A Directional Theory of Rule Application

in Phonology

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Irwin Howard

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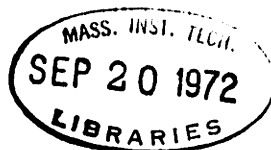Department of Modern Languages & Linguistics
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A DIRECTIONAL THEORY OF RULE APPLICATION IN PHONOLOGY

Irwin Howard

This work takes the position that phonological rules
are applied across a string either from left-to-right or from
right-to-left in a direction that is predictable from the
relative locations of the conditioning factor and the segment
undergoing the rule (focus). It thus diverges from the
"standard theory" of N. Chomsky & M. Halle, as well as from
the alternative theories of C. D. Johnson and S. Anderson.

The first part of this work develops the directional
theory of rule application through consideration of a large
number of empirical examples drawn from a wide variety of
languages. A comparison is made throughout the work with
the treatments required by the standard theory. Chapter 1
introduces the problem and reviews some relevant aspects of
the standard theory. Chapter 2 illustrates directional rules
and how directionality is to be predicted. Chapter 3 dis-
cusses disjunctive ordering and its treatment within the
directional theory. Chapter 4 calls for a distinction between
the unmarked repetitive and marked simultaneous modes of
application. Chapter 5 presents the crossover constraint,
which prohibits the application of a rule to a segment that
is separated from the conditioning factor by a segment meeting
the internal requirements of the focus. It is argued that
disjunctive ordering is characteristic of accent rules, while
the crossover constraint is characteristic of nonaccent
rules. Chapter 6 considers those cases, such as intervocalic,
where the conditioning factor is on both sides of the focus.

The second part of the thesis is a comparison among the
various theories of rule application. Chapter 7 introduces
Johnson's and Anderson's theories and compares these and the
standard theory with the directional one. Chapter 8 deals
with a type of rule that is a potential counterexample to
the directional theory and shows how the various theories
treat it. Finally, Chapter 9 briefly summarizes the major
claims of the work.

"It is not enough to show that something <u>may</u>
be done in such-and-such a way; it is important
to show that it <u>must</u> be done that way."

-- Morris Halle -

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INTRODUCTION

The purpose of this work is to present, exemplify, and attempt to justify a particular view of rule application in phonology. Since that view is characterized by the claim that all phonological rules are applied in a given direction across a string and that the direction is predictable on the basis of the formal properties of the rule, it seems appropriate to refer to this view as a "directional" theory of rule application.

The title of this work is in a certain sense presumptuous, for what I have done is to provide an outline of various important aspects of the theory and have necessarily ignored others and left some problems unsolved. Consider, for example, notational devices such as parentheses, subscripted expressions, braces, angled brackets, mirror-image rules, etc. These devices are utilized within generative phonological theory to collapse a set of rules into a single more comprehensive statement which Chomsky & Halle (1968) refer to as a <u>schema</u>. In this work I refer frequently to parentheses and subscripted expressions and their positions within the theory are accordingly quite clear. Other notational devices in common usage are either not used in this work or used sparingly in a way that requires some comment here.

Consider brace notation as a case in point. A number of rules in this thesis use the brace notation but nowhere

in the work itself will one find a statement of how this notation is to be interpreted in the directional theory. This is not an accidental omission, but rather a strategic one. I maintain that brace notation is <u>not</u> a legitimate abbreviatory device and is therefore not to be included within a statement of this theory. Yet, I have used it several times in a very restricted and straightforward way in order to make other theoretical points without having to entertain lengthy arguments dealing with brace notation and its alternatives. In the first draft of this work approximately 150 pages were devoted to the brace notation and certain other conventions subordinate to it, such as the optional shifting of features from the left of the arrow to the corresponding position in the environment. Since that draft my views on this subject have developed much further and it would have been far too unwieldly to incorporate these arguments into this work. The reader is thus asked to bear with the postponement of this issue and perhaps to raise for himself the question as to whether the rules expressed herein using brace notation constitute legitimate generalizations and, if so, how the generalization might most appropriately be captured if the brace notation is disallowed.

Angled brackets have been omitted from consideration here for two major reasons. First, if this notation is to be incorporated into the theory it would have to be substantially clarified. Chomsky & Halle provide two <u>contradictory</u>

conventions of expansion for expressions abbreviated with angled brackets and it would be necessary to argue for the correctness of one or the other. This would involve a substantial investment of space for an issue of peripheral significance to the principal claim of this work. In fact, the first draft of this dissertation contained a lengthy chapter dealing with this convention alone and that barely touched upon the significant issues posed by angled brackets.

second, no novel properties are claimed for angled brackets that would force further elaboration of the theory. The most significant claim made about this notation is its disjunctive ordering and this is capturable within the directional theory in precisely the same way as disjunctive ordering is captured in the case of parentheses. In general, the interesting problems posed by angled brackets fall into a domain somewhat outside the scope of this dissertation, namely the question of how the modifications in the string are made. The focus of this work is rather upon how segments meeting the structural description of the rule are identified and the relative ordering of one application of a rule and another.

Perhaps a more interesting omission from this work is the question of how mirror-image rules might be incorporated into the directional theory. The problem here is that the mirror-image convention abbreviates a pair of rules and the directional theory would predict from one of these rules

that it should apply from left-to-right across the string, but it would predict the opposite direction from the other rule. If a schema abbreviated by the mirror-image convention constitutes a unitary generalization, the question arises as to how it might be applied in a theory with predictable directionality.

Three major types of response can be offered to this challenge. The first would be to deny the existence of mirror-image rules altogether. This is a distinct possibility that should not be overlooked, despite the growing number of interesting cases that have been reported. Lightner (1971) has recently questioned the validity of mirror-image rules as unitary generalizations (cf. Chapter VI, footnote 3) and this convention is not included in SPE. It is probable, however, that a total prohibition on mirror-image rules is too strong a position to be maintained in the face of the wide variety of empirical examples.

A second alternative would be to assume that the first rule of the pair is applied across the string in the direction predicted for it and that when all applications of this rule are completed the second rule is applied in its own predicted direction. The third alternative would be to apply the rule across the string in a direction predicted by the first expansion, but successively attempting to match the string against the first and then the second expansion.

The purpose of this discussion on mirror-image rules is not to argue for a particular way of incorporating them into the directional theory (or indeed for their incorporation at all), but rather to illustrate that there are a number of possible alternatives that require consideration. To deal with these adequately would have required a very extensive treatment, since there is a real question as to the validity of most individual cases of mirror-image rules. Lightner's admonition is based upon one type of objection, the question of whether a mirror-image rule is in any sense a simplification of a pair of separate rules (or of only one of these rules). Anderson (1969) pointed out that some mirror-image rules apparently have to be disjunctively applied and others conjunctively applied, which would give this convention the unique honor of allowing nonpredictable disjunction. I consider these issues to be significant and to be a cause for caution in relation to attempting to modify a theory -- or justify a theory -- in terms of mirror-image rules.

As a final qualification of this work I would like to point out that there is one well-known rule which simply cannot be expressed in terms of the more restrictive theory developed here. That rule is the Main Stress Rule of English as described in SPE. If that rule is correct as it stands, the theory I am proposing must be considered falsified, for this theory denies the existence of schemata involving the complex interrelationships of braces, parentheses and angled

brackets utilized by that analysis. My theory claims that the
MSR is not a legitimate generalization about English and I
believe this claim to be correct. To substantiate it in any
convincing way would require a lengthy argument well beyond
the immediate purposes of this work, however, and this has
been deliberately omitted. I therefore accept the MSR as a
potential counterexample to the directional theory I am
proposing and will make only passing reference to it in the
text to follow.

It is with great pleasure that I take this opportunity to
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First and foremost among these acknowledgements must be to the
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In recognizing a few of the most significant contributors
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To Morris Halle I extend a particular debt of gratitude.
He educated me in phonology through his excellent course
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Noam Chomsky, through his provocative writings, brought
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came into contact with generative grammar and for an entire

summer every time I thought I understood something, Les showed me why I **didn't**. This helped me to avoid many of the basic pitfalls of learning generative grammar and provoked me to seek out the critical appraisals of others, as well as to supply self-criticism during the remainder of my career as a linguist.

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I am grateful to the National Science Foundation for the grant which enabled me to attend the Summer Institute sponsored by the Linguistic Society of America at Ann Arbor in 1965 and to M.I.T. for awarding me an N.D.E.A. Title IV fellowship (No. 66-2311) under which I pursued my graduate studies.

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children, Erik and Karen, I would like to say, "I told you

so".

In concluding these acknowledgements I would like to add

that none of those who contributed in any way to this work

should be held responsible for errors, inconsistencies, and

deviant opinions that it may contain.

CHAPTER I

GENERAL BACKGROUND

1.0 The Problem. This work is an attempt to provide a
more satisfactory answer to the question, "How are phono-
logical rules applied?". It follows in the footsteps of other
attempts to deal with the question, most notably Chomsky &
Halle's extremely significant work entitled The Sound Pattern
of English. In a very short period of time that book has
stimulated an extraordinary amount of research into a wide
variety of problems in phonological theory, as well as into
the specific languages (especially English) analyzed by those
authors.

As part of their overall theoretical framework, Chomsky
& Halle present a very specific proposal concerning the appli-
cation of phonological rules. This proposal has been chal-
lenged at least twice, leading to the alternative theories of
Johnson (1970a) and Anderson (1971). This current work is
also a challenge to the SPE position and at the same time a
challenge to the other alternatives that have been presented.
In the course of presenting the directional theory of rule
application I shall use the "standard theory" of SPE for
comparison in order to provide perspective. Accordingly,
sections 2 and 3 of this chapter briefly review some of the
more relevant aspects of the SPE position that will be referred
to in the exposition. General familiarity with this position,
however, will be assumed. A more detailed comparison of all

of the theories discussed above will be presented in Chapters VII and VIII.

When we raise the question of how phonological rules are applied it is natural to think in terms of an _answer_ to that question. The answer may be a formal algorithm for rule application similar to, but more carefully stated than, the algorithm I have tried to outline in this work. On the other hand, it may be argued quite appropriately that any attempt to answer this question at this point in time is premature. A formal algorithm for rule application necessitates an understanding of what phonological rules are and implies a clear knowledge of all of the notational devices that correctly may be used in such rules.

This objection is without doubt well-taken, since we are very far from having a theory of phonological rules that is anywhere near adequate to capture the facts of language. How can we talk about how rules apply if we are not even sure of what (legitimate) phonological rules are in the first place?

The answer to this objection is really very simple: we must be careful not to take ourselves too seriously. We must understand that the theories we offer are merely steps toward the right answer and that each theory must be judged in comparison with alternative theories in terms of their ability to deal with the knowledge currently available. Most importantly, we must regard a theory as a research tool. By attempting to force what we know and what we believe to be

true into a single logical framework we become more aware of
the pieces that don't fit in, of the internal inconsistencies,
and of problems that remain unresolved. In this sense there
is enormous value to the postulation of a theory of rule
application for it brings into focus what we need to know in
order to have a truly adequate theory -- not only of rule
application but also of those other aspects of phonological
theory upon which a theory of rule application depends. It
is in this spirit that this work is written.

2.0   The Standard Theory.

2.1   Levels of Representation.   The phonological compo-
nent of a grammar contains a level of representation which we
refer to as the phonetic level. As its name implies, it is
the closest representation within the grammar to the actual
sound of sentences. However, it must be understood that the
phonetic level is itself an abstraction (Chomsky 1964; Chomsky
& Halle 1968). It characterizes the grammatically predictable
aspects of the sound continuum and is, in effect, an idealiza-
tion of that continuum.

The phonetic level is conventionally represented as a
linear sequence of matrices each of which contains a number of
rows indicating some articulatory or acoustic feature together
with a value (generally an integer value) for each feature.
For most expository purposes this degree of detail is ignored
and phonetic symbols representing entire matrices are used.

Phonetic representations are customarily enclosed in square brackets "[...]" and this notation will be used throughout this work whenever confusion might otherwise arise.

At the other end of the phonological component is a more abstract level of representation which may be referred to as the underlying, phonological, or (systematic) phonemic level. Virtually every theory of phonology has assumed the existence of some level more abstract than the phonetic level, although there has been considerable disagreement over the degree of abstractness of that level and the nature of the rules that interrelate it with the phonetic level. Representations at this more abstract level are conventionally enclosed within diagonal lines "/ ... /", a practice that will be followed throughout this work.

Chomsky & Halle (1968:9-11) distinguish between "lexical representation" and "phonological representation". Lexical representation involves the syntactically-derived surface structure stated in terms of constituents with labelled bracketing. Within these brackets are formatives as they are entered in the lexicon. Each formative consists of a string of matrices representing phonological segments (in terms of their feature composition) and other information idiosyncratic to the formatives such as exceptionality to various rules.

There are major differences between the matrices at the lexical level and those at the phonetic level, however. For one thing, the value for a given feature at the phonetic level

will be "an integer specifying the degree to which the segment in question is characterized by the corresponding property" (Chomsky & Halle 1968:165), while at the lexical level there is only a binary choice of values for each feature, representing categorical presence or absence of the characteristic. Another crucial difference is that the lexical representation includes only information that is idiosyncratic to the formative and all information that may be predicted by general rule is omitted. The lexical representation is therefore redundancy-free.

The phonological representation is identical to the lexical representation except for the contribution of a set of rules of a restricted character. One subset of these rules modifies the syntactic surface structure in various ways, such as by raising subordinate clauses to the level of conjuncts and by converting syntactically-given word boundaries to morpheme boundaries in certain contexts. This type of rule is called a "readjustment" rule.

Another subset of rules mediating between lexical and phonological representations supplies the values for features which are redundant in relation to other features of the same formative. These are the "morpheme structure" rules of the early model of generative phonology (cf., for example, Halle 1959). Morpheme structure rules have largely been replaced by more general universal redundancy rules (or "marking conventions") according to the model proposed in Chapter 9 of SPE.

Whichever device is used, the subset of rules in question converts a redundancy-free lexical representation of a formative to a phonological representation that is fully specified in pluses and minuses for each feature in each matrix.

2.2 <u>Phonological Rules</u>. The phonological representation as described above constitutes the input to the phonological rules of the grammar. These rules mediate between the phonological and phonetic levels of representation and may change feature values or add, delete, or permute segments. At some point the binary specifications for features are converted into the scalar values characteristic of the phonetic level, but little attention has been paid by phonologists to this type of rule and it will be similarly ignored here. It is important to point out, however, that it is an empirical issue whether the subset of rules performing the conversion from binary to scalar values has the same properties as the rules phonologists are typically referring to when they speak of "phonological" rules.

2.2.1 <u>Form of Phonological Rules</u>. Each phonological rule has the general form A → B / X ___ Y, where any of the symbols A, B, X, Y may be null, except that either A or B must be nonnull. This may alternatively be written XAY → XBY and is simply an instruction to replace a string characterized by XAY with another string characterized by XBY. Rules of this shape (or their notational equivalents) are used in all

phonological theories, although theories differ as to how X, A, B, and Y may be specified, the way in which such rules may be ordered relative to each other, etc. The restricted use of a finite set of features, for example, is one sort of constraint placed upon the form of such rules. I shall return to the implications of such a constraint shortly.

2.2.2 <u>Linear Ordering</u>. The claim embodied in SPE and discussed in greater detail in Chomsky (1967) is that phonological rules are linearly ordered. The rules constitute an ordered sequence from rule R_1 to rule R_n. Rule R_1 applies to an underlying string S converting it to S_1. If the structural description of rule R_1 is not met, the change from S to S_1 is vacuous. Rule R_2 then applies to S_1 and converts it to S_2. This procedure is followed with each rule applying in turn until the last rule of the grammar R_n is reached. The output of this rule, S_n, is the phonetic representation and the derivation is terminated.

In contrast, the ideal of structuralist phonology was that each rule converting an underlying segment, or phoneme, into its corresponding phonetic realization is specified only in terms of neighboring phonemes. No derived elements (or strings) can participate in derivations. This is essentially the position that phonological rules are <u>simultaneously</u> ordered, the changes described by all rules being performed at once.

It cannot be emphasized strongly enough that the issue of rule ordering is not a matter of taste or of a priori "simplicity". It is an empirical hypothesis about the nature of language subject to support or to falsification on empirical grounds. The justification for the position that rules are sequentially (rather than simultaneously) ordered has been provided in many places, including especially Halle (1962), Chomsky (1967), Chomsky & Halle (1965, 1968), and Postal (1968). I am in full accord with the statement by Chomsky & Halle (1968:342) that "the hypothesis that rules are ordered ... seems to us to be one of the best-supported assumptions of linguistic theory", and I see no reason to attempt to justify it further here. It is worth pointing out, however, that the precise character of this sequential ordering is still open to debate and alternatives to the SPE position (e.g., Anderson 1969) are beginning to appear.

2.2.3 <u>Transformational Cycle</u>. An important addition to this basic notion of rule ordering is what Chomsky & Halle term the <u>transformational cycle</u>. According to this hypothesis, phonological rules are applied to a string in a way governed by the syntactic constituent structure of the string as modified by the readjustment rules. Rules are applied first within those constituents with no internal constituent structure and are then reapplied to successively larger constituents until the level of the sentence is reached. This hypothesis,

which "asserts, intuitively, ... that the form of a complex expression is determined by a fixed set of processes that take account of the form of its parts" (Chomsky & Halle 1968: 20), is usually illustrated by stress rules from English, but since these examples have been repeated so often in the literature I shall refer the reader to SPE for illustrations of the transformational cycle at work.

It is of some interest to note that the SPE position concerning the transformational cycle appears to be frequently misunderstood. Since not all rules can be applied cyclically and still derive the correct empirical outputs, a distinction must be drawn between those rules which are cyclic and those which are not. Noncyclic rules, in general, are applied only at the level of the word. The common misunderstanding arises over the question of what is meant by a cyclic rule and its application relative to noncyclic rules. It is easy, but incorrect, to infer that a given cyclic rule, R_j, will apply only after all rules R_i ($i<j$) have been applied and at that point R_j is applied beginning with innermost constituents and working outward. R_j would then be followed by all rules R_k ($j<k$) until the last rule of the grammar is reached. This is a possible interpretation of the transformational cycle, but not the one that Chomsky & Halle have in mind.

The transformational cycle according to Chomsky & Halle involves the repetition of the entire linear sequence of rules at each level of constituent structure, with the qualification

that some rules are only allowed to apply when the level of
the word is reached and not before or after that level.
Chomsky & Halle (1968:20) characterize this view as follows:[1]

(1) a. "The rules of the phonological component are linearly
        ordered in a sequence $R_1, \ldots, R_n$.

     b. Each rule applies to a maximal string containing no
        internal brackets.

     c. After applying the rule R_n, we proceed to the rule
        R_1.

     d. Unless an application of R_n intervenes, the rule R_j
        cannot be applied after the rule R_i ($j < i$) has applied.

     e. R_n is the rule: erase innermost brackets."

This characterization of the transformational cycle is a
strong hypothesis defining a specific relationship between
embedding of constituents and the number of cycles in which
the rules are applied. For each level of embedding there is
exactly one cycle, and one more for the matrix sentence.

There is an empirical difference to these two conceptions
of the cycle that should not be overlooked. According to the
SPE view described above, it is possible for a noncyclic rule
to precede a cyclic rule at that stage in the cycle (at the
level of the word) where both are allowed to apply, but for
the cyclic rule to precede the noncyclic one by applying on

an earlier cycle. Thus the order of applications of the two
rules can be R_c (on cycle one); R_n, R_c (both on cycle two).
With the first conception of cycle described above the cyclic
rule must always either precede or follow a given noncyclic
rule (or cyclic rule for that matter), never both.

The evidence in favor of the SPE interpretation comes
primarily from the relative ordering of cyclic rules with other
cyclic rules. It can be shown that, if the analysis of English
stress presented in SPE is correct in general outline, certain
of these rules must both precede and follow others when com-
plicated constituent structures are involved. The transforma-
tional cycle is thus an interesting and important hypothesis
concerning rule ordering.

2.3 <u>Notational Conventions</u>. A fundamental characteristic
of the SPE theory is its use of various notational devices to
"abbreviate" or "collapse" sets of rules into "schemata".
Thus, given a pair of rules such as those in (2) below, the
theory (under certain well-defined conditions) requires that
they be expressed with parenthesis notation as in (3):

(2)   a. A → B / X ___ Y Z

      b. A → B / X ___ Z

(3)   A → B / X ___ (Y) Z

It is important to understand that the use of abbreviatory
conventions has no effect upon the ability of phonological

rules to map a given set of underlying strings into a corresponding set of phonetic strings.[2] For each expression such as (3) there is a set of rules (perhaps specified in somewhat more detail than those in (2)) which can perform the equivalent mapping. Thus the justification for abbreviatory conventions is not in terms of generative power but rests on other grounds.

The justification for including abbreviatory conventions in the theory of grammar comes instead from our concern with capturing the notion "linguistically significant generalization". If we hold, as we must, that there is a set of processes which is characteristic of human languages and a converse set which is not characteristic of human languages, it is necessary for us to distinguish the two sets. If we want to define the properties of human language, we must certainly differentiate them from the properties of nonlanguage. An abbreviatory convention, therefore, constitutes an empirical claim that each set of rules that it may abbreviate into a schema constitutes a unitary linguistically significant generalization. It is quite clear that the various conventions that have been postulated thus far have had differential success in relation to this claim.

The general character of abbreviatory conventions may be illustrated with a rather nonconventional example. We normally do not think of our phonological feature system as an abbreviatory convention for collapsing rules into schemata, but it is

just that and must be justified in exactly the same way as parentheses and other abbreviatory devices. Consider, for example, a language with five vowels (a, i, e, o, u) and three nasal consonants (m, n, ŋ). Assume that this language has a general rule nasalizing vowels before nasal consonants, which we would conventionally write as follows:

(4)   [+ syll] → [+ nasal] / ___ [+ nasal]

The use of the feature system allows us to abbreviate into this one expression what might otherwise be regarded as a set of 15 nasalization rules, one for each vowel in the system before each nasal consonant.

Rule (4) would meet general acceptance as a linguistically significant generalization. Why should this be so? What evidence is there to support such a claim? First of all, it seems quite clear from our understanding of phonetics that (4) constitutes a unitary generalization in terms of the articulatory process involved. That is to say, the changes that take place have a common phonetic motivation.

A second fact that lends credibility to such generalizations is that we fully expect all of the 15 subrules to share the same ordering relations with other rules. Suppose, for example, there is a rule of epenthesis inserting an i between the second and third members of a consonant cluster. Assume that all three nasal consonants can occur as the third member of the consonant sequence. Now, under the assumption that (4)

constitutes a unitary generalization we would expect either
of the following results: (a) all of these epenthetic vowels
are nasalized before a nasal consonant; or (b) none of these
epenthetic vowels are nasalized.[3] In the first case, the
nasalization rule (4) follows epenthesis and in the second
case it precedes epenthesis. What we do not expect is that
epenthetic i will nasalize before m but not before n and ŋ,
yet this result would be perfectly plausible if (4) were
replaced by 15 separate nasalization rules which did not share
the same ordering relations with other rules. Thus, the
feature system regards the generalization (4) as more highly
valued than a set of separate rules and this is corroborated
by empirical observations concerning shared crucial rule
orderings.

A third fact which lends support to this view is that
rules tend to apply symmetrically to natural classes. It is
quite common that a language with the inventory of vowels and
nasal consonants mentioned above will nasalize only a subset
of vowels. Under these circumstances, however, we normally
find that the vowels that nasalize constitute a natural class.
Under the assumption that rule (4) should be replaced by a
set of 15 rules, there would be no reason not to expect i and
o or some other arbitrary subset of vowels to be the only ones
in the system that nasalize.

A feature system is thus intended to capture the notion
of linguistically significant generalization. The fact that

it succeeds very well in doing so is attested by the observa-
tion that its various empirical consequences are generally
supported rather than falsified.

Similar considerations apply to notational devices such
as parentheses, braces, angled brackets, etc. To be abbre-
viated by these conventions, two rules must be adjacent in
the ordering -- i.e., they must share identical ordering
relationships with the other rules of the grammar. They must
be formally similar in ways which tend to insure that they
have common phonetic motivation. In some cases, they have
additional empirical consequences such as disjunctive ordering
which support them. These arguments and others may all be
adduced in support or falsification of the hypotheses posed
by any given notational convention.

3.0 <u>Multiple Application</u>. The most significant battle-
field upon which the contest among theories of rule applica-
tion will be fought is what I call the problem of multiple
application of rules. This question arises when a string
has more than one segment that meets the structural description
of the rule, or when the output of the rule can also serve as
its (nonvacuous) input. Different theories of rule application
make different claims about what happens under these circum-
stances and these positions have broad ramifications which
render them amenable to empirical confirmation or disconfirma-
tion.

3.1 <u>Simultaneous Application of Rules</u>. The position
taken in SPE is a somewhat complex one. On the one hand,
the basic view of rule application is as follows:

(5)   "To apply a rule, the entire string is first scanned
       for segments that satisfy the environmental constraints
       of the rule. After all such segments have been
       identified in the string, the changes required by the
       rule are applied simultaneously." (Chomsky & Halle
       1968:344)

This implies that when there is more than one segment in the
string meeting the structural description, all of these undergo
the rule and the application of the rule to one segment cannot
affect the application of that rule to another segment. It
is also understood that this position prohibits the applica-
tion of a rule to its own output.

On the other hand, the transformational cycle makes a
different claim. It states that under certain conditions if
a string contains two segments meeting the structural descrip-
tion of a rule, the rule will apply first to one of these and
then to the other on a later cycle. Such sequential applica-
tion is reasonably well-defined, however, by the role of
bracketing in the operation of the transformational cycle.
Simultaneous application and the transformational cycle apply
under mutually exclusive circumstances, with simultaneous
application holding only within the domain of a single cycle.

It is important to point out this relationship between the principle of simultaneous application and the transformational cycle because similar arguments might be advanced by the proponents of alternative theories. The directional theory to be defended here, for instance, claims that application of a rule is sequential across a string rather than simultaneous. This view is not incompatible with the transformational cycle any more than the principle of simultaneous application is. It is perfectly possible to maintain that for cyclic rules application is directional on each cycle. Thus, the existence of the transformational cycle is not sufficient in itself to falsify the directional theory of rule application.

3.2 <u>Simultaneous Application of Schemata</u>. Chomsky & Halle extend their principle of simultaneous application in a very interesting way. They claim that simultaneous application is not only a characteristic of rules, but also of certain schemata as a whole. These schemata are abbreviations for infinite sets of rules and are defined in terms of two related types of notational conventions: (a) subscript zero; and (b) parenthesis-star. Chomsky & Halle (1968:344) extend the principle of simultaneous application to cover these schemata as follows:

(6)   "In the case of a schema standing for an infinite set
        of rules, convention (39) /= (6) above: IH/ is applied

to each rule of the set and all changes are made
simultaneously rather than in sequence."

To illustrate the use of the subscript zero convention,
consider a language with a rule of final stress that has
words ending in from zero to three consonants. In the SPE
formalism, such a rule would be written as follows:

(7)   V → [+ stress] / ___ C_o #

According to Chomsky & Halle, the expression above abbreviates
an infinite set of rules that are identical except that the
number of consonants they contain ranges from zero to infinity:

(8) a. V → [+ stress] / ___ #

     b. V → [+ stress] / ___ C #

     c. V → [+ stress] / ___ CC #

     d. V → [+ stress] / ___ CCC #

     e. V → [+ stress] / ___ CCCC #

          .
          .
          .

Rules (8a-d) are necessary for the language in question if
stress regularly falls on the final syllable. The proposal
to collapse these into a single schema is justified by con-
siderations of adjacency and formal similarity parallel to
those discussed in the last section.

The claim that these phenomena should be handled by an
infinite schema rather than by an abbreviation confined to

(8a-d) rests on different grounds. This claim is justified by the fact that the upper limit on the number of consonants is an arbitrary one contingent only upon the maximal number to be found in the strings of that language. If a word with four final consonants should be added to the language we fully expect it to behave as predicted by (8e). The fundamental fact here is that the number of consonants is <u>entirely irrelevant</u> to the operation of the rule. The notation chosen in (7) expresses this clearly and, I think, correctly.

This notation may also be used in a way more crucial to the problem of multiple application that concerns us. Suppose that rule (7), instead of stressing the vowel in the final syllable, devoices a consonant in exactly the same environment:

(9) $C \rightarrow [- \text{voice}] / \underline{\hspace{2em}} C_o \#$

The schema in (9) abbreviates an infinite set of rules identical to (8) in terms of its environmental specifications. In this case a word with three final consonants will meet the structural description of the first three expansions of the schema (parallel to (8a-c)). According to Chomsky & Halle, each of the consonants in the final sequence will be identified as meeting the structural description of some rule in the set and the changes will be made simultaneously to all consonants thus marked. It is specifically <u>not</u> the case that the consonants are devoiced in sequence.

A similar claim is made about the parenthesis-star notation, which is really nothing more than the subscript zero notation referring to a sequence of segments. The expression (10) below represents an infinite set of rules varying only in the number of occurrences of the sequence MN:

(10)   A → B / X ___ (MN)* Y

The arguments in favor of this notation are perfectly parallel to those for subscript zero and need not be elaborated here. Counterarguments to this notation, however, will be given throughout this work beginning with Chapter II.

4.0 <u>Summary</u>. The crucial issue with which we are confronted is just how our theory should deal with the multiple application of phonological rules. The SPE position may be summarized as follows:

(11) a. Application of a rule to two different segments in a string may be sequential provided that (1) the rule is cyclic and (2) the two segments fall within the domain of different cycles.

b. Application of a rule is simultaneous under all other circumstances.

c. Schemata abbreviating infinite sets of rules are applied simultaneously.

d. Except under the conditions provided in (a), rules may not apply to their own outputs.

In the remainder of this work I will argue that the SPE
position on rule application is incorrect and will propose
an alternative theory and attempt to justify it on empirical
grounds.

NOTES

[1] This statement is still quite imprecise, as the authors point out, but it is sufficient to illustrate the points under consideration here.

[2] The closest thing to a counterexample to this statement is the use of variables in "exchange rules". These rules effect a mapping of A onto B and B onto A under the same environmental constraints. This cannot be carried out as a sequence of operations A → B followed (or preceded) by B → A, since the application of the second rule will not only do what it is supposed to do but will also reverse the changes made by the first rule. Either all instances of A will become B or vice-versa, but never both.

The validity of this type of rule is somewhat questionable, although exchange rules have been postulated in several languages. If such rules are valid, however, it would be possible to derive the same results by a less direct sequence of rules in which A becomes C (which is otherwise nonexistent in that context in the particular language) before B becomes A and later these instances of C are converted to B.

It might be pointed out that this problem does not arise in the directional theory since both rules could not be applied to the same segment.

[3] Alternative (a) seems far more likely than alternative (b), owing no doubt to the fact that (a) is "transparent" in the sense defined in Kiparsky (1971).

CHAPTER II

DIRECTIONAL RULES

1.0 <u>Introduction</u>. The simultaneous theory of rule
application presented in SPE has been challenged by Johnson
(1970a), who proposes that each phonological rule applies in a
linear sequence of applications across a string. Johnson
refers to rules of this type as <u>linear</u> rules, a somewhat un-
fortunate choice of terminology due to potential confusion
with the currently accepted use of the term "linear" in refer-
ence to rule ordering, as in Chomsky (1967).

Johnson's argument in favor of linear rules takes several
forms. First, he points out that many rules are more economi-
cally stated when they are assumed to apply in a linear fashion.
Some rules are more economically stated when applied from left
to right and others when applied from right to left. The
former are termed <u>right linear</u> rules and the latter <u>left linear</u>
rules. Still other rules may be stated in either way because
the choice of one mode of application over the other is incon-
sequential.

Second, Johnson provides a mathematical argument that a
theory utilizing linear rules of both types is no more powerful
than a theory utilizing only simultaneous rules. In fact, he
contends that there is no difference in power between a theory
which uses both linear rules and simultaneous rules and a
theory which uses only linear rules. There is thus no reason
to dismiss the possibility of linear rules on the grounds of
excessive power.

Finally, Johnson argues that there appear to be no rules which <u>require</u> a simultaneous application and cannot be stated as either left or right linear rules. He provides an example of what such a case would look like (cf. Chapter IV, §2.0) and concludes that until we have evidence to the contrary, theoretical consistency forces us to maintain that simultaneous rules must be eliminated from phonological theory.

The theory that will be developed on the pages to follow is based to a large degree upon the fundamental insight of Johnson that rules are applied across a string either from right to left or from left to right. There are some differences, however, in the conception of precisely how this application takes place. I shall therefore use the term <u>directional rules</u> to differentiate this particular conception from Johnson's linear rules. Accordingly, I shall also use the term <u>directional theory</u> to differentiate my overall position from that of Johnson.

It may also be pointed out that Johnson's arguments in favor of linear rules are equally valid for directional rules. The one qualification that must be made in this statement is that some of the more significant insights of the directional theory can be incorporated into the theory only if simultaneous rules of a particular type are also allowed (cf. Chapter IV). The discussion that follows is devoted to the explication of the directional theory. A comparison between the directional

theory and Johnson's linear theory will not be made in a
systematic fashion until Chapter VII.

2.0 _"Feeding" and "Bleeding"_. Kiparsky (1968a) proposed
that there is a naturally optimal ordering between any pair of
rules. When rule A provides an output which is appropriate
input to rule B and the rules are ordered A, B, Kiparsky refers
to this as _feeding order_. That is, A creates new input to B
that would not have been available if A were not in the language
or if A followed B in the ordering. A _bleeding order_ is when
rule A operates on potential input to B and modifies it so
that it is no longer input to B. In addition to these two
possibilities, of course, is the nonfeeding-nonbleeding situa-
tion in which neither rule affects the other. I shall refer
to this as _neutral order_.[1]

.. An analogous distinction may be drawn with the sequencing
of applications of a single rule within the directional theory.
Unlike the simultaneous theory of SPE, the directional theory
allows rules which may create new input or destroy potential
input to subsequent applications of the same rule. It seems
reasonable to adopt a parallel terminology for these cases.
Feeding application is thus the case where one application of
a rule creates new input for a second application of that rule,
while _bleeding application_ is where one application destroys
a potential second application. I shall refer to rules of the
former type as _self-feeding_ and those of the latter type as

self-bleeding.[2] Neutral application denotes the large number of cases where self-feeding and self-bleeding are impossible.

2.1 Feeding Application.

2.1.1 Tshiluba 1-Nasalization. In Tshiluba, a Bantu language of the Congo, the lateral 1 becomes n if the preceding consonant is a nasal. The following data are taken from Johnson (1970a:83):

(1) a. ku-kwat-a   'to take'

     b. u-kwač-ile   'he took'

     c. ku-kwač-il-a   'to take (benefactive)'

     d. u-kwač-id^Y-ile   'he took (benefactive)'

(2) a. ku-d^{Y}im-a   'to cultivate'

     b. u-d^{Y}im-ine   'he cultivated'

     c. ku-d^{Y}im-in-a   'to cultivate (benefactive)'

     d. u-d^{Y}im-in^Y-ine   'he cultivated (benefactive)'

Of particular relevance to this problem are the stem morphemes -kwat- 'take' and -d^{Y}im- 'cultivate' and the suffixes -il- (benefactive) and -ile- (simple past). Johnson states that the changes from t to č and 1 to d^Y (and presumably n to n^Y) are quite regular in the environment before the high front vowel.

In examples (2b) and (2c), the lateral of the suffix becomes a nasal due to the nasal consonant in the preceding syllable. In (2d), however, both suffixes undergo the change

to n. These facts would be expressed within the standward

theory by the following rule:

(3) $[+ \text{lat}] \rightarrow \begin{bmatrix} + \text{nasal} \\ - \text{lat} \end{bmatrix}$ / $[+ \text{nasal}]$ $(V_o \, [+ \text{lat}])* \, V_o \, \underline{\quad}$

The parenthesis-star notation is used here to express the fact

that in any sequence of such syllables containing 1 which

follows a nasal consonant, all instances of 1 will (simulta-

neously) be modified to n.

The directional theory asserts that nasalization is

propagated along the string from left to right. The first

modification in the string is due to the influence of the

underlying nasal consonant, but subsequent modifications are

due to the influence of derived nasal consonants. The Tshiluba

1-nasalization rule may be stated within the directional theory

as follows:

(4) $[+ \text{lat}] \rightarrow \begin{bmatrix} + \text{nasal} \\ - \text{lat} \end{bmatrix}$ / $[+ \text{nasal}]$ $V_o \, \underline{\quad}$

Rule (4) must be applied from left to right. A rightward

application yields the following derivation of udⱽiminⱽine:

(5)   /u-dim-il-ile/[3]   input string

       u-dim-in-ile   first application

       u-dim-in-ine   second application

       u-dⱽim-inⱽ-ine   palatalization

The facts of Tshiluba 1-nasalization are statable in

either the directional or simultaneous theory as has already

been shown. A comparison of these two formulations, however, reveals that the simultaneous rule is identical to the directional rule except that it involves an extra expression within parenthesis-star notation:

(6) $(V_o [+ lat])*$

It is frequently the case that simultaneous formulations require less concise statements than the equivalent directional rules, which is a major point that Johnson tried to argue. This is not necessarily a fault, it should be recognized, since it is always possible that a theory which involves lengthier descriptions of processes makes more correct claims about the nature of those processes and their relative naturalness. Thus, for example, Chomsky & Halle argue in Chapter 9 of SPE that a rule which converts t to θ should have to mention [- strident] in the structural change, even though there is no change of this feature, while a change from t to s need not mention [+ strident]. The purpose of this formalism is to capture the naturalness of the change to the strident dental fricative by adding to the cost (in terms of feature-count) of retaining the value [- strident]. In such a case, it is not a valid argument that a theory which expresses the change of t to θ without mentioning the feature strident is in any sense superior to the theory utilizing marking conventions. Thus, simplicity can be sensibly judged only within a single theory.

There is another aspect to this argument that must be considered, however. The extra expression shown as (6) above

is not a random sequence of segments. It contains a lateral segment which is in itself in the correct environment to undergo the rule. In fact, the parenthesis-star notation is intended to capture the notion of a recursively enumerable set of environments in which the modification will take place. Anderson (1969:118-21), in discussing stress assignment in Tübatulabal, showed that the environment within parenthesis-star notation was an extremely complex one and yet was largely a repetition of the environment to be found outside of that expression. That is, the same complex statement had to be stated twice in order to describe the process within a simultaneous framework. Clearly, the more complex the expression that must be repeated, the more suspicious the formalism becomes. Anderson thus quite properly took the parenthesis-star notation to task for its redundant character.

In the examples to follow, I shall refer to the repetitions or partial repetitions of the environment necessary for the shortest expansion to apply as redundant expressions, or redundancies. The complexity of the redundant expressions required in different rules varies, but the strongest evidence comes, as Anderson recognized, from the cases where the redundant expression is a very complex one. Tshiluba l-nasalization is a relatively simple case illustrating this redundancy in comparison with a theory that involves application of a rule to its own output.[4]

2.1.2 <u>Arabela Vowel Nasalization</u>.   An even simpler case
is the process of vowel nasalization in Arabela, a Zaparo
language of northern Peru.   Vowel nasalization is a process
that frequently involves a spreading effect that is captured
neatly by directional rules, and the Arabela case is a parti-
cularly simple and straightforward example of that phenomenon.
The following data are taken from Rich (1963).   Note that in
Arabela <u>h</u> is an underlying nasal.[5]

(7)   a. ['tukͻru?]   'palm leaf'

      b. ['tͻkwɩ?]   'clothes'

      c. ['mõnũ?]   'to kill'

      d. ['nũw̃ã?]   'partridge'

      e. ['kɩronɪ̃?]   'deep'

      f. ['h̃ũw̃ã?]   'a yellow bird'

      g. ['nỹæ̃æ̃'rĩ?]   'he laid it down'

      h. ['h̃ẽẽ̃gɩ?]   'termites'

      i. ['mw̃ẽræti'tyenũ?]   'cause to be seen'

Nasalization, once initiated by an underlying nasal segment,
is stopped only by oral consonantal segments or word boundary.
As a simultaneous rule within the SPE theory, Arabela nasaliza-
tion would be expressed as:[6]

(8)   [- cons] → [+ nasal] / [+ nasal] [- cons]$_o$ ____

The same facts within the directional theory would be expressed
by a rightward rule of the following shape:

(9)   [- cons] → [+ nasal] / [+ nasal] ·____

In this case the redundancy is only a subscripted nonconsonantal segment, but it still represents a sequence of segments all of which will themselves undergo the rule.

2.1.3 <u>Southern Agaw Vowel Raising</u>. Some types of vowel raising rules can be of a feeding nature. In Southern Agaw (also known as Awiya; cf. Palmer 1970:579), a Cushitic language of northern Ethiopia, a mid vowel becomes high when the following syllable contains a high vowel. Vowel raising has a spreading effect toward the left of the string, as shown in the following examples (cf. Johnson 1970a:81-82; Hetzron 1969a:8-9):[7]

(10) a. muliqísí   'monk'   moleqéská   (pl.)

     b. dunizi   'potato'   donezka   (pl.)

     c. dikití   'healthy'   deketká   (pl.)

     d. liggisimí   'long'   leggesemká   (pl.)

In a simultaneous format, the required rule would be expressed:

$$(11) \quad \begin{bmatrix} + \text{syll} \\ - \text{low} \end{bmatrix} \rightarrow [+ \text{high}] \; / \; \underline{\quad} \; C_o \; (\begin{bmatrix} + \text{syll} \\ - \text{low} \end{bmatrix} C_o)^* \begin{bmatrix} + \text{syll} \\ + \text{high} \end{bmatrix}$$

By comparison, the same facts would be stated in a directional theory as the following leftward rule:

$$(12) \quad \begin{bmatrix} + \text{syll} \\ - \text{low} \end{bmatrix} \rightarrow [+ \text{high}] \; / \; \underline{\quad} \; C_o \begin{bmatrix} + \text{syll} \\ + \text{high} \end{bmatrix}$$

Once again, the entire redundant parenthetical expression required by the simultaneous format may be omitted from the directional rule.

2.2 Bleeding Application.

2.2.1 Woleaian Low Vowel Dissimilation.

Woleaian is a
Micronesian language closely related to Trukese. In a very
insightful analysis, Sohn (1971) describes a rule which dissi-
milates the first of a pair of low vowels to e. The operation
of this rule can be seen in the following noun paradigm:

(13) a. [ma:t]   /mata/   'eye (indep. form)'

      b. [metaj]   /mata + ji/   1st sg.

      c. [metamʷ]   /mata + mu/   2nd sg.

      d. [metal]   /mata + la/   3rd sg.

      e. [metaš]   /mata + ca/   1st (inc.) pl.

      f. [matemam]   /mata + mami/   1st (exc.) pl.

      g. [metami]   /mata + mii/   2nd pl.

      h. [meta:r]   /mata + jire/   3rd pl.

The underlined vowels are those which undergo dissimilation.
In the representations above, j is a glide.

The alternating pattern of dissimilation can be most
clearly observed in (13f) [matemam]. The following data
demonstrate this pattern even more clearly:

(14) a. [tepaŋi]   /tapaŋ+ija/   'to help it'

      b. [xetapetɐp]   /xa+tapaŋ=tapaŋ/   'to make help'

      c. [xetapetepa] /xa+tapaŋ=tapaŋ+ja/   'to support him'

Example (14a) illustrates the simple case of dissimilation
where only two vowels are involved. In (14b) the alternating
pattern emerges clearly. Note that reduplications involve an

internal word boundary, here represented as "=", which shares
some of the properties of full word boundaries. The stem-
final consonant deletes word-finally as well as before internal
word boundary. Moreover, the apparently irregular pattern in
(14c) is explained by a general rule which raises _a_ to _e_ in
prejunctural position.

An initial attempt to state the low vowel dissimilation
rule of Woleaian within the simultaneous theory of SPE might
be:

$$(15) \quad \begin{bmatrix} + \text{syll} \\ + \text{low} \end{bmatrix} \rightarrow \begin{bmatrix} -\text{back} \\ - \text{low} \end{bmatrix} / \underline{\quad} (C_o \begin{bmatrix} + \text{syll} \\ + \text{low} \end{bmatrix} C_o \begin{bmatrix} + \text{syll} \\ + \text{low} \end{bmatrix})* \ C_o \begin{bmatrix} + \text{syll} \\ + \text{low} \end{bmatrix}$$

Even though this formulation is already very complex, it is
still inadequate to deal with the facts. Within the SPE
theory, (15) would be interpreted as an infinite set of rules
differing in the number of occurrences of the expression in
parenthesis-star. Any vowel which meets the structural
description of _any_ of these rules will undergo the stated
change. But notice that the shortest expansion of (15) is:

$$(16) \quad \begin{bmatrix} + \text{syll} \\ + \text{low} \end{bmatrix} \rightarrow \begin{bmatrix} - \text{back} \\ - \text{low} \end{bmatrix} / \underline{\quad} C_o \begin{bmatrix} + \text{syll} \\ + \text{low} \end{bmatrix}$$

According to the shortest expansion, then, any low vowel which
itself is followed by a low vowel will undergo the dissimilatory
process. The effect of (15) is thus to front and raise _every_
low vowel in a sequence of syllables containing low vowels,
except for the last vowel in that sequence. This is not the

alternating pattern we desire. In order to achieve such an alternating pattern, it is necessary to build into rule (15) the fact that the _last_ low vowel in the sequence is the reference point from which the various changes emanate. This must be done as follows:

$$(17) \quad \begin{bmatrix} + \text{ syll} \\ + \text{ low} \end{bmatrix} \rightarrow \begin{bmatrix} - \text{ back} \\ - \text{ low} \end{bmatrix}$$

$$/ \underline{\quad} (C_o \begin{bmatrix} + \text{ syll} \\ + \text{ low} \end{bmatrix} C_o \begin{bmatrix} + \text{ syll} \\ + \text{ low} \end{bmatrix})* \ C_o \begin{bmatrix} + \text{ syll} \\ + \text{ low} \end{bmatrix} C_o \left\{ \begin{matrix} \# \\ \begin{bmatrix} + \text{ syll} \\ - \text{ low} \end{bmatrix} \end{matrix} \right\}$$

The formulation of the Woleaian low vowel dissimilation process within the directional theory is far less complicated. It may be stated as the following leftward rule:

$$(18) \quad \begin{bmatrix} + \text{ syll} \\ + \text{ low} \end{bmatrix} \rightarrow \begin{bmatrix} - \text{ back} \\ - \text{ low} \end{bmatrix} \ / \ \underline{\quad} \ C_o \ \begin{bmatrix} + \text{ syll} \\ + \text{ low} \end{bmatrix}$$

The difference between the two formulations is as follows:

$$(19) \quad (C_o \begin{bmatrix} + \text{ syll} \\ + \text{ low} \end{bmatrix} C_o \begin{bmatrix} + \text{ syll} \\ + \text{ low} \end{bmatrix})* \ \ldots \left\{ \begin{matrix} \# \\ \begin{bmatrix} + \text{ syll} \\ - \text{ low} \end{bmatrix} \end{matrix} \right\}$$

In this case, the expression in parenthesis-star notation must refer to _four_ low vowels: one as the determinant, one as the focus, and two more to characterize the alternating sylla-bles in which this process occurs. Needless to say, this is highly redundant in comparison with the expression required by the directional theory as given in (18).

Another interesting problem that occurs here is the following word boundary or nonlow vowel. This expression is included in the simultaneous rule only to guarantee that the last low vowel in the sequence is the point of reference from which all others are measured. The fact that such a statement is _not_ needed within the directional theory is a claim that such behavior is expected from the simple dissimilatory nature of the process itself. That is, a leftward rule _automatically_ defines the last low vowel in the sequence as the focal point.

2.2.2 _Warao Alternating Stress_. The phenomenon of alternating stress bears many similarities with the Woleaian rule just considered. Alternating stress is perhaps one of the commonest manifestations of bleeding application and numerous other examples of alternating stress will be considered elsewhere in this work. The rule required for Warao is particularly clear and straightforward and thus will serve well to illustrate directional rules at this early point in the exposition.

Warao is a language spoken in Venezuela and adjacent areas of Guyana. It has been classified as "Independent" by McQuown (1955:526). According to Osborn (1966:115), "alternate syllables are stressed with a weaker secondary stress, counting back from the strongly stressed syllable." This pattern is illustrated by the following examples:

(20) a. nàhoròahàkutái   'the one who ate'

     b. yàpurùkitàneháse   'verily to climb'

     c. enàhoròahàkutái   'the one who caused him to eat'

     d. yiwàranáe   'he finished it'

Within the simultaneous format of SPE these facts could be expressed as follows:

(21) $[+ \text{syll}] \rightarrow [2 \text{ stress}] / \underline{\quad} (C_oVC_oV)*C_oVC_o\acute{V}$

Here, as in the Woleaian example, the parenthetical expression is used to capture the notion "alternate syllable".

In the directional theory proposed here, these facts have a much simpler expression. If the rule is <u>leftward</u>, it is only necessary to state that the vowel following the vowel to be stressed is unstressed:

(22) $\begin{bmatrix} + \text{syll} \\ - \text{stress} \end{bmatrix} \rightarrow [2 \text{ stress}] / \underline{\quad} C_o \begin{bmatrix} + \text{syll} \\ - \text{stress} \end{bmatrix}$

According to this formalization, the word <u>nàhoròahàkutái</u> would be derived as follows:

(23)   /nahoroahakutai/   underlying form

         nahoroahakutái   primary stress placement

         --------------| *not followed by $\breve{V}$

         ------------|-   *not unstressed

         ----------|---   *not followed by $\breve{V}$

         nahoroahàkutái   first application

         -------|-------   *not followed by $\breve{V}$

nahoròahàkutái	second application
---|-----------	*not followed by V̆
nàhoròahàkutái	third application

The vertical line represents the vowel under consideration at each point in the derivation.

Notice that the more concise formulation of the process as a leftward directional rule obviates the necessity of having a redundant expression to characterize the notion of alternating syllables.

It is worth noting here that the analysis given above and that provided by Osborn assume an independent rule for primary stress placement. There is good reason to doubt the independence of these two processes and to consider primary stress assignment as part of the alternating stress phenomenon. Restricting our attention to the examples in (20), which constitute the predominant pattern of primary stress, a generalization of the alternating stress rule will provide for all stresses of the word:

$$(24) \quad [+ \text{ syll}] \rightarrow [+ \text{ stress}] \ / \ \underline{\hspace{1cm}} \ C_o \begin{bmatrix} + \text{ syll} \\ - \text{ stress} \end{bmatrix}$$

It will be necessary in addition to have a rule providing for the relative stress values, but this can be part of the low level rules which interpret pluses and minuses in terms of scalar values.

There are certain complications in this collapsing of primary and secondary stress placement which are not worth

extended treatment here. These are morphologically defined contexts in which primary stress falls either on the final or on the antepenultimate syllable, as well as a few unassimilated Spanish loans and onomatopoetic forms. The former appear to be attributable to relative strengths of boundaries in different contexts, and when this is taken into account can probably be regularly derived by rule (24). The latter require lexical stress and/or exceptionality which reflects their true non-systemic status.

2.2.3 <u>Southern Paiute Alternating Stress</u>. A particularly famous example of alternating stress is that found in Southern Paiute, a Uto-Aztecan language spoken in southwestern Utah and northwestern Arizona. The treatment of Southern Paiute alternating stress given here diverges significantly from that found in other works on the subject. In actuality, the alternating stress rule is only partially responsible for the stress patterns of the language and justification for the treatment given here will be presented in the context of a more extensive discussion of the language in Chapter V.

The alternating stress rule of Southern Paiute stresses the second mora of each word and every alternate mora following it. This effect would be achieved in a simultaneous format as follows:

(25) $[+ \text{syll}] \rightarrow [+ \text{stress}] / \#C_oV(C_oVC_oV)* C_o \underline{\quad}$

Within the directional framework, Southern Paiute alternating

stress is simply expressed as the rightward rule:

(26)   [+ syll] → [+ stress] / $\breve{V}$ C_0 ___

As in the case of Woleaian low vowel dissimilation, the

Southern Paiute alternating stress rule in its simultaneous

formulation not only has a redundant characterization of

alternating syllables but must also have a word boundary and

word initial syllable in order to provide a point of reference

from which the process begins.

A comparison of the Southern Paiute alternating stress

rule and the alternating stress rule from Warao demonstrates

that the same type of phenomenon may be a rightward rule in

one language and a leftward rule in another. This is an

interesting and important fact.

    2.2.4 <u>Klamath Deglottalization</u>. In a recent paper,

Kisseberth (1972b:1) discusses a rule of deglottalization in

Klamath:

(27)   "Klamath, an Amerindian language spoken in southwestern

         Oregon, has phonemically both glottalized stops and

         also glottalized sonorants -- i.e., p̓, t̓, c̓, k̓, q̓ and

         m̓, n̓, y̓, w̓, l̓. The glottalized stops are deglottalized

         in pre-consonantal position, except before the voiced

         non-glottalized sonorants <u>m</u>, <u>n</u>, <u>w</u>, <u>y</u>, <u>l</u>. All other

         consonants -- obstruents, voiceless sonorants,

glottalized sonorants -- require the deglottalization
of a preceding stop. The glottalized sonorants, on
the other hand, are deglottalized in <u>all</u> pre-consonantal
positions (with certain minor restrictions not relevant
here)."

Kisseberth illustrates the various possibilities for deglottal-
ization with simple examples, but the crucial cases for his
argument are those given below:

(28) a. ňčoq̓-lg̣-a   'ears are stopped up'

     b. ňčoq-ł̓aq-Wi:y-a   'ears are almost stopped up'

     c. toq̓-lg̣-a   'stops an action'

     d. hos-taq̓-lg̣-a   'makes someone stop an action'

     e. hos-taq-ł̓aq   'make him stop'

     f. sno-nt̓ap̓-lg̣-a   'causes to rot down'

     g. sno-nt̓ap-ł̓aq-s   'rotted wokas'

In these examples there is an alternation of <u>lg̣</u> and <u>ł̓aq</u>. The
vowel is apparently epenthetic and the alternation between
g̣ and q is the result of a very general rule neutralizing the
aspirated-nonaspirated distinction.

If the base form is <u>lg̣</u> with the first member of the cluster
an underlying glottalized sonorant, the deglottalization would
follow naturally from the rule of deglottalization needed in
other cases. If the nonglottalized alternant were taken as
basic, an ad hoc rule would be required to glottalize the <u>l</u> in
the context <u>łaq</u>, a very unreasonable and unlikely rule.

In the last example of each group in (28) the epenthetic vowel prevents the liquid from deglottalizing. As a result, the glottalized consonant preceding the liquid is forced to deglottalize. In the remaining examples, however, there is no epenthetic vowel and the liquid itself thus deglottalizes. Notice that in these cases the deglottalization of the stop preceding this liquid does <u>not</u> take place. Kisseberth correctly argues that this phenomenon is not explainable in a theory using simultaneous rules. Since both the stop and the following liquid are in the correct position in the underlying string to undergo the rule, a simultaneous theory would predict that <u>both</u> would be deglottalized.

In a theory based on directional rules the phenomena observed in Klamath are exactly what would be predicted. A leftward rule of deglottalization will apply first to the liquid and this would remove the necessary environment for the deglottalization of the stop which precedes it. Kisseberth does not attempt to give a formal statement of the deglottalization rule nor will I attempt it here. There are interesting problems with such a formulation that deserve more extensive treatment elsewhere.

2.2.5 <u>Eastern Ojibwa Glide Formation</u>. Another common type of rule that is of a bleeding character is that of glide formation. Quite commonly vowels become glides intervocalically or prevocalically and consequently when one becomes a glide its

neighbor may no longer be intervocalic or prevocalic. As an example, consider the rule described in Johnson (1970a:80) and taken from Bloomfield (1956:4-5). Eastern Ojibwa is an Algonquian language spoken along the north shore of the Great Lakes. It is thus a close relative of Menomini, which will also receive extensive treatment in this work.

According to Bloomfield, Eastern Ojibwa has a three vowel system with vowels /i, o, a/. Glides are predictable from the two nonlow vowels. The rule upon which Johnson focusses (and the one most relevant here) turns o and i into w and y, respectively, when they are prevocalic. Bloomfield points out that this rule must operate from right to left in order to derive eniniwak[8] 'men' from underlying /eninioak/. Applying the rule in the opposite direction (or simultaneously, as in SPE) would incorrectly give *eninywak.

To state this process in a simultaneous theory would be very difficult. If the rule is stated as prevocalic glide formation /eninioak/ would incorrectly yield *[eninywak], since two vowels in the underlying string are prevocalic. To state the rule as intervocalic glide formation would work correctly above but would not be able to handle sequences of only two vowels. Moreover, in a string of four or more vowels several adjacent vowels could be converted to glides since they would all be intervocalic in the underlying string. It is even impossible to state the rule as follows and achieve the correct output:

(29) $\begin{bmatrix} + \text{ syll} \\ - \text{ low} \end{bmatrix} \rightarrow \begin{bmatrix} - \text{ syll} \\ + \text{ high} \end{bmatrix} / \underline{\qquad} (\begin{bmatrix} + \text{ syll} \\ + \text{ low} \end{bmatrix} [+ \text{ syll}])^* [+ \text{ syll}]$

Although this is the way the alternating pattern was provided

for in earlier examples, it fails here because one rule of

the infinite set abbreviated by (29) will convert a nonlow

vowel to a glide before any vowel. Since the claim made by

a simultaneous theory is that any vowel meeting the structural

description of that rule in the underlying string will undergo

the rule, (29) will derive *[eninywak] and other incorrect

outputs. It is not immediately obvious how this difficulty

could be resolved within the simultaneous theory.

A leftward directional statement of this process is simple

enough:

(30) $\begin{bmatrix} + \text{ syll} \\ - \text{ low} \end{bmatrix} \rightarrow \begin{bmatrix} - \text{ syll} \\ + \text{ high} \end{bmatrix} / \underline{\qquad} [+ \text{ syll}]$

This follows perfectly the spirit of Bloomfield's own rule.

The real situation in Eastern Ojibwa is slightly more

complex than Johnson represents it, however. Bloomfield

(1956:4) presents an additional rule of glide formation which

must clearly precede (30):

(31)   "At the end of the word, in the sequence oi, the o is

        nonsyllabic, yielding wi: epwi 'paddle', muwi 'he

        weeps'. In all other combinations, final i and o

        after a vowel are nonsyllabic: nentay 'my dog', pešiw

        'lynx'."

All of these sequences except for oi (= wi) violate the pattern presupposed by (30), where it should be the first vowel in a pair that becomes a glide. The simplest way to deal with these facts seems to be to assume a rule like the following:

(32)
$$\begin{bmatrix} + \text{syll} \\ - \text{low} \end{bmatrix} \rightarrow \begin{bmatrix} - \text{syll} \\ + \text{high} \end{bmatrix} \Big/ \begin{bmatrix} + \text{syll} \\ - \text{round} \end{bmatrix} \underline{\quad} \#$$

This rule will give ay, aw, and iw. Apparently sequences of identical vowels do not exist here and thus we do not have to worry about the potential outputs of /oo/ or /ii/. With /oa/ and /ia/ rule (32) cannot apply because the final vowel is low. Rule (30) will then apply to correctly yield wa and ya. In the remaining case, /oi/ is not permitted to undergo (32) because of the restriction that the preceding vowel be unround and therefore it will also undergo (30) to yield wi.

2.3 <u>Neutral Application</u>. Neutral applications are those where a given rule is incapable of creating on one application a new input for a second application and is at the same time incapable of destroying a potential second application. In other words, neutral rules are those which are neither feeding nor bleeding. Neutral rules provide little evidence for the nature of rule application since they are compatible with most theories and hence are relatively insignificant. The following examples are intended only to illustrate this type of rule.

2.3.1 <u>Woleaian Vowel Assimilation</u>. In addition to the rule which dissimilates a low vowel to e when preceding a low

vowel and to the prejunctural rule which raises <u>a</u> to <u>e</u>,
Woleaian has a more assimilatory rule which raises <u>a</u> to <u>e</u>.
In this case the relevant environment is a high vowel in both
adjacent syllables. The assimilation rule is demonstrated in
the following noun paradigm taken from Sohn (1971:17):[9]

(33)	a. [ü:l]	/ülüm/	'drinking object (indep. form)'
	b. [ülüm<u>e</u>j]	/ülüm-a-ji/	1st sg.
	c. [ülüm<u>em</u>ʷ]	/ülüm-a-mu/	2nd sg.
	d. [ülümal]	/ülüm-a-la/	3rd sg.
	e. [ülümaš]	/ülüm-a-ca/	1st (inc.) pl.
	f. [ülümemam]	/ülüm-a-mami/	1st (exc.) pl.
	g. [ülüm<u>em</u>i]	/ülüm-a-mii/	2nd pl.
	h. [ülüm<u>e</u>:r]	/ülüm-a-jire/	3rd pl.

The underlined instances of <u>e</u> are the result of assimila-
tion. In (33f) the mid vowel is instead the result of
dissimilation. Where neither of these factors is operable,
the vowel is <u>a</u>. Notice that in these cases of assimilation
the underlying high final vowels are relevant to the application
of the rule and therefore assimilation must be earlier in the
ordering than final vowel deletion.

Since the vowels on either side of the vowel to be
modified must be high vowels, it is obvious that there will be
no other vowel potentially affected by one application of this
rule. It is therefore an example of neutral application.

2.3.2 <u>Kaliai-Kove Vowel Laxing</u>. One very general type of neutral rule is exemplified here. In some instances, the rule involves specific influence of a consonant on a vowel or vice versa. In such cases it is impossible for the output of one application to be input to another unless, for example, the vowel loses its syllabicity by the rule and hence will be able to qualify as a consonant for the next application.

In Kaliai-Kove, a Melanesian language of New Britain described by Counts (1969), non-low vowels are laxed before the velar nasal:

(34) a. [imíɣimíɣi]   'he lives'

     b. [owaíŋa]   'cats cradle game'

     c. [loβóne]   'today, now'

     d. [βóŋi]   'evening'

     e. [ŋaúnu]   'I drink'

     f. [unóŋa]   'a drink'

     g. [isóɣo]   'he decorates'

     h. [soɣóŋa]   'decoration'

The fact that vowels lax before the velar nasal is most clearly shown by comparing (34e, f) or (34g, h). Each pair involves the same morpheme and the final vowel of the stem can be seen to lax before the nominalizing suffix.

This rule is very simply stated as below. It could be applied in either direction or simultaneously with no difference in output.

(35) $\begin{bmatrix} + \text{ syll} \\ - \text{ low} \end{bmatrix} \rightarrow [- \text{ tense}] / \underline{\hspace{1cm}} \begin{bmatrix} + \text{ nasal} \\ - \text{ ant} \end{bmatrix}$

2.4 <u>Feeding and Bleeding Reconsidered</u>. There are very
meaningful things to be said about feeding and bleeding appli-
cations aside from the fact that these cases constitute some
of the best evidence for determining the nature of rule appli-
cation. For example, several of the rules given above involve
feeding application: Tshiluba <u>l</u>-nasalization, Arabela vowel
nasalization, and Southern Agaw vowel raising. All of these
cases share something in common -- they are clearly <u>assimila-</u>
<u>tory</u> processes. That assimilatory processes should tend
toward feeding application is quite natural since the effect
of the rule is to modify a segment to become more like the one
which caused the change. It stands to reason, then, that the
derived segment is likely to be able to cause a further change
by itself.

The examples given of bleeding application were Woleaian
low vowel dissimilation, Warao and Southern Paiute alternating
stress, Klamath deglottalization, and Eastern Ojibwa glide
formation. There is good reason for considering all of these
to be <u>dissimilatory</u> processes. The way in which an alternating
stress rule is stated in the directional theory clearly
attributes the stressing of one vowel to the unstressed charac-
ter of the adjacent vowel -- a dissimilation. The most basic
context for Klamath deglottalization is before another
glottalized segment -- another dissimilation. Finally, Eastern

Ojibwa glide formation converts a vowel to a glide before another vowel, likewise a dissimilation.

In the case of dissimilations it is reasonable to expect a bleeding or "alternating" pattern to develop. In dissimilation we begin with a sequence of like things and make one less similar to the others. The result is to make it unlikely that this modified segment will have the properties required to cause a change in another segment. It has become unlike the very factor that caused the rule to apply in the first place.

It is possible to conceive of cases where dissimilatory rules may actually be feeding. One would be an exchange rule such as the following. Suppose that for any sequence of syllables involving a liquid and a vowel the first liquid dissimilates from the second liquid in laterality:

$$(36) \quad \begin{bmatrix} + \text{ son} \\ + \text{ cons} \\ - \text{ nas} \end{bmatrix} \rightarrow [-\alpha \text{ lat}] / \underline{\quad} [+ \text{ syll}] \begin{bmatrix} + \text{ son} \\ + \text{ cons} \\ - \text{ nas} \\ \alpha \text{ lat} \end{bmatrix}$$

In this case if we had a sequence /rV1V1/ we would have the following derivation:

(37) /rV1V1/

rVrV1	first application
1VrV1	second application

Such circumstances are undoubtedly rare if they exist at all.

When there is any possibility that one application of a
rule can affect a subsequent application, the following
generalization holds:

(38)   Assimilatory processes are conducive to feeding
        application and dissimilatory processes are conducive
        to bleeding application.

Neutral rules, which by definition are those where one applica-
tion cannot affect a subsequent application, are irrelevant to
this generalization.

Kiparsky in his discussion of feeding and bleeding orders
formulates the following hypotheses:

(39) a. Feeding order tends to be maximized.

     b. Bleeding order tends to be minimized.

How far may the analogy between rule ordering and rule applica-
tion be pushed? Are the analogs to (39) applicable to the
domain of rule application?

(40) a. Feeding application tends to be maximized.

     b. Bleeding application tends to be minimized.

In some sense there is validity to this extension, in
that dissimilation is much less common in general than assimila-
tion. For certain types of rules, however, dissimilation is
both common and obviously "natural". Examples of this type
are glide formation rules, which are dissimilations to adjacent
vowels, and alternating stress rules, which are dissimilations

to adjacent unstressed vowels. In these cases we certainly do not expect a historical change which would make them assimilatory (or feeding) in character. The forces that motivate them are clearly of a nature which yields alternating or dissimilatory patterning.

3.0 <u>Predictability of Directionality</u>. According to the theory advanced by Johnson, directionality is an ad hoc property of phonological rules. Each rule may have associated with it a marker indicating the direction in which the rule is to be applied. For rules which are self-feeding or self-bleeding in character, there will generally be different empirical consequences depending upon the direction in which the rule is applied. Such a theory, then, allows the generation of approximately double the number of different outputs as the number of rules in this class.

Suppose that it could be shown that each rule must be applied in a given direction across a string. A theory that is revised to incorporate this predictability will be capable of generating only a single output for each rule rather than the two generated by a theory with ad hoc directionality. As a result, a certain subset of phonological processes described by the theory with ad hoc directionality cannot be described by the revised theory. Whether this is a vice or a virtue, of course, is contingent upon whether there are any empirically valid cases which fall into the controversial subset of

describable rules. If none exist, the more restrictive theory (the one with predictable directionality) is more highly valued.

A major claim of this work is that the directionality of a rule is predictable from its formal properties. To illustrate the relevant properties, I shall repeat below the _rightward_ rules which have already been presented:

(41)   TSHILUBA L-NASALIZATION

$$[+ \text{lat}] \rightarrow \begin{bmatrix} + \text{nasal} \\ - \text{lat} \end{bmatrix} / [+ \text{nasal}] \, V_o \, \underline{\quad}$$

(42)   ARABELA VOWEL NASALIZATION

$$[- \text{cons}] \rightarrow [+ \text{nasal}] / [+ \text{nasal}] \, \underline{\quad}$$

(43)   SOUTHERN PAIUTE ALTERNATING STRESS

$$[+ \text{syll}] \rightarrow [+ \text{stress}] / \breve{V} \, C_o \, \underline{\quad}$$

The most obvious quality that these three rules share is that the segment to be affected (henceforth the _focus_ of the rule) is on the right extreme of the environment. A look at the leftward rules presented thus far demonstrates that the opposite condition holds for these rules:

(44)   SOUTHERN AGAW VOWEL RAISING

$$\begin{bmatrix} + \text{syll} \\ - \text{low} \end{bmatrix} \rightarrow [+ \text{high}] / \underline{\quad} C_o \begin{bmatrix} + \text{syll} \\ + \text{high} \end{bmatrix}$$

(45)   WOLEAIAN LOW VOWEL DISSIMILATION

$$\begin{bmatrix} + \text{syll} \\ + \text{low} \end{bmatrix} \rightarrow \begin{bmatrix} - \text{back} \\ - \text{low} \end{bmatrix} / \underline{\quad} C_o \begin{bmatrix} + \text{syll} \\ + \text{low} \end{bmatrix}$$

(46)   WARAO ALTERNATING STRESS

$$[+ \text{ syll}] \rightarrow [+ \text{ stress}] / \underline{\quad} C_o \begin{bmatrix} + \text{ syll} \\ - \text{ stress} \end{bmatrix}$$

(47)   EASTERN OJIBWA GLIDE FORMATION

$$\begin{bmatrix} + \text{ syll} \\ - \text{ low} \end{bmatrix} \rightarrow \begin{bmatrix} - \text{ syll} \\ + \text{ high} \end{bmatrix} / \underline{\quad} [+ \text{ syll}]$$

KLAMATH DEGLOTTALIZATION is also clearly a leftward rule which
would parallel the ones above in terms of the relative location
of its focus.

Is this relationship between the directionality of a rule
and the position of its focus an accidental one? It is my
claim that the relationship is _not_ accidental and that it
suggests that an intuitively reasonable and linguistically real
principle is in operation. In each case, the rule is applying
from the conditioning factor toward the focus of the rule. In
phonetic terms, we can say that the conditioning factor exerts
a force (usually assimilatory) on the focus and this force is
either progressive or regressive. In a regressive or anticipa-
tory assimilation, the effect extends to the left of the
conditioning factor and hence the rule is leftward. In a
progressive assimilation the effect is rightward.

Since the "conditioning factor" now serves two functions --
(1) constituting the phonetic motivating force for the change
and (2) determining the direction of the rule -- I will hence-
forth use the term _determinant_ to refer to it. The fundamental
principle for predicting directionality is then:

(48)   A rule is applied across a string from the side

corresponding to the location of the determinant to

the side corresponding to the focus.

This principle will be further developed in following chapters.
It has numerous interesting implications which bring about
greater theoretical simplicity and also appears to be more
adequate to handle many phonological phenomena.

4.0 Preliminary Informal Statement of Algorithm. In
proposing a theory as to how phonological rules are applied
it is important to be as precise as possible, for it is only
when a position is made explicit that it can be challenged and
falsified. In this section I will provide an initial statement
of what directional rules mean, which will be revised and
extended in several important respects later in this work.

The application of a phonological rule involves two basic
operations. The first is a procedure for matching a string and
a rule to determine whether the string meets the structural
description of the rule. The second is the modification of
the string to be made in accordance with the structural change
of the rule. By and large, theoretical differences with regard
to application of rules rest primarily upon the way in which
a string is matched with a rule rather than upon the modifica-
tion procedure. I will therefore focus in this section upon
the matching algorithm.

A phonological string involves a sequence of fully specified matrices, together with lexical category symbols, syntactic bracketing, and certain information about exceptionality, etc. A fully specified matrix is one in which every universal feature is mentioned, together with a plus, minus, or integer value for each feature. For the purposes of this discussion, I will refer to each matrix, category symbol, etc. in the string as a segment.

A rule consists of two basic parts, a structural description and a structural change. The structural description specifies the requirements that a string must meet in order to undergo the modification, while the structural change specifies the particular nature of the modification. The structural description of a rule likewise consists of a sequence of matrices, category symbols, etc., but these are generally only partly specified, mentioning only the subset of features which define the requirements the string must meet. A more important distinction between a phonological rule and a string is that the rule often contains abbreviatory devices such as parentheses, subscripts, etc., which a string may not contain. These devices are intended to capture generalizations and may be regarded for our purposes here as special instructions about how to match the rule against the string. Some of these devices will be considered in subsequent chapters. In this immediate context I shall only deal with the most simple cases of matching where no abbreviatory devices are used.

To illustrate the matching algorithm, consider the following modified version of the Southern Agaw vowel raising rule:

(49)
$$\begin{bmatrix} + \text{ syll} \\ - \text{ low} \end{bmatrix} \rightarrow [+ \text{ high}] \; / \; \underline{} \; [- \text{ syll}] \; \begin{bmatrix} + \text{ syll} \\ + \text{ high} \end{bmatrix}$$

C   C   B   A

This rule has been simplified for expository purposes by removing the subscript zero from the [- syll] element in the environment. Each element in the structural description has been assigned a letter in order to facilitate reference to it in the following discussion.

How is this rule applied to a given string of the language? Take the form /#deketí#/ as an example. The leftward directionality of the rule is an instruction to begin the matching process at the rightmost extreme of both the word and the rule. Each match is a pairwise relationship between one element in the rule and one segment in the string. The first attempt to match is illustrated below:

(50)
$$\overset{C}{\begin{bmatrix} + \text{ syll} \\ - \text{ low} \end{bmatrix}} \quad \overset{B}{[- \text{ syll}]} \quad \overset{A}{\begin{bmatrix} + \text{ syll} \\ + \text{ high} \end{bmatrix}} \qquad \text{rule}$$

d e k e t í   #   string

   8 7 6 5 4 3 2   1

Again, I have labelled each segment in the string with a number to facilitate reference. The letters and numbers are assigned in such a way that the earliest letter and lowest number are

at the rightmost extreme of the rule and string, respectively.
The match between A-1 clearly fails, but the match between
A-2 is successful.

What does it mean to say that an element in a rule and a
segment in a string <u>match</u>? Matching is an inclusion relation-
ship, such that the string segment is included in the set
defined by the partially specified matrix of the rule. The
match A-2 is <u>successful</u> because the fully specified segment
<u>i</u> falls within the set of high syllabics defined by A. On the
other hand, the match A-1 <u>fails</u> because the matrix corresponding
to the symbol # does not fall within the set defined by A.
The structure of the theory and notation we are using makes it
quite obvious whether a string segment is or is not included
within the set defined by a rule element. If the segment
contains a feature value which is <u>contradictory</u> to the value
for the same feature in the rule element, the match fails.
A contradiction occurs when the rule element is specified with
a plus, minus, or integer value for some feature and the seg-
ment has a different value for that same feature.[10] If there
is no contradiction, the match succeeds.

It is useful to differentiate between the <u>pairwise match</u>
of a single segment and a single element in a rule, and a
<u>match sequence</u>. A match sequence is a series of pairwise
matches terminated by one of three conditions: (1) all elements
in the rule have been matched with corresponding string
segments, indicating that the structural description of the

rule has been satisfied; (2) all segments in the string have been exhausted, but the rule elements have not; or (3) a pairwise match between a segment and a rule element fails.

In the above example, the first match attempted was between A and 1. Since 1 is not included in A, the match failed. This also ended the match sequence begun at 1. The next step was to attempt a match between A and 2, which in fact succeeded. Since none of the three conditions mentioned in the preceding paragraph are met, the following match will be in the same match sequence. That match will be between B and 3.

It is easier to discuss the matching process if the notion of markers is introduced. Let us say that when a string segment and a rule element are being matched, a match marker is associated with each of them. The match marker associated with the string segment will be called a string marker and that associated with the rule element will be called a rule marker. In addition, a sequence marker will indicate the string segment at which each match sequence begins.

In matching A-2, the rule marker will be at A and both the string marker and sequence marker will be at 2:

(51)   C   B   A   # d e k e t í #
                                 8 7 6 5 4 3 2 1
                      •
                •   •
                                             •

Since that match is successful, both match markers are advanced and the next pairwise match attempted between B and 3:

$$\begin{array}{cccccccc} & & & & \# \ d \ e \ k \ e \ t \ \acute{\text{\i}} \ \# \\ (52) & C & B & A & 8 \ 7 \ 6 \ 5 \ 4 \ 3 \ 2 \ 1 \end{array}$$

Notice that the sequence marker remains at the same location, indicating the point at which the match sequence was begun. Finally, the match C-4 will be attempted and successful, completing the match sequence:

$$\begin{array}{cccccccc} & & & & \# \ d \ e \ k \ e \ t \ \acute{\text{\i}} \ \# \\ (53) & C & B & A & 8 \ 7 \ 6 \ 5 \ 4 \ 3 \ 2 \ 1 \end{array}$$

The successful completion of the match sequence indicates that the string segment corresponding to the dash in the rule (C in this case) will be subject to the modification stated in the structural change. The string #deketí# thus becomes #dekití#.

Under the assumption of simultaneous application of rules as in the SPE theory, for rules such as the simple case under consideration here it makes no difference where a match sequence is begun or what happens to the sequence marker at the termination of each sequence. The algorithm need only be able to determine which segments belonging to the type specified as the focus occur in the correct environments. The order in which these segments are determined is inconsequential, since no changes will be effectuated until all such segments are identified. When the basic assumption changes, however, so that rules are allowed to apply to their own outputs, the question of from where the first match sequence and each

subsequent sequence is attempted becomes a significant one. In many such cases, there is an empirical consequence to the choice.

The fundamental claim of a theory with predictable directionality is that the choice of a point from which the first match sequence originates is fixed -- namely, at the end of the string corresponding to the position of the determinant in the rule. Upon completion of each match sequence, however, where do we reposition the sequence marker? That is, from which point in the string is the next match sequence attempted?

One possibility which can immediately be eliminated is that the sequence marker moves to any point more advanced in the string (to the left of, in a leftward rule; to the right of, in a rightward rule) than the previous focus. If such were the case it would preclude the possibility that the change in a string made on one application of a rule could affect a second application. That is to say, this view is not congruent with the notions of "self-feeding" or "self-bleeding" as espoused here.

Another alternative would be to move the sequence marker to the beginning of the string -- that is, to the point from which the first match was attempted. Obviously this cannot be done when a match sequence fails, since failure of the first pairwise match would result in infinite cycling upon that pair. It would be possible to advocate that after each successful match sequence the sequence marker is returned to the beginning

of the string, however. This is what Johnson refers to as
iterative application, using the term in a specialized sense
differentiated from his linear application (or my directional
application), which would normally also be called iterative.
Johnson points out that this mode of application allows
generation of languages which are not finite-state in character,
and therefore adds to the power of the theory, an undesirable
consequence. Furthermore, it creates difficulties with the
formulations of certain rules, since it permits multiple
application of a given rule to the same segment. An example
of such a rule is the vowel shift rule of English, according
to the analysis in SPE, which is of the basic type known as
"exchange" rules:

(54)   [α f] → [-α f] / X ___ Y

The output of this rule is always potential input to the same
rule and if iterative application is allowed in Johnson's sense
rule (54) would keep reapplying to the same segment ad infinitum.
A similar problem would be posed by a rule which converted t
to d and d to ð intervocalically. By this application algorithm
the rule would apply to an intervocalic t to derive d but a
subsequent application will convert the derived d to ð. It
would thus be impossible to block the change of t to ð.[11]

While both of these algorithms appear to be incorrect,
other candidates present themselves. One possible algorithm
is to move the sequence marker one segment forward after each

match sequence, regardless of whether the termination of that
sequence was due to success or failure. In the string under
discussion, after the first application of the rule the string
and sequence markers would both be positioned on the segment
immediately to the left of the point from which the preceding
sequence was begun:

```
                              # d e k i t í #
(55)      C     B     A       8 7 6 5 4 3 2 1
                •                       •
                                        ;
```

In simple rules of this type, there would be as many match
sequences as there are segments in the string, since the
sequence marker is only moved one position at a time.

An alternative to this view is that the sequence marker
advances one position each time a match sequence ends in
failure, but that if the sequence is successful the marker
moves to the segment undergoing the change. For purposes of
this discussion the algorithm under consideration may be termed
the "complex advance" algorithm and the one characterized by
moving the sequence marker a single position regardless of the
reason for terminating the sequence may be referred to as a
"simple advance" algorithm.

These two algorithms appear to have different empirical
consequences, but only in a fairly small subset of rules in
which various optional elements may appear. Under special
circumstances, the simple advance algorithm could conceivably
cause a single segment to undergo a change more than once where
the complex advance algorithm would not allow it.

Consider, for example, the rule of vowel harmony in Finnish to be discussed in greater detail in Chapter V. According to Kiparsky (1968b), back vowels are modified in such a way that native words conform to the generalization that all vowels in the word belong either to the harmonic set (i, e, u, o, a) or the set (i, e, ü, ö, ä). Notice that the vowels i and e are "neutral" in that they may appear with vowels of either harmonic set. The vowel harmony rule in question makes a back vowel agree in backness with a vowel preceding it. The vowel causing the modification may be separated from the vowel to be changed only by a sequence of neutral vowels; in all other cases it is the immediately preceding vowel. Thus, the sequence aCu does not change (or rather the u changes vacuously), nor does the sequence aCiCu since the intervening vowel is neutral. If the sequence is äCu or äCiCu where the ä is derived by a previous application of the rule (or perhaps is the result of a morpheme structure condition -- cf. Chapter V), the u harmonizes and becomes fronted. If the only preceding vowel is neutral, it functions as a front vowel and causes a change: e.g., #CiCu... becomes #CiCü...

Suppose that we are confronted with a string of the following shape: CaCiCiCu. With either the simple or complex advance algorithm, the first match sequence will involve all four vowels. The sequence begins with the cause of the (vacuous) change, namely a, includes the neutral vowels i, and ends with the back vowel that is the focus of the rule.

In terms of the complex advance algorithm, the next match sequence will begin with the preceding focus, namely u. With the simple advance algorithm, however, the sequence marker would be moved only one step at a time, first to the C following the a and then to the neutral vowel i. By beginning a match sequence with a neutral vowel the algorithm will yield an incorrect result, fronting the u that follows. It thus appears that cases like Finnish vowel harmony support the complex advance algorithm over the simple advance algorithm.

The purpose of this discussion has been to provide a somewhat more explicit account of what is meant by directional rules. Some of the terminological points that arose, such as the notion of "match" or "match sequence" will allow greater clarity in developing further the notion of directional rule later in this work. It should be clear, also, that different algorithms commonly make different empirical claims and when algorithms are sufficiently clarified they can be subject to falsification.

5.0 _Summary_. The principal evidence supporting directional rules must come from cases which are self-feeding or self-bleeding, since here there is empirical content to a difference in mode of application. In this chapter, therefore, I have attempted to illustrate these self-feeding and self-bleeding rules and to discuss some of their basic properties. Self-feeding rules were shown to be strongly correlated with

assimilatory processes and self-bleeding rules with dissimila-

tory processes. The position was taken that rules are applied

in a direction that is predictable from the shape of the

rules themselves -- in particular, from the relative locations

of focus and determinant. Finally, an initial attempt was

made to characterize somewhat more precisely what is meant by

a directional rule through the discussion of various possible

algorithms for matching a rule with a string.

[1] It is possible for rule A to feed rule B in the order A, B and for rule B to feed rule A in the order B, A. Koutsoudas et al. (1971:2), by taking such factors into consideration, expand the total number of possibilities to nine.

A significant development of this idea was made by Anderson (1969), where he argued that the question of natural or "unmarked" rule orderings is not a diadic relationship between rules but rather a triadic relationship between rules and a form to which they apply. Thus two rules applied in the order A, B may be feeding with regard to one linguistic form but nonfeeding or even bleeding in relation to another linguistic form. Anderson assumes that the rules will tend to apply in the order that is optimal in relation to each form. That is, different forms may undergo the rules in a different order.

[2] The terms "self-feeding" and "self-bleeding" have been suggested to me independently by Steve Anderson and Bob Hsu.

[3] The same surface string could be derived from either a stem with underlying 1 or one with underlying d.

[4] The facts described above are not peculiar to Tshiluba. A great many western Bantu languages also convert a liquid to a nasal in the syllable following a nasal consonant. In Kongo (Laman 1936:LV-LVI), Lamba (Doke 1938:203, 235, etc.), Ndonga

and Herero (Brincker 1886:9-10) it is clear that nasalization

of a sequence of syllables containing liquids takes place just

as in Tshiluba. Herero is additionally interesting in that

the liquid is r rather than l. Two further examples of lan-

guages in which l is converted to n in the syllable following

a nasal consonant are Mbundu and Kuanyama (Meinhof 1932:180-81),

but I have been unable to locate material on these languages

which will demonstrate whether or not the effect spreads to

sequences of syllables. It is clear, however, that the

phenomena observed in Tshiluba are not idiosyncratic of that

language.

[5] The association of nasalization with glottal and

pharyngeal consonants and with low vowels is well attested.

Art Crisfield has pointed out to me that in Thai (Noss 1964:15),

low vowels are nasalized after nasal consonants, /h/, and in

"zero initials": /'maa/ 'come', /'hɛɛ/ 'parade', and /'ɔɔg/

'exit'. What Noss represents as a "zero initial", however,

begins phonetically with a glottal stop, which is almost cer-

tainly the cause for the nasalization. For other examples of

the association between glottal and pharyngeal consonants

and nasalization see also Ohala 1971 a, b, c, Hetzron 1969b

(but Leslau 1970 for a different view), and the treatment of

Sundanese vowel nasalization presented in Chapter III.

It is also worth noting that nasalized vowels are

associated with h and glottal stop in certain English expressions,

such as the interrogative huh? and the exclamations for 'yes'
and 'no' represented roughly as uh huh and uh uh, respectively.
That this is not an isolated idiosyncracy of English can be
seen in the following quote from Bright (1957:11) concerning
the Karok language:

"Certain vowel sounds, found in exclamations, either
do not occur at all elsewhere, or do not occur else-
where in the same phonetic environment. Thus nasalized
vowels occur in hậ. 'yes' and ha?i. (exclamation of
annoyance)."

[6] The use of [- cons] to the left of the arrow in this
formulation implies that glottal stop could also be nasalized.
There are two solutions to this problem. First, glottal stop
is predictable in Arabela and therefore the rule inserting it
could be ordered after the nasalization rule. The second
possibility is that the glottal stop is indeed nasalized --
i.e., articulated with the velum lowered. I suspect that the
latter alternative is correct. For discussion of a directly
related case, see my treatment of vowel nasalization in Sunda-
nese in Chapter III.

[7] It appears from Hetzron's description that these
phenomena are somewhat more complex than the facts above. Part
of this complexity is certainly a direct consequence of the
model in which his work was done. In any case, the general
character of the analysis seems to be sound.

[8] A subsequent rule reducing short vowels to u before w will convert this string to eninuwak (cf. Bloomfield 1956:5).

[9] The forms of the suffix morphemes are as in Sohn. The treatment of the stem-final consonant and an assumed epenthetic a is a modification of his treatment, however, for which he should not be held responsible.

[10] The relationship between plus and minus values for a feature and integer values is a very important one. It is obvious that there is linguistic significance to fairly fine dist_nctions on each phonetic continuum, yet at the same time there are strict limitations upon what feature values can function contrastively. The standard view -- and very probably the correct one -- is that features at the level of underlying representations are binary and serve a classificatory function and that these are ultimately mapped onto n-ary scales which are phonetically more real. The question arises, then, as to how the conversion from binary to n-ary takes place. It would be tempting to hold that only the value 'plus' can be mapped onto an integer value other than 0. If such were the case, since 0 implies minus it would be possible to state that no contradiction occurs (and therefore there can be a match) when a rule specifies plus for a given feature and the segment with which it is being matched has any positive integer value. A more realistic position, however, is that a certain range of integers corresponds to the minus value for a feature as well.

This suggests that a segment may have various integer values for a feature and not contradict a plus (or a minus) for that feature in the corresponding rule element.

[11] The strength of this argument is contingent, of course, upon the existence of rules of these types.

CHAPTER III

PARENTHESES AND DISJUNCTIVE ORDERING

1.0 <u>Disjunctive Ordering</u>. Disjunctive ordering is a relationship between rules whereby the application of one rule is precluded by the application of the other. Its use in phonological theory is consistent with the notion of linear ordering, since one of the disjunctively ordered rules must be tried before the other. Disjunctively ordered rules thus constitute an internally ordered block.

A directional theory of rule application has very interesting consequences for disjunctive ordering. In this chapter I will first present a description of the role of disjunctive ordering in the standard theory, with special reference to its association with the parenthesis notation. The latter part of the chapter will view parentheses and disjunctive ordering from the perspective of a directional theory.

2.0 <u>Disjunction in the Standard Theory</u>.

2.1 <u>Properties of Parenthesis Notation</u>. Chomsky (1967) and Chomsky & Halle (1968) have offered an extremely profound proposal concerning disjunctive rule application. They note that rules which have been abbreviated with the parenthesis notation in generative analyses of language share several properties. The first two properties are purely formal: (1) the rules abbreviated by parentheses are similar in appearance, in that each performs the same operation as the other and the environment of one "is included in" the environment of

the other; (2) the rules are "adjacent"[1] in the ordering so
that they share the same crucial ordering relations with other
rules of the grammar.

In addition, there are two properties relating to rule
application. The first of these, which I will refer to as the
principle of longest expansion, states that the longest expan-
sion -- the rule that "includes" all of the other rules of the
disjunctively ordered set -- is the first rule that must be
tried. The second property is the principle of disjunctive
application which prohibits any member of a disjunctively
ordered set from applying if an earlier rule of that set has
already applied.

The notion of disjunctive ordering can be illustrated with
a well-known example from English. In the table below, the
verbs in column I have stress on the penultimate syllable,
those in columns II and III have stress on the final syllable,
and those in column IV have stress on their only syllable.

(1)

I	II	III	IV
astónish	maintáin	collápse	rún
édit	eráse	defénd	wín
elícit	devóte	adápt	gét

Chomsky & Halle note that the verbs in column I are character-
ized by ending in a weak syllable, containing a lax vowel and
at most a single consonant. They therefore propose the fol-
lowing rule:

(2) $V \rightarrow [1 \text{ stress}] / \underline{\quad} C_o \breve{V} C_o^1 \#$

This rule will correctly place the stress on the penultimate syllable of the forms in column I. It would be possible to write similar rules for columns II, III, and IV:

(3) a. $\begin{bmatrix} V \\ + \text{ tense} \end{bmatrix} \rightarrow [1 \text{ stress}] / \underline{\quad} C_o \#$

    b. $V \rightarrow [1 \text{ stress}] / \underline{\quad} C_2 \#$

    c. $V \rightarrow [1 \text{ stress}] / \# C_o \underline{\quad} C_o \#$

Chomsky & Halle cogently argue, however, that such a proliferation of stress rules misses a very basic generalization. The appropriate statement would seem to be that stress in English is basically <u>final</u> unless other special conditions are met, such as those given in (2). They therefore suggest that the phenomena in (1) are best explained by a pair of rules as follows:

(4) a. $V \rightarrow [1 \text{ stress}] / \underline{\quad} C_o \breve{V} C_o^1 \#$

    b. $V \rightarrow [1 \text{ stress}] / \underline{\quad} C_o \#$

The first member of this pair assigns stress to the penultimate syllable when the final syllable is weak and the second member, which is the "elsewhere" case, assigns stress to the final syllable.

This statement would capture the appropriate generalization perfectly except for one difficulty. If our assumption about rule ordering is that rules apply in a simple linear sequence, the forms in column I meet the structural descriptions of <u>both</u>

rules and would therefore incorrectly receive stress on both of the last two syllables. On this account Chomsky & Halle propose that the notion of disjunctive ordering be introduced into phonological theory to preclude the application of (4b) to strings which have already been subject to (4a).

2.2 <u>Disjunction as a Consequence of the Notation</u>. One possible position that might be taken is that disjunctive ordering is an option available to any pair of rules in a grammar. Such a position could be implemented by the free use of rule features (cf. Kiparsky 1968b; Chomsky & Halle 1968: 374-75; Lakoff 1965:I5-8) in the structural change of phono-logical rules. Thus, if I want to claim that rules 7 and 15 are disjunctively ordered I can add [- Rule 15] to the struc-tural change of rule 7. Together with the generally accepted convention that a segment must be specified [+ Rule n] to undergo Rule <u>n</u>, this addition to the structural change of rule 7 would make rules 7 and 15 disjunctively ordered. It can readily be observed that in order to make any more restrictive claim about the nature of disjunctive ordering than the one proposed in this paragraph, it is necessary to constrain the use of rule features considerably. Unless this is done any more restrictive claim will be empty.

A second position that could be taken is that there are certain necessary conditions for disjunctive ordering, such as the conditions mentioned in 2.1. This position implies that there is still a free choice between disjunctive ordering and

some alternative (say, conjunctive ordering), but that the circumstances under which disjunction is possible at all are well-defined.

The strongest position that could be taken is that there is a defining set of conditions which are both necessary and sufficient to establish disjunctive ordering. In this view there is no freedom of choice and disjunctive ordering is a direct consequence of other independent conditions of the grammar. This is, in fact, the position taken by Chomsky & Halle.

The strong position deserves some elaboration since its significance appears to be frequently overlooked. In the Chomsky & Halle view, there exists an optimal organization of any set of linguistic data or of any grammar. This is not to say that we know what constitutes an optimal organization on a priori grounds but rather that this is the fundamental question for linguistic research. It is also not a denial that there may be alternative "optimal" organizations. Rather, in such a case it is assumed that there is a restricted and definable set of optimal grammars as distinguished from non-optimal grammars which differ on more fundamental properties. Suppose, for example, that some speakers of English have an underlying representation for speak with /p/ while others have a representation with /b/. Current theory assumes that the optimal representation is with /p/ (Schane 1968b) and that therefore we must assume for all normal speakers a mental

representation with /p/. Current theory thus makes a claim divergent from our hypothetical truth. Would this lead us to conclude that there is no optimal representation? The answer to this question must be that there is no optimal representation for the second segment in speak that is more narrowly defined than the set {/p/, /b/}. However, such a situation would not destroy the fact that the grammar allowing this optionality is more nearly optimal than grammars allowing underlying representations beyond the set {/p/, /b/}. That is to say, the optimal grammar may allow some indeterminacy but it remains true that grammar is more nearly optimal in comparison with yet other alternative grammars.

This notion of an optimal organization is supportive of the idea of having an evaluation criterion or simplicity metric. If it is true that there is reason to prefer one grammar over another and that the child acquiring a language in fact makes such a choice, it must necessarily be possible to give an account of this choice by determining the factors taken into consideration and their "weighing". This is not an argument that a particular evaluation metric such as that found in Halle (1962) or the revised version found in Chomsky & Halle (1968) is correct, but rather that the notion of an evaluation metric, however complex it must be, is consistent with and follows from the notion of an optimal grammar.[2]

Chomsky & Halle utilize this general argument in the following way. They assume that the child, in acquiring his

language, determines the set of rules required to generate the
surface strings of that language and orders them in an optimal
way. He then regards certain pairs of rules as constituting
unitary generalizations of some sort, collapsing them into a
more abbreviated representation or schema. Such collapsing is
a recursive process (Chomsky 1967:121) by which a schema and
a rule may be further collapsed into a new schema. At this
point disjunctive ordering or its absence are determined on
the basis of the notation of representation involved.

The important thing to note here is that disjunction and
other modes of rule application are not considered relevant to
how rules are collapsed. The only thing that is relevant is
the shape of the rules themselves. Thus, given the pair of
rules in (4), there is an optimal representation (5) which is
determined by purely mechanical evaluation procedures from the
shape of the rules:

(5) $V \rightarrow [1 \text{ stress}] / \underline{\quad} C_o (\breve{V} C_o^1) \#$

It is then a <u>consequence</u> of parenthesis notation that the
second expansion is not allowed to apply if the first applies.

The mechanical nature of this process of collapsing is
well illustrated by the following footnote from Chomsky & Halle
(1968:30), as well as in numerous other places in the two
works in question:

(6)   "The question of when a sequence of rules is to be
         abbreviated by the parenthesis convention is not a

matter of choice but rather one of fact. That is, the convention regarding parentheses is just one part of an evaluation procedure to be applied to grammars. This procedure is perfectly general (language-independent) and performs the function of determining which of the grammars consistent with the data is to be selected as the grammar of the language for which the data provide a sample."

That disjunctive ordering is determined directly from the abbreviated set of schemata can be similarly shown in the following statement by Chomsky & Halle (1968:36):

(/)   "In earlier work these notations have been regarded solely as part of the system for evaluating grammars... But now we are also making use of the notations to determine how the rules apply, in particular, to determine disjunctive ordering. That is to say, we are proposing that certain formal relations among rules, statable in terms of the notations that are used for the evaluation of grammars, are significant in determining how the grammar generates derivations."

The claim made by Chomsky and Halle, therefore, is that the following hierarchy holds, where the arrow is to be read as "determines":

(8)   FORM OF THE RULES
                    ↓
              NOTATIONAL CONVENTION
                              ↓
                        MODE OF APPLICATION

As can be seen, the proposal offered by Chomsky & Halle
is a very strong position, the strongest of the three dis-
cussed above. Chomsky (1967:120) points out that this
position removes disjunctive ordering from the status of
being a "prime" of the theory, since it is uniquely determi-
nable from other facts of the grammar.

   2.3 Domain of Disjunction. In order to give content
to a proposal that disjunctive ordering is a property of
phonological rules it is crucial to establish the domain of
disjunction. In spite of occasional statements that disjunc-
tive ordering is a diadic relationship between pairs of rules,
it is clearly recognized by Chomsky & Halle that the relation-
ship is basically triadic, involving the pair of rules and
a string from that language:

(9) a. "... two rules R_1 and R_2, linearly ordered so that R_1
        precedes R_2, are said to be DISJUNCTIVELY ORDERED if
        R_2 cannot apply to a given string at a certain stage
        of the cycle if R_1 has already applied to this string
        at this stage of the cycle." (Chomsky 1967:120)

     b. "A certain subsequence may form a block of rules which
        are 'disjunctively ordered' in the sense that if one
        of these rules applies to a certain substring, the

other members of the block are not applicable to this

substring in this stage of the cycle." (Chomsky &

Halle 1968:60)

The question that must be resolved, then, is what is the

"given string" or "certain substring" spoken of in the above

two paragraphs, which define the domain over which the dis-

junctive relationship is applicable? This question is clearly

not a trivial one, but absolutely crucial to any meaningful

claim about disjunctive ordering.

In the remaining parts of section 2.3 several hypotheses

about the domain of disjunction will be discussed. Within the

general framework of SPE it can be shown that the domains of

disjunction that have heretofore been proposed are clearly

falsifiable, although a revised hypothesis might be capable of

accounting for the facts.

2.3.1 Word-Level Disjunction. The impression one derives

from reading the first several chapters of SPE is that the

domain of disjunction is the word. In considering a case like

edit and why it does not receive two stresses, it is very easy

to conclude that the second stress rule is blocked because the

first stress rule has already applied to that word.

It is quite clear that within the general framework of

SPE the domain of disjunction cannot be the word. A myriad of

examples could illustrate this point. One of the earliest

sources of my own skepticism with regard to disjunctive

ordering was the observation that it would make incorrect and counterintuitive claims about a rule such as aspiration in English. One environment in which aspiration applies is when a voiceless stop precedes a stressed vowel, whether or not there is an intervening liquid or glide. Consider, for example, the following words:

(10)   appease   appraise   applaud   acquire   acute

In each case the first consonant of the word is aspirated before a stressed vowel, although appraise and applaud have intervening liquids and acquire and acute have intervening glides.

These facts may be expressed in the following rule:[3]

(11) $\begin{bmatrix} - \text{ cont} \\ - \text{ voice} \end{bmatrix}$ → [+ asp] / ___ ($\begin{bmatrix} - \text{ syll} \\ + \text{ son} \\ - \text{ nasal} \end{bmatrix}$) [+ stress]

If word-level disjunction is assumed, the theory would predict that if a word contains two voiceless stops, one immediately before a stressed vowel and the other separated from the following stressed vowel by a liquid or glide, only the latter would aspirate. Since (11) abbreviates a pair of rules which are disjunctively ordered, when the first expansion applies to the latter sequence it would preclude the second expansion from applying to the former sequence. It seems quite clear that word-level disjunction makes a claim here that is not only false but counterintuitive. In a word like proCRAstinaTOry, the capitalized sequences are possible inputs

to (11). Word-level disjunction would predict that the last
_t_ of the word would _not_ aspirate, counter to fact. That such
a phonetic rule could be prevented from applying by considera-
tions such as these seems completely contrary to our beliefs
about how language works.

A similar case is given in Johnson (1970a:127-30), who
points out that the rule that tenses and unrounds underlying
lax /u/ in English appears to falsify the notion of disjunctive
ordering:[4]

$$(12) \quad \begin{bmatrix} - \text{ tense} \\ + \text{ back} \\ + \text{ high} \end{bmatrix} \rightarrow \begin{bmatrix} + \text{ tense} \\ - \text{ round} \end{bmatrix} / \underline{\quad} C_0^1 \left(\begin{bmatrix} \alpha \text{ voc} \\ \alpha \text{ cons} \\ - \text{ ant} \end{bmatrix} \right) [- \text{ cons}]$$

Johnson points out that the word _usual_ involves one
instance of lax /u/ before a consonant followed by a noncon-
sonantal segment and one instance of /u/ immediately before a
nonconsonantal segment. If word-level disjunction were valid,
the second /u/ would be prevented from undergoing the rule
because the first expansion would have applied. Thus, this
is a second case where word-level disjunction gives a false
statement about disjunctive relations, given the other aspects
of the framework presented in SPE.

2.3.2 _Environmental Disjunction_. Bever (1967:110-11)
proposed an alternative principle of disjunction which he called
"segmental disjunction". According to this principle, when
the longer of a pair of disjunctively ordered rules is matched
against a string, each segment of the string corresponding

to an element in the <u>environment</u> of that rule is marked with a [- Rule] feature so that it cannot undergo the next rule. The term "segmental" was used to characterize this notion of disjunctive ordering presumably because segments in the string are marked with the [- Rule] feature. For reasons that will appear obvious in the next section, I prefer to characterize this form of disjunction on the basis of the <u>domain</u> over which this restriction holds, namely the segments corresponding to the elements in the entire environment of the rule.

The operation of environmental disjunction may be illustrated with a rule of the following abstract form:

(13)   A → B / ___ (A) C

A sequence AAC will be matched first against the longest expansion of (13). The first instance of A will be changed by the application of that rule. By the principle of environmental disjunction, the second A and the C will be marked with a [- Rule] feature for the next rule since they correspond to the elements in the environment of the rule. Thus, the final result is BAC. On the other hand, given an input string AACAC, the same facts hold true for the first three segments but the final AC do not correspond to any elements in the environment of the first application of the rule and are thus not marked with [- Rule] features. This enables the second expansion to apply, yielding the final string BACBC. This output differs from that yielded by word-level disjunction (BACAC) or from having no disjunctive ordering at all (BBCBC).

It is easy to demonstrate that environmental disjunction is incorrect within the SPE framework. The example of tensing and unrounding of /u/ given in the preceding section not only falsifies word-level disjunction but also environmental disjunction. Consider again the word usual. Since the second u corresponds to an element in the environment for the first expansion, it will be marked as unable to undergo the shorter expansion. The derived form would then be *[yūwzūwəl].[5] The incorrectness of this derivation is directly attributable to the principle of environmental disjunction.

A similar example would be a rule which lengthens a vowel in an open syllable:

(14)

$$V \rightarrow \bar{V} \ / \ \underline{\quad} \ \begin{Bmatrix} C_o^1 \\ \# \end{Bmatrix} \quad \begin{matrix} \text{(a)} \\ \text{(b)} \end{matrix}$$

According to Chomsky & Halle, (14a) abbreviates a pair of rules differing only in the presence or absence of the consonant. The two rules are thus disjunctively ordered. However, with either word-level or environmental disjunction, the string VCVVC would become $\bar{V}$CVVC instead of the expected $\bar{V}$C$\bar{V}$VC.

In the section of Chapter 8 where Chomsky & Halle introduce their own version of environmental disjunction they clearly intend it to replace word-level disjunction everywhere. It is noteworthy that even the move in this direction does not appear to add greater precision to the notion of domain of disjunction:

(15)   "When we try to make this notation precise, we

        immediately face a variety of cases where a specific

        decision arises as to how the formalization should

        proceed. There is no difficulty in principle in

        resolving these cases, one way or another, but having

        so little relevant information, it would be pointless

        to make these decisions. We therefore leave the

        matter in this semiformalized state, noting simply that

        further empirical evidence is needed to determine just

        how the relevant conditions should be formulated."

        (1968:366)

2.3.3 <u>Parenthetical Disjunction</u>. Since neither word-
level disjunction nor environmental disjunction are workable
within the SPE framework, one might propose a further modifi-
cation in the domain of disjunction which is still more limited.
Instead of marking all segments in the word as being unable to
undergo the second expansion if the first expansion applies,
or marking all segments corresponding to the environment of
the first expansion, a more limited alternative would be to
mark only the segments corresponding to the parenthetical
expression itself. The difference between environmental and
parenthetical disjunction can be illustrated by the following
rules:

(16) a. A → B / ___(A) C

     b. A → B / ___(C) A

With environmental disjunction, any A which corresponds to either A in the environments of the above rules will be marked as unable to undergo the shorter expansion of that schema. Under parenthetical disjunction, however, only an A which corresponds to an A in parentheses will be so marked. An A which corresponds to the A in the environment of (16b) will not be marked. Thus we would have the following derivations:

(17)   ENVIRONMENTAL   PARENTHETICAL

AAC	ACAA	AAC	ACAA	underlying string
BAC	BCAA	BAC	BCBA	output
(16a)	(16b)	(16a)	(16b)	

The cases that were used to falsify both word-level and environmental disjunction can be handled adequately with parenthetical disjunction. Consider again the rule for tensing and unrounding /u/. What was optional in that rule was the consonant between the u and the following vowel. With parenthetical disjunction the consonant would be unable to undergo the following rule, but the second u in usual would be free to undergo it. The same situation holds for the rule lengthening vowels in open syllables, where it is again the consonant which is optional, not the following vowel.

3.0 Disjunction Within a Directional Theory. In the preceding section I demonstrated that disjunctive ordering makes a valuable and profound claim about the nature of language. It allows us to state many generalizations that

are clearly linguistically significant in a concise and straightforward form. At the same time, the claims are not truly meaningful until the notation is well-defined, and the domain of disjunction is crucial in this regard. I have shown that word-level disjunction is overly restrictive and clearly falsified and that parenthetical disjunction is more in accord with the facts. In this section I will consider the role of disjunctive ordering within a directional theory of rule application and show that the same insights are capturable within this theory.

3.1 <u>English Romance Stress Rule</u>. Consider again the data presented in section 2.1 and the rule used to express these facts:

(18) $V \rightarrow [1 \text{ stress}] / \underline{\quad} C_0 (\breve{V}C_0^1) \,\#$

In the directional theory proposed here, rule (18) is predictably <u>leftward</u>.

In discussing the algorithm for applying rules directionally in Chapter II, the example used was simple in that it contained no abbreviatory devices. The question that must be raised here, then, is how rules with optional elements are to be treated. One possibility, of course, is to consider the two expansions of (18) to be separate rules which are sequentially applied to a string. This requires the adoption of a principle of disjunctive ordering similar to that needed within the standard theory.

For expository purposes let us consider the role of disjunctive ordering with reference to the algorithm provided in Chapter II. Recall that in simple expressions with no abbreviatory devices a sequence of pairwise matches were used to determine whether a rule can apply to a given string. When abbreviatory devices such as parentheses are used it is possible for more than one sequence of pairwise matches to be consistent with the rule. For example, the string #edit# allows two possible sequences of pairwise matches that will satisfy (18). The theory of rule application proposed in SPE requires that the longest expansion be attempted first. The principle of longest expansion must also be adopted in the directional theory in order to make the correct choice of match sequences with strings like #edit#. We may therefore state:

(19)   In matching a string with a rule, the longest possible
        match sequence must be attempted from any given point.

The effect of the principle of longest expansion is to correctly stress the first vowel of _edit_. By the algorithm presented in Chapter II, when this match sequence is completed the sequence marker is moved to the position of the first vowel of _edit_. This procedure makes it impossible for any further application to take place since there is no possible match sequence from that point which will satisfy the conditions of the rule. In this way, by the algorithm independently required for simple rules with no abbreviatory conventions, the

directional nature of the rule together with the principle of longest expansion yield disjunctive ordering. The principle of disjunctive application is thus independently motivated in the directional theory as part of the algorithm defining directional rules.

One additional problem arises when rules with abbreviatory conventions are considered. In deriving a word like _erase_ (from /#ērǣs#/), the longest expansion of (18) is partially fulfilled. It is not until the match between the vowel ǣ and the lax vowel in parentheses is attempted that the longest expansion fails. If the algorithm presented in Chapter II is maintained as stated, the failure of this match sequence would cause the sequence marker to be advanced and there would be no application of rule (18) to the string at all. This is obviously incorrect and what is required is that if the longest expansion is not satisfied, the next longest expansion must be attempted, and so on, until all possible expansions have been exhausted. Only then can it be said that the rule does not apply.

One modification that must therefore be made in our algorithm is that the sequence marker must not be advanced after failure of a match sequence unless that is the shortest expansion from that point. Recall that in the algorithm presented in Chapter II, the sequence marker is advanced differently depending upon whether the match sequence was successful or not. The facts of disjunctive ordering accentuate

the difference between success and failure, for when a given

expansion of a rule with optional elements is satisfied the

sequence marker is advanced immediately, but when that expan-

sion fails it is not advanced until the shortest expansion is

reached.

A second modification that must be made is that in order

to deal with shorter expansions when longer expansions have

been partially successful it is necessary to unmatch certain

pairs. For example, in deriving the word erase the final

consonant is matched with the optional consonant in parentheses

and when the longer expansion ultimately fails, it must be

matched instead with the subscripted consonant preceding the

parenthetical expression. In terms of the algorithm presented

here it would be necessary to keep track of the options that

have been taken in matching the string and, when a given option

fails, to return to the point where that option (the last

preceding one) was taken and to match the segment instead with

the rule element adjacent to that option. This may be thought

of as a kind of "layering" and "extraction" process. A more

formal account of this algorithm has been developed by Bob Hsu

of the University of Hawaii, with encouragement and occasional

assistance from Ron Scollon and myself.

It is perhaps easier to depict this layering and extraction

process, however, in the way that Chomsky & Halle presented it.

Rule (18) in their terminology represents a sequence of expan-

sions equivalent to separate rules and one first attempts to

match the longest expansion and then each shorter expansion until either one expansion is satisfied or all expansions are exhausted. The difference in these two ways of presenting the algorithm is essentially trivial and chosen primarily for expository purposes. There are some real differences in claim that are involved, but these are not necessarily fundamental components of the two types of statement. For example, Chomsky & Halle assume that there is an independent order of expansion for different abbreviatory devices contingent not upon their position in the rule but rather upon the type of device. Thus, there is a fixed order of expansion of braces in relation to parentheses, etc. I have assumed, however, that the order of expansion is such that successively shorter expansions of the optional elements nearest the focus must be taken first and optional elements nearest the determinant last. This constitutes an empirical difference in claim, but it is not crucial to either position.

Another difference is that the SPE framework is stated as if the domain of disjunction were the word. Yet, it has been argued earlier in this chapter that the notion of parenthetical disjunction is what is required. If this revision is made within the SPE theory, it will be necessary to speak of an order of expansion as related to different substrings centered about each potential focus. That is, there may be two or more (potentially overlapping) substrings upon which disjunctive ordering must be defined. This necessary

modification in the SPE theory thus makes it more closely

parallel with the directional theory, since the latter requires

disjunctive ordering to be defined <u>with the sequence marker</u>

<u>as a fixed point of reference</u>. Since the sequence marker may

be anywhere in a string, there is a possibility of utilizing

disjunctive ordering in more than one substring.[6]

It is important to add that this account of disjunctive

ordering within a directional theory is contingent upon having

predictable directionality. As a predictably leftward rule,

(18) yields the correct output by the algorithm I have

stated. If (18) were allowed to be a rightward rule, however,

the result would be application of the rule to both vowels of

<u>edit</u>. If the possibility existed of treating a rule like (18)

as rightward, the theory would fail to capture the significant

theoretical claims concerning disjunctive ordering made by

Chomsky & Halle in SPE. This point will be returned to in

Chapter VII in relation to a comparison of the directional

theory presented here with Johnson's linear theory.

3.2 <u>Latin Stress</u>. A case very similar to the rule

discussed above is the Latin stress rule as presented in

Schane (1969:28). In Latin, stress falls on the antepenul-

timate syllable if one exists and if the penultimate syllable

is weak (i.e., has a lax vowel and no more than one conso-

nant). Stress falls on the only vowel in monosyllables and

is penultimate under all other conditions. Schane offers rule

(20) to account for these facts:

(20) $V \rightarrow [+ \text{stress}] / \_\_\_ C_o ((\breve{V}C_o^1) VC_o) \#$

This rule abbreviates the sequence of expansions:

(21) a. $V \rightarrow [+ \text{stress}] / \_\_\_ C_o \breve{V}C_o^1 VC \#$

   b. $V \rightarrow [+ \text{stress}] / \_\_\_ C_o VC_o \#$

   c. $V \rightarrow [+ \text{stress}] / \_\_\_ C_o \#$

Latin stress, like English stress, is a leftward rule. The algorithm for rule application presented here will yield the correct disjunctive results as it did in the case of English stress.

3.3 _Komi Jaźva Stress._ A more interesting example was presented by Johnson (1970a:136-37) from Komi Jaźva, a Permian language (Uralic) spoken in Komi A.S.S.R. in the European part of the Soviet Union. According to Harms (1968:74), Komi Jaźva words are stressed on the rightmost vowel that is not preceded anywhere in the word by a tense vowel. Thus, stress falls on the first tense vowel of the word or, if the word contains no tense vowel, upon the final vowel of the word.

Johnson stated that the SPE framework is inadequate to capture the disjunctive ordering involved in Komi Jaźva stress. The parenthesis-star notation, necessary to express the idea "any number of syllables containing lax vowels", requires simultaneous application in the SPE framework and therefore would incorrectly stress _every_ vowel of the word that is not preceded by a tense vowel. Johnson claimed that these facts

could not be expressed within the SPE theory, but his claim is incorrect because the following rule, though definitely not very attractive, is adequate to deal with the relevant facts:

$$(22) \qquad V \rightarrow [+ \text{ stress}] \; / \; \# \; (C_o \breve{V})* \; C_o \left\{ \begin{array}{c} \left[\begin{array}{c} \overline{\qquad} \\ + \text{ tense} \end{array} \right] \\ \left[\begin{array}{c} \overline{\qquad} \\ - \text{ tense} \end{array} \right] \; C_o \; \# \end{array} \right\}$$

Johnson proposed his own way of handling Komi Jaźva stress but his device is of peripheral significance here and more relevant to the discussion in Chapter VII, so discussion of it will be delayed until that point in the exposition.

Within the directional theory of rule application, however, Komi Jaźva stress is simply and adequately accounted for. Consider the following rule:

$$(23) \qquad V \rightarrow [+ \text{ stress}] \; / \; \# \; (C_o \; \breve{V})_o \; C_o \; \underline{\qquad}$$

It follows directly from the explication of the revisions in the algorithm that are required in order to handle optional expressions with parentheses that rule (23) will yield the correct outputs for Komi Jaźva stress. By taking the longest expansion available and by advancing the sequence marker when some expansion is satisfied, rule (23) will apply disjunctively and stress the correct vowels. Thus, the directional theory differs from the simultaneous theory of SPE in claiming that subscripted expressions are <u>disjunctively</u> applied and Komi Jaźva stress is evidence that the claim made here is correct.[7]

3.4 <u>Sundanese Vowel Nasalization</u>. In his review of the
work of the London School, Langendoen (1964:318; 1968:100-1)
proposed a generative analysis of Sundanese nasalization that
appears to violate the conventions associating disjunctive
ordering with parenthesis notation. According to Robins
(1957),[8] vowels in Sundanese nasalize after nasal consonants
and the nasalization extends as far as the next supraglottally
articulated consonant (any consonant other than <u>h</u> or glottal
stop). If there is no following consonant, the nasalization
will extend as far as the end of the word. Langendoen proposes
the following rule to describe this phenomenon:

(24)   [+ voc] → [+ nasal] / [+ nasal] [- cons]$_0$ ____

There is a very curious wrinkle to Sundanese nasalization,
however, beyond that described by rule (24). Sundanese has a
plural infix of the shape <u>al/ar</u> which immediately follows the
first consonant of the stem, if the stem begins with a con-
sonant. Unlike the other supraglottally articulated consonants,
including <u>l</u> and <u>r</u> in other environments, this particular
consonant permits the passage of nasalization over onto the
following vowel sequence. An additional peculiarity is that
the vowel <u>immediately</u> following the plural infix is not
nasalized but the subsequent ones are. Thus there are contrasts
between forms like [mãriãk] from /m + ar + iak/ and [mãrios]
which is monomorphemic. Langendoen proposes to capture these
facts with the following rule:

(25) $[+ \text{voc}] \rightarrow [+ \text{nasal}]/[+ \text{nasal}](+ \text{Plural } [\ ])[- \text{cons}]_0\_\_\_$

This rule is intended to apply to /m + ar + iak/ in the

following way. First, the longest expansion will apply, skip-

ping over the plural morpheme and the following segment

(indicated as [ ]) and nasalize the remaining vowel, yielding

m + ar + iãk. Then the shorter expansion, identical to (24),

will apply to nasalize the vowel of the infix.

Although these rules are abbreviated with parentheses,

Langendoen clearly intends them to apply conjunctively rather

than disjunctively. In this sense, Sundanese nasalization

appears to be counterevidence to the proposal associating

disjunctive ordering with parentheses. Moreover, it would

also serve as a counterexample to the directional theory of

rule application proposed here.

The solution suggested by Langendoen is not a very natural

one, although it is straightforward and yields the correct

output if the restrictions on disjunctive application are

relaxed. There are two peculiarities to this problem, however:

(1) the consonant of the infix does not block the spread of

nasalization, and (2) the vowel following the infix doesn't

nasalize although the vowels after it do. Both of these

peculiarities are handled in an ad hoc way in rule (25) -- the

first by referring to the morpheme [+ Plural] and the second

by including the empty brackets [ ].

I propose that it is more natural to think of Sundanese

vowel nasalization as consisting of the interplay of several

rules. The first of these to be considered is:

(26)   [- cons] → [+ nasal] / [+ nasal] ____

Rule (26) is exactly the same rule that was posited for nasalization in Arabela. We can see its operation most clearly in a form like [mĩãk], which results from the sequential application of the rule to the two vowels.

Aside from the intricacies involved with the plural infix, (26) appears to have one failing. According to Robins, nasalization spreads over h̲ and glottal stop but is blocked by supraglottally articulated consonants, including y̲ and w̲. Yet rule (26) is stated as if all of these segments (vowels, h̲, y̲, w̲ and glottal stop) get nasalized. In spite of this discrepancy, I believe (26) to approximate the correct statement of the main nasalization rule in Sundanese.

Anderson (1972a), in a paper stimulated by an earlier draft of this dissertation has an extensive discussion of the problem of including h̲ and glottal stop in the rule. To use [- cons] as in (26) or in Langendoen's formulation is too broad, since y̲ and w̲ would be included and apparently nasalization neither passes over them nor do they become nasalized. There is no provision in the SPE feature system for stating the laryngeal glides and vowels together as a class opposed to the vocalic glides. The closest we could come is to have a disjunctive expression to incorporate the vowels and laryngeal glides and exclude y̲ and w̲.

Anderson recognizes three alternatives to the problem:
"First, we could simply accept the disjunctively defined class
just given, and deny that the class in question constitutes
a unified generalization; secondly, we might suggest a modifi-
cation of the feature system which would allow us to define
the class in question more naturally; or thirdly, we might
look for evidence that our formulation of the rule is incorrect."
(1972:22)

Anderson argues that the first two alternatives are
inappropriate and that the resolution of the problem lies in
the third. He points out that if the rule is an iterative (or
directional) rule there is no need to combine vowels and
laryngeal glides. One could state the nasalization rule thus:

(27)   [+ syll] → [+ nasal]/[+ nasal] ($\begin{bmatrix} - \text{ cons} \\ - \text{ syll} \\ - \text{ high} \end{bmatrix}$) ___

and simply include an optional laryngeal glide between the
nasal segment and the vowel to be affected in each case. How-
ever, this solution is possible only if the laryngeal glides
are not in themselves nasalized, for if they were the disjunc-
tive expression would reappear at the left of the arrow and
little would have been gained.

The question of whether the laryngeal glides are nasalized
appears to be answerable in terms of the kymographic tracings
presented in Robins (1957). Anderson points out that the nasal
tracings for h are sufficiently weak to suggest no nasalization,

even when between nasalized vowels. When <u>h</u> <u>immediately</u> follows a nasal consonant as in [bʏŋɦã̃r] the nasal tracing indicates true nasalization. Anderson thus concludes that there is a separate rule nasalizing <u>h</u> immediately following a nasal consonant, but otherwise <u>h</u> does not become nasalized. These facts would argue for his formulation of the nasalization rule as in (27).

This solution seems unreasonable in one principal respect. It is assumed that the velum is <u>raised</u> for <u>h</u> and glottal stop and then lowered again in articulating the following vowel. Yet, the very <u>reason</u> we would expect <u>h</u> and glottal stop to be skipped over is that they can be easily articulated with the velum lowered. For glottal stop, in particular, the position of the velum is entirely irrelevant since no air passes through the upper vocal tract during the articulation.

A further inspection of the kymographic evidence suggests the solution. During the articulation of intervocalic <u>h</u>, it is not only the nasal tracing which is weak but also the <u>oral</u> tracing. The instance of <u>h</u> after a nasal consonant shows <u>both</u> tracings very strong. In this instance Robins notes peripherally that the <u>h</u> is also voiced. The important fact, it seems to me, is that the nasal tracings for each type of <u>h</u> in this environment are parallel to their respective oral tracings. This suggests that the velum is open during the articulation and that the two cavities are thus subject to the same influences. I therefore believe that it is correct to consider <u>h</u> (and

presumably glottal stop) as being [+ nasal] in these environ-
ments, the feature nasal being defined in terms of the position
of the velum during the articulation.[9]

This modification still does not resolve the difficulties
posed by the grouping of vowels and laryngeal glides to the
exclusion of consonants and vocalic glides. I believe that
this difficulty represents an inadequacy in the feature system
and that what is relevant here, as Robins' statement assumes,
is the lack of a radical obstruction in the upper vocal tract.
Rather than construct and elaborate argument on the feature
system here (on admittedly sketchy evidence), I would rather
note that there is an articulatory parameter shared by vowels
and laryngeal glides that is not captured in the current
feature system and I will assume that it is relevant to the
formulation of this rule. With this simplifying assumption,
rule (26) is taken to be the basic nasalization rule of
Sundanese with the feature relating vowels and laryngeal glides
replacing [- cons] in that rule.

In an earlier analysis of this problem I proposed that
nasalization skipped over the plural morpheme (but not the
following vowel) to give the intermediate representation
m + ar + ĩãk. This was followed by a simple and natural rule
which requires that a vowel agree in nasality with an immediate-
ly preceding consonant.

(28)   [+ syll] → [α nasal] / $\begin{bmatrix} + \text{ cons} \\ \alpha \text{ nasal} \end{bmatrix}$ _____

Rule (28) would operate on the intermediate representation m + ar + ĭãk resulting from the first nasalization rule and would nasalize the vowel of the infix while denasalizing the vowel following the infix, correctly yielding [mãriãk].

Anderson cogently argues that the plural infix must be regarded as a prefix at some stage of the derivation. If infixation is ordered after nasalization, it will not be necessary to include reference to the plural morpheme in the nasalization rule, as was necessary in my original proposal and that of Langendoen. We would thus have the following derivation:

(29)   /ar + miak/

      ar + mĭãk   primary nasalization

      m + ar + ĭãk   infixation

      m + ãr + ĭãk   nasal agreement

Since Sundanese also has prefixes that remain prefixes, under what conditions does infixation take place? Aside from the plural infix, there are two other infixes: -in- and -um-. Anderson observes that these and only these "prefixes" have a VC form. He thus proposes a rule of infixation which metathesizes a VC prefix with a stem-initial consonant:

(30)   + V C # (C) V

       1 2 3 4 (5) 6 ⟹ 4 (5) 2 3 6

Anderson insightfully points out that this type of infixation has some phonetic motivation. By changing a VC#CV structure

to CVCV, a costly consonant cluster is broken up and the basic
canonical form preserved. Notice that prefixes of other
shapes (e.g., CV, CVC, C) will not give any advantage if they
are thus metathesized.

This proposal with regard to infixation has crucial
consequences for the analysis we have proposed. While the
ordering given in (29) works fine for the plural infix, it is
not adequate to deal with the other infixes. The infix -um-
can be added to a stem such as dɤhɤs 'to approach (a supe-
rior)' yielding dumɤhɤs. While Robins does not provide any
such form in phonetic transcription, it is reasonable to
assume that nasalization spreads here yielding [dumɤhɤs].
Given the same ordering assumptions as in (29), we would have
the following derivation:

(31)   /um + dɤhɤs/

    ----------   primary nasalization

    d + um + ɤhɤs   infixation

    *d + um + ɤ̃hɤs   nasal agreement

The crucial point here is that nasal agreement is not a
spreading rule since the vowel affected must be preceded by
a consonant. We must therefore assume that it is primary
nasalization which is responsible for nasalizing the vowels
in this word. This implies a different ordering:

(32)   /um + dɤhɤs/

             d + um + ɤhɤs   infixation

             d + um + ɤ̃h̃ɤ̃s   primary nasalization

             ---------------   nasal agreement

An ordering paradox such as this creates difficulties
for a theory based upon strict linear ordering, such as the
standard theory of SPE. Anderson, however, has proposed a
theory of <u>local ordering</u> that is based upon the natural
ordering between pairs of rules in terms of the considerations
advanced in Kiparsky (1968a). That is, the natural ordering
between a pair of rules A and B will be one that maximizes
feeding and minimizes bleeding. In this theory, it is
possible and even expected that the ordering of rules may be
different in relation to different forms. Anderson thus
assumes the following order of application:

(33)   primary nasalization

             infixation

             primary nasalization

             nasal agreement

It will also be noted that there is no adverse effect of
applying nasalization both before and after infixation in
the two examples considered.

        There are two principal ways in which this problem may
be handled within the general view of rule ordering of SPE.
First, and least attractive, would be to posit two different

infixation rules, one for the nasal infixes (which are derivational) and one for the plural infix (which is inflectional). The rule ordering would then be:

(34)   nasal infixation

primary nasalization

plural infixation

nasal agreement

This would be sufficient to derive both [mãriãk] and [dumỹhỹs]. There are obvious reasons for regarding (34) with scepticism. In particular, the separation of infixation into two rules would appear to be losing a generalization. However, it is not an entirely unreasonable analysis, in that the two classes of infixes are different in nature. Furthermore, consider the following forms from Robins (1959:356):

(35) a. gəde   'to be big'

b. guməde   'to be conceited'

c. garuməde   (regularly formed plural of
guməde)

The form garuməde illustrates double infixation. The order of infixes is consistent with the ordering of rules in (34).

The facts in (35), taken together with the nasalization processes under discussion, suggest another more plausible analysis within the more standard SPE theory of rule ordering. It is quite conceivable that the rules under discussion are applied as part of a phonological cycle. In this view, the ordering of rules would be:

(36)   1.   infixation

        2.   primary nasalization

        3.   nasal agreement

Infixation thus precedes nasalization on any given cycle.
Consider the following derivations:

(37)   [ar[miak]]   [um[dɤhɤs]]   [ar[um[gəde]]]

----	-----	----	1
[ar[mĭãk]]	-----	----	2
----	-----	----	3

[marĭãk]	[dumɤhɤs]	[ar[guməde]]	1
[mãrĭãk]	[dumɤ̃ɦɤ̃s]	[ar[gumə̃de]]	2
[mãriãk	-------	---------	3

[garumə̃de]	1
--------	2
--------	3

    A cyclic interpretation of the Sundanese nasalization
phenomena seems clearly a preferable treatment within the
ordering assumptions of SPE. It, of course, is contingent
upon the validity of the cycle as a theoretical device[10]
as well as upon the consistency of this analysis with other
facts of Sundanese and with the general conditions under
which cyclicity is expected.

Anderson's analysis is also consistent with the facts
of Sundanese, if the infixation rule is applied iteratively
(cf. the discussion of Anderson's theory in Chapter VII).
It is just as concise as the cyclic explanation and just as
adequate, but is also subject to the general validity of the
theoretical devices required. It is thus useful to present
these analyses side by side in the hope that future researches
will be able to differentiate between them on crucial
empirical grounds or in terms of the general theoretical
devices.

This discussion of Sundanese nasalization began with a
rule proposed by Langendoen which violates the conventions of
disjunctive ordering. Both of the analyses offered here
replace this rule with a sequence of more natural rules
(primary nasalization and nasal agreement), together with
the independently needed rule for infixation. Either assump-
tion -- cyclicity or local ordering -- is consistent with
directional rules to handle the nasalization processes, as
well as with the strong claim concerning disjunctive order.

4.0 Summary.

The discovery that certain types of phonological rules
must be disjunctively applied is a major contribution of
Chomsky & Halle. Their claim is a profound one and it seems
imperative for any competing theory to capture the same
insights. In the preceding sections I have shown that the

domain of disjunctive ordering is a relatively restricted one

comprising only the segments in the optional expression

itself. This modification must be made in the theory regard-

less of whether the directional theory is to be preferred

in other respects. I have shown that the directional theory

deals with disjunctive ordering in a straightforward way as

a result of the algorithm for application provided in Chapter

II with the addition of the notion of longest expansion. It

was pointed out that this is true only if the directional

theory involves predictable directionality. Finally, it was

argued that subscripted expressions behave like parentheses

in that they, too, must be disjunctively applied.

NOTES

[1] This notion of "adjacency" is modified in a case such as the Main Stress Rule of English, where a set of conjunctively ordered rules belonging to the same rule schema intervenes between members of the disjunctively ordered set.

[2] However, see McCawley (1968) for a dissenting opinion.

[3] This is, of course, only one context for aspiration. Voiceless stops also aspirate in word-initial position for most speakers, regardless of the stress on the vowel of that syllable. The feature [+ asp] is intended only as a shorthand for what Halle & Stevens (1971) refer to as [+ spread glottis].

[4] Although this rule uses the subscript-superscript notation (e.g. C_0^1) as well as parentheses, Chomsky and Halle (1968:62) assume that the former is definable in terms of the latter and shares with it the property of disjunctive ordering. Henceforth in this work the two notations will be used interchangeably.

[5] The second u would tense by another rule since it is prevocalic, but it would not receive the y-glide and hence would not cause palatalization.

[6] In a recent paper, Kiparsky (1972) argues, however, that disjunctive ordering is independent of the use of

abbreviatory conventions like parentheses or angled brackets. He claims instead that there are more general conditions which characterize the circumstances under which disjunctive ordering holds. Kiparsky's provocative paper came to my attention only when this dissertation was in its final typing stages and it has been impossible to give his arguments the attention that they deserve. His argument if valid would force a different interpretation of disjunctive ordering upon all current theories, including the directional one. Kiparsky's evidence is far from conclusive, however, and such modification in the theory must not be made prematurely.

[7] This claim is further supported by the stress rule of certain dialects of Eastern Cheremis, a related language. Kiparsky (1972:16) refers to the description of Eastern Cheremis stress as described in Itkonen (1966:156):

(I) a. The accent falls on the syllable containing the last full vowel of the word.

b. If the word has only reduced vowels, the accent is usually on the first syllable.

These facts can be expressed in the following way:

(II) $V \rightarrow [+ \text{stress}] / \underline{\quad} C_0 \; (\breve{V}C_0)_0 \; \#$

As Kiparsky points out, the Eastern Cheremis rule is a perfect mirror-image of the Komi Jaźva stress rule and must also be applied disjunctively. The Komi Jaźva stress

rule thus does not stand alone as evidence for the disjunctive character of subscript notation.

[8] See also Robins 1953a, 1953b, 1959, 1965.

[9] This view of the feature _nasal_ is supported by recent experimental evidence. See Ohala 1971a, b, c.

[10] Although the cycle has been called into question with regard to its use word-internally in English (Ross 1969), in Yawelmani (Rice 1969), and elsewhere, there is recent renewed interest in and evidence for cyclic rules (cf. Kisseberth 1971, 1972a; Selkirk 1972).

CHAPTER IV

SIMULTANEOUS RULES

1.0 <u>Introduction</u>. In proposing his linear theory,
Johnson (1970a) argued that there is no evidence to support
the existence of simultaneous rules. He presented a descrip-
tion of the type of evidence which is required to prove that
simultaneous rules exist, which will be discussed in section
2 of this chapter. Since the theory I am proposing differs
in crucial ways from Johnson's linear theory, however, it is
appropriate to reconsider this question in greater detail.

The most crucial difference between Johnson's theory and
that presented here is that the direction in which a rule
applies is an ad hoc fact of each rule in the former and a
predictable fact of each rule in the latter. The significance
of this difference lies in the fact that there is a small sub-
set of rules which appear to violate the predicted direction-
ality. Johnson's theory can handle them by applying the rule
in the opposite direction from that which the directional
theory requires. Unless there is some way of extending the
directional theory to account for these cases, they constitute
counterevidence to it.

One obvious possibility is to allow <u>reversal of direction-
ality</u>, by which I mean applying a rule in the opposite direc-
tion from that predicted by the principle given in Chapter II.
This essentially merges the directional theory with the linear
one. An alternative possibility, however, is to apply certain
rules <u>simultaneously</u>. In this chapter I will attempt to

illustrate the different consequences of these two alternatives and will propose that simultaneous application, rather than reversal of directionality, is the correct alternative. Moreover, I will propose some tentative generalizations about simultaneous rules.

2.0 <u>Terena Vowel Raising</u>. What kind of example would be necessary to prove the need for simultaneous rules within a theory like Johnson's where rules may be applied to either direction? A crucial case would be one in which both left and right linear application are inadequate, but simultaneous application will work. Johnson illustrates such an example with the vowel raising rule of Terena, an Arawakan language spoken in the Mato Grosso of Brazil, as stated by Langendoen (1968).

The second person singular prefix in Terena[1] has the underlying shape <u>y</u>, which appears before vowel-initial stems. When the stem begins with a consonant, the prefix disappears but various changes take place in the stem vowels. If the first vowel of the word is <u>e</u> or <u>u</u> it becomes fronted and raised to <u>i</u>. If the first vowel is <u>a</u> or <u>o</u>, it becomes modified to <u>e</u>. When the first vowel or sequence of vowels in the word is <u>i</u>, these changes take place in the vowel immediately following that <u>i</u> or sequence of <u>i</u>'s. The following forms illustrate the operation of this rule:

(1) a. ayo   'her brother'

     b. yayo   'your brother'

c. otopiko   'he cut down'

d. yotopiko   'you cut down'

e. kurikena   'his peanut'

f. kirikena   'your peanut'

g. nokone   'he needs'

h. nekone   'you need'

i. piho   'he went'

j. pihe   'you went'

In the directional theory, it would appear that the appropriate statement of the rule is as follows:

$$(2) \quad \begin{bmatrix} + \text{ syll} \\ <- \text{ back}> \end{bmatrix} \rightarrow \begin{bmatrix} - \text{ back} \\ - \text{ low} \\ <+ \text{ high}> \end{bmatrix} \; / \; \begin{bmatrix} - \text{ syll} \\ - \text{ cons} \\ - \text{ back} \end{bmatrix} \; (C \begin{bmatrix} + \text{ syll} \\ + \text{ high} \\ - \text{ back} \end{bmatrix})_{o} C \underline{\quad\quad}$$

Rule (2) will make the first non-_i_ vowel of the word become nonlow and nonback. In addition, if that vowel was _e_ it will also become high.

In addition to the above facts, under certain circumstances a sequence of _e_'s will all become raised to _i_:

(3)   a. xerere   'his side'

   b. xiriri   'your side'

   c. nene   'his tongue'

   d. nini   'your tongue'

Langendoen (1968) asserts that the behavior described in (3) occurs only when all vowels of the word are _e_. Johnson

correctly points out that if this were true, a simultaneous rule would be necessary to express the facts. To see this, assume that alongside the underlying form /nene/ there exists underlying /nine/. If we try to handle the spreading effect of vowel raising here by a right linear (or rightward) rule, /nene/ would first become nine and subsequently nini. At the intermediate stage, however, it becomes identical with /nine/. Under Langendoen's interpretation of the facts, the nine from /nene/ would have to undergo a further application but the nine from /nine/ could not. In other words, this could not be handled by a rightward rule. Moreover, similar arguments obtain when we attempt to treat it as a leftward rule. Only by making all of the changes simultaneously could the correct output be derived.

While this example illustrates the condition which would call for a simultaneous rule, it is not in itself a valid case. Johnson shows that Langendoen misinterpreted Bendor-Samuel's original statement, which was that when the first two or more vowels of the word are e they are both raised to i. Within Johnson's theory, this behavior of e could be handled by a left linear rule. The left linear character guarantees that only mid front vowels can intervene between the prefix and each e to be affected.

Johnson does not really provide a solution for the Terena problem, however. As any reader can easily discover for himself, it is no simple task to describe the phenomena in (1) and those

in (3) in any coherent fashion. The most that Johnson attempts
is a formulation of the "main clause" of the Terena $\underline{y}$-prefix
rule, namely that governing the cases in (1) above:

(4) $\underline{L}$: $\left\{\begin{array}{l}\begin{bmatrix}+ \text{ syll} \\ + \text{ back}\end{bmatrix} \rightarrow \begin{bmatrix}- \text{ low} \\ - \text{ back}\end{bmatrix} \\ \begin{bmatrix}+ \text{ syll} \\ - \text{ back}\end{bmatrix} \rightarrow [+ \text{ high}]\end{array}\right\} / \begin{bmatrix}- \text{ cons} \\ - \text{ syll} \\ - \text{ back}\end{bmatrix} [- \text{ syll}] \left\{\begin{array}{l}[- \text{ syll}] \\ \begin{bmatrix}- \text{ back} \\ + \text{ high}\end{bmatrix}\end{array}\right\}_o \underline{\quad}$

Rule (4) is intended to capture the fact that the first non-$\underline{i}$
vowel after the $\underline{y}$ prefix undergoes certain modifications. It
can be seen that Johnson's interpretation of braces is different
from that in SPE -- these do not represent a conjunctive se-
quence. If they were interpreted conjunctively, the mid front
vowel derived from $\underline{a}$ or $\underline{o}$ by the first part of the rule would
incorrectly be changed to $\underline{i}$ by the second part. The subscripted
braces in the environment, on the other hand, represent a se-
quence of segments which are either nonsyllabic or high front
vowels. This captures the notion "first non-$\underline{i}$ vowel".

Johnson speaks of rule (4) as a formulation of the "main
clause" of the Terena $\underline{y}$-prefix rule. As such it is equivalent
to rule (2) within a directional theory. It is useful to
observe at this point the reason for the complication resulting
when we try to extend this main clause to account for the cases
in (3). It is easy enough to modify rule (2) so that it derives
the cases in (3):

(5) $\begin{bmatrix}+ \text{ syll} \\ <- \text{ back}>\end{bmatrix} \rightarrow \begin{bmatrix}- \text{ back} \\ - \text{ low} \\ <+ \text{ high}>\end{bmatrix} / \begin{bmatrix}- \text{ cons} \\ + \text{ high} \\ - \text{ back}\end{bmatrix} C \underline{\quad}$

This rule would convert yxerere to yxirere by the first application and the derived i would cause a modification of the e that follows it. The final result, after deletion of the prefix, would be xiriri.

Rule (5) is clearly incorrect for Terena, not because it fails to derive all of the correct forms but because it derives numerous incorrect forms as well. For example, any internal high vowel will affect the vowels which follow it, not only in the presence of the prefix. Thus, kurikena would become kurikine by application of this rule (unless it is underlying kurikana or kurikona to begin with -- a possibility that must be considered). More importantly, the i derived from e should be able to affect any following vowel, not just another e. Thus tetukoti 'he is cutting' would yield *[titiketi] instead of the correct [titukoti] for 'you are cutting'.

It must also be pointed out that underlying u also becomes i by the y-prefix rule. Rule (5) would treat underlying u and e in the same way. To some extent this appears to be correct, since Bendor-Samuel (1966:32) states: "With some speakers the feature of fronting and raising also extends through the first two syllables when these are both U but this pattern is found much less frequently." Thus surunea 'his pan' but sirinea 'your pan'. Note that the following e is unaffected by the fronting of the u, contrary to the expectations of rule (5).

Let us return at this point to consider a further aspect of Johnson's Terena rule presented as (4) above. Notice that

this is a _left_ linear rule, although the directional theory
demands that a rule of this form be rightward directional. It
becomes appropriate to inquire as to the cause for this dis-
crepancy in direction. Why does Johnson regard (4) as left
linear? First, consider the second part of the rule, the one
affecting non-back vowels. As a left linear rule the first
vowel to meet the structural description of the rule is the
rightmost _e_ (or _i_) which is separated from the prefix by only
syllables with high front vowels. After the rule applies here,
only vowels to the _left_ can be considered and here the rule
applies vacuously. The result of left linear application, then,
is to allow only a single vowel to be changed.

Suppose, however, that the second part of the rule is
applied in a right linear fashion. Here, the first vowel to be
considered will be the _leftmost_ vowel separated only by high
front vowels (actually, each of these underlying high front
vowels will be considered and the rule will apply to them
vacuously). After the change of an _e_ to an _i_, the following
vowel will be in the correct position to undergo the rule and
it is the next to be considered. The effect of right linear
application, then, is to get the spreading effect illustrated
in forms like _xiriri_ from /y+xerere/. Yet, as already observed,
the spreading effect has other bad consequences in that it
implies that a sequence like _y+CeCa_ will become _y+CiCe_, or that
y+CiCeCe will become _y+CiCiCi_, both of which differ from the
intent of the rule.

It is for reasons like the above that Johnson attempts to limit the application to a single vowel by making the rule left linear. (Notice that with the algorithm already discussed for directional rules, a rightward directional rule will also affect only a single vowel). He apparently assumes that the integration of this rule with another rule to account for spreading effects with e (and u?) will be a straightforward task, but this is certainly not the case. Unfortunately, since Johnson does not offer any workable solution for Terena vowel raising, it cannot be firmly concluded that the rules required are not simultaneous.

Examination of the data presented in the various works on Terena strongly suggests that there is something crucial being missed in the analysis. The effect of stress is not to be disregarded, nor is the underlying (or derived) vowel length that is masked by the prosodic analysis chosen. For example, according to Bendor-Samuel (1966), bisyllabic words which have u, o, or a as their first vowels have a peculiar pattern of stress:

(6) a. pâho   'his mouth'   peâho   'your mouth'

     b. vô'u   'his hand'   veô'u   'your hand'

     c. tûti   'his head'   tiûti   'your head'

The circumflex accent represents an increase in volume, as with the other stresses, but is accompanied by length of the vowel being stressed and by a low or low falling pitch on that syllable. The pattern we observe in the second person forms

is precisely what we would expect from a long vowel in the initial syllable. Vowel length (or vowel sequences) clearly must play a part in this process.

Although the data are inadequate to test any hypotheses, the correct answer to this problem may lie in the following direction. Consider the following statement by Bendor-Samuel (1960:354):

(7)   "Occasionally (emphasis mine:IH), when the first two or more vowels of the word are e (or, less commonly, u) all are replaced by i. In the case of two-syllable words with both vowels e, this is always so."

One wonders about the character of those cases which do not undergo the rule. An inspection of the instances where sequences of e raise and sequences of u front shows that the intervening consonant is always a sonorant (liquid or nasal). It would be very interesting if the exceptions involve obstruents instead. If such were the case it might be possible to posit a rule which performs a secondary assimilation between vowels separated by sonorant consonants.

As to why bisyllabic forms always undergo this rule, the explanation may lie in a deeper understanding of the vowel length problem relating to the items in (6) above. Recall that the generalization is that all two-syllable words whose first vowels are back have type B stress, which involves lengthening of the stressed vowel and an unusual pitch contour. What happens in this context to nonback vowels? Is it possible that

the obligatory raising of e̲ in bisyllables is related to factors involving vowel length and perhaps also neutralization of front vowels?

In the absence of adequate data to test these hypotheses, one can only speculate as to the most likely outcome of a deeper investigation. Johnson showed that in spite of Langendoen's statement Terena vowel raising is not convincing evidence for simultaneous rules. I hope to have shown also that it is not a convincing counterexample to the position that the directionality of rule application is predictable. Until a workable solution is developed and other data brought forth to validate it, Terena vowel raising is not convincing evidence for anything.[2]

3.0 <u>Southern Kikuyu Voicing Dissimilation</u>. A different sort of case is presented by the Southern Kikuyu version of Dahl's Law, a rule occurring in a number of Bantu languages of East Africa (cf. Johnson 1970a:86-87 and Bennett 1967). In Southern Kikuyu, k̲ dissimilates to become γ̲ when the next following consonant in the word is voiceless.[3] Any number of vowels may intervene between the k̲ and the voiceless segment. This rule may be written:

(8)
$$k \rightarrow \begin{bmatrix} + \text{ cont} \\ + \text{ voice} \end{bmatrix} \; / \; \underline{\quad} \; [+ \text{ syll}]_o \; [- \text{ voice}]$$

According to the predictions of the directional theory, rule (8) would be leftward and should apply to a form like <u>nekakaakeroma</u> 'he will bite him' to yield <u>nekaγaakeroma</u>. However,

the correct output is neɣaɣaakeroma. This cannot be derived

with a leftward rule of the type thus far defined, although it

can be derived by either a rightward or a simultaneous rule.

Phenomena such as Southern Kikuyu voicing dissimilation, quite

clearly, stand as counterexamples to the claim I have made.

It would be possible to argue that counterexamples of this

type are sufficient to negate the general claim that rules are

predictably directional. Assuming that this is a valid phono-

logical rule, the theory must be extended in order to handle it.

4.0 <u>Simultaneity vs. Reversal of Directionality</u>. One way

in which the theory can be extended is to allow at least some

rules to apply in the direction opposite to that expected by

the principles stated thus far. It is also possible to accom-

plish the same effects by allowing these rules to be simulta-

neous. It is interesting to inquire as to whether there is a

difference in the empirical consequences for the theory of one

modification or the other. Should the theory admit simultaneous

rules which, after all, do not add to the power of the theory,

or should it allow rules to reverse their directionality?

First, it is important to clarify how simultaneous rules

would function in the directional theory proposed here. The

basic meaning of simultaneous application is that a segment

must be in the correct position in the input string in order to

undergo a given rule. It is necessary to identify all those

segments which are in the correct position first and then to

apply the rule simultaneously to all segments thus identified.

This still leaves some leeway as to how the algorithm should be stated which determines which segments are in the correct position.

The simplest assumption that could be made is that the algorithm for determining these segments is identical to the algorithm needed elsewhere for nonsimultaneous rules. This implies that simultaneous rules are directional, in that the matching process begins at one end of the string and proceeds to the other. The difference between simultaneous and nonsimultaneous rules, then, would rest upon the point at which application takes place. Simultaneous rules are applied only after all segments meeting the structural description of the rule are identified, while nonsimultaneous rules involve application after each segment is identified.

Consider the Southern Kikuyu rule as an example. If the rule were simultaneous we would have the following derivation:

(9)   /nekakaakeroma/   input string

    nekakaakeroma   identify

    nekakaakeroma   identify

    neɣaɣaakeroma   apply

On the other hand, if the rule were rightward, it would imply the following derivation:

(10)   /nekakaakeroma/   input string

    neɣakaakeroma   first application

    neɣaɣaakeroma   second application

In most cases, reversing the predicted directionality and applying the rule simultaneously in the way I have described above will have the same empirical consequences. The only situations I am aware of in which this is not true are: (1) when parenthetical or subscripted expressions are involved; and (2) when the rule is optional, as with the Warao labial voicing rule discussed later in this chapter.

Consider again the English stress rule discussed in Chapter III:

(11) $V \rightarrow [\text{1 stress}] / \underline{\hphantom{xx}} C_o (\breve{V} C_o^1) \#$

Assuming the principle of longest expansion, (12) would be a derivation under simultaneous application, while (13) involves reversal of directionality.

(12)   /edit/   input string

         edit   identify
         ↑
         édit   apply

(13)   /edit/   input string

         édit   first application

         édít   second application

Notice that the two modes of application make different claims. When parenthetical expressions are involved, simultaneous application has no different effect than nonsimultaneous appli-cation, while reversing the directionality yields a different output which is inconsistent with the claims of disjunctive ordering. Since there is a great deal of support for the

disjunctive effect of parentheses and no rules have been
seriously advanced and supported which have the character of
reversed directionality with parenthetical expressions, it
follows that simultaneous application is the preferred alter-
native. Simultaneous application is more restrictive in its
empirical consequences and therefore, until evidence is given
to support reversal of directionality, simultaneous application
must be adopted.

On the basis of this evidence I propose a distinction
between _repetitive_ rules, such as those discussed in the pre-
ceding chapters, and _simultaneous_ rules. With such a distinc-
tion being made, there are several possible positions that can
be taken. The most restrictive position would be that the
mode of application is predictable from the form of the rule
(or from its content). Thus there would be necessary and
sufficient conditions for determining when a rule is repetitive
or simultaneous, much like Chomsky & Halle propose necessary
and sufficient conditions for disjunctive ordering. I believe
that this position is incorrect, for reasons that will appear
in the next section.

At the opposite extreme, mode of application would have
to be noted ad hoc for each rule, just as the direction in
which a rule is to be applied is noted ad hoc in Johnson's
theory. Intermediate between these positions, however, is one
in which there are certain necessary but not sufficient condi-
tions for determining mode of application. It is this

intermediate position that I will attempt to justify in this chapter.

5.0 Some Further Examples.

5.1 Finnish Degemination. The degemination part of the consonant gradation phenomenon in Finnish is also a simultaneous rule.[4] At the beginning of short, closed, noninitial syllables, geminate clusters are simplified. The statement of the environment given below is taken directly from S. Anderson (1969:106):

(14)

$$C_i C_i \rightarrow C_i \ / \ \underline{\hspace{1cm}} \begin{bmatrix} + \text{ syll} \\ \text{stress} \neq 1 \end{bmatrix} (j) \ [- \text{ syll}] \begin{Bmatrix} [- \text{ syll}] \\ \\ \# \end{Bmatrix}$$

As a repetitive rule, the prediction made by the theory is that degemination will involve an alternating pattern. That is, applying _leftward_, the result of one application would not be input to a following application. Thus a string of the shape $CVC_i C_i VC_j C_j VC\#$ would become $CVC_i C_i VC_j VC\#$ by the first application and the remaining geminate cluster would no longer be in a gradation environment.

In actual fact, however, _both_ clusters degeminate in Finnish. This output cannot be derived by a leftward repetitive rule, although it may be derived by a leftward _simultaneous_ rule.

Under the assumption that it would also be possible to have a rule identical to the Finnish degemination rule but applied repetitively to give an alternating pattern, it is

appropriate to ask which mode of application is the more normal
one. The argument that will be made here, unlike every other
theory with which I am familiar, is that the normal or "unmarked"
mode of application is repetitive and simultaneous rules are
"marked". I therefore propose the following principle:

(15)   The unmarked mode of rule application is the repetitive
        one.

To say that something is unmarked has certain implications.
It implies that some kind of "pressure" exists which is condu-
cive to the unmarked thing and for something to be marked it
must involve extra effort in opposing that pressure. Expected
consequences of this are that the unmarked thing will be more
frequently observed in language, that it will be found in the
most diverse circumstances, and that it will constitute the
motivation for linguistic change, particularly in the sense of
defining the direction in which children make mistakes in their
acquisition of language. Finnish degemination is an interesting
place to compare marked and unmarked modes of application.

The prediction made by principle (15), then, is that
children acquiring Finnish will make mistakes in the direction
of an alternating pattern of degemination. Although I have no
truly definitive evidence on the acquisition of Finnish, there
is some very tentative and suggestive anecdotal evidence bearing
on this claim. Consider the three words below:

(16) a. nappi   /nappi/   'button'

    b. napittaa   /nappi+tta+a/   'to button'

    c. napitan   /nappi+tta+n/   'I button'

Since (16a) has no geminate cluster in a degemination environment and (16b) has only one such cluster, they are irrelevant to our concern. That is, there is no difference between repetitive and simultaneous application in these cases in terms of empirical consequences.

Example (16c) is a different story, however, since repetitive application would predict the incorrect form *[nappitan]. I asked Elsa Carroll, a Finnish student at the University of Hawaii, for her feelings as to how a Finnish child might mispronounce napitan. She had no immediate reaction to this general question and the form *nappitan was given to her. Her reaction to this form was that it sounded like quite a plausible mispronunciation that a Finnish child might make. When the form *napittan was given her, however, her reaction was immediate and strong that it was not a plausible mispronunciation. Her own explanation for this fact was that *nappitan is plausible because of the analogy with nappi, but of course this does not explain the negative reaction to *napittan, since it is analogous with the closely related form napittaa. On the other hand, the principle governing unmarked mode of rule application makes precisely the correct prediction here. It will be interesting to see whether this claim will be supported by other data from language acquisition.

5.2 <u>Mandarin Tone Dissimilation</u>. Among the tone sandhi
rules of Mandarin is a rule which dissimilates sequences of
third tones.[5] According to Chao (1968:27), "When a 3rd Tone
is followed by another 3rd, the first one changes into a 2nd
Tone." The prediction made by a directional theory is that
tone dissimilation will yield an alternating pattern because
it is self-bleeding. Informally, the rule might be written
thus:

(17)   [3 tone] → [2 tone] / ___ [3 tone]

In reality, however, the tonal pattern is not a simple
alternating one but is much more complex. Cheng (1971:48)
provides a Mandarin sentence consisting of five words with
underlying third tones. The possible pronunciations are given
as follows, with (18a) representing the slowest speech form
and (18e) the fastest. For clarity of exposition I use simple
numerals to represent the tones rather than any of the various
tone alphabets proposed:[6]

(18)   3   3   3   3   3
        lau   li   mai   xau   tɕiʏu   'Old Li buys good
                                               wine'
    a. 2   3   3   2   3
    b. 2   2   3   2   3
    c. 2   3   2   2   3
    d. 2   2   2   2   3
    e. 2   1   1   1   3

The last possibility can be eliminated from the discussion of
the third tone dissimilation rule since it represents the

application of a further rule upon the sequence given in (18d).
This "fast speech" rule is stated by Cheng (1971:43) as follows:

(19)   "In fast conversational speed, a second tone becomes

        first when preceded by first or second tone and followed

        by any tone other than neutral tone."

This rule will be discussed further in Chapter VI.

Looking at the remaining possibilities in (18), it is not
immediately obvious how the rule is applied. Cheng proposes
a fairly complex solution, but this is apparently based on some
incorrect data.[7] The correct solution seems to be that the
tone dissimilation rule is applied simultaneously.

If this rule is applied simultaneously, (18d) and (18c)
are relatively easy to explain. The sequence 2-2-2-2-3 is the
result of simultaneous application with the domain of the rule
being the whole string. The sequence 2-3-2-2-3, on the other
hand, shows a division of the string into two syntactic units
corresponding to the division between the subject NP and the
VP, with the rule applying simultaneously in each phrase. It
stands to reason that the sequence implying a domain of the
whole string would be the faster speech style and the two-phrase
analysis a slower speech style.

The remaining two possibilities appear at first glance to
be quite puzzling. The 2-3-3-2-3 pattern could be derived by
analyzing the string into two phrases and applying the rule
repetitively in both, thus getting an alternating pattern. But,
surely, it is not very desirable to allow such differences in

mode of application, particularly when the unmarked repetitive mode is in the _slower_ speech style. On the other hand, the pattern 2-2-3-2-3 is puzzling because it would seem to imply that the major break in the sentence is not between the subject and the verb.

The answer to this dilemma is that the first two examples involve _contrastive stress_ on the verb, _mai_.[3] The tone dissimilation rule does not apply under contrastive stress and hence the verb retains its third tone. The pattern 2-3-3-2-3 results from contrastive stress on the verb, together with an analysis of the string into two phrases. The rule thus applies independently and simultaneously to each phrase. The peculiar pattern of 2-2-3-2-3 is the result of contrastive stress on the verb with the sentence being analyzed as a single unit. Thus, while the verb retains its third tone, it is still within the domain relevant to modifying the subject elements and will therefore cause them, by the simultaneous application principle, to be changed to second tone.[8]

5.3 _Slovak "Rhythmic Law"_. In Slovak, a long vowel (or diphthong) is shortened in the syllable following another long vowel or diphthong. (Browne 1970, 1972). Compare the behavior of the stem _čīta-_ 'read', which has an underlying long vowel in the first syllable, with that of _vola-_ 'call':

(20) a. čīta-t   'to read'

    b. vola-t   'to call'

c. čīta-m   'I read (present)'

d. volā-m   'I call (present)'

e. čīta-va-m   'I read (present iterative)'

f. volā-va-m   'I call (present iterative)'

The first person singular morpheme -m requires an a preceding it to be lengthened. The iterative marker -va also causes the preceding vowel to be lengthened. This can be observed in (20d) and (20f), respectively.

Why is the final vowel of the stem čīta- not lengthened in (20c) and (20e)? According to Browne's analysis, it is due to the operation of the "rhythmic law" which shortens that vowel subsequent to the lengthening process. Thus, underlying /čīta-m/ becomes čītā-m by the rule that lengthens a before -m and this in turn is modified to čīta-m by the rhythmic law.

In (20f) the lengthened vowel is due to the iterative suffix -va, but according to the rule the vowel preceding the suffix -m should also be lengthened. The fact that it is superficially short may be attributed again to the operation of the rhythmic law.

The crucial case is (20e), which should have a sequence of three long vowels after the lengthening rule: čītā-vā-m. In this case the rhythmic law must shorten two vowels. Yet, this can be accomplished by a repetitive rule only if it is leftward, but the theory predicts that the rule is rightward. Rightward application would yield the incorrect output: čīta-vā-m.

If the Slovak rhythmic law is a simultaneous rule, however, it will operate correctly. All vowels which are in the syllable immediately following long vowels in the input string will be shortened.

6.0 <u>Simultaneous Rules and Dissimilation</u>. The question was raised in section 4 as to whether there are necessary and sufficient conditions for determining when a rule will apply simultaneously, whether there are just necessary (but not sufficient) conditions, or whether such a determination must be made ad hoc in each case. This question may be fruitfully examined at this point in the discussion.

Consider the strongest position, that there are necessary and sufficient conditions. This view implies that no two rules can differ solely in the mode of application -- for any difference in application there must be some other formal property that distinguishes the two rules. The discussion of Finnish degemination in section 5.1 challenges this strong position, precisely because it implies that the same rule may conceivably be applied in two different ways. If the argument about Finnish acquisition is supportable, it may be taken as counterevidence to the strong claim.[9] Under any circumstances, it would be necessary to propose a set of criteria which are necessary and sufficient and at this point I cannot foresee what they might be.

The examples of simultaneous rules discussed above all share an interesting characteristic, however. The rules from Southern Kikuyu, Mandarin, and Slovak are all clearly

<u>dissimilatory</u> in character. The same is true of Finnish degemination, although the term "dissimilation" is not conventionally used in this context. Degemination in Finnish is nevertheless stimulated by the <u>likeness</u> of adjacent syllables and the rule operates to make a geminate cluster less like the following one. In effect, it is a dissimilation in terms of syllabic structure.

It would be extremely important if all simultaneous rules fell into the class of dissimilatory processes. This would mean that a <u>necessary</u> condition for simultaneous application exists. On the other hand, there appear to be processes like Woleaian low vowel dissimilation, alternating stress and glide formation rules, and Klamath deglottalization where dissimilatory rules are repetitive. These suggest that dissimilation is not a <u>sufficient</u> condition for simultaneous application.

On the basis of these observations, I would like to propose the intermediate claim that necessary but not sufficient conditions for simultaneous application exist.

7.0 <u>Assimilatory Simultaneous Rules</u>. A clear implication of the claim made in section 6 is that there are no simultaneous rules which are assimilatory. In this section, I will consider two potential counterexamples to this claim. The first, a voicing assimilation rule of Chipewyan, appears to be an incorrect analysis of the phenomena in question. The second, a rule of vowel shortening in Menomini, is open to interpretation. In one interpretation, the determinant is the quality of the

preceding vowel, in which case the rule must be simultaneously applied. In the other interpretation, the determinant is the syllabic structure, in which case the problem disappears.

7.1 Chipewyan Continuant Devoicing. An example of what superficially appears to be a simultaneous assimilatory rule is the continuant devoicing rule from Chipewyan, an Athabascan language spoken in Alberta. Johnson (1970a:91) makes the following observation:

(21)   "Again, consider the rule of Chipewyan which devoices a continuant consonant that immediately follows a voiceless continuant consonant (Li 1946:400). The rule causes <u>tɛszáih</u> 'I split' to become <u>tɛssáih</u> (ultimately <u>tɛsáih</u>). It will also cause <u>náslzɛ́</u> 'I am hunting' to become <u>násɫzɛ́</u> (ultimately <u>nászɛ́</u>). Notice that <u>náslzɛ́</u> will not become *<u>násɫsɛ́</u>; it is the immediately preceding sound in the original input that determines whether devoicing of a continuant consonant will take place."

Given the facts as Johnson states them, we would have the following rule, which must be applied simultaneously:

(22) $\begin{bmatrix} + \text{ cons} \\ + \text{ cont} \end{bmatrix} \rightarrow [- \text{ voiced}] \ / \ \begin{bmatrix} + \text{ cons} \\ + \text{ cont} \\ - \text{ voiced} \end{bmatrix} \ \underline{\quad}$

There is good reason to believe, however, that Johnson's statement is an oversimplification of what is happening in Chipewyan. In order to deal with this problem in more depth, consider the following statements from Li (1946:400):

(23) a. "The fricative initial of a stem syllable is always in the voiceless form when standing alone, and is voiced when a prefix is added, thus θuθ 'spear'; bɛ-ðuθ 'his spear' ... ła 'many'; ho-la 'many times' ... The only exception seems to be the initial y- which sometimes may stand alone, such as ya 'sky' ... We may distinguish morphophonemically two kinds of y-, one which alternates with c-, and one which does not become a c- in absolute initial positions."

b. "The voiced initial fricative will be unvoiced when immediately preceded by a voiceless fricative, thus θi·-ɣar 'I shake it'; θuh-xar 'you (pl.) shake it' ... "

c. "Whenever the voiced initial of the stem syllable is preceded by a voiceless fricative and yet it does not become unvoiced, it always means that the preceding voiceless fricative is of voiced origin, secondarily unvoiced due to contraction, thus ná-s-zɛ́ 'I am hunting' < ná-s-l-zɛ́; yɛ-kó-dɛ-nɛ́-ł-yá 'he has learnt it' < yɛ-kó-dɛ-nɛ́-θ-l-yá."

d. "When identical consonants come together, they are simplified to a single consonant. There are no true long or double consonants, thus tɛsáih 'I split' < tɛ-s-sáih < tɛ-s-záih; hi·lał 'go to sleep!' < hi·-l-lał, etc."

There is a seeming contradiction between (23a) and (23b). The first statement claims that initial fricatives are basically voiceless, while the second speaks of voiced initial fricatives. What is intended, of course, is that the two statements are ordered. Thus, voiceless fricatives become voiced after any prefix and subsequently, if the preceding continuant is voiceless, the fricative will devoice again. This interpretation has been confirmed by Fang-Kuei Li in personal communication.

I believe what is happening here is that all true fricatives are voiceless in underlying representations. The fact that both y and c occur in initial position but that this contrast is neutralized elsewhere indicates that both of these are underlying segments. On the other hand, the fact that l and ł contrast intervocalically and elsewhere, but not in initial position suggests a rule operating to devoice l initially:

(24)   [+ lateral] → [- voiced] / # ___

Notice that this is the only devoicing rule required in initial position.

With the assumption that underlying fricatives are voiceless, rule (23b) is essentially unnecessary. Fricatives can be assumed to remain voiceless in this context. Instead, fricatives become voiced when the preceding segment is voiced and they are followed by a vowel:

(25)   [+ cont] → [+ voice] / [+ voice] ___ [+ syll]

The crucial form that Johnson cites is násźέ from

ná-s-l-zέ. He assumes that the l devoices following the voice-

less continuant, but that since the z doesn't devoice also the

rule must be leftward or simultaneous. Ultimately, the voice-

less l is deleted, presumably by the degemination rule (23d).

In the analysis proposed here, however, the underlying represen-

tation is not ná-s-l-zέ but rather na-s-l-sέ. Rule (25) would

then apply to voice the second s and subsequently the liquid

would drop out.

It is important to compare násźέ with the other example

given in (23c): yε-ǩó-dε-nέ-ɬ-yá from yε-ǩó-dε-nέ-θ-l-yá.

Notice that in the sequence slz it was the medial l which got

eliminated, but in the sequence θɬy it was the first segment.

If degemination is the means by which these sequences get

reduced it will be necessary to have two separate assimilation

rules, one operating in each direction!

Perhaps a more plausible alternative arises when we inquire

as to why the s remains but the θ deletes. Notice first that

the devoicing of l after θ generalizes naturally with rule (24),

which devoices laterals in initial position:

(26)

$$[+ \text{ lateral}] \rightarrow [- \text{ voice}] / \left\{ \begin{array}{c} \# \\ [- \text{ voice}] \end{array} \right\} \underline{\quad}$$

This rule also implies that the sequence slz in naszε also

goes through an intermediate stage sɬz. Acoustically and

articulatorily, θ and ɬ are extremely similar, while s and ɬ

are more distinct. It seems quite reasonable, then, that
phonetic pressures will assimilate the θ (but not the s̲) to ł̲.
I thus posit the following rule:

(27) $\begin{bmatrix} + \text{ cont} \\ + \text{ cor} \\ - \text{ strid} \end{bmatrix} \rightarrow \begin{bmatrix} + \text{ sonorant} \\ + \text{ lateral} \\ + \text{ strident} \end{bmatrix}$ / ___ [+ lateral]

The derived sequence ł̲ł̲y̲ then feeds into the degemination rule
(23d) to yield ł̲y̲. In order to deal with s̲ł̲z̲ it would be
possible to posit another assimilation rule making ł̲ become s̲
after s̲, but since this does not appear to be very well moti-
vated phonetically I would rather assume a rule deleting the
liquid in a sequence of consonants (or perhaps, more specifical-
ly, in a sequence of continuant consonants):

(28)   [+ lateral] → ∅ / [- syll] ___ [- syll]

I have thus posited a sequence of five ordered rules to
explain the continuant devoicing and related phenomena of
Chipewyan. The five rules and their crucial ordering relations
are as follows:

(29) a. continuant voicing   (25)
     b. lateral devoicing   (26)
     c. θ-lateralization   (27)
     d. degemination   (23d)
     e. lateral deletion   (28)

On the basis of this reanalysis the problem of a simulta-
neous assimilatory rule in Chipewyan disappears. The continuant

devoicing rule has become specifically limited to laterals and therefore násźé presents no special difficulty.

7.2 <u>Menomini Vowel Lengthening</u>. One of the earliest, most comprehensive, and most insightful "generative" grammars was Bloomfield's study of Menomini morphophonemics (1939). Since the data is explicitly and revealingly stated, it is not surprising that Menomini should be called upon to illustrate theoretical arguments. In this section, I will present a reanalysis of Bloomfield's classic treatment of the alternations of vowel length in Menomini, considering in the process a rule of vowel shortening which comes very close to being a simultaneous assimilatory rule.

Menomini, an Algonquian language spoken in Wisconsin, has the following basic processes relating to vowel length (Bloomfield 1939:113-14):[10]

(30) a. "In monosyllables, short vowels are replaced by long."

b. "After a closed syllable, a long vowel in an open syllable is replaced by a short vowel."

c. "If the first two vowels of a word are short, the second is replaced by a long."

d. "If the even (second, fourth, etc.) syllable after the next preceding long vowel ... is open and has a long vowel, this long vowel is replaced by a short."

e. "If the even syllable ... is closed and contains a short vowel, this short vowel is replaced by a long."

In the analysis above there are certain ordering relations which are crucial. These are represented below by the curved lines connecting the rules.

(31) a. MONOSYLLABLE LENGTHENING

b. POST-CLUSTER SHORTENING

c. SECOND SYLLABLE LENGTHENING

d. EVEN SYLLABLE SHORTENING

e. EVEN SYLLABLE LENGTHENING

To illustrate these crucial orderings, consider first those relating to POST-CLUSTER SHORTENING. This rule is stated as follows:

(32) $\quad$ [+ syll] $\rightarrow$ [- long] / CC $\underline{\qquad}$ $C_o^1 \left\{ \begin{array}{c} V \\ \# \end{array} \right\}$

POST-CLUSTER SHORTENING applies only to vowels in open syllables, but the definition of an open syllable in Menomini is somewhat different than that in most languages. While VCC constitutes a closed syllable, VC# does not. It is necessary to add to rule (32) the requirement that the last optional consonant be followed by either a vowel or word boundary in order to insure an open syllable. Thus, rule (32) is not allowed to apply if the vowel is followed by more than one consonant.

The crucial ordering pertaining between POST-CLUSTER SHORTENING and SECOND SYLLABLE LENGTHENING is most clearly demonstrated by a bisyllabic word such as /ahkōk/. In (33a) the ordering is as given in (31), while (33b) involves the inverse ordering.

(33) a. /ahk$\overline{o}$k/   input string

     ahkok   POST-CLUSTER SHORTENING

     ahk$\overline{o}$k   SECOND SYLLABLE LENGTHENING

b. /ahk$\overline{o}$k/   input string

     -----   SECOND SYLLABLE LENGTHENING

    *ahkok   POST-CLUSTER SHORTENING

Unless these rules apply in the correct order, some words which should have long vowels in the second syllable will wind up with short vowels.

POST-CLUSTER SHORTENING must precede EVEN SYLLABLE SHORTENING, as in the following example:

(34) a. /k$\overline{e}$hk$\overline{a}$ + m + $\overline{a}$ + w/   input string

     k$\overline{e}$hka + m + $\overline{a}$ + w   POST-CLUSTER SHORTENING

     k$\overline{e}$hka + m + a + w   EVEN SYLLABLE SHORTENING

b. /k$\overline{e}$hk$\overline{a}$ + m + $\overline{a}$ + w/   input string

     -----------------   EVEN SYLLABLE SHORTENING

    *k$\overline{e}$hka + m + $\overline{a}$ + w   POST-CLUSTER SHORTENING

SECOND SYLLABLE LENGTHENING must also precede EVEN SYLLABLE SHORTENING:

(35) a. /a$\check{c}$e$\check{c}$+e+k$\overline{a}$powe+h+$\overline{\varepsilon}$w/   input string

     a$\check{c}$$\overline{e}$$\check{c}$+e+k$\overline{a}$powe+h+$\overline{\varepsilon}$w   SECOND SYLLABLE LENGTHENING

     a$\check{c}$$\overline{e}$$\check{c}$+e+kapowe+h+$\overline{\varepsilon}$w   EVEN SYLLABLE SHORTENING

b. /a$\check{c}$e$\check{c}$+e+k$\overline{a}$powe+h+$\overline{\varepsilon}$w/   input string

     -----------------   EVEN SYLLABLE SHORTENING

    *a$\check{c}$$\overline{e}$$\check{c}$+e+k$\overline{a}$powe+h+$\overline{\varepsilon}$w   SECOND SYLLABLE LENGTHENING

I do not have any examples to illustrate the crucial ordering between EVEN SYLLABLE LENGTHENING and either POST-CLUSTER SHORTENING or SECOND SYLLABLE LENGTHENING. It seems abundantly clear, however, that this ordering is crucial. First, there is an empirical difference contingent upon the ordering of these rules. Second, there is clear empirical justification (presented above) for the ordering POST-CLUSTER SHORTENING → SECOND SYLLABLE LENGTHENING → EVEN SYLLABLE SHORTENING. Third, Bloomfield, who was extremely conscious of ordering relations, "collapsed" the EVEN SYLLABLE LENGTHENING rule together with EVEN SYLLABLE SHORTENING. Since this strongly suggests that empirical cases justifying the ordering do exist, I have taken the liberty of entering these relations as crucial in (31) above.

The most interesting aspect of the alternations of vowel length is the problem of dealing with notions like "even syllable" and "closed syllable". Consider how EVEN SYLLABLE SHORTENING might be stated in the simultaneous format of SPE:

(36)
$$V \rightarrow [- \text{long}] \; / \; \bar{V}C_o\breve{V}C_o(VC_o\breve{V}C_o)* \; \underline{\quad} \; C_o^1 \begin{Bmatrix} V \\ \# \end{Bmatrix}$$

This would correctly shorten vowels in open syllables that are an even number of syllables away from the preceding long vowel.

The EVEN SYLLABLE LENGTHENING rule stated in the SPE format would look strikingly similar:

(37)
$$V \rightarrow [+ \text{long}] \; / \; \bar{V}C_o\breve{V}C_o(VC_o\breve{V}C_o)* \; \underline{\quad} \; CC$$

It is impossible within the SPE format to collapse these two
rules in any way which would capture the generalization which
appears to hold between them. I would contend, however, that
this is precisely because the generalization is a spurious one.
It requires not only the complex simultaneous format that was
called into question in Chapter II but also the ability to refer
to closed and open syllables categorically, instead of by their
segmental composition. Thus, in order to collapse (36) and (37)
we would have to be able to say that a vowel becomes alpha long
in a syllable which is alpha closed, if it is an even number
of syllables away from the preceding long vowel. Aside from
the general undesirability of extending the power of the theory
so that it can refer categorically to the notion "closed sylla-
ble", recall that a closed syllable in Menomini is already
unusual in not including the sequence VC#. Hence a collapsed
version of (36) and (37) does not turn out to be a terribly
exciting alternative.

How can these same facts be stated in a directional theory?
It is no great difficulty to lengthen the vowels of alternating
syllables by a rule perfectly parallel to an alternating stress
rule:

(38)   V → [+ long] / $\breve{V}C_0$ ___

By the very way this rule is stated (and consequently by the
phonetic motivation implied), a vowel will lengthen two sylla-
bles after an underlying long vowel as well as after a derived
long vowel, providing in both cases that the intervening vowel

is short. Moreover, rule (38) would make SECOND SYLLABLE
LENGTHENING unnecessary since the first context in which it
could apply would be exactly that of the SECOND SYLLABLE
LENGTHENING rule.

As attractive as rule (38) is, it does not have the same
empirical consequences as EVEN SYLLABLE LENGTHENING. Recall
that EVEN SYLLABLE LENGTHENING will lengthen a vowel an even
number of syllables away from the preceding long vowel even
if there is a long sequence of short vowels intervening. Rule
(38), on the other hand, will lengthen alternate syllables
across a string, leaving no sequences of short vowels.

This difficulty is clearly related to the fact that EVEN
SYLLABLE LENGTHENING was stated in terms of _closed_ syllables,
while rule (38) will lengthen a vowel whether the syllable is
open or closed. We might thus consider the possibility of
revising rule (38) in the following way:

(39) $V \rightarrow [+ \text{long}] / \breve{V}C_0 \underline{\quad\quad} CC$

Rule (39) fails us in two ways. First, if the syllable two
syllables away from the preceding long vowel is open but the
next syllable is closed, (39) will incorrectly lengthen that
third vowel. For example, in a word of the underlying shape
/CV CVC CV CV CVC CV/, rule (39) will lengthen the second
vowel because it is preceded by a short vowel and is in a
closed syllable. The following vowel is not preceded by a
short vowel so it cannot be lengthened. The fourth vowel is
preceded by a short vowel, but not in a closed syllable so it

cannot be lengthened. The fifth vowel, however, is both precededby a short vowel .nd in a closed syllable and would be incorrectly lengthened.

The second difficulty is that if the requirement of being in a closed syllable is imposed on (38), it can no longer do the work of the SECOND SYLLABLE LENGTHENING rule, for that rule applies where the second syllable is open as well as closed.

These difficulties, however, are not insurmountable. Suppose that (38) is adopted as the EVEN SYLLABLE LENGTHENING rule and allowed to operate freely. It would incorrectly lengthen some vowels, while correctly lengthening others. The interesting fact, however, is that in every case where the rule incorrectly lengthens a vowel, that vowel is in the appropriate environment for EVEN SYLLABLE SHORTENING! That is, if we let (38) lengthen some vowels incorrectly, EVEN SYLLABLE SHORTENING can be called upon to straighten things out.

To illustrate this fact, consider the abstract string presented above. The following derivation assumes (38) as the correct expression of EVEN SYLLABLE LENGTHENING.

(40)   /CV CVC CV CV CVC CV/   input string

        CV C$\bar{V}$C CV C$\bar{V}$ CVC C$\bar{V}$ EVEN SYLLABLE LENGTHENING

        CV C$\bar{V}$C CV CV CVC CV   EVEN SYLLABLE SHORTENING

If we can adopt rule (38), what then is the correct state- ment of EVEN SYLLABLE SHORTENING? A preliminary version of this revised rule is as follows:

(41)

$$V \rightarrow [- \text{ long}] \; / \; \bar{V}C_o \breve{V}C_o \underline{\quad\quad} C_o^1 \left\{ \begin{matrix} V \\ \# \end{matrix} \right\}$$

Rule (41) is intended to shorten a vowel if it is in an open syllable and if it is exactly two syllables from the immediately preceding long vowel.

Before considering how this rule is applied, it is worthwhile revising it somewhat further. Recall that the reason the long vowel had to be mentioned was that if it were omitted EVEN SYLLABLE SHORTENING would incorrectly shorten the second vowel of the word if that were otherwise in the correct environment. Since this is exactly the environment of SECOND SYLLABLE LENGTHENING, we might ask whether EVEN SYLLABLE SHORTENING (41) can be simplified by allowing SECOND SYLLABLE LENGTHENING to follow it and adjust the incorrect outputs.

I have earlier argued that SECOND SYLLABLE LENGTHENING is no longer necessary if EVEN SYLLABLE LENGTHENING is formulated as in (38). In order to fulfill the new function of compensating for incorrect outputs of a revised EVEN SYLLABLE SHORTENING rule, it would have to be reintroduced into the grammar. It is quite clear, however, that sufficient simplification is achieved to warrant the reintroduction of this rule. For one thing, EVEN SYLLABLE SHORTENING can now be stated as:

(42)

$$V \rightarrow [- \text{ long}] \; / \; \breve{V}C_o \underline{\quad\quad} C_o^1 \left\{ \begin{matrix} V \\ \# \end{matrix} \right\}$$

An additional bonus is that it is possible to collapse SECOND
SYLLABLE LENGTHENING with the MONOSYLLABLE rule, as Bever (1967)
did:

(43) $V \rightarrow [+ \text{long}] \, / \, \# \, (C_o \breve{V}) \, C_o \underline{\qquad}$

This rule is not much more complicated than the MONOSYLLABLE
rule by itself. By using the parentheses notation, then, it
is possible to add SECOND SYLLABLE LENGTHENING at very little
cost to the MONOSYLLABLE rule, but at the same time simplifying
the EVEN SYLLABLE SHORTENING rule.

One consequence of this analysis is that the revised
SECOND SYLLABLE LENGTHENING rule must follow EVEN SYLLABLE
SHORTENING though it precedes that rule in the analyses of
Bloomfield and Bever. The revised statement of the rules is
then:

(44)

a. $V \rightarrow [- \text{long}] \, / \, CC \underline{\qquad} C_o^1 \left\{ \begin{matrix} V \\ \# \end{matrix} \right\}$

b. $V \rightarrow [+ \text{long}] \, / \, \breve{V}C_o \underline{\qquad}$

c. $V \rightarrow [- \text{long}] \, / \, \breve{V}C_o \underline{\qquad} C_o^1 \left\{ \begin{matrix} V \\ \# \end{matrix} \right\}$

d. $V \rightarrow [+ \text{long}] \, / \, \#(C_o \breve{V})C_o \underline{\qquad}$

Having gained a further simplification of the EVEN SYLLABLE
SHORTENING rule, let us ask once again how the rule is to be
applied. Notice that there is material on both sides of the
focus in the rule. To the left of the focus is a syllable
containing a short vowel, while to the right is the requirement

that the focus be in an open syllable. Which of these is to be regarded as the determinant?

The answer to this question does not seem at all clear. Unlike the large majority of rules where our understanding of the process is sufficiently advanced to tell us what the determining factor is, this rule is quite peculiar and puzzling. For one thing, the expectancy is that a vowel will _lengthen_ rather than shorten in open syllables. For another, a preceding short vowel does not commonly cause a following long vowel to shorten. Both aspects of the process are therefore unusual and this makes the determinant less than obvious.

At the same time, it is important to look at the empirical implications of applying the rule in different directions and in different modes. As a rightward repetitive rule, (42) works incorrectly. To see this, consider a string containing a sequence of long vowels in open syllables: CV C$\bar{V}$C CV C$\bar{V}$ C$\bar{V}$. If rule (42) is applied in a rightward repetitive fashion, it will first shorten the penultimate vowel but then the final vowel will be in the correct position to undergo the rule and will incorrectly shorten. On the other hand, if rule (42) is leftward repetitive, only the penultimate vowel will shorten.

The empirical inadequacy of a rightward repetitive rule might be taken as evidence against considering the preceding short vowel to be the determinant, and in favor of the syllable structure as being the relevant factor. On the other hand, the ultimate argument must rest on independent grounds. If it

should turn out that the preceding vowel is indeed the deter-
mining factor, the rule would have to be a rightward simultaneous
rule in order to achieve the correct output.

The problem encountered here, then, is to decide what the
relevance of this rule is to the theoretical claims of the
directional theory. Until the rule is better understood, in
terms of its motivating factors, no real decision can be made.
But notice that if the preceding short vowel is the determinant,
the rule must be both simultaneous and assimilatory, and there-
fore would be a counterexample to the claim made in the preced-
ing sections of this chapter. On the other hand, if the
syllabic structure is the relevant determinant, the rule is
repetitive and there is no difficulty.

The above analysis has dealt with only a part of the length
alternations in Menomini and, although of peripheral significance
here, it is interesting to carry the analysis into greater com-
pletion. Bloomfield describes a set of words which he calls
"glottal words" which do not behave precisely like the ones
characterized by the rules above. They are called glottal words
because they all have a short vowel in the first syllable fol-
lowed by a glottal stop. Glottal words have the following
peculiarities, stated in terms of Bloomfield's original analysis:

(45) a. glottal words do not undergo SECOND SYLLABLE LENGTHENING.

   b. in the two rules affecting even syllables, the lengthen-
      ing and shortening effects occur in even syllables after
      the beginning of the word and after every long vowel.

Both of these pecularities can be handled by a minor modification of the SECOND SYLLABLE LENGTHENING rule. Instead of rule (43), rule (46) is required:[11]

(46) $V \rightarrow [+ \text{ long}] / \# \ C_o \ (\breve{V} \ [- \text{ glot}]_o) \ \underline{\hspace{1cm}}$

Consider the following derivations:

(47)   /a?sek+ɛn+ē̄w/   input string

         ----------   POST-CLUSTER SHORTENING

         a?sēk+ɛn+ēw   EVEN SYLLABLE LENGTHENING

         a?sek+ɛn+ɛw   EVEN SYLLABLE SHORTENING

         ----------   SECOND SYLLABLE LENGTHENING

(48)   /a?sek+ɛn+ahk+wā?/   input string

         a?sek+ɛn+ahk+wa?   POST-CLUSTER SHORTENING

         a?sēk+ɛn+āhk+wa?   EVEN SYLLABLE LENGTHENING

         a?sek+ɛn+a̅hk+wa?   EVEN SYLLABLE SHORTENING

         --------------   SECOND SYLLABLE LENGTHENING

(49)   /nɛ?nɛw/   input string

         ------   POST-CLUSTER SHORTENING

         nɛ?nēw   EVEN SYLLABLE LENGTHENING

         nɛ?nɛw   EVEN SYLLABLE SHORTENING

         ------   SECOND SYLLABLE LENGTHENING

In all of these cases, the peculiarities of glottal words are adequately accounted for simply by assuming that they don't undergo SECOND SYLLABLE LENGTHENING, _if_ SECOND SYLLABLE LENGTH-ENING is ordered after the other rules, rather than before as in Bloomfield's and Bever's analyses.

It is quite possible that there is even more to be gained from this reanalysis than meets the eye. Bever pointed out that glottal words have several other peculiarities in addition to their aberrations of vowel length. Among these are the following:

(50) a. The rule of vowel raising (to be discussed in Chapter V) raises mid vowels to high when a high vowel or post-consonantal glide follows anywhere in the word. This applies only to long vowels and to short vowels in the first syllable of glottal words.

b. It is always the case that initial vowels are unstressed, except that the first vowel of glottal words is stressed much more than any other short vowel is ever stressed.

c. Initial short vowels undergo a height neutralization and are distinguished only by frontness or backness. In glottal words, vowels maintain this height distinction.

Bever was aware that these aberrations would follow fairly naturally from an assumption that the first vowel in glottal words is a long vowel at some point in the derivation. In attempting to account for the various oddities related to glottal words, Bever assumed a peculiar sequence of rules which modified an initial glottal sequence as follows:

(51) $/\#C_0\breve{V}?C.../$ input string

       $\#C_0\breve{V}?\breve{V}C...$ epenthesis

       $\#C_0\bar{V}?\breve{V}C...$ lengthening

$$\#C_o\breve{V}?\breve{V}C... \qquad\qquad \text{shortening}$$

$$\#C_o\breve{V}?C... \qquad\qquad \text{deletion}$$

The first pair of rules performs a modification crucial to the lengthening rules and the others mentioned above, while the second pair of rules undoes the work of the first pair at the proper time.

As unreasonable as the particulars of Bever's proposal may sound, he is undoubtedly correct in assuming that there is a common explanation to the deviant behaviors of glottal words. He is probably also correct in assuming that the common explanation involves vowel length. We might then ask how these facts and assumptions relate to the analysis proposed here.

In substituting rule (46) for Bever's combined MONOSYLLABLE/SECOND SYLLABLE LENGTHENING rule, the glottal stop was called upon to block the lengthening of the second syllable of glottal words. A consequence of this measure, however, is that the shorter expansion <u>will</u> apply to glottal words, lengthening the first vowel. Thus, the same device that was used to account for the differences between glottal words and nonglottal words with regard to patterns of vowel length also functions to lengthen the first vowel of glottal words at no extra cost. It is then possible to handle the peculiarities of vowel raising, stress, and height neutralization on the basis of the length of this vowel.

The only remaining problem is to reduce the long vowel in the first syllable of glottal words to a phonetic short one.

Superficially, this is a simple matter calling only for a rule shortening the first vowel of a word before a glottal stop. The matter is complicated somewhat, however, by the fact that there is a surface contrast between long and short vowels in these syllables. How can a rule shorten only the correct vowels?

If this were an underlying distinction of vowel length there would be some problems. Perhaps it would be necessary to have underlying long vowels _exceptional_ to the required short-ening rule, or perhaps this would be another case to support the position taken in Kenstowicz & Kisseberth (1970). Fortu-nately, it is apparently the case that vowel length in these positions is predictable on other grounds. Consider, for example, the following forms:

(52) a. koqtan   'it is feared'

b. koqtam   'he fears it'

c. koqnɛw   'he fears him'

d. neko·qnaw   'I fear him'

e. ko·qnak   'one whom I fear'

Although these forms obviously involve the same morpheme, the first three are glottal words and the last two are not. It is easy to explain (52d), because it is prefixed and the glottal syllable is no longer in initial position, but it is more diffi-cult to explain why (52e) should have a long vowel and therefore not be a glottal word.

A similar example is the following:

(53) a. poqsɛ·hkam   'he dons it'

     b. nepo·qsɛhkan   'I don it'

     c. po·qsɛhkah   'when he donned it'

Again, the same root functions to make the word a glottal word
or a nonglottal word in different morphological environments.

Bloomfield refers to one of the processes of Menomini as
"initial change". Initial change is a modification of the first
vowel of a stem under certain morphological conditions (in the
changed and iterative tenses of the conjunct verb and, in
sporadic instances, in the secondary derivation of nouns and
particles). Since the modification of short o that takes place
under initial change is to lengthen it, Bloomfield (1962:92)
notes:

(54)   "When a stem in simple form yields glottal words, its
        form with prefixes or under initial change yields non-
        glottal words."

If it can be correctly assumed that all instances of long
vowels in initial glottal syllables are attributable to initial
change, it is possible to have a general rule shortening vowels
in initial glottal syllables which is subsequently undone by
the process of initial change in special instances.[12]

A summary of the rules proposed will be given here for
convenience of reference:

(55) a. $V \rightarrow [- \text{long}] / CC \underline{\quad} C_o^1 \begin{Bmatrix} V \\ \# \end{Bmatrix}$

b. $V \rightarrow [+ \text{long}] / \breve{V}C_o \underline{\quad}$

c. $V \rightarrow [- \text{long}] / \breve{V}C_o \underline{\quad} C_o^1 \begin{Bmatrix} V \\ \# \end{Bmatrix}$

d. $V \rightarrow [+ \text{long}] / \#C_o (\breve{V} [- \text{glot}]_o) \underline{\quad}$

e. vowel raising, stress, etc.

f.[13] $V \rightarrow [- \text{long}] / \#C_o \underline{\quad} [+ \text{glot}] C_o V$

g. initial change (or relevant parts thereof)

8.0 <u>Optional Simultaneous Rules: Warao Labial Voicing</u>.

Assume that the distinction between repetitive and simultaneous
rules is a valid one and that this distinction is crosscut by
a division of rules into those which are obligatory and those
which are optional. Obligatory repetitive and obligatory simul-
taneous rules have already been illustrated, but what would
optional repetitive and simultaneous rules look like? In
particular, is there any difference between the two?

The basic difference between the repetitive and simultaneous
modes of application in terms of the algorithm presented is in
the ordering of the processes of (1) identification of segments
which meet the structural description of the rule and (2)
application of the rule. With repetitive rules, these two
processes alternate so that there is an application after each
focus is identified; with simultaneous rules application comes
only after <u>all</u> foci have been identified. If there is any
difference between optional repetitive and simultaneous rules,
then, it is likely to be a matter of what happens when the

application process comes into play. If we assume that an
optional rule is one in which application may or may not take
place, the repetitive rule presumably has this option each time
a segment is identified but the simultaneous rule has it only
once. An example of an optional repetitive rule will be given
in Chapter VII (French schwa-deletion) and a possible candidate
for an optional simultaneous rule will be considered here.

According to Osborn (1966:109), the phoneme /p/ in Warao
has allophones [p] and [b]. In every word with only a few
exceptions, alternation between [p] and [b] is possible as
free variants. However,

(56)   "In words like the one cited, with two or more occurrences
        of /p/, the allophones are consistently [b] or [p] for
        each utterance of the word. If the first occurrence
        of /p/ in the word is [b], the following occurrence(s)
        will be [b]. If the first occurrence is [p], the
        following occurrence(s) will be [p]."

The voicing of labial stops in Warao is somewhat peculiar,
in that one expects free variation to be free enough to allow
a choice in each instance. Yet, Warao words are restricted so
that either all or no instances of labial stops are voiced. It
appears that this fact should be accounted for by an optional
simultaneous rule.[14]

If Warao labial voicing is admitted as an optional simulta-
neous rule, it has some effects upon the generalizations made
earlier. It has been stated that assimilatory rules apparently

cannot be simultaneously applied and that only dissimilatory rules can. It is not clear how Warao labial voicing should be treated -- as assimilatory, dissimilatory, or as "unconditioned". I am not about to propose a revision in the earlier statement on the basis of Warao labial voicing, because its status is marginal in several respects, but if it is a valid example of an optional simultaneous rule the generalization I proposed might have to be modified.

A further fact of interest contingent upon this being a valid rule is that what is accomplished here by a simultaneous rule <u>cannot</u> be accomplished by a mere reversal of directionality. This kind of case, then, is of the character that can choose between these alternative theories. On the basis of this one example, however, it would be foolish to draw a very strong conclusion.

9.0 <u>Summary</u>. If it could be maintained that all phonological rules are applied repetitively according to the algorithm previously given and that the directionality of each rule is uniquely determined from its shape, there would be a very strong argument indeed for adopting the directional theory. The existence of rules such as those discussed in this chapter weaken but do not nullify the basic argument. It is necessary, however, to provide a mechanism for dealing with rules of this type and I have proposed a particular version of simultaneous application as the appropriate means of accomplishing this end.

Two significant generalizations have been proposed about
simultaneous rules. First, it was claimed that simultaneous
application is the marked mode of application, which has
consequences for acquisition, etc. Second, it was suggested
that assimilatory rules cannot be simultaneous. There are thus
necessary, although not sufficient, conditions governing simul-
taneous application.

[1] Terena has been described by Bendor-Samuel (1960, 1962, 1963, 1966), Harden (1946), Ekdahl & Grimes (1964) and Eastlack (1968). Langendoen's commentary on Terena is in the context of a review of the work of the London School and of Bendor-Samuel in particular.

[2] It is also possible that these facts from Terena do not reflect the operation of a regular phonological rule, but rather of a "morpholexical" rule (cf. Chapter VIII). In this case the process in question is clearly a "spelling" of the morphological category "2nd person" and is found nowhere else in the language. I am indebted to Steve Anderson for this interpretation of the Terena facts.

[3] Dahl's Law was named after the missionary Edmund Dahl, who first discovered this dissimilatory process in Nyamwezi (1915). Dahl's Law appears in several variants in a number of Bantu languages, including Dzalamo, Ruanda-Rundi-Ha, Shambala (Meinhof 1932:181-83). It appears that the basic process is strikingly like Grassman's Law in Sanskrit. Dahl's original observation from Nyamwezi, quoted in Meinhof, was: "When two successive syllables each begin with an aspirate, the first of these loses its aspiration and becomes voiced."

The Southern Kikuyu version of Dahl's Law is apparently much more restricted in nature, both by applying only to velars and by the fact that a k in the stem of a word will not change

(Barlow 1960:9). Myers (n.d.) reports numerous other complexities of the behavior of Dahl's Law.

It might also be noted (with particular relevance to Anderson's theory of rule application discussed in Chapter VII) that Dahl's Law may affect sequences of three k's. Barlow (1960:9) gives the form (in conventional orthography) gĭgĭgĭthŭka 'and so it went bad (or, was spoilt)'. This form appears to be reduplicative, however, which might substantially affect the argument that a sequence of three k's is directly affected by the rule.

[4] I am indebted to Paul Kiparsky for this example.

[5] I am indebted to Fang-Kuei Li for calling this problem to my attention and for aiding in numerous ways in its solution.

[6] Third tone has a falling-rising contour (214), while second tone is rising (35). Woo (1968) has argued, however, that the 214 contour of third tone is not the underlying shape but rather the product of a rule applying in phrase final position. According to her analysis, third tone is a sequence of two low tones in underlying representation which are modified according to context. More recently, Anderson (forthcoming b) has argued that given Woo's analysis these phenomena cease to be evidence for directional rules. The simultaneous nature of the rule assumed in this discussion may thus be subject to revision when the details of Anderson's argument became known.

[7] Informants raise serious doubts about the validity of a sentence homophonous with that given in (18) but with a different syntactic structure.

[8] One further type of case not accounted for above is exemplified by <u>uɣ mai xau tɕiɣu</u> 'I buy good wine', which has a tone contour of 2-3-2-3 according to Cheng. Cheng proposes that the dissimilation rule applies obligatorily if two third tones are adjacent at either end of a sentence, but optionally within a sentence. We have seen that sentence-internal behavior is not a matter of optionality but rather of the interplay of contrastive stress and the two possible analyses of the sentence.

The problem posed above appears to demand a different explanation than that proposed by Cheng. Pronominal subjects, like those in many other languages (including English), are phonologically closely linked with the verb phrase and do not normally stand as separate phonological constituents. This effectively eliminates the possibility of parsing the sentence into two -- only the analysis including the sentence as a whole is relevant to the tone dissimilation rule here. Expected outputs are therefore 2-2-2-3, 2-1-1-3 under normal conditions; 2-3-2-3 with contrastive stress on the verb; and 3-2-2-3 with contrastive stress on the subject. The pattern 3-3-2-3 which Cheng rules out by his proposal is not possible because it requires two different elements to be under contrastive stress.

[9] It is, of course, conceivable that the acquisition data, if valid, could be explained on other grounds. For example, if criteria do exist that are necessary and sufficient to determine simultaneous application, it may be the case that young children cannot apply these for reasons having to do with physiological maturation. Evidence from acquisition, then, must be taken as only a part of the argument required to falsify necessary and sufficient conditions.

[10] For alternative analyses, see Bever (1967:121-32), Bloomfield (1962:89-94), Goddard, Hockett & Teeter (1972:1-2).

[11] I use the feature [± glottal] informally here to represent [± constricted glottis], as in Halle & Stevens (1971).

[12] One minor problem remains in this analysis if the rest of Bloomfield's proposal is accepted intact. In order to have initial change undo the effects of a general shortening rule in certain specific circumstances, initial change must follow shortening. Bloomfield (1962:99) states, however, that initial change is "descriptively prior" to rules of internal combination, although he acknowledges that in certain instances the reverse is true.

It is not immediately obvious which processes of internal combination Bloomfield is referring to. There are several facts, however, which suggest that the difficulty posed for my analysis by Bloomfield's ordering of initial change is not a serious one. First, as mentioned above, is the fact that certain instances of

initial change must follow internal combination, while others precede. Second, initial change is presented as a list of alternations, rather than as a unified phonological process or set of such processes.

These facts indicate that there is a loss of generality in Bloomfield's treatment. In treating initial change as a complex set of alternations rather than as a set of more natural rules resulting from the influence of one morpheme upon another, there is something being missed. In particular, it is likely that the ordering anomaly with which Bloomfield is confronted is due to his treating initial change as a single rule that must occur at a given point in the grammar. If it is, in reality, the interaction of several rules, they can be interspersed with other rules of internal combination.

In sum, I do not believe that Bloomfield's statement with regard to the ordering of initial change should be taken as serious counterevidence until the process of initial change is reasonably formulated.

[13] The following vowel is required in this rule in order to prevent monosyllabic words with glottal syllables from undergoing shortening.

[14] There are other possible explanations for these facts, of course. For example, the difference between [p] and [b] may reflect a difference in style (e.g., formal vs. informal, etc.) and may be obligatorily [p] in one style and [b] in another.

There is not enough data to deal with this problem effectively and simultaneous application is merely being presented as <u>one</u> possible explanation for these facts.

CHAPTER V

THE CROSSOVER CONSTRAINT

1.0 <u>Introduction</u>. From the time the first proposal of disjunctive ordering was made with regard to English phonology, there has been an undercurrent of opinion that this property is restricted to rules governing suprasegmental phenomena. This view has been expressed most frequently in oral comments, but it is manifest in print as well. For example, Johnson (1970a:127) asserts that disjunctive ordering seems properly associated only with a subset of the rules governing primary accentuation.

From the standpoint of the theory being developed here, there is increasing reason to suspect that such a restriction is valid. I will argue in this chapter that there is a converse property to that of disjunctive ordering, which I will refer to (with due apologies to Paul Postal) as the <u>crossover constraint</u>. It appears that disjunctive ordering is a property of accent rules and the crossover constraint of nonaccent rules.

2.0 <u>Menomini Vowel Raising</u>. One of the last rules mentioned in "Menomini Morphophonemics" is a rule which raises vowels under the following conditions:

(1)   "If postconsonantal y, w, or any one of the high vowels,
        i, Ī, u, ū, follows anywhere in the word, the vowels ē
        and ō are raised to Ī and ū, and the vowel o in the
        first syllable of a glottal word is raised to u ... "

The relation of this rule to glottal words has already been discussed in Chapter IV, where it was shown that mid vowels in initial glottal syllables behave as if they were long. Note that the vowel <u>e</u> does not occur in the first syllable of glottal words and therefore the generalization may be extended to all mid vowels in that environment.

If we assume that the explanation for the peculiar behavior of glottal words rests in the initial vowel being long at this point in the derivation, we may state the raising rule more generally as:

(2)
$$\begin{bmatrix} + \text{ syll} \\ - \text{ low} \\ + \text{ long} \end{bmatrix} \rightarrow [+ \text{ high}] \; / \; \underline{\hspace{1em}} \; C_o (VC_o)_o \; C \begin{bmatrix} - \text{ cons} \\ + \text{ high} \end{bmatrix}$$

This rule works perfectly to handle such alternations as the following:

(3) a. mayēček   'that which he eats'

   mayĬčckwaʔ   'that which they eat'

   b. āteʔnōhkɛw   'he tells a sacred story'

   āteʔnūhkuwɛw   'he tells him a sacred story'

   c. čēk-ɛskonēw-Eh-

   čĬkeskoniah   'by the fire'

   d. koʔnaǯen   'if he fears him'

   kuʔnatwāʔ   'if they fear him'

In all of these cases, the rule affects only a single mid vowel. What would happen, however, if a word contained two long mid vowels, both of which precede a high vowel later in the word? Bloomfield does not present such a case, but the spirit of his statement as well as its explicit form suggest that both mid vowels would raise. If only one vowel raised, presumably he would have chosen a different way of expressing these facts than saying the change will occur if a high vowel or postconsonantal glide follows _anywhere_ in the word. Moreover, the sole source of phonetic [ū] is from the operation of this rule. By including ū as one of the segments which can _cause_ the change Bloomfield clearly indicates the repetitive nature of the rule.

If we inspect rule (2) carefully, it will be evident that the rule does not do what we want it to do. According to the principle of longest expansion, only the _first_ long mid vowel of a word would be raised. Consider the following example, where the principle of longest expansion would include the sequence indicated:

(4)

$$\underline{} \quad C_o \quad (VC_o)_o \quad C \quad \begin{bmatrix} - \text{cons} \\ + \text{high} \end{bmatrix} \qquad \text{RULE}$$

$$C \quad \bar{e} \quad C \quad \underbrace{aC \;\; \bar{e}C} \quad C \quad \quad i \qquad \text{STRING}$$

The principle of longest expansion requires that the rightmost instance of ē in the above string be matched with the expression in subscripted parentheses, thereby allowing application of the rule only to the leftmost long mid vowel.

There are two ways in which this situation could be corrected. The first is to impose a language-specific constraint on (2) which allows only low or short vowels to be skipped over:

(5) $\begin{bmatrix} + \text{ syll} \\ - \text{ low} \\ + \text{ long} \end{bmatrix} \rightarrow [+ \text{ high}] / \_\_\_ C_o \left(\begin{bmatrix} + \text{ syll} \\ \begin{Bmatrix} + \text{ low} \\ - \text{ long} \end{Bmatrix} \end{bmatrix} C_o \right)_o C \begin{bmatrix} - \text{ cons} \\ + \text{ high} \end{bmatrix}$

This revision of the rule will derive the correct outputs because the rightmost long mid vowel cannot be matched with the vowel in subscripted parentheses. The shorter expansion will apply, yielding CēCaCīCCi. The derived high vowel will now function as the determinant for a second application of the rule to yield CīCaCīCCi.

3.0 <u>Crossover Constraint</u>. An alternative approach that may be taken is to propose a <u>universal</u> constraint on phonological rules, rather than a language-specific one. The constraint would have to prevent any long mid vowel from being skipped over in the application of the rule. In more general terms, the effect of this constraint would be to prohibit skipping over a segment which itself meets the structural description of the rule. One possible statement of this constraint (a <u>weak</u> version) is as follows:

(6)   No segment may be matched with an element in a rule other than the focus or determinant if that segment can also undergo the rule.

The choice between these two alternatives -- a language-specific statement and a universal principle -- is far more than a matter of personal preference. Each constitutes a particular empirical claim about the nature of language. The language-specific modification presented as rule (5) is a claim that it is an _accident_ that Menomini does not just raise the first mid vowel, and furthermore that this fact is more costly (in features) than a rule which raises just the first mid vowel. The specific modification, then, is arbitrary, accidental, and a sacrifice of generality.

A universal constraint such as that proposed here is a claim that it is natural and expected that Menomini will behave the way it does and that this is indeed more g neral than a rule which permits any number of syllables containing, say, _rounded_ vowels to intervene between the mid vowel and the high vowel or glide which causes the change. It also claims that vowels cannot be nasalized by skipping over another vowel, as in a hypothetical rule like:

(7)   [+ syll] → [+ nasal] / ___ ([+ syll]) [+nasal]

This effectively rules out a single rule solution to the Sundanese nasalization problem on universal grounds.

It is possible, however, to advocate a stronger version of the crossover constraint. As expressed in (6), the crossover constraint will disallow (7) because the vowel in parentheses also meets the structural description of the rule.

Principle (6) would allow the expression of the following rule, however:

(8)   [+ syll] → [+ nasal] / ___ [+ syll] [+ nasal]

In this case the intervening vowel is not in a position to undergo the rule itself. Yet, it seems to be as unlikely as rule (7) to be a valid rule for the same reason that we do not expect nasalization to affect a more distant vowel without affecting less distant vowels. A stronger version of the cross-over constraint may be proposed which rules out both of the above rules:

(9)   No segment may be matched with an element other than

            the focus or determinant of a rule if that segment

            meets the internal requirements of the focus of the

            rule.

The stronger version of the crossover constraint appears to be an intuitively reasonable and essentially correct limitation on phonolcgical rules. Subject to the qualification that it applies only to nonaccent rules, I propose that principle (9), the strong version of the crossover constraint, be adopted into our linguistic theory.

Since formulating this principle, I have become aware of a similar claim made by Palacas (1971). Palacas refers to an earlier statement by Margaret Stong and John Jensen[1] and then formulates his own revision of their statement which he refers to as the <u>adjacency principle</u>:

(10)   "In a phonological rule, the segments of the
         environment responsible for the change and the segment
         affected must be adjacent according to the following
         definition: the segments of the environment and the
         segment affected are adjacent if (1) they are contig-
         uous or (2) if they are of the same type and are
         separated by a string of elements that are not of that
         type." (1971:5)

The intention of the adjacency principle and that of the
crossover constraint are very similar. Both are designed to
rule out a certain subset of phonological rules on the basis
of general principles. There are three main differences be-
tween these two principles, however. First, the adjacency
principle is vague in that there is no characterization of the
notion "same type", while the crossover constraint is quite
specific (and hence falsifiable). Second, the notion of adja-
cency requires that both the determinant and the focus be of
the same type and different from the intervening segments.
This requirement is overly strong and is falsifiable by such
things as neutral vowels in rules of vowel harmony (cf. the
next section). Third, the adjacency principle disallows rules
of particular shapes but the crossover constraint may be re-
garded as disallowing applications of a rule. Thus, the
Menomini vowel raising rule presented as (2) above is ill-
formed according to the adjacency principle and a directional
theory that attempts to incorporate the adjacency principle

would have to use rule (5). In contrast, rule (2) is well-
formed in relation to the crossover constraint but not
permitted to apply in longest expansion under certain condi-
tions. Rules like (7) and (8) are totally ill-formed according
to the crossover condition, however, since _all_ of their
potential applications are disallowed.

4.0 Some Further Examples.

4.1 Finnish Vowel Harmony. In his very well-known but
unfortunately still unpublished work on the abstractness of
phonological representations, Kiparsky (1968b:26ff) presents
a particular view of Finnish vowel harmony involving two dis-
tinct manifestations of that harmony:

(11)   "(1) a morpheme structure condition which excludes the
          cooccurrence of vowels from the sets (u, o, a) and
          (ü, ö, ä) in morphemes, and (2) a phonological rule
          which makes the vowels of suffixes fronted if the last
          non-neutral vowel of the root is fronted." (1968b:29)

Kiparsky points out that the vowels _i_ and _e_ can occur
freely with vowels from both harmonic sets and may therefore be
called "neutral" vowels. The treatment of these vowels in
various analyses has taken different shapes (cf. especially
Lightner 1965, Bach 1967, Zimmer 1967), most of which involve
a more abstract representation. Kiparsky's own view is that _i_
and _e_ are simply underlying /i/ and /e/ and that the phonolog-
ical rule for vowel harmony is as follows:

(12)
$$\begin{bmatrix} V \\ + \text{back} \end{bmatrix} \rightarrow [\alpha \text{ back}]/ \begin{bmatrix} V \\ \alpha \text{ back} \end{bmatrix} \left(C_o \begin{bmatrix} V \\ - \text{rnd} \\ - \text{low} \end{bmatrix} C_o \right)_o \# X \underline{\quad}$$

The formulation above is Kiparsky's[2], and he follows it with

the statement (1968b:29):

(13)   "(where X does not contain a word boundary, and #

denotes the boundary between root and affixes). The

rule is to be applied with the longest interpretation

of the parenthetical expression which is possible; it

applies disjunctively, in that the rule is not reap-

plied to shorter environments which also might meet the

structural analysis of the rule."

The intent of this proposal is that a back vowel will

modify its value of backness to agree with the closest pre-

ceding non-neutral vowel, if there is one. If only neutral

vowels precede, it agrees with the neutral vowels and is thus

fronted. Kiparsky's insistence upon longest expansion and

disjunctive ordering are necessary in the simultaneous theory

he assumed or else the shorter expansion would cause any back

vowel following a neutral vowel in _any_ context to be fronted.

Thus, given a sequence CuCiCa the longer expansion would retain

the backness of _a_ but if the rules were not disjunctive the

shorter expansion would then incorrectly front the vowel to _ä_.

Note that this case of disjunctive ordering in relation to the

parenthesis-star notation violates the basic assumptions of

SPE.

In the directional theory proposed here, it is reasonable to assume the following formulation for Finnish vowel harmony:

(14)
$$\begin{bmatrix} + \text{ syll} \\ + \text{ back} \end{bmatrix} \rightarrow [\alpha \text{ back}] \ / \ \begin{bmatrix} + \text{ syll} \\ \alpha \text{ back} \end{bmatrix} \ (C_0 \begin{bmatrix} + \text{ syll} \\ - \text{ low} \\ - \text{ rnd} \end{bmatrix})_0 C_0 \ \underline{\quad\quad}$$

As a predictably rightward rule, (14) will have exactly the right effects -- namely, to make a vowel agree with the non-neutral vowel which precedes it (or neutral vowel if there is no preceding non-neutral vowel).

In the context of the present discussion it is of interest to ask whether the crossover constraint can be invoked here to gain further simplification of the rule. The answer is quite clearly no. Yet, it seems plain that the crossover constraint does make a correct claim with regard to vowel harmony rules. By disallowing applications where a vowel in the string meets the internal requirements of both the focus and the neutral vowel, it claims that in no language can a vowel which undergoes harmony itself function as a neutral vowel.

One issue that should be considered before leaving the topic of Finnish vowel harmony is the constraint Kiparsky placed on his rule to allow it to operate only outside of root morphemes. Kiparsky has argued that the different classes of exceptions indicate that there are two manifestations of harmony -- the phonological rule given above, which admits of no exceptions -- and a morpheme structure condition which allows violations of the harmony principle in various foreign loanwords. By stating the phonological rule as specifically

as he has, Kiparsky prevents the rule from undoing the cases
which violate the morpheme structure conditions. It seems
reasonable to me, however, to put the exceptionality where it
belongs, namely on the lexical items in question. I assume
that rule (14) is correct and that the particular deviant
vowels in foreign loanwords are marked as exceptional to both
the morpheme structure condition and the phonological rule.[3]

4.2 <u>Icelandic u-umlaut</u>. An interesting case in relation
to the crossover constraint is the rule of <u>u</u>-umlaut in Icelan-
dic. This process has been treated in Anderson (1969) and in
subsequent papers where he has proposed a revised and more
interesting analysis.

The most basic fact of <u>u</u>-umlaut is that an <u>a</u> is modified
by a <u>u</u> in a following syllable. In a stressed syllable (essen-
tially the first syllable of the word), the <u>a</u> becomes mid front
rounded <u>ö</u>:

(15) a. fata   'pail'   fötu   (obl.sg.)

     b. stað   'place'   stöðum   (dat.pl.)
                  (acc.sg.)

     c. fagran   'beautiful'   fögru   (n.dat.sg.)
                  (m.acc.sg.)

In unstressed syllables the result of <u>u</u>-umlaut is [Ü]
(orthographic <u>u</u>):

(16) a. meðal   'drug,   meðulum   (dat.pl.)
                  medicine'

     b. hérað   'region'   héruðum   (dat.pl.)

Anderson relates the change of a to u to the general fact that vowels are reduced in unstressed syllables. While the vocalic inventory in stressed syllables is very rich, only [I], [Ü], and [a] are found in unstressed syllables. The difference between [ö] and [Ü] as the output of u-umlaut can thus be attributed to the vowel reduction rule which raises all nonlow unstressed vowels:

(17)
$$\begin{bmatrix} + \text{ syll} \\ - \text{ stress} \\ - \text{ low} \end{bmatrix} \rightarrow \begin{bmatrix} + \text{ high} \\ - \text{ tense} \end{bmatrix}$$

Deviant cases of numerous types occur. For example, many nouns end in -ur in the nominative singular without showing umlaut:

(18) a. dalur   'valley'

     b. akur   'field'

     c. faraldur   'epidemic'

The same stems do show umlaut, however, when followed by other endings containing u, such as the -um of the dative plural. One must conclude that the failure of these forms to umlaut in the nominative singular is not a peculiarity of the stems but rather of the suffix. Anderson thus constructs an argument, taking other factors into consideration, for a rule of u-epenthesis which will follow u-umlaut and account for the above cases.

There are also Icelandic forms which show the effects of u-umlaut yet which do not possess a u in the phonetic

representation:

(19) a. barn   'child'   börn   'children'

     b. blað   'newspaper'   blöð   'newspapers'

     c. tagl   'horsetail'   tögl   'horsetails'

Here, as in his treatment of i-umlaut in Icelandic, Anderson argues for an underlying distinction between tense and lax vowels with subsequent deletion of lax u. The validity of this distinction will not be at issue here.

Some words undergo the u-umlaut rule more than once. Consider the following examples:

(20) a. fatnaður   'suit of   fötnuðum   (dat.pl.)
                        clothes'

     b. safnaðar   'congregation' söfnuðum   (dat.pl.)
                        (gen.sg.)

Since the change from ö to u can be accounted for by the vowel reduction rule, these cases of double application can be treated within the simultaneous framework of SPE by allowing both instances of a to become ö by u-umlaut and then raising the one in the unstressed syllable by the rule of vowel reduction. With this in mind, an initial formulation of the u-umlaut process (in informal terms) might be:

(21) $a \rightarrow ö \;/\; \underline{\quad} \; (C_o \; a)^* \; C_o \; u$

Notice that in rule (21) the vowel in parentheses is a, the very same vowel which constitutes the focus of the rule. Any other vowel intervening between the focus and determinant

will block <u>u</u>-umlaut:

(22)   akkeri   'anchor'   akkerum   (dat.pl.)

Since the vowel <u>a</u> is allowed to intervene between the focus
and the determinant, rule (21) could not be taken over into an
analysis of <u>u</u>-umlaut within the directional theory without
falsifying the crossover constraint. It must then be asked
whether this is indeed a correct formulation of the process.

In other cases where a simultaneous description involved
repetitions of the environment within parentheses, the corre-
sponding analysis in the directional theory was simply able to
omit the parenthetical expression altogether. Thus, the rule
of vowel raising in Southern Agaw discussed in Chapter II would
require the following statement in the SPE framework:

(23) $\begin{bmatrix} + \text{syll} \\ - \text{low} \end{bmatrix} \rightarrow [+ \text{high}] \ / \ \underline{\quad} \ C_o \ (\begin{bmatrix} + \text{syll} \\ - \text{low} \end{bmatrix} C_o)* \begin{bmatrix} + \text{syll} \\ + \text{high} \end{bmatrix}$

The corresponding statement within the directional theory was:

(24) $\begin{bmatrix} + \text{syll} \\ - \text{low} \end{bmatrix} \rightarrow [+ \text{high}] \ / \ \underline{\quad} \ C_o \begin{bmatrix} + \text{syll} \\ + \text{high} \end{bmatrix}$

If this approach were followed with Icelandic <u>u</u>-umlaut, the
relevant rule would be:

(25) $a \rightarrow \ddot{o} \ / \ \underline{\quad} \ C_o \ u$

Rule (25) fails to give the correct output, however, since the
application of the rule does not yield an output which con-
stitutes further input to the rule. That is, to be parallel

with the Southern Agaw example the low vowel should become a high back vowel so that it might cause a preceding low vowel to undergo a subsequent change. Yet, such a modification of the rule cannot be directly accepted for Icelandic.

It is appropriate at this point to return to further details of Anderson's analysis. He claims, quite properly, that the change from a to ö is sufficiently unusual to suggest that another formulation might be preferable. He proposes that the u-umlaut rule should not yield ö directly but rather that this output is the result of a number of steps. The first of these steps, the revised u-umlaut rule, converts a to ɔ. That is, u-umlaut is regarded as a simple process of rounding:

(26)   a → ɔ / ___ (C$_o$ a)* C$_o$ u

Anderson's second step is a consequence of his observation (1969:35) that "as a late phonecic fact ... the vowel represented by underlying o is pronounced as a low vowel [ɔ]." The output of the revised u-umlaut rule and underlying o can then be interchanged by means of a vowel shift rule:

(27) $\begin{bmatrix} + \text{syll} \\ - \text{high} \\ + \text{round} \\ - \text{tense} \\ \alpha \text{ low} \end{bmatrix}$ → [-α low]

Thus the underlying vowel a becomes ɔ through the application of u-umlaut and is subsequently raised to o by vowel shift. Vowel reduction will raise this further to u if it is in an unstressed syllable.

The remaining rule that is required is a rule of fronting. This rule is independently needed, for underlying /u/ in unstressed syllables is phonetically [Ü]:

(28)
$$\begin{bmatrix} + \text{ syll} \\ - \text{ low} \\ - \text{ tense} \end{bmatrix} \rightarrow [- \text{ back}]$$

The derivation of a form like fötnuðum could then proceed as follows:

(29)   /fatnað+um/   underlying form

      fɔtnɔð+um   u-umlaut

      fotnoð+um   vowel shift

      fotnuð+um   vowel reduction

    [fötnüð+üm]   fronting

An interesting and important difficulty with any formulation of Icelandic u-umlaut is the class of exceptions to it. There are two basic types of exceptions:

(30) a. almanak   'calendar'   almanökum   (dat.pl.)

     b. akarn   'acorn'   akörnum   (dat.pl.)

     c. Japani   'Japanese'   Japönum   (dat.pl.)

     d. apaldur   'apple tree'   apöldum   (dat.pl.)

(31) a. kafald   'blizzard'   köföld   (nom.pl.)

     b. hafald   (weaving term) höföld   (nom.pl.)

The first type of exception is deviant in that the u-umlaut process is undergone only one time, unlike fötnuðum. Moreover, the vowel in that syllable is unreduced. Anderson's

original proposal (1969) was that these anomalous forms could

be accounted for by assuming a lexical stress on the final

vowel of the stem. This stress would block the reduction of

the vowel after u-umlaut and a minor modification of the u-

umlaut rule could prevent a vowel from undergoing the rule if

the following vowel is stressed. Thus the stress would at once

block vowel reduction and a second application of the rule.

In Anderson (1972b), however, it was argued that there is

a more direct relationship between the failure to undergo vowel

reduction and the failure of u-umlaut to apply more than once

to a word. Anderson claims that the reason that there is no

further umlaut in the examples in (30) is that the derived

vowel has not been raised to u by vowel reduction and hence

cannot cause a further application of the rule. Anderson

(1972b:7) thus proposes that the derivation of fötnuðum pro-

ceeds as follows:

(32)   /fatnað+um/   underlying form

        fatnöð+um   u-umlaut

        fatnuð+um   vowel reduction

        fötnuð+um   u-umlaut

Such nontransitive ordering is prohibited in the SPE theory,

but is an integral part of the theory of rule ordering pro-

pounded in Anderson (1969) and illustrated by Anderson in

numerous other papers. It is also a formalization of the

traditional description (as Anderson points out), as can be

exemplified by the following quote from Einarsson (1949:31):

(33)   "If a occurs in a suffix or an inflexional ending, it

        is changed to u (which in turn changes a preceding a

        of the root syllable to ö) ..."

Anderson's position, then, is that the examples in (30)
are exceptional to vowel reduction and the fact that these
words only undergo u-umlaut once is a direct consequence of
that exceptionality. He acknowledges that the failure to
undergo vowel reduction may be due to the presence of secondary
or lower stresses (about which little is known), or perhaps to
some other factor. An obvious possibility is simple exception-
ality to the vowel reduction rule.

The forms in (31) are treated as "complete exceptions,
consistent with the feeling of native speakers that these are
rather strange words" (1972b:10). These are apparently the
only two members of the class. According to Anderson, hafald
is a very rare word not found in many dictionaries, while
kafald is usually given with the "regular"[4] plural kaföld in-
stead of köföld. The decision to regard these as complete
exceptions thus seems to be a well-motivated one.

The essential point of this discussion is that what start-
ed out as a rule in violation of the crossover constraint has,
by virtue of Anderson's reanalysis, become fully consistent
with it. It is of some interest, however, to briefly consider
the implications of alternative solutions within a theory

involving transitive rule ordering.

Both of these alternative solutions rely on a different treatment of vowel shift than that offered by Anderson. In the analysis just considered, u̱-umlaut is a process of rounding which is followed by a vowel shift rule interchanging o̱ and ɔ̱. Suppose, however, that the change from o̱ to ɔ̱ is a separate rule preceding u̱-umlaut and u̱-umlaut is modified to make vowels nonlow. This analysis avoids the problem of merging the outputs of u̱-umlaut and vowel shift, eliminates an exchange rule,[5] and is consistent with other ordering arguments.

The first alternative assumes that the output of u̱-umlaut in unstressed syllables is u̱, while that in stressed syllables is ö. A word like fötnuðum in this analysis is derived by successive applications of the u̱-umlaut rule followed by the fronting rule. The effect of this proposal is to make the output of u̱-umlaut in unstressed syllables a segment that can itself function as the determinant for a subsequent application. The required modification of the u̱-umlaut rule is as follows:

(34)
$$\begin{bmatrix} + \text{ low} \\ <- \text{ stress}> \end{bmatrix} \rightarrow \begin{bmatrix} <+ \text{ high}> \\ - \text{ low} \\ + \text{ round} \end{bmatrix} / \underline{\hspace{1cm}} C_o \begin{bmatrix} + \text{ high} \\ + \text{ round} \end{bmatrix}$$

This solution, of course, relies upon Anderson's initial suggestion that it is lexical stress which blocks vowel reduction in forms like almanökum.

A second alternative assumes that the output of u-umlaut

is regularly o, but that both u and o can be determinants for

the rule. By this modification fötnuðum goes through an inter-

mediate stage fotnoðum before vowel reduction and fronting

yield the correct final output. The problem with this analysis

is the familiar one of dealing with the exceptional cases in

(30). One way of resolving this problem is to utilize lexical

stress:

(35)

$$[+ \text{ low}] \rightarrow \begin{bmatrix} - \text{ low} \\ + \text{ round} \end{bmatrix} / \underline{\hspace{1cm}} C_o \begin{bmatrix} - \text{ low} \\ + \text{ round} \\ - \text{ stress} \end{bmatrix}$$

The requirement that the determinant be unstressed prevents an

a that precedes a stressed o (ultimately ö) from being modified.

Another way of resolving this difficulty is mentioned here

for its interest value. The u-umlaut rule would be stated as

in (36):

(36)

$$[+ \text{ low}] \rightarrow \begin{bmatrix} - \text{ low} \\ + \text{ round} \end{bmatrix} / \underline{\hspace{1cm}} C_o \begin{bmatrix} - \text{ low} \\ + \text{ round} \end{bmatrix}$$

Under normal repetitive application, rule (36) will correctly

derive forms like fötnuðum. To prevent almanökum from becoming

*ölmunukum, however, we can assume that the rule is applied

simultaneously to these cases. That is, a possible theoretical

position is that some lexical items can be exceptional in

undergoing a rule simultaneously while regular lexical items

undergo it repetitively. The effect of simultaneous applica-

tion would be to modify only the single instance of a that

occurs in the correct environment in the underlying form.

This solution is not entirely adequate as it stands, however, even if this device is accepted. Irregular forms like almanökum would be incorrectly derived with a reduced vowel, even if the rule is applied simultaneously to them. They must also be considered exceptional to the process of vowel reduction. It would therefore be possible to assume a redundancy rule of the following shape:

(37)   [- repetitive Rule u-umlaut] ⊂ [- Rule vowel reduction]

By this analysis, the forms in (30) would be specified as simultaneous, while those in (31) would be exceptional to vowel reduction alone.

This type of analysis requires some additional commentary. Clearly the two devices required -- allowing exceptions to be simultaneous rather than repetitive and redundancy rules like the above -- add a great deal of power to the theory and should therefore be accepted only with reluctance and used only with caution. They are mentioned here because they should not be ruled out on a priori grounds and are, in fact, not terribly different in nature from other devices that have been proposed. For example, it appears that individual lexical items can be exceptional in undergoing rules in a marked order, may undergo rules optionally when other items undergo them obligatorily, etc. As far as redundancy rules are concerned, they have been used by Schane (cf. footnote 3 of this chapter) to handle implicational relations of exceptionality to one rule in

relation to exceptionality to another. Anderson (1972b:22)
uses them to state that words with certain segmental composi-
tion will undergo a particular pair of rules in unmarked order.

If any of the above analyses should turn out to be correct,
the original difficulty with which we were confronted -- a rule
in violation of the crossover constraint -- disappears. If
none of these analyses are correct, it is highly likely that
the correct analysis will be in conformity with the crossover
constraint.[6]

5.0 _Accent Rules_. In Chapter III it was argued that the
property of disjunctive ordering is attributable to the direc-
tional principle and the principle of longest expansion. For
disjunctive ordering to have any content, it is necessary that
one of the elements in a parenthetical or subscripted expres-
sion be a potential focus of the rule. Since this element is
skipped over in taking the longest expansion, disjunctive
ordering occurs precisely where the crossover constraint is
directly violated.

The crossover constraint and the notion of disjunctive
ordering are incompatible if both are allowed to apply to the
same range of cases. The only way in which both may be main-
tained is by defining the circumstances under which each is
operable. Since both of these principles appear to be correct
and significant, it becomes imperative to provide mutually
exclusive definitions of these two sets of circumstances.
Within the framework of this dissertation, the problem is when

to define the notion of longest expansion in one way and when
to define it in another.

As mentioned in the first section of this chapter, the
relevant distinction seems to be between those rules which in-
volve accentual phenomena and those which do not. The former
violate the crossover constraint and can involve disjunctive
ordering while the latter do not. An important goal of lin-
guistic theory must then be to characterize the notion of
"accent rule" relative to the issue at hand.

The relevant notion is certainly not that of the "prosody"
of the London School. Such phenomena as nasalization and
palatalization, which are subject to prosodic analysis, clearly
obey the crossover constraint. Yet the domain of accent rules
needed here cannot be as narrow as the class of stress rules.
Vowel lengthening rules and stress rules both appear to qualify
as accent rules. Perhaps certain other phenomena must be
admitted to this class as well.

One fundamental property which accent rules share is that
they are generally applied obligatorily to every content word
of the language. All English words have some stressed syllable,
while all Menomini words contain a long vowel.[7] Is there a
language which must palatalize some segment in every word?
Nasalize some segment? I don't believe so.

The basic principle I wish to advocate here is that there
are only certain phenomena which can constitute accent rules --
which can be obligatorily assigned to every content word of a

language -- and that only rules pertaining to these phenomena
violate the crossover constraint. All other rules are subject
to it. Undoubtedly there are other characteristics that such
rules share, but this remains an area for future investigation.

In the remainder of this chapter I wish to consider a
number of examples of accent rules which will serve to illus-
trate violations of the crossover constraint as well as to
demonstrate further the directional principle and related
phenomena.

5.1 Southern Paiute Alternating Stress. Southern Paiute,
a Uto-Aztecan language spoken in southwestern Utah and north-
western Arizona, has been most extensively studied by Sapir
(1930, 1933). Sapir's provocative analysis is still stimula-
ting new ideas and new analyses forty years after its publica-
tion. Recent reanalyses include Harms 1966; Rogers 1967;
Chomsky & Halle 1968:344-49; Nessly 1971; Palacas 1971.

Chomsky & Halle in their discussion of Southern Paiute
quote Sapir (1930:39) regarding the alternating stress rule:

(38)   "According to this all odd moras are 'weak' or rela-
        tively unstressed, all even moras are 'strong' or
        relatively stressed. The theoretically strongest
        stress of the word comes on the second mora. Hence
        all words beginning with a syllable containing a long
        vowel or diphthong ... are accented on the first
        syllable ... On the other hand, all words beginning
        with a syllable containing an organic short vowel ...

are accented on the second syllable, unless the second

syllable is final, and therefore unvoiced, in which

case the main stress is thrown back on the first

syllable."

Chomsky & Halle (1968:347) point out that Sapir's statement is

not entirely correct, since stress is never placed on final

vowels, even in polysyllabic forms.

In their analysis, Chomsky & Halle propose that the alter-

nating stress rule consists of two subrules, one of which

applies to polysyllabic forms and one of which applies to mono-

syllabic forms:

(39) a.   V → [1 stress] / #C_oV(C_oVC_oV)*C_o ___ [+ seg]$_o$$C_o$V#

     b.   V → [1 stress] / #C_o ___ C_oV#

The first of these rules utilizes the parenthesis-star notation,

which abbreviates a simultaneously ordered infinite set of rules

and serves to place stress on every alternate syllable from the

left but not upon the last vowel of the word.   The second rule

stresses the first syllable of bisyllabic forms.   Chomsky &

Halle abbreviate these two rules as follows:

(40)   ... / # $\langle C_o$V(C_oVC_oV)*$\rangle$ C_o ___ $\langle$[+ seg]$_o\rangle$ C_oV#

The above rule is more complex than it has to be, even

within the Chomsky & Halle framework.   It is evidently only a

matter of oversight that the rule was not expressed in a way

to take advantage of the principle of disjunctive ordering:

(41)   ... / # (C_oV (C_oVC_oV)*) C_o ___ C_oV

The rule presented in (41) adequately deals with the facts in
terms of the standard theory, but the principle of longest
expansion would create difficulties if this rule were treated
simply as rightward directional.

I propose that the alternating stress rule of Southern
Paiute is as follows:

(42)   V → [+ stress] / $\breve{V}C_o$ ___

This rule will correctly stress every alternate vowel from the
beginning of the word but has two undesirable consequences.
One of these is to stress final vowels in polysyllabic forms
when they contain an even number of syllables; the other is to
give the wrong stress contour to bisyllabic forms.

In an earlier draft of this work I proposed that the solu-
tion to Southern Paiute alternating stress involved rule (42)
followed by a rule which retracts stress off final syllables.
In order to give the same patterns provided by Chomsky & Halle
and implied by Sapir, it would be necessary to retract stress
two syllables on polysyllabic forms, thus placing it redundant-
ly on a syllable that is already stressed, and one syllable in
bisyllabic forms. Informally, such a rule might be stated:

(43)   V (CV) CV́ # ⇒ V́ (CV) CV #

Ken Hale has informed me, however, that both Sapir's anal-
ysis and that of Chomsky & Halle overlook an important fact.

There is good evidence from the segmental phonology of Southern
Paiute to indicate that the penultimate syllable receives
stress at some point in the derivation and that this is the
only environment where a sequence of two stressed syllables
may occur.

Hale's observation is quite inconsistent with the analysis
proposed in Chomsky & Halle. It would require only a minor
change in the retraction rule that I have proposed, however.
Instead of retracting stress two syllables if there are two
syllables or more preceding and one syllable otherwise, stress
could be retracted one syllable in all cases. This would con-
stitute a simplification of the retraction rule.

With the discovery of this additional information, however,
a much more attractive solution presents itself. It is possi-
ble to account for all of the above outputs by means of two
very common and natural rules:[8]

(44) a. V → [+ stress] / ___ $C_o V\#$

b. V → [+ stress] / $\breve{V}C_o$ ___

The interaction between these two rules may be illustrated in
the derivations of the following forms:

(45)   /CVCVCVCV/   /CVCVCVCVCV/   /CVCV/

         CVCVCV́CV   CVCVCVCV́CV   CV́CV   penultimate stress

         CVCV́CV́CV   CVCV́CVCV́CV   ----   alternating stress

The application of the penultimate stress rule to these forms
makes it impossible to stress the final syllable, since that is

no longer preceded by a stressless vowel. This prevents the alternating stress rule from applying to bisyllables and limits its application in polysyllables.

The alternating stress rule as stated within the directional theory does not violate the crossover constraint. The preceding unstressed vowel is assumed to be the determinant and no vowel intervenes between the determinant and the focus. With the penultimate stress rule, however, the crossover constraint is violated. Assuming the determinant of this stress rule to be word boundary, a vowel does in fact intervene between the determinant and the focus. Penultimate stress rules illustrate the fact that a rule need not be disjunctively applied in order to violate the crossover constraint.

A further interesting implication of this analysis is that there are monosyllabic forms in Southern Paiute, too, and these also receive stress. It would be extremely difficult to incorporate this fact into the analysis provided by Chomsky & Halle, but very simple and straightforward within the analysis proposed here. The penultimate stress rule must be restated as:

(46) $V \rightarrow [+ \text{ stress}] / \underline{\quad} (C_o V) \#$

The inability to use rule (41) within the directional theory has forced a new analysis based on stress retraction. This new analysis has turned out to be consistent with facts of the language that were not known at the time it was formulated, while the analysis upon which it was based could not take these

new facts into account very easily. In a sense, the directional theory predicted data that diverged from that reported in the literature. In cases like this the value of a formal theory becomes obvious. The step from an analysis based upon stress retraction to one based upon a penultimate stress rule then became very straightforward.

5.2 Tübatulabal Alternating Stress. Another language which manifests alternating stress phenomena is Tübatulabal, a Uto-Aztecan language of southern California and a close relative of Southern Paiute. According to Voegelin (1935:75-78), stress in Tübatulabal is governed by the following regular factors:

(47) a. "With very few exceptions ..., the main stress falls on the final vowel of the stem; or if suffixes are appended, on the final vowel of the last suffix."

b. "Counting backward from the main stress, every second mora is stressed where possible."

c. "When a stressed vowel is preceded by a short vowel (one mora), which is in turn preceded by a long vowel (two morae), the alternate accent falls on the third mora counting backward from the stressed vowel."

d. "Two short vowels of the same phoneme which are kept separated by a glottal stop are treated in alternation of stress as a single accentual unit; but only if both belong to the same grammatical element -- that is, if

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both belong to the same stem (the vowel repeated in initial reduplication is external) or if both belong to the same suffix."

e. /certain instances of glottal stop are counted as a mora./

f. "Alternation of stress is modified in certain elements which contain vowels that are stressed in all circumstances. The vowel having such fixed stress serves as a point of departure for alternation of stress in the word, counting backward."

In order to explain this pattern, we can assume the operation of two major stress rules. FINAL STRESS accounts for (47a) and may be stated as follows:

(48) $V \rightarrow$ [+ stress] / ___ $C_o \#$

It is apparent from statement (47c) that a leftward version of the Southern Paiute alternating stress rule will be inadequate for Tübatulabal. Instead we need to assure that if stress is to fall on any part of a long vowel it will be the first part. This can be accomplished by considering long vowels as sequences and skipping over a postvocalic vowel:[9]

(49) $V \rightarrow$ [+ stress] / ___ $(\breve{V})$ C_o $\breve{V}$

The FINAL STRESS and ALTERNATING STRESS rules together account directly for (47a-c), which may be illustrated by the following examples:

(50) a. wɪta'ŋhata'l   'the Tejon Indians'

  b. wɪ'taŋha'tala·'batsu' 'away from the Tejon Indians'

  c. pïtï'tpïtï·'dina't 'he is turning it over
             repeatedly'

  d. yu·'udu·'yu·'ʊda't 'the fruit is mashing'

The cases of fixed stress discussed in (47f) would appear to be consistent with the above, except that underlying stressed syllables are required.

  The roles of (47d,e) are more problematic, however. These are exemplified by the following:

(51) a. ku'ʔudžubɪ'l 'the little one'
    (*kuʔu'džubɪ'l)

  b. uyu'ʔµm   'it got word out'
    (*u'yuʔµ'm)

  c. ï'mbïŋwi'baʔa't 'he is wanting to roll string
            on his thigh'

  d. na·'adï'ʔi' 'the cat (obj.)'

  e. kô'ʔôci'ʔi' 'the minnow fish (obj.)'

Here the first two forms illustrate a sequence of vowels separated by glottal stop functioning as a "single accentual unit". The third form does not behave this way because the two vowels separated by glottal stop belong to different grammatical elements. The last two examples are presented to show the glottal stop counting as a full mora.

  In his discussion of Tübatulabal stress, Johnson (1970a: 78-79) ignores the complexities of (47d-f) and treats (47a-c) as a sequence of three rules, one stressing final vowels, one

stressing long vowels, and a separate alternating stress rule. Anderson (1969:118-21) attempts to build the peculiarities of the behavior of glottal stop into the alternating stress rule and proposes the following statement of the rule:

(52)

$$V \rightarrow [+ \text{stress}] / \underline{\hspace{1cm}} (?(\begin{bmatrix} + \text{syll} \\ - \text{stress} \end{bmatrix}))C_0 (\left\{\begin{matrix} \begin{bmatrix} + \text{syll} \\ - \text{long} \\ - \text{strs} \end{bmatrix} \\ ? \end{matrix}\right\})C_0 \begin{bmatrix} + \text{syll} \\ + \text{strs} \end{bmatrix}$$

As complicated as this rule appears, Anderson points out that it only stresses a single vowel before the final stressed vowel. In order to allow this rule to yield a sequence of stresses as is necessary in Tübatulabal, the SPE framework would require the use of parenthesis-star notation. It has been shown in Chapter II that rules written with parenthesis-star notation commonly involve a repetition within parentheses of the environment of the rule. In the case of the Tübatulabal rule above, the entire sequence presented as the environment of (52) must be repeated within parenthesis-star. The enormous complexity of that expression detracts from the likelihood that the parenthesis-star notation is valid. Anderson concludes that rule (52) must instead be applied iteratively.

While Anderson's basic argument is sound and undoubtedly correct, it seems unreasonable to build these peculiarities of glottal stop into the stress rule. For one thing, there are special rules relating to glottal stop discussed in McCawley (1969), Lightner (1971), and Swadesh & Voegelin (1939). These

may very well be the source of the surface peculiarities of

stress. For example, one of these rules (number 8 in McCawley's

analysis) inserts an epenthetic vowel between a glottal stop

and certain consonants. This may be what is responsible for

what is happening in ku'ʔudžubι'l and uyu'ʔµm. The last two

examples in (51), na·'adϊ'ʔi' and kô'ʔôci'ʔi' where the glottal

supposedly has the value of a mora are suggestive of a deletion

rule. It is interesting that Voegelin (1935) does not define

an environment where this property of glottal stop holds, al-

though the fact that both examples are objective forms points

to a peculiarity in the behavior of that suffix.

In addition to these factors which would enhance the like-

lihood that the correct solution involves removing the pecu-

liarities of glottal stop from the statement of the alternating

stress rule, there are more immediate reasons for objecting to

Anderson's formulation of the rule: (1) It does not allow the

derivation of forms like (51c) which have glottal stop but

behave "normally" in relation to the final and alternating

stress rules I have given; (2) It does not derive (51b) and

would be forced to attribute the same peculiar behavior of

glottal stop to the rule for final stress; and (3) It would

stress the first vowel of every word, since that vowel always

meets the structural description of the expansion in which no

optional elements are chosen. These are rather serious objec-

tions and cannot be overcome by minor adjustments of the rule.

I would assert that the stress phenomena of Tübatulabal are the result of a rule of final stress followed by a leftward alternating stress rule. The similarities between these two rules allow them to be stated as follows:

(53)

$$
V \rightarrow [+ \text{ stress}] / \underline{\hspace{1cm}} \left(\begin{bmatrix} + \text{ syll} \\ - \text{ stress} \end{bmatrix} \right) C_o \left\{ \begin{matrix} \# \\ \begin{bmatrix} + \text{ syll} \\ - \text{ stress} \end{bmatrix} \end{matrix} \right\}
$$

If this rule approximates a correct analysis of Tübatulabal stress (or even if Anderson's analysis were correct), the fact that a mora is skipped over in the alternating stress rule constitutes a violation of the crossover constraint. This demonstrates that even alternating stress rules are capable of violating the crossover constraint.

5.3 <u>Eastern Ojibwa Alternating Stress</u>. Eastern Ojibwa presents an interesting comparison with the stress rules of Southern Paiute and Tübatulabal just discussed. While the other two languages are closely related Uto-Aztecan languages spoken in the southwestern United States, Eastern Ojibwa is Algonquian and spoken along the northern shores of the Great Lakes.

In his study of Eastern Ojibwa, Bloomfield (1956:5) makes the following statement about vowel reduction:

(54)   "Within a word, in any succession of (one or more) short vowels, the vowels of the odd-numbered (first, third, etc.) syllables are reduced, with the exception

that the last vowel of a word is never reduced."

The reduced vowels are spoken with less loudness and are often whispered or entirely omitted. They also undergo changes in quality. Johnson (1970a:74-76) reasonably interprets this to mean that the reduced vowels are those which are unstressed.

In order to stress the converse set of vowels, Johnson proposes three rules. The first of these stresses long vowels, the second final vowels, and the third alternating unstressed vowels.

I propose that Eastern Ojibwa stress involves a pair of rules (ordering being noncrucial in this case) which stress the final syllable and alternating syllables from left to right. The FINAL STRESS rule is straightforwardly stated:

(55) $V \rightarrow [+ stress] / \_\_\_ C_o \#$

The ALTERNATING STRESS rule operates from left to right and must contain a three-mora provision like the Tübatulabal rule did:

(56) $V \rightarrow [+ stress] / \breve{V}C_o(\breve{V}) \_\_\_$

These two rules will handle the stress phenomena described by Bloomfield and by Johnson.

Notice the great similarity between the three languages just discussed. Tübatulabal and Eastern Ojibwa share a rule stressing final syllables. Southern Paiute diverges by having a penultimate stress rule instead. All three languages have

alternating stress rules, which for convenience of reference I repeat below:

(57) a. $V \rightarrow$ [+ stress] / $\breve{V}C_o$ ___   SOUTHERN PAIUTE

b. $V \rightarrow$ [+ stress] / ___ $(\breve{V})C_o\breve{V}$ TÜBATULABAL[10]

c. $V \rightarrow$ [+ stress] / $\breve{V}C_o(\breve{V})$ ___   EASTERN OJIBWA

The alternating stress rule of Eastern Ojibwa seems to be mid-way between the rules of the other two languages. It shares with Southern Paiute a common directionality, but with Ṭübatulabal the optional mora. Yet, the two languages which are genetically related are Southern Paiute and Tübatulabal!

6.0 Conclusion. In this chapter I have proposed the crossover constraint, which claims that no segment meeting the internal requirements of the focus of the rule can intervene between the determinant for a given application and the segment affected by that application. This principle makes an interesting claim about language, since it immediately rules out a large number of imaginable phonological rules and declares them to be impossible. On the other hand, in order to maintain the crossover constraint it is necessary to draw a distinction between the circumstances in which the constraint may be violated and those in which it is valid.

I have proposed that the basis for this distinction has to do with accent and nonaccent rules. This notion demands further clarification and has been offered here only as what I believe

to be a step in the right direction of such a characterization. Rules which apply to nearly every vocabulary item, such as stress rules or vowel length rules in languages like Menomini, fall into the class of accent rules and therefore do not obey the crossover constraint.

NOTES

[1] Palacas did not give a specific reference, although he does state that their proposal was made in the context of a discussion of Hungarian vowel harmony.

[2] This statement differs from Kiparsky's only in replacing two instances of C with C_o. This was clearly Kiparsky's intention, as can be seen on page 30 of that same work.

[3] Although it seems reasonable enough to put the exceptionality on the deviant words, this position is open to the objection that these vowels are thus exceptional to two rules -- the morpheme structure rule and the harmony rule -- and therefore a generalization is being missed. This objection can be countered by pointing out the need to do precisely the same thing in other languages. Thus, Schane (1968a:9) states that for French: "A morpheme which is an exception to the rule for truncation is also an exception to the rule for final consonant deletion." In English a word like chamber is exceptional to the morpheme structure rule requiring lax vowels before nondental clusters, but it also must be exceptional to the phonological rule which laxes vowels in that position. This kind of multiple exceptionality appears to be a natural and expected phenomenon.

[4] The term "regular" here is borrowed from Anderson (1972b:10), but kaföld must still be regarded as an exception to vowel reduction as with the forms in (30).

[5] The status of exchange rules in phonological theory is still problematic. It is for this reason that an analysis which is otherwise reasonable and avoids an exchange rule is of some interest.

[6] There are interesting problems with all of these proposed analyses that are worth mentioning here. First of all, the use of lexical stress to handle exceptions like almanökum is somewhat questionable. The principle motivation for this is that the result of u-umlaut is universally ö in syllables where the existence of stress is well-established (e.g. in the first syllable of a word). However, as Anderson points out, there is little or no direct phonetic evidence of stress on the third syllable of almanökum and in other similar environments crucial for this analysis.

Another problem arises in Anderson's revised analysis if we assume simple exceptionality to vowel reduction. What is the unit which is exceptional? Is it the entire morpheme or just the vowel in question? If it is the entire morpheme, the claim must be that no other vowel in that morpheme can undergo vowel reduction. Anderson presents no cases which would falsify this, since a does not undergo vowel reduction and in all cases given the other stem vowels are a. If any case exists which contains a mid vowel, however, there is clear falsification of this position.

On the other hand, suppose it is the vowel which is exceptional to vowel reduction, much as I assume it is

particular vowels in borrowed words of Finnish which are
exceptional to the harmony rules. The question to be asked is
why it is always the last a of the stem which is exceptional
and not any other vowel. Why are there no forms like
*almönukum, for example? Notice that this question must also
be raised with regard to solutions based on lexical stress.

[7] This is not strictly true for Menomini because cer-
tain glottal words have no long vowels. Nevertheless, the
analysis presented in the preceding chapter assumed that at
some point in the derivation a vowel was lengthened even in
these cases.

[8] The output of these two rules must, of course, be
ultimately modified by the rule which destresses a vowel if
the vowel preceding it is stressed.

[9] It may seem ad hoc to speak of long vowels as sequen-
ces here, when many were derived by vowel lengthening rules
from short vowels. This reflects a general inadequacy of our
theory in dealing with syllables and morae. Even within the
same language, it appears to be necessary to refer to certain
units sometimes as long vowels and other times as sequences.
Suppose there were a feature ϕ which differentiated the parts
of a long vowel into "nucleus" and "satellite", much as the
feature syllabic differentiates between the nucleus and
satellite of a diphthong. Rule (49) could then be written:

$$V \rightarrow [+ \text{stress}] / \underline{\quad} [-\varphi]_o \begin{bmatrix} + \text{syll} \\ - \text{stress} \end{bmatrix}$$

where $[-\varphi]_o$ also refers to consonants, etc. Notice that forms like <u>u·'gibï·'l</u> 'the bunch grass' indicate that a similar modification is necessary for the final stress rule:

$$V \rightarrow [+ \text{stress}] / \underline{\quad} (\breve{v}) \, C_o \#$$

or

$$V \rightarrow [+ \text{stress}] / \underline{\quad} [-\varphi]_o \#$$

[10] The alternating stress rule of Tübatulabal has been separated from the final stress rule for purposes of comparison.

BALANCED ENVIRONMENTS

1.0 <u>Problem</u>. In the theory being proposed here, the
directionality of the rule is a function of the relative
locations of the focus and the determinant of the rule. This
principle, of course, presupposes that we know what a determi-
nant is and how to find one. Yet, all linguists are familiar
with certain rules, such as intervocalic voicing rules, where
the determining factors appear to straddle the focus. How is
directionality to be determined in such a case? More generally,
when the determining factors are found on both sides of the
focus, how is the phonological rule applied?

In the following sections I will present four examples of
rules with balanced environments. In two of these cases, there
is no empirical consequence to whether the rule is applied in a
leftward, rightward, or even simultaneous fashion. In two
other cases, however, it appears that the rules must be right-
ward. This leads me to posit that rules with balanced environ-
ments must universally be applied from the left end of the
string to the right end.

2.0 <u>Some Cases Considered</u>.

2.1 <u>Mandarin First Tone Assimilation</u>. In discussing the
Mandarin third tone dissimilation rule in Chapter IV, a rule of
first tone assimilation was called upon to modify the output in
fast conversational style. Cheng (1971:43) expressed the rule
as follows:

(1)   "In fast conversational speed, a second tone becomes

        first when preceded by first or second tone and followed

        by any tone other than neutral tone."

It is clear from this description that the formal statement of
the rule will involve an environment on both sides of the focus.
Still in informal terms, the rule looks approximately as fol-
lows:

(2)   [2 tone] → [1 tone] / [$\left\{\begin{array}{c} 1 \\ 2 \end{array}\right\}$ tone] ____ [∿ neutral]
                                                              tone

The tone symbols used here, however, are arbitrary designations
and are not intended to reflect the physical properties of the
tones themselves. In order to understand what is going on here
it is necessary to deal with these tones in a more meaningful
way.

        Chao (1968:26) presents the following description of the
four tones of Mandarin. Each tone is presented in three ways:
(1) a verbal characterization of height and contour; (2) a
numerical representation, where 5 is the highest level and 1
the lowest level; and (3) a tone graph showing the height and
contour in relation to a vertical line, according to the system
developed in Chao (1930).

(3)

TONE	DESCRIPTION	PITCH	GRAPH
1st	high-level	55	⌐
2nd	high-rising	35	⌐
3rd	low-dipping	214	⩗
4th	high-falling	51	∖

Neutral tone is apparently only a secondary result of the lack of stress. According to Chao (1968:35):

(4)   "Weak Stress: the Neutral Tone. In weak stress, the tone range is flattened to practically zero and the duration is relatively short. Most cases of weak stress occur enclitically, that is, closely following a stressed syllable, whose tone determines the pitch of the weakly stressed syllable ... Almost any morpheme in one of the four regular tones can be in the neutral tone under certain conditions, there being only a very small number of morphemes, such as suffixes and particles, which are always in the neutral tone ... "

From the above description, it appears that the rightmost portion of the environment should be stated as [+ stress]. But how are the other tones to be represented?

First and second tones share in common the fact that they terminate in a high pitch. According to the framework advanced by Woo (1968, 1969), the high-level first tone is an underlying sequence of two high tones while the high-rising second tone is a sequence of a mid and a high. The effect of first tone assimilation, then, is to raise the part of a second tone that is mid to high just when it stands between two high tones:[1]

(5)   [+ MID] → [+ HIGH] / [+ HIGH] ___ [+ HIGH] [+ stress]

This process is clearly an assimilation to the terminal height of the preceding tone. As such, we might wonder why the

third tone, which is 214, does not affect a following second tone, since it terminates in a relatively high pitch as well. In actual fact, the first tone assimilation rule interacts with another tone sandhi rule affecting third tones. According to Chao (1968:27), a third tone loses its rising contour and thus becomes 21 when followed by any tone other than third. If we assume the 1/2 3rd Tone rule, as Chao calls it, to <u>precede</u> first tone assimilation, the four possible tones which may precede a second tone are as follows:

(6)	ORIGINAL TONE		AFTER 1/2 3rd TONE RULE	SECOND TONE
a.	1st:	55	55	35
b.	2nd:	35	35	35
c.	3rd:	214	21	35
d.	4th:	51	51	35

If it is correct to order the 1/2 3rd Tone rule before the first tone assimilation rule, it is plain to see why only the first two tones can influence a second tone in this way. Only these two tones are high at their termination, while the remaining two tones are low.[2]

Although the first tone assimilation rule has requirements on both sides of the environment, there is not any question about what is the determinant. The rule is clearly an assimilation to the preceding tone and the requirement that a stressed syllable follows is just a restriction on the rule. The

directional theory therefore asserts that the rule is <u>rightward</u>.
In actual fact, the rule could just as well be applied leftward
or simultaneously, since there is no empirical difference in
output, but the theory claims rightward directionality and this
is at least consistent with the facts.

2.2 <u>Chipewyan Continuant Voicing</u>. In Chapter IV I pre-
sented a reanalysis of Chipewyan which included a rule of
continuant voicing:

(7)   [+ cont] → [+ voice] / [+ voice] ___ [+ syll]

In this case there is also a balanced environment and, although
it again makes no difference in empirical output which way the
rule is applied, we might question what prediction would be
made by the theory.

The crucial example for deciding the particular shape of
the rule was <u>nás-1-sé</u>. Here the second <u>s</u> is voiced because it
is in the correct environment, but the first <u>s</u> is not voiced
even though it is flanked by the same segment types but in the
inverse order. We also know from relations like <u>θu̧θ</u> : <u>bɛ-ðu̧θ</u>
that an intervocalic environment causes voicing.

What can be concluded from these facts? It is tempting
to say that since a vowel is <u>required</u> to the right of a segment,
while any voiced segment is satisfactory on the left, the vowel
is the determinant and the rule is leftward. On the other hand,
one might want to argue that simple voicing is sufficient on
the left precisely because that is the main determinant, while

the extra requirement of being syllabic amounts to a restriction.

In order to resolve an issue like this, it is important to study intervocalic environments carefully. What do continuant voicing rules look like in other languages? How many languages are there where a prevocalic environment is all that is required? How many in which a voiced segment preceding is the only requirement? Perhaps these facts will help us resolve the issue.

Yet another possibility that must be considered is that the core rule corresponding to Chipewyan continuant voicing is simply:

(8)   [+ cont] → [+ voice] / [+ voice] ___ [+ voice]

and therefore that the balanced environment is basic. In such a situation, if there are any rules where a difference of directionality has a corresponding difference in empirical result, it is necessary to either introduce ad hoc directionality or a further universal principle to govern such cases. In the Menomini glide formation example to follow, I will very tentatively suggest what such a principle might look like.

2.3 <u>Menomini Glide Formation</u>. If there are in fact any rules with balanced environments in which direction of application has empirical consequences, glide formation is an interesting place to look for them. Consider, for example, a rule which makes a vowel become a glide intervocalically:

(9)   V → G / V ___ V

When applied to a string of four or more vowels, there is a clear empirical difference associated with direction or mode of application. In a sequence of four vowels, the following patterns result:

(10)   RIGHTWARD   LEFTWARD   SIMULTANEOUS
        _____

           VGVV   VVGV   VGGV

In this section I will consider an example of glide formation .from Menomini which involves an intervocalic environment. Since the particular rule of greatest concern is embedded in a complex analysis, however, it will be necessary to disentangle it first. A number of interesting and important issues relate to Menomini glide formation and these will also be dealt with in the following discussion.

According to Bever (1967:107-16), Menomini glides are predictable by rule from underlying mid vowels. Bever combines a number of environments of glide formation into a single complex schema similar to the Main Stress Rule (MSR) of English as presented in SPE:

(11) $\begin{bmatrix} + \text{ voc} \\ - \text{ comp} \\ - \text{ long} \end{bmatrix} \rightarrow \begin{bmatrix} - \text{ voc} \\ + \text{ diff} \end{bmatrix} \ / \ ([+ \text{ voc}]) \underline{\qquad} \begin{Bmatrix} [+ \text{ voc}] \\ + \end{Bmatrix}$

Bever argues that this schema represents the set of rules given below and must be expanded in the order A-B-C-D. The first two rules are ordered conjunctively, as are the last two rules. The relationship between the pair of rules AB and the pair CD is disjunctive, as represented by the square lines connecting them.

(12)
$$
\begin{bmatrix} + \text{ voc} \\ - \text{ comp} \\ - \text{ long} \end{bmatrix} \rightarrow \begin{bmatrix} - \text{ voc} \\ + \text{ diff} \end{bmatrix}
\begin{array}{llll}
/ \ [+\text{ voc}] \ \_\_\_ \ [+\text{ voc}] & \text{(A)} \\
/ \ [\dot{+}\text{ voc}] \ \_\_\_ \quad + & \text{(B)} \\
/ \qquad\quad \_\_\_ \ [+\text{ voc}] & \text{(C)} \\
/ \qquad\quad \_\_\_ \quad + & \text{(D)}
\end{array}
$$

Bever's treatment of Menomini glide formation is within the same framework as SPE. It assumes that phonological rules are applied simultaneously and that disjunctive ordering is imposed on schemata in a particular way. Bever's analysis is thus at variance with the theory being proposed here, which has no provision for handling complex schemata of the type Bever utilizes. It follows that if Bever's analysis is correct, the directional theory is inadequate. Therefore it is appropriate to examine Menomini glide formation more closely to determine the adequacy of Bever's formulation of it.

Several of the ordering relationships involved in (12) are crucial. A is clearly the first rule to apply, while B must precede C. There is no possible ordering argument that will apply to rule D other than the fact that it must follow A. We may graphically depict the crucial arguments as follows:

(13)
$$
\overset{\frown}{\underset{A \quad\quad B \quad\quad C \quad\quad D}{}}
$$

The evidence for these crucial ordering arguments is given below.

(14)   <u>A precedes B,D</u>   <u>B precedes C</u>   <u>A precedes C</u>

/æoe/   /oēskoo/   /oēkeoam/

↓   ↓   ↓

[æwe]   [wēskow]   [wēkewam]

If the rules were applied in the opposite order in each case,
the resulting forms would be: *[æoy], *[wēskwo], *[wēkywam].

Bever's formalization also limits the number of possible
sequences in which these rules might apply through the imposi-
tion of disjunctive ordering. With no disjunctive ordering
there are 11 possible sequences of two or more rules, but with
the imposition of disjunctive ordering claimed by Bever only
two such sequences are permitted: AB and CD. One type of
support for Bever's analysis, then, would be to show that such
disjunctive ordering is needed and useful.

When the content of the particular rules is considered,
it becomes apparent that the imposition of disjunctive ordering
is trivial in every sequence except for AD. In all other cases,
allowing the rules to apply conjunctively will yield the correct
results. Thus disjunctive ordering supports Bever's analysis
only in an extremely limited way.

By utilizing a schema which imposes disjunctive ordering,
it is possible to express the Menomini glide formation rules
with greater conciseness. It is not the case, however, that
this schema is the only way to represent these facts. It is
possible to achieve exactly the same effects with the following
set of ordered rules. Rule (15d) must be stated with a [+ cons]

segment in the environment to accomplish the same ends as
disjunctive ordering:

(15)
 a. $V \rightarrow G \;/\; V \;\underline{\quad}\; V$

 b. $V \rightarrow G \;/\; V \;\underline{\quad}\; +$

 c. $V \rightarrow G \;/\; \underline{\quad}\; V$

 d. $V \rightarrow G \;/\; C \;\underline{\quad}\; +$

The curved lines here represent crucial orderings.

  While I have just shown that Bever's rule of glide forma-
tion can be replaced by a set of conjunctively ordered rules,
this fact alone is not sufficient to demand such a reformulation.
In particular, Schane (1969:19) pointed out that _any_ set of
intrinsically ordered rules (including those involving nontrivial
disjunctive ordering) can be replaced by a set of unordered
rules by specifying the environments in greater detail. Thus
my demonstration above is also trivial in itself and the argu-
ment against Bever must rest on other grounds.

  To what extent is the formal apparatus employed in Bever's
statement of the rule motivated outside of this example itself?
If the apparatus is required for the expression of generaliza-
tions in other languages this would at least lend some plausibi-
lity to Bever's analysis. On the other hand, if the apparatus
is not required elsewhere and especially if it is at variance
with conventions needed for better established rules, this
would detract from the plausibility of the analysis.

  The most obvious place to seek support for this theoretical
apparatus is in the analysis of English presented in SPE. In

particular, Chomsky & Halle's formulation of the Main Stress
Rule of English closely resembles Bever's rule in its complex
use of braces and parentheses. To the extent that these two
schemata share similar properties, the correctness of one
analysis makes the other more reasonable. In the two cases
under consideration, however, it is interesting that the
formalisms are really in conflict and not mutually supportive.

It is peculiar that neither Bever nor Anderson (1969:153-58),
who discusses the issue in relation to his own theory, mentions
the order of expansion of Bever's rules. This order of expan-
sion is only superficially similar to that offered in SPE.
Consider the Main Stress rule of English. Almost the same
formal relationships hold internal to that rule as hold within
the Menomini glide formation rule. Focusing upon the combined
affix-noun rules and the stressed syllable rules in relation
to the weak and strong cluster cases, the MSR has the following
shape:

(16)
$$V \rightarrow [1 \text{ stress}] / \underline{\quad} (W) \begin{Bmatrix} \text{Affix-Noun} \\ \text{Stressed Syllable} \end{Bmatrix}$$

For comparison, I repeat Bever's rule here:

(17)
$$V \rightarrow G / (V) \underline{\quad} \begin{Bmatrix} V \\ + \end{Bmatrix}$$

The desired expansions in the two cases can be seen side by
side, with curved lines representing conjunctive and square
lines disjunctive ordering:

(18)
		a.	/ ___ W A-N			a.	/V ___ V
		b.	/ ___ A-N			b.	/V ___ +
		c.	/ ___ W SS			c.	/ ___ V
		d.	/ ___ SS			d.	/ ___ +

It is plain that the MSR and Menomini glide formation rule involve a different order of expansion of parentheses. The result is that the second and third expansions of the two schemata differ. Yet, the ordering in both cases is crucial between b and c. This has been shown already for Menomini with the form [wēskow], while inhibitory is crucial for the MSR. Since both schemata require a different crucial ordering, they either require two conflicting theories or there must be a general principle differentiating the circumstances under which one ordering or the other is to be chosen. No such principle has been posited and I believe that these two theories are in fundamental conflict. Therefore, it may be argued that there is no external support for Bever's rule.

Another way in which Bever's rule may be challenged is in terms of its adequacy to express the linguistically significant generalizations of Menomini glide formation. This question was raised by Anderson (1969:153-58) in providing support for his theory on the ordering of phonological rules. Anderson introduces several other rules into the discussion, all of which act to modify sequences of vowels. One of these deletes short vowels adjacent to long vowels as well as the second of a pair of short vowels. Anderson writes this rule, which I shall call

vowel drop, as a mirror-image rule:

(19) $\begin{bmatrix} + \text{ syll} \\ - \text{ long} \end{bmatrix} \rightarrow \emptyset$ % [+ syll] + ___

The rule of A-drop, which I shall not bother to state formally

here, shortens a sequence of two long $\bar{a}$.

Any remaining sequence of vowels, which must necessarily

be long vowels after the rules above, is broken up by the

insertion of a y-glide. The rule of Y-epenthesis is given

below:

(20) $\emptyset \rightarrow y$ / [+ syll] ___ [+syll]

There is a similar epenthesis rule inserting the vowel e

after a nonsyllabic and before a consonant:

(21) $\emptyset \rightarrow e$ / [- syll] ___ [+ cons]

Bever collapses the Y-epenthesis and E-epenthesis rules with

judicious use of features and variables. The main thrust of

Anderson's argument, however, is that there is a more funda-

mental unity here than Bever accounts for. All other instances

of y are derived from e by glide formation rules. Since the

glide inserted by Y-epenthesis is in the proper environment for

glide formation, Anderson argues that the only epenthesis rule

should be E-epenthesis and glide formation should apply to make

certain instances of epenthetic e become glides. This treat-

ment would establish the fundamental unity of e and y and

achieve greater generalization.

The essence of Anderson's argument is appealing, though not compelling. If we accept his position that a significant generalization is being lost, however, we are immediately confronted with an ordering anomaly. The glide formation rules were necessary to create certain environments where E-epenthesis applies, and hence must precede E-epenthesis. If Anderson's claim is correct with regard to the unity of e and y, the glide formation rules must also follow E-epenthesis. The required ordering is then:

(22) a. glide formation

b. vowel drop

c. A-drop

d. E-epenthesis

e. glide formation

Anderson sees Menomini glide formation as a set of phenomena which support his theory that rule ordering is not strictly transitive and that certain rules can thus both precede and follow other rules. His claim rests upon the idea that a generalization is in fact being lost, namely that all instances of y derive from e. Whether this is a valid generalization or not is open to some question and I will return to this problem shortly. Notice also that Anderson accepts Bever's formulation of the glide formation rule as it stands. Obviously, if glide formation is split up into separate rules, some of which precede E-epenthesis and some of which follow it, this would have serious implications for Anderson's argument.

In the following discussion I will attempt to justify a view of Menomini glide formation as a set of processes that are not collapsible into a single schema since they are not located at a single point in the grammar. This view has several implications: (1) it allows the complex interrelationship between braces and parentheses to be dispensed with; (2) it allows the associated simultaneous application and disjunctive ordering to be dispensed with; (3) it removes Menomini glide formation from the domain of supportive evidence for Anderson's nontransitive theory of rule ordering. In addition, the proposed reanalysis yields a rule with a balanced environment which has implications for the theory of directional rules.

Let us assume that the glide formation rules are to be broken up along the lines presented in (15) above and repeated for convenience here:

(23) a. $V \rightarrow G / V \underline{\quad} V$

b. $V \rightarrow G / V \underline{\quad} +$

c. $V \rightarrow G / \underline{\quad} V$

d. $V \rightarrow G / C \underline{\quad} +$

Which of these rules could be ordered after E-epenthesis in order to derive epenthetic y from e as Anderson suggests? Since other parts of the E-epenthesis process apply between a non-syllabic (including glides) and a consonant, morpheme final glides must already be determined before E-epenthesis. Therefore rules (23b, d), which create final glides, must precede E-epenthesis. Since (23a) precedes (23b), it must also precede

E-epenthesis. The only rule which need not precede E-epenthesis,
then, is (23c), the prevocalic glide formation rule. I will
therefore pursue the implications of using the prevocalic glide
formation rule to convert epenthetic e to y.

If we adopt the ordering given in (22) but make the se-
quence of rules (23a, b, d) correspond to the first occurrence
of glide formation and rule (23c) to the second occurrence of
glide formation, we would have the following ordering:

(24) a. V → G / V ___ V

b. V → G / V ___ +

c. V → G / V ___ +

d. vowel drop

e. A-drop

f. E-epenthesis

g. V → G / ___ V

Before attempting to collapse any of these rules further,
it must be pointed out that there are a number of immediate
difficulties with this formulation. For example, if we have
the string /oēskoo/ following a vowel, the initial vowel would
not be changed into a glide until (24g), the prevocalic glide
formation rule. Yet, vowel drop, which deletes the second of
a pair of short vowels, precedes prevocalic glide formation and
therefore deletes the vowel before it has a chance to become a
glide. We could not then derive the correct phonetic form
[wēskow].

It would be possible to resolve this difficulty with relatively little cost by reordering vowel drop after all the other rules. Another possibility, however, is to make rule (24b) a mirror-image rule,[3] thus converting an initial vowel into a glide when followed by a vowel, or a final vowel into a glide when preceded by a vowel.

(25)   V → G % V ___ +

This revision would correctly turn the first vowel in /oēskoo/ and other similar forms into a glide before E-epenthesis.

By making (24b) a mirror-image rule we allow for the resolution of another problem that is not considered by either Bever or Anderson. Bloomfield (1939:109) reports that E-epenthesis also takes place between a morpheme ending in Vw and one beginning with w. If this addition to E-epenthesis is to be ordered together with the others, it requires that the initial vowel of [oēskoo] be made a glide before E-epenthesis. In this case, reordering of vowel drop is not adequate, but making (24b) a mirror-image rule works correctly.

With the revisions discussed above the generalization that Anderson seeks to express could be captured without relaxing the transitivity of rule ordering. At the same time, the revised solution pulls apart the various rules of glide formation, claiming that they do not constitute a single linguistically significant generalization. I have already shown that to adopt Bever's rule is very costly in that it admits to linguistic theory a complex type of disjunctive

ordering, simultaneous application of the SPE variety, an order of expansion that is not even compatible with the MSR, and the relaxation of transitive rule ordering. I feel that these are quite serious consequences and that they suggest the revised analysis is more correct.

There is even further reason to adopt this analysis, however. It is interesting that the first two glide formation rules as I have stated them appear to be basically morpheme structure rules, converting vowels to glides intervocalically within morphemes and at the periphery of morphemes. They are not dependent upon information about adjacent formatives. The last glide formation rule to apply, however, is the one which applies across morpheme boundaries, as we would expect.

Bloomfield had set up underlying glide phonemes and did not attempt to predict glides from vowels in Menomini as he had done in Eastern Ojibwa. The analysis with no underlying glides was a contribution of Bever, rather than of Bloomfield. The reason for Bloomfield's choice will become clear when other deficiencies in Bever's formulation are pointed out.

Consider the following proposed underlying form taken from Bever (1967:108) and how his rules would apply to it.

(26)   /+ kone + eoe + o +/

    a. + kone + ywy + o +   / V ___ V

    b. -- ----------------   / V ___ +

    c. ------------------   / ___ V

    d. ------------------   / ___ +

Bever's first rule, applying within the simultaneous format of SPE, will convert all three intervocalic vowels to glides. If it were not for Bever's imposition of (environmental) disjunction, the remaining two vowels would also become glides by (26d). The correct phonetic result, however, is not *[koneywyo] as derived above, but [konyewew].

Consider a second example for comparison:

(27)   /+ æn + kapooe + o +/

    a. + æn + kapowy + o +   / V ___ V

    b. -------------------   / V ___ +

    c. -------------------   / ___ C

    d. -------------------   / ___ +

The correct result this time is not *[ænkapowyo], but rather [ænkapowew].

In both of these cases I have adopted Bever's own assumed underlying forms and his rules and yet the correct outputs are not derived. Why should this be the case? One possibility that might be tested is that the intervocalic glide formation rule is directional rather than simultaneous as in the SPE format. With [konyewew], however, the directional principle will fail no matter in which direction the rule is applied. The directional hypothesis must therefore be rejected.

A second possibility is that the domain of these rules is more restricted. If the rules are applied to each morpheme independently, the correct results will be obtained. This amounts to claiming that these glide formation rules are

morpheme structure rules and thus approximates Bloomfield's position. At the same time, the fact that these glide formation rules are morpheme structure rules creates serious difficulties for Anderson's proposal. To derive y from epenthetic e by glide formation, epenthesis must be a morpheme structure rule (that is, it must precede other morpheme structure rules). Moreover, even if glide formation were allowed to follow e-epenthesis all instances of epenthetic e would be converted to y, since all presumably precede a morpheme boundary. In short, Anderson's proposal rests on the unity of the glide formation rules and the unity of the e-epenthesis rules. Since the latter, as Anderson would like to formulate it, can neither precede nor follow the glide formation rules in Bever's formulation, one analysis or both must be rejected.

If the analysis I have proposed is accepted, it is possible to unite the epenthetic y and epenthetic e as Anderson desires. In order to do this it is necessary to abandon Bever's unitary formulation of the glide formation processes in the way proposed in (24). This effectively meets Anderson's objections at the same time as it allows retention of transitive rule ordering.

One of the rules discussed above, the intervocalic glide formation rule, clearly involves a balanced environment. As such it poses a problem for a directional theory like that being entertained here, since it predicts neither a leftward nor a rightward direction. It is appropriate, then, to ask

whether there are any circumstances in which the direction of application makes a difference.

I pointed out at the beginning of this section that when a sequence of four or more vowels is involved, an intervocalic glide formation rule will have different outputs when applied leftward, rightward and simultaneously. In the case of Menomini, the sequence of four vowels must be within the same morpheme, for reasons given above. While Bever does not give any examples to substantiate his claim, he argues (1967:115) that under the simultaneous application algorithm, "the sequence /+ C æ o e æ --/ would be <u>correctly</u> (emphasis mine: IH) transformed to /+ C æ w y æ --/, since both the /e/ and /o/ are intervocalic ... " At the same time, he points out that the simultaneous algorithm makes counterintuitive claims about sequences like /+ C æ o e o æ --/ by predicting that all three internal vowels will become glides.

The directional theory proposed here would make the intuitively correct prediction about a sequence of five vowels: /C æ oeo æ --/ would become /C æ wew æ --/ whether the rule is leftward or rightward. For a four vowel sequence, however, it would predict VVGV if leftward or VGVV if rightward, neither of which are correct. Recall, however, that there is an independently motivated rule of prevocalic glide formation which must follow the rule governing intervocalic environments. If we assume that the intervocalic rule is <u>rightward</u>, the resultant VGVV pattern can subsequently be converted to VGGV by the prevocalic rule.

If there exists evidence that four vowel sequences behave
as Bever claims, it appears that the intervocalic glide forma-
tion rule must be a rightward rule, in spite of its balanced
environment. This would leave us with several theoretical
alternatives: (1) allow nonpredictable directionality for
rules with balanced environments, thereby making directionality
a prime under some conditions; (2) propose a general principle
which applies to cases with balanced environments; or (3) some
combination of these, such as requiring different directions
for different types of rules with balanced environments. On
the basis of the Menomini evidence, I shall propose the fol-
lowing subsidiary principle of directionality:

(28)   Rules which have truly balanced environments are
        universally applied in a rightward direction.

This is the strongest of the positions we can take, and hence
should be the easiest to falsify.

It is possible that the intervocalic glide formation rule
in Menomini tells us little about the behavior of phonological
rules with balanced environments. If it is a morpheme struc-
ture rule there is no necessity that principle (28) should hold
for phonological rules as well. Even in SPE, the first four
marking conventions, which assign plus and minus values for the
features _consonantal_ and _vocalic_, are applied in sequence in a
rightward direction. Nevertheless, the issue of directionality
in rules with balanced environments is a real one and empirical
evidence must be brought to bear upon it.

2.4 <u>Tübatulabal Vowel Lengthening</u>. Another example which may be relevant to establishing the principle of unmarked directionality is the famous vowel lengthening rule of Tübatulabal. The rules relating to vowel length constituted the focus of Swadesh & Voegelin (1939), McCawley (1969), and Lightner (1971).

Vowel length in Tübatulabal is basically the result of three interrelated factors: (1) an underlying distinction of vowel length; (2) a rule governing alternating length; and (3) a set of rules which act to modify the pattern created by (1) and (2) in various ways. In this section I will deal primarily with the rule for lengthening vowels.

The essential fact of vowel lengthening is that "in a sequence of syllables containing short vowels, every other vowel, starting with the leftmost vowel in the sequence, is lengthened, with the overriding condition that a short vowel cannot be lengthened if adjacent to a syllable containing a long vowel." (Lightner 1971:227) This rule can be illustrated by the following forms from Swadesh & Voegelin (1939:90):

(29) a. ta·wəgi·nana·la   'to go along causing him to see'

     b. a·dawə·gina·nala   'he went along causing him to see'

     c. pələ·la   'to arrive'

     d. ə·bələ·la

The first pair of forms illustrates what happens when there are no underlying long vowels. Lengthening applies to every alternate vowel beginning with the first vowel of the word. Notice

that the final vowel is not lengthened in (29b). This discrepancy will be returned to in the following discussion.

In the second pair of examples, the second schwa of the stem is an underlying long vowel, which prevents the first vowel from being lengthened in (29c). In (29d), however, the first vowel of the word is lengthened because it is two syllables away from the underlying long vowel.

In his discussion of Tübatulabal vowel lengthening, McCawley (1969:409) proposes a rule which violates three conventions of the standard theory. First, it is a left-to-right _iterative_ rule rather than the simultaneous type of rule demanded by that theory. Second, it involves the _mirror-image_ convention which is not a part of the SPE formalism. Third, it involves the statement of _negative environments_, or conditions under which the rule is not allowed to apply. McCawley's rule is thus expressed as follows:

(30)   LR iterative: $[+ \text{syll}] \rightarrow [+ \text{long}]$

        except in environment $\% \underline{\quad} [- \text{syll}]_0 \begin{bmatrix} + \text{syll} \\ + \text{long} \end{bmatrix}$

Lightner (1971:234-35), in commenting upon McCawley's formulation, states that the intention of (30) is not to abbreviate a sequence of rules lengthening vowels, but rather the following sequence:

(31) a. $\left\{ \begin{array}{l} V \rightarrow [- \text{next rule}] \ \% \ \bar{V}C \underline{\quad} \\ V \rightarrow [+ \text{long}] \end{array} \right\}$

     b.

                                                       (left-to-right iterative)

Thus a vowel is marked as being unable to undergo the lengthening rule if it is in an environment adjacent to a long vowel and then all vowels not marked are lengthened.

This formulation could work mechanically if one is willing to allow the various notational devices being used here. Among other objections that may be made against this formulation, the strongest must be that the use of negative environments in an extraordinarily powerful convention which allows the expression of a multitude of spurious generalizations about language. I contend that it is a "fudge" which masks the reality of the phenomena in question, rather than explaining it. In this case, for example, (31b) is an unconditioned change affecting all vowels. Are there any languages which lengthen every vowel in the word? The mirror-image negative environment is treated as a restriction upon the application of (31b), rather than as offering any motivation for lengthening.

Lightner (1971:235) expresses his dissatisfaction with McCawley's formulation in terms of his feeling that there has not been enough convincing evidence for either the revised mirror-image convention as in (31) above or iterative rules. In the same paragraph, however, he states that within the SPE theory "the best that can be done is the following unpleasant formulation":[4]

(32)

$$V \rightarrow \bar{V} \ / \ \left\{ \begin{array}{c} \# \\ \bar{V}C_o\breve{V} \end{array} \right\} \ (C_o V C_o \breve{V})* \ C_o \ \underline{\quad\quad} \ C_o \left\{ \begin{array}{c} \# \\ \breve{V} \end{array} \right\}$$

What is the appropriate way to express Tübatulabal vowel
lengthening in a directional theory? It is reasonable to
expect from observation of previous alternating stress and
length rules that the fundamental (or core) part of the rule
would be as follows:

(33) $V \rightarrow \bar{V} / \breve{V} \, C_0 \underline{\quad}$

That is, we are dealing with an essentially dissimilatory
process, as in other alternating rules.

Rule (33) is inadequate for Tübatulabal in several respects.
First, it would lengthen every even vowel of a sequence begin-
ning with the second vowel of the word, while in actual fact it
is the first, third, ... vowels which are lengthened. This
might be resolved by postulating another rule lengthening the
vowel in an initial syllable which would precede the alternat-
ing length rule.

(34) $V \rightarrow \bar{V} / \# \, C_0 \underline{\quad}$

Both of these rules fail, however, in another respect.
Although they meet the condition that they are not immediately
preceded by a syllable containing a long vowel, they do not
block application when a long vowel follows. Thus, (34) would
incorrectly lengthen the first vowel of (29c) pələ·la.

One way to deal with this difficulty would be to allow the
two rules above to apply incorrectly in these cases and to pos-
tulate another rule which will shorten long vowels when in a
syllable immediately preceding a long vowel. This is not

feasible in Tübatulabal because there are sequences of syllables with underlying long vowels which would be incorrectly modified by such a rule. It appears, then, that the constraint on following syllables must be built in as a restriction on the rules. Consider the following restatement of alternating length:

(35)

$$V \rightarrow \bar{V} \; / \; \breve{V} \; C_o \underline{\hspace{1cm}} C_o \left\{ \begin{array}{c} \# \\ \breve{V} \end{array} \right\}$$

This rule will work correctly when applied from left to right, with the sole exception of final vowels in words like (29b) a·dawə·gina·nala, which would be lengthened by the rule. One might question, therefore, whether it is possible to eliminate the word boundary from the right side of the environment:

(36) $V \rightarrow \bar{V} \; / \; \breve{V} \; C_o \underline{\hspace{1cm}} C_o \breve{V}$

While this would yield the correct results for (29b) by not lengthening that vowel at all, it would also fail to lengthen any vowel in a closed final syllable. In actual fact, however, such syllables are lengthened, as in təwəla·n 'to fix it for him'. This form has no underlying long vowels and therefore the last vowel is lengthened by rule. The fact that the first vowel is short is the result of a secondary shortening process. It thus appears that rule (36) must be rejected in favor of rule (35).

In final vowels are to be incorrectly lengthened by (35), there must be some way of shortening them later. In fact, all

treatments of Tübatulabal mentioned above assume a later rule
which shortens or deletes final vowels. I will make the same
assumption here.

Since both lengthening rules must contain the same con-
straint on following syllables, it is reasonable to assume that
a generalization would be lost if they were stated separately.
We can therefore assume that a more correct statement of
Tübatulabal vowel lengthening is as follows:

(37)

$$V \rightarrow \bar{V} \;/\; \left\{ \begin{matrix} \# \\ \breve{V} \end{matrix} \right\} C_0 \;\rule{1cm}{0.4pt}\; C_0 \left\{ \begin{matrix} \# \\ \breve{V} \end{matrix} \right\}$$

This revised statement replaces both the initial length rule
and the alternate length rule.

If (37) is to be accepted as the rule governing vowel
lengthening in Tübatulabal, it poses a problem for a theory
with predictable directionality, since the environments on
both sides of the focus are identical. Since there is no
principled basis for selecting a determinant, the principle
of unmarked directionality is called into play. In this case,
as well as the intervocalic glide formation rule of Menomini
previously discussed, the principle of unmarked directionality
makes the correct prediction -- the rule must be applied from
left to right.

3.0 Conclusion. Balanced environments present a special
problem for a theory of rule application that predicts direc-
tionality from the relative locations of focus and determinant.

If the determinant truly straddles the focus, the basic prin-
ciple for determining how a rule applies will be inadequate
in these circumstances and a subsidiary principle will be
necessary. There are clearly several logically possible
alternatives: (1) such rules are simultaneous, in the SPE
sense, having no directionality; (2) such rules are univer-
sally leftward; (3) such rules are universally rightward; (4)
such rules may be either leftward or rightward, an ad hoc
statement of directionality being required in each case; (5)
some of these rules may be leftward and others rightward,
depending upon the nature of the process.

The evidence of Tübatulabal vowel lengthening and Menomini
intervocalic glide formation, both of which must be rightward,
eliminates the possibility that such rules are universally
simultaneous or universally leftward. The other possibilities
are, of course, not falsified by these examples. Nevertheless,
the strongest position that can be taken on the basis of this
evidence -- and therefore the one that should be adopted until
it can be proven false -- is that rules with balanced environ-
ments are universally rightward.

NOTES

[1] For purposes of presentation here, other details of
the rule dealing with optional consonants and word boundaries
are omitted. Note also that in the alternative framework
proposed by Wang (1967), these facts would be handled by a
rule of the following shape:

[+ HIGH] → [- contour] / [+ HIGH] ___ [+ stress]

Thus, second tone loses its contour in this environment. A
comparison between this rule and (5) shows Woo's framework
here to be a more revealing account of the process under
consideration.

[2] The above discussion, of course, assumes that the
underlying representation of third tone is its form in isolation,
214. If this is true, the required ordering of rules would be:
THIRD TONE DISSIMILATION → 1/2 THIRD TONE → FIRST TONE ASSIMI-
LATION. If Woo is correct in treating third tone as an under-
lying sequence of low tones, the specifics of this argument
would have to be modified but the general fact would hold. In
this case the reason that third tone does not cause the assimi-
lation would be that at this point in the derivation it is a
low tone sequence.

[3] In view of Lightner's recent caution against the use
of mirror-image rules (1971:234) based upon the absence of
evidence from historical change that a mirror-image expression
is a "simplification" of its two component rules, it is

instructive to note that there may be evidence in Menomini for treating (25) as two rules with different crucial ordering relations. Bever points out (1967:115) that the only incorrect results from his analysis are cases with two initial semivowels, such as [wyæw] from /oeæo/. He cannot derive these correctly because the intervocalic environment applies first, destroying the conditions for any other rule which may apply to the initial vowel. If (25) is broken up into two parts, one of which precedes the intervocalic rule and one of which follows, this output can be regularly derived:

(I) a. V → G / + ___ V

     b. V → G / V ___ V

     c. V → G / V ___ +

Rule (Ia) must precede the intervocalic rule or it would never have an opportunity to apply, while (25'c) must follow the intervocalic rule for reasons given in the text. The prevocalic glide formation rule which must follow all of these will ultimately convert the second vowel into a glide:

(II)   /+ o e æ o +/

     a. + w e æ o +   / + ___ V

     b. -----------   / V ___ V

     c. + w e æ w +   / V ___ +

     d. + w̥ y æ w +   /   ___ V

     In order to deal with these cases, Bever adds an additional rule making initial vowels become glides before the

operation of his complex disjunctively ordered set. Since he believes these forms to be exceptional, however, I have included these observations only parenthetically here. It should be obvious, however, that whether the examples are exceptional or not, the modification proposed in this footnote will be adequate to deal with these cases.

[4] The rule presented above is slightly "cleaned up" version of Lightner's rule, which is as follows:

(32)

$$V \rightarrow \bar{V} \ / \left\{ \begin{array}{c} \# \\ \bar{V}CV \end{array} \right\} C \ (CVCV)^* \ \underline{} \ C \left\{ \begin{array}{c} \# \\ V \end{array} \right\}$$

Lightner's formulation will not work for reasons that should be obvious.

ALTERNATIVE THEORIES OF RULE APPLICATION

1.0 <u>Introduction</u>. In the preceding chapters of this dissertation I have presented and attempted to justify a particular theory of rule application in phonology. At various points in the exposition I have compared the treatment afforded by the directional theory with that of the SPE theory. The SPE theory has become the standard against which alternative claims about phonological theory are compared and it has therefore been utilized within this dissertation to provide a valuable kind of perspective.

The SPE theory is not the only alternative theory of rule application, however. Johnson's linear theory has already been mentioned as a competing view and yet another theory has been proposed by Anderson in various papers. In this chapter I will compare the directional theory with each of these alternatives in an attempt to evaluate their relative merits. One partic- ular aspect of this comparison -- the treatment of rules in which a single determinant directly causes more than one change -- will be postponed until Chapter VIII where it will be dealt with in greater detail.

In the discussion that follows I will be differentiating between a <u>rule</u> and a <u>process</u>. For purposes of this discussion, a <u>rule</u> will refer to a statement of the form A → B / X ___ Y, together with its various abbreviatory conventions. Such statements are assumed in each of the theories considered,

although particulars about what type of abbreviatory devices
are allowed may differ. What is more important, however, is
that the conventions on how rules are to be applied differ in
each of these theories and therefore the same formal statement
(rule) may yield different outputs when considered within one
theory or another. I shall therefore distinguish between a
rule and a process, where the latter indicates the relationship
between a set of input strings and their associated output
strings as the result of the application of a given rule.

There are thus certain processes (or "mappings") that can
be described by means of a single rule within one theory but
not within another. It is these processes which help us to
choose among theories. If a theory does not allow the state-
ment of empirically valid processes it is inadequate, while if
it allows the description of processes which are not empiri-
cally attested it is excessively powerful. One way to support
a given theory, then, is to show that it can handle an empiri-
cally attested case where other alternative theories cannot do
so. The strength of such an argument, of course, depends upon
the strength of the empirical example in terms of the likeli-
hood that it is a valid generalization about the language in
question.

A second way to support a given theory over an alternative
is to show that there is a set of processes that it cannot
describe while the alternative theory can, if there are no
empirically attested cases of such processes. The burden of

proof falls upon the less restrictive theory -- the one which
can describe these processes -- and until its proponents can
provide empirical support for that claim the more restrictive
theory must be preferred.

2.0 The SPE Theory.

2.1 Crossover Constraint: Simple Expressions and
Partial Options. The crossover constraint that I have pro-
posed constitutes a significant restriction upon the set of
processes describable within the theory. In this section, I
will consider the difference between the two theories where
rules using no abbreviatory conventions or just simple (not
subscripted) parentheses are concerned.

The following examples illustrate rules with no abbrevi-
atory conventions:

(1) a. V → Ṽ / [+ nasal] V ___

b. [+ lat] → [+ nasal] / [+ nasal] V [+ lat] V ___

Suppose we interpret these expressions as rules within the SPE
theory. The first rule represents a process in which the
second vowel in a vowel sequence following a nasal segment is
nasalized. The second makes a lateral become a nasal if it
follows a nasal segment with the sequence V [+ lat] V inter-
vening. Both of these cases violate the crossover constraint
in that a segment meeting the internal requirements of the
focus intervenes between the focus and determinant without it-
self undergoing the rule.

If we interpret these same expressions as rules within the directional theory, the crossover constraint will not allow them to apply. They may thus be regarded as ill-formed and it is claimed that they do not correspond to any empirically valid process. The directional theory with crossover constraint receives some support from cases like these, since the crossover constraint appears to make the correct claim. At least, the burden of proof is on the proponent of a theory which denies the validity of the crossover constraint to show an empirical case in point.

It is appropriate to add here, however, that the argument provided above means only that the crossover constraint itself is a contribution to the theory. It has not been shown that the SPE theory is _incompatible_ with the crossover constraint. In the contexts considered in this section, the crossover constraint could be added to the SPE theory as easily as it was added to the directional theory. The only requirement would be to draw a distinction between accent and nonaccent rules and to associate the crossover constraint, as stated earlier, with nonaccent rules.

2.2 _Crossover Constraint: Subscripted Expressions._ With subscripted expressions the situation is different. In this context it can be shown that the SPE theory is in fact incompatible with the crossover constraint.

Consider the following rules:

(2) a. [+ lat] → [+ nasal] / [+ nasal] (V [+ lat])* V ___

    b. V → $\tilde{V}$ / [+ nasal] V_o ___

If these are interpreted as rules within the SPE theory, the simultaneous treatment of subscripted expressions (including parenthesis-star) will derive outputs like the following:

(3) a. analalala → anananana

    b. anaio → $an\tilde{a}\tilde{\imath}\tilde{o}$

These outputs are perfectly in accord with the crossover constraint in the context considered thus far.

    When we extend this context slightly, however, the situation changes. Consider the following pair of rules:

(4) a.

[+ lat]→[+ nasal]/[+ nasal](V$\begin{bmatrix} - \text{ son} \\ - \text{ cont} \end{bmatrix}$V [+ lat])*V ___

    b. V → $\tilde{V}$ / [+ nasal] (V $\begin{bmatrix} - \text{ son} \\ - \text{ cont} \end{bmatrix}$)* ___

These are well-formed rules (though admittedly fairly complex) within the SPE theory. They yield the following outputs:

(5) a. anatala → anatalana

    b. anatatai → $anatat\tilde{a}\tilde{\imath}$

It seems clear that the processes described here by the SPE theory are not valid linguistic processes. A critic of this claim would, of course, have to produce an empirically valid example to make his case. While the SPE theory allows the description of these unrealistic processes, the directional

theory does not allow them to be expressed, thanks to the crossover constraint.

It is still possible to build the crossover constraint into the SPE theory to handle cases like (4). In these cases, the letter of the crossover constraint may be violated, but not its spirit. That is, for a given application of the rule, a segment may intervene between the focus and determinant which itself meets the internal requirements of the determinant; however, the intervening segment which violates the crossover constraint undergoes another expansion of the rule, thereby eliminating the violation. All of the cases discussed thus far could then be handled within the SPE theory by the following principle:

(6)   No segment may intervene between the focus and determinant for a given application of a rule if that segment meets the internal requirements of the focus, unless that segment is also identified as undergoing the rule.

We might then add to the algorithm for simultaneous application (within the SPE theory) that application is blocked if any such segments intervene and are not identified as undergoing the rule.

Although principle (6) works in the cases discussed above, it may be easily falsified. There are certain phenomena involving alternating patterns that are not

consistent with principle (6). Consider, for example, the low vowel dissimilation rule from Woleaian presented in Chapter II. This rule dissimilates <u>a</u> to <u>e</u> before another <u>a</u> and affects every second vowel in a sequence of low vowels, beginning at the right extreme of the sequence. The rule is stated as follows within the directional theory:

(7) $a \rightarrow e / \underline{\quad} C_o a$

The corresponding statement of this process within the SPE theory is:

(8)

$$a \rightarrow e / \underline{\quad} (C_o a C_o a)* C_o a C_o \left\{ \begin{matrix} \# \\ \left[\begin{matrix} + \text{ syll} \\ - \text{ low} \end{matrix} \right] \end{matrix} \right\}$$

Notice that there are <u>two</u> elements within the parenthetical expression which meet the internal requirements of the focus. These are both necessary if the rule is to be formulable within the SPE theory. Any segment in a string which is matched with the second of these is consistent with principle (6), since it is also going to undergo the rule. The first low vowel in the parenthetical expression is a different matter, however. Any segment which can be matched with this vowel will <u>not</u> undergo the rule. Such segments clearly violate the crossover constraint as stated in (6). That is, such segments falsify (6) as a principle to be incorporated into the SPE theory for the purpose of capturing the essence of the crossover constraint.

The Woleaian low vowel dissimilation rule is not the only example which disconfirms principle (6). Lightner (1971:227) cites a number of rules of the required character:[1]

(9) a. "In Borgstrøm's interesting (but controversial) paper on IE vowel-gradation ... he proposes (pp. 141, 144, et passim) a rule of the following type: 'in each word-form, the final vowel was preserved and then every second vowel from the end was syncopated.'

b. "In Old Irish, every second vowel from the beginning was apparently dropped (tomnibther < *to-monibither, for example; cf. Thurneysen, p. 67).

c. "In Modern Kalmyk, a dialect of Mongolian, every other unstressed vowel is reduced (= laxed and centralized); cf. Binnick.

d. "In Slavic, every other unaccented jer (= lax u or i) was dropped, starting at the end of the word and working toward the beginning.

e. "In Japanese, every other unaccented lax u or i, starting from the beginning of the word, may be pronounced voiceless between voiceless consonants (cf. Ishida)."

All of the above examples are easily expressed within the directional theory and are fully compatible with the crossover constraint as presented in Chapter V. At the same time, to

express these rules within the SPE theory would require a violation of principle (6). Thus the simple constraint required within the directional theory cannot be matched by a similar constraint with the SPE theory. To the extent, then, that the crossover constraint is correct (and the burden of proof is upon its opponents), it gives strong support for the directional theory. It is important to add that the crucial evidence for determining the incompatibility of SPE theory with the crossover constraint comes precisely in the area where the two theories differ in their most fundamental way -- directional vs. simultaneous treatment of multiple applications of a rule.

2.3 <u>Optional Rules: French Schwa-Deletion</u>. One type of rule that constitutes fairly strong evidence against the SPE analysis is an optional rule of the character of French schwa-deletion. The fact that attempts have been made to effect a revision of the SPE framework in order to handle these phenomena (cf. section 4 of this chapter) is an indication that the French example is indeed an important one. There has been considerable literature on this topic, but the following treatment is based entirely on the analysis in Dell (1970), which may be consulted for further bibliography.

The most interesting and significant rule in Dell's analysis is the rule which deletes a schwa when it immediately follows the first consonant of the word and the preceding word

ends in a vowel:

(10)   ə → ∅ / V # C ___

According to the theory proposed here, this rule would be a
rightward rule and should have the effect of deleting every
alternate schwa. Consider the implications of this rule for
a string of schwas, as in the phrase <u>la queue de ce renard</u>
'the tail of this fox'.

(11)   /#la ⫽kö ⫽də ⫽sə ⫽rənar⫽/

          ⫽la ⫽kö ⫽dø ⫽sə ⫽rənar⫽   first application

          ⫽la ⫽kö ⫽dø ⫽sə ⫽rǿnar⫽   second application

In this case the first and third instances of schwa are
deleted. If we replace <u>queue</u> with <u>tête</u>, a different pattern
results:

(12)   /#la ⫽tet ⫽də ⫽sə ⫽rənar⫽/

          ⫽la ⫽tet ⫽də ⫽sø ⫽rənar⫽

Here the first schwa is unable to delete because the preceding
word does not end in a vowel. The second vowel is, however,
able to delete because the first schwa remains.

     Notice that a rightward repetitive rule is self-bleeding,
in that each application of the rule destroys the conditions
for deletion of the following schwa.

     The description of schwa deletion presented thus far is
an oversimplification of the real facts of French. Instead of
the single pronunciation of <u>la queue de ce renard</u> given in

(11) there are <u>five</u> acceptable alternative pronunciations:

(13) a.   la kö də sə rənar

    b.   la kö d∮ sə r∮nar

    c.   la kö d∮ sə rənar

    d.   la kö də s∮ rənar

    e.   la kö də sə r∮nar

The fact that all five of these pronunciations are acceptable indicates that the schwa is <u>optionally</u> deleted when it meets the structural description of the rule.

If all of these schwas are simply allowed to delete optionally, there are three more possible outputs in addition to those given above:

(14) a.   *la kö d∮ s∮ rənar

    b.   *la kö də s∮ r∮nar

    c.   *la kö d∮ s∮ r∮nar

As the asterisks indicate, these three pronunciations are inadmissible. How, then, can schwas be optionally deleted to fit the patterns in (13) without also deriving those in (14)?

Within the directional theory this constitutes no problem at all. The inadmissible sequences in (14) are pre-cisely those which involve the deletion of two or more <u>successive</u> schwas. If the rule is applied in the rightward direction required by the theory and each schwa is optionally deleted when its turn comes, the set of outputs derived is exactly the set of acceptable alternatives given in (13).

Since the rule will not apply when there is more than a single
intervening consonant and any application of the rule creates
a consonant sequence, the vowel which follows a deleted schwa
can never be deleted. Thus, given the string #la #kö #dø #sə
#rənar # which results if the first option is taken, the
second schwa will not be able to delete since it is no longer
in the correct environment.

This same process cannot be expressed within the simul-
taneous theory of SPE. The only way to capture an alternating
pattern is through the use of the parenthesis-star notation.
We might therefore consider the possibility of expressing
these facts with the following rule:

(15)   ə → ø / V (#Cə #Cə)* #C ____

Rule (15) is immediately suspicious because of the clear
redundancy of its environment. The difficulty extends well
beyond an awkwardness of statement, however, for (15) and any
conceivable alternative within the SPE framework cannot derive
the correct outputs.

Since it is clear that French schwa-deletion (in the
context under consideration here) is an optional rule, we must
ask what optionality means within the simultaneous theory of
SPE. There are two reasonable alternative meanings of the
term "optional" where rules abbreviating infinite schemata
are concerned. The first would be that all relevant schwas
are identified and each vowel may be optionally deleted. The

second would require that all such schwas be deleted or none of them. The meaning of optionality in such cases is not spelled out in SPE, but in the context of rule (15) it is clear that neither definition will suffice. The <u>intention</u> of rule (15) is to delete only alternate schwas, but in fact odd numbered schwas may be deleted as well as even numbered ones. Moreover, the first and fourth may be deleted. Rule (15) fails to capture the notion "nonadjacent".

I have underlined the word "intention" above, since (15) is open to another more damaging criticism. Rule (15) fails not only because it cannot handle odd alternations as well as even ones, but also because it does not prevent successive schwas from deleting! The reason for this is that the parenthesis-star notation abbreviates an infinite set of rules which are simultaneously applied and the shortest member of that set is:

(16)   ə → ∅ / V # C ___

In the derivation of, for example, <u>la queue de ce renard</u> all three schwas meet the structural description of (16) and hence <u>all</u> can be deleted.

While French schwa deletion is perfectly accounted for in the directional theory, these same facts cannot be handled within the simultaneous theory of SPE. This is a significant piece of evidence in favor of the theory of rule application being advanced here. For further discussion of this rule in

the context of recent attempts to revise the SPE theory, see

section 4 of this chapter.[2]

2.4 Subscripted Expressions and Disjunctive Ordering.

In the SPE theory, subscripted expressions always involve

simultaneous application of an infinite set of rules. Such

application is neither conjunctive nor disjunctive. A result

of this interpretation of the parenthesis-star notation is

that the stress process in Komi Jaźva can be expressed only

in an extremely complicated and non-general way in the SPE

theory, while it has a very direct expression within the

directional theory. Komi Jaźva[3] stress therefore constitutes

counterevidence to the SPE theory and supports the direc-

tional theory.

It can also be noted that if the directional theory's

interpretation of subscripted expressions is correct, the

similarity between these full options and partial options

(represented by parenthesis notation) would be much greater.

We can then say of both types of options that they involve

(a) the crossover constraint (for nonaccent rules) and (b) the

longest expansion and effective disjunction (for accent

rules).

There is independent support for each of these properties

of subscripted expressions. The crossover constraint for non-

accent rules can be observed crucially with regard to Menomini

vowel raising and Finnish vowel harmony, while the principle

of longest expansion is illustrated by Komi Jaźva stress.
The fact that there is independent support for extending
these properties to subscripted expressions indicates that
these two notations are fundamentally similar.

2.5 <u>Glide Formation: Eastern Ojibwa</u>. Eastern Ojibwa
glide formation illustrates a set of rules which creates
problems for the SPE theory. As pointed out in Chapter II,
Eastern Ojibwa has a glide formation rule which converts
nonlow vowels to glides prevocalically. Bloomfield pointed
out that this rule must be applied from the right end of the
string to the left. Within the directional theory, the rule
may be stated simply as:

(17) $$\begin{bmatrix} + \text{ syll} \\ - \text{ low} \end{bmatrix} \rightarrow \begin{bmatrix} - \text{ syll} \\ + \text{ high} \end{bmatrix} / \underline{\quad} [+ \text{ syll}]$$

I pointed out in the earlier discussion that rule (16),
if interpreted within the SPE theory, will work incorrectly.
A sequence of nonlow vowels followed by a vowel, as in
/eninioak/, will incorrectly yield two glides, as in
[*eninywak]. An intervocalic rule will work correctly here,
but does not account for sequences of two vowels. Moreover,
as Bever pointed out with regard to Menomini, it would make
an intuitively incorrect prediction about 5 vowel sequences.

Another possibility would be to try to state this rule
with parenthesis-star notation. Consider the following:

(18)
$$\begin{bmatrix} + \text{ syll} \\ - \text{ low} \end{bmatrix} \rightarrow \begin{bmatrix} - \text{ syll} \\ + \text{ high} \end{bmatrix} / \underline{\quad} \text{ [+ syll]* [+ syll]}$$

Rule (18) fails because its shortest expansion is:

(19)
$$\begin{bmatrix} + \text{ syll} \\ - \text{ low} \end{bmatrix} \rightarrow \begin{bmatrix} - \text{ syll} \\ + \text{ high} \end{bmatrix} / \underline{\quad} \text{ [+ syll]}$$

and therefore every nonlow vowel that is followed by a vowel in the underlying string will be made a glide. The same failure holds for (20):

(20)
$$\begin{bmatrix} + \text{ syll} \\ - \text{ low} \end{bmatrix} \rightarrow \begin{bmatrix} - \text{ syll} \\ + \text{ high} \end{bmatrix} / \underline{\quad} \text{ ([+ syll] [+ syll])* [+ syll]}$$

In this last case, the intention of the rule is to make every alternating vowel become a glide, but the failure would seem to be that the expression involves subrule (19), which need not adhere to the alternating pattern. To resolve this same difficulty with Woleaian low vowel dissimilation, it was necessary to indicate that the vowel outside of the subscripted parentheses is the final vowel of the sequence. Thus, we might consider the following modification of (20):

(21)
$$\begin{bmatrix} + \text{ syll} \\ - \text{ low} \end{bmatrix} \rightarrow \begin{bmatrix} - \text{ syll} \\ + \text{ high} \end{bmatrix} / \underline{\quad} \text{ (V V)* V} \begin{Bmatrix} \# \\ [- \text{ syll}] \end{Bmatrix}$$

Rule (21) "anchors" the point of reference to the final vowel of the sequence. Thus, it will correctly derive [eniniwak] from /eninioak/ because the longest expansion cannot apply, while the shorter expansion makes the penultimate vowel become a glide. Unfortunately, however, this solution is still inadequate, since a sequence like /aiaiC/ would not

meet the structural description of <u>any</u> subrule of (21) and
the output would therefore be *[aiaiC].

I can see no way of resolving the above problem within
the SPE theory. Here the SPE theory is more restrictive than
the directional theory I have proposed, but at the same time
the existence of a counterexample suggests that it is <u>overly</u>
restrictive. These facts again suggest that the directional
theory is to be preferred.

2.6 <u>Redundancy</u>. It was pointed out that the extra
complexity of statement required by the SPE theory is far
from random, but rather bears an interesting relationship to
the remainder of the rule. In general, the extra complication
takes the form (directly or indirectly) of a repetition of the
shortest expansion of the rule. This redundancy, while not a
necessary and sufficient cause for rejecting the SPE theory
outright, must certainly be evaluated less highly than a
theory which avoids the complexity and redundancy.

2.7 <u>Simplicity</u>. It is not only the case that attempts
to formulate various rules within the SPE theory lead to re-
dundancy of statement, but these rules also appear to make
incorrect claims internal to the SPE theory.

The simplicity metric was constructed to evaluate alterna-
tive formulations of the same rule within the same theory,
giving preference to the one which utilizes the fewest fea-
tures. The general assumption (quite clearly only partially

true), is that this procedure within the current theory will give preference to the rule which is truly more general. While it is beyond the scope of this metric to compare two radically different rules (e.g., a vowel nasalization rule and a palatalization rule) in terms of which is more general -- and hence also in terms of the simplicity metric -- it is a reasonable demand to make of a simplicity metric that it will allow the more general of two <u>closely related</u> rules to be stated with fewer features. This is a clear implication of the discussions of the simplicity metric in Halle (1962), Chomsky & Halle (1968), and elsewhere.

Consider, then, the claim that is made by the SPE formalism. Obviously, if rule A is identical with rule B except that it contains an additional expression, A is more costly than B. Thus, (22a) below (the <u>l</u>-nasalization rule of Tshiluba) must be regarded as more costly than (22b):

(22) a. $[+ \text{lat}] \rightarrow [+ \text{nas}] / [+ \text{nas}] V_o ([+ \text{lat}] V_o)* \underline{\quad}$

   b. $[+ \text{lat}] \rightarrow [+ \text{nas}] / [+ \text{nas}] V_o \underline{\quad}$

This amounts to a claim that rules which must be stated within the directional theory as simultaneous rules are more general (more to be expected) than rules which are repetitive. However, when one examines phonological rules within the framework proposed here, it seems apparent that simultaneous rules are the <u>exceptional</u> cases rather than the norm.

2.8   Summary of Comparison.   There appear to be many arguments for favoring the directional theory over the standard theory as presented in SPE.   In the above sections I have shown that there are several types of empirically attested cases which cannot be described within the SPE theory, yet which are directly and naturally expressed within the directional theory.   These examples were Komi Jažva stress, French schwa-deletion, and Eastern Ojibwa glide formation.

At the same time, the SPE theory allows the description of processes that have been ruled out by the directional theory due to the crossover constraint.   It was argued that the SPE theory is incompatible with the crossover constraint, due to cases like Woleaian low vowel dissimilation, etc. Finally, the redundancy of statement and improper claims made by the simplicity metric within the theory of SPE reflect inadequacies of that theory.

3.0   Johnson's Linear Theory.

3.1   Description of the Theory.   In order to provide a comparison between these two theories, it is first necessary to present Johnson's theory in some detail.   Although the theories are quite similar in many respects, they differ in other respects and these differences are significant.   They differentiate what appears to be a more restrictive but more adequate theory from a less restrictive and less adequate one.

Johnson illustrates the operation of linear rules with an example from Sanskrit. The rule in question causes a dental n̲ to be retroflexed when the following conditions are met:

(23) a. the n̲ is preceded somewhere in the same word by a retroflex continuant without an intervening palato-alveolar, retroflex, or dental consonant;

    b. the n̲ is followed immediately by a sonorant.

Within the formalism Johnson provides, these facts are expressed as:

(24)

$$
R: \begin{bmatrix} + \text{ nas} \\ + \text{ cor} \\ \sigma \end{bmatrix} \rightarrow \begin{bmatrix} - \text{ ant} \\ (\sigma) \end{bmatrix} / \ \$* \begin{bmatrix} + \text{ cor} \\ + \text{ cont} \\ - \text{ ant} \\ - \text{ distr} \end{bmatrix} [- \text{ cor}]* \underline{\hspace{1cm}} [+ \text{ son}]\$
$$

The symbol R̲ indicates the direction of rule application. The dollar sign represents any segment and the asterisk is equivalent to subscript zero. Sigma, which represents the rest of the features in the matrix, can be ignored for this and subsequent discussions.

Johnson provides a formal description of the notion of a right linear rule, characterizing what successive lines of a derivation look like. The application of rule (24) to the string u̲ṣnataraanaam to yield u̲ṣṇataraaṇaam proceeds as follows. Note that r̲ is a retroflex continuant, even though it is not conventionally indicated as such by the use of the lowered dot.

(25) 1. uṣ → uṣ / ____ nataraanaam

    2. n → ṇ / uṣ ____ ataraanaam

3. ataraa → ataraa / uṣṇ ___ naam

4. n → ṇ / uṣṇataraa ___ aam

5. aam → aam / uṣṇataraaṇ ___

The formal principles that Johnson discusses guarantee that
application of the rule proceeds from the left end of the
string to the right, with no retreats to the left. Each even
numbered step is a "subrule" of (24), while the odd numbered
steps are vacuous. These steps are related in such a way that
the left environment for each step must become longer than
that in each preceding step, but no potential subrule can be
missed. The reader who desires more detailed information on
Johnson's proposal can refer back to his original work.

One interesting point about the way in which Johnson
chose to present his proposal is that it is not directly in
the form of an algorithm for applying a rule, but rather in
the form of a set of well-formedness conditions on a deriva-
tion. Thus what we see illustrated in (25) is a character-
ization of what a proper application of the rule would be but
not a step-by-step procedure for applying the rule.

When we attempt to translate these well-formedness
conditions into an application algorithm similar to the one I
have discussed in Chapter II, we arrive at a more suitable
basis for comparison of the two theories. In reality, there
is (not surprisingly) an equivalence class of algorithms that
are consistent with Johnson's well-formedness conditions. I
will discuss two of these in turn.

One way in which both of these algorithms differ from the one I have proposed, which is based upon the conventional way of writing rules, is that the rule is matched with the <u>entire</u> string (interpreted as the stretch between word boundaries unless word boundary is itself mentioned in the rule) rather than with a substring. It is unlikely that this has any serious empirical content, but it is consistent with Johnson's notation and with his well-formedness conditions on derivations.

<u>Algorithm I</u>. In the terminology developed in Chapter II, this algorithm first locates the sequence marker and string marker at the left extreme of the string (for a right linear rule). The rule marker, instead of pointing to the left extreme of the rule, is placed at the <u>focus</u> of the rule. The first pairwise match, then, is with the leftmost string segment (= word boundary) and the focus of the rule. As each pairwise match with the focus fails, the sequence marker is advanced to the right. If a pairwise match with the focus succeeds, the string and rule markers are moved both to the left and to the right to determine whether all of the other requirements of the rule are met. There must be a complete match between the string and the rule for an application to take place. After such an application, the sequence marker is again advanced. Algorithm I may be characterized as a "focus-searching" algorithm, since it seeks each segment which is a potential focus (skipping over none) and then determines

whether or not the remainder of the requirements of the rule are met.

Algorithm II. Proceeding as in the algorithm presented in Chapter II, locate the sequence and string markers at the left extreme of the string (again for a right linear rule) and the rule marker at the left extreme of the rule. At each failure to match, advance the sequence marker and begin a new match sequence. If the match succeeds, attempt to match all following segments in the string with following elements in the rule. If the matching procedure indicates that the string fits the rule, apply the rule to the segment indicated by the sequence marker and advance the sequence marker to the right.

The algorithm given thus far is similar to that given in Chapter II, except for the requirement that the entire string be matched with the rule. A more crucial difference may be observed, however, in that in order to insure that no potential focus is skipped over, it is necessary to take the shortest possible expansion of parentheses or subscripted expressions first. In rule (24), the leftmost element in the rule is $* and unless the shortest expansion of this expression is taken only the rightmost n in /uṣnataraanaam/ will be retroflexed. This convention of shortest expansion is thus diametrically opposed to the principle of longest expansion presented in Chapter III.

3.2 <u>Comparison</u>.

3.2.1 <u>Simple Expressions</u>. In using this term I wish to confine attention to those rules which do not make crucial use of the subscript notation nor of disjunctive ordering. Within this classification there are two types of rule. The first of these is characterized in Chapter II as "neutral application." That is, these rules can never be self-feeding or self-bleeding in their application and consequently a leftward, rightward or simultaneous treatment of them will all yield the same empirical consequences. As a result, they are of little value in differentiating among the theories under consideration in this chapter.

For any simple expression which is not neutral in character, however, there is a relevant theoretical distinction. Consider, for example, the Tshiluba <u>l</u>-nasalization rule:

(26) $[+ \text{ lat}] \rightarrow [+ \text{ nas}] \; / \; [+ \text{ nas}] \; [+ \text{ syll}]_0 \underline{\quad}$

If rule (26) were interpreted as a right linear rule (making minor revisions in the formalism to accomodate it to Johnson's theory), it would correctly characterize the facts of Tshiluba, nasalizing every <u>l</u> in the sequence. If the same rule were applied as a left linear rule, however, only the <u>l</u> closest to the nasal would nasalize. Such simple expressions, then, yield different outputs depending upon the direction in which they are applied.

If one advocates a directional theory where direction-
ality is fully predictable and all rules are repetitive, then
in such a theory there would be only one possible output for
any rule in this category. The linear theory of Johnson
would therefore allow the statement of twice as many of these
rules as the directional theory. But the situation is not so
simple, for once the repetitive vs. simultaneous distinction
is made within the directional theory the number of possible
rules doubles.

Do such simple expressions offer anything to choose be-
tween the linear and directional theories if both are capable
of stating the same set of rules? In a certain sense the
answer is no. On the other hand, the directional theory as I
have presented it makes two additional claims concerning
simultaneous application: (1) that assimilatory rules cannot
be applied simultaneously; and (2) that the simultaneous mode
of application is marked. The first of these claims, which I
regard as much more tentative than the second, does in fact
restrict the number of rules that may be stated, since it
allows a choice of mode of application for only a limited sub-
set of rules. The second claim is a valuable one because of
the predictions that it makes about the relative frequency of
occurrence of one member of each pair of rules as opposed to
the other, because of its implications for language acquisi-
tion, and so forth. As the theories are currently stated,

then, there _is_ some basis for choice. The theory which makes
the more restrictive and interesting claim is currently the
directional theory.

It is worth considering whether the claim about marked-
ness of mode of application is a contribution to linguistic
theory that is of greater significance in deciding between
the two theories, or whether it is a contribution to the
theory that is compatible with other linguistic theories. To
the extent that such a principle can be stated coherently only
within the directional theory the other theories would be
shown to be inadequate.

As far as the category of cases currently being consid-
ered is concerned, it is a simple matter to incorporate these
observations into the linear theory. The output provided by
a repetitive rule is equivalent to the output provided by the
linear theory if the direction of application is the same. If
the rule is simultaneous, it is equivalent to using the oppo-
site direction within the linear theory. Thus instead of
having a principle of unmarked mode of application, the linear
theory could here have a principle of unmarked directionality.
It would appear from these observations that the difference
between the two theories is not a crucial one, but this ques-
tion will be raised again shortly.

3.2.2 _Disjunctive Ordering_. Johnson contends that "the
principle of disjunctive ordering is grossly over-generalized

for it seems to be properly associated only with certain rules which introduce a primary accent (whether of pitch or stress)" (1970a:127). Johnson's specific proposal is to link disjunctive ordering with those rules utilizing the stress reduction convention of Chomsky & Halle (1968:16-17) whereby when a primary stress is assigned to some vowel in a string, the stresses on all other vowels in the string under consideration are reduced by one. Such rules, he suggests, should be written as assigning [0 stress] and the stress reduction principle should be extended to apply to all vowels, reducing the [0 stress] to [1 stress].

This proposal in itself would have no great empirical consequences for the theory, except that Johnson wishes to retain rules which assign [1 stress] in addition to those which assign [0 stress]. The difference between the two is that the latter call into play the stress reduction convention and disjunctive ordering, while the former do not. English stress and Komi Jaźva stress are rules which assign [0 stress], while the alternating stress rule of Southern Paiute assigns [1 stress].

Since the difference between [0 stress] and [1 stress] is subsequently neutralized, it is important to ask how such a distinction may be justified. Let us assume, first of all, that there is no other fact relevant to the assignment of zero or one stress than the presence or absence of disjunctive ordering. While such a distinction can function mechanically

to differentiate disjunctive rules from those which are not,
it is an ad hoc device fully equivalent to marking each rule
[± disjunctive]. The strong claim made by Chomsky & Halle --
that the disjunctive character of the rules is a consequence
of the notation used to represent them which is in turn a
consequence of their form -- falls by the wayside. The use
of such a stress distinction would require knowledge of
whether the rules are to be applied disjunctively or not in
order to determine the choice of notation. The argument
thereby becomes completely circular.

Johnson, as we have seen, suggests that there is another
property associated with disjunctive ordering, and with zero
stress. Using the stress rules of English as paradigm
examples, he argues that the stress reduction phenomenon
claimed for English by Chomsky & Halle and disjunctive order-
ing go hand in hand. Confining our attention for the moment
to the English cases, it is implied that the observation of
stress reduction in operation forces us to choose [0 stress]
in the formal representation of the rule, and this in turn in-
forms us that the rule is to be applied disjunctively. It
would follow from this, then, that for disjunctive ordering to
be a consequence of the notation, it must be possible to
observe stress reduction.

Consider a case like the Latin stress rule. If there are
no other stresses in the word, how can one determine whether
the stress reduction principle is in operation or not? Clearly

one cannot use this as a criterion in a non-ad hoc way. For
at least that subset of languages where words have only one
stress, the choice of zero vs. one stress is an arbitrary one
and cannot therefore be used to "predict" disjunctive
ordering.

One apparent counterexample of a different type is the
second syllable lengthening rule in Menomini discussed in
Chapter IV:

(27) $V \rightarrow [+ \text{long}] / \# C_o (\breve{V} [- \text{glot}]_o) \underline{\quad}$

In order to accomodate this rule into Johnson's theory, it
would be necessary to assume that the rule assigns the value
[0 long] and that there is an equivalent principle reducing
the value of vowel length. This would seem to be an unreason-
able claim.

Johnson never states explicitly what he means by disjunc-
tive ordering. It appears that he is thinking of it in terms
of the word-level disjunction principle, rather than in terms
of any more restricted domain. He does <u>not</u> treat disjunctive
ordering in either the same way that it is treated in SPE or
as treated in the directional theory. He states explicitly
that in his formalism "there is no explicit analogue to the
notion of ordered expansion of rules" (1970a:129), which means
that he cannot say, as in SPE, that the shorter expansions are
not permitted to apply if the longer ones apply. It is also
not the case that disjunctive ordering is achieved by "skipping

over" a potential focus without applying the rule until the longest expansion is reached. Rather, disjunctive ordering appears to mean simply allowing a <u>single</u> application of the rule and no more.

In order to treat disjunctive ordering in this way, it is necessary to insure that the first segment one comes to which meets the structural description of the rule is the one that must in fact undergo the rule. After that application, his version of the principle of disjunctive application dictates that no further applications are possible.

While the directional theory would treat the Latin stress rule and the English main stress rule as predictably leftward rules, in Johnson's linear theory these must be right linear rules. The first vowel to which the rule can apply is the one which meets the structural description of the longest expansion (in SPE terms) and disjunctive application of the rule in this manner therefore yields the correct result. Thus, one interesting aspect of Johnson's treatment of disjunctive ordering is that such rules must be stated in a direction opposite to that claimed by the directional theory.

Notice parenthetically that if we attempt to apply either the Latin stress rule or the English main stress rule as a left linear disjunctive rule the stress will always be placed on the final syllable. There would be no motivation for expressing the rule in the complex form using parentheses, but it may simply be expressed as:

(28) $V \rightarrow \acute{V}$ / ___ C_o #

In section 3.1 it was pointed out that if one wanted to incorporate the claim made by unmarked mode of application into a linear theory, as far as simple expressions are concerned it would be possible to have an unmarked directionality instead. This direction would be the same as that predicted by the directional theory. Where disjunctive application is concerned, however, the direction of the rule is necessarily exactly the opposite. It is somewhat puzzling that this situation should arise, if there is any natural principle governing directionality.

3.2.3 <u>Parentheses Without Disjunctive Ordering</u>. The purpose of this section is to investigate the behavior of rules involving parentheses or subscripted expressions which do <u>not</u> at the same time involve disjunctive ordering.

It is clear from Johnson's treatment that rules of this type will yield the same output if applied in either direction. consider a rule such as the Latin stress rule presented earlier:

(29) $V \rightarrow \acute{V}$ / ___ C_o $((\breve{V}C_o^1)$ $VC_o)$#

If this were a rule that assigned [1 stress] and were therefore not disjunctive, it would apply in the following way. Assuming a string which allows the fullest expansion to apply and right linear application, when the antepenultimate vowel is reached

it is identified as being in the proper environment to undergo the rule and the rule will be applied. When the penultimate vowel is reached, it too will be so identified and that vowel will receive stress. The same holds true of the final vowel. Thus, all three of the last vowels get stressed. If the rule were applied as a left linear rule, each vowel would still be stressed when its turn came and thus regardless of the direction, the effect would be to stress the last three vowels of such a string.

Within the directional theory, as well as the theory of SPE, there is no way to derive such outputs from a rule like (29). Whether simultaneous or repetitive, the rule must be leftward directional, must take the longest expansion, and hence will apply only to the leftmost vowel meeting the structural description of the rule. Within the SPE theory, the principle of longest expansion and the principle of disjunctive application bring about a similar result.

When these theories are compared, then, it can be seen that the directional theory maintains the SPE strong claim about disjunctive ordering and is consistent with it in output. The linear theory, if we ignore the existence of disjunctive ordering temporarily, also allows a single output in these cases but it is regularly the opposite claim to that made by SPE and the directional theory. Thus, instead of getting a single application, there are multiple applications. To the extent, then, that the SPE claim about parentheses is

correct (and, within the domain of accent rules, I believe it to be correct), the linear theory is inadequate. I do not know of any empirical examples which would support the view of parentheses taken by Johnson. It thus appears that the set of rules characterized here give support to the directional and SPE theories of rule application.

3.2.4 <u>Subscripted Expressions</u>. The treatment of subscripted expressions is different in all three theories. In the SPE theory, the notation always implies simultaneous application and hence, in the crucial cases under consideration, multiple application of the rule. In the directional theory, subscripted expressions, like simple parentheses, are always disjunctive (as far as accent rules are concerned). In the linear theory, however, rules stated with the zero value of the stress feature are disjunctive while all other rules with subscripted expressions are not.

As was the case with simple parentheses, in order to achieve disjunctive ordering the directionality of the rule has to be the opposite of that predicted by the directional theory -- or of that which would be unmarked in relation to simple expressions within the linear theory.

3.2.5 <u>Crossover Constraint</u>. Although the crossover constraint is not part of the linear theory, it seems fairly straightforward to build it in. It does not appear that the same difficulties would arise here as arise for the SPE theory.

On the other hand, this is true only if the theory is defensible on other grounds. The ad hoc treatment of disjunctive ordering is a key issue in point. If we accept that treatment, there appears to be no problem incorporating the crossover constraint. If we reject it, the necessary revision in the theory would have implications for the question of whether the crossover constraint can or cannot be incorporated.

3.2.6 <u>Optional Simultaneous Rules</u>. There are very few rules statable within the directional theory which are not statable within the linear theory, since the latter is somewhat more powerful. Among the rules which can be stated in the directional theory but not in the linear theory are disjunctive rules of accent not involving stress (e.g., the Menomini second syllable lengthening rule) and the optional simultaneous rules (e.g., Warao labial voicing).

Recall that in Warao a /p/ may optionally be pronounced as [b] but if one instance of /p/ became [b], all such instances in the word were pronounced the same way. Neither the SPE[4] nor the linear theory can deal with these facts.

3.2.7 <u>Summary of Comparison</u>. It is much more difficult to compare the linear theory with the directional theory than it is to compare either of them with the simultaneous theory of SPE. The differences in the latter case are quite salient, while those in the former are more subtle. One can voice a preference for the directional theory on the grounds that it

embodies the crossover constraint and the principle of
unmarked mode of application, but it is not clear that this
really chooses between the theories in any _fundamental_ way.
The linear theory can be criticized for not being able to
handle Warao labial voicing or the second syllable lengthening
rule of Menomini. But these should not be regarded as
extremely compelling counterexamples.

Perhaps the most significant aspect of the comparison
made thus far is in the treatment of disjunctive ordering. By
allowing both zero and one stress, Johnson is reducing disjunc-
tive ordering to an ad hoc property of rules, weakening the
strong claim of Chomsky & Halle that has also been incorporated
into the directional theory. This means that for each rule
involving accentuation which utilizes [1 stress], the linear
theory derives an output that is not derivable in the SPE or
directional theories. Since such stress patterns appear to be
unlikely, the linear theory makes an incorrect claim here.

If one admits that the ad hoc treatment of directionality
and its associated consequences of being able to state a set
of unnatural rules detract from the value of the theory, one
might attempt to find a better formulation of the conditions
under which disjunctive ordering holds. A likely candidate
would be to base the distinction between disjunctive and non-
disjunctive rules upon accent vs. nonaccent rules, as in the
directional theory proposed. If this is attempted, however,
it poses problems for alternating stress rules since they are

not disjunctive.

One might attempt to make a further specification within the class of accent rules which defines those rules that are disjunctive as opposed to those which are not. This specification would have to differentiate between the Latin or Komi Jaźva stress rules on the one hand and the Southern Paiute alternating stress rule on the other. If we make this distinction upon the basis of whether the rule contains parentheses or subscripted parentheses, the theory would not be able to express alternating stress rules which involve parentheses, such as the Tübatulabal and Eastern Ojibwa stress rules. Such a differentiation thus fails to separate disjunctive rules from nondisjunctive rules in the proper way.

Another question that must be raised about the linear theory is how the idea of an unmarked mode of application may be captured. For rules with no abbreviatory devices it would be necessary to say that the unmarked directionality is that which corresponds to the prediction made by the directional theory. Within this group, however, it may be the case that assimilatory rules have no option at all, while dissimilatory rules have a marked and unmarked directionality. For rules with options, the directionality is obligatorily the opposite of that predicted in the directional theory if the rule is in the class, however defined, of disjunctively applied rules. Other rules with options presumably apply in the predicted direction. What these facts show, then, is that there is

little uniformity to the direction in which a rule is applied

and markedness considerations are not very neatly captured.

4.0 <u>Anderson's Revised Simultaneous Theory</u>. Anderson

(1971) has recently proposed yet another alternative theory of

rule application, similarly stimulated by difficulties en-

countered with the standard theory. In order to consider the

implications of this position and to compare it with the

others presented thus far, it will be necessary to present a

brief outline of the theory first.

4.1 <u>Outline of Theory</u>.

4.1.1 <u>Principle 1 and the RSAC</u>. In section 2 of this

chapter I presented an analysis of the schwa-deletion

phenomena of French. Recall that the rule under discussion

was of the following shape:

(30)   ə → ∅ / V # C ___

This rule is optional and its application within the direc-

tional theory correctly predicts that any number of schwas

that are in the correct position in the input string can be

deleted, except that no two <u>adjacent</u> schwas can be deleted.

In his original presentation of this data, Dell (1970)

was fully aware that the facts of schwa-deletion cannot be

captured by the simultaneous application algorithm of SPE.

He considered the possibility that the rule is applied sequen-

tially from left to right, but rejected it in favor of an

alternative proposal, suggested to him independently by
Anderson and by Chomsky, which attempts to modify the simulta-
neous application algorithm rather than allow rules to be
applied directionally. Dell proposed what he called the "K
Condition" as a principle of phonological theory. Anderson
(1971:160) refers to the same condition as "Principle 1":

(31)   "A rule may not apply simultaneously in two places
        if the environment necessary for one application in-
        cludes a segment affected by another application."

As stated thus far, this principle is certainly inade-
quate because it does not inform us as to what happens when
the environment for one application does contain a segment
affected by another application. One logical possibility is
that the rule is not well-formed, while another is to prevent
both of the relevant segments from undergoing the rule.
Neither of these consequences is claimed for Principle 1 and
it therefore becomes necessary to find out which of the
relevant segments may undergo the rule and which may not.

To deal with this question, Anderson proposes to incorpo-
rate Principle 1 into the simultaneous application algorithm
of SPE with some modification. He refers to the new algorithm
as the "Revised Simultaneous Application Convention", or RSAC.

(32)   "Scan the string for segments that satisfy the con-
        straints of the rule. When such a segment is found,
        identify it, and associate with that identification

an identification of the environmental analysis that

makes the rule applicable to that segment. Then

principle 1 applies: If any environment contains a

segment marked as undergoing the rule (other than

the one with whose applicability this environment is

associated), mark that as a violation. Then erase

the _minimal_ number of applicability identifications

and their associated environment specifications that

will eliminate all of the violations. Apply the rule

simultaneously to the segments remaining marked as

undergoing the rule." (1971:161)

Anderson illustrates the use of the RSAC with the deriva-
tion of the string _envie de te le demander_. Each arrow
indicates the segment that is to undergo the rule and the line
associated with it represents the environment which makes such
application possible. I shall refer to the segment and its
associated environment together as a _field_ and shall speak of
removing a field in order to eliminate violations of Principle
1. Violations are marked with an asterisk.

(33)   /...i ǂ də ǂ tə ǂ lə ǂ dəm.../
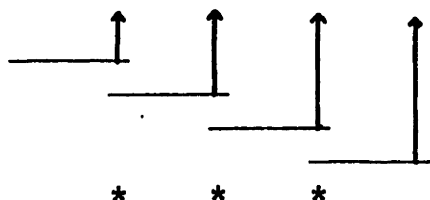
Discussion of this example is somewhat complicated by the
fact that the schwa-deletion rule is an _optional_ rule and

Anderson does not discuss the modifications of the algorithm that are necessary to handle optionality. It would seem reasonable, on the basis of his statement of the RSAC, to assume that the RSAC is activated and the segments that remain identified after the minimal two fields are removed will optionally undergo the rule. This is not Anderson's intention (Anderson, personal communication). Instead, he assumes that segments are optionally identified as meeting the structural description of the rule, the RSAC comes into play after that, and finally the rule is applied obligatorily to all segments that remain identified. In the course of this discussion I will consider both of these views on optionality in relation to Anderson's theory.

According to Anderson's position, any combination of the fields shown in (33) may be optionally represented. Anderson's claim is that the set of possible outputs from these various combinations in interaction with the RSAC is exactly the set of valid French pronunciations.

4.1.2 Principle 2. Proceeding from the premise that the above example demonstrates the RSAC to be a viable alternative to a left-right sequential theory, Anderson then seeks a case which will help decide between the two alternatives. He suggests that a crucial example is provided by Acoma, a Keresan language spoken in New Mexico.

According to Miller (1965), in certain morphological categories all vowels receive high tone. In the examples below, high tone vowels are marked with an acute accent. I depart from Miller's (and Anderson's) representations by using the accent over both members of a vowel cluster. Forms illustrating the operation of this rule are:

(34) a. súwágéní   'when I got dressed'

     b. šíízáácǔwání   'when I woke him up'

In addition to the "accent ablaut" rule illustrated above, there is a rule of tone loss which eliminates the accent of a short vowel when it is between two obstruents and followed in the next syllable by an accented vowel. Anderson writes this rule of tone loss as follows:

(35)

$$V \rightarrow [- \text{ high tone}] \ / \ [+ \text{ obst}] \left[\overline{} \atop - \text{ long} \right] [+ \text{ obst}] \ C_o \ \acute{V}$$

The operation of tone loss can be seen in forms like the following:

(36) a. sisíúsdyání   'when I roped him'

     b. šipəkááwáíí   'when I chopped wood'

     c. kapišéní   'at night'

Notice that in (36b) and (36c) tone loss applies to more than one vowel in a sequence. In Johnson's linear theory, this could be accomplished by a right linear rule. A left linear rule would fail because the first application would "bleed" a potential second application. In the directional

theory proposed here, this output could only be derived by a leftward _simultaneous_ rule. The determinant is clearly to the right, which requires the rule to leftward, but the normal repetitive mode of application would fail in just the way a left linear rule fails.

Consider how this phenomenon would be treated under the RSAC. First, the string would be analyzed as follows:

(37)   š í p ə́ k á á w á n í
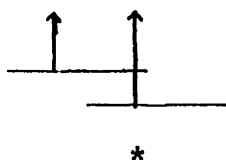
Here there is only a single violation of Principle 1, so removing either field will eliminate the violation. In this case, whichever choice is made the output will be incorrect. Removing the first field will modify the high tone only on the second vowel, while removing the second field will modify the tone only on the first vowel. In neither case will both vowels be affected.

Anderson proposes a further distinction among rules into those which _iterate_ (reapply to their own outputs) and those which do not (i.e., are simultaneous). He does not defend the distinction between iterative and simultaneous rules in this paper, nor does he elaborate on what "iterative" means in terms of an application algorithm. These issues will presumably be treated in detail in Anderson's work (forthcoming a)

on the Organization of Phonology. An interesting concomitant of his decision to allow some rules to be iterative is his decision to disallow the parenthesis-star notation (1971:159) on the grounds that it does not sufficiently delimit the class of iterative processes. It is clearly his belief that iterative rules are adequate substitutes for the parenthesis-star notation.[5]

Anderson proposes that Acoma tone loss is an iterative rule, reapplying to its own output. The effect of such reapplication depends upon which field was removed by the RSAC in order to eliminate the violation. Compare the two derivations below:

(38)   /šípə́kááwání/   /šípə́kááwání/   input string

        šípəkááwání   šípə́kááwání   first application

        ----------   šipəkááwání   second application

The second derivation is obviously the correct one and Anderson therefore proposes an additional convention to insure that it will be the choice taken. He refers to this convention as "Principle 2":

(39)   "When, in applying RSAC, two or more possibilities

        exist for eliminating the violations in an analysis

        of a form with respect to a rule, and each is minimal,

        in that it eliminates the smallest possible number

        of applications of the rule within the form, and the

        rule is an iterative one, choose that elimination set

which allows the rule to reapply over one that does
not allow reapplication." (1971:163)

Principle 2 is regarded as a special instance of Kiparsky's
principle of maximization of feeding order.

The addition of the RSAC, Principle 2, and the notation
of iterative rules to the basic algorithm of SPE would appear
to allow the correct derivation of words with two adjacent
short unaccented vowels in Acoma, as well as to provide for a
correct set of outputs for French schwa deletion. At the same
time, it is clear that a rightward repetitive (or right
linear) application of the schwa deletion rule and a leftward
simultaneous (or right linear) application of the tone loss
rule will also give correct solutions. Is there any way, then,
to choose between these alternatives?

Anderson points out that the tone loss rule of Acoma also
applies when words have three consecutive syllables which meet
the structural description of the rule. Both the leftward
simultaneous rule and the right linear rule which are required
to derive the outputs given above would predict that in such
cases where three syllables are involved all three would lose
their high tones. In actual fact, however, the accent on the
middle syllable is retained, as in:

(40) a. kagéçədíní   'when it is in bloom'

     b. sucítistáání   'when I was thinking'

To derive the correct outputs for both types of forms by a single rule within the directional theory (or Johnson's linear theory) would be exceedingly complex. Two-syllable forms would have to be simultaneous and three syllable forms repetitive. This is an unlikely sort of constraint to be stable within a theory and it opens up the floodgates by admitting a sizeable set of statable rules which are very unreasonable.

· Compare the treatment required in the directional theory with that provided by Anderson's theory. Take, for example, the form sučítistáání:

(41)   s ú č í t í s t á á n í

* *
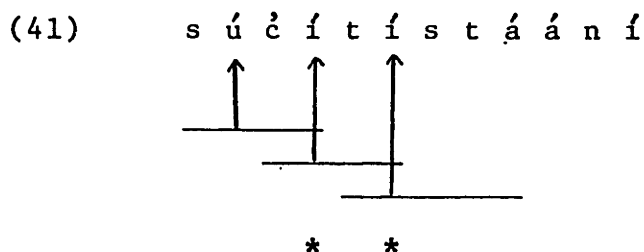
Here there are two violations of Principle 1. The minimal number of fields that needs to be removed to eliminate all violations is one, and that is uniquely the middle field. The RSAC will therefore allow only the tone loss on the first and third vowels, which is precisely the correct output. It thus appears that what the directional theory must handle in ad hoc and clumsy manner may be derived in a simple and straight-forward fashion by Anderson's theoretical principles. This would seem to lend support to Anderson's theory as opposed to any available alternative.

4.2 Critical Appraisal.

4.2.1 French Schwa-Deletion. As has already been

pointed out, French schwa-deletion has served as a stimulus
for the development of Anderson's theory, as well as to exem-
plify that theory. A careful consideration of this rule,
however, shows that the theory as currently formulated is
inadequate to deal with the empirical facts.

To illustrate this point it will be necessary to deal
with schwa-deletion under two alternative assumptions:
(a) that it is a simultaneous rule and (b) that it is an
iterative rule. Let us assume first of all that it is simul-
taneous. Consider how the theory would handle a case like
tu le retrouve:

(42)   /t ü # lə #rə # t r u v/[6]
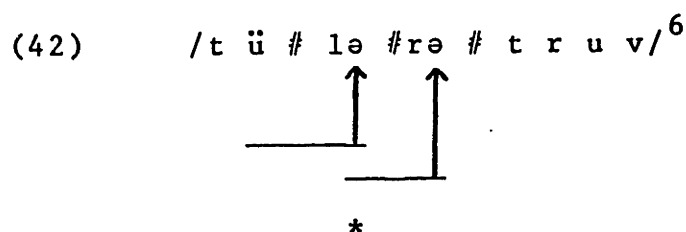
Here then is a single violation of Principle 1, but there are
two ways to eliminate that violation: (a) by removing the
first field, and (b) by removing the second field. Anderson's
theory provides no principled way of dealing with this situa-
tion. Principle 2 is applicable only to iterative rules and
there is no comparable principle relevant to simultaneous
rules. Anderson's theory as currently stated, then, provides
no output for this particular string.

Suppose, however, that we assume schwa-deletion to be an iterative rule. Given Anderson's notion of optionality, it is still possible that all segments meeting the structural description remain identified as such (i.e., that no options be taken), and (42) would thus constitute the input string to the RSAC. In the case of an iterative formulation of schwa-deletion, unlike the simultaneous formulation, there _is_ a well-defined output. Principle 2 tells us to remove the field which will allow a subsequent application of the rule. The field that will be removed, then, will be the first one and the second schwa will be deleted. Upon iteration, the first schwa will be in the correct environment to undergo the rule and will also be deleted. Thus, in addition to deriving the correct outputs, Anderson's theory also derives *tu lə rə truv.

Whether French schwa-deletion is a simultaneous or iterative rule, then, it cannot be correctly derived by Anderson's theory as currently stated. As an iterative rule it predicts an incorrect set of outputs, while as a simultaneous rule there is no principle to resolve a derivational indeterminacy. In the latter case the theory can presumably be saved by an ad hoc principle requiring removal of, say, the rightmost field when there is more than one possible way of removing the minimal number of fields, but such a principle appears to be quite arbitrary.[7]

It is also worth noting that if we attempt to revise the notion of _optional rule_ so that the optional choice comes at

the point of application rather than identification, the consequences are more severe. In such a case, if a string has a sequence of three (or any odd number beyond one) deletable schwas, the RSAC will uniquely determine which fields should be removed. It would then be impossible to delete any even-numbered schwa in the string, regardless of whether the option was taken to delete the schwa preceding it. In addition, all of the problems encountered by Anderson's notion of optionality would be present.

4.2.2 <u>Eastern Ojibwa and Woleaian</u>. Perhaps a more serious set of objections may be raised against Anderson's proposal when rules like Eastern Ojibwa glide formation and Woleaian low vowel dissimilation are considered. In Eastern Ojibwa (cf. Chapter II), the two nonlow vowels become glides when they precede vowels. Bloomfield recognized that this rule must be applied from the right extreme of a sequence of vowels to the left. Within the directional theory, the rule would be formalized:

(43) $\begin{bmatrix} + \text{ syll} \\ - \text{ low} \end{bmatrix} \rightarrow \begin{bmatrix} - \text{ syll} \\ + \text{ high} \end{bmatrix} / \underline{\hspace{1cm}} [+ \text{ syll}]$

If this same formalization of the glide formation process were accepted within Anderson's theory, it would be impossible to derive the correct outputs. In a sequence consisting of an odd number of nonlow vowels, such as <u>ioi</u>, a simultaneous application of rule (43) would fail to provide any output

because there is no principle to determine how the violation should be removed. An iterative application would also run into difficulties, as Principle 2 would make the wrong prediction and the resultant string would be *vwi.

Anderson (personal communication) suggests, however, that (43) is not the correct formulation of the process. He advocates rule (44) in its place:

(44)
$$\begin{bmatrix} + \text{ syll} \\ - \text{ low} \end{bmatrix} \rightarrow \begin{bmatrix} - \text{ syll} \\ + \text{ high} \end{bmatrix} / \ ([+ \text{ syll}]) \ \underline{\quad} \ [+ \text{ syll}]$$

To see how (44) resolves the difficulties discussed above, I will present the derivations of several sequences in which (44) is applied as an iterative rule. First of all, consider the following sequence:

(45)   i o i

Here there is only a single segment that meets the structural description of the longest expansion. It will therefore undergo the rule, yielding iwi. The first vowel, though it was in the correct position in the underlying string to undergo the shorter expansion of the rule, has been prevented from doing so due to the bleeding effect of the first expansion.

There is also no problem in deriving other forms with an odd number of relevant vowels, since in these cases RSAC provides a unique interpretation:

(46)   i o i o i

```
        ↑  ↑  ↑
   ┌────┘  │  │
   │    ┌──┘  │
   │    │  ┌──┘
   │    │  │
   └────┼──┘
        │
   ─────┘
```

        * * *
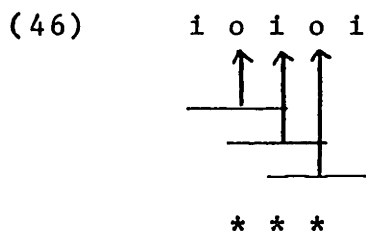
According to the RSAC, the middle field must be removed and
the second and fourth vowels will become glides, yielding
iwiwi. Again the second expansion is bled by the applicatⁱⁿn
of the first.

A more interesting situation arises, however, when the
string contains an even number of vowels:

(47)   i o i o

```
        ↑  ↑
   ┌────┘  │
   │    ┌──┘
   └────┼─┘
        │
   ─────┘
```

        *
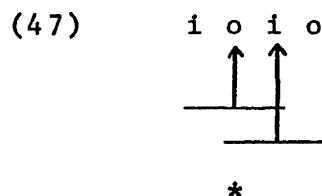
Here there are two ways to remove the minimal number (one) of
violations of Principle 1. Let us consider them both.
Suppose, first of all, that we remove the first field. This
leaves the third vowel as the only one marked to undergo the
rule and the string thus becomes ioyo. The first vowel of the
word is still in the correct position to undergo the shorter
expansion, and if it does the string will correctly become
yoyo.

Suppose, however, that we had chosen to remove the second
field. This yields the string iwio by the first expansion.
Again, there is a vowel that meets the structural description

of the second expansion and the string might be expected to become *iwyo.

It is obvious that removing the first field is the empirically correct choice. The problem is, how can we guarantee that this is the choice to be taken? The answer to this seems relatively straightforward. Rule (44) uses the parenthesis notation which, according to the SPE theory, requires disjunctive ordering. Let us assume that the domain of disjunction is as Bever postulated -- the environment of the rule. With this assumption, if we remove the second field and thereby get iwio from application of the first expansion, the following i will not be allowed to undergo the second expansion since it constituted a part of the enabling environment for the first expansion. Thus *iwio would be the final output. On the other hand, if we chose to remove the first field, the output ioyo is subject to application of the second expansion since the vowel i was not part of the enabling environment of the first expansion.

Notice that Principle 2 will make the correct choice here if it is extended to refer to schemata like (44). The correct output is the one which undergoes an application of the second expansion, while the incorrect output is blocked from doing so by the disjunctive property of the schema. It thus appears quite feasible that Anderson's formulation of the Eastern Ojibwa glide formation rule could be made to work consistently with his theory.

There are several reasons to object to (44) as a formulation of the glide formation process, however. First of all, notice that the parenthetical expression adds no content whatsoever to the decision as to whether a vowel meets the structural description of the rule. When we write a rule in the standard format A → B / X ___ Y where X and Y, let us say, are nonnull, this is not to be interpreted as saying that the string ends with X and Y. What it claims is that anything to the left of X or to the right of Y is irrelevant to application of the rule. If we write a rule like A → B / (X) ___ Y we are saying no more than that X is null. If X may or may not be there without affecting the operation of the rule, it is no different from Z which also may or may not be there. In short, there is no reason for expressing ([+ syll]) in rule (44) other than that it gives the correct order of expansion to make the rule work. I contend that such a device is entirely ad hoc and that a general principle of well-formedness must be applied to phonological rules which disallows any optional elements at either extreme of the environment.

A second fact that must be noticed is that the expression in parentheses is redundantly a statement of the type of segment which can undergo the rule. Just as Anderson properly criticized the parenthesis-star notation on the grounds that the elements it contained were redundant in relation to the shortest expansion, rule (44) and what it attempts to do must be criticized on parallel grounds of redundancy.

To see this somewhat more clearly, consider the low vowel dissimilation rule of Woleaian, which must be stated as follows within the directional theory:

(48)   a → e / ___ C_o a .

This rule is parallel to the Eastern Ojibwa glide formation rule in that it is dissimilatory in an alternating pattern leftward. In order to express this in Anderson's theory it is necessary to state it as follows:

(49)   a → e / (a C_o) ___ C_o a

Here we can see clearly that the material in parentheses is redundant.[8] This general fact constitutes strong grounds for calling into question Anderson's formulation of the glide formation and low vowel dissimilation processes.

In this section, then, I have argued that attempts to reformulate processes such as glide formation to take advantage of disjunctive ordering and Principle 2 are ill-founded. If it is accepted that the use of parenthetical expressions solely to determine the order of expansion is illegitimate and that the redundant character of the expression required is an argument against such a formulation, how may these processes be captured with minimal modification of Anderson's theory?

4.2.3 **Principle 3?** In discussing French schwa-deletion above, I pointed out that the rule could be made to work if it

were applied simultaneously and some additional principle were posited in order to resolve the indeterminacy when more than one way exists to eliminate violations of Principle 1. The required principle, let us refer to it as Principle 3, would have to remove the rightmost violation in the schwa-deletion rule.

Such a principle might resolve the dilemma of Eastern Ojibwa glide formation if that rule is considered as simultaneously applied. Assuming the validity of arguments against Anderson's formulation, it would be necessary to state the rule as in the directional theory:

(50)
$$\begin{bmatrix} + \text{ syll} \\ - \text{ low} \end{bmatrix} \rightarrow \begin{bmatrix} - \text{ syll} \\ + \text{ high} \end{bmatrix} / \underline{\qquad} [+ \text{ syll}]$$

Suppose we have a string with an odd number of vowels, such as:

(51)

i o i

RSAC does not resolve this indeterminacy, nor does Principle 2 help since it is a simultaneous rule. In this case, the right result will be derived only if Principle 3 removes the leftmost field.

Can Principle 3 be a viable principle if it must remove the rightmost field in one case and the leftmost field in another? The answer is yes, since there is another property

of these rules which determines which field is to be removed.
French schwa-deletion has the structural properties of a
rightward rule, while Eastern Ojibwa glide formation has the
structural properties of a leftward rule. Other rules confirm
this association (e.g., Woleaian low vowel dissimilation,
Southern Paiute alternating stress,[9] Warao alternating stress,
etc.). Thus, if Principle 3 is the resolution to the diffi-
culties encountered by Anderson's theory, it is interesting
that it must take cognizance of precisely the factors relevant
to predictable directionality. This fact constitutes strong
support for the general principles of the directional theory.

4.2.4 <u>Mandarin Third Tone Dissimilation</u>. In the discus-
sion of the third tone dissimilation rule in Mandarin in
Chapter IV, I demonstrated that the facts could be accounted
for by making the following assumptions: (a) the rule is
(leftward) simultaneous; (b) there are two ways to parse the
sentence, either into two major constituents or as a whole;
(c) the verb may or may not be contrastively stressed. These
assumptions yielded all of the possible outputs and did so in
a way which gave a plausible relationship between the way in
which the sentence was parsed and speed of speech.

An iterative treatment of this rule in Anderson's theory
comes remarkably close to yielding the same outputs under the
same assumptions. The only place it fails is when the parse
is of the entire string and the verb is not contrastively

stressed. From a string of five underlying third tones, Anderson's theory ambiguously provides the outputs 23223 and 22323, but cannot derive the correct 22223.[10]

4.2.5 <u>Acoma Tone Loss</u>. Since the rule of tone loss in Acoma has been instrumental in the development of Principle 2 and presumably in the establishment of an iterative vs. simultaneous distinction, it is worth reconsidering here. The argument that Anderson has advanced is that Acoma tone loss is a crucial case differentiating between his revised simultaneous theory and a theory like the linear or directional which involves sequential application of a rule across a string. I contend that the attempt to treat Acoma tone loss as a valid linguistic generalization is ill-advised and that, in fact, the theory which predicts that such an output is <u>not</u> possible is a more correct one.

One important fact about Acoma tone loss is that the application of the rule is confined to certain morphological contexts (Miller 1965:85-6). These contexts are listed below:

(52) a. in words with accent ablaut

b. in descriptives, with or without the reduplicative morpheme $\{R_1\}$

c. in·themes with $\| :\|$, the variable length morphophoneme

d. in forms with thematic syllable expansion that result in $\| \acute{u}\overset{\circ}{w}\acute{a} \|$

e. in short syllables that result when the thematic prefixes $\| -qja- \|$ and $\| -'- \|$ are added.

I have provided these environments in clumsy detail in order to demonstrate that either the environment of the rule involves a quite complex list of morphological environments or there is certainly some phonological genralization or set of such generalizations obscured by the terminology of the analysis.

If we assume that the morphological environment listed above must be stated for tone loss, it would be fair to conclude that Acoma tone loss is very likely not a true phonological rule but rather a morpholexical process (cf. footnote 1 in Chapter IV and the discussion to follow in Chapter VIII). If this assumption is correct, it is not very sound for us to base a theory of phonological rule application on this example, particularly when no corroboratory cases of the same crucial character have been put forth.

If we assume, on the contrary, that Acoma tone loss is a legitimate phonological rule then the contexts in (52) do not express the relevant phonological factors which condition the rule. It seems certain that there are important facts of tone behavior that are hidden by the analysis.

Although Miller's treatment was extremely competent within the model in which he was working, it is not easily

translatable on the basis of the data given into the type of
generative treatment upon which all of our claims about theory
are based. In my opinion, there is a great deal of work left
to be done to meet the demands of a generative grammar of
Acoma, particularly where tone and other vowel sandhi
phenomena are concerned. I am reluctant to admit the list of
morphological environments given in (52) as comprising part
of a phonological rule and until more adequate phonological
conditions are presented I feel that the case is a very weak
one.

Another significant fact is that the examples given by
Miller show an interesting regularity. Given the basic rule
that a vowel loses its high tone between obstruents when fol-
lowed by a high tone vowel, it appears that the tone loss is
essentially a dissimilation (both in terms of the tonal
environment and the stiffness of the glottal cords in relation
to the neighboring consonants) and predictably leftward. As
a repetitive rule, the problem arises when a form has only
two adjacent syllables of the proper shape, as in kápísóní,
where the predicted output would incorrectly retain high tone
on the first of these syllables: *kápisóní. It is inter-
esting, then, that in all of the examples provided by Miller,
the intransigent syllable -- the one which retains high tone
incorrectly by a leftward repetitive rule -- is the first
syllable of the word.

It seems quite possible to assume the existence of a rule of tone loss affecting first syllables under essentially similar conditions to the tone loss rule described above. In fact, a very similar rule is needed for final syllables when the consonant of that syllable is an obstruent or glottalized sonorant (Miller 1965:82). If the initial tone loss rule preceded the tone loss rule discussed above, it would yield the correct outputs in all the relevant cases.[11]

Whether the alternative analysis proposed above is valid or not, there are good reasons to object to our basing a theory on Acoma tone loss. It is highly questionable as a phonological rule per se, and therefore of questionable merit for constructing a theory of phonological rule application.

4.2.6 <u>Summary of Comparison</u>. Anderson's theory has been proposed as a revision of the simultaneous theory of SPE. In reality, it is more than a simple revision -- it is a fundamental change in the notion of rule application. It shares with SPE the fact that all segments in a string which meet the structural description of a rule are identified as such simultaneously. It differs radically from SPE, however, in that the rule can reapply to its own output in many cases, as well as fail to apply to segments which meet the structural description in the input string, due to Principle 1. This departure from the SPE theory is more appropriately thought of as an alternative to the theory of SPE (like the linear

and directional theories), rather than as a revision or extension of it.

In this section I have tried to survey the general adequacy of Anderson's alternative theory relative to the directional theory I have proposed. I have shown that the theory, as it stands, is inadequate to deal with French schwa-deletion and I have argued that the formulation of rules like Eastern Ojibwa glide formation or Woleaian low vowel dissimilation required by his theory is objectionable on other more general grounds. The rule of Acoma tone loss which is crucial in supporting Anderson's theory over the other alternatives was also subject to criticism, contesting whether or not it is a phonological rule in the true sense of the term. Clearly, Anderson's position would be strengthened if other empirical cases could be adduced which have the same crucial character.

[1] Alternating stress rules, though they would have the correct form, are irrelevant since they are accent rules and not expected to obey the crossover constraint. Some of the facts below may be accounted for by assuming an alternating stress process (e.g., the syncopation in IE and in Old Irish), but it is unlikely that all of the counterexamples to principle (6) can be dispensed with in this way.

[2] It is worth pointing out parenthetically that another interesting issue arises when this rule is related to a similar rule applying <u>within</u> words. Dell states this second rule as follows:

(I)   ə → ∅ / VC ____

The formal similarities between rule (I) and the schwa deletion process that has been under discussion here seems to demand collapsing the two rules as:

(II)   ə → ∅ / V (#) C ____

The only difficulty with rule (II) is that it applies optionally across word boundary, as we have seen, but is <u>obligatory</u> within words, as in the second vowel of <u>acheteur</u>. Thus, the same rule must be optional in one context and obligatory in another!

It seems clear, however, that linguistic theory will have to provide for optionality in a more complex way. Many descriptions point out that what is clearly the same rule will

apply obligatorily in one context and optionally in another. It is not just a peculiarity of this rule in French.

A great deal more research is needed on this topic, since there are definitely nonarbitrary relations holding here. It seems quite reasonable to expect a rule to be optional across word boundaries but obligatorily applied within the word, but the reverse would be much stranger. The conditions on variability (relative optionality) presented in Labov (1969), for example, reflect a natural hierarchy in which the general relation appears to hold: the greater the phonetic motivation, the less the optionality.

Similar but far more extensive observations of this sort were made by Kiparsky (1971).

[3] Eastern Cheremis stress constitutes further crucial evidence. Cf. Chapter III.

[4] It is not really clear whether or not the SPE theory can handle these facts, since there is no statement made in that work as to how optional rules are to be applied. It would be possible to state that optionality is a choice of whether to apply the rule to all relevant segments in the word or to none, thus handling the Warao case. However, it would make the SPE theory incapable of dealing with true free variation, where each segment meeting the structural description of a rule may optionally undergo the rule. These cases seem far more typical of optional rules than the Warao example.
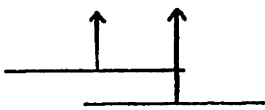
[5] Anderson (personal communication) has clarified that his objection is to the use of parenthesis-star notation as they are used in SPE to represent infinite schemata applied simultaneously. He assumes, as I do here, that subscripted parentheses are disjunctively applied.

[6] The word boundary between the prefix re- and the stem is a departure from Dell's treatment but is necessitated (even within Dell's analysis) by the fact that a schwa in the first syllable of the root following this prefix (e.g., redevenait) is optionally deleted in accord with the above rule, while schwa in true internal positions is obligatorily deleted (e.g., acheteur).

[7] It may be that this new principle is required only by the schwa-deletion rule. No other simultaneous rules of the required character have been postulated, to my knowledge. However, see the following discussion, especially section 4.2.3.

[8] It might be argued that the vowel in parentheses need not be as specific as a, and therefore that we are not dealing with a true redundancy. This position can be falsified if we consider a string such as the following:

(I)   C i C a C a C a

If we replace the <u>a</u> in parentheses with the more general class
of [+ syll], both the second and third vowels of this string
will be in the correct position to undergo the rule. If the
first field is removed to eliminate the violation, the result-
ant string will be <u>CiCaCeCa</u>, which can undergo no further
application. If the second field is removed, the output will
be <u>CiCeCaCa</u> and disjunctive ordering will prevent any further
application. Since in each case there is only a single
application, Principle 2 is inadequate to choose the correct
derivation. Assuming a broader class than <u>a</u> in parentheses,
then, would necessitate postulating yet another principle of
application just to undo the damage this assumption has
created.

[9] Given Anderson's current theory, it is not possible
to state alternating stress rules as I have done. Instead of
(I) below, it would be necessary to write (II):

(I) $\quad V \rightarrow \acute{V} \: / \: \breve{V} \: C_0 \: \underline{\quad}$

(II) $\quad V \rightarrow \acute{V} \: / \: \left\{ \begin{matrix} \# \\ \acute{V} \end{matrix} \right\} C_0 \: \breve{V} \: C_0 \: \underline{\quad}$

With Principle 3 it would be possible to use (I) as a simul-
taneous rule and derive the correct outputs. This is, of
course, no particular argument in favor of either (I) or
Principle 3, but it is interesting when we consider that
Principle ↙ has basically the same effect as making rules
directional.

[10] Browne (1972) has also argued against Anderson's position on the basis of this Mandarin rule. Anderson (forthcoming b) answers these criticisms and claims that Mandarin low vowel dissimilation is consistent with his theoretical position. As I had not seen his argument at the time this dissertation was in the final typing stages, I have been unable to comment further on the issue.

[11] This is not to say the analysis is devoid of problems. There are, indeed, forms with high tone on both the first and second syllables. Many of these seem to be exceptional words (onomatopoeia or borrowings), while others are quite conceivably due to the complex contractions that take place in surface initial syllables. In any case, the force of this argument is not contingent upon the analysis provided here being fully correct.

CHAPTER VIII

FIXED DETERMINANTS

1.0 <u>Introduction</u>. In the comparison of theories that was made in the preceding chapter there was one important type of rule that was neglected. According to the directional theory as it has been developed thus far, each determinant is capable of affecting only a single focus directly. The spreading effect witnessed in rules such as Arabela nasalization or Southern Agaw vowel raising is due to the fact that the first application of the rule creates a new determinant which can serve as the basis for a second application. In no case has a single determinant by itself caused more than one change.

The directional theory stands alone among those considered here in being unable to state rules where the determinant remains in a "fixed" position for several applications. Whether this is a vice or a virtue, of course, depends upon the strength of the empirical evidence that is relevant to the issue. The reason that rules with fixed determinants warrant a chapter in themselves is that the issue is, indeed, not easily resolvable.

Apparent counterexamples to the claims of the directional theory do exist and will be discussed in this chapter. As with several of the more complex rules presented in earlier chapters, there is a legitimate question here as to whether these counterexamples constitute valid phonological rules,

or whether they are morpholexical processes, or even whether
they are valid rules in any sense.

Expanding the power of the theory so that such rules
may be captured is a relatively simple task, but it has
important ramifications for other aspects of the theory.
Since there are interesting claims that will be given up by
such an extension, my purpose in this chapter is to focus
on these claims and to raise, rather than resolve, the issue
as to whether fixed determinants are characteristic of
phonological rules.

2.0   Examples of Fixed Determinants.

2.1   Acoma Accent Ablaut.   In discussing Anderson's
theory it was pointed out that Acoma has a rule which spreads
high tone across a word in certain morphological categories.
Consider how such a rule might be stated.   One possibility
within the SPE theory would be:

(1) $V \rightarrow \acute{V}$ / ___ $(C_o V)* C_o + X$

where X represents the set of suffixes which cause the tone
spreading to take place.   According to the SPE theory, every
vowel in the word will be in the correct environment to
undergo some expansion of this schema and therefore all will
receive high tone.

Within the directional theory rule (1) has a different
implication.   If we assume that a tone rule like this one is

an "accent" rule (and this is by no means established), the
principle of longest expansion would cause only the leftmost
vowel of the word to receive high tone in the presence of
these suffixes. On the other hand, if the rule is not an
accent rule and therefore obeys the crossover constraint,
the first application will be to the vowel immediately
preceding the suffix. The matching algorithm presented
earlier, however, requires that the sequence marker be moved
after each match sequence is completed and the effect of this
is to prevent any further matches with X as the determinant.
As a result, only a single vowel can receive high tone and
Acoma accent ablaut cannot be handled by means of a rule
like (1).

One question that must be raised is in what sense X is
a determinant of the change that takes place. Is X really
a list of different morphological categories which cause a
phonological change, or is there a general characteristic
which all of these suffixes share? If such a characteristic
exists, is it morphological or phonological?

Miller (1965:81-82) provides a list of the various
morphemes which cause accent ablaut. The single accent in
parentheses to the left of the segmental phonemes is the way
Miller indicates that the morpheme causes accent ablaut.
The double accent means that the last vowel of the stem is
also lengthened:

(2) a. -(')í   (forms temporal adverbial clauses)

     b. -(')   (nominalizing suffix)

     c. -(')wá, -(')yá   ('times'; e.g., 'twice, three times')

     d. -(')ná   ('by...'s'; as in 'by fives', etc.)

     e. -(')mí   (suffix nominalizing directional advs.)

     f. -(')yá   ("   "   "   "   )

     g. -(')m̥a, -('')m̥a ('each', 'every')

     h. -('')ná   (nominalizer for descriptives)

     i. -('')k̬áw̬a̬aka   (nominalizer used with directionals)

     j. -('')zé   ('at the time of' used with adverbs)

     k. -('')ci   (suffix forming locative adverbs)

     l. -('')   (suffix forming irregular plural

                          stems for two impersonal verbs)

If the accent ablaut rule has to be complicated by a statement
of this complexity I think there is some question as to
whether it is a legitimate phonological rule.[1]

It is important to note that the majority of these
suffixes have high tones themselves. The ones which do not
have high tone apparently lose it by a regular rule:

(3)   "A final syllable with an initial obstruent or

       glottalized sonorant is normally unaccented."

       (Miller 1965:82)

It might be more sensible, then, to think of accent ablaut
being caused by the assimilation to a high tone vowel in a
suffix than to think of it as abstractly conditioned by a

<u>list</u> of morphemes with no reference to their phonological content. To take such a position, however, would necessitate justifying a treatment of suffixes (2b) and (21) with underlying vowels that disappear through assimilation or some other process. Whether such a position could eventually be defended is questionable and the rule looks rather parallel to German ablaut where the historical conditioning factor has been lost in many cases and the rule is most probably not phonological but rather morpholexical. For the purposes of the following discussion, however, I will assume that a solution with a high toned suffix can be defended.

One way in which the directional theory can spread high tone across a word is by a rule of the following shape:

(4) $V \rightarrow \acute{V} \ / \ \underline{\hspace{2em}} \ C_o \ \acute{V}$

As a leftward rule, the high tone vowel in the suffix will cause the vowel that precedes it to become high tone and this in turn will bring about a further change, continuing to the beginning of the word. The difficulty with this solution is that high tone vowels occur elsewhere in Acoma -- i.e., in forms which do not involve accent ablaut -- and rule (4) would incorrectly apply to them, making all vowels become high tone when they precede <u>any</u> high tone vowel.

If, instead, we choose to write an obligatory morpheme boundary after the focus the rule will correctly apply before the suffix, but will not be able to affect any other vowels

in the string if there is no morpheme boundary separating
them from the vowels that immediately follow. Thus, within
the directional theory there is no way to state accent
ablaut as long as there are vowels with high tone elsewhere
in the word which do not cause accent ablaut. In other
words, rules of this type which require fixed determinants
are apparent counterexamples to the theory being proposed.

2.2 Terena Nasalization. Terena, a language of the
Mato Grosso in Brazil (cf. Chapter IV), provides an interest-
ing example of a phenomenon which appears to call for a rule
with a fixed determinant. According to Bendor-Samuel (1960),
the grammatical category of first person (either nominative
or genitive[2]) is realized by a complex nasalization of the
stem. This complex nasalization involves the following:

(5)   a. "the nasalization of all vowels and semi-vowels in
         the word up to the first stop or fricative. In
         words without stops or fricatives all vowels and
         semi-vowels are nasalized, together with

      b. a nasalized consonantal sequence replacing the first
         stop or fricative in the word as follows: mb
         replaces p, nd replaces t, ŋg replaces k, nz replaces
         both s and h and nʒ replaces both ʃ and hy."
         (1960:350)

If (5a) is considered in isolation, we would hypothesize
the existence of an underlying nasal prefix and a rule which

nasalizes a vowel or glide after a nasal segment, as in

Arabela. Such a rule might be stated as follows:

(6)   [- cons] → [+ nasal] / [+ nasal] ___

The fact that the nasal prefix "disappears" can be handled

by a rule which deletes it before a vowel initial stem:

(7)   [+ nasal] → ∅ / # ___ + [+ syll]

Finally, the prenasalization (or perhaps insertion of a

nasal) before the stop or fricative can be accomplished by

a further rule.

That this analysis is impossible becomes clear when

certain other facts are presented. Consider, for example,

the data which Bendor-Samuel presents to illustrate this

phenomenon:

(8)   a. ẽ'mõʔũ   'my word'   e'moʔu   'his word'

       b. 'ãȳõ   'my brother'   'ayo   'his brother'

       c. 'mbiho   'I went'   'piho   'he went'

       d. 'õw̃õŋgu   'my house'   'owoku   'his house'

       e. a'nʒaʔaʃo   'I desire'   a'hyaʔaʃo   'he desires'

If we adopt the analysis presented above, e'moʔu 'his

word' would also undergo the rule nasalizing the vowels. It

does not, however, for Bendor-Samuel assures us that the

nasalization features under discussion do not occur outside

of the first person forms "except for a very few words

almost all of which are clearly words borrowed from

Portuguese" (1960:350). We are thus confronted with another
case where the phenomenon in question initiates only from an
affix and not from stem-internal segments which are other-
wise identical to it.

There are several ways of dealing with this problem.
Perhaps the most straightforward available within the theory
proposed here would be to posit a pair of vowel nasalization
rules, the first of which would be:

(9)   [- cons] → [+ nasal] / [+ nasal] + ___

and the second of which would be:

(10)   [- cons] → [+ nasal] / $\begin{bmatrix} - \text{ cons} \\ + \text{ nasal} \end{bmatrix}$ ___

While this would work mechanically, it seems clear that it
misses a generalization. It might be possible, however, to
justify such a view if a stem that begins with a semivowel
did not nasalize. Rule (9) would be stated with [+ syll]
at the focus in such a case and we would have good evidence
that the analysis really requires two rules. In the absence
of such evidence, however, a solution like this seems to be
a fudge.

Another alternative solution would be to account for
the prenasalization of the stops and fricatives by infixing
the nasal. One could even do it by having the nasal go to
the first stop or fricative if there is one or else to the
end of the word and having nasalization proceed from right

to left. This would be possible since this is the only
context where consonant clusters (alternatively, prenasal-
ized consonants) occur. In any case, a fixed determinant
is necessary in order to state the nasalization process as
a single rule.

2.3 <u>Xhosa Palatalization</u>. In Xhosa, a southern Bantu
language spoken in South Africa, labial consonants become
palatal consonants in certain environments.[3] Among these
environments is in the position before the passive suffix
-<u>wa</u>. According to Ziervogel (1967), the changes effected
are as follows:

(11) a. [ɓ] → [c']   (= a voiceless ejective prepalatal
                            explosive)

     b. [b] → [dʒ̥]   (= a devocalized prepalatal affricate)

     c. [pʰ] → [tʃʰ]   (= a voiceless ejective prepalatal
                            affricate)

     d. [m] → [ɲ]   (= a voiced prepalatal nasal)

     e. [mp] → [ɲtʃ']   (= a voiceless ejective prepalatal
                            affricate preceded by a voiced
                            prepalatal nasal)

     f. [mb] → [ɲdʒ]   (= a fully voiced prepalatal affricate
                            preceded by a voiced prepalatal
                            nasal)

For further information and for a treatment of these individual changes within the distinctive feature framework see Peters (1966).

These changes may be illustrated by the following forms. Xhosa orthographic conventions, rather than the phonetic symbols given above, are used here. Examples are taken from Ziervogel (1967:163-64):

(12) a. -goba   'bend'

    b. -gotywa   'be bent'

    c. -bhubha   'perish'

    d. -bhujwa   'be perished'

    e. -phupha   'dream'

    f. -phutshwa   'be dreamt'

    g. -luma   'bite'

    h. -lunywa   'be bitten'

    i. -mpompa   'pump'

    j. -mpontshwa   'be pumped'

    k. -bamba   'catch'

    l. -banjwa   'be caught'

In all of the examples given above, the labial consonant is immediately adjacent to the _w_ of the passive suffix. However, consider the following forms taken from Peters (1966:132ff.):

(13) a. /-onwabis-/   'make happy'

     b. u-y-onwatyis-wa   'she is made happy'

     c. /-oŋgamel-/   'overwhelm'

     d. onganyel-weyo   '(who) were overwhelmed'

     e. /-lumul-/   'wean'

     f. lu-lunyul-we   'it was weaned'

An initial attempt to formulate the above process,
ignoring the minor differences involved, might be:

(14)

$$\begin{bmatrix} + \text{ant} \\ - \text{cor} \end{bmatrix} \rightarrow \begin{bmatrix} + \text{cor} \\ + \text{high} \end{bmatrix} / \underline{\hspace{1cm}} ([+ \text{syll}][- \text{syll}]_0)_0 \begin{bmatrix} - \text{syll} \\ + \text{high} \\ + \text{back} \end{bmatrix}$$

Notice the use of the subscripted parentheses to capture
the facts represented in (13). In the theory presented in
the body of this work, rule (14) not only handles the
palatalization process, but also appears to account for the
failure of the first of two labial consonants to palatalize,
as in (12c, d) -bhubha → -bhujwa and not to *-jujwa. The
reason is that the algorithm given earlier allows each
determinant to affect only a single segment. In this case,
the output of the rule is not a w and therefore cannot
itself cause a subsequent application of the rule.

There is good reason to believe, however, that rule (14)
must be independently constrained so that it may not apply
to a labial consonant which is the first consonant in the
verb root (Peters 1966:132ff.):

(15) a. /-boŋga-/   'praise'

  b. i-ya-bong-wa   'he is praised'

  c. /-amukel-/   'receive'

  d. amkelwa   'be received'

The latter example is especially interesting, for it demonstrates a crucial ordering between the rule which drops u after m and the palatalization rule. Compare (15c, d) with (16):

(16) a. /-lumukel-/   'care for'

  b. lunyukelwa   'be cared for'

The palatalization of the labial consonant in (16) blocks the u-deletion rule, while the failure of m to palatalize in (15d) because it is the first consonant of the stem results in subsequent deletion of u.

  A crucial example, brought to my attention by Ann Peters, is the following:[4]

(17) a. nqumamisa   'bring to a stop'

  b. nqunyanyiswa   (passive)

In this example, more than one labial consonant is affected. It is interesting to note that in this case both are internal to the verb root, which lends plausibility to the hypothesis that the rule is not allowed to apply to the first consonant of the verb root. We would therefore have to build this restriction into rule (14), which could probably be done

simply by requiring a CV to the left of the focus under the assumption that the boundary between prefix and root is a higher level boundary than simple morpheme boundary.

The relevance of this example is that the output of the rule is not a determinant for a subsequent application and yet here we find two applications of the rule. To incorporate this fact into a single rule would apparently require the notion of a fixed determinant, involving an extension of the algorithm thus far provided.

Xhosa palatalization is a very weak argument for rules with fixed determinants, partly because of the paucity of crucial examples like (17) and partly because of the very unusual nature of the rule itself. The change from labial consonants to palatals (rather than palatalized labials) is peculiar enough, but the fact that it is a dissimilatory reaction to a following w̲ makes it all the more peculiar. Rule (14), therefore, should be approached with caution and skepticism.

A more reasonable resolution of this problem may proceed along the following lines. According to the algorithm already provided, multiple application of the rule results either from (a) the first application creating a segment which can function as the determinant to a further application; or (b) the segments affected by the rule being in the proper environment in the input string to begin with. The latter case includes simultaneous application where the

unmarked repetitive application would have destroyed the relevant environment for a second application. Simultaneous application will not help us here, since the crossover constraint in its strong form will not allow the application of the rule to the leftmost labial due to the intervening labial segment. Moreover, and more importantly, the simultaneous application algorithm is stated like the repetitive application algorithm as not allowing fixed determinants.

Suppose, however, that we operate under assumption (a) above. This implies that the change brought about by the rule under consideration be conceived of as one which, in fact, can function as a determinant for a second application. What might such a change be? The most reasonable expectation would be that the rule be a more natural assimilatory process rather than the peculiar dissimilatory one. The effect a w would be expected to have on a labial is quite naturally a labialization and velarization effect. Thus, working with this assumption, the first application of the rule to nqumamiswa would lead to nqumamwiswa. It is further plausible (and workable since there are no underlying labialized labials) that the rule be extended to involve not only w but other labialized (rounded) nonsyllabics as determinants. This would mean that the derived mw could serve as determinant for the second application of the rule.

The modification of (14) implied above not only allows for the multiple change by means of our regular repetitive

algorithm with no fixed determinants, but also does so by
means of a far more natural rule. Moreover, this would
explain why it is the labials which are affected by the rule
-- labialization being much more likely to apply <u>exclusively</u>
to the labial series of consonants (as, for example, in many
Micronesian languages) than palatalization is.

The remaining step in the argumentation must be to
reduce sequences like <u>mw</u> to their palatal counterparts. This
would now be a matter of an <u>internal</u> dissimilation rather
than something conditioned by an external environment. Pre-
sumably the changes follow a pattern like: mw → my → ɲy.
The first step is internal dissimilation, followed by assimi-
lation of the primary articulation to that of the secondary
one.

The plausibility of this analysis is enhanced by
observations like the following. Doke (1967:94) speaks of
palatalization in Nguni, the subgroup of Bantu languages to
which Xhosa belongs:

(18)   "This process, due primarily to the incompatibility
         in Nguni of <u>w</u> with bilabial consonants, involves the
         substitution of a palatal (or prepalatal) sound for
         a bilabial..."

Doke's statement, of course, could just as well be stated
as a direct dissimilation to the <u>w</u> of the passive, but it
instead assumes that what is occuring here is a <u>general</u>

constraint affecting labials and not just a peculiarity related to the passive. It also demonstrates that a modification of (14) to be assimilatory will not be interfered with by other phonotactic constraints.

The most insightful treatment of this problem however, may be found in Tucker (1929:74-83). His concern is with the SotoChuana group of southern Bantu languages, the principal members of which are SeChuana, SeSuto, and SePedi. He begins his discussion of the issue with the following statement, under the heading: "The Labialization of Labial Consonants".

(19)   "Labialization of sounds which are already labial has puzzled many. In SePedi the problem is at its clearest, and I shall therefore confine myself temporarily to that language...

"In the case of labial sounds ... the native rounds his lips and raises <u>the middle of his tongue</u> instead of the back, with the result that we hear a <u>palaralized</u> <u>w</u> running through the original consonant... This type of labialization we may call '<u>front labialization</u>' because it is combined with a raising of the 'front' of the tongue (i.e. that part of the tongue opposite the hard palate)." (1929:77)

SePedi seems to demonstrate clearly the intimate interrelationship between the rounding and palatalization

processes I have assumed. Labialization of labial consonants
occurs here with a secondary palatal articulation, while
other consonants have a (secondary) velar articulation in
addition to rounding. In SePedi, moreover, the assumed
intermediate representation presented for Xhosa (or something
very similar to it) actually occurs -- the primary articula-
tion at the lips is retained, while the palatal dissimilation
occurs.

In comparing SePedi with SeChuana and SeSuto, Tucker
continues:

(20)   "In the case of labial consonants, front-labialization
        has been carried on one step further. Whereas in
        SePedi the main articulation is at the lips and the
        secondary articulation with the front of the tongue,
        in SeSuto and SeChuana the palatal secondary articula-
        tion has become the main one, there is no more lip
        contact, while the lip-rounding is combined with
        re-raising of the back of the tongue. What we hear,
        then, are back-labialized palatals instead of front-
        labialized labials." (1929:80)

While SePedi seems to occupy an intermediate point in
the historical development of this palatalization process,
I would also claim that its system reflects an intermediate
stage in the synchronic derivation of Xhosa palatals from
labials, and most likely for those in SeChuana and SeSuto

as well. This assumption would yield a more natural and plausible phonological rule and would furthermore provide a simple and regular explanation for the multiple application of the palatalization process, without resorting to rules with fixed determinants.

3.0 <u>Extending the Theory</u>. One possible conclusion that could be drawn from the inadequacy of the directional theory to deal with some of the above cases is that the theory should be extended so that it may capture these phenomena as unitary generalizations. Suppose we adopt this assumption. How could the theory be modified to incorporate them?

There are two ways of extending the theory that are fairly obvious and very similar in their consequences. One of these is reversal of directionality, a possibility that has been discussed earlier in other contexts. The other is by means of "anchoring" a match sequence to a fixed deter- minant. I shall discuss these possibilities in turn.

Reversal of directionality would allow us to derive the correct outputs in these cases by using subscripted expressions to accomodate changes at variable distances from the deter- minant. Consider how Terena nasalization might be expressed.

(21) $[- \text{cons}] \rightarrow [+ \text{nasal}]/\# [+ \text{nasal}] + ([- \text{cons}][+ \text{nasal}]_0)_0 \_\_$

Instead of applying in the expected rightward manner, this
rule would be applied leftward and would have some formal
indication (such as Johnson's use of L and R to the left of
the rule) of this property. By the requirement that the
longest expansion be taken, rule (21) will apply to the
rightmost segment which meets the structural description of
the rule (e.g., the final vowel in #n + ayo#) and then
successively to those closer to the determinant. This will
yield the correct output for Terena nasalization and the
other processes discussed above.

Whatever reversal of directionality helps us to express,
it still has the same consequences described in relation to
Johnson's theory. If reversal is available to all rules,
it has undesirable consequences for disjunctive rules,
assuming that we do not allow Johnson's ad hoc treatment of
disjunctive ordering.

In order to accomodate this subset of rules by allowing
reversal of directionality, it will also be necessary to
modify the statement of the crossover constraint. The
revision which was considered in the preceding chapter as
an attempt to incorporate the crossover constraint into the
SPE theory is sufficient modification here. That is, if we
require that all intervening segments which meet the internal
requirements of the focus must also undergo the rule, the
derivations required to handle the above cases would be

permitted but others, of the type we <u>want</u> to exclude, will

be disallowed.

An alternative way of accomodating this subset of rules

is to allow the sequence marker to remain on the determinant

until no further application of the rule is possible. To

illustrate this, consider rule (21) above to be a predictably

rightward rule. Given a string like #n + ayo#, the crossover

constraint requires us to apply the rule to the vowel <u>a</u>,

since matching any greater sequence against the expression

in subscripted parentheses will violate the constraint. As

currently stated, the crossover constraint will prohibit any

further application, but a modification fully in keeping with

the spirit of the constraint will allow the correct deriva-

tion:

(22)   No segment may be matched with an element other than

         the focus or determinant of a rule if that segment

         meets the internal requirements of the focus of the

         rule, <u>unless</u> that segment also has the characteristics

         described by the structural change.

With this revision of the crossover constraint, once

the vowel <u>a</u> is nasalized it can be matched with the noncon-

sonantal element in subscripted parentheses, allowing

application of the rule to <u>y</u>. This is under the assumption

that the sequence marker remains on the determinant until

there can be no further application.[5] Thus, whenever a rule

has optional elements there can be several applications of a rule directly conditioned by a single determinant and the revised crossover constraint would play a crucial role in this process.

The anchoring solution has several undesirable consequences of its own. For one thing, the addition of anchoring makes it possible to express processes that violate the SPE position on disjunctive ordering. Consider, for example, a stress rule that is expressed as follows:

(23) $V \rightarrow [1 \text{ stress}] / \underline{\quad} C_o (\begin{bmatrix} + \text{syll} \\ - \text{tense} \\ + \text{stress} \end{bmatrix} C_o^1) \#$

This rule is identical to the English stress rule except that the vowel in the environment is stressed as well as lax. Suppose we have an input string like #edit# and attempt to apply rule (23) under the anchoring assumption. The longest expansion cannot be applied because its structural description is not met, but once the shorter expansion is applied it becomes possible to apply the longer one. We will be able in this theory to stress both vowels and thus to describe a process that violates the SPE strong constraint. I consider this to be an undesirable consequence and it becomes obvious, then, that we would have to restrict anchoring to nonaccent rules.

Another negative consequence is that although anchoring is sufficient to describe the same processes as simultaneity,

it seems to do so in an indefensible way. Consider here the
voicing dissimilation rule of Southern Kikuyu (cf. Chapter IV),
by which a velar stop becomes a voiced velar spirant when
preceding a voiceless consonant (with vowels allowed to
intervene). Recall that this rule applies to a sequence like
<u>nekakaakeroma</u> to yield <u>neɣaɣaakeroma</u>, demanding simultaneous
application. Instead of being a simultaneous rule, we could
treat this Southern Kikuyu rule as having a fixed determinant:

(24) $k \rightarrow \gamma$ / ___ $(V_0\gamma)_0$ V_0 [- voice]

While (24) will yield the correct results in a direc-
tional theory with anchoring, it is open to the same
objections about redundancy that have been raised earlier.
The gamma in parentheses is an undesirable redundancy that
reveals the expression of these processes to be inadequate.

In comparing these two alternatives for revision, then,
it seems clear that both have consequences for the theory
that go beyond the ability to express processes such as
Terena nasalization and Acoma accent ablaut. I suggest that
we should be hesitant and reluctant to add this extra power
to the theory, but before returning to this issue I would
like to present another subset of rules in relation to which
a theory utilizing fixed determinants and the theory as
proposed prior to this chapter make quite different claims.

4.0 <u>Deletion Rules</u>. Deletion rules in phonology are
obviously something special. They constitute perhaps the most

drastic modification a string can undergo -- complete removal of the segment affected. It is quite possible that deletion rules should be treated somewhat specially in terms of application algorithms, etc., but it is interesting to consider here the implications of the more restrictive theory I have proposed (without fixed determinants) for deletion rules.

4.1 <u>Ponapean Final Vowel Deletion</u>. In Ponapean,[6] a Micronesian language, vowels are deleted in the final position in a word. The following forms illustrate this process:

(25)	Elicitation Form	Construct Form	Gloss
a.	p^{w}iil	p^{w}ilin	'gum'
b.	ṭuuk	ṭukun	'tree stump'
c.	saar	sɛrɛn	'crab hole'
d.	p^{w}uuk	p^{w}ukɛn	'book'
e.	paak	pɛkin	'cutting'
f.	uus	usɛn	'net float'

The vowel which appears before the final consonant in the construct form is the final vowel of the stem. It is lost in the elicitation form where it is in word-final position. The long vowel in all of the elicitation forms is due to a rule of compensatory lengthening which requires that all nouns which are monosyllabic on the surface have long vowels. The alternation between <u>a</u> and <u>ɛ</u> is conditioned

by the final vowel of the suffix, <u>i</u>, which is lost by the same rule which eliminates stem-final vowels in the elicitation form:

(26) $V \rightarrow \emptyset$ ___ #

Rule (26) works correctly for the forms in (25), but appears to run into difficulty when the forms below are considered:

(27) | Elicitation Form | Construct Form | Gloss |
|---|---|---|
| a. p^wili | p^wiliin | 'shell' |
| b. ṭuukɛ | ṭuukɛɛn | 'tree' |
| c. sara | saraan | 'sp. of fish' |
| d. p^wukɔ | p^wukɔɔn | 'responsibility' |
| e. pako | pakoon | 'shark' |
| f. usu | usuun | 'star' |

In each of these examples, the elicitation form ends in a vowel, contrary to the deletion rule for final vowels. The explanation for this fact becomes clear, however, when we note that the construct forms in (27) all have long vowels in their final syllables, unlike the forms in (25). These facts may thus be accounted for by assuming that the stems in (27) end in long vowels (vowel sequences) and those in (25) end in short vowels. Rule (26) then applies to both sets of forms when the stem vowel is word-final and has the effect of deleting a short vowel but shortening a long vowel.

While all of this seems natural and expected, the theory built upon fixed determinants and the one which does not allow them make different claims here. In the revised theory, after the final vowel is deleted the sequence marker remains on the word boundary and another application is attempted. For those forms with underlying final vowel sequences, the remaining vowel will now be in a position to meet the structural description of the rule and will also delete. The effect of this is to incorrectly delete the entire final vowel sequence.

It would be possible to get the correct results in Ponapean even within the revised theory if the theory retained the notion of simultaneous rules, since only the underlying final vowel is in the correct position in the string to be deleted. It would also be possible to handle these facts if rule (26) were allowed to be rightward. However, in either of these cases we would be saying that the rule is marked and therefore less natural than a rule which deletes a whole string of final vowels. I am not convinced that this is a proper characterization of the Ponapean rule, especially since similar rules exist in Trukese, Woleaian, and probably Kusaien.

A directional theory without fixed determinants makes a correct claim, as far as the Ponapean deletion rule is concerned. Since the sequence marker is obligatorily moved off the word boundary after the final vowel is deleted, the vowel

which precedes it is no longer capable of meeting the structural description of the rule. What is a much more interesting consequence of this discussion, however, is that the unrevised directional theory is <u>incapable</u> of deleting any sequence of final vowels or consonants by a single rule, unless special conditions exist, such as cyclic application. Since rules deleting final segments are relatively common, this becomes an interesting and significant claim. It is a claim, in fact, which is capable of falsifying the theoretical position taken thus far, although it could conceivably be maintained that deletion rules constitute a subset of phonological rules which must be handled by a different algorithm.

4.2 <u>Final Consonant Deletion in French</u>. It is widely known that sequences of consonants are lost in French at the end of a word. French is probably the case that Chomsky & Halle had in mind when they illustrated the use of subscript notation with a rule deleting word-final consonant clusters of arbitrary length (1968:343-44). It is also what Schane was concerned with (1969:35) when he proposed a deletion rule with C_o at the left side of the arrow.

If sequences of consonants delete in word-final position in French, how can one maintain that rules can be constrained to delete only a single segment in that position? One possible answer would be that the consonants are deleted by

separate rules. Another would be that the rules must be stated in terms of conditions which may be independently met by different members of a final cluster. Yet a third would be that the rules are applied cyclically. It may even be possible, and this is what I will argue here, that <u>all</u> these factors are relevant to the French example.

One of the deletion rules in French is the well-known process of <u>elision</u>, by which a consonant deletes when followed across word boundary by another consonant:[7]

(28)   C → ∅ / ___ # C

The elision process, as it relates to consonants, may be illustrated by forms like the following. The deleted consonants are underlined.

(29) a. [pəti kamarad]   peti<u>t</u> camarade   'little comrade'

   b. [pətit ami]   petit ami   'little friend'

   c. [trwa kamarad]   troi<u>s</u> camarades   'three comrades'

   d. [trwaz ami]   trois amis   'three friends'

In addition to the elision rule, French has a rule which drops consonants in phrase-final position, which includes the citation form of any word:

(30) a. [il ɛ pəti]   il est peti<u>t</u>   'he is small'

   b. [pəti]   peti<u>t</u>   'small'

   c. [trwa]   troi<u>s</u>   'three'

I shall use the symbol ## to indicate phrase boundary. The phrase-final deletion rule, then, would be stated as follows:

(31) $C \rightarrow \emptyset$ / ___ ##

Consider a form like the following, which seems to suggest that a sequence of consonants may be deleted before phrase boundary:

(32)   [il sɔ̃ pəti]   ils sont peti<u>ts</u>   'they are small'

A form like this could be used to argue that the phrase-final deletion rule must use the phrase boundary as a fixed determinant.

On the other hand, a similar fact seems to hold for the elision rule:

(33)   [pəti kamarad]   peti<u>ts</u> camarades   'little comrades'

Here two consonants are getting deleted where the phrase-final deletion rule cannot possibly be of any help.

It can be shown that the deletion of the <u>t</u> in (33) is not contingent upon the deletion of <u>s</u>, contrary to what a fixed determinant would suggest. Consider a case where the <u>s</u> is not deleted because it is followed by a vowel:

(34)   [pətiz ami]   peti<u>ts</u> amis   'little friends'

This indicates that the <u>t</u> is either deleted by a separate rule or the elision rule must be extended to handle it. As presented in (28), elision will not delete the <u>t</u> because it is not word-final. If deletion of the <u>t</u> is a separate rule,

then it may well be true for French that final consonant
sequences delete as the result of the application of more than
one rule and no fixed determinants are necessary.

Schane, however, makes a different assumption. He
suggests that the similarity between a rule which deletes a
consonant before another consonant across word boundary and
one which deletes a consonant before another consonant across
morpheme boundary is not coincidental. He thus accounts for
the deletion of t in these examples by modifying the elision
rule so that the two consonants need only be separated by a
boundary:

(35)   C → ∅ / ___ [- seg] C

Since both the t and the s in petits camarades are in the
correct position in the underlying string both can be deleted
by rule (35) without resorting to fixed determinants.

Such was Schane's intention, but it was a product of the
SPE theory based upon simultaneous application of phonological
rules. In the directional theory, however, rule (35) will
be predictably leftward and will cause the deletion of s
first. If fixed determinants are taken into account, the t
will be deleted after deletion of the s since it will come
to be in the correct environment in relation to k. Without
fixed determinants, however, the sequence marker will have
moved off the k and the t will not be in the correct environ-
ment and will not delete. Thus, the extension of the elision

rule represented by (35) does not automatically save the directional theory from the necessity of adding the power of fixed determinants.

It would be possible to treat the elision rule as <u>simultaneous</u>, if it is stated as in (35). Yet, this seems as undesirable as treating the final vowel deletion in Ponapean as simultaneous.[8]

Yet another possibility, and one which requires serious consideration, is that there is another general principle which forms part of the solution. This is the <u>cyclic</u> principle. It is certainly conceivable that elision is a cyclic rule, for if any rule is likely to be cyclic it is one that applies both within and between words. As a cyclic rule, elision would cause the deletion of <u>t</u> on the word-internal cycle and deletion of <u>s</u> on a subsequent cycle. It is interesting, then, that both Schane (1968a) and Selkirk (1972) argue for the cyclicity of these consonant deletion rules on other grounds.

In general, the French data is consistent with this cyclic view. One set of apparent counterexamples, however, consists of certain words with final consonant clusters that are <u>not</u> separated by any boundary:

(36) a. respe<u>ct</u>   'respect'

   b. respe<u>cts</u>   'respects'

   c. mes respe<u>cts</u> amicaux   'yours sincerely'

   d. respecter   'to respect'

These examples demonstrate that the c deletes only when the t deletes and does not delete when the t remains. This pattern is further confirmed by the following case, where elision would take place if the following word began with a consonant:

(37)   un indirect ennemi   'an indirect enemy'

The fact that c remains here shows clearly that these examples are different than those considered earlier, for in petits amis the t drops independently of the s.

It would appear from the above cases that ct is functioning like a unit where ts is a more independent sequence. This difference in behavior could be neatly accounted for in a theory using fixed determinants, since c can only be deleted when the prior deletion of t brings it into the correct environment, while t is in the correct position in the underlying string.

Within the unrevised directional theory, it would be necessary to account for this difference in behavior in a more indirect way. As the analysis has been stated thus far, there is no rule which will delete the c in the above cases. A separate rule to this effect would have to be added, deleting the penultimate consonant of the stem when the stem is followed by a word boundary.[9] Such a rule seems somewhat ad hoc and this objection was raised by Selkirk (1972) in response to Schane's analysis in which he postulated a

penultimate deletion rule to handle these cases as well as

the second person plural suffix (orthographically -ez), which

he derives from /-Ets/.

Schane argues that there are forms which illustrate that

the deletion of the penultimate consonant is in fact independ-

ent of the deletion of the final consonant. Consider the

following forms:

(38) a. sept   'seven'

    b. septante   'seventy' (Swiss and Belgian)

The numeral '7' is an exception to both the elision and

phrase-final deletion rules, since the t never deletes. As

can be seen from (38a), however, the p that is assumed in

the underlying form deletes anyway. This could not be handled

by the fixed determinant assumption, while the penultimate

deletion rule would work fine.[10] If Schane's argument is

valid, French final consonant deletion poses no problem for

the more restrictive unrevised directional theory in spite

of the fact that sequences of consonants are deleted.

4.3 <u>Syncopation of Alternate Vowels</u>. The syncopation

of alternate vowels appears to be fairly common. Lightner

(1971:227) cites examples of this phenomenon from Old Irish,

Slavic and Proto Indo-European (cf. Chapter VII, section 2.2).

In the following discussion I will use Lightner's characteri-

zation of Old Irish as the relevant example: every second

vowel from the beginning of the word is deleted. It will also

be assumed here that it is correct to regard this as a straightforward deletion process rather than a sequence of rules consisting of an alternating stress rule followed by a rule deleting unstressed vowels. Under these assumptions, the Old Irish rule would be stated:

(39)   V → ∅ / V C$_o$ ___

If rule (39) were interpreted within a theory with fixed determinants, when the second vowel of the word is deleted the third vowel comes to be in the correct environment to undergo the rule. As each vowel is deleted, the subsequent vowel will come to meet the structural description. As a result, rule (39) within such a theory would delete every vowel in a word but the first.

In a theory without fixed determinants, precisely the correct claim is made. After the second vowel is deleted the sequence marker must move and the next relevant match sequence will begin with the underlying third vowel, which will cause the fourth vowel to delete. Thus, every alternate vowel will delete, as is the intention of the rule.

5.0 _Fixed Determinants Reconsidered._ This chapter constitutes a challenge to the more restrictive version of the directional theory as presented earlier in this work. Rules which require that a single determinant cause more than one change are not expressible within the unrevised directional

theory, although each of the other theories with which it was compared (including the revised directional theory) can express such processes. This has already been illustrated in relation to the revised directional theory and the SPE theory. In Johnson's theory it is simply a matter of using the directionality that is opposite to the one predicted by the directional theory.

Anderson's theory makes a less restrictive claim than the directional theory due to the way in which disjunctive ordering must be defined. Take, for example, the following potential statement of the Terena nasalization process:

(40) $[- \text{cons}] \rightarrow [+ \text{nasal}]/\#[+ \text{nasal}] + ([- \text{cons}][+ \text{nasal}]_o)_o$ ——

If rule (40) is allowed to iterate and the disjunctive property is defined (as I understand it to be) so that it only blocks application if the _focus_ for the second application is part of the enabling environment of the first application, then successive iterations will be able to describe processes requiring fixed determinants. It might be possible to extend the disjunctive principle to block such processes from being stated, but this is likely to run into difficulties in other cases.

The unrevised directional theory is thus the only one under consideration that makes a restrictive claim with regard to fixed determinants. Obviously, the validity of the overall theoretical position is contingent upon the validity of this

claim. In the course of this chapter, therefore, I have
presented some relevant empirically attested cases which
would seem to controvert the claim and others which give it
(admittedly rather weak) support.

Several observations must be made about the evidence
presented. All of the processes which required fixed deter-
minants are rather peculiar. Each is confined to very
particular morphological contexts and in each case the phono-
logical cause, if there is one, "disappears" in a significant
proportion of cases. As was observed in discussing Acoma
accent ablaut, these rules might very well belong in the same
category as modern German ablaut and perhaps should not
properly be considered phonological rules. If such is the
case, the directional theory would be more highly valued
because it cannot, in fact, express these processes.

The evidence from deletion rules is also significant,
since the directional theory makes a strong claim about which
there are numerous relevant cases. I have tried to deal with
a representative selection of such cases, including deletion
of final vowels, final consonants, and alternate vowels (no
rules of alternate consonant deletion exist to my knowledge).
On the basis of the evidence presented here, it would be
possible to maintain the unrevised theory, although considera-
tion of other cases may force a change in this position.
Deletion rules, as I have suggested, should be regarded in
any circumstances with considerable caution. They are quite

different in kind from our basic feature-changing rules and it would not be terribly surprising to find out that they, like morpholexical processes, behave somewhat differently. Thus, falsification of the directional theory on the basis of deletion rules is likely to be a rather weak falsification, still admitting the plausible alternative that feature-changing rules are directional.

The main function of this chapter has been to place these issues in perspective. By advocating a restrictive position even in the face of some possible counterexamples, I am calling for us to focus our attention upon the cases which are crucial. It is necessary to collect and study rules that fall into the class demanding fixed determinants to see whether they are indeed phonological rules, whether they form a discrete set of rules such as deletion processes, and what other properties they may share. I feel that the validity of rules with fixed determinants is still a very open question -- and a very interesting one -- deserving considerable further research.

NOTES

[1] It is interesting to add here that one of the
several contexts in which Anderson's crucial rule of tone loss
applies is where the forms have undergone accent ablaut. The
environments of (2), however they are to be correctly repre-
sented, must then also be environments of tone loss.

[2] All examples Bendor-Samuel gives are of these two
types, though his statements would lead one to expect the
same to be true in other first person contexts.

[3] I am grateful to Ann Peters for calling my attention
to Xhosa palatalization and making me cognizant of its rele-
vance.

[4] Cf. McLaren (1963:109-10).

[5] The meaning of "until there can be no further appli-
cation" must be stated more specifically, of course. We
would have to exclude vacuous application or else there would
be infinite reapplication to the same segment in many cases.
"Exchange rules" such as Anderson's rule of vowel shift for
Icelandic would have the same difficulty. Probably the best
way of handling this would be to provide a general constraint
on reapplication of a rule to the same segment. This is the
most appropriate usage of the term "segmental disjunction".

[6] I am grateful to Ken Rehg for the data and analysis
upon which this discussion is based.

[7] For purposes of this discussion, I will ignore the details of this rule such as the fact that it applies only to obstruents and that it is intimately interrelated with a rule deleting final vowels in complementary circumstances. However, see Schane 1968a; Chomsky & Halle 1968:353-55; and Milner 1967 for details.

[8] Schane (1968a:128), in demonstrating that phrase-final deletion was a later historical addition to the grammar of French than the elision rule, provides the following quotation indicating pronunciation in the sixteenth century:

> "[Dubois] ajoute cette double règle: 'A la fin des mots, on ne prononce aucune consonne, à moins qu'une voyelle ne suive, ou que la phrase ne soit terminée.' ... la dernière partie de la règle posée par Dubois ... peut se formuler ainsi: les consonnes finales se prononcent à la fin des phrases: Dans: le(s) femme(s) son(t) bones, la consonne finale se prononce seulement dans bones." (Livet, La Grammaire française et les grammariens du XVIe siècle, pp. 8-9)

Although not stated specifically, the phrase on ne prononce aucune consonne would seem to imply that consonant sequences were deleted here as well. If the ts sequence was deleted in the sixteenth century it would seem unlikely that the phenomenon should be treated so specially as to be a simultaneous rule.

[9] This rule necessitates a revision in the treatment of elision. Instead of extending the elision rule to apply across morpheme boundaries as in (35), it would be necessary to state that the plural suffix _s_ is preceded by a word boundary and that elision is confined to the context across higher level boundaries. Without this assumption, deletion of _c_ in _respects amicaux_ as opposed to retention in _respecter_ could not properly be stated.

[10] It must be emphasized that Schane's argument is a very weak one if it is based upon forms like those in (38). Selkirk appropriately questions whether these forms are synchronically related at all in rejecting Schane's penultimate deletion rule. Yet, it should be pointed out that the subset of examples represented by (36) and (37) is in itself rather peculiar and it may be as artificial to base one's case for a general treatment of deletion upon these examples as upon those in (38).

CHAPTER IX

CONCLUSION

At the outset of this work the question was raised as to how phonological rules apply. If we achieve a satisfactory answer to this question our knowledge of the nature of language will be substantially increased. The purpose of this work, then, has been to provide a more satisfactory answer than that offered by the various alternative theories currently available.

Chapters II through VI presented and elaborated the basic set of concepts which characterize the directional theory of rule application which I propose. It is probably unnecessary at this point to repeat these concepts in detail, but a brief summary may not be out of place:

1. The directional theory is built upon the assumption that rules are applied across a string in a leftward or rightward direction.

2. The direction in which each rule is applied is predictable from the relative locations of the determinant and focus.

3. Two types of rules must be distinguished: accent rules and nonaccent rules.

4. Disjunctive ordering is a characteristic only of accent rules.

5. Disjunctive ordering may be accounted for by the interaction of the principle of longest expansion and the

predictable directionality of the rule.

6. Nonaccent rules are subject to the crossover constraint, which prevents any segment satisfying the internal requirements of the focus from intervening between the focus and determinant for any given application.

7. A distinction must be made between the repetitive and simultaneous modes of application, with repetitive application being unmarked.

8. There are no necessary and sufficient conditions for determining mode of application in general, but assimilatory processes must be repetitive.

9. Rules in which the determining factors are found on both sides of the focus are universally rightward.

Since this is not the first work that deals with the nature of rule application in phonology, it is necessary to evaluate it in relation to competing theories. Chapter VII was thus devoted to a comparison of various alternative theories. In the course of that chapter I attempted to explore points of difference and similarities among the theories and concentrated most heavily upon the difficulties encountered by each theory in accounting for empirical cases.

Chapter VIII pointed out a limitation upon the directional theory as it had been presented in the earlier chapters. Several potential counterexamples were given to that theory and two alternative positions were presented. One view was

that these cases constitute valid counterexamples and the
theory should therefore be extended by some means such as
reversal of directionality or anchoring. The other view was
that these cases should be dismissed as either faulty analyses
or "morpholexical" processes and that the more restrictive
directional theory should be maintained. I have argued that
if for no other reason than as a research strategy the more
restrictive theory should be held at this point, but that
there were also important things that would be given up by
extending the theory to handle these cases. The chapter thus
represents an important research area that must certainly
become a focus for argumentation over phonological theories.

Throughout this work I have attempted to illustrate and
justify the proposed directional theory with empirical evidence.
Frequently this required new and original interpretations and
analyses of specific language data and these analyses were
often at a greater breadth and depth than offered elsewhere
in the literature. Part of the contribution of this work,
then, lies in the substantive reanalysis of these specific
language problems.

Although this work has been critical of the positions of
Chomsky & Halle, Johnson, and Anderson, I wish to make per-
fectly clear that each of these works has been and remains
valuable in its own right. All of them have attempted to
clarify the nature of the problem of rule application and each
has brought highly interesting evidence and insight to bear

upon its solution. It should be obvious to any reader that it would have been difficult, if not impossible, to arrive at the theory and insights presented here without the benefit of these other works.

The value of a theory is as much in the questions that it raises as in the answers that it provides. There is no question in my mind that _all_ of the theories discussed above are far from the correct answers we seek. This should not cause us to dismiss them all as "merely" incorrect, but should lead us instead to examine them in detail to determine _why_ they are wrong. This concern for falsification and clarification of the basis for falsification is the major step toward providing better answers. Each of the theories discussed here has been stated in very explicit terms because the authors recognize that through explicit statements the implications of a theoretical position can be seen more clearly. Explicitness helps us to determine just where the theory makes claims that are unreasonable and just where it makes claims that are reasonable. Above all, it allows the theory to be _falsified_, and falsification, or the potential for it, is at the very core of scientific inquiry.

It is in this vein that I hope this work will be judged. I do not claim that the theory proposed here is the ultimate correct theory. What I have attempted to do is to outline a theory which meets most of the objections raised to alternative theories and to justify it through empirical evidence. I

contend that this theory is the most adequate among the alternatives available today, but I hope that the result of this work will not be passive acceptance of the ideas contained herein. This work will have fulfilled its purpose only if it provides the challenge and some of the insight required for developing a theory that will replace it. Accordingly, I have attempted to expose not only the strong points of the directional theory but also its weaker points in the hope that further research will help to resolve the issues that have arisen. The discussion of fixed determinants in Chapter VIII exemplifies this point. It would have been easy to ignore this subset of rules and hope that others fail to notice the problem that it poses, but the progress of our inquiry depends upon our _raising_ questions, _especially_ those which potentially challenge the theory, rather than our suppressing them.

In sum, I wish this work to be judged as critically as the works of others have been judged above and if all of the ideas contained within it should be proven wrong but the stimulus for the falsification is provided by what I have done, the purpose of this work will have been fulfilled.

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BIOGRAPHY

The author was born on March 10, 1941 in Trenton, New Jersey. From the ages of 1-6 he lived in New Bedford, Massachusetts until, in the summer of 1947, he escorted his family across the continent and helped them to establish a new life in the Golden West. Through a series of moves progressively south along the San Francisco Peninsula he attended grade school in South San Francisco and high school in Menlo Park.

Upon completion of a moderately successful but far from superb career at Menlo-Atherton High School, the author entered Reed College in Portland, Oregon, where he was an outstandingly average student. Just when he appeared to be losing the race to grow up academically and socially sufficiently to meet the great pressures required to graduate from Reed, the author received an unusual opportunity. He had been majoring in anthropology and at the end of his sophmore year he received an invitation from his brother, Alan, to participate in bona fide anthropological research. Alan was doing his doctoral research in anthropology on the island of Rotuma in the (then) Colony of Fiji.

The invitation was intended to be for only a summer, but within this short period of time the author made himself so invaluable to the project that it was decided he should remain in the field for a full year. This decision, of course, had not been in any way influenced by his vivid threats as to what

would happen if he were not allowed to stay. As a result, the
author missed the precious opportunities of a year of formal
education, but benefited greatly from the responsibilities
and excitement of professional research.

In the fall of 1961, on his return from Rotuma, the
author enrolled at the University of Hawaii to pursue a degree
in anthropology with specialization in the Pacific area. In
February, 1962 he received one of the few undergraduate grants
offered to Americans by the newly-established East-West Center
and he was therefore able to continue his undergraduate educa-
tion at the University of Hawaii without the burden of
financial dependence.

The author completed his B.A. in 1963 and continued in
the graduate program in anthropology until February, 1964. At
this time, under the stimulus and encouragement of Samuel
Elbert, he began a period of anthropological research on a
remote Polynesian outlying atoll off the Solomon Islands in
the Territory of Papua and New Guinea. This research was
under the partial and grudging support of the East-West Center,
with most of the financial resources being provided by the
author's parents. One month was spent in Australia gathering
documentary material and seven months on the atoll, Takuu,
itself.

As perhaps the only nonnative speaker of Takuu, the
author became interested in describing this language and upon
return to the University of Hawaii for the spring semester of

1965 he began taking courses in linguistics. When frictions developed with the anthropology department and they decided he could not be seen through to a Ph.D., he was immediately adopted into the linguistics department by Howard McKaughan and George Grace, to whom he remains deeply grateful. Through their efforts the author received an NSF grant to attend the Summer Institute of the Linguistics Society of America at Ann Arbor in 1965, as well as a teaching assistantship in linguistics for the following year.

At the Institute the author had his first exposure to the writings of Noam Chomsky and the basic principles of generative grammar and was immediately excited by them. Although his intention at the beginning of the Institute was to get an M.A. in linguistics and return to anthropology for the Ph.D., by the end of the summer his fate had been determined. Returning to Hawaii for a year of study and for his teaching assistantship, he applied to M.I.T. and was accepted with a three-year NDEA Title IV fellowship.

During this year he also did some linguistic research on the syntactic properties of the passive construction in Japanese as part of a large-scale psycholinguistic study by Agnes M. Niyekawa. The collaboration being so rewarding, the author soon found himself on his way to the alter and has gained in the process two very wonderful children.

The author spent three years at M.I.T. from 1966-69, returning each summer to Hawaii to continue research on the

Japanese passive. He also taught two phonology courses at the University of Hawaii during the summer of 1968. After the first two years, the return to Boston was too much for his tropical blood to stand and after several bouts with the flu and bronchitis, his good spirits returned only when he was offered a teaching position at the University of Hawaii.

From 1969 to date he has been teaching at the University of Hawaii.

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