When Roman Jakobson proposed, in Child Language, Aphasia, and Phonological Universals, his universal laws of implication, which predict the presence of a more expected segment in a language which admits the corresponding but less expected (i.e. more marked) segment, he gave an explicit form to the notion that certain phonological inventories or systems are more natural than others. The idea of the naturalness of a phonological system has continued to motivate students of language, and in The Sound Pattern of English, Chomsky and Halle have proposed a set of "markedness conventions" to characterize the degree of naturalness of phonological systems.

Both the implicational hierarchies and the markedness conventions, however, are metalinguistic frameworks—they impose abstract constraints on phonological systems from outside. A desire to derive the constraints from within the phonological systems themselves has led David Stampe to propose, instead, "an innate system of phonological processes which resemble the implicational laws and markedness conventions in content but have the same ontological status as the natural processes (so-called "rules") of the phonological system of any individual language" (Stampe, "On Chapter Nine," forthcoming).

There are several things that make such processes attractive. They can account for the implicational hierarchies suggested by Jakobson, and they can measure the complexity of systems, much as the markedness conventions do. However, processes can also predict the substitutions made by children and by other speakers borrowing from one system into another.

According to Stampe's view, a process affects a class of segments which share a feature that is inaccessible to the inborn capacity for speech. For these segments, the speaker substitutes segments from another class identical to the first except that the inaccessible feature is eliminated. In general, then, segments with fewer inaccessible features are substituted for those with more—in regular fashion. Thus, the first segments acquired by children will be those with fewest "unusual" or inaccessible features. In order for any but the simplest segments to be acquired, the speaker must suppress or limit the processes which simplify the more complex segments. In view of this, the phonological inventory of a language may be described in terms of the suppressions that the language requires of its
However, more than one set of suppressions may produce the same vowel inventory, so that only the actual substitutions will reveal the entire pattern of suppression. I will comment on this again later.

suppressed the natural process which unrounds palatal vowels--i.e., which substitutes \( i \) for \( y \).

The basic hypothesis of natural phonology, then, is that the restrictions on inventories of underlying phonological segments—in this case, on vowel systems—are due to processes, rather than abstract hierarchies or morpheme structure constraints. If such processes exist, they ought to be discoverable in two ways: one might look at the substitutions (in child language, historical change, synchronic alternation, or loan phonology) which manifest such processes, and then apply the processes discovered to the limitations on systems; or one could hypothesize the processes on the basis of the existent systems and then look for the substitutions. In practice, it is generally necessary to use both methods almost simultaneously, but if I have favored one, it is that of looking first at the systems.

In this paper, I will first describe the processes with which I am going to deal; then I will survey the possible systems which alternative suppressions of the processes will generate; and after that, I will examine a variety of child substitutions and historical changes which the processes describe.

I will base my comments regarding systems on my observation of a number of vowel systems (over two hundred) collected from various sources—notably, from Trubetzkoy's *Principles of Phonology*, from Hockett's *Manual of Phonology*, and from studies in the *International Journal of American Linguistics*. The processes I suggest are based on these systems and on substitutions—child substitutions from Jakobson, Valten and Leopold, and historical changes from assorted sources (some of them oral).

There are certain arbitrary limitations on the scope of this paper. First, I have limited my study to monophthongs. Second, I have confined my observations to the processes which determine the "space" features—the quality features—of vowels. Thus, there is relatively little attention paid to stress, tenseness, nasality, tone, etc.

This paper is essentially an attempt to provide a first approximation to the form the natural processes take. It is intended to explore the feasibility of the basic idea of natural phonology and to discover the problems that confront any attempt to refine the theory.
CHAPTER II

THE PROCESSES PROPOSED

A. The Nature of the Processes.

The processes are assumed to be innate, or intrinsic, and their function is the simplification of the system: the more completely the processes apply, the simpler the vowel system they generate will be. Since the natural state of the processes is application, a cost in terms of learner-effort is attached to the suppression or limitation of any process. The complete application of all processes

3 The term "limitation" refers to the suppression of a subpart of a process—a decrease in the generality of its application. For instance, if the process (i) is limited to application to non-high vowels (ii), then a subpart of the process (i.e. (iii)) is suppressed as a result of the efforts of the speaker.

\[
\begin{align*}
(i) & \quad V \rightarrow \neg \text{Rnd} \\
(ii) & \quad V \quad +\text{Pal} \rightarrow \neg \text{Rnd} \\
(iii) & \quad V \quad +\text{Pal} \rightarrow \neg \text{Rnd} \quad +\text{High}
\end{align*}
\]

Limitations of processes—or suppressions of subprocesses—will be illustrated in the generation of vowel systems (in Chapter III).

results in the single, maximally vocalic vowel, \( \text{a} \). This is the simplest possible system.

The input to the processes is the range of possible vowels (assuming that there is a limit set on this range by a kind of threshold of perceptual and/or articulatory distinctiveness), and the rules serve to restrict and structure this range—i.e., to produce a vowel system.

This restriction by innate processes produces certain implicational effects, like the implicational hierarchies suggested by Jakobson. Like these hierarchies, the processes can be discovered not only through surveying existent synchronic vowel systems, but also by studying child substitutions.

In the child learning language, all the processes apply,
merging all vowels to a. Acquiring an opposition involves the suppression or limitation of one of the processes. The more of these natural processes the child learns to suppress, the more complex his vowel system becomes, until he finally has made enough suppressions to allow him the full set of oppositions present in his parents' language.

These processes do not appear in child language alone, however. They can also be seen at work in historical language change. If a generation or group of speakers, for example, fails for some reason to suppress a process that is suppressed in the language of their parents or "parent language community," then the language of this group will lack one of the oppositions that the parent language had. If, on the other hand, the younger generation should suppress or limit a process that was operative in the conservative form of the language, the new form will have an additional opposition.

Synchronously, too, the processes are observable in the morpheme structure rules, which limit, through substitutions, the forms available to a language. Loan phonology, the study of such substitutions, may reveal the processes operating in a language by noting the substitutions made when the language borrows from a language with a more complex system.

B. The Features Used Here.

Because the set of processes I am about to describe is meant to be suggestive rather than definitive, and because of the difficulty (cf. Ladefoged 1967, 67-72) of dealing with four-height vowel systems in terms of binary features, I have used features that will account for systems with a maximum of three heights. The tense-lax distinction will account for some apparently four- or five-height systems, however, and the rules are easily adaptable to other height descriptions.

I have used a similar strategy regarding timbre, which will become clearer with a description of the features I am using.

The set of features used is small and fairly simple, but some explanations might be useful:

+Palatal (+Pal) applies to those vowels in which the tongue is thrust forward and/or somewhat upward (with reference to the mandible or lower jaw) toward the hard palate. It refers, in fact, to those vowels traditionally called "Front".

+Round (+Rnd) applies to those vowels for which the lips are rounded.

+Low applies to those vowels for which the jaw opening is larger and/or the tongue is somewhat lower than in the speech-ready position (cf. Chomsky and Halle, 1968).

+High applies to vowels for which the jaw opening is small and the tongue is raised from the speech-ready position.

In the processes as I have written them, I have had occasion to refer to degrees of a feature. For example, "higher", in a
structural change, is used to refer to the addition of one degree of height to any vowel specified by the structural description. "Lower" in a structural description, on the other hand, refers to the increasing likelihood of application of a process as the vowel the process affects is less and less high. The use of this "degree-feature" notation has an important use: it indicates that the process is asymmetrical in that it can be limited in one direction (e.g., for "lower", to -High or +Low vowels) but not in the other (e.g., not to +High vowels).

Since there do not seem to be any languages with more than four systematic or distinctive timbre classes, I refer to central vowels simply as non-palatal. There do not seem to be any distinctions within languages between central rounded and back rounded vowels, or between central unrounded and back unrounded vowels.

The maximal system under these features, then, would be:

\[
\begin{array}{c|ccc}
 & +P & -P \\
+H & y & \bar{u} & \\
-H, -L & \bar{a} & e & \bar{a} \\
+L & \bar{a} & e & a \\
+R & -R & +R
\end{array}
\]

In this set of features, there will be three that are considered primary: +Palatal, +Round, and +Low, and each of these may be considered the principal characteristic of one of the three primary vowels: i, u, and a. This implies a certain primacy of +Low over +High. This will be attributed to the fact that +Low denotes maximal openness, and openness is the defining quality of vowels; +Low, then, is maximally vocalic, and +High may be considered a feature which deals only with less-than-maximal vocalism. This priority of +Low can affect the formulation of a rule by occasionally determining whether +Low or -High will be specified.

I have also used two less usual features to suit my purposes. These features have an essentially abbreviatory function, and they require explanation.

+Color is a cover term which includes +Palatal and +Round. It is intended to express a privative opposition between vowels which are either palatal or round or both and vowels which are neither palatal nor round. The use of this feature will be justified by the presence of some processes that affect vowels that are +Color but not those that are -Color, and other processes that affect -Color but not +Color vowels.

The term is only intended for rule-writing and expository purposes, however. No language seems to have a distinction of color without specification as to whether
the +Color items are +Palatal or +Round. It is not, then, to be considered a particular timbre, or another name for timbre, but a division within the set of timbre classes.

Neutral here refers to a vowel which is negatively specified for all of the above features. Thus, the Neutral vowel is the -High, -Low, -Pal, -Round vowel, A. However, as will be noted, a language may admit more than one neutral vowel, so "neutral" (small u) will denote the class of vowels which a language treats as neutral.

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

C. The Processes.

Based on these largely traditional feature descriptions, the following rules are suggested as describing the processes discovered. The rules will be loosely grouped and titled by function, and they are presented in unmarked order.

(1) Neutralization.

\[ V \rightarrow \text{Neutral} \]
\[ !-\text{Stress} \]
\[ !-\text{Tense} \]

This process, then, describes a certain tendency for vowels to be negatively marked with regard to the features used here.

The full form of this process applies only in child language, but a limited form of the rule continues to operate in many adult languages. This limited form,

\[ V \rightarrow \text{Neutral} \]
\[ !-\text{Stress} \]
\[ !-\text{Tense} \]

can be observed in the common phenomenon of vowel reduction.

Neutralization can be limited in a variety of ways. Evidence for this may be found in some of the different kinds of vowel reduction found in languages.

According to Bloomfield's description of Eastern Ojibwa (1956, 5-6), the structural change of the neutralization process is limited so that it lacks the !-Round feature, since there are two reduced vowels, a schwa and an indistinct vowel, roughly y or ə. The lax vowel system Bloomfield described is

\[ \ {\vphantom{0}} \gamma \]
\[ \ {\vphantom{0}} ə \]
and the neutralization process (i.e., the vowel reduction process) might, for this language, be written

\[
\begin{align*}
V & \rightarrow \text{Pal} \\
\text{-Stress} & \rightarrow \text{-High} \\
\text{-Tense} & \rightarrow \text{-Low}
\end{align*}
\]

so that the reductions are:

\[
\begin{align*}
\hat{i} & \rightarrow \dot{a}, \text{ and } \hat{o} & \rightarrow \dot{u}.
\end{align*}
\]

The front and back jers of Slavic (Shevelov, 432-433) represent a kind of reduction wherein -Palatal is the feature deleted from the structural change. Thus \( i \) reduces to a front jer (a +Pal, -High, -Low, -Rnd vowel), and \( u \) reduces to a back jer (a -Pal, -High, -Low, -Rnd vowel), by

\[
\begin{align*}
V & \rightarrow \text{-High} \\
\text{+High} & \rightarrow \text{-Low} \\
\text{-Long} & \rightarrow \text{-Rnd}
\end{align*}
\]

In English, neutralization applies to unstressed vowels, short or long. In certain contexts, however, (before high consonants) the structural change is limited so that the palatality specification is not changed—that is,

\[
\begin{align*}
V & \rightarrow \text{-Rnd} \\
\text{-Stress} & \rightarrow \text{-Low}
\end{align*}
\]

Thus, the final syllable of "comic" [kamik] remains distinct from that of "havoc" [hevuk].

In languages with certain rare vowel systems, a limited form of neutralization may continue to affect stressed vowels even in the adult language. The systems which result seem to lack distinctions of timbre, though some admit distinctions of height; and they will be mentioned again in the section dealing with timbre.

Neutralization, it seems, is (almost) always the first process to be limited or suppressed by children, and it is almost universally limited to unstressed or non-tense vowels in adult language. In its most general form, then, neutralization is the weakest process.

(2) Neutral-vowel Lowering.

\[
\begin{align*}
V & \rightarrow \text{+Low} \\
\text{Neutral} & \rightarrow \text{+Low} \\
\text{! +Stress} & \rightarrow \text{! +Tense}
\end{align*}
\]

Fed by the neutralization rule, this process lovers the neutral vowels \( \hat{i} \) and \( \hat{o} \) to \( \dot{a} \) and \( \dot{e} \), especially when these neutral
vowels become stressed or tensed. Processes (1) and (2), then, may
be viewed as the source of the "universal a" which appears to be
present in all child language—Hjellevag's "prince of vowels" (Jakobson 1962, 385).

The lowering process is parallel to the tendency toward maximal
vocalism or sonority. This tendency, as noted by Jakobson (1968, 69
et passim) is extremely strong in child language, but correlates
can also be found in adult substitutions (as in [bat] for English
"but" by speakers whose native language includes no a vowel), or in
historical change.

In adult systems where neutralization has been limited or
suppressed so that colored and high vowels may occur, such vowels do
not undergo this lowering, but the process may continue to affect
the neutral vowels.

Unless this process is limited or suppressed, the a vowel does
not appear in a language system. Since this vowel is neither rare
nor universal, the process cannot be considered either extremely
strong or extremely weak. Its operation appears to be independent
of the operation of any other rule.

This rule may be related to Jakobson's principle of maximal
distinction (Jakobson and Halle 1956, 37 et passim). The tendency
for -Color vowels is to lower to a, and the raising of the +Color
vowels then maximizes the articulatory and perceptual difference
between these sets. Furthermore, higher vowels maximize the color
features: i is fronter (more palatal) than e, and u rounder than o.
This can be seen in their greater tendency to palatalize or round
adjacent consonants.

The Color Rules

I have grouped these rules together because of their similar
functions, and also because of their similar forms. They appear,
however, to be descriptive of separate and largely independent
processes.

(3) V
       +Pal  → -Rnd
       !lower

(4) V
       +Rnd  → -Pal
       !lower

(5) V
       -Pal
       !more back  → +Rnd
       !-Low

(6) V
       -Rnd  → +Pal
       !lower
       !-Low
The processes which determine vowel color conspire to provide that vowels with a single positive color marking are preferred over vowels with two positive color markings or two negative ones. In effect, i, e, u, and o are to be preferred over y, ə, ɪ, and ʌ.

Processes (5) and (6) rarely apply to low vowels; apparently the neutralization rules, which remove positive color-markings from low vowels, are far stronger than these rules, which provide a positive marking. Application of processes (3) and (4) to low vowels coincides with the operation of the unrounding and depalatalization rules.

With respect to possible systems, processes (3) and (4) are functionally equivalent: both eliminate y, ə, and ʊ. By the same token, (5) and (6) are equivalent in eliminating ɪ, ʌ and (rarely) ə.

In each of the processes, one color specification is given, and the other results from the operation of the process. Operation of (3) and (5) as opposed to (4) and (6) implies that -Palatal is the given—the dominant—feature; operation of (4) and (6) makes -Round more basic. This may be a way of accounting for systems that are essentially -Palatal or -Round, as Trubetzkoy (1969, 100-101) characterized many of the two-timbre systems he described.

It is worth noting here, however, that (3) and (5) seem to operate in appreciably more cases than (4) and (6). Thus i and e are more likely substitutions for y and ə than are u and ʊ; and u and ʊ are more probable substitutions for ɪ and ʌ than are i and e.

The "lower" and "more back" labels are intended to indicate that the process so marked is increasingly likely to apply as the input vowel becomes less high or more retracted. The results of these varying scales of likelihood are that mid vowels (and sometimes low vowels) are more likely to be changed by these processes than are the corresponding high vowels.

There is an apparent problem here in that this might lead one to believe that the presence of ʌ in a system implies the presence of ɪ, in the same way that ə may be said to imply y. Yet systems with ʌ but no ɪ are quite common among the world’s languages. It is possible, however, to limit the input of the neutralization process to vowels that are -Rnd, -Pal, and -Low, so that ɪ + ʌ. There is no parallel possibility involving y and ə.

The mutual independence of rules (3) and (6) will be seen later in this paper, in looking at the systems generated by suppression of one or more of these processes. Certain relationships among these processes do obtain, however. The pairs (3) and (4), and (5) and (6) are mutually bleeding; if the height specification is the same for both processes in a pair, operation of one of the processes allows the other to apply only vacuously. If the height specifications within a pair are different, unnatural results are noted. For example, if the input of (3) is limited to -High, ʊ + ʌ and ə + e. If, in the same system, (4) applies to all heights, ɣ + u. The unlikelihood of such substitutions lends some credibility to Trubetzkoy’s descriptions in terms of one color distinction or another: for our purposes, it requires the specification that (3) - (4) and (5) - (6) are unlikely combinations in an adult system.

There are also processes which have a neutralizing effect on low vowels. These may eradicate the effects on low vowels of rules such
as (5) and (6).

(7) Unrounding.

\[ V + \text{Low} \rightarrow -\text{Round} \]

(8) Depalatalization.

\[ V + \text{Low} \rightarrow -\text{Palatal} \]

The unrounding rule provides that \( \varepsilon \rightarrow \varepsilon \) and \( \partial \rightarrow a \), and the depalatalization rule, that \( \varepsilon \rightarrow \partial \) and \( \partial \rightarrow a \). If both of these processes operate, the result is a single low vowel, \( a \).

Although these rules look similar, and although they frequently both apply in a given language, the processes they represent appear to be independent of each other, in that the application of one does not imply the application of the other.

(9) The Raising Rule.

\[ V + \text{Color} -\text{High} \rightarrow \text{higher} \]

\[ !+\text{Tense} \]

\[ !+\text{Low} \]

This rule, difficult to state in any conventional notation, describes the process by which colored non-high vowels add one degree of height: the mid vowels become high and the low vowels become mid. In its most general form, the process raises all Palatal and all Round vowels, but it may be limited to one series or the other, as, historically, in Sao Miguel Portuguese (King 1969a, 17), where only the round vowels were raised. It can also be limited to the intersection of these two sets, the +Round, +Palatal vowels, as in Middle Scots \( \partial \rightarrow \chi \) (Wright 1923, 28), or French \( \partial \rightarrow \phi \) (Morin 1971, 104-105).

As indicated by the \( !+\text{Low} \) condition, the process is stronger for low vowels than for mid vowels. Thus, the process may have its input limited to low vowels only, but not to mid vowels only; that is, if the process is suppressed for +Low vowels, it will also be suppressed for -Low vowels. It follows that for any one timbre class, a low vowel in that class implies a mid vowel in that class.

This is not the case for -Color vowels, but the raising process does not seem to apply to such vowels, a fact which has been noted in discussions of vowel shifts.

The \( !+\text{Tense} \) feature reflects the fact that tenseness is favorable to vowel raising, \(^4\) possibly because tenseness involves greater

---

\(^4\) It might be possible to state a distinct, but at least logically related process affecting lax vowels, such as
Tense

which would account for such occurrences as I + a, but the lack of such occurrences as e + a inclines me, instead, to account for such facts in terms of a limitation of the neutralization rule.

deviation from the neutral position. In English, for example, only stressed tense vowels underwent the Great Vowel Shift (Chomsky and Halle 1968, 256).

The following table summarizes the preceding sections by listing the processes:

TABLE I

SUMMARY OF THE PROCESSES

(1) Neutralization

\[
\begin{align*}
V \\
-T & \rightarrow \text{lower}
\end{align*}
\]

(2) Neutral-vowel Lowering

\[
\begin{align*}
V \\
\text{Neutral} \\
!+ & \rightarrow +\text{low} \\
!+ & \rightarrow +\text{tense}
\end{align*}
\]

(3) Palatal-vowel Unrounding

\[
\begin{align*}
V \\
+ & \rightarrow -\text{low} \\
! & \rightarrow \text{lower}
\end{align*}
\]

(4) Round-vowel Depalatalization

\[
\begin{align*}
V \\
+ & \rightarrow -\text{pal} \\
! & \rightarrow \text{lower}
\end{align*}
\]

(5) Nonpalatal-vowel Rounding

\[
\begin{align*}
V \\
- & \rightarrow +\text{Rnd} \\
! & \rightarrow \text{more back} \\
! & \rightarrow \text{Low}
\end{align*}
\]

D. How the Processes Operate.

The generation of a few simple systems should be enough to show
how the processes operate. A tentative ordering, set up here by the
criterion of maximal feeding (or, considering the nature of the
processes, minimal bleeding) order, will follow the order in which
the processes were just listed.

The most elementary situation—that of the child just beginning
to talk—produces the one-vowel system consisting of the maximally
open and sonorant \( a \). Such a system requires operation of all of the
natural processes.

If the neutralization rule is suppressed or is limited to
unstressed vowels, a three-vowel system will result. Depalatalization
and unrounding will change the low vowels to \( a \), the raising rule will
eliminate the mid vowels, and the color rules will leave only \( i \) and
\( u \) in the high series. The resulting

\[
i \quad u
\]

system is probably the simplest system found in adult languages.
The neutralization rule is extremely weak with respect to stressed
vowels; stressed vowels seem to neutralize only in child language, and
there they are nearly always lowered to \( a \) precisely because they are
stressed.

It should be noted here that, even with this solitary limitation
of a rule, there is more than one way for the system to be generated.
If raising occurred before depalatalization and unrounding, the +Low
vowels might be raised to \( \hat{a} \), \( e \), and \( o \), and, if rules may reapply,
then to \( \hat{\varepsilon} \), \( i \), and \( u \). Low-vowel unrounding and depalatalization
would reduce the vowel inventory to \( i \), \( u \), and \( a \) as above. While this
account is perfectly credible as a set of historical processes, I am
inclined to reject it as a synchronic description for two reasons.
First, it seems unnecessary to assume that one of the processes
applies twice and another applies vacuously. More important than this
"economy-based" reason, however, is that such an analysis would
require the prediction that any +Low, +Color vowel in a word borrowed
into the system would become a +High vowel of the appropriate timbre
class, rather than \( a \). I have never seen any evidence of such occurrences
as child substitutions of \( \hat{a} \) for \( e \), or for adult borrowings of this
nature.

Generation of the extremely common five-vowel triangular system

\[
i \quad u \\
\varepsilon \quad o \\
\hat{a}
\]

follows the same pattern as generation of

\[
i \quad u \\
\hat{a}
\]

but the five-vowel system requires an additional suppression: the
raising rule is limited to +Low vowels. Thus \( e \) and \( o \) are no longer
eliminated.

Here the possibility of more than one use of the processes to
generate the system seems a bit more probable. Since the raising
rule must be limited to +Low vowels, the +Low, +Color vowels may either be raised to merge with the mid vowels, or unrounded and depalatalized to merge with ə. In such a system, substitutions for ə and ɔ will be e and o if raising applies to them, or ə (for both) if depalatalization and rounding apply. Unlike the i-for-ə and u-for-ɔ substitutions required by the generation rejected above, substitutions of this kind (e for ə and o for ɔ) are not unexpected.5

5Mieko Ohso has pointed out to me that Japanese, which has a five-vowel system of this type, borrows ə and ɔ as a and o respectively. Thus ə apparently undergoes low-vowel depalatalization, but ɔ is raised rather than unrounded.

E. Complexity of Systems.

Some systems, of course, can be generated with fewer suppressions or limitations than others. The above are among the simplest and most common systems. (The ə-only system is common only in child-language, of course.)

Simplicity will be measured here in terms of the freedom with which the processes are allowed to operate: the greater the number and scope of the limitations and suppressions, the more complex the system will be. Thus, simplicity is not always directly related to the number of vowels in the system. The

\[
\hat{i} \\
\hat{u} \\
\hat{a}
\]

of certain Caucasian languages (Trubetzkoy 1969, 97–98), generated with limitation of the neutralization rule to

\[
y + \rightarrow \text{Rnd} \\
y + \rightarrow \text{Pal}
\]

and the suppression of lowering, raising, and the color rules (6) through (9) is far more complex than the

\[
\hat{i} \\
\hat{u} \\
\hat{a}
\]

system of Arabic and many other languages (Trubetzkoy 1969, 106), although both have the same number of vowels, since only neutralization need be suppressed to generate the latter system.

In order for the processes suggested here to be flexible enough to generate such systems as the rare

\[
\hat{i} \\
\hat{u} \\
\hat{a}
\]
Lyle, they must also be capable of generating, through further limitations, systems that look even more "unnatural." For example, if the neutralization rule can be limited to

\[ V + -P + -\text{Nd} \]

in producing the system above, there is at least no logical reason for it to be unable to be limited to

\[ V + -P + -\text{Nd} \]

which, with identical suppression of all the other processes, would generate the system

\[
\begin{align*}
\text{i} & \rightarrow \text{y} \\
\varepsilon & \rightarrow \phi \\
\lambda & \rightarrow a.
\end{align*}
\]

Obviously, an evaluation system is needed to measure the complexity of vowel inventories.

One possible way of measuring the complexity of the systems would be to count the features of the processes that are blocked out. Such feature-counting might require that there be a certain cost to the grammar for each addition to the structural description of a rule and a like cost for each deletion from the structural change. Deletion of the entire structural change, the most extreme form of such deletion, would be equivalent to suppression of the process.

Some form of feature-counting of this sort must be a part of the evaluation system, and yet if feature-counting is not supplemented by some weighting device, limitation of the neutralization process (which is universal in adult language) will be no more probable than, say, suppression of the low-vowel unrounding rule. Feature-counting alone does not take into account the relative strengths of rules.

Each feature added to the structural description or deleted from the structural change of a process could be counted, and the total number (of the changed features) could be multiplied by the assigned "weight" of the process. The results would then be totaled and the final figure would represent the complexity of the vowel system.

To reflect the likelihood of a rule's being limited to a !-marked value, removal of an ! could be assigned a cost one-half that of adding or deleting a feature.

In order to weight the processes, a scale of strength based statistically on frequency of application might be desirable, but it is hardly possible within the scope of this paper.
CHAPTER III
SOME EVIDENCE FOR THE PROCESSES

With a variety of suppressions or limitations, this relatively small set of processes may thus generate a large number of vowel systems, which should correspond to the vowel systems which actually do occur. Then, if the occurring systems are results of actual processes, one could expect to find independent evidence of these processes in the context-free processes affecting vowels in the developing phonological systems of children, and in the historical development of vowel systems.

A. Evidence from the limitations on systems.

First, the rules here are designed for generating a large proportion of the vowel systems of the world. They do so by producing the possible height and timbre combinations and distinctions.

1. Height

It seems that all—or almost all—languages have more than one vowel. Among the great proportion that must be viewed as having vowel distinctions, there do not seem to be any systems that lack a distinction of height. Languages may lack timbre distinctions entirely, but they do not seem to be able to do without height distinctions.

The above processes seem to reflect this. Only when the neutralization and lowering rules apply in their most complete form does a system lacking height distinctions result, and the neutralization rule is the weakest rule of all. As soon as this weakest process is limited, a height contrast is unavoidable.

2. Timbre

Distinctions of timbre, though apparently secondary to distinctions of height, are, of course, extremely common in languages. They are also, it seems, more complex; there are more variables associated with timbre.

The timbre distinctions used here, *Palatal* and *Round*, are simplifications in the same sense that all valued articulatory features are simplifications: they divide the "vowel space" into categories rather than treating it as a continuum. In general, the processes can be described in terms of these featural categories, but sub-featural variations can affect the strengths of various forms of the rule. In these cases, indicators such as "lower" have been included in the rules. This may not be a particularly attractive choice in terms of notation, but it seems that the various vowels should be able to be assigned relative degrees of these physical
qualities in fairly straightforward ways, and the terms allow for 
greater accuracy of description of the processes that do occur.

The principal use of these indicators occurs in the color rules, 
where the degree of lowness seems to affect the strength of the 
process. The meaning of the "!lower" indicator is fairly obvious: 
application of a process thus marked to +High vowels implies application 
to -High, -Low vowels, which in turn implies application to +Low 
vowels. Conversely, blocking the process for a lower vowel implies 
blocking it for any higher vowel, since the process is strongest for 
the lowest vowels and weaker for the higher ones.

The rules (7) and (8)—unrounding and depalatalization—and the 
!-Low markings on the color rules seem to conspire to eliminate low 
vowels other than a, and thus to produce a triangular system (i.e., 
one with no timbre distinctions in the low vowel series). In the 
systems generated so far, these processes were allowed to operate. 
Obviously, not all systems are triangular; the suppression of 
(7) or (8), with the optional elimination of the !-Low marking of the 
appropriate color rule, can produce a quadrangular system.6

6 The distinction triangular vs. quadrangular, however, is not 
really a very interesting one, since it amounts to no more than any 
other expression of the tendency toward fewer timbre distinctions 
among the more open vowels. Such a distinction apparently has favored 
some rather inappropriate vowel arrangements (such as (i) for the 
system (ii) or (iii)).

    (i) i y u
        e ø o
        a

    (ii) y i u
        ø e o
        a

    (iii) i y u
        e ø o
        a

I am trying to avoid such arrangements here; this accounts for my 
less-than symmetrical arrangements of some perfectly "natural" 
systems.

In the suggested set of processes, the "!lower" indicators on 
the color rules (and the depalatalization and rounding rules for low 
vowels) reflect the fact that there may be more timbre distinctions 
in the higher vowel series than in the lower ones, but usually not 
more distinctions in the lower than in the higher series.

Probably the most logical way of dealing with the variety of 
timbre systems is to break down the possible systems in terms of the 
number of distinctions within the language or system.
a. Languages without distinctive timbre classes

In a few languages (which appear to be concentrated in the West Caucasus), the timbre qualities of the vowels appear to be phonologically conditioned, and only vowel height seems distinctive. In such languages, it appears that some form of the neutralization rule must continue to apply to stressed vowels in the adult language, as perhaps

\[ V \rightarrow -\text{Pal} \]
\[ \quad -\text{Rnd} \]

and neutral-vowel lowering and the context-free color processes must be suppressed. The retention of any form of the neutralization rule for stressed vowels is extremely unusual, and the combination of this retention and the suppressions noted above is even more unlikely. The system of these languages is correspondingly rare.

b. Languages with two timbre classes

If there is a single timbre distinction in a language, it is often based on the overlap of the two colors. In such cases, the +Palatal vowels are -Round, and the -Palatal vowels are +Round. This is the case with the familiar

\[
\begin{align*}
&i \quad u \\
&é \quad o \\
&ó \\
&á
\end{align*}
\]

system of such languages as Spanish (Hockett 1955, 85), Fijian (Hockett 1955, 86), and Lake Miwok (Broadbent and Callaghan 1960, 301).

Other languages, however, give reason to believe that either +Palatal or -Round is the essential distinction of timbre, with the other distinction having secondary status, so that this other feature-value may be changed by various context-sensitive rules. Trubetzkoy (1969, 99 et passim) suggests that certain Montenegrin dialects have an essentially +Palatal timbre division, and that Russian has an essentially -Round distinction.

Such possibilities may be described within the set of processes suggested by the choice of the color rules used to generate the system. A system with a basically +Palatal distinction would be generated by the processes

\[ V \rightarrow \text{+Pal} \]
\[ \text{+Pal} \rightarrow -\text{Rnd} \]
\[ -\text{Pal} \rightarrow +\text{Rnd} \]
\[ \text{!Lower} \]
\[ \text{!Lower} \]
\[ \text{!-Low} \]
while a basically round system would be set up by the processes

\[
\begin{align*}
V & \quad V \\
+\text{Rnd} & \quad -\text{Pal} & \quad -\text{Rnd} & \quad +\text{Pal} \\
!\text{Lower} & \quad !\text{Lower} & \quad !\text{Low} & \quad !\text{Low}
\end{align*}
\]

c. Languages with more than two timbre classes

In systems with more than two timbre classes, the question of whether only one color feature is distinctive does not arise; obviously, both features are distinctive. These systems involve the suppression of one or more of the color processes.

By various suppressions and limitations, the set of processes proposed here do seem to be able to generate the occurring three- and four-timbre systems.

(1) Systems with three classes.

(a) +\text{Pal} -\text{Pal} -\text{Pal} \\
-\text{Rnd} -\text{Rnd} +\text{Rnd}

A vowel system that includes these three classes might be one like that found in Bororo (Huestis 1963, 231) and Maidu (Hockett 1955, 84):

\[
\begin{align*}
i & \quad a \\
e & \quad o \\
\end{align*}
\]

Here the neutralization, lowering, and raising processes are suppressed, but depalatalization and unrounding affect the low vowels. Characteristic of this set of timbre classes is the suppression of all the color processes except

\[
\begin{align*}
V & \\
+\text{Pal} & \quad -\text{Rnd} \\
!\text{Lower} & \quad !\text{Lower}
\end{align*}
\]

If raising and lowering are allowed to operate, the simpler, two-height system of Amahuaca (Hockett 1955, 84) results:

\[
\begin{align*}
i & \quad a \\
e & \quad o \\
\end{align*}
\]

If, instead, depalatalization and unrounding are also suppressed, the system

\[
\begin{align*}
i & \quad u \\
e & \quad o \\
\text{a} & \quad \text{a} \\
\end{align*}
\]
is generated. This system, according to Hockett (1955, 87) is the system of Trukese and Thai.

A "hollow" system, the

\[
\begin{align*}
&\text{i} \rightarrow \text{u} \\
&\text{e} \rightarrow \text{o} \\
&\text{a} \\
\end{align*}
\]

of languages like Tübutulabal (Trubetzkoy 1969, 112) and Choco (Loeven 1963, 358) may also be achieved. Neutralization and raising are suppressed (or raising is limited to +Low vowels), but lowering operates, eliminating the \( \_ \). The only unsuppressed color rule is still

\[
V \\
+\text{Pal} + -\text{Rnd} \\
!\text{lower}
\]

Alternatively, this system could be achieved by allowing the -Low, -High, -Pal vowels to be rounded by (5) (i.e., by limiting (5) instead of suppressing it).

(b) +\text{Pal} +\text{Pal} -\text{Pal} \\
-\text{Rnd} +\text{Rnd} +\text{Rnd}

If the color processes are limited differently, it is possible to generate systems with this different set of three timbres. An example of this kind of system is the

\[
\begin{align*}
&\text{i} \rightarrow \text{y} \rightarrow \text{u} \\
&\text{e} \rightarrow \text{o} \\
&\text{a} \\
\end{align*}
\]

of German (Hockett 1955, 87), of some French dialects (ibid), and of certain dialects of Tibetan (C. and F. Voegelin 1965, 32). The characteristic difference between this system and systems of the Bororo type can be attributed to a different limitation of the color rules: instead of allowing

\[
V \\
+\text{Pal} + -\text{Rnd} \\
!\text{lower}
\]

to operate and suppressing the others, these systems require that all the color rules except
be suppressed.

Additional systems may be generated by varying the limitations and suppressions of the other processes. The

\[
\begin{align*}
\text{I} & \quad \text{y} & \quad \text{u} \\
\text{e} & \quad \varnothing & \quad \text{o} \\
\text{a} & \quad \text{a}
\end{align*}
\]

of Middle Greek (Trubetzkoy 1969, 112) and Taki-Taki (Hockett 1955, 87) differs from the above system in that raising is limited to the +Pal, +Rnd vowels, at least in the non-low degrees of height.

The Middle High German long vowels (Wright 1955, 4-5),

\[
\begin{align*}
\text{i} & \quad \text{y} & \quad \text{u} \\
\text{e} & \quad \varnothing & \quad \text{o} \\
\text{a} & \quad \text{a}
\end{align*}
\]

form a similar system, except that the low-vowel depalatalization process is suppressed. (Also, it seems that raising does not operate here, unless it is limited to +Rnd vowels; I am more inclined to think that it is suppressed.)

(2) Systems with four classes.

Suppression of all of the color processes results in a four-timbre system; this is the maximal set of distinctions. Turkish, with its

\[
\begin{align*}
\text{i} & \quad \text{y} & \quad \text{u} \\
\text{e} & \quad \varnothing & \quad \text{o} \\
\text{a} & \quad \text{a}
\end{align*}
\]

system (Trubetzkoy 1969, 107) is probably the best-known example. Here neutralization is suppressed, and raising is at least limited to +Low vowels.

The color rules need not be entirely suppressed to produce a four-timbre system. In some cases, there are four timbres in the +High series only. (Eastern Cheremis (Trubetzkoy 1969, 104) is an example.) In such cases, the color rules may be limited to application to -High vowels and thus eliminate the non-high vowels of some timbres by changing a roundness or palatality marking, or the raising rule applies to certain timbre classes only, merging the non-high vowel with the high vowel of the same timbre.

From these examples, it is easy to see that a large proportion of the world’s vowel systems can be accounted for by the processes suggested. Some systems, especially a number of those found in
American Indian languages, remain, but the processes work in most situations, and they strongly favor the same vowels favored by Jakobson's implicational laws and Chomsky and Halle's marking conventions. In order to produce a less-favored vowel, more processes have to be suppressed, and the less-favored vowel occurs only in opposition to a more-favored one.

B. Evidence from substitutions.

In order to see the processes in action, however, it is necessary to look at them through the more dynamic aspects of language study—through language acquisition and language change.


It is in language acquisition, perhaps, that the operation of the processes is most obvious. The child acquiring language has a vowel system, however rudimentary, into which he must fit any word he chooses to say. If the adult form of the word contains a vowel not included in his system, the vowel form must be changed into one that he can use, and it is so changed by means of these innate or intrinsic natural processes. Thus, when the child has not suppressed any of the processes, all of his vowels are ordinarily pronounced as a no matter what the vowel is in the original word. (The phonetic environment may alter the quality of the vowel to a certain extent, but there is no distinctiveness to separate two vocalic segments in the system.)

Even when he has begun to limit at least one process and can therefore maintain a distinction, the child's system is still smaller (and simpler) than the adult's; when he uses a word containing a vowel he does not have, he must still make substitutions, and his substitutions are still governed by the processes that remain active.

a. Jakobson's predictions.

To a great degree, this progressive limitation can parallel the order of acquisition of distinctions predicted by Jakobson in Child Language, Aphasia and Phonological Universals and by Jakobson and Halle in Fundamentals of Language. According to Jakobson, the first vowel is the maximally open and therefore maximally vocalic a. The first vowel distinction acquired is one of height—the one distinction that seems to be universally present in vowel systems. The next distinction acquired is usually that of "palatal vs. velar" in the high vowels, generally expressed as i and u, in accordance with the principle of maximal distinctiveness.

This third system, the

\[ \text{i u} \]

system, is in a sense the optimal one, since it maintains at least two distinctions within each pair of two vowels. The distinction
maintained here between palatal and velar high vowels must precede the distinction between palatal and velar low vowels (a/a), between rounded and unrounded narrow palatal vowels (y/i), or between rounded and unrounded velar vowels (u/έ). The y/ι distinction must precede that between rounded and unrounded wide palatal vowels (a/a).

Jakobson also cites a common fourth vowel system:

\[ \text{i u e a} \]

This system can also be described using the suggested processes. Just as it is for the

\[ \text{i u e a} \]

system, neutralization is suppressed. The color rules, the lowering rule, and the depalatalization and unrounding rules may apply, but the raising rule is limited to

\[ V \]
\[ -\text{High} \rightarrow \text{higher} \]
\[ +\text{Tense} \]

Tracing the phonological development of a child, and suggesting how the processes might account for the substitutions made is another way of establishing the appropriateness of the rules proposed. The speech of two children will be observed here.

b. Joan Velten's speech.

Joan Velten's first words (Velten 1962, 25 et passim)—from the end of her eleventh month through her fourteenth month—contained only one vowel, a. This situation represents the operation of all the processes.

Joan's first distinction is the high- vs. low distinction separating u from a. This is apparently accomplished by a limitation of the neutralization rule from

\[ V \]
\[ !\text{-Stress} + \text{Neutral} \rightarrow !\text{-Stress} + \text{-Pal} \]
\[ !\text{-Tense} \rightarrow !\text{-Tense} \]

The effect of the weakening of the structural change of this process is that the process now leaves the output

\[ \text{i u e a} \]

instead of \text{a} alone. The neutral vowel, a, is still lowered to a; the color rules provide that \( \text{i} \rightarrow \text{u} \); and low-vowel unrounding substitutes
a for a. Raising makes o + u, and the system is reduced to the two vowels, u and a.

Joan's substitutions give substance to this conjecture. The English low vowels and a are articulated as a (as in ai by monophthongization), and the mid and high vowels become u. Allowing for some lack of fit between Velten's notation and that used here, the situation is, it seems: a, a, ai, a, a, and e (before liquids and nasals) → a, and ı, i, e, O, e (possibly ı), u, u, ı, ı, ı, or, and ı (these last three labials), and e (before obstruents) → u.

 Acquisition of i may be due to limitation of the neutralization rule to unstressed syllables or to its complete suppression. Either way, the result is the three-vowel system

i  u  a

The high front vowel is substituted for English i and e, and the rest of the substitutions are as before. In both the two- and three-vowel systems, it seems that the color rules operating are the stronger (5) and (6) Velten does tell us that Joan used a lax variant, ı, for the i vowel.

The rest of Joan's vowels were acquired after a considerable time, and all within the space of seven weeks. Her father says that their chronological order was e, e, o, e, e, which seems to be approachable from the point of view of the suggested rules. Since he does not list these acquisitions as they were substituted for the English vowels, however, we can no longer trace the exact suppressions the child made.

c. Hildegard Leopold's speech.

A brief view of Hildegard Leopold's acquisition of vowels (Leopold 1953-54, 353 et passim) can also be described within the system of processes suggested, although the exact phonetic values would have to be examined to determine which substitutions made by the child were really context-free and which were allophonic variations conditioned by the context. Hildegard's first vowel was also a, and, like Joan's a, it replaced e, A, and a. Her second vowel was i (as opposed to Joan's ı), with ı and y as allophones (y followed bilabials, with obvious assimilatory rounding).

The i suggests that Hildegard limited the neutralization rule to

V
!-Stress → -Round.
!-Tense

Lowering, the color rule,

V
-Rnd → +Pal

depalatalization and unrounding, and raising provide that e, A, and u be replaced by a, and that other mid vowels and high vowels be replaced by i.
Then u was acquired, "briefly and experimentally," according to Leopold; the father thinks of e as Hildegard's third stable vowel. If u really was acquired before e, the development of the

i u

system would be similar to Joan Velten's. If, instead, e was indeed the third vowel and Hildegard's three-vowel system was

i e a

one could explain that raising was limited to +Round vowels before neutralization was entirely suppressed for stressed vowels. When this limitation of neutralization does occur, u appears, and the common

i u e a

system is achieved.

Hildegard substituted u for "all standard high and mid back vowels," although a or even au was occasionally used to replace o. Her next acquisition was o—a result of the complete suppression of the raising rule. (The fact that o did not appear simultaneously with u indicates that raising had previously been limited only, not suppressed.) The y vowel was not acquired until quite late, apparently because of the strength of the lowering rule, and because suppression of this rule forces a change from an essentially two-timbre to a three-timbre system.

There are some obvious flaws in the above tracing of the vocalic development of these two children. First, neither is complete, and the final systems described are not even identical, although both children were learning the same language. Second, no attempt is made here to deal with any variations in the representations to determine what forms are the results of context-free processes and what forms have been changed by their environments.

These two troublesome problems could probably be resolved, but a precise analysis would be a problem sufficient for another paper of this size, especially for Leopold's highly detailed description. My intention here has been to give a brief sketch which would illustrate how the rules suggested here can account for the systems of child language, and to show that implicational hierarchies like Jakobson's might be seen—considering that the child is actually making substitutions—as processes that are active in the child's phonological system.

2. Historical change.

If these observations are considered to be processes, then it is not surprising that they would turn up in the historical development of a language. It can be somewhat difficult to find evidence in historical language study for context-free vowel changes because
such changes often fail to leave internal evidence. Nevertheless, a good number of context-free changes have been reconstructed. These changes parallel the context-free processes described here, and they too may be seen as evidence that the implicational hierarchies might be described as actual processes.

In the view put forth by natural phonology, "rule addition" may be the failure of a generation or a group of speakers to suppress a process that is suppressed in the standard language. For example, in order for a language to admit an a vowel, the low-vowel depalatalization process must be suppressed. The context-free historical change of œ to œ, then, may represent the failure of a language group to suppress this depalatalization process. This change actually occurred in Middle English, when Old English appel, for instance, became appel (Wright 1923, 19).

In Early Modern English this change was reversed (a far less usual circumstance), and a > œ, so that ME appel became our "apple" (Wright 1924, 38). This change could be described in terms of the suppression of low-vowel unrounding, with the consequent application of

\[
\begin{array}{c}
V \\
-Rnd + \text{Palatal} \\
\text{!lower}
\end{array}
\]

I would assume that this palatalizing process had been overridden (for low vowels), in the system with œ, by low-vowel depalatalization, which is ordered after palatalization. Suppression of the later depalatalization process allows palatalization to appear.

The parallel changes of œ to œ and œ to œ are also represented historically. English "not" ([not]) has become American [nat], and the set of processes which generate the Yiddish system has produced such forms as [noxl] from Middle High German nach (Sapir 1915, 257). As the œ/œ changes represented operation or suppression of low-vowel depalatalization, these œ/œ changes represent the operation and suppression (respectively) of low-vowel unrounding. (Suppression of low-vowel unrounding in Yiddish was accompanied by rounding of the non-palatal low vowels, which the unrounding process had previously overridden.)

The Color processes may be operated and their operations may vary to change in various ways the uncolored vowels and the doubly-colored vowels in the world's languages. The +High, -Palatal, -Round vowel, œ, for instance, may become either i or u in the course of an historical change. In order for œ to exist in a language, both

\[
\begin{array}{c}
V \\
+\text{Rnd} + \text{Pal}
\end{array}
\] \quad \begin{array}{c}
V \\
-\text{Pal} + \text{Rnd}
\end{array}
\]

must be suppressed. The pattern of the change which eliminates œ depends on which of the two is no longer suppressed (and thus operates on œ).

In Southern Welsh (Bowen and Jones 1960, 12), for example, the innate process
\[ V - \text{Rnd} + + \text{Pal} \]

was not suppressed and thus \( *i > i \). In the Mundipada dialect of Remo, a Munda language (personal communication, David L. Stampe), on the other hand,

\[ V - \text{Pal} + + \text{Rnd} \]

was not suppressed and \( *i > u \).

There are numerous examples of the unrounding of palatal vowels:

\[ V + \text{Pal} + - \text{Rnd} \]

Yiddish, with

\[ y \rightarrow i \]
\[ \emptyset \rightarrow e \]

is one of the most familiar instances (Sapir 1915, 259-260). Here MHG

mul > Yid. mill, "mill;" and MHG hörner > Yid. herner, "horns."

A good example of the kind of subprocess hierarchy denoted by the degree-feature "lower," is a comparison of this Yiddish change with one that occurred in Old English (Wright 1923, 32), where \( \emptyset > e \) but not \( y > i \). In Yiddish, the change followed the most general form of the process:

\[ V + \text{Pal} + - \text{Rnd} \]

In Old English, the process was limited to

\[ V + \text{Pal} + - \text{Rnd} - \text{High} \]

as favored by the "lower" specification in the process as originally presented.\(^8\) This subprocess operation is parallel to the operation

\[^8\text{It might be noted here that English later underwent a generalized form of this unrounding when Middle English } \emptyset (< \text{æ}) > e \text{ and the original } y > i \text{ (Wright 1923, 29-30).}\]

of subprocesses in the generation of systems with high front rounded vowels but no mid or low front rounded ones.
CHAPTER IV

PROBLEM AREAS: SOME OBSERVATIONS

A. Diphthongization, Monophthongization and Vowel Shifts.

1. Diphthongization and monophthongization.

Strictly speaking, the processes suggested here do not attempt to account for diphthongization and monophthongization. Such occurrences may be controlled by natural processes, and these processes may be related to the ones suggested here for simple vowels, but I have not examined diphthongs sufficiently to state what their controlling processes may be.

Such a study might be interesting, though, because it is possible that diphthongization and monophthongization are responsible for some of the changes which cannot be accounted for by the processes suggested here. A change like $u \rightarrow y$ might actually be the result of a series of processes involving diphthongization and monophthongization: $u \rightarrow uw \rightarrow iw \rightarrow y$. Similarly, in a diphthongization without monophthongization, $i \rightarrow ai$ might be the result of $i \rightarrow ii \rightarrow si \rightarrow si$. This is not meant to suggest that such historical changes are necessarily gradual, but simply that they may be accounted for by a series of processes that need not be directly counter to the ones suggested here.

2. Vowel shifts.

Conspicuous by their absence from the above material, perhaps, are vowel shifts. I have left these for a separate section because they are not entirely accounted for by the processes as suggested.

Frequently these chain-reaction changes in vowel systems are "set off" by an occurrence, such as diphthongization, that does not fall within the province of these processes, or by a process which, though it may be accounted for by these rules, is marked as extremely weak, or even by a change (e.g., $u \rightarrow y$) that completely controverts the processes as written.

For example, in the Sao Miguel dialect of Portuguese, a vowel shift involving raising of the non-palatal vowels and rounding of $a$ was begun, according to King (1969a, 17) with the change $u \rightarrow y$, a change not accounted for in the suggested framework. The changes that followed can be described by the rules, however. Raising provides that $o \rightarrow u$ and $\sigma \rightarrow o$. Low-vowel unrounding, which was already suppressed in the language (as evidenced by the presence of $\sigma$) remained suppressed, and the color rule
was allowed to operate on low vowels, so that \( a > \emptyset \).
The English vowel shift, under a similar interpretation, would have been touched off by the diphthongization of \( i \) to \( ē \) (through \( ē ē \)) and \( u \) to \( ow \) (through \( uw \)).

B. Counter-examples.

An instance of the kind of apparent counter-example which can be accounted for fairly easily within the suggested system is the lowering, in Sanskrit, of \( e \) and \( o \) to \( a \) (T. Burrow 1965, 103 et passim). This may be described in terms of the neutralization and lowering processes, which might be limited to

\[
\begin{align*}
&V \quad -\text{ Pal} \quad +\text{ Rnd} \\
&!-\text{ Low}
\end{align*}
\]

This is to some extent supported by the fact that \( a \) had the quality of an \( ē \), and

\[
\begin{align*}
&V \\
&\text{Neutral} \quad +\text{ Low}
\end{align*}
\]

More threatening counter-examples exist, however. A great number of American Indian languages have a solitary non-low back vowel represented as \( o \), without having an \( u \). The \( o \) may vary--freely or under stated conditions--with \( u \) or \( y \), but the nonlow back vowel is named \( o \) so frequently in studies of these languages that such naming can hardly be attributed to accident, or to perversity on the part of the people who describe them.

Several suggestions could be made as to the nature of such systems. One—that is many of these languages, the vowels are articulated with a peculiarly lax quality which may have something to do with the lowering of the highest possible back vowels—may, in fact, be in some way applicable to systems such as the

\[
\begin{align*}
&e \quad o \\
&\text{a}
\end{align*}
\]

of Upper Chehalis (Kinkade 1963, 181), but it does not explain the lowering of \( o \) when the vowel system still contains an \( i \). Trubetzkoj notes (1969, 107) that in certain systems "the vowels of the back class are realized more openly than the corresponding front vowels," but he makes no generalizations about such asymmetrical systems.

In an article on Swedish vowel production, Lindblom and Sundberg (1969, 17) distinguish the \( u \) tongue position, which involves a humping-up of the tongue toward the soft palate or velum, from both the palatal and the retracted articulations of the other vowels.
This articulatory gesture might for some reason be disfavored in certain languages, so that a lowering \( \text{u} \rightarrow \text{u} \) takes place and the raising \( \text{o} \rightarrow \text{u} \) is suppressed.

Admittedly, the processes suggested here offer no real explanation for such systems (which have been largely ignored in studies of vowels and the constraints on vowel systems). There seems to be an as-yet undiscovered process (perhaps a general lowering, especially of non-palatal vowels) at work, which is in some sense peculiar to this fairly large group of languages.

Finally, there are other occurrences, exemplified by some historical changes, which cannot be described precisely in terms of these processes. In some languages, the processes suggested here can be controverted, but here the suggested inventory can help to characterize the cost to the learner of these controversies. In others, the processes can operate in a kind of tangential manner which requires that, in a stronger-than-usual way, the vowel space must be regarded as a continuum.

Examples of such "tangential" operation are the unrounding of \( \ddot{\text{y}} \) to \( \dddot{\text{e}} \) as occurred in Kentish (Wright 1923, 22) rather than to \( \text{i} \), and the fronting or rounding of \( \ddot{i} \) to \( \text{e} \) or \( \text{e} \) rather than to \( \text{i} \) or \( \text{u} \) as occurred in two different dialects of Soran (personal communication, David Stampe). Such occurrences may be related to an articulatory or auditory difference in height between \( \text{i} \) and \( \ddot{\text{y}} \) or \( \dddot{\text{e}} \), such that if \( \text{y} \) and \( \ddot{\text{e}} \) are lower than \( \text{i} \), it becomes possible for them to unround, to palatalize, or to round to become vowels lower than \( \text{i} \).

It seems, then, that the processes are somehow sensitive to the precise phonetic shape that a segment takes in a language. This may seem strange because, in another sense, the processes control the shapes of segments, but the occurrences noted seem to indicate that it is true to some extent.
CHAPTER V

CONCLUSION

The conclusions to be drawn from the above discussion seem, at this point, to be fairly straightforward and to require little more than a brief summary. The preceding section has made all too obvious the intractability of certain systems and changes under the set of rules suggested. Perhaps some adjustments in the processes as described here are necessary, or perhaps the intractable systems and changes require certain language-particular context-free rules (learned rules) in addition to the natural processes suggested here. It is also possible that some of these problems could be resolved with the addition of processes (such as those affecting length or tenseness) that I have not dealt with here.

Nevertheless, the processes retain their appeal. They do characterize implications, both for vowels in a system (as $\phi \Rightarrow y$) and for changes operating in a language (as $y + i \Rightarrow g + e$). Finally, they do have the ability to account for substitutions made by children and by borrowing adults.

Supported by the evidence presented in Chapter III, then, these processes may well be part of a natural phonological system which represents certain intrinsic limitations of the speech capacity. Undoubtedly, the content and perhaps also the form of the processes, as formulated here, will require revision in the light of further study. What should emerge from this paper, at least, is that the principles governing possible phonological inventories can be identified with the processes themselves, and thus, ultimately, with the intrinsic character of the human speech capacity.


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