SOME CONTEXT-FREE PROCESSES
APPEARING VOWELS

A Thesis
Presented in Partial Fulfillment of the Requirements
for the Degree Master of Arts

by
Patricia Donovan Filler
The Ohio State University
1971

Approved by

David Stampe
Advisor
Department of Linguistics
# TABLE OF CONTENTS

I. Introduction 1

II. The Processes Proposed 5
   A. The nature of the processes 5
   B. The features used here 7
   C. The processes 10
   D. How the processes operate 20
   E. Complexity of systems 23

III. Some Evidence for the Processes 26
   A. Evidence from the limitations on systems 26
   B. Evidence from substitutions 34

IV. Problem Areas: Some Observations 44
   A. Diphthongization, monophthongization and vowel shifts 44
   B. Counter-examples 46

V. Conclusion 49
I would like to thank Professor David L. Stampe for his valuable ideas and suggestions, and for his patience.
I. Introduction.

When Roman Jakobson proposed, in *Child Language, Accents, 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 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 or complexity 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 VII., "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, such as the rank orders conventions do. However, processes can also predict the substitutions made by children and by other speakers borrowing from one system into another.

According to Stamp's view, a process is a potential substitution for a class of segments with a common feature inaccessible to the inherent 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" 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 speakers. For instance, if a language admits an $a$ vowel, it has suppressed the natural process which rounds

---

1. 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 suppressions. I will comment on this again later.
palatal vowels - i.e., which substitutes \( 1 \) 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 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, Hockett, and studies in the International Journal of American Linguistics. The processes I suggest are based on study of

2. For the majority of these IJAL systems, I'd like to thank Leslie Koster, who plowed through far more volumes than I did.
these systems and of substitutions - child substitutions from Jakobson, Velten 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.
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 vocal system they generate will be. Since the natural state of the processes in application, a cost in terms of learner-effort is attached to the suppression of limitation of any process. The complete application of all processes results in the single, maximal vocalic vowel. 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 vocal system.

This restriction by innate processes produces certain implicational effects, like the implicational hierarchies

3. The term “limitation” refers to the suppression of a subset of a process - a decrease in the generality of its application. For instance, if the process 

\[ V + {\text{Pal}} \] - and is limited to application to non-high vowel 

could then be a subset of the process (i.e., \[ V + {\text{Pal}} \] - and)

\[ {\text{High}} \]

is suppressed as a result of the efforts of the speaker. Limitations of processes - or suppression of subpro- cesses - will be illustrated in the generation of vowel systems (in Part III).
suggested by Jakobson. Like these hierarchies, the processes can be discovered not only through surveying extant 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.

3. 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, pp. 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 maxillary or lower jaw) toward the hard palate. It refers, in fact, to those vowels traditionally called "Front."

*Round* (+Rød) applies to those vowels for which the lips are rounded.
that applied 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). This 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 -hiq or -loq vowels) but not in the other (e.g., not to -hiq 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 language between central rounded and back rounded vowels, or between central unrounded and back unrounded vowels.

The maximal system under these features, then, would be:
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 priority 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 vocaletic, and *High may be considered a feature which deals only with low-than-vocaletic vocaletic. This priority of *Low can affect the formulation of a rule by increasingly 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, Α. However, as will be noted, a language may admit more than one neutral vowel, so “neutral” (small n) will denote the class of vowels which a language treats as neutral.

A ! notation is also used. It indicates that the most common, or strongest, 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 unordered order.

(1) Neutralization.

\[ V \rightarrow \text{Neutral} \]

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

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,

\[ V \rightarrow \text{neutral,} \]

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, 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 \( \hat{u} \) or \( \hat{e} \). The lax vowel system Bloomfield describes is \( i \), and the neutralization process (i.e.,

the vowel reduction process) might, for this language, be
written $\bar{y} \rightarrow \bar{\bar{\bar{y}}}$, so that the reductions are

\[
\begin{align*}
\text{Stress} & \rightarrow \bar{\text{Stress}} \\
\text{Vowel} & \rightarrow \bar{\text{Vowel}}
\end{align*}
\]

$\bar{} \rightarrow \bar{}$, and $\bar{} \rightarrow \bar{}$.

The front and back jers of Claudio represent a kind of reduction wherein -Palatal- is the feature deleted from the structural change. Thus $\bar{y}$ reduces to a front jer (a $+$Pal, $-$High, $-$Low, $-$Back vowel), and $\bar{y}$ reduces to a back jer (a $-$Pal, $-$High, $-$Low, $-$Back vowel), by

\[
\begin{align*}
\text{Stress} & \rightarrow \bar{\text{Stress}} \\
\text{High} & \rightarrow \bar{\text{High}} \\
\text{Low} & \rightarrow \bar{\text{Low}} \\
\text{Back} & \rightarrow \bar{\text{Back}}
\end{align*}
\]

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 - i.e.,

\[
y \rightarrow \bar{n}.
\]

Thus, the final syllable of "knee" [knee] remains distinct from that of "knee" [knee].

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 height, though some adult distinctions of height may be maintained again in the motion following with stress.

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-initial vowels in adult language. In the next general form, then,
neutralization in the most frequent process.

(2) Neutral-vowel Lowering.

\[ \begin{align*}
\text{Neutral} & \rightarrow \text{Low} \\
\text{Strong} & \rightarrow \text{Tense}
\end{align*} \]

Fed by the neutralization rule, this process lowers the neutral vowels \( \varepsilon \) and \( \Delta \) to \( \varepsilon \) and \( \Delta \), especially when those neutral vowels become stressed or tensed. Processes (1) and (2), then, may be viewed as the source of the "universal \( \varepsilon \)" which appears to be present in all child language - Stumpf's "prince of vowels."

The lowering process is parallel to the tendency toward maxima, vocalism or sonority. This tendency, as noted by Jakobsen, 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 \( \Delta \) 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 \( \Delta \) 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 minimal distinctness. The tendency for -color vowels in § lower to ə, and the raising of the +color vowels then maximizes the articulatory and perceptual difference between these sets. Furthermore, higher vowels maximize the color features: 1 is fronter (more palatal) than ə, and ə rounder than ə. This can be seen in their greater tendency to palatalize or round adjacent consonants.

The process may, without actually being suppressed, fail to apply to +low vowels because the neutralization rules (unrounding and depalatalization) may remove the positive color markings required for raising.

The Color Rules.

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

(3) \( y \) \( \rightarrow \) -Pal
   Flower
(4) \( u \) \( \rightarrow \) -Pal
   Flower
(5) \( a \) \( \rightarrow \) +Pal
   Have been
   I -Jose
(6) \[ \text{V} \rightarrow +\text{Pal} \]

The processes which determine vowel color can be seen to converge 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, \( \text{I, E, U} \), and \( \text{O} \) are to be preferred over \( \text{Y, A, E, and O} \).

Processes (2) and (6) rarely apply to low vowels; apparently the neutralization rules which remove positive color-markings from low vowels are far stronger than those rules which provide a positive marking. Application of processes (3) and (4) to low vowels coincides with the operation of the surrounding and depalatalization rules.

With respect to possible systems, processes (3) and (4) are functionally equivalent: both eliminate \( \text{I, A, and O} \). By the same token, (5) and (6) are equivalent in eliminating \( \text{E, A, and (rarely) O} \).

In each of the processes, one color specification is given, and the other results from the operation of the process. Operation of (2) and (3) as opposed to (4) and (6) implies that +Palatal is in 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 characterized many of the two-color systems he described.

It is worth noting here, however, that (3) and (5)
appear to operate in approximately more cases than (b) and (c). Then 1 and 2 are more likely substitutions for 2 and 2 than are 1 and 2. 2 and 2 are more probable substitutions for 2 and 2 than are 1 and 2.

The “Marker” and “more back” labels are intended to indicate that the process so marked is increasingly likely to apply as the input vowel became less high or more retracted. The results of these varying scales of likelihood are that old 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 2 in a system implies the presence of 2, in the same way that 2 may be said to imply 2. Yet systems with 2 but no 2 are quite common among the world’s languages. It is possible, however, to limit the input of the neutralization to vowels that are -фр, -пал, and -лей, so that 2 + 2. There is no parallel possibility involving 2 and 2.

The mutual independence of rules (2) and (6) will be seen later in this paper, in looking at the system generated by suppression of one or more of these processes. Certain relationships among these processes do obtain, however. The pairs (2) and (6), and (5) and (4) are mutually blocking. In the height specification in the case for both processes in a pair, operation of one of the processes blocks the other to apply only maximally. If the height
specification within a rule are different, number of results are needed. For example, if the input of (7) is limited to \(-3\), \(\mathbf{a} \rightarrow \mathbf{A}\) and \(\mathbf{a} \rightarrow \mathbf{A}\), \(\mathbf{A}\), in the same syntax, \(\mathbf{A}\) applies to all heights, \(\mathbf{A} \rightarrow \mathbf{A}\). The unlikeliness of such specifications lends some credibility to Predelatal's derivations in terms of one color distinction or another; for our purposes, it requires the specification that \(\mathbf{a} \rightarrow \mathbf{A}\) and \(\mathbf{a} \rightarrow \mathbf{A}\) are unlikely combinations in a 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.
\[
\begin{align*}
V & \rightarrow -\text{Round} \\
+\text{Low} & 
\end{align*}
\]

(8) Depalatalization.
\[
\begin{align*}
V & \rightarrow -\text{Palatal} \\
+\text{Low} & 
\end{align*}
\]

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

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.
(7) The Raising Rule.

\[ \text{Raising} \rightarrow \text{Higher} \]

\[ \text{+Color} \rightarrow \text{+High} \]

\[ \text{-Form} \rightarrow \text{-Low} \]

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 São Miguel Portuguese, where only the round vowels were raised, or Scots, where only palatal vowels were affected. It can also be limited to the intersection of these two sets, the +Round, +Palatal vowels, as in Middle Scots \( a \rightarrow \varepsilon \), or French \( e \rightarrow \varepsilon \).

As indicated by the +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 +Tense feature reflects the fact that tenenom
in favorable to vowel raising, possibly because tenseless involves greater deviation from the neutral position. In English, for example, only stressed tense vowels underwent the Great Vowel Shift.

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

Table I: Summary of the Processes

1. Neutralization
   \[ \text{v} \rightarrow \text{Neutral} \]
   \[ \text{1-Stress} \rightarrow \text{1-Tense} \]

2. Neutral-vowel Lowering
   \[ \text{v} \rightarrow \text{+Low} \]
   \[ \text{1-Neutral} \rightarrow \text{1-Tense} \]
   \[ \text{1-Sense} \rightarrow \text{1-Sense} \]

3. Palatal-vowel Unrounding
   \[ \text{v} \rightarrow \text{-Rud} \]
   \[ \text{1-Pal} \rightarrow \text{1-Pal} \]
   \[ \text{1-Nor} \rightarrow \text{1-Nor} \]

4. Round-vowel Depalatalization
   \[ \text{v} \rightarrow \text{-Pal} \]
   \[ \text{1-And} \rightarrow \text{1-And} \]
   \[ \text{1-Nor} \rightarrow \text{1-Nor} \]

*It might be possible to state a distinct, but at least logically-related process affecting lax vowels, such as \( \text{v} \rightarrow \text{lower} \), which would account for such occurrences as \( \text{z} \rightarrow \text{o} \), but the lack of such occurrences as \( \text{z} \rightarrow \text{u} \) troubles us, instead, to account for such facts in terms of a limitation of the neutralization rule.*
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 bonding (or, considering the nature of the processes, minimal bonding) 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 initially open and central \( \tilde{a} \). 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 surrounding will change the low vowels to \( \tilde{a} \), the raising rule will eliminate the mid vowels, and the color rules will leave only \( \tilde{i} \) and \( \tilde{u} \) in the high series. The resulting \( \tilde{i} \), \( \tilde{u} \) 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 these are nearly always lowered to \( \tilde{a} \) 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 surrounding, the low vowels might be raised to \( \tilde{a} \), \( \tilde{i} \), and \( \tilde{u} \), and, if rules may reapply, thence to \( \tilde{a} \), \( \tilde{i} \), and \( \tilde{u} \). Low-vowel surrounding and depalatalization would then apply vacuously, and the remaining processes would reduce the vowel inventory to \( \tilde{a} \), \( \tilde{i} \), and \( \tilde{u} \) 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-minded" 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 in child substitutions of 1 for a, or for adult borrowings of this nature.

Generation of the extremely common five-vowel triangular system /i, u, a, o, e/ follows the same pattern as generation of i, u, but the five-vowel system requires an additional suppression: the raising rule is limited to +Low vowels. Thus a and u 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 a. In such a system, substitutions for i and u will be a and o if raising applies to them, or e (for both) if depalatalization and rounding apply. Unlike the 1-for-i and u-for-a substitutions required by the generation rejected above, substitutions of this kind (a for i and o for u) are not unexpected.
2. 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 θ-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 A of certain Casavian languages, generated with limitation of the neutralization rule to V → -Pal and the suppression of lowering, raising, and the color rules (6) through (9) is far more complex than the i u system of Arabic and many other languages, 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 θ type, 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 → -Pal in producing the system above, there is at least no logical reason for it to be unable to be limited to V → -Ed, which, with identical suppression of all the -Pal
other processes, would generate the system  

Obviously, an evaluation system is needed to measure the complexity of vowel inventories. One possible way of measuring the complexity of the system would be to count the features of the processes that are blocked out. Each feature-counting might require that there is 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 suppression of the low-vowel unrounding rule. Feature-counting alone does not take into account the relative strengths of rules. 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.

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

The weights used here will be crude and somewhat arbitrary, as the proportionate costs of the various vessel systems will certainly be inexact, but the given weights are only intended to illustrate how such a measure might work, and even this crude measure gives some indications that coincide with general notions of what is more and less natural in vessel systems.

To reflect the likelihood of a rule's being limited to a 1-point value, removal of an I could be assigned a cost one-half that of adding or deleting a feature.
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.

I. 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 need 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 do 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 looseness seems to affect the strength of the process. The meaning of the "lower" indicator is fairly obvious; application of a process thus ranked 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 (9) - unrounding and dephalantilization - and the + low markings on the color rules seen to conspire to eliminate low vowels other than a, and thus to produce a triangular system (i.e., one with no / nue/ 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 (9), with the optional elimination of the + low marking of the appropriate color rule, can produce a quadrangular system. 5

5. 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 throat distinctions among the more nasal vowels. Such a distinction apparently has several superficially inappropriate vowel arrangements (such as / y u/ o / p o), for the system y l u or i y u, I am trying to avoid such arrangements here; this accounts for my less-than-ideal statistical arrangements of most possibly "natural" systems.
In the suggested set of processes, the "lower" indicators on the color rules (and the degemination 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 Caucasian), 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

\[ V \rightarrow \text{PAL} \text{; and neutral-vowel lowering and the context-}
\]

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 \text{a} system of these languages is correspondingly rare.
b. Languages with two timbre-classes.

If there is a single timbre distinction on 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 1-color system of such languages as Spanish, Fijian, and Lake Tivak.

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 suggests that certain Montenegro 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

\[ V \rightarrow -\text{Pal} \quad \text{and} \quad V \rightarrow +\text{Pal}, \text{ while a basically} \]

\[ -\text{Pal} \quad \text{and} \quad +\text{Pal}. \]

A +Round system would be set up by the processes

\[ V \rightarrow -\text{Pal} \quad \text{and} \quad V \rightarrow +\text{Pal}. \]

\[ -\text{Pal} \quad \text{and} \quad +\text{Pal} \]

\[ -\text{Round} \quad \text{and} \quad +\text{Round}. \]
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 does seem to be able to generate the occurrent three- and four-timbre systems.

(1) Systems with three classes.
(a) +Pal -Pal -Pal
   -Rnd -Rnd +Rnd

A vocal system that includes these three classes might be one like that found in Bororo and Maidu: i u o

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:

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

Flower

If raising and lowering are allowed to operate, the simpler, two-height system of Jivaro or Anamawa results: i u

Hence, instead, depalatalization and unrounding are also
suppressed, the system $i + u$ is generated. This system, according to Hockett, is the system of Prakar and Thai.

A "hollow" system, the $i + u$ of languages like the

can be achieved. Neutralization and raising are suppressed (or raising is limited to $+Low$ vowels), but lowering operates, eliminating the $L$. The only unsuppressed color rule is still

$V \rightarrow -Low$. 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) $+Pal$ $-Pal$ $-Pal$ $-nd$ $+nd$ $+nd$

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 $i + u$ of German, of some French dialects, and of certain

dialects of Tibetan. 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 $V \rightarrow -nd$ to operate and suppressing the

others, these systems require that all the color rules
except $\gamma$ → + and be suppressed.

River
$\sim-\text{low}$

Additional systems may be generated by varying the limitations and suppressions of the other processes. The $i\gamma u$ of Middle Creek and Cali-Calri differs from the above system in that raising is limited to the +-vowels, at least in the monosyllabic degree of height.

The Middle High German long vowels, $i\gamma u$, form a similar system, except that the law-vowel depalatalization process is suppressed. (Also, it seems that raising does not operate here, unless it is limited to +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-class system: this is the minimal set of distinctions. Turkish, with its $i\gamma u$ system, 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-class system. In some cases, there are four classes in the +high vowels only. (Eastern Cheyenne is an example.) In such cases, the color rules may be
United so ordinarily to high vowels and then applied to
the non-high vowels or were shared by changing a member of
polysyllabic words; or the raising rule applies to certain 
high vowels only, carrying the non-high vowel with the high vowel of the same syllable.

From these examples, it is easy to see that a large proportion of the world's vocal 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 implication 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.

3. 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 vocal 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 sys-
tem, the vocal form must be changed into one that he can
use, and it is so changed by means of these innate or in-
trinsic natural processes. Thus, when the child has not
suppressed any of the processes, all of his vowels are ordi-
narily pronounced as ə, 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 the 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 sys-
tem 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 in the
maximally open and therefore maximally vocalic ə. The first
vowel distinction acquired is one of height - the one
distinction that seems to be universally present in vowel systems. The next distinction required is usually that of "palatal vs. velar" in the high vowels, generally expressed as \( \text{i} \) and \( \text{u} \), in accordance with the principle of maximal distinctiveness.

This third system, the \( i-u \) 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 (\( \text{e}/\text{e} \)) between rounded and unrounded narrow palatal vowels (\( \text{y}/\text{y} \)), or between rounded and unrounded velar vowels (\( \text{u}/\text{u} \)). The \( \text{y}/\text{u} \) distinction must precede that between rounded and unrounded wide palatal vowels (\( \text{e}/\text{e} \)).

Jakobson also cites a common fourth vowel system: \( i-u \). This system can also be described using the suggested processes. Just as it is for the \( i-u \) system, neutralization is suppressed. The color rules, the lowering rule, and the de-palatalization and unrounding rules may apply, but the raising rule is limited to \( \text{y} \rightarrow \text{higher, e.g.} \text{gig} \rightarrow \text{heg} \).

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 traced here.
Jean Valton’s speech.

Jean Valton’s first words—from the end of her eleventh month through her fourteenth month—contained only one vowel, ɑ. This situation represents the operation of all the processes.

Jean’s first distinction is the high-mid-low distinction separating ɑ from ɒ. This is apparently accomplished by a limitation of the neutralization rule from ɒ → Neutral

1-Stress

1-Force

to ɑ → -Pal. The effect of the weakening of the structural change is that the process now leaves the output ɑ instead of ɑ alone. The neutral ɑ → ɑ

vowel, ɑ, is still lowered to ɑ; the color rules provide that ɑ → ə and low-vowel surrounding substitutes ə for ɑ. Raising rules ə → ɒ, and the system is reduced to the two vowels, ɑ and ə.

Jean’s substitutions give substance to this conjecture. The English low vowels and ɑ are articulated as ɑ (as in ɑ1 by nonophthongization), and the mid and high vowels become ɒ. Allowing for some lack of fit between Valton’s notation and that used here, the situation is: It seems: ɑ, ə, ɒ, ɔ, ɑ, ə, and ɔ (before liquids and nasals) → ɑ and ə, ɑ, ɔ, ə (possibly ə?), ɔ, ə, ɒ, ə, and ɔ (these last
three after labials, and u (before obstruents) \( \rightarrow \mu \).

Acquisition of \( \mu \) 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 \( \hat{i} \mu \). The high front vowel is substituted for English \( \hat{i} \) and \( \hat{u} \), 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 \( \hat{u} \) and \( \hat{0} \). Walton does tell us that Joan used a lax variant, \( \hat{\hat{a}} \), for the \( \hat{i} \) 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 \( \hat{\hat{a}} \), \( \hat{\hat{e}} \), \( \hat{\hat{a}} \), 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.

1. Hildegarde Leopold's speech.

A brief view of Hildegarde Leopold's acquisition of vowels 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. Hildegarde's first
vowel was also e, and, like John's u, it replaced a, o, and æ. Her second vowel was i (as opposed to John's y), with e and æ as allophones (y followed bilabials, with obvious assimilatory rounding).

The ı suggests that Hildagard limited the neutralization rule to 

<table>
<thead>
<tr>
<th>Stress</th>
<th>Round</th>
<th>Lowering</th>
<th>the color rule</th>
</tr>
</thead>
</table>

Y → +Pal, deaptilalization and unrounding, and raising

-provided that e, o, and æ be replaced by i, and that other mid vowels and high vowels be replaced by ı.

Then u was acquired, "briefly and experimentally," according to Leopold; the father thinks of u as Hildagard's third stable vowel. If u really was acquired before æ, the development of the i æ u system would be similar to John沃伦’s. If, instead, æ was indeed the third vowel and Hildagard’s three-vowel system was i æ, 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, æ appears, and the common i æ u system is achieved.

Hildagard substituted u for "all standard high and mid back vowels," although æ or even æu was occasionally used to replace æ. Her next acquisition was æ—a result of the complete suppression of the raising rule. (The fact that æ did not appear simultaneously with æ indicates that raising
and previously been limited only, not suppressed.) The A 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 tonal
classification to a three-integer 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 re-
solved by close attention to the data provided, but a pre-
cise 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 sub-
stitutions - 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 \( e \) vowel, the low-vowel depalatalization process must be suppressed. The context-free historical change of \( e \) to \( a \), then, may represent the failure of a language group to suppress this depalatalization process. This change actually occurred in Middle English, when Old English \( ameal \), for instance, became \( ameal \).

In Early Modern English this change was reversed (a far less usual circumstance), and \( a > e \), so that \( be ameal \) became our "apple." This change could be described in terms of the suppression of low-vowel surrounding, with the consequent application of \( V \rightarrow +\text{Palatal} \). I would assume that this palatalizing process had been overridden (for low vowels), in the system with \( u \), by low-vowel
depalatalization, which is ordered after palatalization. Suppression of the later depalatalization process allows palatalization to appear.

The parallel changes of ə to ə and ə to ə are also represented historically. English "not" ([nʌt]) has become American [nat], and the set of processes which generate the Yiddish system has produced such forms as [not] from Middle High German nacht. As the ə/ə changes represented operation or suppression of low-vowel depalatalization, these ə/ə changes represented the operation and suppression (respectively) of low-vowel unrounding. (Suppression of low-vowel unrounding in Yiddish was accomplished 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, ə, for instance, may become either ı or ɨ in the course of an historical change. In order for ə to exist in a language, both ı → +Round -Pal and ɨ → +Pal must be suppressed. The pattern of the change which eliminates ə depends on which of the two is no longer suppressed (and thus operates on ə).

In Southern Welsh, for example, the innate process

ı → +Pal was not suppressed and thus ə → ɨ. In the
Hawaiian dialect of Pomo (a Kumia language), on the other hand, \( \text{Y} \rightarrow \text{H} \) was not suppressed and \( \text{R} \rightarrow \text{N} \).

There are numerous examples of the unrounding of palatal vowels (\( \text{Y} \rightarrow \text{H} \)), Yiddish, with \( \text{Y} \rightarrow \text{I} \), \( \text{W} \rightarrow \text{O} \),

is one of the most familiar instances. Here \( \text{HCH} \rightarrow \text{Y} \),

\( \text{M} \), "hur," and \( \text{HCH} \) homer \( \rightarrow \text{Y} \), homer, "homer."

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, where \( \text{A} \rightarrow \text{E} \) but not \( \text{E} \rightarrow \text{I} \). In Yiddish, the change followed the more general form of the process, \( \text{Y} \rightarrow \text{H} \), \( \text{E} \rightarrow \text{O} \), \( \text{Y} \rightarrow \text{I} \), and in Old English, the process was limited to \( \text{Y} \rightarrow \text{Y} \), \( \text{E} \rightarrow \text{E} \), \( \text{Y} \rightarrow \text{Y} \), and in Old English, the process was

favored by the "lower" specification in the process as originally presented.\(^6\) This subprocess operation is parallel to the operation of subprocesses in the generation of systems with high front rounded vowels but no mid or low front rounded ones.

\(^6\) It might be noted here that English later underwent a generalized form of this unrounding when Middle English \( \text{A} \) \( \rightarrow \text{A} \) and the original \( \text{A} \rightarrow \text{I} \).
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 $v \rightarrow u$ might actually be the result of a series of processes involving diphthongization and monophthongization: $v \rightarrow uv \rightarrow eu \rightarrow u$. Similarly, in a diphthongization without monophthongization, $i \rightarrow ai$ might be the result of $i \rightarrow ai \rightarrow at \rightarrow ai$. 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 → 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, with the change u → y, a change not accounted for in the suggested framework. The changes that followed can be described by the rules, however. Raising provides that a > u and 2 > 2. Low-vowel unrounding, which was already suppressed in the language (as evidenced by the presence of 2) remained suppressed, and the color rule V \_Pal \_Low \_Pal was allowed to operate on low vowels, so that 2 > 2.

The English vowel shift, under a similar interpretation, would have been touched off by the diphthongization of a to ai (through i), and u to ow (through u).
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 \( a \) and \( u \) to \( i \). This may be described in terms of the neutralisation and lowering processes, which might be limited to

\[
V \rightarrow -\text{End} \quad (\text{this is to some extent supported by the fact that } a \text{ had the quality of an } A) \quad \text{and} \quad V \rightarrow +\text{Low, Neutral}
\]

More threatening counter-examples exist, however. A great number of American Indian languages have a solitary non-low back vowel represented as \( a \), without having an \( u \).

The \( a \) may vary - freely or under stated conditions - with \( u \) or \( w \), but the nolow back vowel is never \( u \) as 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 in 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 - say, in fact, be in some way applicable to systems such as the \( e - o \) of Upper Cowlitz, but it does not explain the lowering of \( a \) when the vowel system still contains an \( i \). Trubetzkoy notes that in certain systems "the vowels of the back class are realized more openly
then the corresponding front vowels;” but he makes no
generalizations about such articulatory systems.

In an article on Swedish vowel production, Lindblom
and Sundberg distinguish the u tongue position, which in-
volves a bumping-up of the tongue toward the soft palate
or velum, from both the palatal and the retracted articu-
lations of the other vowels. This articulatory gesture
might for some reason be disfavored in certain languages,
so that a lowering u → a takes place and the raising a → 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 ven-
cles) 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 controversial, but here the
suggested inventory can help to characterize the cost to
the learner of these controversies. In others, the pro-
cesses can operate in a kind of tangential manner which re-
quires skill; in a stranger-than-usual way, the vowel system
must be regarded as a continuum.

Examples of such “tangential” operation are the
unrounding of a to a (as occurred in Kentish) rather than to a, and the fronting or rounding of a to u or o rather than to a or o (as occurred in the different dialects of Scots). Such occurrences may be related to an articulatory or auditory difference in height between a and u or o, such that if a and u are lower than a, it becomes possible for them to unround, to palatalize, or to round to become vowels lower than a.

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.
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 here. 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 $\hat{a} \rightarrow y$) and for changes operating in a language (as $y \rightarrow i \rightarrow \hat{a} \rightarrow o$). Finally, they do have the ability to account for substitutions made by children and by borrowing adults.

Supported by the evidence presented in Part III, then, these processes may well be part of a natural phonological system which represents certain intrinsic limitations of the human speech capacity. Undoubtedly, the context 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 then, ultimately, with the intrinsic character of the human speech capacity.
BIBLIOGRAPHY


(For forthcoming), Natural Phonology.


Trubetzkoy, N. S. (1969), Principles of Phonology (translated by Christiane A. M. Baltaxe), Berkeley and Los Angeles, University of California Press.
