:								
son	m	m	m	m		m	m		m
Complexity	2	1	3	3		4	2		3

(56a)	ϕ	f	θ	s	s, š	ç	x	x ^w	χ
syl	-	-	-	-	-	-	-	-	-
cons	u	u	u	u	u	u	u	u	u
ant	u	u	u	u	m	m	m	m	m
back	u	u	u	u	m	m	u	u	u
low	u	u	u	u	u	u	u	u	m
lab	m	m	u	u	u	u	u	m	u
son	u	u	u	u	u	u	u	u	u
cor	u	u	u	u	u	m	u	u	u
spr	u	u	u	u	u	u	u	u	u
high	u	u	u	u	m	u	u	u	u
nas	u	u	u	u	u	u	u	u	u
cont	m	m	m	m	m	m	m	m	m
StVC	u	u	u	u	u	u	u	u	u
SlVC	u	u	u	u	u	u	u	u	u
SG	m	u	m	u	u	u	u	u	u
CG	u	u	u	u	u	u	u	u	u
lat	u	u	u	u	u	u	u	u	u
DR	u	u	u	u	u	u	u	u	u
stri	u	u	u	u	u	u	u	u	u
flap	u	u	u	u	u	u	u	u	u
trill	u	u	u	u	u	u	u	u	u
Complexity	3	2	2	1	2	3	4	2	3

(56b) β v ʃ z z, ž ʒ γ γ^w g

Exactly like (56a) except:

StVC	m	m	m	m	m	m	m	m	m
Complexity	4	3	3	2	3	4	5	3	4

(57)	l	L	ĩ	ly	ĩ	ɸ	λ
syl	-	-	-	-	-	-	-
cons	u	u	u	u	u	u	u
ant	u	u	u	m	u	u	u
back	u	u	u	u	u	u	u
low	u	u	u	u	u	u	u
lab	u	u	u	u	u	u	u
son	m	m	m	m	m	u	u
cor	u	u	u	u	u	u	u
spr	u	u	u	u	u	u	u
high	u	u	m	u	u	u	u
nas	m	m	m	m	m	u	u
cont	u	u	u	u	u	m	u
StVC	u	m	u	u	u	u	u
SlVC	u	u	u	u	u	u	u
SG	u	u	u	u	u	m	u
CG	u	u	u	u	u	u	u
lat	u	u	u	u	u	m	m
DR	u	u	u	u	u	u	u
stri	u	u	u	u	u	u	u
flap	u	u	u	u	m	u	u
trill	u	u	u	u	u	u	u
Complexity	2	3	3	3	3	3	1

(58)	β_1	r	R	δ_1	r^Y	y	γ_1	w	h	?
syl	-	-	-	-	-	-	-	-	-	-
cons	m	m	m	m	m	m	m	m	m	m
ant	u	u	u	u	u	u	u	u	u	u
back	m	m	m	m	m	m	u	u	u	u
low	u	u	u	u	u	u	m	m	u	u
lab	m	u	u	u	u	u	m	u	u	u
son	u	u	u	u	u	u	u	u	u	u
cor	u	u	u	u	u	u	u	u	u	u
spr	u	u	u	u	u	u	u	u	u	u
high	u	u	u	u	m	u	u	u	u	u
nas	u	u	u	u	u	u	u	u	u	u
cont	u	u	u	u	u	u	u	u	u	m
StVC	u	u	u	u	u	u	u	u	m	m
SlVC	u	u	u	u	u	u	u	u	u	u
SG	u	u	u	u	u	u	u	u	u	u
CG	u	u	u	u	u	u	u	u	u	u
lat	u	u	u	u	u	u	u	u	u	u
DR	u	u	u	u	u	u	u	u	u	u
stri	u	u	u	u	u	u	u	u	u	u
flap	u	u	m	m	u	u	u	u	u	u
trill	u	u	u	m	u	u	u	u	u	u
Complexity	3	2	3	4	3	2	3	2	2	3

5.1 In most treatments of markedness within the theory of generative grammar it is proposed that the complexity of a segment is equal to the number of marks, m's, in its underlying representation--the more m's the more complex the segment.⁸ Using such a measure of segmental complexity the values of complexity in (54)-(58) are obtained.

It has further been suggested that "the complexity of a [segmental] system is equal to the sum of the marked features in its members."⁹ The complexity of a system is clearly related to its likelihood. For example, it is quite inconceivable that the consonant system of some language would consist solely of the segments /k̂p, ʃ, pf, kx/--each segment being fairly highly marked. Thus, simpler systems seem to be more positively valued than complex systems. Therefore, (59) is proposed.¹⁰

(59) The 'value' of a segmental system is the reciprocal of the sum of the marked features of its members.

5.2 If (59) were the sole determinant of systemic value and likelihood there would be no way to preclude the possibility of there being a language with the segmental system /t, a/--a system which is infinitely valued.

5.2.1 There must be a certain richness to every segmental system and it is this fact which the evaluation measure (59)

misses. Most every language makes at least a three-way distinction of place in consonants. In vowel systems it is usually the case that in addition to /a/ there is a front high vowel and a back rounded vowel. The features specified by the conventions III-VIII will be called 'm-obligatory' features. To capture the fact that a segmental system must have a certain variety of segments (60) is proposed.

- (60) For each m-obligatory feature there exists at least one segment which is marked for that feature in the segmental system of a language.

While (60) rules out the possibility of there being a segmental system which consists solely of /t, a/, it introduces the possibility of there being a segmental system such as (61).

- (61) /a, ly, β₁, q/ (complexity 8)

To conclude that (61) is a possible segmental system for a human language is to suspend all considerations of reality. To rule out such systems, the further condition (62) is proposed.

- (62) For each of the m-obligatory features, F_i^m, \dots, F_n^m , there exists at least one segment S which is $[m F_j^m]$ and one segment S' which is $[u F_j^m]$, all other m-obligatory

specifications and the specification of syllabicity in S and S' being equal.

5.2.2 (62) is, however, too strong a condition, as the following data taken from Hawaiian show. In Hawaiian there are five vowels, five consonants, and three glides.¹¹

(63) Vowels:	i	u
	e	o
	a	
Consonants:	p	k
	m	n
	l	
Glides:	w	h ?

The vowels i, u, and a serve to satisfy condition (62) with respect to the features back and low. Both the h and ? satisfy condition (62) with respect to the feature consonantal. The obligatory mark for labial is that of m, which matches with n. The obligatory mark for sonorant is also carried by m, which matches with p. There is, however, no match for the feature anterior. Either a t or an ŋ would be necessary in the system to maintain (62).

(64)	<u>p</u>	<u>n</u>	<u>m</u>	<u>k</u>	* <u>t</u>	* <u>ŋ</u>
consonantal	u	u	u	u	u	u
anterior	u	u	u	m	u	m
back	u	u	u	u	u	u
low	u	u	u	u	u	u
labial	m	u	m	u	u	u
sonorant	u	m	m	u	u	m

Since neither t nor ŋ occurs in Hawaiian phonemically, (62) cannot be maintained. However, observe that for each obligatory mark it can be said that no single segment is necessarily fulfilling the role of carrying more than one obligatory mark.

5.2.3 Consider the segmental system (65).

(65) a	Vowels:	i	u
		a	
	Consonants:	t	k
		m	
	Glide:		h
b	<u>m</u>	<u>t</u>	<u>k</u>
cons	u	u	u
ant	u	u	m
back	u	u	u
low	u	u	u
lab	m	u	u
son	m	u	u

In the system (65) the segment m has a dual role with respect to (60)--it carries the obligatory marks for labial and for sonorant. No language could have the consonant system (65); in no language is a single segment the sole carrier of two obligatory marks. To capture this (66) is proposed.

- (66) In every segmental system,
- (i) for each of the \underline{m} -obligatory features, F_1^m, \dots, F_n^m , there exists at least one segment S which is $[m F_i^m]$, and
 - (ii) for each two \underline{m} -obligatory features, F_i^m and F_j^m , either there is no segment which is marked for both, or there is a segment S which is marked for both and a segment S' marked for one feature but not the other, and which agrees with S for all other \underline{m} -obligatory features.

Hawaiian is a well-formed segmental system under (66), but (65) is not. Two further examples of languages with somewhat unusual segmental systems are given below.

Garvin (1950) proposes the segmental system in (67) for Wichita.

- (67) Vowels: i u
 ε a
- Consonants: k^w t k
 c
 s
 \tilde{r}
- Glides: w h ?

The segment \tilde{r} is a nasal which alternates with \underline{r} .¹² The segmental system of Wichita satisfies condition (66), as is

illustrated in (68).

(68)	<u>a</u>	<u>i</u>	<u>u</u>	<u>t</u>	<u>k</u>	<u>k^w</u>	<u>ř</u>	<u>h</u>
cons	u	u	u	u	u	u	u	m
ant	u	u	u	u	m	m	u	u
back	u	m	u	u	u	u	u	u
low	u	u	m	u	u	u	u	u
lab	u	u	u	u	u	m	u	u
son	u	u	u	u	u	u	m	u

The necessary mark for consonantal is that of h; the necessary mark for anterior is that of k; the necessary mark for back is that of i, for low that of u; the necessary mark for labial is that of k^w (k^w is marked for anterior and labial but k is marked for anterior so (66) is satisfied); and the necessary mark for sonorant is that of ř.

In Kaititj (Arandic) there is apparently the two-vowel system /ə, a/.¹³

(69) a Kaititj [-syl] segments

Stops:	p	<u>t</u>	t	<u>ṭ</u>	ty	k
Nasals:	m	<u>ṇ</u>	n	<u>ṇ</u>	ny	ŋ
Nasals (with delayed velic opening):						
	M	<u>Ṇ</u>	N	<u>Ṇ</u>	Ny	Ŋ
Laterals:		<u>ḷ</u>	l	<u>ḷ</u>	ly	
Glides:	w		r	<u>ṛ</u>	y	γ

(69) b	<u>p</u>	<u>t</u>	<u>ty</u>	<u>k</u>	<u>a</u>	<u>ə</u>	<u>ɣ</u>	<u>w</u>	<u>n</u>
cons	u	u	u	u	u	u	m	m	u
ant	u	u	m	m	u	u	u	u	u
back	u	u	m	u	u	u	u	u	u
low	u	u	u	u	u	m	m	m	u
lab	m	u	u	u	u	m	m	u	u
son	u	u	u	u	u	u	u	u	m

The obligatory mark for consonantal is that of ɣ, which is marked for consonantal as well as low and labial, the latter two marks also being carried by ə. The obligatory mark for anterior is that of k. ty is marked for back and anterior; given that k is also marked for anterior, ty satisfies (66) with respect to the feature back. The obligatory mark for low is that of ə; while ə is marked for two features, low and labial, the segment p is marked for labial. The obligatory mark for labial is satisfied by p. The segment n suffices to satisfy (66) with respect to sonorant.

5.3 The features segment and syllabic are both m-obligatory. If we accept I', it follows that in no language will all morphemes be monosyllabic; accepting I" it would follow that in no language are all morphemes disyllabic; and accepting I''' it would follow that in no language are all morphemes of the form +CVC+. In no language do all morphemes contain the same number of syllables, all with identical canonical form. This fact follows from the fact that segment is an m-obligatory feature.

While there are languages which have very strict conditions on the canonical forms of strings on the surface, to argue that syllabic is not an m-obligatory feature would require claiming that there exists a language in which all morphemes are underlyingly +CV(C(V))+. There is no evidence to my knowledge that any such language exists.

That segment and syllabic are m-obligatory is a fact about strings, not about single segments in segmental systems. Therefore, rather than reformulating (66) to accomodate these features, (70) is proposed.

(70) Obligatory Markedness of Strings

In no language are all strings unmarked for the major features, segment and syllabic.

Those features which are not m-obligatory will be called u-obligatory. While it must be the case that every segmental system contains segments which are marked for the m-obligatory features, it is not the case that for each u-obligatory feature a segmental system must contain a segment which is marked for that feature. Rather, it is claimed that in general for each u-obligatory feature if a segment is marked for that feature there exists another segment in the system which is unmarked for that feature, all other features being equal.

It is stipulated that the conventions for the

m-obligatory features are extrinsically ordered before the conventions for the u-obligatory features. There are then two orderings of the markedness conventions, one which is intrinsic, that derives from the relations which hold among particular conventions (those given in (48b)), and one which is extrinsic, which characterizes the ordering relation between the m-obligatory features and the u-obligatory features. In order to keep these two orderings distinct, the former will be called hierarchical, the latter extrinsic.

That the extrinsic ordering 'dominates' the hierarchy is to be expected. Were this not the case it would open the possibility of there being an m-obligatory feature whose specification was contingent on the specification of some u-obligatory feature. Such a situation would be bizarre since by allowing u-obligatory features to be specified before m-obligatory features a primary distinction in a segmental system could be contingent on a secondary one.

Given these two orderings of markedness conventions an inherent partial ordering of the features can be established. Thus, in addition to saying that the convention for segment is the 'first' convention, we can say that the feature segment is F_1 ; similarly we can say that the feature syllabic is F_2 , etc. For expository purposes, each feature will be assigned the integer of its markedness convention in (48a); thus F_4 will be anterior, F_8 will be sonorant, F_{20} will be strident,

etc. Strictly speaking, anterior and sonorant are unorderable with respect to each other. However, what is important is that F_1, \dots, F_8 are inherently ordered before all of the other conventions. Thus, the m-obligatory features of (66) are F_3, \dots, F_8 .

(71) Obligatory Markedness of Segments

In every segmental system,

- (i) for each feature F_3, \dots, F_8 , there exists at least one segment which is $[m F_i]$, $3 \leq i \leq 8$, and
- (ii) for each pair of features F_i and F_j , $3 \leq i < j \leq 8$, if there is any segment which is marked for both F_i and F_j , then there are two segments S and S' , such that S is marked for both F_i and F_j , S' is marked for one but not both of F_i and F_j , and S and S' agree for all other features F_k , $3 \leq k \leq 8$, $k \neq i, j$.

6. The optimal (simplest) phonological system capable of satisfying condition (71) is:

(72) Vowels: i u
 a
Consonants: p t k
 n
Glides: h/?/w/y

There is apparently no language with only these eight segmental phonemes. The question therefore arises as to whether there are m-obligatory features in addition to those discussed above. It appears that there are not. The logical candidates for expanding the list of m-obligatory features are those features ordered just after the features F_1 - F_8 .

The feature stiff vocal cords is ordered just after sonorant. If it were an m-obligatory feature then it would be predicted that in every language there are voiced and voiceless consonants, voiced and voiceless nasals, or voiced and voiceless glides. As is shown by Wichita, stiff vocal cords cannot be an m-obligatory feature.

The feature nasal is also ordered just after sonorant. Were nasal an m-obligatory feature it would mean that in every language there is a lateral. There are l-less languages: Wichita, Crow, Mandan, Hidatsa, Ioway, Oto, Winnebago, Tikopian, Fila, Rarotonga, Easter Island, Maori, Tahitian.¹⁴ Therefore, nasal cannot be an m-obligatory feature.

The feature coronal is ordered just after the feature labial. If it were an m-obligatory feature then it would follow that every language had either an r or a k. There are, however, languages with neither of these segments: Klamath, Yankton, Santee, Teton, Osage, Kansa, Kwapa, Biloxi, Marquesas, Hawaiian, Ellice Islands, Samoan, Niue.¹⁵ Therefore, coronal cannot be an m-obligatory feature.

If continuant were an m-obligatory feature then every language would have to have a fricative series. Since there are languages without such a series (Kaititj) .. it follows that continuant is not m-obligatory.

It is clear that none of the other features could be m-obligatory. There are languages without flaps or trills, without distinctive stress, without distinctive length, and without pharyngealization. Glottalization and aspiration are not distinctive in a large number of languages, nor are affrication and stridency. If lateral were m-obligatory one would predict that lateral affricates or fricatives occurred in every language. If spread were m-obligatory then every language would have either p^w, a ɬ as in Russian, or a ɸ as in Japanese. If high were m-obligatory then every language would have e, o, ö, ə, or an alveopalatal. Thus it appears that (71) is a necessary but not sufficient condition on the richness of phonological systems, phonological systems apparently always being more varied than required by (71).

7.1 As yet, little has been said about the properties of the u-obligatory features. It is not the case that they can be freely marked or unmarked in a language. If this were true there would be no way to preclude a language in which all stops were voiced, or in which all nonsonorant consonants were fricatives. Given that there are no languages such as these it must be that there are further conditions on the specification of features within languages.

While it is generally the case that if a language has some voiced stop it also has the voiceless counterpart of that stop, there are cases where this does not hold. For example, in both Arabic and Palauan there are the stops /t, k, b, d, g/.¹⁶ There are, however, no languages with the stop system /t, b, d, g/. Thus, while systems such as those of Arabic and Palauan are not particularly likely, they are probable, but a system such as the latter one is totally improbable. To account for this condition (73) is proposed.

(73) a If in the segmental system (phonological alphabet) of a language there exists a segment which is marked for some feature F, then that system also contains a segment which is unmarked for F, all other markedness specifications for nonmajor features, F_3, \dots, F_{25} , being equal.

b There is a probability \underline{n} , where \underline{n} is

small, assigned to its being the case that the antecedent of (73a) is true and the consequent false.

From (73) it follows that while there is not a high probability of there being a stop series such as that of Arabic and Palauan, it is not improbable. However, it also follows that the probability of there being a system /t, b, d, g/ is very small, \underline{n}^2 , such a system implying the existence of both /p/ and /k/.

Returning again to Hawaiian, while that language does satisfy (61), it comes fairly close to flouting (73). The stop system /p, k/ implies that there will also be a stop /t/ by (73a). Holding \underline{n} constant over all features, the probability of there being a language such as Hawaiian is quite small. Were there many languages with such a segmental system, (73) could not be maintained. However, Hawaiian is the only language attested to have such a system. That such a system should be exceedingly rare follows from (73).

In Wichita, there is a /k^w/, but not, as implied, a /p/. By (73), in the ideal case, every language with /k^w/ would have not only /k/, but also /p/.

It follows from (73) that in fricative systems there always be at least an /s/. However, there are languages with fricatives but no /s/. In Maori, Marquesas, Tahitian, and Tuamotu one finds /f/ as the sole fricative.¹⁷

Apparently in no language does one find the fricative system, e.g., /f, x/.

There are two possible ways in which (73) might be interpreted and have the consequences stated above. Consider the case of English which has /θ/ and /ð/ but neither /t^h/ nor /d^h/. On the one hand it could be said that this constitutes a double violation of (73); /θ/ implies not only /s/ but also /t^h/, and /ð/ implies not only /θ/ and /z/, but also /d^h/. On the other hand, a form of chaining might be allowed such that if /ð/ implies /θ/ and there were a /t^h/, condition (73a) would be satisfied, and if there were no /t^h/ there would only be one violation of (73a). If this latter alternative were taken then it would be predicted that the stop-fricative series /p, t, k, f, s, x, v, z, γ/ would be as likely as /p, t, k, b, d, g, f, s, z/ or /p, t, k, b, d, g, f, s, x, v, z, γ/. The reasoning would be that since, e.g., /z/ implies /s/ and there is an /s/, and /s/ implies /t/ and there is a /t/, (73a) is satisfied. Any sort of chaining proposal would fail to capture the fact that in languages with voiced and voiceless fricatives there are also characteristically voiced and voiceless stops. Similarly, under the chaining proposal it would follow that there is nothing deviant in the system /t, f, s, x/. Such systems must be excluded. Therefore, (73) must be interpreted as predicting a straight pairing of matrices, one-to-one, for each marked specification in a segment.

The existence of /o/ in a system implies /u/ by (73), the two segments differing only with respect to their markedness specifications for high. /o/ only implies /u/ and not /u/ and something else since there can be no segment which differs from /o/ only in its markedness specification for low, since such a segment would be specified on the surface $\begin{bmatrix} + \text{high} \\ + \text{low} \end{bmatrix}$. Therefore, (73a) must be restricted to implying matching only to possible segments. It would make no sense to predict that /o/ will match a segment which cannot exist. Similarly, the vowel /e/ implies /i/, the two segments differing only with respect to their specifications for high. /i/ is the only possible segment which is implied by /e/. There is no vowel which is marked for high, and unmarked for all other features, since such a vowel would be $\begin{bmatrix} + \text{high} \\ + \text{low} \end{bmatrix}$.

7.2 There is no language in which segment is always marked; all morphemes must begin with a boundary. Similarly, there is no language in which syllabic is always marked, i.e. a language in which all morphemes are strings of vowels.

- (74) In every language,
- (i) there exists a unit which is $[m F_1]$,
and there exists a unit which is $[u F_1]$,
 - (ii) the leftmost unit of every string is $[u F_1]$, and

(iii) given a segment which is $\begin{bmatrix} \alpha & F_1 \\ m & F_2 \end{bmatrix}$,
 where α is u or m, there exists a
 possible string with a segment which
 is $\begin{bmatrix} \alpha & F_1 \\ u & F_2 \end{bmatrix}$.

It is proposed that conditions (71) and (73) are conditions on surface segmental systems as well as underlying segmental systems. Were this not the case there would be no means of precluding the language *Kaititj for which the underlying system is that of Kaititj but in which there is a rule which collapses both the vowels as ɔ. That is, given the condition (71) one would be forced to postulate two vowels in *Kaititj on the basis of the other segments in the system. *Kaititj can only be blocked if (71) is a condition on surface systems and underlying systems. By postulating (73) as a surface condition it is predicted that in no language will only voiceless stops occur on the surface. If condition (73) is only a condition on underlying systems then it would follow that there could be a *Wichita in which there was a rule of obstruent voicing which applied everywhere, or a language in which all vowels are pharyngealized. Such languages do not exist. Therefore, (73) must be a condition on both levels of phonological representation.

Conditions (70) and (74) are not, however, conditions on both underlying and surface strings. There appear to be

languages with very strict surface canonical patterns which violate both conditions. That (71) and (73) hold at both levels while (70) and (74) do not is a further reflection of the distinction between the major features and the features defined on single segments. Within the theory of markedness proposed here it is to be expected that these classes of features would have distinct properties at all phonological levels.

Footnotes to Chapter 1

1. In general features are used here as they are used in SPE. There are, however, significant points of variation; these are discussed in the Appendix.

2. The concept of markedness has its origin in the work of the Prague Circle, in particular that of Trubetzkoy (1969). The concept is used here as it was used in SPE, which is somewhat different from Trubetzkoy's use.

3. The claim reflected in (13) and (14) is that for any given feature there is one and only one markedness convention, that there is a single principle governing the specification of that feature across all classes of segments; if the unmarked value of any feature F is $[+ F]$ in some environment E then the unmarked value of F must be $[- F]$ in the complement of E , i.e., $\sim E$ --that is, the markedness specification of any feature may not vary arbitrarily across classes of segments.

Not only is it a consequence of (13) that there cannot be a set of conventions associated with one feature

which vary arbitrarily, it is also a consequence of (13) that there can be no conventions such that [u F] is [+ F] and [- F] or where [u F] is [α F] in some environment [α G], where α is a variable across + and -, except insofar as such rules follow from the Complement Convention. The Complement Convention is not an algorithm for an 'alpha' rule. By (14) if [u F] is [+ F] in the environment $\begin{bmatrix} + & G \\ - & H \end{bmatrix}$, then [u F] is [- F] in $\begin{bmatrix} - & G \\ + & H \end{bmatrix}$, $\begin{bmatrix} + & G \\ + & H \end{bmatrix}$, and $\begin{bmatrix} - & G \\ - & H \end{bmatrix}$. Such an expansion cannot be characterized by variables on features.

4. I take the notion of unitness to be primitive. If units must in fact be specified + then that implies that the \emptyset element is [- Unit]. There is, however, no reason to assume that the zero element is so specified, and there are reasons to assume that it is not. By admitting the specification [- Unit] the zero element is no longer empty. [- Unit] then ceases to be any different from, e.g., [- seg]. However, while the specification [- seg] can crucially specify the environment for a phonological rule, [- Unit] cannot. By assuming that unitness is specified + then one is forced to give up postulating u and m as the only primitive specifiers of phonological representations. This leaves inexplicable why only Unit need be specified + or -; having admitted + and - specifications for one case there is no principled means for excluding them in other cases.

5. If one assumes that underlying representations are in terms of +/- matrices and that the rules of markedness are a means of evaluating the likeliness of such matrices, it still must be the case that they apply in a fixed order. That is, to translate a +/- matrix into a u/m matrix would require that the convention for back apply before the convention for anterior, for once the +/- specification of anterior has been 'translated' into a u or m there is no way of establishing whether the specification of back is marked or not, since to do so requires knowing whether the segment is + or - anterior.

6. The list of cooccurrence restrictions in (51) is obviously incomplete. Given twenty-four features with binary specifications, there are over 16 million possible segments characterizable. Of these segments something over 16 million are nonoccurring in phonological systems. Any theory of phonology which assumes the current feature framework must have some mechanism for excluding these nonoccurring segments. The cases in (51) are meant to be illustrative of the types of segments which must be disallowed in phonological systems. Further research in this area is called for.

7. While the implication (51m) can apply under (53), the implication (52c) cannot, the consequent being nonunique. The specifications of delayed release and continuant are

earlier than the specification of strident; therefore, any segment which is not potentially [+ stri] will be specified [- stri].

8. Chomsky and Halle (1968), Cairns (1972), and Schane (1973).

9. SPE, p. 409, (8).

10. The statement of (59) intentionally parallels the statement of the evaluation procedure for grammars given in SPE, p. 304, (8):

The 'value' of a sequence of rules is the reciprocal of the number of symbols in its minimal representation.

Thus, the larger the number assigned as the 'value' of a segmental system or system of rules, the more highly valued it will be.

11. Voegelin and Voegelin (1964), Chapin (1973).

12. In Garvin's analysis of Wichita no underlying nasal is postulated; rather he postulates an underlying r. See §14.4 for the argument as to why there is an underlying n and not an underlying r.

13. These data are from Hale's field notes. From going over Hale's field notes it appears that the underlying system

/i, a/ might be postulated for Kaititj rather than /ə, a/.
The point made here remains the same under either analysis.

14. Hockett (1955), Matthews (1958), Voegelin and
Voegelin (1964).

15. Barker (1963), Matthews (1958), Voegelin and
Voegelin (1964).

16. Brame (1970), Wilson (1972).

17. Voegelin and Voegelin (1964).

Chapter 2

Conditions on Segmental Alternation

8. ...the problem to which the linguist addresses himself is to account for the child's construction of a grammar and to determine what preconditions on the form of language make it possible. Our approach to this problem is two-pronged. First we develop a set of formal devices for expressing rules and a set of general conditions on how these rules are organized and how they apply. We postulate that only grammars meeting these conditions are "entertained as hypotheses" by the child who must acquire knowledge of a language. Secondly, we determine a procedure of evaluation that selects the highest valued of a set of hypotheses of the appropriate form, each of which meets a condition of compatibility with the primary linguistic data.¹

The so-called simplicity metric--"The 'value' of a sequence of rules is the reciprocal of the number of symbols in its minimal representation"--is such an evaluation procedure.² This evaluation procedure constitutes an empirical

hypothesis as to what is a linguistically significant generalization. It is an integral part of the theory of generative phonology and cannot be postulated antecedently; there is no a priori determination of such a measure.

In generative phonology the set of notational devices and the classificatory features are central to the evaluation measure--that is, the measure makes no sense in a theory of phonology which has neither features nor notational devices.

8.1 Consider a theory of phonology without distinctive features, but with all the notational devices of the SPE framework.

$$(1) \quad \begin{Bmatrix} k \\ g \end{Bmatrix} \rightarrow \begin{Bmatrix} \text{ç} \\ \text{j} \end{Bmatrix} / \text{---} \begin{Bmatrix} i \\ y \end{Bmatrix}$$

$$(2) \quad q \rightarrow i / \text{---} \begin{Bmatrix} l \\ f \end{Bmatrix}$$

Rule (1) is a fairly common phonological rule; rule (2) on the other hand is quite inconceivable.

Assume a language with the underlying segments given in (3).

(3)		i	e	a	o	u	p	t	č	k	q	b	d	ǰ	g	f	s	l	m	n	w	y	
	Syl	+	+	+	+	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Cons	-	-	-	-	-	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	-	-
	Son	+	+	+	+	+	-	-	-	-	-	-	-	-	-	-	-	-	+	+	+	+	+
	Back	-	-	+	+	+	-	-	-	+	+	-	-	-	+	-	-	-	-	-	-	+	-
	Lab	-	-	-	-	-	+	-	-	-	-	+	-	-	-	-	+	-	-	+	-	-	-
	High	+	-	-	-	+	-	-	+	+	-	-	-	+	+	-	-	-	-	-	-	+	+
	Low	-	-	+	-	-	-	-	-	-	+	-	-	-	-	-	-	-	-	-	-	-	-
	Cor	-	-	-	-	-	+	+	-	-	-	+	+	-	-	+	+	-	+	+	-	+	-
	Cont	+	+	+	+	+	-	-	-	-	-	-	-	-	-	-	+	+	+	-	-	+	+
	StVC	-	-	-	-	-	+	+	+	+	+	-	-	-	-	-	+	+	-	-	-	-	-
	Nas	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	+	-

Given a set of distinctive features, rule (1) can be stated as rule (4) and rule (2) as rule (5), for a language with the segmental system (3).

$$(4) \quad \begin{bmatrix} + \text{ cons} \\ + \text{ high} \end{bmatrix} \longrightarrow \begin{bmatrix} - \text{ back} \\ + \text{ cor} \\ + \text{ DR} \\ + \text{ stri} \end{bmatrix} / \text{---} \begin{bmatrix} - \text{ cons} \\ - \text{ back} \\ + \text{ high} \end{bmatrix}$$

$$(5) \quad \begin{bmatrix} + \text{ cons} \\ + \text{ low} \end{bmatrix} \longrightarrow \begin{bmatrix} + \text{ syl} \\ - \text{ cons} \\ + \text{ son} \\ - \text{ back} \\ + \text{ high} \\ - \text{ low} \\ + \text{ cont} \\ - \text{ StVC} \end{bmatrix} / \text{---} \left\{ \begin{array}{l} \begin{bmatrix} + \text{ son} \\ + \text{ lat} \end{bmatrix} \\ \begin{bmatrix} - \text{ son} \\ + \text{ cont} \\ + \text{ lab} \end{bmatrix} \end{array} \right\}$$

Without the assumption of distinctive features, (1) is less highly valued than (2), since (2) is the 'simpler' rule. If, however, the theory of distinctive features is accepted then (4) (= (1)) is more positively valued than (5) (= (2)).

The theory of features introduces the notion of

'natural class' of segments--that there is, e.g., a nonaccidental relation between k and g, and between i and y, in (1/4), but that there is no significant relation between q and i, and l and f, in example (2/5).³

8.2 The evaluation measure makes no sense if the theory of features is accepted but not the notational devices. Consider two hypothetical languages, L and L', each with the segmental system (3). In L consonants are velarized before back vowels and glides and palatalized before front vowels and glides. These facts are captured in (6).

- (6) a all [+ cons] segments become [+ back]
before $\begin{bmatrix} - & \text{cons} \\ + & \text{back} \end{bmatrix}$ segments
- b all [+ cons] segments become [- back]
before $\begin{bmatrix} - & \text{cons} \\ + & \text{back} \end{bmatrix}$ segments

In L' consonants are velarized before back vowels and glides and palatalized before front vowels. These facts are captured in (7).

- (7) a all [+ cons] segments become [+ back]
before $\begin{bmatrix} - & \text{cons} \\ + & \text{back} \end{bmatrix}$ segments
- b all [+ cons] segments become [- back]
before $\begin{bmatrix} + & \text{syl} \\ - & \text{back} \end{bmatrix}$ segments

In terms of counting features (or features and words) (6) and (7) are equivalent. However, if we accept formulations such as (6) we are missing a generalization--in L consonants agree with following vowels and glides for the feature back. In a language which distinguishes 'hard' and 'soft' derived consonants (6) is far more likely to be the case than (7). If the theory of phonology has a sufficiently rich system of notational devices then the fact that the facts of (6) are more probable than the facts of (7) can be captured.⁴

$$(8) (= (6)) \quad [+ \text{ cons}] \longrightarrow [\alpha \text{ back}] / \text{ ______ } \begin{bmatrix} - \text{ cons} \\ \alpha \text{ back} \end{bmatrix}$$

$$(9) (= (7)) \quad \text{a} \quad [+ \text{ cons}] \longrightarrow [+ \text{ back}] / \text{ ______ } \begin{bmatrix} - \text{ cons} \\ + \text{ back} \end{bmatrix}$$

$$\quad \text{b} \quad [+ \text{ cons}] \longrightarrow [- \text{ back}] / \text{ ______ } \begin{bmatrix} + \text{ syl} \\ - \text{ back} \end{bmatrix}$$

The 'alpha' notation of (8) makes an empirical claim that there is a linguistically significant generalization to be captured about the facts of L but not about the facts of L'.⁵

9. If the rules of a grammar are quite complex then that grammar will not be highly valued. Were we to discover that in fact most grammars were made up of rules of great complexity then the evaluation procedure (the features and/or the notational devices) would be without empirical support and would have to be rejected. That the rules of grammar for natural languages are, in general, relatively simple gives strong empirical support for the evaluation procedure. It is

a consequence of this that those rules which are more likely to occur in phonologies will be those which are most positively valued.

Consider now the rules in (10).

- | | | | | |
|--------|----------|---|---|-------------|
| (10) a | [- son] | → | $\begin{bmatrix} + \text{ DR} \\ + \text{ CG} \end{bmatrix}$ | (i)
(ii) |
| b | [+ cons] | → | $\begin{bmatrix} + \text{ cont} \\ + \text{ lab} \end{bmatrix}$ | (i)
(ii) |
| c | [+ syll] | → | $\begin{bmatrix} + \text{ nas} \\ - \text{ back} \end{bmatrix}$ | (i)
(ii) |

By each of the rules in (10) some segment(s) are specified for two features; the rules of (10) are fairly simple. However, none of these rules is attested. The theory of grammar is not justified to the extent that it places a positive value on rules which do not occur in the grammars of human languages.

For each of the rules of (10) each feature change taken singly is not at all unusual. A rule such as (10a-i) is a rule of affrication (as is found historically in German); (10a-ii) is a rule of glottalization (as is found in Klamath); (10b-i) is a rule of spirantization (as in Grimm's Law); (10b-ii) is a rule of labialization (as is found in Nupe); (10c-i) is a rule of nasalization (as in French); (10c-ii) is a rule of umlaut (as is found in German). Therefore, the peculiarity of the rules in (10) is not a function of their component parts taken individually.

Consider now the rules in (11).

- (11) a [+ syl] → [- back]
 b [+ syl] → [- lab]
 c [+ syl] → $\begin{bmatrix} - \text{ back} \\ - \text{ lab} \end{bmatrix}$

All of the rules of (11) are attested. Therefore, it cannot be the case that if the component parts of a well-formed rule are themselves common rules, a rule resulting from their combination is not a possible rule. Such a condition would exclude virtually every rule changing two or more features.

The question then is, by what principle are the rules of (10) excluded as possible rules of natural (human) languages? In Chapter 1 it was argued that there is a hierarchy of features which is derivable from the intrinsic ordering of the markedness conventions. Observe now that in each of the rules in (10) the two features specified by each rule are not hierarchically related--there is no intrinsic relation based on markedness between delayed release and constricted glottis, between continuant and labial, or between nasal and back. However, there is an intrinsic order of the features in (4) and of the features of (11c). Within the theory of markedness it is therefore possible to exclude as possible rules the rules in (10) on the basis of (12).

- (12) No rule may specify a segment for two or more features which are not hierarchically related.

The hierarchy of features is thus motivated on two independent grounds: (i) to account for the structure of underlying segmental systems, and (ii) to account for the nonoccurrence of a large class of well-formed phonological rules. There is no a priori necessity for it to be the case that the same factors which play a role in determining possible phonological orthographies should also play a role in determining possible phonological rules. An empirically falsifiable claim is being made here that not only is there a system of markedness conventions which express the intra-segmental relationships among features and which are intrinsically ordered, but also that that intrinsic order plays a crucial role in delimiting the class of possible sound systems and the class of possible phonological processes.

A partial list of features which, by (12), cannot be specified by a single phonological rule is given in (13-15); in each case the features in the (a) column cannot cooccur in a rule with the features in the (b) column.

- | | |
|--|---|
| (13) (a) Constricted glottis
Spread glottis | (b) Slack vocal cords
Lateral
Flap
Trill
Low
Back
Labial
Coronal
Spread
Anterior
High |
|--|---|

- | | | | |
|----------|--|-----|--|
| (14) (a) | Sonorant
Continuant
Nasal | (b) | Low
Back
Labial
Coronal
Spread
Anterior
High |
| (15) (a) | Stiff vocal cords
Slack vocal cords | (b) | Nasal
Continuant
Low
Back
Labial
Coronal
Spread
Anterior
High
Delayed release
Lateral
Flap
Trill |

10. Consider now the rules in (16).

- | | | | | |
|--------|----|--|---|--|
| (16) a | i | $\left\{ \begin{array}{c} k \\ g \end{array} \right\}$ | → | $\left\{ \begin{array}{c} \check{c} \\ \check{j} \end{array} \right\}$ |
| | ii | $\left\{ \begin{array}{c} \check{c} \\ \check{j} \end{array} \right\}$ | → | $\left\{ \begin{array}{c} k \\ g \end{array} \right\}$ |
| b | i | t | → | s |
| | ii | t | → | θ |
| c | i | n | → | r |
| | ii | r | → | n |

Considering such examples, Chomsky and Halle observe that in each case the examples (16a,b,c-i) involve "more features than or at least as many features as case ii; but in each pair case i is more to be expected in a grammar than

case ii and should therefore be 'simpler' in terms of an empirically significant evaluation measure."⁶

It is proposed that these data follow from the fact that there is a formal relation between phonological rules and markedness conventions--call it linking--such that:⁷

(17) Given the phonological rule

$$X \longrightarrow \begin{bmatrix} \alpha_i & F_i \\ \vdots & \vdots \\ \alpha_n & F_n \end{bmatrix}$$

where (a) F_i, \dots, F_n are distinctive features,

(b) $\alpha_i, \dots, \alpha_n$ are + or -, and

(c) F_j is the hierarchically latest feature specified,

each markedness convention which is for a u-obligatory feature, which is hierarchically ordered after the convention for F_j , and whose environment is satisfied, applies to the segment under derivation as if the segment were unmarked for the feature specified by that convention.

The rest of this chapter will be devoted to elaborating this proposal. In essence, the claim is made by (17) that there is a cost assigned to obliterating any feature specification which is potentially necessary for the well-formedness of the segmental system of a language, and that when a phonological rule applies there will be a minimization

of markedness in natural classes of segments for features which do not play a crucial role in the well-formedness of segmental systems.

11. The First Velar Palatalization in Slavic is a rule like (16a-i).⁸

(18)	underlying	k	g	x
	derived	č	ǰ	š

Under the linking hypothesis, (17), the First Velar Palatalization must be stated as (19).

$$(19) \begin{bmatrix} - & \text{son} \\ - & \text{ant} \end{bmatrix} \longrightarrow [- \text{back}] / \text{---} \begin{bmatrix} - & \text{cons} \\ - & \text{back} \end{bmatrix}$$

Consider first the application of (19) to k and g. The rule applies to specify these segments [- back]; convention IX, for the feature coronal, is hierarchically ordered after the convention for back; it can apply to the segments under derivation since they are $\begin{bmatrix} + & \text{cons} \\ - & \text{back} \\ - & \text{lab} \end{bmatrix}$. Convention XI, for high, is inapplicable, its environment not being satisfied. Convention XIX, the delayed release convention, can apply since its environment is satisfied and the segments under derivation are therefore specified [+ DR]. Convention XX can also apply since its environment is satisfied and the two segments are specified [+ stri]. The conventions for lateral and flap, XVIII and XXI, are potentially applicable; however, since the segments under derivation are [+ cons] neither convention can apply.

(20)	<u>k</u> , <u>g</u>	<u>č</u> , <u>ǰ</u>	
	+ cons		
	- ant		
	+ back	- back	(19)
	- low		
	- lab		
	- son		
	- cor	+ cor	IX
	- spr	----	X
	+ high	----	XI
	- cont		
	- DR	+ DR	XIX
	- stri	+ stri	XX

The derivation of ǰ from x is somewhat different. The rule applies to specify x [- back]. The coronal convention, IX, applies because the segment is $\begin{bmatrix} + \text{ cons} \\ - \text{ back} \\ - \text{ lab} \end{bmatrix}$. Convention XI is inapplicable. Convention XIX cannot apply because the segment is [+ cont]. Convention XX can apply to specify the segment [+ stri], its environment being satisfied.

(21)	<u>x</u>	<u>ǰ</u>	
	+ cons		
	- ant		
	+ back	- back	(19)
	- low		
	- lab		
	- cor	+ cor	IX
	- spr	----	X
	+ high	----	XI
	- cont		
	- DR	----	XIX
	- stri	+ stri	XX

The linking hypothesis captures the asymmetry of k/ǰ alternations, for given that hypothesis the rule (16a-ii) must be stated as (22).

$$(22) \quad \text{ç} \longrightarrow \begin{bmatrix} + \text{ back} \\ - \text{ cor} \\ - \text{ DR} \\ - \text{ stri} \end{bmatrix}$$

It is not possible to simplify this rule under the linking hypothesis. The classes of segments for which [- DR] and [- stri] are the unmarked specifications are not natural classes of segments and therefore not characterized by markedness conventions.

It is not particularly surprising that linking should be restricted to markedness conventions. It is only markedness conventions which, of necessity, apply to natural classes of segments; markedness rules do not necessarily apply to natural classes. For example, consider the convention for spread.

$$(23) \quad [\text{u spr}] \longrightarrow [+ \text{ spr}] / \begin{bmatrix} + \overline{\text{ cons}} \\ + \text{ lab} \\ - \text{ cor} \\ - \text{ back} \end{bmatrix} \quad \text{X}$$

Convention X applies to the class of segments which is $\begin{bmatrix} + \text{ cons} \\ + \text{ lab} \\ - \text{ cor} \\ - \text{ back} \end{bmatrix}$

(and unmarked for spread); this is a natural class of segments.

The complement of this class is those segments which are

$\left\{ \begin{bmatrix} [- \text{ cons}] \\ [+ \text{ ant}] \\ [- \text{ cor}] \\ [- \text{ back}] \end{bmatrix} \right\}$; this is not a natural class of segments--that is,

it is not a set of segments definable on a single matrix.

Phonological rules, like markedness conventions, only apply to natural classes of segments.

The Complement Convention is, therefore, motivated in two ways. First, it phonologically delimits the class of possible features by requiring that only relations of a particular character can hold among them. Second, it characterizes the class of feature specifications which characteristically arise as a consequence of the application of phonological rules.

12. If the theory of linking were motivated only to account for the asymmetry in the alternations between k and č then its validity would be open to serious question. The examples in (16b) also pose a problem for the standard theory. There the question is not one of asymmetry in alternation but rather one of how to predict that nonvelar, nonaspirated stops characteristically spirantize as strident fricatives, but aspirates characteristically spirantize as nonstrident fricatives.

12.1 Kenstowicz (1966) shows that there is a spirantization rule in Lithuanian such as (16b-i).

(24)	meta	veda	3rd sing. pres.
	mesti	vesti	infinitive
	mesiu	vesiu	1st sing. fut.
	mesdava	vezdava	3rd sing. frequent.
	meskite	veskite	2nd pl. imper.

For the purposes of the present discussion, the details of the environment will be ignored (see Kenstowicz), as will voicing adjustment, which, as Kenstowicz shows, must be a separate rule.⁹

To account for these alternations within the linking theory rule (25) is postulated.

$$(25) \quad \begin{bmatrix} - \text{son} \\ + \text{cor} \\ + \text{ant} \end{bmatrix} \longrightarrow [+ \text{cont}] / \text{ in some context}$$

The markedness conventions for the features spread glottis, constricted glottis, strident, distributed, and lateral are all ordered after that for the feature continuant; they are all potentially linking rules. The latter feature, however, does not have its feature specifications altered through linking to rule (25) since it crucially requires that a segment be [+ son]. The conventions for spread glottis and constricted glottis are also inapplicable since they only apply to [- cons] segments. (25) applies to specify, e.g., /t/ as [+ cont]; XX applies to specify the segment [+ stri].

In Modern Hebrew there is spirantization of /p, b, k/ as /f, v, x/, respectively, under certain conditions.¹⁰

(26)	safar 'he counted'	yispor 'he will count'
	baxar 'he chose'	yivxar 'he will choose'
	katav 'he wrote'	yixtov 'he will write'

To account for this spirantization rule (27) is

proposed.

$$(27) \quad \left[\begin{array}{l} - \text{son} \\ - \text{cor} \\ <- \text{lab}>_a \\ <+ \text{StVC}>_b \end{array} \right] \rightarrow [+ \text{cont}] / \text{ in some context} \\ a \rightarrow b$$

Rule (27) applies to the labials in the following way: they are specified [+ cont] by rule (27); XX applies to specify the segments [+ stri]; /f/ and /v/ are thereby derived from /p/ and /b/ respectively. The application of (27) to the velar /k/ proceeds as follows: the segment is specified [+ cont] by rule (27); XVIII cannot apply to a velar; XIX is inapplicable; XX cannot apply to a velar; therefore, a non-strident fricative, x, is derived from k.

In English there is a morphologically conditioned rule of spirantization which accounts for alternations such as: resident ~ residency, democrat ~ democracy, permit ~ permissive. This is then another example of a rule which spirantizes coronal stops as strident fricatives.

12.2 Spirantization does not always yield strident fricatives from labials and coronals. Grimm's Law is a spirantization rule which yields nonstridents. It is generally taken that Grimm's Law applied in three stages.

$$(28) \quad \begin{array}{cccc} & & (a) & (b) & (c) \\ /t/ & \longrightarrow & t^h & \longrightarrow & \theta \\ /d/ & \longrightarrow & & \longrightarrow & t \\ /d^h/ & \longrightarrow & & \longrightarrow & \text{ʃ} \end{array}$$

The first part of Grimm's Law aspirates voiceless stops; the second part, (28b), spirantizes aspirated stops; and the third part, (28c), devoices stops. For the purposes of the present discussion we will only be concerned with the first two stages.

The rule of aspiration can be stated as (29).

$$(29) \quad \begin{bmatrix} - \text{son} \\ - \text{cont} \\ + \text{StVC} \end{bmatrix} \longrightarrow [+ \text{SG}] / \# (X [+ \text{son}]) \text{ ______}$$

The only convention hierarchically ordered after that for spread glottis is that for strident, XX. XX cannot apply to the output of (29) since its environment is not satisfied.

Under the linking hypothesis, given the conventions postulated in Chapter 1, the rule of spirantization can be stated as (30).

$$(30) \quad \begin{bmatrix} + \text{cons} \\ + \text{SG} \end{bmatrix} \longrightarrow [+ \text{cont}]$$

As was the case with the rules of spirantization (25) and (27), there is no change in the specification of the feature lateral through linking to (30). (30) specifies an aspirate [+ cont]; XX is inapplicable because the segment is [+ SG].

The linking hypothesis and the conventions proposed above make the empirically falsifiable claim that when an aspirate is spirantized it will, in the most likely case, be

realized as a nonstrident segment, but that when a nonaspirate is spirantized it will be realized as a strident segment.

12.3 In Kiowa-Tanoan there are alternations between aspirates and fricatives which offer further support for the claim that aspirates spirantize as nonstridents.¹¹

(31)	Kiowa	/p ^h , t ^h , k ^h /
	Taos	/p ^h , t ^h , x/
	Rio Grande Tewa	/f, θ ~ s, x/
	Jemez	/φ, t ^h , h/

Positing aspirates as the original segments, in Kiowa there are no changes. In Taos the velar aspirate is spirantized; in Rio Grande Tewa and Jemez there is spirantization of (some) aspirates.

$$(32) \quad \begin{bmatrix} - \text{son} \\ + \text{SG} \end{bmatrix} \longrightarrow [+ \text{cont}]$$

By rule (32) all of the aspirates become nonstrident fricatives in Rio Grande Tewa. To account for the change of φ to f and some θ's to s, rule (33) is necessary.

$$(33) \quad [+ \text{cont}] \longrightarrow [- \text{SG}]$$

By rule (33) φ is specified [- SG]; by linking to XX it is specified [+ stri]. Those θ's subject to (33) are specified [- SG] by rule (33); [+ stri] by XX.

In Jemez rule (32) applies to the noncoronals. In addition to (32) a rule is needed to take x to h (as is also

needed for Grimm's Law--see §13.5 for discussion of such glide forming rules).

12.4 In Thakali there is optional spirantization of voiceless labial and velar affricates in intervocalic position: $\text{ʔap}^{\text{h}}\text{i} \sim \text{ʔa}\phi\text{i}$, 'aunt'; $\text{tik}^{\text{h}}\text{um} \sim \text{tixum}$, 'one piece'. These alternations can be accounted for by rule (34).¹²

$$(34) \quad \begin{bmatrix} \alpha \text{ back} \\ -\alpha \text{ lab} \\ + \text{ SG} \\ + \text{ StVC} \end{bmatrix} \longrightarrow [+ \text{ cont}] / \text{V} \text{ ____ } \text{V}$$

Glover, 1970, reports that in Gurnung voiceless labial aspirates become nonstrident fricatives in word initial position: $/\text{p}^{\text{h}}\text{u}/$, $[\phi\text{u}]$, 'egg'; $/\text{p}^{\text{h}}\text{eba}/$, $[\phi\text{eba}]$, 'cost'.

In the same language velar stops alternate with nonstrident fricatives when they occur intervocalically following a breathy vowel: $/\text{a}^{\text{h}}\text{gi}/$, $[\text{a}^{\text{h}}\text{ɣil}]$, 'eldest brother'. The velar aspirate also spirantizes intervocalically following a breathy vowel: $/\text{a}^{\text{h}}\text{k}^{\text{h}}\text{a:}/$, $[\text{a}^{\text{h}}\text{xa:}]$, '(I) am not able'. To account for these alternations within the linking framework two rules are necessary, one of aspiration assimilation, (35), and one of spirantization, (36).

$$(35) \quad \begin{bmatrix} + \text{ cons} \\ + \text{ back} \end{bmatrix} \longrightarrow [+ \text{ SG}] / \begin{matrix} \text{V} \\ [+ \text{ SG}] \end{matrix} \text{ ____ }$$

$$(36) \quad \begin{bmatrix} + \text{ cons} \\ + \text{ back} \end{bmatrix} \longrightarrow [+ \text{ cont}] / \begin{matrix} \text{V} \\ [+ \text{ SG}] \end{matrix} \text{ ____ } \text{V}$$

12.5 While it is the case that the linking hypothesis predicts that nonaspirated, nonvelar stops will spirantize as strident fricatives and that aspirated stops and velars will spirantize as nonstrident fricatives, this does not preclude the alternation of nonaspirates with nonstridents or of aspirates with nonstridents.

Thus, in Classical Hebrew there was spirantization of stops as nonstrident fricatives (see footnote 10).

(37)	kāθaβ	'he wrote'	yixtōβ	'he will write'
	sāφar	'he counted'	yispōr	'he will count'
	gan	'garden'	bəγan	'in a garden'
	bāḥar	'he chose'	yibḥar	'he will choose'
	dayyān	'judge'	ləḥayyān	'to a judge'
	melex	'king'	malkī	'my king'

If the segments which were the input to this rule were non-aspirates then a rule such as (38) would be necessary.

(38)	$\begin{bmatrix} + \text{ cons} \\ \alpha \text{ back} \\ \alpha \text{ high} \end{bmatrix} \longrightarrow \begin{bmatrix} + \text{ cont} \\ - \text{ stri} \end{bmatrix} / \text{ in certain contexts}$
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There are no markedness conventions for u-obligatory features which are hierarchically ordered after the convention for strident.

In Spanish voiced stops are realized as nonstrident fricatives in most environments. Here again it is necessary to specify the derived segment [- stri].¹³

In the Dacca dialect of Bengali the labial and velar aspirates, /p^h, b^h, k^h, g^h/, reportedly alternate with strident fricatives. To account for such an alternation rule (39) would be necessary.¹⁴

$$(39) \quad \begin{bmatrix} - & \text{cor} \\ + & \text{SG} \end{bmatrix} \longrightarrow \begin{bmatrix} + & \text{cont} \\ - & \text{SG} \end{bmatrix} / \text{ in certain contexts}$$

The specification of the segments as [- SG] would then trigger the application of the linking rule for stridency.

In Arizona Tewa, a Kiowa-Tanoan language (see §12.3), one finds /p^h, t^h ~ s, k^h/. To account for the alternation t^h ~ s rule (40) is necessary.

$$(40) \quad \begin{bmatrix} + & \text{cor} \\ + & \text{SG} \end{bmatrix} \longrightarrow \begin{bmatrix} + & \text{cont} \\ - & \text{SG} \end{bmatrix}$$

The theory presented here makes the claim that rules which spirantize nonaspirates as stridents and aspirates as nonstridents are more 'plausible' than rules which spirantize nonaspirates as nonstridents or aspirates as stridents. The theory makes a distinction between these cases of spirantization which is not made within the standard framework of generative phonology. The linking theory accounts for the fact that (16b-i) is a more common rule than (16b-ii).

13. Before considering other apparent cases of spirantization, it is first necessary to consider the role of the implications discussed in §4.2 in the application of phonological rules.

conditions were:

- (43) a $\begin{bmatrix} - \text{son} \\ + \text{lat} \\ - \text{SG} \end{bmatrix} \rightarrow [+ \text{DR}]$
 b $[+ \text{DR}] \rightarrow [- \text{cont}]$

In §4.2 the condition (53) was proposed; it is repeated here as (44).

- (44) Whenever a segment is specified to be $[\alpha F]$, where F is a feature and α is + or -, all implications whose antecedents are satisfied apply to that segment.

By condition (44), (43) will apply in the derivation of lateral affricates.

Consider now a rule which takes l to a lateral fricative.

- (45) $l \longrightarrow \begin{bmatrix} - \text{son} \\ + \text{SG} \end{bmatrix}$

If the features specified by rule (45) are specified sequentially, first $[- \text{son}]$ and then $[+ \text{SG}]$, following the first specification the implication (43a) could apply and the segment would be specified $[+ \text{DR}]$. By the specification of the segment $[+ \text{SG}]$ an aspirated lateral affricate will be derived. To block such a derivation it is proposed that there is simultaneous specification of all features which appear to the right of the arrow in a phonological rule. By imposing simultaneity on feature specifications assigned by phonological rules, the implicational rules will apply to matrices

which are specified for all the features mentioned in the rule. The segment derived by application of (45) will then be a lateral fricative.

13.2 Consider the fact that the $\underset{\sim}{j}$ derived by the First Velar Palatalization, §11 (19), becomes $\underset{\sim}{z}$. Such an alternation of an affricate with its cognate fricative is not uncommon. Without condition (44), to account for such alternations the derived segment would have to be specified by rule $\left[\begin{array}{l} + \text{ cont} \\ - \text{ DR} \end{array} \right]$. However, given condition (44) and the contrapositive of (43b),

$$(46) \quad [+ \text{ cont}] \rightarrow [- \text{ DR}]$$

the rule which takes $\underset{\sim}{j}$ to $\underset{\sim}{z}$ can be stated as (47).

$$(47) \quad \underset{\sim}{j} \rightarrow [+ \text{ cont}]$$

13.3 In Old English one finds alternations between \underline{s} and \underline{r} , between \underline{x} and $\underline{\gamma}$, between \underline{x}^w and $\underline{\gamma} \sim \underline{w}$, and between $\underline{\theta}$ and \underline{d} , Verner's Law.¹⁶

(48)	infinitive	sg.past	pl.past	pple.	
	/ceosan/	ceosan	ceas	coron	coren 'choose'
	/fleuxon/	flēon	flæax	fluγon	floyen 'flee'
	/līxon/	līon	lax	liγon	liyen 'lend'
	/sex ^w on/	seon	sæax	sayon	seyen 'see'
				~ sawon ~ sewen	

If we accept (44) then to account for these alternations the following rules are necessary. First, there must be a general rule of voicing, (49), which applies to these segments.

$$(49) \quad \begin{bmatrix} - \text{son} \\ + \text{cont} \\ - \text{lab} \end{bmatrix} \longrightarrow [- \text{StVC}] / \text{in certain contexts}$$

By (49) s becomes z, x becomes ɣ, x^w becomes ɣ^w, and θ becomes ð.

To account for ð becoming d, rule (50) is necessary.

$$(50) \quad \text{ð} \longrightarrow \begin{bmatrix} - \text{cont} \\ - \text{SG} \end{bmatrix}$$

sayon is derived by (51) from say^won.

$$(51) \quad \gamma^w \longrightarrow [- \text{lab}]$$

In the derivation of sawon from say^won, rule (52a) applies and then the implication rule (52b).

$$(52) \quad \begin{array}{l} \text{a} \quad \gamma^w \longrightarrow [- \text{cons}] \\ \text{b} \quad [- \text{cons}] \rightarrow [+ \text{son}] \end{array}$$

Consider now the rhotacism of the coronal. The rule must specify intermediate z as [- cons].

$$(53) \quad z \longrightarrow [- \text{cons}]$$

An r so derived will be [+ stri]. There are, however, the conditions (54).

$$(54) \quad \begin{array}{l} \text{a} \quad [- \text{cons}] \rightarrow [+ \text{son}] \\ \text{b} \quad [+ \text{son}] \rightarrow [- \text{stri}] \end{array}$$

By permitting (54a,b) to apply as rules there is no problem in accounting for the z to r rule. The derived segment is specified [+ flap] by XXI.

13.4 Sapir (1922) writes that:¹⁷

Probably the most far reaching phonetic law touching the Takelma vowels is an assimilatory process that can be appropriately termed "i-umlaut." Briefly stated, the process is a regressive assimilation of a non-radical -a- to an -i-, caused by an -i- (-ī-) in an immediately following suffixed syllable, whether the -i- causing the umlaut is an original -i-, or is itself umlauted from an original -a-.

- (55) a wak!ayayini'^εn 'I caused him to grow
with it'
k!ayayana'^εn 'I caused him to grow'
- b īyulu'yili'^εn 'I rub it'
īyulu'yalhi 'he rubs it'
- c s'a's'inī 'he stands'
s'a's'ant'^a'a 'he will stand'
- d bu^ubini`'t'k' 'my arm'
bu^uba`n 'arm'
- e t!omõxinik' 'we kill each other'
t!omõxa^εn 'they kill each other'

Without (44) the rule (56),

$$(56) \quad \begin{matrix} \text{V} \\ [+ \text{ low}] \end{matrix} \longrightarrow \begin{bmatrix} - \text{ back} \\ + \text{ high} \end{bmatrix} / \begin{bmatrix} \text{---} \\ - \text{ Root} \end{bmatrix} \text{ C } \begin{bmatrix} - \text{ cons} \\ - \text{ back} \\ - \text{ high} \end{bmatrix}$$

would apply to a to derive a segment which was $\begin{bmatrix} + \text{ high} \\ + \text{ low} \end{bmatrix}$. The implication (57) was motivated to block segments with such specifications from occurring in underlying representations.

$$(57) \quad [+ \text{ high}] \rightarrow [- \text{ low}]$$

By (44), (57) will apply to the segment derived by (56) and specify it [- low].

13.5 The x derived by Grimm's Law becomes h. The proposal of (44) leads to the statement of this rule as (58).

$$(58) \quad x \longrightarrow [- \text{ cons}]$$

The implication rule (59) will apply to a segment specified [- cons] by rule.

$$(59) \quad [- \text{ cons}] \rightarrow [+ \text{ son}]$$

A nonsyllabic sonorant which is $\begin{bmatrix} + \text{ StVC} \\ + \text{ SG} \end{bmatrix}$ is subject to the rule (60).

$$(60) \quad \begin{bmatrix} - \text{ syl} \\ - \text{ cons} \\ + \text{ StVC} \\ \alpha \text{ SG} \\ -\alpha \text{ CG} \end{bmatrix} \rightarrow \begin{bmatrix} + \text{ back} \\ + \text{ low} \\ - \text{ cor} \\ - \text{ spr} \end{bmatrix}$$

The markedness conventions IX, X, and XI are inapplicable. XII applies vacuously to specify the segment [- nas]. XIV applies to specify the segment [- StVC], and

XV is inapplicable. There is no h which is $\begin{bmatrix} - & \text{StVC} \\ - & \text{SlVC} \end{bmatrix}$, therefore such a set of feature specifications must be blocked in all h's. Since voiceless h is the typical case of h it must be the case that:¹⁸

$$(61) \quad \begin{bmatrix} - & \text{cons} \\ - & \text{syl} \\ + & \text{back} \\ + & \text{low} \\ + & \text{SG} \\ - & \text{SlVC} \end{bmatrix} \rightarrow [+ \text{StVC}]$$

XVI applies vacuously to specify the segment [+ SG].

Conventions XVII-XX are inapplicable.

Consider now glide formation from s. In Latin, Indo-European *s becomes r intervocalically (Skt. snusa, L. nura; Skt. visa, L. virus). To account for this change rule (62) is necessary.

$$(62) \quad s \rightarrow [- \text{cons}]$$

By implication a segment subject to (62) will be specified [+ son] and [- stri]; the markedness convention XIV will apply to specify the segment [- StVC], and then the convention XXI will apply to specify it [+ flap].

In Greek, Indo-European *s becomes h word initially and intervocalically, eventually deleting in the latter environment and before consonantal sonorants (Skt. sad-, Gk. 'εδος, L. sedere; Skt. snusa, Gk. υυος). To account for this change the rule (63) is necessary.

$$(63) \quad s \rightarrow \begin{bmatrix} - & \text{cons} \\ + & \text{SG} \end{bmatrix}$$

The implication (60) will apply to the output of (63). From that point on the derivation is the same as that of h from x. The theory and conventions therefore make the prediction that the most likely glide to be derived from s is r.

13.6 That condition (44) allows for the simplification of certain rules is not its only motivation. (44) is in fact motivated on more general grounds. Without such a condition there would be no way to preclude intermediate stages in derivation where segments were specified e.g. $\begin{bmatrix} + \text{ high} \\ + \text{ low} \end{bmatrix}$. To allow segments so specified to occur at any intermediate stage in derivation would be to allow a segment to carry along its derivational history and to allow ad hoc phonological rules at later stages in derivation. Just as ill-formed segments must be excluded at the level of underlying representation, they must also be excluded in derivations. Not to exclude them would be to seriously weaken the fundamental idea behind distinctive features--that there is a fixed set of features with cooccurrence restrictions which classify segments at all levels of representation. Given that the rules of implication and (44) are independently motivated to delimit the class of possible underlying segments, there is no motivation for introducing any new mechanisms to capture cooccurrence restrictions in the course of derivations. Any such additional restrictions would be completely redundant. The rules of implication are an integral part of the theory of markedness

proposed in Chapter 1. The linking hypothesis makes the claim that the theory of markedness not only plays a crucial role in the characterization of underlying segmental systems but also in the application of phonological rules. Therefore, if this claim is to be maintained it must be that the rules of implication play a role in the application of phonological rules.

14. Consider now lenition rules, i.e. rules which take voiceless and voiced stops to voiced continuants. Such a rule would, apparently, require that both the features stiff vocal cords and continuant be specified by rule in violation of condition (12). It will be argued here that lenition rules are in fact rules which create glides.

14.1 One of the most well-known lenition rules is that of Southern Paiute.¹⁹

(64) naβ ₁ aβ ₁ ini	na-	paβ ₁ i-
'brothers'	(recip.)	'elder brother'
ai'rai' ⁱ	ai-	tai' ⁱ
'new shirt'	'new'	'shirt'
cī'γ ₁ aitcox'U	cī-	qaitcox'U
'woman's basket cap'	'squaw-bush'	'hat'

The striking characteristic of most lenition rules is that coronals are generally realized as r and not as ʃ. To account for the lenition in Southern Paiute, under the assumption that it is a spirantization rule, would require rules (65a,b,c).

(65) a	$\begin{bmatrix} - \text{son} \\ - \text{stri} \end{bmatrix}$	\longrightarrow	$\begin{bmatrix} + \text{cont} \\ - \text{StVC} \end{bmatrix}$	/ v _____ v
b	$\begin{bmatrix} + \text{cont} \\ + \text{stri} \end{bmatrix}$	\longrightarrow	$[- \text{stri}]$.
c	$\begin{bmatrix} + \text{cor} \\ + \text{cont} \\ - \text{StVC} \end{bmatrix}$	\longrightarrow	$[+ \text{son}]$	

By condition (12), the rules (65a) and (65b) cannot be collapsed. Rules (65b) and (65c) are unorderable.

Under the linking hypothesis, the specification of a segment as a sonorant will automatically lead to its specification [- StVC]. The segment affected by (65c) will then be specified as a flap by that convention (XXI).

If it is assumed that all segments derived by lenition are sonorants then the rule for Southern Paiute can be stated as (66).

$$(66) \quad \begin{bmatrix} - \text{son} \\ - \text{stri} \end{bmatrix} \longrightarrow [- \text{cons}] / \text{V} \text{ ___ } \text{V}$$

Rule (66) will specify p, t, and k [- cons]. A segment which is [- cons] is subject to the implication (67),

$$(67) \quad [- \text{cons}] \rightarrow [+ \text{son}]$$

and is specified [+ son]. Convention XIII will apply to specify these segments [+ cont]. Convention XIV applies to specify the segments [- StVC]. Convention XXI will apply to the [+ cor] segment and specify it [+ flap].

It is argued then that β₁, r, and γ₁ are glides, i.e. $\begin{bmatrix} - \text{syl} \\ - \text{cons} \\ + \text{son} \end{bmatrix}$. Southern Paiute lenition offers support for this claim on the basis of the effects of rules on segments.

14.2 A second argument in favor of this position comes from Karok. In Karok the nasals m, n are denasalized before vowels.²⁰

(68) ?isra:m	'deer lick'	?isra:β ₁ is	'marshy place'
?atayra:m	'star'	?atayraβ ₁ ipux	'starless'
tisra:m	'valley'	tisra:β ₁ ara	"Scott Valley"
kusta:n		kusta:ras	
β ₁ a:san		β ₁ a:saras	
xu:n		xuras	

To state the rule for the denasalization of m, under the assumption that β₁ is really a nonstrident fricative (i.e. β) would require (69) under linking.

$$(69) \quad m \rightarrow \begin{bmatrix} - \text{son} \\ - \text{nas} \\ + \text{cont} \end{bmatrix} / \text{ ______ } V$$

To account for the alternation of n with r rule (70) would be required.

$$(70) \quad n \rightarrow [- \text{cons}] / \text{ ______ } V$$

Convention XIII applies to specify the segment [- nas] and convention XXI applies to specify the segment [+ flap].

If it is assumed that there is no labial glide β₁, then under the linking hypothesis there is no relation between the rule which denasalizes m prevocalically and the rule which denasalizes n prevocalically except with respect to their environments. If, however, β₁ and r are glides, then only one rule, (71), is necessary.

$$(71) \quad [+ \text{nas}] \rightarrow [- \text{cons}] / \text{ ______ } V$$

As in the case of Southern Paiute, a generalization

is missed if one claims there is no glide β_1 .

In Karok there is an underlying β_1 . The question arises as to whether this segment is a glide or a nonstrident fricative. There is a rule of gemination which applies to consonants.

(72) /mu # ta:t/	mutta:t	'his mother'
/ʔu + paθ/	ʔuppaθ	'he throws'
/ʔamβ ₁ a # ma:n/	ʔamβ ₁ amman:n	'salmon skin'
/imxaθa # ke:m/	imxaθakke:m	'bad odor'
/ʔas + ara/	ʔassara	'wet'
/mu # xaβ ₁ is/	muxxaβ ₁ is	

Knecht (1974) states this rule as (73).

(73)	$C \rightarrow [+ \text{long}] / [- \text{long}] \text{ ______ } \overset{V}{\text{V C}}$
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While all the examples in (72) have gemination taking place at a boundary, a boundary is not necessary in the statement of the rule, for word internally in that environment consonants are realized as geminates.

(74) /ʔisaha/	ʔissaha	'water'
/yufis/	yuffis	'salt'
/ʔakah/	ʔakkah	'father'

Gemination does not apply to glides.²¹

- (75) /ʔu + paris/ ʔupparis
 /ʔu + kuha/ ʔukkuha
 /mura # po:ra/ murappo:ra

Nor does gemination apply to /β₁/: /mu # xaβ₁is/, muxxaβ₁is.

If it is assumed that β₁ is a nonstrident fricative then the rule of gemination must be restricted so that it applies to all consonants except /β₁/. This is not a natural class.

If, however, β₁ is a glide then the rule can be stated as (76).

- (76) [+ cons] → [+ long] / $\begin{matrix} \text{V} \\ [- \text{long}] \end{matrix} \text{ ______ } \text{V C}$

Knecht argues that there is a rule deleting continuant sonorants in the environment $\begin{matrix} \text{V} \\ [- \text{long}] \end{matrix} \text{ ______ } [- \text{seg}] \begin{matrix} \text{V} \\ [- \text{long}] \end{matrix}$.

- (77) /ʔay + at/ ʔa:t
 /iyvay + isrih/ iyve:srih

In this environment /β₁/ deletes.

- (78) /ikyaβ₁ + arax/ ikya:ra
 /ʔanaβ₁ # ikyaβ₁a:n/ ʔane:kyaβ₁a:n

These data provide strong evidence for the postulation of a β₁ as a glide in Karok. There is then no argument against lenition as a rule creating sonorants based on a claim that there is no such thing as the glide β₁.

14.3 To accept an analysis of lenition as spirantization would require rule complication and the abandonment of

condition (12), as noted above. Lenition is a process which is not infrequently attested; therefore it is not clear that there is any empirical support for rule complication.

Liljenblad (1950) reports that in Bannock there is free variation in initial position between voiceless stops and their lenited counterparts: [pia], [β_1 ia], 'female'. There is also free variation in Bannock of voiced stops with nonstrident fricatives in intervocalic position: [paga], [pa γ_1 a], 'arrow'; [hibi], [hi β_1 i], 'to drink'. If lenition is treated as spirantization then there is an untoward increment in complexity necessitated by such examples.

In Comanche, as in Southern Paiute, there is lenition by rule. A voiceless labial or coronal stop in initial position is lenited when preceded by certain morphemes: /pa:ka/ 'arrow', [na β_1 a:ka] 'bullet (its arrow)'; /pu:nI/ 'to see', [na β_1 u:nI?] 'mirror'; /pu:ka/ 'horse', [na β_1 u:kua:?] 'car'; /ti β_1 o:pI/ 'paper', [niri β_1 o:;I] 'my paper'; /tihka/ 'eat', [narihka] 'groceries'.²²

In Lower Grand Valley Dani there is lenition in intervocalic position of /p, t, k, k^w/ as / β_1 , r, γ_1 , w/.²³

14.4 Garvin (1950) proposes that there is an r but no n in Wichita. In §5.2.3 n but not r was listed as a phoneme of Wichita. According to Garvin, n and r are in complementary distribution: n occurs word-initially, precoronally, and in geminates (Garvin's /rr/ becomes [nn]), r occurs elsewhere.

If it is assumed that \underline{r} is a segmental phoneme then there must be three rules to account for the distribution of \underline{n} 's in Wichita; these are stated informally as (79a,b,c).

- (79) a $r \rightarrow n / \# \underline{\quad}$
 b $r \rightarrow n / \underline{\quad} [+ \text{cor}]$
 c $r \rightarrow n / n \underline{\quad}$

If, on the other hand, it is assumed that there is an \underline{n} rather than an \underline{r} underlyingly then only one rule, (80), is needed to account for the distribution of \underline{n} 's and \underline{r} 's.

- (80) $n \rightarrow [- \text{cons}] / [- \text{cons}] \underline{\quad} [- \text{cor}]$

Neither \underline{r} nor \underline{n} appears as the second member of a consonant cluster, therefore all cases of preconsonantal \underline{r} are also instances of post- $[- \text{cons}] \underline{r}$. Thus, given Garvin's data, the simpler analysis of Wichita requires postulation of an underlying \underline{n} rather than an underlying \underline{r} . That the analysis with phonemic \underline{n} is indeed simpler becomes even clearer if the statement of the rules of (79) is made explicit within the linking framework.

- (81) $r \rightarrow \left[\begin{array}{l} + \text{cons} \\ + \text{nas} \\ - \text{flap} \end{array} \right] / \left\{ \begin{array}{l} \# \underline{\quad} \\ \underline{\quad} [+ \text{cor}] \\ [+ \text{nas}] \underline{\quad} \end{array} \right\} \begin{array}{l} (= (79a)) \\ (= (79b)) \\ (= (79c)) \end{array}$

In §11 it was shown that the linking hypothesis captured the asymmetry of $\underline{k} \sim \check{\underline{c}}$ alternations. From this example it is shown that it also captures the asymmetry of

n ~ r alternations. The theory and conventions presented here place a higher value on rules which take n to r than on rules which take r to n.

15. It was proposed in (17) that only the markedness conventions for the u-obligatory features participate in linking. This proposal is supported by consideration of alternations of glides with consonants.

15.1 Harris (1969) argues that in Spanish y and w become ɥ and ɥ^w, respectively, in the environment V ____ (#) [- cons]. Within the framework developed here, to account for this alternation rule (82) is necessary.

$$(82) \quad \begin{bmatrix} - \text{ cons} \\ + \text{ high} \end{bmatrix} \longrightarrow [- \text{ son}] / \text{V} \text{ ____ } (\#) [- \text{ cons}]$$

By the implication (83) any segment subject to (82) will be specified [+ cons].

$$(83) \quad [- \text{ son}] \rightarrow [+ \text{ cons}]$$

The markedness conventions XII-XX are ordered with respect to that for sonorant. XII is inapplicable, XIII applies vacuously; XIV is inapplicable; XV applies to specify the segment [+ SLVC]; XVI-XX are inapplicable. ɥ and ɥ^w are thereby derived from y and w.

The specification [+ cons] does not entail the specification [- son]; therefore, the rule (84) will not account for this alternation.

$$(84) \quad \begin{bmatrix} - \text{ cons} \\ + \text{ high} \end{bmatrix} \longrightarrow [+ \text{ cons}]$$

15.3 It is not always the case that w becomes $\underline{\gamma}^w$ when it loses its sonorance. There are also cases of w becoming $\underline{\gamma}$ and \underline{v} .

Considering first the derivation of $\underline{\gamma}$ from w, one possible analysis is to allow rule (85) to apply to the output of rule (82).

$$(85) \quad \gamma^w \longrightarrow [- \text{lab}]$$

There is no productive linking to (85).

Alternatively, $\underline{\gamma}$ can be derived from w by the application of rule (86) prior to the application of rule (82).

$$(86) \quad w \longrightarrow [- \text{lab}]$$

There are also two possible analyses for the derivation of \underline{v} from w. One analysis would involve the postulation of rule (87), which would apply to the output of rule (82).

$$(87) \quad \gamma^w \longrightarrow [- \text{back}]$$

By linking the markedness convention X would specify the segment [+ spr]. Since all spread labial consonants are [+ ant], it will follow by implication that the segment subject to (87) is [+ ant]. Convention XI will apply to specify the segment [- high], and convention XIX will specify it [+ stri].

The second possible analysis requires the postulation of rule (88), which is ordered before rule (82).

$$(88) \quad w \longrightarrow [- \text{back}]$$

Application of (88) would yield the segment β_1 . If then (82) applies there will be linking not only to XV (as noted above) but also to X, XI, and XIX as in the case of rule (87).

None of the rules (85)-(88) can be collapsed with rule (82) since the features back and labial are not hierarchically ordered with respect to the feature sonorant. Thus, it is a consequence of this theory that any change from w to either ɣ or y must happen in two distinct stages.

15.4 When y is consonantalized it sometimes becomes \check{z} and not \check{J} . There is only one straightforward way to account for such a change; that is by the addition of rule (89), which is ordered after (82).

(89) $\check{J} \rightarrow [+ \text{cor}]$

By linking to XIX the derived segment would be specified [+ stri].

The derivation of \check{z} from y by the application of a rule of coronalization, (90), followed by (82) is unlikely.

(90) $y \rightarrow [+ \text{cor}]$

Coronal glides are (generally) r's. Application of XI would specify the segment [- high] and application of XXI would specify it [+ flap] and r would be derived.

15.5 Kim (1975) proposes the rule (91) for Korean.

(91) $l \rightarrow r / [- \text{cons}] \text{ ____ } [- \text{cons}]$

Within the linking framework, to account for this alternation rule (92) is necessary.

(92) [+ lat] → [- cons] / [- cons] ____ [- cons]

The specification [+ lat] is incompatible with the specification [- cons]; by implication any segment subject to (92) will therefore be specified [- lat]. The specification [+ ant] is also incompatible with the specification [- cons]; so, a segment subject to (92) is also implicationally specified [- ant]. The only productive linking is to convention XXI which specifies the segment [+ flap].

Consider now the consequences of a rule such as (92) if there were linking to the conventions for m-obligatory features as well as to the conventions for u-obligatory features. A segment subject to (92) would be specified [+ back] by convention V and [+ low] by convention VI. To the best of my knowledge, there is no language in which l alternates with an r which is pharyngealized. By limiting linking to the conventions for u-obligatory features it is predicted that l will alternate with a regular r, as it does, and not with a pharyngealized r, as apparently never occurs.

15.6 Another example which supports the claim that there is linking only to the conventions for u-obligatory features comes from consideration of rules which specify vowels [+ back]. Given a rule such as (93),

(93) V → [+ back]

if there were linking to the conventions for m-obligatory features then any vowel subject to (93) would be specified [+ low] by convention VI. That is, if there were linking to convention VI then any unrounded vowel subject to (93) would become ɔ. Such consequences are clearly not supportable.

Given that there is no linking to the conventions for m-obligatory features it follows that when vowels are backed there is no change in the specification of the vowel for either height or rounding.

16. As yet nothing has been said about rules which affect the syllabicity of a segment. Sievers' Law is such a rule. Following Kiparsky (1973), it is assumed that by this rule /śacīā + ā/ is realized as śacyā and that /adug + dhvam/ is realized as adugdhuam. The rule then has two parts: (i) one which specifies a vowel [- syl], and (ii) one which specifies a glide [+ syl].

Sievers' Law is yet another example which provides strong evidence in favor of restricting linking to the conventions for u-obligatory features. The conventions for the features consonantal and sonorant are given in (94).

$$(94) \text{ III} \quad [u \text{ cons}] \longrightarrow [+ \text{ cons}] / \left[\begin{array}{c} - \\ \text{---} \\ \text{syl} \end{array} \right]$$

$$\text{VIII} \quad [u \text{ son}] \longrightarrow [- \text{ son}] / \left[\begin{array}{c} + \\ \text{---} \\ \text{cons} \end{array} \right]$$

If there were linking to the conventions for m-obligatory features then any segment subject to case (i) of Sievers' Law would be specified $\left[\begin{array}{c} + \text{ cons} \\ - \text{ son} \end{array} \right]$. Since it is the case that when i and u alternate with y and w, respectively, there is only one feature changed--syllabic--the entailment of allowing linking to the conventions III and VIII is unacceptable.

It might be proposed that the conventions for consonantal and sonorant are not III and VIII, but rather III' and VIII' as given in (95).

$$(95) \text{ III}' \quad [u \text{ cons}] \longrightarrow [- \text{ cons}] / \left[\begin{array}{c} + \\ \text{---} \\ \text{syl} \end{array} \right]$$

$$\text{VIII}' \quad [u \text{ son}] \longrightarrow [+ \text{ son}] / \left[\begin{array}{c} - \\ \text{---} \\ \text{cons} \end{array} \right]$$

While the conventions of (95) would allow for linking in the case of Sievers' Law without untoward results, serious problems would arise in rules which, e.g., syllabify nasal consonants. The rule (96) would link to convention III' and specify, e.g., n [- cons].

$$(96) \quad [+ \text{nas}] \longrightarrow [+ \text{syll}] / \text{ ____ } (\text{C X}) \#$$

Such a result would be intolerable.

There is in fact no evidence to indicate that a specification of a segment for syllabicity ever triggers linking--even to the conventions for n-obligatory features. Were (96) to trigger linking then convention XII would apply and the segment derived would be specified [- nas]. Since all nonnasal sonorants are continuants by implication the derived segment would then be specified [+ cont]. Since when nasals are syllabified they do not typically lose their nasality it must be the case that there is no linking triggered by a rule which affects the syllabicity of a segment. Therefore, (17) must be reformulated as (97).

(97) Linking

Given a phonological rule

$$X \longrightarrow \begin{bmatrix} \alpha_i & F_i \\ \vdots & \vdots \\ \alpha_n & F_n \end{bmatrix}$$

where (a) F_i, \dots, F_n are distinctive features,

(b) $\alpha_1, \dots, \alpha_n$ are + or -, and

(c) F_j , $j \geq 3$, is the hierarchically latest feature specified,

each markedness convention for a feature F_k , $k \geq 9$, which is hierarchically ordered after the convention for F_j , and whose environment is satisfied, applies to the segment under derivation as if the segment were unmarked for the feature specified by that convention.

In Chapter 1 it was argued that the features segment and syllabic stood in a class apart from the other features. This was a consequence of the fact that they were defined on strings rather than single segments. The linking hypothesis makes the claim that there is a systematic relation between the markedness of segments and the way in which phonological rules apply. Given that segment and syllabic are distinguished from the other features in terms of the markedness of segments--that there is intrasegmentally no notion of markedness for either of these features--it would in fact be expected that they behave differently from the other features with respect to linking. The fact that there can be no linking to a rule which specifies a segment for syllabicity maintains this distinction.

17. It follows from (97) that when a segment is inserted in a string by a rule of epenthesis that it must be specified by rule for all m-obligatory features. If such an epenthesized segment were then subject to all the markedness conventions for u-obligatory features then it will follow that epenthesis of an anterior coronal consonant is more natural than epenthesis of a consonant with some other place of articulation. There is linking only to markedness conventions, not to markedness rules. The markedness convention for coronal, IX, specifies nonback nonlabial consonants [+ cor]. It cannot apply to specify a segment [- cor]. Therefore, if an epenthesized consonant is either [+ back] or [+ lab] then the rule of epenthesis must explicitly mention the specification [- cor]. Similarly, the convention for high, XI, specifies segments [- high]. Therefore, if the epenthesized segment is [- cor], $\begin{bmatrix} - & \text{lab} \\ - & \text{spr} \end{bmatrix}$, or $\begin{bmatrix} + & \text{cor} \\ - & \text{ant} \end{bmatrix}$ the epenthesis rule must explicitly specify the derived segment for the feature high. From the coronal convention it would follow that the epenthesis of a coronal consonant is simpler than the epenthesis of a labial or velar, and from the high convention it would follow that epenthesis of a labial or coronal consonant is simpler than epenthesis of a velar.

There is, however, a serious problem with assuming that epenthesis triggers linking in the sense of (97). The conventions XIII-XVIII would all be inapplicable and a

derived stop would be without specifications for the features continuant, stiff vocal cords, slack vocal cords, spread glottis, constricted glottis, and lateral. Depending on its place of articulation such a segment could also be without specifications for delayed release and strident. It therefore must be that epenthesis does not trigger linking.

The question then remains as to what is the character of epenthesis rules. It is clearly the case that some types of epenthesis are more natural than others. One way to capture this is to say epenthesis rules insert markedness matrices which are then interpreted by the markedness rules. Thus, the complexity of an epenthesis rule would be a function of the number of m's in the segment inserted. Alternatively (and equivalently) it could be said that epenthesis rules insert fully specified matrices and that the complexity of an epenthesis rule is equivalent to the number of m's in the markedness matrix such a +/- matrix would yield. It would follow that epenthesis of a is more likely than epenthesis of i (by a factor of 1) and than epenthesis of ö (by a factor of 3). Similarly, it would follow that epenthesis of an anterior coronal consonant is more likely than epenthesis of a labial or velar (by a factor of 1) and that epenthesis of a stop is more likely than epenthesis of a nasal or fricative (also by a factor of 1).

18. The theory of markedness developed in §§1-17 is based on the postulation of the existence of a set of universal statements--markedness conventions--which characterize the most likely conjunctions of specified features in segments. The theory claims that the markedness conventions play a role in determining the structure of phonological systems. It is further claimed that every distinction made among the features at any level of phonological representation will also be made at every other level. Such a theory makes explicit and empirically falsifiable claims about the structure of sound systems.

18.1 On the basis of the properties of the features it was argued that there were two classes of features--the major features and the features defined on single segments (§2). The distinction between these two classes was reflected in the fact that conditions on the well-formedness of systems based on the major features hold only at the level of underlying representation, while conditions on the well-formedness of systems based on the other features hold at both the underlying and surface levels of phonological representation (§7). In the area of the application of phonological rules it was argued that the specification of a segment for a major feature does not trigger linking, but that the specification of a segment for any other feature does (§§11 and 16).

18.2 The features defined on single segments were claimed to be of two types--m-obligatory features and u-obligatory features. The m-obligatory features are features for which there must be marked specifications in underlying representations and at the surface (§5). The u-obligatory features need not be marked at any level of representation (§§5 and 7). This distinction was maintained by the fact that the markedness conventions for the m-obligatory features never apply as rules of linking--only the conventions for u-obligatory features are potential linking rules (§15).

The limiting of potential linking rules to the class of u-obligatory features provides a natural way for capturing the fact that there are certain types of changes in segmental systems which are more 'costly' than others. There is a cost entailed in changes in feature specifications which affect features whose specifications potentially are playing a crucial role in the segmental system which is not necessarily entailed by a change in the specification of a u-obligatory feature.

The u-obligatory features by definition play no crucial role in the well-formedness of segmental systems. That systemic simplicity is valued over complexity is reflected in the fact that application of the markedness conventions for u-obligatory features in linking reduces the complexity of a segmental system. There is no cost

entailed by the reduction of segmental complexity where that complexity is not potentially crucial to the well-formedness of a system.

18.3 It was proposed that the class of possible markedness conventions was formally restricted (§1). As a consequence of this formal restriction there is an intrinsic ordering of the conventions which gives the hierarchy of features (§3). The earliest features in the hierarchy are the major features; ordered just after them are the m-obligatory features defined on single segments; the latest features in the hierarchy are the u-obligatory features (§§5 and 6).

Given that the major features are the hierarchically earliest the fact that the specification of a segment for syllabicity is never contingent on its place or manner of articulation follows. That is, from the fact that a segment is [+ back] or [- DR] nothing follows as to whether that segment is a vowel, consonant, or glide. While there are characteristic places and manners of articulation associated with [+ syl] segments as distinct from those of [- syl] segments, it is not the case that based on place or manner information anything is known as to whether that segment will have a marked or unmarked specification for syllabicity.

From the ordering of the m-obligatory features before the u-obligatory features it could never be the case that there exists an m-obligatory feature whose unmarked

specification is contingent on the marked or unmarked specification of a u-obligatory feature. Were there not this ordering it could be that the markedness convention for an m-obligatory feature took as its environment the marked specification of a u-obligatory feature; from this it could follow that the only unmarked specifications of some m-obligatory feature are in a marked context. The distinction between m-obligatory features and u-obligatory features would be rendered nearly meaningless were such a situation possible. The ordering of the m-obligatory features before the u-obligatory features is a crucial part of the distinction between these two classes of features (§5).

The hierarchy of features is not a simple linear ordering of features. It has often been observed that there is little connection between the place and manner of segments; that is, from knowing that a segment is [+ nas] nothing about its place of articulation follows, or from knowing that a segment is [+ back] nothing about its manner of articulation follows. The hierarchy of features captures this fact. There is no ordering between the conventions of place and the conventions of manner; place and manner features are in general hierarchically unrelated (§§2 and 3).

That there do not exist phonological rules which specify segments, e.g., [+ CG] and [+ lab] has a principled explanation in this theory. A phonological rule can only

specify a segment for two features which are hierarchically related (§9). A further fact which follows from the hierarchy of features is that when a segment is specified, e.g., [+ cont] by a phonological rule there is usually no concomitant change in its specification for nasality, but there is often a change in its specification for stridency if it is a consonant. The expected concomitant changes in feature specifications which accompany the specification of a segment for some feature(s) are always for features which are hierarchically later than the feature(s) specified by the rule (§10). That is, from the hierarchy it is possible to predict the class of features whose specifications are likely to change as a consequence of the specification of a segment for some feature(s) by a phonological rule.

18.4 Given the Complement Convention it follows that the markedness specifications of features will not vary arbitrarily across classes of segments (§1). Phonological systems are therefore not made up of discrete classes of segments such as consonants and vowels, where there are particular conditions on the well-formedness of one class as opposed to any other. The postulation of m-obligatory features would make little sense if there were not systematic relations between the markedness specifications of features in all classes of segments. From the Complement Convention it follows that segmental systems must be viewed in totality; one cannot establish the

well-formedness of a vowel system of a language in the absence of any information on the glide and consonant systems. It makes no more sense to talk about the well-formedness of a system of [+ cons] segments in a language than it does to talk about the well-formedness of the system of [+ lab] segments in a language. There is no principled basis on which these two natural classes of segments can be distinguished, the one somehow characterizing a more important class than the other. In considering the well-formedness of a segmental system what is crucial is the relation of each of the parts to the whole. As Sapir (1925) observed, "the relational gaps between the sounds of a language" are crucial; sounds must have 'places' in systems.

The Complement Convention requires that for each feature there exist a natural class of segments for which it has an unmarked specification (the markedness convention case of a markedness rule) and that in the complement of that class it has the opposite unmarked specification. As was noted above, phonological rules apply to natural classes of segments. It is only that instance of the markedness rules for any given feature which is of necessity defined on a natural class which can apply in linking. That is, the feature specifications which arise as a consequence of the application of phonological rules are always specification of natural classes of segments. The force of the claim that phonological rules

apply to natural classes of segments would be weakened if it were not the case that it is only specifications associated with natural classes which arise through their application.

Footnotes to Chapter 2

1. Chomsky and Halle (1968), p. 331.
2. Ibid., p. 334.
3. For further discussion of this point, see Halle (1961, 1962, and 1964).

4. Using indexed bracketings, (9) can be stated as

$$[+ \text{ cons}] \longrightarrow [\langle + \text{ back} \rangle_b] / \left[\begin{array}{c} \text{---} \\ \langle + \text{ syl} \rangle_a \\ - \text{ cons} \\ \langle + \text{ back} \rangle_c \end{array} \right] \quad b \rightarrow (a \ \& \ c)$$

5. For further discussion see in particular Chomsky (1955 and 1965).
6. Chomsky and Halle (1968), p. 403.
7. The term 'linking' is taken from SPE. For a brief discussion of the SPE theory see §19.
8. These data are from Chomsky and Halle (1968), and Morris Halle, personal communication.

9. Details of environments are not directly relevant. It is clear that some rules are more 'natural' than others; for example A is quite likely as a rule of grammar but B is quite unlikely.

$$\begin{array}{l}
 \text{A} \quad \begin{bmatrix} + \text{ cons} \\ - \text{ back} \end{bmatrix} \longrightarrow [+ \text{ back}] / \text{ ____ } \begin{bmatrix} - \text{ cons} \\ + \text{ back} \end{bmatrix} \\
 \text{B} \quad \begin{bmatrix} + \text{ cons} \\ + \text{ lab} \end{bmatrix} \longrightarrow [+ \text{ CG}] / \text{ ____ } \begin{bmatrix} + \text{ syl} \\ + \text{ nas} \end{bmatrix}
 \end{array}$$

Obviously any complete theory of phonology must capture such facts. However, I am concerned here only with the issue of how a segment subject to a phonological rule changes.

10. The data from Hebrew used here and in §12.5 were provided by Alan Prince. He informs me that there is evidence from Greek transcriptions that (some) Classical Hebrew stops were aspirated. For example, Hebrew [kərūβ] (cherub) is transcribed as κερούβ in the Septuagint and not as κερούβ.

- 11. Hale (1967).
- 12. Hari (1970).
- 13. Harris (1968).
- 14. Ray, Hai, and Ray (1966).
- 15. Bogoras (1922).
- 16. O'Neil (1970) and Quirk and Wrenn (1955).

17. P. 24. The segment y triggers i-umlaut as well. Evidently the rule is blocked by the presence of certain intervening h's.

18. As was noted in Chapter 1, there must be many conditions, some of which will perforce be highly specific like (61).

19. Sapir (1930).

20. Bright (1957), Knecht (1974).

21. There appear to be no available examples of the effects of this process on ? and y.

22. Casagrande (1954).

23. Bromley (1961).

Chapter 3

Three Recent Approaches to a Theory of Segmental Systems

19. In SPE Chomsky and Halle present a theory of markedness which is in its general goals the same as that presented here. While their theory is admittedly incomplete it is quite suggestive and of sufficient detail to bear comparison with the theory presented above. The two theories differ in several substantive ways.

19.1 The most obvious difference between the theories is that in the SPE system the class of possible markedness conventions is formally quite unconstrained. There is no obvious reason why there should be formal constraints on markedness conventions, just as there is no obvious reason why phrase structure rules should be context free. The types of markedness conventions admitted within the SPE theory are illustrated in (1).

(1) a [u seg] → [- seg] (SPE I, 404)

b (SPE XXVII, 407)

$$[u stri] \rightarrow \left\{ \begin{array}{l} [- stri] / \left\{ \begin{array}{l} [+ \overline{son}] \\ [- \overline{ant}] \\ [- cor] \end{array} \right\} \\ [\alpha stri] / \left\{ \begin{array}{l} [\alpha \overline{DR}] \\ \{ [+ ant] \} \\ \{ [+ cor] \} \end{array} \right\} \end{array} \right\}$$

c (SPE XXIII, 406)

$$[u cor] \rightarrow \left\{ \begin{array}{l} [- cor] / \left\{ \begin{array}{l} [- \overline{ant}] \\ [+ nas] \end{array} \right\} \\ [\alpha cor] / \left\{ \begin{array}{l} [-\alpha \overline{back}] \\ [- ant] \end{array} \right\} \\ [+ cor] / \left\{ \begin{array}{l} [+ \overline{ant}] \\ \{ [+ nas] \} \\ \{ [m cont] \} \end{array} \right\} \end{array} \right\}$$

The postulation of formal constraints on possible markedness conventions makes an empirical claim as to what is a possible phonological feature. The SPE system admits the possibility of there being a feature F^* which has the unmarked specification + in the class of segments which is $\left[\begin{array}{l} + son \\ + back \end{array} \right]$ and the class of segments which is $\left[\begin{array}{l} + cor \\ + ant \end{array} \right]$, and the unmarked specification - elsewhere. It follows from the theory of markedness presented here that there can be no feature F^* . Thus, from constraining the class of conventions

it follows that there is a purely linguistic criterion delimiting the class of possible features. Without formal constraints on possible conventions the class of possible features is left open. Therefore, (13), §1.2, makes a metatheoretical claim of a type which is not entertained in the SPE theory.

Chomsky and Halle postulate a set of markedness conventions which is associated only with vowels, a set associated only with consonants, a set associated only with glides, and a set associated only with liquids. That is, it is the claim of the SPE system that there is no systematic markedness relation across all classes of segments. It follows from the Complement Convention ((14), §1.2) that markedness relations for some feature across all classes of segments are not arbitrary. Given that there are languages with no liquids it is somewhat surprising that this class of segments should have a unique set of markedness conventions; one might as well expect the class of pharyngeals to have their own set of markedness conventions, or for that matter any other arbitrary class of segments.

Within the SPE system conditions on possible segmental systems can be naturally stated on classes of segments such as vowels or consonants as well as on features. Since their system breaks segments down into classes, each with its own properties, one would in fact expect that there are

different conditions associated with the different classes. The theory of markedness presented above makes no distinction between classes of segments such as vowels and glides; there are no special properties associated with such individual classes of segments. The conditions on the well-formedness of segmental systems cannot therefore be stated in terms of such classes. Rather they must be stated in terms of the features of all classes. It follows from this that segmental systems are viewed as 'wholes', that one cannot talk about the well-formedness of a vowel system of a language without considering the consonant and glide systems of that language. A vowel system is only well-formed if it is part of a well-formed segmental system. Thus, the two theories differ in the class of possible conditions on segmental systems which each admits.

In SPE the conventions are presented in such a way as to lead one to assume that there is not a single hierarchy of features across all classes of segments; that is, the conventions are ordered differently for the different classes of segments. However, one can maintain all of the SPE conventions completely unchanged and claim that there is a single hierarchy of features. That hierarchy is given in (2).

- (2) segment (SPE I)
 consonantal (SPE II)
 vocalic (SPE III)
 nasal (SPE XIII)
 sonorant (SPE IV, XIV, XV)
- low (SPE VI, XVI, XXXVI)
 high (SPE VII, XVIII, XXXVII)
 back (SPE X, XX, XXXVIII)
 round (SPE XI, XXXIX)
 voice (SPE V, XXI)
- anterior (SPE V, XXII, XXIX, XXXV)
 coronal (SPE V, XXIII, XXXI, XXXV)
 lateral (SPE V, XXXIII)
 continuant (SPE V, XXIV, XXXIV)
 delayed release (SPE XXVI)
 strident (SPE V, XXVII)

This single hierarchy of features requires only one modification in the SPE system--the inclusion of nasal in the set of conventions for major features. There is no argument given as to why the class of major features should consist of segment, consonantal, vocalic, and sonorant in [+vocalic] segments. Since the convention for nasal is the same in all classes of segments no problems arise from its inclusion with the major features. In fact, given that the convention is the same in all classes it would seem that it should be one of the major features.

It is purely accidental that the SPE system admits a single hierarchy of features. It could just as well be the case that the hierarchy of features varied wildly from one class of segments to another--that the ordering presented reflected some real fact. That there is a single hierarchy

of features follows here from the constraint on possible markedness conventions. Given that constraint there must be intrinsic ordering among the conventions. The hierarchy is not accidental but rather follows from one general constraint on the relationships which must hold among features. That there is this unexplained hierarchy in the SPE system must be viewed as a shortcoming of that system.

It is claimed in SPE that the markedness conventions are not adequate to characterize the specifications of all segments. Thus, as is illustrated in (3), some vowels are not specified u or m for the feature back.

(3)	a	i	u	æ	ɔ	e	o	ü	ɨ	ɛ	ö	ə
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

(SPE (7), 409)

The convention for back in vowels is given in (4).

$$(4) \quad [u \text{ back}] \longrightarrow [+ \text{ back}] / \left[\begin{array}{c} \text{---} \\ + \text{ low} \end{array} \right]$$

(SPE X, 405)

Commenting on this convention they say: "Convention (X) specifies the feature 'back' for low vowels. It should be noted that there is no parallel specification of 'back' for nonlow vowels. It follows from this that in nonlow vowels the feature 'back' will have to be specified as + or - in

lexical representations" (p. 409). Thus there is an important distinction between (4) and (5).

$$(5) \quad [u \text{ low}] \longrightarrow \left\{ \begin{array}{l} [+ \text{ low}] / \left[\begin{array}{l} \overline{u \text{ back}} \\ u \text{ round} \end{array} \right] \\ [- \text{ low}] \end{array} \right\} \quad (\text{SPE VI, 405})$$

The 'elsewhere' environment of (5) ensures that all vowels will be u or m for low. The absence of an elsewhere environment in (4) assures that /u/ and /i/ will be equally marked. It is to get this marking equality that the device of omitting an environment is introduced.

The device of omitting an environment is also employed in the convention for coronal in consonants. (See (1c) above.) Since /t/ is [+ ant] and [u cont] in the SPE system at the time (1c) applies it does not meet any of the environments of (1c); therefore, it must be specified [+ cor] in underlying representation. /p/ is also [+ ant] and [u cont] so (1c) fails to apply to it and it must be specified [- cor] in underlying representation. The device of the missing environment serves here to insure that /p, t, k/ are all equally marked.

It is particularly striking that the device of a missing environment is called into play in order to insure 'reasonable' complexity measures for the most common segments. A theory of markedness should predict, if anything, the specifications of the most common segments. Within the theory presented here all segments can be characterized exclusively

in terms of markedness without +'s or -'s in representations. It follows from the set of markedness conventions that /i/ and /u/ are equally marked and that /p/ and /k/ are equally marked. In this system /t/, like /a/, is unmarked for all the nonmajor features.

Within the SPE system /t/ is as marked as /s/. This leaves open the question as to why almost every language has /t/ (Hawaiian being the only known case of a t-less language) but languages without /s/ are not nearly so rare.

19.2 The two theories also differ in the class of rules each admits and in their evaluations of different rules. There being no hierarchy postulated in SPE, there can be no condition such as (12), §9. The rules in (6) are possible phonological rules in the SPE framework.

$$(6) \quad \begin{array}{l} C \longrightarrow \left[\begin{array}{l} + \text{lab} \\ + \text{SlVC} \end{array} \right] \\ \\ V \longrightarrow \left[\begin{array}{l} + \text{nas} \\ + \text{spr} \end{array} \right] \\ \\ C \longrightarrow \left[\begin{array}{l} + \text{DR} \\ + \text{CG} \end{array} \right] \end{array}$$

The theory presented here claims that these cannot be phonological rules; a phonological rule can only specify a set of segments for features which are hierarchically related. The SPE system can only exclude such rules by listing pairs of features; it can offer no principled reason as to why the rules in (6) are impossible but the rules in (7)

possible.

$$(7) \quad \begin{array}{l} c \longrightarrow \left[\begin{array}{l} + \text{ cont} \\ + \text{ SG} \end{array} \right] \\ v \longrightarrow \left[\begin{array}{l} + \text{ back} \\ + \text{ lab} \end{array} \right] \\ c \longrightarrow \left[\begin{array}{l} + \text{ cor} \\ + \text{ ant} \end{array} \right] \end{array}$$

Given the constraint on possible conventions, the hierarchy of features was a consequence. From that it is possible to exclude the rules of (6) on a basis which is not ad hoc. In the SPE system there is no restriction on the set of possible features which can be specified by any single phonological rule. Thus the SPE theory admits a larger class of possible phonologies than does this system.

The condition (8) is proposed in SPE.

- (8) A linking rule applies either to all or to none of the segments formed by a given rule.

(SPE (49), 431)

Without this condition, the round convention, (9), would apply to the output of the umlaut rule, (10), yielding /i, e, æ/ rather than /ü, ö, æ/.

$$(9) \quad \begin{array}{l} \text{(SPE XI, 405)} \\ [u \text{ round}] \longrightarrow \left\{ \begin{array}{l} [\alpha \text{ round}] / \left[\begin{array}{l} \alpha \overline{\text{back}} \\ - \text{low} \end{array} \right] \\ [- \text{round}] / \left[\begin{array}{l} + \overline{\text{low}} \end{array} \right] \end{array} \right\} \end{array}$$

$$(10) \quad \begin{bmatrix} + \text{voc} \\ - \text{cons} \end{bmatrix} \longrightarrow [- \text{back}] / \text{ in certain contexts} \quad (\text{SPE (55), 431})$$

Condition (8) however leaves unexplained why it is in languages with umlaut rules which do not affect low vowels that vowels characteristically retain their rounding (e.g. o > ö in Hopi and Rotuman).¹

Within the feature system employed here (10) is stated as (11).

$$(11) \quad [+ \text{syl}] \longrightarrow [- \text{back}] / \text{ in certain contexts}$$

The application of this rule triggers no applications of linking rules--in particular the labial convention, VII, is inapplicable since labial is an m-obligatory feature. There is no problem in accounting for either the fact that vowels do not unround when high and low vowels are fronted or the fact that the fronting of nonlow back vowels does not characteristically alter rounding.

Condition (8) is used in SPE to predict that when a spirantization rule applies to labials, coronals, and velars the output segments will be [- stri]. In the theory presented here such a spirantization rule is simply more complicated.

By condition (8) it is predicted that when p, t, and k are spirantized by a single rule they will be realized as nonstrident fricatives, since the second case of the strident convention (see (1b) above) applies to velars and

the third case to labials and coronals. Here the two theories and two feature systems used make different predictions. In the theory presented here a rule of spirantization will take p and t to strident fricatives and k to a nonstrident fricative (the arguments for this are given in §12 above).

Another case where the two theories make different predictions as to the most likely outputs of rules is the case of vowel backing. In the SPE system if a nonlow vowel is backed it will be rounded by the convention (9). To derive an unrounded back vowel the rule of backing must therefore be complicated by the additional specification [- round]. Since the convention for labial does not apply in linking in the theory presented here, it is claimed that the most likely output of a vowel backing rule is an unrounded back vowel and that to derive a rounded back vowel such a rule would have to be complicated by the addition of the specification [+ lab].

Within the SPE system a rule which specifies a segment for more than one feature applies sequentially; that is, a segment subject to the rule is first specified for one of the features in the rule, then there is linking; it is then specified for another feature in the rule, and there is linking again, and so on. As they show, different ordering of the feature specifications made by a rule can lead to different outputs. They cite the following example; consider

the two rules (12) and (13) and the markedness conventions (14).

$$(12) \quad \begin{bmatrix} - \text{ ant} \\ - \text{ stri} \end{bmatrix} \longrightarrow \begin{bmatrix} - \text{ back} \\ + \text{ ant} \end{bmatrix} \quad \begin{array}{l} \text{(a)} \\ \text{(b)} \end{array}$$

$$(13) \quad \begin{bmatrix} - \text{ ant} \\ - \text{ stri} \end{bmatrix} \longrightarrow \begin{bmatrix} + \text{ ant} \\ - \text{ back} \end{bmatrix} \quad \begin{array}{l} \text{(a)} \\ \text{(b)} \end{array}$$

$$(14) \quad \text{(SPE (24), 421/422)}$$

$$\text{XXII} \quad [\text{u ant}] \longrightarrow \left\{ \begin{array}{l} [- \text{ ant}] / \begin{bmatrix} + \overline{\text{high}} \\ + \text{ cor} \\ \alpha \text{ cont} \end{bmatrix} \\ [+ \text{ ant}] \end{array} \right\} \quad \begin{array}{l} \text{(a)} \\ \text{(b)} \end{array}$$

$$\text{XXIII} \quad [\text{u cor}] \longrightarrow \left\{ \begin{array}{l} [- \text{ cor}] / \begin{bmatrix} - \overline{\text{ant}} \\ + \text{ nas} \end{bmatrix} \\ [\alpha \text{ cor}] / \begin{bmatrix} - \alpha \overline{\text{back}} \\ - \text{ ant} \end{bmatrix} \\ [+ \text{ cor}] / \begin{bmatrix} [+ \overline{\text{ant}}] \\ \{ [+ \text{ nas}] \} \\ \{ [m \text{ cont}] \} \end{bmatrix} \end{array} \right\} \quad \begin{array}{l} \text{(a)} \\ \text{(b)} \\ \text{(c)} \end{array}$$

$$\text{XXIV} \quad [\text{u cont}] \longrightarrow \left\{ \begin{array}{l} [+ \text{ cont}] / + \text{ ______ } [+ \text{ cons}] \\ [- \text{ cont}] \end{array} \right\} \quad \begin{array}{l} \text{(a)} \\ \text{(b)} \end{array}$$

$$\text{XXV} \quad [+ \text{ cont}] \longrightarrow [+ \text{ DR}]$$

$$\text{XXVI} \quad [\text{u DR}] \longrightarrow \left\{ \begin{array}{l} [+ \text{ DR}] / \begin{bmatrix} - \overline{\text{ant}} \\ + \text{ cor} \end{bmatrix} \\ [- \text{ DR}] \end{array} \right\} \quad \begin{array}{l} \text{(a)} \\ \text{(b)} \end{array}$$

(14) continued

XXVII

$$[u \text{ stri}] \rightarrow \left\{ \begin{array}{l} [- \text{stri}] / \left\{ \begin{array}{l} [+ \overline{\text{son}}] \\ [- \overline{\text{ant}}] \\ [- \text{cor}] \end{array} \right\} \\ [\alpha \text{ stri}] / \left\{ \begin{array}{l} [\alpha \overline{\text{DR}}] \\ \{ [+ \text{ant}] \} \\ \{ [+ \text{cor}] \} \end{array} \right\} \end{array} \right\} \begin{array}{l} \text{(a)} \\ \text{(b)} \\ \text{(c)} \end{array}$$

In each case it is assumed that the (a) feature is specified first and then the (b) feature. By (12) an alveopalatal affricate, c, is derived from k (derivation (15) in their system). By (13) a palatalized labial, p^y, is derived from k (derivation (16) in their system).

(15)	<u>k</u>		<u>c</u>
	+ high		
	+ back	- back (12a)	
	- ant		+ ant (12b)
	- cor	+ cor (XXIIIb)	
	- cont		
	- DR	+ DR (XXVI)	
	- stri	+ stri (XXVIIc)	+ stri (XXVIIc)

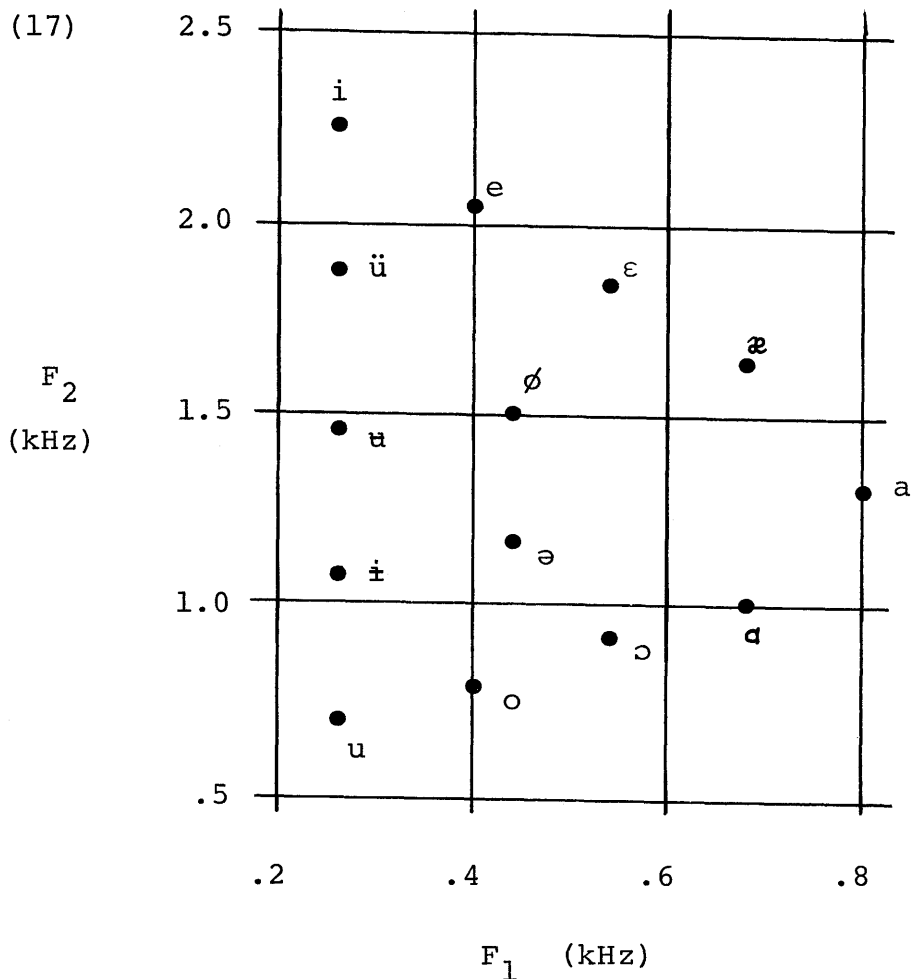
(16)	<u>k</u>		<u>p^y</u>
	+ high		
	+ back		- back (13b)
	- ant	+ ant (13a)	
	- cor		
	- cont		
	- DR		
	- stri	- stri (XXVIIc)	- stri (XXVIIc)

The question then arises as to whether (12) or (13) is the 'correct' rule. They propose that (12) is the correct rule because it is a more likely rule and therefore must be "'simpler' in some linguistically important sense."² Just how (12) is 'simpler' than (13) is left open--to be incorporated in linguistic theory in the future. Within the theory proposed here there is no 'simplest' interpretation of a phonological rule as opposed to some more complex interpretation. There is a unique interpretation for every phonological rule.

20. Most consideration of possible segmental systems has been concerned with 'optimal' vowel systems--the consideration of vowels in the absence of the other segments of a language. Two recent proposals toward the characterization of likely vowel systems are those of Liljencrants and Lindblom and of Stampe and Miller. Both these theories are briefly considered below.

20.1 Liljencrants and Lindblom (1972) develop a numerical model "in order to establish the extent to which the principle of maximal perceptual contrast can be used in phonological theory to explain the phonetic structure of vowel systems. [The] preliminary results obtained with the model indicate that perceptual contrast appears to play an important role as a determinant of such systems."³

The acoustic (perceptual) space they are concerned with is illustrated in (17). Their research involved developing a program which would generate vowel systems of arbitrary size where for any given vowel system the acoustic space would be maximally utilized. Their results are not consistent with the conclusion that maximization of acoustic space plays "an important role as a determinant" of vowel systems. In almost every case they discuss they predict that there will be either more high vowels than are characteristically found, or more low vowels than are characteristically found. Furthermore, serious questions must be raised



about the legitimacy of their basic assumptions.

20.1.1 Liljencrants and Lindblom do not discuss two-vowel systems. It would seem by inspection that they would predict that the optimal two-vowel system is one with either i or u and with ɹ, a, or ɜ. However, it appears to be the case that two-vowel systems consist of central vowels--for example, /ə, a/ in Kaititj. Neither of these systems 'maximizes' acoustic space.

They predict that the most likely vowel systems with from three to seven members are those given in (18).

- (18) a /i, a, u/
 b /i, ε, u, a/
 c /i, ε, ɔ ~ a, ɔ, u/
 d /i, ε, a, ɔ, u, ʌ/
 e /i, ε, a, ɔ, u, ɨ, ʌ ~ u/

where ~ means either/or

Their symbol $\underline{\varepsilon}$, used in (18), "stands for a quality closer to $\underline{\alpha}$ than to \underline{e} ."

There can be little disagreement with their prediction of the three-vowel system. It should be noted however that their prediction is that the high vowels will be tense and it is not entirely clear that this is the most common case.

The most noticeable aspect of their four-vowel system is the lowness of the nonhigh front vowel. This prediction is not supported. Their theory cannot account in any way for the fact that /i, e, a, o/ and /i, e, a, u/ are the common four-vowel systems. Their theory offers no explanation as to why in four-vowel systems there is typically a mid front vowel.⁴

The system (18c) is striking for the fact that there are three relatively low vowels, and not two high

vowels, two mid vowels and one low vowel as is the characteristic case with five-vowel systems. They cite sixty-five languages which purportedly have /i, e, a, o, u/ vowel systems, and no languages which have five-vowel systems where three of the vowels are fairly low; that is, their own data do not support their conclusion in this case.

The basic deviation between (18d) and reality also lies in the fact that there are too many low vowels in (18d). Vowel systems characteristically only have /ε/ and /ɔ/ if they also have /e/ and /o/. It appears to be the case that /i, e, a, o, u, ɨ/ is the most common six-vowel system (it is evidently the system of Araucana, Chasibo, Comanche, Choco, Jiliapan Pame, Lower Pima, Mixtec, Sierra Miwok, Sierra Popoluca).⁵

It is their prediction that the most common seven-vowel systems should have four high vowels. Here again the prediction is not consistent with the facts. The most common seven-vowel system is probably /i, e, ε, a, ɔ, o, u/ (Bariba, Loma, Senadi, Sup'ide).⁶ As they observe, there are apparently no languages which have seven vowels of which four are high.

20.1.2 Their theory rests on the assumption that there is reason to believe that phonological vowel systems are structured to maximize acoustic (phonetic) space. This assumption hinges on two distinct claims: (a) that there is a low vowel, usually /a/, in every vowel system, and (b) that /i/ and /u/

are members of every vowel system because they are most perceptually distinct from /a/ (and, perhaps, they are the keys on which the hearer normalizes for varying vocal tract lengths (Joos (1942), Lieberman (1973))). Claim (b) is false if one is concerned with the structure of phonological systems (as opposed to phonetic systems). There are languages which do not have phonemic /i/ and /u/, Kaititj for example. Thus, in terms of underlying systems these segments are not essential.

The potentially attendant claim that systems must contain [i] and [u] in order to allow hearers to normalize for vocal tract length is at best irrelevant since the structure of underlying systems need not reflect this--it could be a surface condition; it is also probably false. Recent research by Strange, Verbrugge, and Shankweiler (1974a, 1974b) has shown that speakers cannot adequately normalize for vocal tract length variation on the basis of [i] and [u]; their results show quite strikingly that consonant information is as or more important than [i]/[u] contrasts.

20.2 Recently a theory called 'natural' phonology has been proposed by Stampe and Miller.⁷ It is the claim of this theory that there is a set of 'natural' phonological processes which are innate and that the task of learning a language involves the (partial) suppression and/or reformulation of

(some of) the natural processes.

Universal grammar is concerned with the essential properties of natural languages. The theory of natural phonology claims to be such a universal theory. Therefore, it must first be addressed on its adequacy as such a theory. A central assumption of natural phonology is that the order of acquisition of production of segments in children reflects the properties of segmental systems, so that, for example, the first three vowels a child acquires are the three vowels of the most common three-vowel system, /i, a, u/. It is the view of this theory that "a process affects a class of segments which share a feature which is inaccessible to the inborn capacity for speech."⁸ By "capacity for speech" must be meant 'controlled production capacity'. It must be controlled since in babbling the child reflects a capacity to produce a wide array of speech sounds, and it must be production since it is clear that children perceive distinctions that they do not produce in speech. Therefore, the theory of grammar has been redefined. In the literature of transformational generative grammar it is taken that a grammar is a description of the competence of an ideal speaker-hearer. Stampe and Miller appear to be proposing that there is an encoding grammar and a decoding grammar.

Miller (1972) is concerned with the structure of vowel systems. Since this is one of the most detailed works

within this theory I will focus on it. The segments and features which she is concerned with are given in (20).

(20)	+ Palatal		- Palatal	
	+ Color		- Color	+ Color
+ High	ü	i	ɨ	u
- High, - Low	ö	e	ə	o
+ Low	œ	ɛ	a	ɔ
	+ Round	- Round		+ Round

The 'Neutral' vowel is /ə/ which is negatively specified for all the features. The processes in (21) are proposed.

- (21) (1) Neutralization $\left[\begin{array}{c} V \\ !- \text{ Stress} \\ !- \text{ Tense} \end{array} \right] \rightarrow \text{Neutral}$
- (2) Neutral-vowel Lowering $\left[\begin{array}{c} V \\ \text{Neutral} \\ !+ \text{ Stress} \\ !+ \text{ Tense} \end{array} \right] \rightarrow [+ \text{ Low}]$
- (3) Palatal-vowel Unrounding $\left[\begin{array}{c} V \\ + \text{ Pal} \\ ! \text{ lower} \end{array} \right] \rightarrow [- \text{ Rnd}]$
- (4) Round-vowel Depalatalization $\left[\begin{array}{c} V \\ + \text{ Rnd} \\ ! \text{ lower} \end{array} \right] \rightarrow [- \text{ Pal}]$
- (5) Nonpalatal-vowel Rounding $\left[\begin{array}{c} V \\ - \text{ Pal} \\ ! \text{ more back} \\ !- \text{ Low} \end{array} \right] \rightarrow [+ \text{ Rnd}]$
- (6) Nonround-vowel Palatalization $\left[\begin{array}{c} V \\ - \text{ Rnd} \\ ! \text{ lower} \\ !- \text{ Low} \end{array} \right] \rightarrow [+ \text{ Pal}]$

(21) continued

- (7) Low-vowel Unrounding $\begin{matrix} V \\ [+ \text{ Low}] \end{matrix} \longrightarrow [- \text{ Rnd}]$
- (8) Low-vowel Depalatalization $\begin{matrix} V \\ [+ \text{ Low}] \end{matrix} \longrightarrow [- \text{ Pal}]$
- (9) Raising $\begin{matrix} V \\ [+ \text{ Color}] \\ [- \text{ High}] \\ [!+ \text{ Tense}] \\ [!+ \text{ Low}] \end{matrix} \longrightarrow [\text{higher}]$

The notation ! "may be read as 'especially when...'. It indicates that the most common or least likely-to-be suppressed form of the process is that which includes the !-marked condition, but that the process can, and in its original form does, apply more generally, without regard to the !-marked feature or condition."⁹

The input to the set of natural processes is the range of possible vowels "and the rules serve to restrict and restructure this range."

Taking as an example the derivation of the one-vowel system /a/, the rules of (21) apply as follows to the segments in (20). All the vowels are made Neutral (i.e., become /ə/) by (21-1); by (21-2) the vowel derived by (1) is lowered to /a/. The other rules of (21) are either inapplicable or vacuous.

The derivation of a three-vowel system requires the suppression of (21-1). "Depalatalization and unrounding will change the low vowels to /a/, the raising rule will eliminate

the mid vowels, and the color rules will leave only /i/ and /u/ in the high series."¹⁰

To generate the two-vowel system /a, ə/, (21-1) must be modified to apply only to [- Low] vowels and (21-2) must be suppressed. By these changes all the non-low vowels become /ə/. (21-5) must also be suppressed to prevent the rounding of /ə/. By (21-7) and (21-8) the low vowels neutralize as /a/. Consider now the derivation of the two-vowel system /i, a/. Rule (21-1) is restricted to [- Pal] segments. By this restriction only back vowels are affected and they all become /ə/; (21-2) then applies to take /ə/ to /a/. By (21-3) all front vowels are specified [- Round]; by (21-8) the low front vowel is backed; by (21-9) /i/ and /e/ are collapsed as /i/. The derivation of a two-vowel system /i, a/ requires less modification and suppression of the natural process than does derivation of the two-vowel system /a, ə/; if complexity of a segmental system is proportional to the number of modifications and suppressions then there is no way to account for the fact that /i, a/ is unattested while /a, ə/ is attested.

Since the processes can be modified then a possible vowel system can be derived by modifying (21-1) as (22).

$$(22) \quad v \longrightarrow \begin{bmatrix} - & \text{Pal} \\ - & \text{Rnd} \end{bmatrix}$$

(21-2) would apply to the /ə/ output of (22), collapsing it

with /a/. (21-5) would apply to /ɨ/ to make it [+ Rnd] and the two-vowel system /a, u/ would be derived. The same system can be derived if (22) is reformulated as (23), (24), or (25).

$$(23) \quad V \longrightarrow [- \text{Pal}]$$

$$(24) \quad V \longrightarrow [- \text{Rnd}]$$

$$(25) \quad \begin{matrix} V \\ [- \text{Rnd}] \end{matrix} \longrightarrow [- \text{Pal}]$$

There is a reason for there being very few unique solutions to vowel systems within Miller's framework. Flexibility is necessary in order to account for varying orders of production acquisition. However, having introduced this variability, problems arise. For instance, there is no way to exclude the system /ü, ö, a, o, u/ which would be derived by (25), with the suppression of (21-3), (21-4), and (21-9).

As the examples given above show, for a two-vowel system the 'least complex' system in terms of modifications and suppressions is less likely than the attested system, but an unattested five-vowel system is more complex in terms of suppressions and modifications than the most frequent one. Thus, there is no way to determine the likelihood of a system within Miller's framework.

There is by Miller's own statement no way to evaluate the complexity or likelihood of a system (development of such a measure "is hardly within the scope of this

paper"¹¹) and no way of excluding any system as totally impossible. Given this it is impossible to determine exactly what her predictions are.

As a theory of language acquisition the processes proposed by Miller entail that the first vowel of every child be /a/. For the first vowel to be /u/ the child would have to suppress (21-2); for the first vowel to be /ɔ/ the child would evidently have to be of restricted linguistic capacity. The system admits to flexibility after /a/ is acquired but not for the first vowel.

Children appear to frequently acquire /a/ first but it is not invariably so; similarly many children acquire /p/ as the first stop but this is not invariable either. Note here that if a theory were to account for production acquisition as well as the structure of segmental systems /p/ would have to be systemically more highly valued than /t/. There would be no explanation for the privilege of coronality in segmental systems.

Footnotes to Chapter 3

1. C. Cairns, personal communication, Langacker (1970).
2. p. 427.
3. p. 839.
4. True four vowel systems are in fact fairly rare; most four vowel systems are really eight vowel systems-- four example Garvin (1950) proposes that Wichita has four vowels, /i, ε, a, u/, and distinctive length; in Klamath there are also four vowels, /i, e, a, o/, both long and short; both of these languages actually have eight vowel systems since 'length' (tenseness and height in the latter case) is not predictable. Two languages which appear to have the real four vowel system /i, e, a, o/ are Campa and Galice-Athapaskan (see Dirks (1953) and Hoijer (1966)). Bloomfield (1942) proposes that Ilocano has the four vowels /i, e, a, u/; his description however is limited to listing the phonemes. Similar systems have been proposed for Tlinget and Eyak (see Krauss (1964)).

5. Shell (1950), Mak (1953), Wonderly (1951), Osborn and Smalley (1949), Hockett (1955).
6. Welmers (1950a, 1950b, 1952), Pulgram (1950), Hockett (1955).
7. See for example Stampe (1969, 1974), Miller (1972).
8. Miller (1972), p. 136.
9. Ibid., p. 141.
10. Ibid., p. 148.
11. Ibid., p. 149.

Appendix

For the most part the features used here are those generally used in current phonological research, and they are used here with their standard interpretations and extensions. There are, however, some points of variation which should be noted.

In SPE the feature delayed release is used to characterize both affricates and fricatives. It is remarked that "the release phase of affricates is acoustically quite similar to the cognate fricative" (p. 318). From this Chomsky and Halle conclude that fricatives as well as affricates should be specified [+ DR]. That during their release phase affricates are acoustically similar to fricatives is not at all surprising. If in the articulation of a segment there is gradual release from a complete closure it follows that such a segment will have continuant properties during the release phase. That affricates have a turbulent phase similar to that of fricatives is a consequence of their non-instantaneous release. It does not, however, follow from the fact that both

fricatives and affricates have acoustic turbulence that fricatives, like affricates, are [+ DR]. Within the feature system used here only affricates are [+ DR]; this feature is assumed to be purely articulatory in definition. That the acoustic consequences of being [+ DR] have properties in common with segments which are $\begin{bmatrix} - \text{son} \\ + \text{cont} \end{bmatrix}$ follows from the gesture.

The specification [+ lab] is associated with rounded vowels and glides, labialized consonants, and labial consonants. A second feature of labiality, spread (abbreviated here as 'spr') is introduced here.

	A	B	C	D
labial	+	+	-	-
spread	+	-	+	-

Segments of class A are the unrounded labial consonants and glides, and the u of Japanese which is often characterized as being like a typical u except it is unrounded, and which is distinct from i. That this segment should be specified [+ lab] at all is motivated by the fact that one finds that it 'holds' labial continuants, e.g. fuji, *huji. Segments of class B are labialized consonants such as k^w, rounded labials, e.g. p^w which contrasts with p, and rounded vowels and glides. The so-called 'barred i' of Russian is distinct in character from the so-called 'barred i' of English, the former being

characterized by a lateral spreading of the lips--a pulling back of the muscles of the cheeks. It is proposed that this sound should be characterized by the feature specifications C. The segments which are of class D are those segments with no labiality, i.e., all nonlabial and nonlabialized consonants and all nonlabial and unrounded vowels. The feature labial is in this system an areal feature in the same way as are coronal and back. The specification of spread in a [+ lab] segment characterizes the type of labiality that segment has--[- spr] in such a segment means that there is lip rounding while [+ spr] means that the lips are in a basically neutral position. In [- lab] segments the specification [+ spr] means that the lips are laterally spread by facial muscles, and the specification [- spr] in such a segment means that the lips are in an essentially neutral position.

It is proposed here that r's are generally glides, $\begin{bmatrix} - & \text{syl} \\ - & \text{cons} \end{bmatrix}$ segments, and not $\begin{bmatrix} + & \text{cons} \\ + & \text{son} \end{bmatrix}$ segments. If there are no r glides then there is an unexplained fact, to wit: why there are no [+ cor] glides. There is no phonological or phonetic reason why there should be this gap. By the postulation of r as a glide the gap disappears. Glides have the 'manner' properties of vowels characteristically. With no coronal glide, it can neither be said that they have the 'place' properties of vowels nor those of consonants. By postulating r as a coronal glide it follows that glides have

the place characterizations of consonants. That is, glides are in one respect like vowels--in their manner--and in another like consonants--in their range of possible 'places'. That there should be such a distribution of properties should in fact be expected, for with respect to the major segmental feature syllabic glides are like consonants, but with respect to the feature of consonantality they are like vowels. An example from Karok is given in §14.2 which shows that r patterns with glides.

It is further postulated here that the nonstrident fricatives characteristically occur with a spread glottis. Two facts follow from this: 1) that aspirates will alternate with nonstrident fricatives, and 2) that while there is a distinction between aspirated and unaspirated s, for example, there is no possible distinction between aspirated and unaspirated θ.

The feature flap is used here in a fairly loose way. The specification [+ flap] on coronal glides designates non-trilled r-ness. On consonants the specification [+ flap] has its conventional interpretation (as in English [rayDr]).

I have included among the features constricted pharynx. It has been suggested by Perkell (1971) that this feature 'replace' the feature low (which I also use). Whether there need only be one of these features is an empirical question, of course. If it is taken that the specification [+ CP] characterizes low vowels as well as

pharyngealized vowels then the two features must be maintained just in case there is a phonological distinction between such segments and between low [-syl] segments and pharyngealized segments. If no such contrasts are found then only one of these features is necessary. Throughout I have used the feature low as it is used in SPE and include the feature constricted pharynx as a possible additional feature needed to characterize (some) cases of pharyngealization.

There is no feature of tenseness (tense or advanced tongue root) used here. The absence of such a feature is a consequence of inadequate data. The theory of markedness is concerned with the typical specifications of features within segments. There is at this point no really clear cut data for a feature of tenseness. In some languages all vowels are lax (Djirbal) while in other languages the nonlow vowels are all tense (Cebuano). In the literature frequently tense vowels are characterized as long (as in Barker (1963)). The situation is further complicated by variation in vowel symbolization--i sometimes represents a tense vowel and sometimes a lax one. That there is no feature of tenseness used here simply reflects the fact that there are insufficient data as to what is the appropriate feature and what its characteristic distribution is.

In SPE the feature distributed is used. It plays a role in the characterization of retroflex consonants and in distinguishing, e.g., t̠ from t̡. This feature is not used

here. Again the issue is basically one of accessibility of clear-cut data. Clearly some feature(s) must be postulated to account for these distinctions. At this point it is unclear to me whether it is appropriate to postulate one or two features to do this, and what the character of the feature(s) involved will be.

Features of r-ness, tenseness, retroflexion, and laminality are not currently well understood in terms of phonological systems. There is a real need for detailed research in each of these areas and it is a shortcoming of this thesis that such features are not considered. It is, however, assumed that development of such features will not vitiate this thesis. The theory presented here makes specific claims about the structure of segmental systems based on twenty-five features and the relations which hold among them; it would be up to the proposer of a feature which could not be accommodated in the theory to put forward another theory that will account for the same range of data. Thus the theory proposed here makes a specific claim about possible phonological features.

Throughout this thesis, when a feature is being referred to by name it will be underlined; when referring to a property of a segment which is also the name of a feature the term will not be underlined; e.g., 'labial' refers to the feature but 'labial' refers to the property of having

a + specification for the feature labial. When a feature is used with a specification it is enclosed in brackets. For every feature whose name has more than four letters (except trill and stress) an abbreviation is used when it is specified. A list of feature abbreviations is given below.

<u>Abbrev.</u>	<u>Feature</u>
seg	segment
syl	syllabic
cons	consonantal
ant	anterior
back	back
low	low
lab	labial
son	sonorant
cor	coronal
spr	spread
high	high
nas	nasal
cont	continuant
StVC	stiff vocal cords
SlVC	slack vocal cords
SG	spread glottis
CG	constricted glottis
lat	lateral
DR	delayed release
stri	strident
flap	flap
trill	trill
long	long
stress	stress
CP	constricted pharynx

Bibliography

- Anderson, S. R., and P. Kiparsky, eds., 1973, A Festschrift for Morris Halle, Holt, Rinehart, and Winston, New York.
- Barker, M. A. R., 1963, Klamath Dictionary (University of California Publications in Linguistics, No. 31), University of California Press, Berkeley.
- Bloomfield, L., 1924, Notes on the Fox Language, IJAL, 3, 219-232.
- Bloomfield, L., 1933, Language, Holt, New York.
- Bloomfield, L., 1939, Menomini Morphophonemics, Travaux du Cercle Linguistique de Prague, 8, 105-115.
- Bloomfield, L. 1942, Outline of Ilocano Syntax, Language, 18, 193-200.
- Boas, F., ed., 1922, The Handbook of American Indian Languages, Part II, Government Printing Office, Washington, D.C.
- Bogoras, W., 1922, Chukchee, in Boas (1922), 631-903.
- Brame, M. K., 1970, Arabic Phonology, unpublished Ph.D. thesis, M. I. T.
- Bright, W., 1957, The Karok Language (University of California Publications in Linguistics, No. 13), University of California Press, Berkeley.

- Bromley, H. M., 1961, The Phonology of Lower Grand Valley Dani, Nijhoff, 's-Gravenhage.
- Cairns, C. E., 1969, Markedness, Neutralization, and Universal Redundancy Rules, Language, 45, 863-885.
- Casagrande, J. B., 1954, Comanche Linguistic Acculturation I, IJAL, 20, 140-151.
- Chapin, P. G., 1973, Translation of 'On the Hawaiian Language', Working Papers in Linguistics, 5, 89-167.
- Chomsky, N., 1955, The Logical Structure of Linguistic Theory, on microfilm at the reference department, Massachusetts Institute of Technology library.
- Chomsky, N., 1957, Review of Jakobson and Halle (1956), in IJAL, 23, 234-242.
- Chomsky, N., 1964, Current Issues in Linguistic Theory, Mouton, The Hague.
- Chomsky, N., 1965, Aspects of the Theory of Syntax, M.I.T. Press, Cambridge, Mass.
- Chomsky, N., 1967, Some General Properties of Phonological Rules, Language, 43, no. 1.

- Chomsky, N., forthcoming, Reflections on Language, Pantheon, New York.
- Chomsky, N., and M. Halle, 1965, Some Controversial Questions in Phonological Theory, Journal of Linguistics, 1, 97-138.
- Chomsky, N., and M. Halle, 1968, The Sound Pattern of English, Harper and Row, New York.
- Dirks, S., 1953, Campa (Arawak) Phonemes, IJAL, 19, 302-304.
- Dyen, I., 1949, On the History of Trukese Vowels, Language, 25, 420-436.
- Fodor, J. A., and J. J. Katz, 1964, The Structure of Language: Readings in the Philosophy of Language, Prentice-Hall, Englewood Cliffs, N.J.
- Garvin, P., 1950, Wichita I: Phonemes, IJAL, 16, 179-184.
- Glover, W. W., 1970, Gurnung Segmental Synopsis, Occasional Papers of the Wolfenden Society on Tibeto-Burman Linguistics, 3, 211-237.
- Hale, K., 1962, Jemez and Kiowa Correspondences in Reference to Kiowa-Tanoan, IJAL, 28, 1-5.

- Hale, K., 1967, Toward a Reconstruction of Kiowa-Tanoan Phonology, IJAL, 33, 112-120.
- Halle, M., 1957, In Defense of the Number Two, Studies Presented to Joshua Whatmough on his 60th Birthday, Mouton, The Hague, 65-72.
- Halle, M. 1959, The Sound Pattern of Russian, Mouton, The Hague.
- Halle, M. 1961, On the Role of Simplicity in Linguistic Descriptions, American Mathematical Society Proceedings of Symposia in Applied Mathematics, 12, 89-94.
- Halle, M., 1962, Phonology in a Generative Grammar, Word, 18, 54-72. Reprinted in Fodor and Katz (1964), 334-352.
- Halle, M., 1964, On the Bases of Phonology, in Fodor and Katz (1964), 324-333.
- Halle, M., 1967, Markedness, Proceedings of the Sixth International Congress of Phonetic Sciences, Academia, Prague, 61-71.
- Halle, M., 1970, Is Kabardian a Vowel-less Language, Foundations of Language, 6, 95-103.

- Halle, M. and K. Stevens, 1972, A Note on Laryngeal Features, Quarterly Progress Report of the Research Laboratory of Electronics, M. I. T., 101, 198-213.
- Hari, M., 1970, Thakali Segmental Synopsis, Occasional Papers of the Wolfenden Society on Tibeto-Burman Linguistics, 3, 258-278.
- Harris, J. W., 1968, Spanish Phonology, M.I.T. Press, Cambridge, Mass.
- Hockett, C. F., 1955, A Manual of Phonology (IJAL, Memoir 11), Waverly Press, Baltimore.
- Hoijer, H., 1966, Galice Athapaskan: A Grammatical Sketch, IJAL, 32, 320-327.
- Jakobson, R., 1939, Observations sur le classement phonologique des consonnes, Proceedings of the Third International Congress of Phonetic Sciences, Ghent. Reprinted in Jakobson (1962), 273-279.
- Jakobson, R., 1940, Kindersprache, Aphasie und allgemeine Lautgesetze, in Jakobson (1962), 328-401.
- Jakobson, R., 1962, Selected Writings I, Mouton, The Hague.
- Jakobson, R., and M. Halle, 1956, Fundamentals of Language, Mouton, The Hague.

Jakobson, R., and M. Halle, 1964, Tenseness and Laxness, in D. Abercrombie et al., eds., In Honour of Daniel Jones, Longmans, London, 96-101. Reprinted in Jakobson (1962), 550-555.

Joos, M., 1942, A Phonological Dilemma in Canadian English, Language, 18, 141-144.

Joos, M., 1948, Acoustic Phonetics (Supplement to Language, 24), The Waverly Press, Baltimore.

Key, M. R., 1968, Comparative Tanacan Phonology, Mouton, The Hague.

Kim, W.-C., 1974, Some Aspects of the Korean Consonant System, unpublished paper, M.I.T.

Kiparsky, P., 1965, Phonological Change, unpublished Ph.D. thesis, Massachusetts Institute of Technology.

Kiparsky, P., 1973, 'Elsewhere' in Phonology, in Anderson and Kiparsky (1973), 93-106.

Kiparsky, P., 1975, A Note on Vowel Features, Papers from the Fifth Annual Meeting of the North Eastern Linguistic Society, 162-171.

Knecht, L., 1974, Karok, unpublished paper, M.I.T.

- Krauss, M. E., 1964, On the Classification in the Athapaskan, Eyak and the Tlingit Verb, Supplement to IJAL, 35.
- Kroeber, A. L., and G. W. Grace, 1960, The Sparkman Grammar of Luisiño (University of California Publications in Linguistics, No. 16), University of California Press, Berkeley.
- Ladefoged, P., 1964, A Phonetic Study of West African Languages (West African Monographs, 1), Cambridge University Press, Cambridge.
- Lamb, S., 1958, Grammar of Mono, unpublished Ph.D. dissertation, University of California, Berkeley.
- Langacker, R. W., 1970, The Vowels of Uto-Aztecan, IJAL, 36, 169-180.
- Lieberman, P., 1973, On the Evolution of Human Language, in Anderson and Kiparsky (1973), 107-127.
- Liljenblad, S., 1950, Bannock I: Phonemes, IJAL, 16, 126-131.
- Liljencrants, J., and B. Lindblom, 1972, Numerical Simulation of Vowel Quality Systems, Language, 48, 839-862.
- Mak, C., 1953, A Comparison of Two Mixtec Tonemic Systems, IJAL, 19, 85-100.

- Mandelbaum, D. G., ed., 1949, Selected Writings of Edward Sapir in Language, Culture, and Personality, University of California Press, Berkeley and Los Angeles.
- Matthews, G. H., 1958, Handbook of Siouan Languages, Ph.D. Thesis, University of Pennsylvania.
- McCawley, J. D., Review of Chomsky and Halle (1968), in IJAL, 40, 50-88.
- Meillet, A., 1964, Introduction à l'étude comparative des langues indo-européennes, University of Alabama Press, University, Alabama.
- Miller, P., 1972, Some Context Free Processes Affecting Vowels, Working Papers in Linguistics (Ohio State University), 11, 136-167.
- O'Neil, W. A., 1970, Explaining Vowel Gradation in Old English, General Linguistics, 10, 149-163.
- Osborn, H., and W. H. Smalley, 1949, Formulae for Comanche Stem and Word Formation, IJAL, 15, 93-99.
- Perkell, J. S., 1971, Physiology of Speech Production: A Preliminary Study of Two Suggested Revisions of the Features Specifying Vowels, Quarterly Progress Report of the Research Laboratory of Electronics, Massachusetts Institute of Technology, 102, 123-139.

- Postal, P. M., 1968, Aspects of Phonological Theory, Harper and Row, New York.
- Pulgram, E., 1950, Spoken and Written Latin, Language, 26, 458-466.
- Quirk, R., and C. L. Wrenn, 1955, An Old English Grammar, Methuen, London.
- Ray, P. S., M. A. Hai, and L. Ray, 1966, Bengali Language Handbook, Center for Applied Linguistics, Washington, D.C.
- Sapir, E., 1922, The Takelma Language of Southwestern Oregon, in Boas (1922), 1-296.
- Sapir, E., 1925, Sound Patterns in Language, in Mandelbaum (1949), 33-45.
- Sapir, E., 1930, Southern Paiute, a Shoshonean Language (Proceedings of the American Academy of Arts and Sciences, 65, nos. 1-3).
- Sapir, E., 1949, The Psychological Reality of Phonemes, in Mandelbaum (1949), 46-60.
- Schane, S., 1973, [back] and [round], in Anderson and Kiparsky (1973), 174-184.
- Shell, O. A., 1950, Cashibo I: Phonemes, IJAL, 16, 198-202.

Stampe, D., 1969, The Acquisition of Phonetic Representation, CLS 5.

Stampe, D., 1974, On Chapter Nine, in Kenstowicz and Kisseberth, Issues in Phonological Theory, Mouton, The Hague, 44-52.

Stevens, K. N., 1972, The Quantal Nature of Speech: Evidence from Articulatory-Acoustic Data, in P. B. Denes and E. E. David, Jr., eds., Human Communication, A Unified View, McGraw-Hill, New York, 1972, 51-66.

Strange, W., R. Verbrugge, and D. Shankweiler, 1974a, What Information Enables a Listener to Map a Talker's Vowel Space, paper read at the 87th meeting of the Acoustical Society of America.

Strange, W., R. Verbrugge, and D. Shankweiler, 1974b, Consonant Environment Specifies Vowel Identity, paper read at the 87th meeting of the Acoustical Society of America.

Swadesh, M., 1953, Salish Phonologic Geography, Language, 28, 232-248.

Trubetzkoy, N. S., 1969, Principles of Phonology, University of California Press, Berkeley.

- Uldall, H. J., 1954, Maidu Phonetics, IJAL, 20, 8-16.
- Voegelin, C. F., 1935, Shawnee Phonemes, Language, 11, 23-37.
- Voegelin, C. F. and F. M., 1964, Languages of the World: Indo-Pacific Fascicle Two (Publication of the Archives of Languages of the World), Indiana University, Bloomington.
- Voegelin, C. F. and F. M., and K. Hale, 1962, Typological and Comparative Grammar of Uto-Aztecan: I (Phonology), supplement to IJAL, 28.
- Waterhouse, V., and M. Morrison, 1950, Chontal Phonemes, IJAL, 16, 35-39.
- Welmers, W. E., 1950a, Notes on Two Languages of the Senufo Group I, Senadi, Language, 26, 126-146.
- Welmers, W. E., 1950b, Notes on Two Languages of the Senufo Group II, Supide, Language, 26, 494-531.
- Welmers, W. E., 1952, Notes on the structure of Bariba, Language, 28, 82-103.
- Welmers, W. E., 1962, The Phonology of Kpelle, Journal of African Languages, 1, 69-93.
- Whitney, W. D., 1941, Sanskrit Grammar, Harvard University Press, Cambridge, Mass.

Wilson, H. E., 1972, The Phonology and Syntax of Palauan
Verb Affixes, Working Papers in Linguistics
(University of Hawaii), 4.

Wonderly, W. L., 1951, Zoque II: Phonemes and Morphophonemes,
IJAL, 17, 105-123.